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When Refrigerant Phaseout Meets Heat Pump Acceleration, Fragmented Policy Could Backfire



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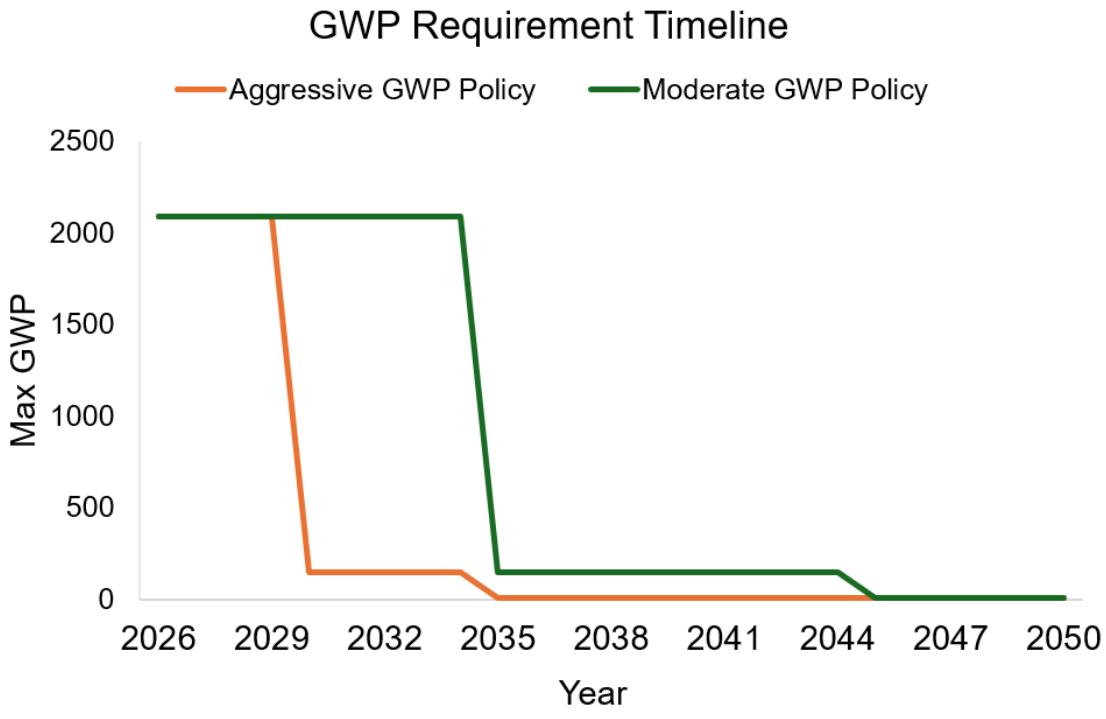
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Key Takeaways

- Policies that promote heat pump adoption and refrigerant transitions should be coordinated within and across jurisdictions. Without careful sequencing of steps, competing policies could not only fail to reduce emissions but also prolong the use of fossil fuels.
- Lifecycle carbon reduction from heat pump adoption (vs. gas baseline) is much higher than lifecycle emissions from refrigerants. When refrigerant requirements add costs, heat pump deployment can slow down. The lost operational carbon savings could outweigh the refrigerant savings.
- Legislation and adoption of codes and policies should move forward together. Legislation without a realistic, cost-conscious implementation path is not effective. Refrigerant requirements should demonstrate that they will not materially reduce heat-pump affordability, availability, efficiency, or deployment.
- The shift from current refrigerants (GWP >2,000) to low-GWP refrigerants (GWP <700) can deliver substantially greater near-term climate benefits than the additional shift to ultra-low-GWP refrigerants (GWP <20), particularly when market readiness and technology constraints are considered.
- Reducing the GWP of refrigerants is only one lever available to policymakers. An equally important lever is keeping refrigerants from being released into the atmosphere through leak prevention, recovery, reclamation, and reuse. These measures can reduce emissions from the large installed base of existing equipment as well as from new heat pumps, while reducing demand for newly produced refrigerant.

Timing and pacing of refrigerant and heat-pump policies for maximum climate benefit

Replacing fossil fuel heating with heat pumps avoids operational emissions. But heat pumps require refrigerant to transfer heat when heating and cooling. The most common refrigerant in use today is R-410A[1], long used in residential and commercial air-conditioning and heat-pump equipment. R-410A has a global warming potential (GWP) of approximately 2,088 GWP_{100}: that is, releasing one unit of R-410A has the same warming effect as releasing 2,088 units of CO_2 over a 100-year period. Recognizing that such a high GWP has negative long-term climate consequences, manufacturers have, since 2025, been moving much of the U.S. heat-pump market toward low-GWP (below 700 GWP_{100}) A2L (mildly flammable) refrigerants, such as R-454B (a blend of R32 and R1234yf) and R-32 (difluoromethane, a single compound).[2] Federal policy under the American Innovation and Manufacturing Act of 2020 is driving this transition (U.S. Environmental Protection Agency 2026a, 2026b). Some states, including New York, are looking beyond this transition toward ultra-low-GWP (<10 GWP_{100}) refrigerants (New York State Department of Environmental Conservation 2025a).[3]



[1] R410A belongs to the family of hydrofluorocarbons (HFC), a blend of R32 and R125, roughly 50/50 by mass. It is the third generation of refrigerants used to resolve ozone depletion. Despite both components being HFCs, they have very different GWPs: R-125 has a much higher GWP (3500) than R-32 (675).
[2] In refrigerant labeling, the "A" means lower toxicity, the "2" means flammable, and the "L" means low burning velocity. So, a "2L" labeling indicates mildly flammable.
[3] For heat pump water heaters (HPWHs), New York State's Hydrofluorocarbon (HFC) Standards and Reporting regulation, known as DEC (Department of Environmental Conservation) Part 494 requires the transition to ultra-low-GWP(GWP_{20}<10) as soon as January 1, 2027. Implications for HPWHs are discussed later in this paper.

As states simultaneously accelerate heat-pump deployment and tighten refrigerant requirements, the two policy pathways affect the same equipment and the same investment decisions. Ambitious jurisdictions could inadvertently adopt competing policies that not only fail to achieve the anticipated reduction in emissions but also unintentionally prolong the use of fossil fuels. Avoiding these regrettable outcomes requires policymakers to accept tradeoffs and consider these questions:

- How quickly should policy push toward ultra-low-GWP refrigerants if added costs for equipment, safety, codes, permitting, or installation could slow heat-pump deployment?
- What combination of refrigerant policy, electrification policy, and refrigerant management delivers the greatest overall emissions reduction?

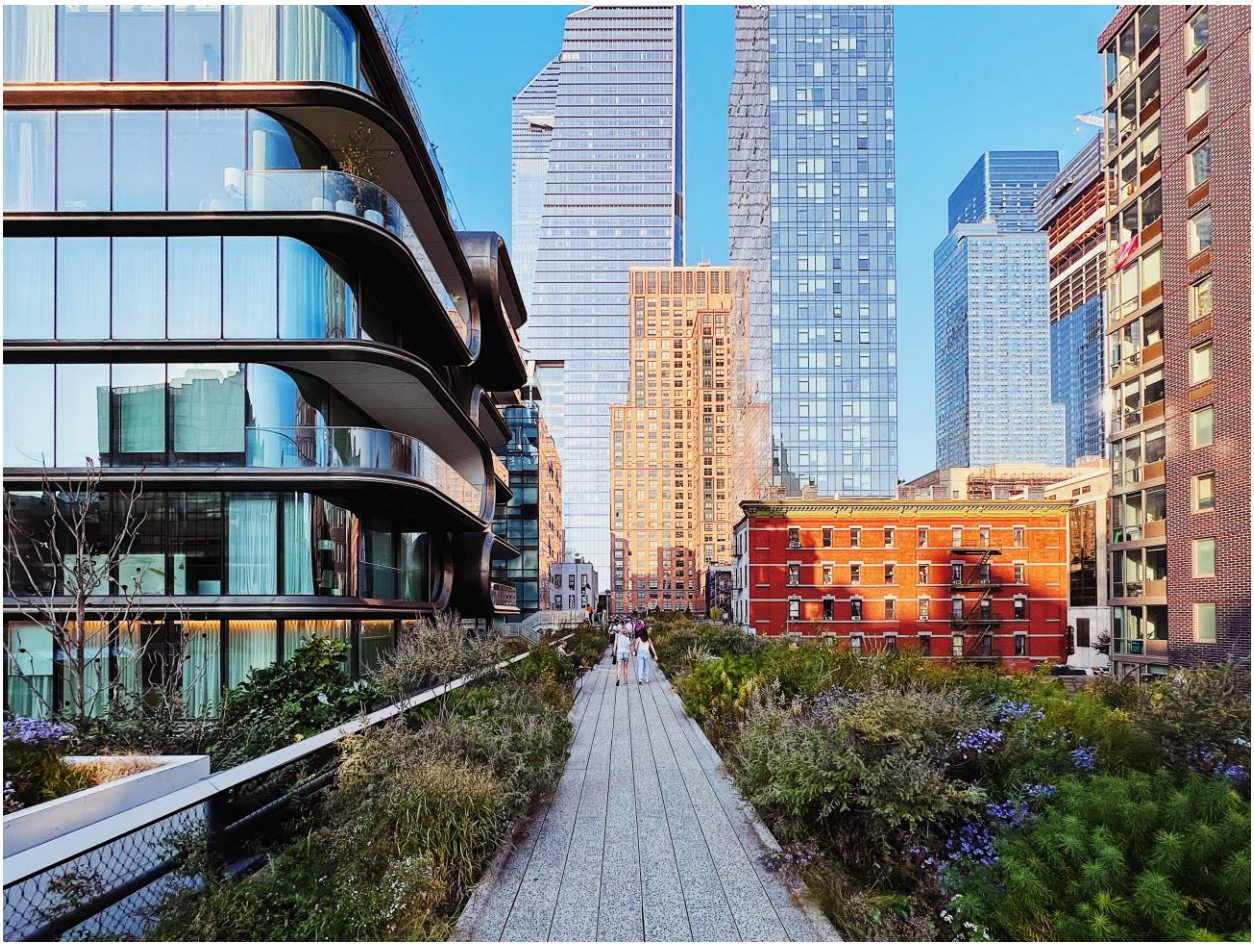
GWP measures potency; emissions volume helps determine total impact

The GWP metric quantifies the warming effect of a gas per unit emitted over a specified time horizon, but GWP alone is inadequate to measure the total climate impact of an emission source, which also depends on the gas's persistence and the quantity released. A 100-year time horizon emphasizes cumulative, long-lived climate impacts and underpins most greenhouse-gas inventories, net-zero frameworks, and refrigerant regulations. A 20-year time horizon has also emerged in policy, placing greater weight on pollutants that drive near-term warming, including methane and many refrigerants. The choice of metric can materially affect how policymakers value methane reductions and refrigerant transitions, particularly when trying to limit warming over the next two decades. However, the key question remains the same: whether the selected metric leads to policies that reduce total emissions by influencing market direction and consumer choices.

New York's experience illustrates how the choice of time horizon can affect policies and their implementation broadly. New York adopted GWP_{20} through the 2019 Climate Leadership and Community Protection Act (CLCPA), replacing the GWP_{100} convention previously used in its state emissions inventory and placing greater weight on methane and other short-lived climate pollutants. That accounting framework shaped the 2024 amendments to Department of Environmental Conservation (DEC) Part 494, New York's HFC Standards and Reporting regulation. DEC reported that hydrofluorocarbons (HFCs) accounted for roughly 6% of statewide greenhouse gas emissions—equivalent to approximately 30% of the state's 2050 emissions budget[4]—and identified food stores, residential air conditioning, and motor vehicles as major sources, without providing a specific breakdown. DEC Part 494 translated the CLCPA's economy-wide targets into equipment-specific requirements, including GWP thresholds, phaseout schedules, leak management, and reporting for refrigeration, air-conditioning, and heat-pump systems. Although New York amended the CLCPA in 2026 to return statewide greenhouse-gas accounting to GWP_{100} (BCLP 2026), DEC Part 494 still contains requirements developed under the earlier GWP_{20} framework. For HVAC and heat-pump policy, the

[4] This means if HFC emissions remained near their reported level while total allowable emissions declined, they could consume about 30% of the remaining 2050 budget.

resulting question is how and when those equipment-specific thresholds will be reconciled with the amended CLCPA.



Commercial refrigeration often uses large refrigerant charges, extensive field-installed piping, and systems with comparatively high leakage; New York's demonstration projects and policy have emphasized supermarkets, grocery stores, and pharmacies. HVAC and heat pumps include millions of smaller systems with lower leakage per unit. Heat pumps also reduce operational emissions when they replace fossil-fuel heating—a benefit commercial refrigeration does not provide in the same way. HFC reductions in commercial refrigeration may therefore be highly beneficial, but applying the same thresholds and timetable to HVAC systems requires a separate assessment.

When setting policy for HVAC, heat pumps, and commercial refrigeration, it is critical to evaluate total emissions, equipment availability, cost, efficiency, and projected impact on heat pump deployment—not simply the GWP of the refrigerants used.

For building decarbonization, shifting from GWP_{100} to GWP_{20} changes the reported balance among methane, refrigerant, and carbon-dioxide emissions. Methane's warming potential rises from roughly 30 times that of CO_2 under GWP_{100} to more than 80 times under GWP_{20}. Many refrigerants also receive higher GWP_{20} values, although refrigerant regulations and product standards generally use GWP_{100}. The metric therefore changes the relative weight assigned to emissions, but not the physical performance or choices of low-carbon solutions. Table 1 compares the emissions associated with providing 10,000 kWh of useful heat (a reasonable assumption of one

home's annual heating demand) using electric resistance, a heat pump, and a natural gas furnace at three assumed methane-leakage rates. The comparison reports results under both GWP_{100} and GWP_{20}.

TABLE 1. EMISSION COMPARISONS OF VARIOUS SOURCES UNDER DIFFERENT CARBON ACCOUNTING FRAMEWORKS

Heating option	Calculation assumptions	Tons CO_2e, using GWP_{100}	Tons CO_2e, using GWP_{20}
Electric resistance	10,000 kWh electricity; 100% conversion of electricity to heat. Emissions are based on U.S. Environmental Protection Agency (EPA) eGRID 2023 U.S. average generation emissions of 767.209 lb CO_2/MWh, 0.057 lb CH_4/MWh, and 0.008 lb N_2O/MWh	3.50	3.51
Heat pump, COP 3.0	~3,333 kWh electricity; 5-pound R-32 charge with 10% refrigerant loss	1.32	1.72
Natural gas, 1.5% methane leakage[5]	95% Annual Fuel Utilization Efficiency (AFUE); EPA's natural-gas combustion factor of 53.06 kg CO_2/MMBtu	2.22	2.76
Natural gas, 2.0% methane leakage		2.32	3.06
Natural gas, 2.5% methane leakage[6]		2.43	3.35

Total climate impact depends on the total quantity released as well as the gas's potency and atmospheric lifetime. A high GWP does not automatically produce a large overall

[5] A Department of Energy (DOE) study estimated roughly 1.4% leakage of pipeline-quality natural gas (vented routinely or leaked unintentionally from various sources) throughout the natural gas supply chain. https://www.energy.gov/sites/prod/files/2014/07/f18/20140729%20DOE%20Fact%20sheet_Natural%20Gas%20GHG%20Emissions.pdf

[6] An assessment of methane emissions from the U.S. oil and gas supply chain published in *Science* estimated U.S. oil and natural gas supply chain methane emissions equivalent to 2.3% of gross U.S. gas production, about 60% higher than the EPA inventory estimate. https://www.energy.gov/sites/default/files/2023-12/Ex.%2012.%20Alvarez%202018.pdf

impact if emission volumes are small; conversely, a lower-potency gas can have a substantial impact when emitted at very large scale.

If the goal of New York's policy is to reduce onsite building emissions, then the important question is: How do refrigerant emissions compare with the operational CO_2 emissions heat pumps are intended to reduce?

Buildings produce three main sources of onsite emissions:

- CO_2 from fossil energy use (operational emissions)
- Methane leakage from natural gas systems
- Refrigerant leakage from cooling and heat pump systems

Our discussion here excludes upstream emissions from electricity generation to focus on reducing onsite building emissions. Grid decarbonization and building emission reductions must proceed simultaneously.

As cooling demand is expected to increase globally, it is obvious that refrigerant emissions should be addressed early, but interrelated factors must also be considered:

- To what degree could the transition to low-GWP refrigerants affect HVAC system efficiency and heat-pump adoption?
- How do refrigerant emissions compare with the operational CO_2 emissions heat pumps are intended to reduce?

These questions do not have simple answers because refrigerant leakage rates vary widely depending on equipment type, installation quality, maintenance, operating conditions, equipment age, and end-of-life recovery practices. Policymakers often need to act without complete data, and uncertainty should not prevent timely action. A practical starting point is to compare the scale of operational and refrigerant emissions and examine how that balance changes over time.

Before turning to the analysis, the next section provides background for readers who may be less familiar with HVAC systems and refrigerants.

Moving beyond R-410A is not a simple substitution

Moving from R-410A to R-454B or R-32 produces a substantial reduction in direct refrigerant emissions. Manufacturers have already redesigned major product lines around these refrigerants, and federal policy is driving the transition (U.S. Environmental Protection Agency 2026a, 2026b). However, R-454B and R-32 are not the ultimate endpoint if the goal is to minimize refrigerant climate impact.

The next step is more complicated because moving from these A2Ls to ultra-low-GWP alternatives is not a simple substitution. Ultra-low-GWP options include not only propane (R-290) and carbon dioxide (R-744), but also ammonia (R-717) and hydrofluoroolefins (HFOs) such as R-1234ze(E) and R-1233zd(E), which are already used commercially in certain refrigeration, chiller, and commercial or industrial heat-

pump applications. These options broaden the available technology pathways, but no single refrigerant is suitable for every HVAC application.

Some ultra-low-GWP refrigerants introduce greater flammability, toxicity, different pressure requirements, charge limitations, or other design and safety considerations. Their suitability depends on equipment type and configuration, efficiency, installation conditions, applicable codes, and available service capacity. These characteristics can affect equipment architecture, installation practices, building and fire code requirements, permitting, and contractor training (Langevin, Satre-Meloy, and Chandra-Putra 2024). The key question for policymakers is not simply "how low can refrigerant GWP go?" but "which ultra-low-GWP options are viable for each application, and how quickly can they be deployed while preserving rapid heat-pump adoption?"

TABLE 2: COMPARISON OF REFRIGERANT TYPES FOR HVAC SYSTEMS

Refrigerant	GWP_{100}	Safety class	Characteristics and considerations
R-410A	2,088	A1	Legacy; high direct climate impact.
R-32	675	A2L	Transitional option; mildly flammable; safety controls and code acceptance required.
R-454B	466–467	A2L	Transitional option; mildly flammable; safety and code acceptance required.
Refrigerants with GWP slightly below 150	≤150	Varies	Policy-threshold case; apply only where a compliant product pathway exists.
R-290 (propane)	3	A3	Near-zero-GWP; higher flammability and application/charge/code constraints.
R-744 (CO_2)	1	A1	Near-zero-GWP; high-pressure equipment and specialized service considerations.
R-717 ammonia	1	B2L	Established in industrial refrigeration and some large commercial systems; highly efficient but requires toxicity and safety controls and specialized design and service.
R-1234ze(E)	1	A2L	Commercially used in chillers and some commercial and industrial heat pumps; mildly flammable and application specific.
R-1233zd(E)	4	A1	Commercially used primarily in low-pressure centrifugal chillers; nonflammable, with equipment architecture suited to larger systems.

Reference: ASHRAE 2022; New York City Department of Housing Preservation and Development 2026

New York City shows why implementation matters: Costs could increase substantially

New York City provides an important early case study because it is pursuing aggressive electrification and aggressive refrigerant policy. DEC Part 494 establishes increasingly stringent requirements for HVAC equipment and refrigerant management. As of January 1, 2026, new residential and light-commercial air-conditioning and heat-pump equipment may not use refrigerants above 700 GWP_{100}, effectively excluding R-410A while allowing current A2L replacements such as R-32 and R-454B. The rule then sets application-specific ultra-low-GWP limits using New York's 20-year metric: factory-charged residential HPWHs must use refrigerants at or below 10 GWP_{20} beginning January 1, 2027; new variable-refrigerant-flow systems must meet the same 10 GWP_{20} limit beginning January 1, 2030; and other new residential and light-commercial air-conditioning and heat-pump systems must meet it beginning January 1, 2034. The restrictions apply to new products and systems rather than requiring existing equipment to be replaced before the end of its useful life (New York State Department of Environmental Conservation 2025a, 2025b, 2026a).

The cost of these refrigerant transitions may come less from the refrigerant itself than from how equipment, safety standards, building codes, fire codes, and permitting requirements interact in actual projects. New York City is one of the most challenging urban environments for HVAC upgrades because of dense multifamily buildings, long refrigerant piping runs, limited mechanical space, complex fire and building codes, and multiple regulatory authorities. In addition, considering the cold climate, electrification in New York is not as simple as replacing heating equipment—it often involves wiring, circuit, panel, and/or service upgrades, condensate management, changes to ventilation systems, more mechanical equipment space—all adding to the upfront costs.



Those implementation constraints differ by system type and should not be treated as a single problem. Direct-expansion systems may have long refrigerant piping runs,

making refrigerant charge, leak detection, mitigation, shaft, and flammability requirements important design considerations. Central hydronic systems generally distribute heating and cooling through hydronic piping, so long refrigerant runs and A2L flammability may be less significant.

For larger central plants in New York City, a more consequential constraint may be the fire code's qualified-operator requirement for systems with compressors of 50 horsepower or more. Scroll-compressor systems[7] can often remain below this threshold, while many larger screw and centrifugal chillers do not, creating an ongoing operating cost that some customers may be unwilling to accept. At the same time, ultra-low-GWP HFOs such as R-1234ze(E) and R-1233zd(E) are not broadly available in the smaller scroll-compressor systems commonly used to remain below the operator threshold. The interaction among refrigerant choice, compressor architecture, plant capacity, and operator requirements can therefore limit ultra-low-GWP options for central systems.

New York City's Department of Housing Preservation and Development developed guidance for projects using A2L refrigerants. Implementation measures include:

- refrigerant charge and room-volume calculations, leak detection and mitigation, and ventilation;
- refrigerant piping, shaft, and puncture-protection requirements;
- alarm and fire-safety interfaces, commissioning, and testing; and
- permitting, inspections, and coordination among designers, contractors, and code officials.

These A2L requirements make the applicable safety standard important. Building and mechanical codes determine how much refrigerant may be used in an occupied space and whether piping, leak detection, ventilation, mitigation controls, or shafts are required. Local Law 77 is a New York City law that changed the NYC Mechanical Code so that A2L refrigerants can be used in HVAC and refrigeration system. Its current framework uses ASHRAE 15-2022. ASHRAE Standard 15-2024 updates the A2L safety framework, and its most consequential newer provision for multifloor buildings is Addendum b. The addendum recognizes that continuous refrigerant piping that is properly joined and pressure-tested presents a lower leakage risk. When specified safety conditions are met, it provides alternatives to some shaft and ventilation measures that might otherwise be required for A2L piping passing through multiple floors.

The practical issue is local adoption. Publication of a newer ASHRAE standard does not automatically change what designers or code officials can use in New York City. Until the city adopts or formally accepts ASHRAE Standard 15-2024 and Addendum b, project teams may still have to design A2L systems under the older framework, potentially adding cost, consuming building space, and discouraging otherwise viable direct-expansion heat-pump projects.

[7] Scroll compressors are commonly found in residential and light-commercial heat pumps, packaged rooftop units, VRF systems, and smaller modular chillers.

NBI's discussions with manufacturers and practitioners indicate that compliance costs, product availability, and uncertainty about agency interpretation and permitting can affect equipment choices differently across system types. On one multifamily rehabilitation project, the project team estimated that accommodating A2L requirements would add approximately $100,000 in redesign costs and consequently moved away from its preferred, most efficient heat-pump systems.

New York State Energy Research and Development Authority (NYSERDA), New York City Housing Authority (NYCHA), and other stakeholders have played a critical role in advancing window heat pump technology, creating market demand and helping manufacturers develop products better suited for retrofitting existing multifamily buildings. These systems expand the range of viable electrification options, but they are unlikely to be the best solution for every building. Where no economically viable alternative is available, some building owners may instead extend the life of existing low-efficiency or fossil fuel systems.

A broader concern is that poorly coordinated climate policies may influence equipment choices and undermine their intended emission reduction outcomes. Higher electrification costs increase the likelihood that some building owners subject to Local Law 97 will find it less expensive to pay fines than to upgrade their building systems.[8] If more owners choose fines as the least-cost compliance pathway, the law may achieve fewer building upgrades and lower emission reductions than intended.

To make more informed policy decisions, policymakers need publicly available project-level data on redesign costs, permit-processing time, schedule impacts, and equipment substitutions to quantify market-wide effects.

Accept tradeoffs and make difficult choices: If a requirement increases costs or delays installations, test whether reduced heat-pump deployment could outweigh the incremental refrigerant benefit

As we grapple with complex policy questions, we need to recognize and accept tradeoffs. To make the policy tradeoff concrete, let's do a simple math exercise to compare emissions from a typical residential heat pump. Using GWP_{100}—the metric shown in Table 3 below—moving from R-32, one of today's lower-GWP A2L refrigerants, to a near-zero-GWP refrigerant avoids about 1.1 metric tons of CO2e over the system's life of 15 years. Starting from R-454B, the incremental savings are even smaller: roughly 0.76 metric tons to 0.24 metric tons. By comparison, the same heat pump is estimated to avoid about 17 metric tons of operational CO_2e over its lifetime[9].

[8] Local Law 97 is a building carbon emissions performance standard. It sets annual greenhouse-gas emissions limits for covered NYC buildings, generally including individual buildings over 25,000 square feet.

[9] Our analysis assumptions include annual useful heating load: 38.2 MMBtu/year; existing gas furnace efficiency: 85%; natural-gas CO_2 factor: 52.91 kg CO_2/MMBtu; heat-pump seasonal COP: 2.5; fossil heating displaced: 90%; heat-pump lifetime: 15.5 years; grid emissions intensity, Year 1: 0.36 kg CO_2e/kWh, final year 0.15 kg CO_2e/kWh.

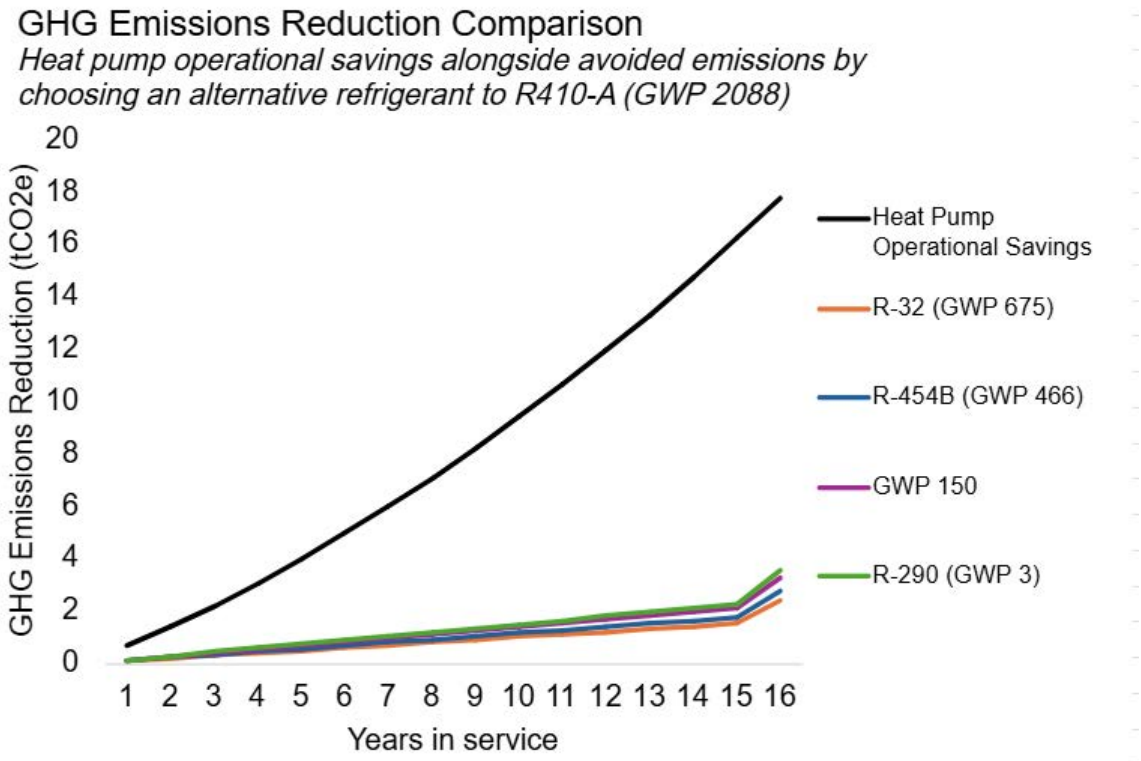
In practical terms, the climate benefit of installing the heat pump is far larger than the additional direct-emissions benefit of moving from a current A2L refrigerant to an ultra-low-GWP option. New York's ultra-low-GWP limits use GWP_{20}, so those thresholds are not directly comparable with the GWP_{100} values below; the time horizon changes the reported refrigerant benefit, but not the central policy question of whether implementation costs or delays could reduce heat-pump deployment enough to outweigh the incremental refrigerant savings.

TABLE 3. LIFETIME DIRECT EMISSIONS OF REFRIGERANTS

Refrigerant	GWP_{100}	Lifetime direct emissions*
R-410A	2088	3.41 t CO_2e
R-32	675	1.10 t CO_2e
R-454B	466	0.76 t CO_2e
Refrigerants with GWP slightly below 150	150	0.24 t CO_2e
R-290	3	~0.005 t CO_2e

** Assumptions: a representative residential heat pump with an 8-pound (3.6287 kg) refrigerant charge, a 15-year life, 2% annual leakage, and 15% refrigerant loss at end of life. These are illustrative assumptions, not predictions for every system.*

Calculation: lifetime emission = 3.6287 kg x (2% per year x 15 years + 15%) x GWP / 1000



In this illustrative example, one heat pump that is not installed would forego considerably more operational emission savings than the additional refrigerant savings achieved by moving more than 20 installed heat pumps from an A2L to an ultra-low-GWP refrigerant. Another way to think about it is that if the increased costs, complexity, or friction introduced by ultra-low-GWP requirements decrease heat pump adoption by 5%, then the policies are doing harm to overall building emission reduction goals—they are reducing the effectiveness of other policy and market drivers.

This analysis is illustrative and uses small residential heat pumps, which generally have lower refrigerant leakage than larger systems with more extensive refrigerant piping and connections. Two other studies discussed below provide broadly consistent findings, although the balance between operational and refrigerant emissions varies with system type.

Langevin, Satre-Meloy, and Chandra-Putra's (2024) analysis of the U.S. residential building stock reached a similar conclusion: the emission reductions from replacing gas equipment with electric heat pumps far exceed the increase in refrigerant emissions. By 2050, even under the least favorable assumptions, operational emission savings are approximately four times greater than additional refrigerant emissions, resulting in roughly 200 Mt CO_2e in net annual savings. Under more favorable assumptions, net annual savings reach approximately 285 Mt CO_2e, with operational benefits about eleven times greater than the added refrigerant emissions.

The MEP 2040 Whole Life Carbon Pilot report (Wrublik 2026) investigated 18 real-world commercial building installations, mostly with higher-GWP refrigerants such as R-410A. The study found that the operational emissions from equipment operation were 6-7 times higher than the emissions from refrigerants. Expanding on the findings of that study, if we consider that those refrigerant emissions were cut in half (for example, due to more aggressive policy), GHG savings from operational emissions would then exceed GHG savings associated with going from legacy refrigerants to low-GWP refrigerants by a factor of 12-14. Moving from low-GWP to ultra-low GWP refrigerants would tend to increase this differential.

In summary, although studies have drawn different conclusions regarding the magnitude of the differential between operational GHG reductions and fugitive emission reductions, emissions from fossil fuels always vastly exceed emissions from refrigerant leakage, and refrigerant policies should be evaluated in this context,

This does not mean ultra-low-GWP refrigerants should not be pursued. The question is when and how. If an ultra-low-GWP requirement has little effect on equipment cost, product availability and performance, or installation complexity, the climate case is straightforward: capture both benefits. But if a requirement materially increases costs or delays installations, policymakers should test whether reduced heat-pump deployment could outweigh the incremental refrigerant benefit.

How might higher costs affect consumer decision-making? Available evidence is insufficient to quantify how changes in upfront price affect heat-pump adoption. The literature indicates that economic factors are important, although they are represented inconsistently across adoption studies (Rao, Siam, and Bond 2025). Here are some economic factors we know about heat pumps:

- DOE's research estimated residential air-source heat-pump installed costs to be $6,900-$8,600, compared with $5,300-$6,000 for central air conditioning alone. Combined central air conditioning and new gas furnace costs at $9,400-$10,100. (Davis 2024)
- The National Laboratory of the Rockies' 550,000-home simulation found 62%–95% of households would reduce bills, but installation cost leaves a smaller portion financially feasible; among 49 million homes using electricity, oil, or propane with air conditioning, modeled median savings were $300–$650/year. A $4,000 incremental heat-pump cost with $600 in annual savings has a 6.7-year simple payback, and every 15% cost increase will add another payback year. (Wilson et al. 2024)
- An analysis of the economics of heat-pump adoption shows that adoption levels are essentially identical for all income levels thanks to heat-pump subsidies. The distribution is different from electric vehicles, solar panels, and other low-carbon technologies, which are disproportionately adopted by high-income households. Electricity prices are a strong deterrent to heat-pump adoption. Adoption is much lower where electricity is expensive: a 10% rise in electricity price is associated with a two percentage-point drop in adoption. (Davis 2024)

For some households or housing providers, that difference may not change the decision. For others already near the economic margin, it could, especially as housing and energy affordability become leading issues nationwide. The key policy question is "how much additional cost can refrigerant requirements add before a heat pump no longer makes economic sense and requirements could push customers toward fossil replacement?" The risk is that refrigerant policy moves faster than the market can accommodate, inadvertently slowing electrification. Heat pump technology is only now gaining broader traction and needs an additional push in the market, rather than added costs.

HPWHs provide an example of this tradeoff. Most current HPWHs use R-134a, yet New York's DEC Part 494 requires residential factory-charged HPWHs manufactured beginning January 1, 2027 to use refrigerants with a GWP_{20} of 10 or less. This effectively requires another technology transition just as the market is beginning to scale. Because the New York requirement differs from the broader national market, manufacturers need to develop compliant products specifically for New York, adding cost and complexity to a technology that already faces an upfront-cost barrier.

One manufacturer estimates that switching to ultra-low-GWP refrigerants in HPWHs could add approximately $100 per unit. While $100 may appear modest relative to the total equipment cost, it could influence consumer choices when HPWHs already carry a cost premium. One New York analysis estimates a typical HPWH retrofit at approximately $3,400, compared with roughly $2,000 for a conventional gas water heater, before incentives. Government programs are helping narrow this cost gap. For example, through 2025, most homeowners could claim a $1,000 rebate for purchasing an ENERGY STAR®-listed HPWH in New York (Urban Green 2026). An additional $100 would increase that approximately $1,400 upfront premium by about 7%. More fundamentally, this highlights a potential policy misalignment: New York is using incentives to reduce the upfront cost of HPWHs and accelerate adoption, while the refrigerant requirement could simultaneously add cost to the same equipment. The question, therefore, is not whether $100 alone would prevent a consumer from

purchasing a HPWH, but whether those dollars could achieve greater near-term climate benefits if they instead reduced consumers' upfront costs and helped accelerate adoption. What if the additional resources and effort instead went toward building consumer awareness, contractor familiarity, and market acceptance for HPWHs?

Additional risks, such as reduced product availability or higher servicing and maintenance costs associated with a distinct product design, could further affect consumer economics, although those impacts are not yet well quantified. If compliant products are not available at comparable cost, performance, serviceability, and scale, New York risks slowing the momentum already established for HPWHs and, ultimately, delaying electrification of the water-heating sector. The issue is not whether ultra-low-GWP refrigerants should be the destination, but whether the timing and sequencing of the transition support or undermine the broader climate objective.

The success of ultra-low-GWP policy depends on market and code readiness

The tradeoffs discussed above do not constitute an argument for weaker refrigerant policy, but they are an argument for setting application-specific policies and transition schedules designed to maximize the effectiveness of climate policies rather than imposing a single timetable across systems and applications with materially different technical and market conditions. Developing such policies requires policymakers and advocates to understand implementation barriers more comprehensively and to assess their implications for manufacturers, designers, contractors, building owners, and consumers. When policy imposes uniform targets across dissimilar applications, the market must comply even where technical and regulatory conditions are not yet adequate. The resulting costs may be passed on to consumers, and equipment performance may be compromised.

Global experience offers useful lessons about the conditions that enable ultra-low-GWP heat pump technologies and how those conditions compare with the U.S. market:

- R-290 (propane) is commercially established in European residential air-to-water heat pumps. The predominant configuration is a factory-sealed outdoor monobloc (a single cast component) that circulates water, rather than refrigerant, into the building. R-744 (carbon dioxide) is well established in Japanese HPWHs and is used in some European space-heating products, although residential R-744 space heating remains a niche application.
- In the United States, EPA currently lists R-290 as acceptable, subject to use conditions, only for self-contained room air-conditioning equipment within residential and light-commercial air-conditioning and heat-pump end use. EPA lists Class 3 refrigerants, which have higher flammability, as unacceptable for retrofit unitary split air conditioners and heat pumps (U.S. Environmental Protection Agency 2026d). EPA's 150 g (0.33 lb) charge limit for R-290 significantly constrains its use in heat pumps. A typical residential ductless mini-split or heat pump contains approximately two to six pounds of refrigerant, while a central residential heat pump often contains five to 15 pounds or more. As a result, hydrocarbon refrigerants such as R-290 and R-600a (isobutane) have been used more commonly in refrigerators and other factory-sealed appliances, where refrigerant charges are much smaller and easier to manage safely.

- R-744 is commercially available for residential HPWHs in the United States. However, the total installed cost remains much higher than that of unitary HPWHs due to higher equipment cost and because their split-system configuration requires a plumber to run water lines between the outdoor unit and the indoor tank. R-744 is used in a limited number of integrated space-and-water-heating systems. While still emerging, this refrigerant is becoming more commonly used in larger commercial and multifamily central heat pump water heating applications.

Global experience supports R-290 in outdoor hydronic equipment and R-744 in water-heating applications, but it does not yet show that either refrigerant can replace most U.S. ducted or ductless direct-expansion residential systems. Europe's R-290 market is centered on outdoor monobloc air-to-water systems, not propane versions of U.S.-style central split systems. The refrigerant remains in a listed outdoor cabinet, while water or glycol circulates through the building. This configuration substantially reduces the risk of a refrigerant release in occupied space, although it still requires appropriate outdoor siting, ignition-source clearances, service controls, drainage, and product listing. The United States should not, however, adopt European hydronic designs indiscriminately. Much of the U.S. replacement market uses ducted forced-air systems; converting to air-to-water equipment may require hydronic emitters, fan coils or an air handler, freeze protection, and additional design expertise. Outdoor monobloc systems are therefore most readily transferable to new construction, boiler replacements, and selected multifamily projects—not to every furnace replacement. Multifamily water heating likewise requires system-level engineering, not merely refrigerant substitution. Inadequate treatment of recirculation loads and poor recirculation or rooftop-airflow design can negate expected equipment performance.

Building and fire codes are frequently cited as barriers to product development and deployment because the U.S. regulatory framework is fragmented and multilayered. European manufacturers generally operate under more consistent product-certification and installation requirements. IEC 60335-2-40 addresses A3 equipment through provisions tailored to equipment architecture and mitigation measures (IEC 2024). In the United States, the compliance pathway involves several interdependent layers:

- **EPA's Significant New Alternatives Policy (SNAP)** determines whether a refrigerant is acceptable for a specific end use and establishes applicable use conditions.
- **UL/CSA product standards** establish the requirements under which equipment can be tested and listed.
- **ASHRAE Standards 15, 15.2, and 34** establish system-safety requirements, refrigerant safety classifications, and refrigerant concentration limits based on flammability and toxicity.
- **ICC mechanical, residential, and fire codes and National Fire Protection Association (NFPA) provisions** incorporate or supplement these standards.
- **State and local code adoption and the authority having jurisdiction** determine which requirements are enforceable for a specific project.

Effective implementation requires alignment across the entire standards and codes chain rather than relying on local jurisdictions to develop additional safety measures.

New York City's experience in developing additional guidance for projects using A2L refrigerants illustrates the consequences when these layers are not aligned.

Recovery and reclamation will reduce emissions

Standards and code revisions take time. State and local policies can accelerate the standards updates by establishing targets and mandates, which send clear market signals. However, standard development will not happen immediately. In the interim, policymakers should focus on emissions reductions that can be achieved today while building the market knowledge and capacity needed for the next phase.

Reducing the GWP of refrigerants is only one lever available to policymakers: An equally important lever is keeping refrigerants from being released into the atmosphere through leak prevention, recovery, reclamation, and reuse. These measures can reduce emissions from the large installed base of existing equipment as well as from new heat pumps, while reducing demand for newly produced refrigerant.

The refrigerant discussion often focuses on new equipment, but millions of existing HVAC systems already contain high-GWP refrigerants. Reliable data are not available to estimate precisely how much refrigerant is released into the atmosphere each year. A Columbia University report cited an estimate from A-Gas President Mike Armstrong that, of the 230 million metric tons of refrigerant consumed in the United States in 2024, only nine million metric tons were recovered (Baraga, Garcia, and Toledano 2026). That represents a recovery rate of less than 4%. Low recovery is not only an environmental concern but also an economic one. As manufacturers reduce production of R-410A, tightening supply could increase refrigerant prices. Owners of HVAC equipment with remaining useful life may face higher service costs or be forced to replace systems earlier than planned, preventing them from realizing the full economic value of their investments and creating additional financial burdens. The associated costs could ultimately be borne by consumers or public programs.

A stronger refrigerant management strategy could:

- require verified recovery and documentation when equipment is replaced;
- provide contractor incentives and strengthen reclaimer logistics and markets;
- require leak-resistant installation, commissioning, and technician training;
- integrate recovery requirements into utility and state heat-pump incentives; and
- collect better data on charge, leakage, recovery, and disposition.

Recovery and reclamation should be viewed as a bridge—not a substitute—for the transition to lower-GWP refrigerants. These strategies can reduce emissions now while ultra-low-GWP products, codes, standards, and installation practices continue to mature. In the meantime, state and local governments should gather better market data and conduct case studies to understand where climate policy requirements materially increase installed costs, constrain product availability, or delay projects. They should also examine permitting and compliance pathways and develop training and technical support before new requirements take effect.

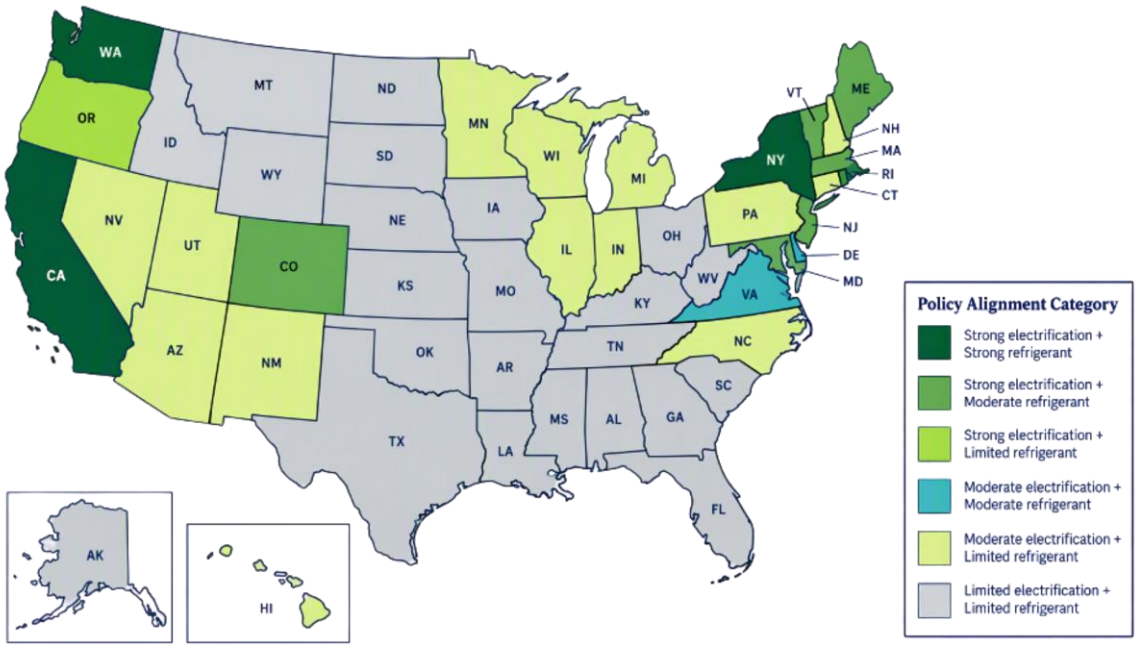
States should coordinate their electrification and refrigerant policies

When multiple states move in the same direction, they send a strong market signal to manufacturers, investors, and building owners. In addition to this state-to-state coordination, individual states should prioritize coordination among their own departments involved in electrification and refrigerant policies. Some states have already coordinated on their heat-pump goals. California, Colorado, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, and Rhode Island committed to a shared goal of 65% heat-pump share of residential heating/cooling/water-heating sales by 2030 and 90% by 2040; Washington joined subsequently (NESCAUM 2024). California and New York have statewide all-electric-building policies, although New York enforcement was paused pending litigation as of the latest policy dashboard update.

On refrigerant policy, California, New York, and Washington are leading the country. Their different climates and building stocks offer valuable test cases. Their success could set a strong precedent for the next tier of 10 states with moderate refrigerant policies, with lessons eventually reaching the next 14 states advancing electrification but with limited refrigerant policies. Rather than measuring refrigerant policy only by GWP thresholds—or electrification policy only by heat-pump installations—states should track and share installed costs, refrigerant-related compliance costs, product availability, permitting time, heat-pump adoption, refrigerant charge and leakage, recovery rates, and total avoided emissions.



STATE ALIGNMENT OF ELECTRIFICATION AND REFRIGERANT POLICIES



Source: *ACEEE's State and Local Policy Database and NASRF's HFC Policy Tracker. https://database.aceee.org/; https://nasrc.org/hfc-policy-tracker/.*

Electrification: Strong = top-10 ACEEE policy environment or binding/MOU heat-pump trajectory plus substantial programs; Moderate = active statewide/major utility incentives or mid-tier policy framework; Limited = primarily fragmented utility incentives.

Refrigerants: Strong = SNAP-plus additional GWP/RMP (Refrigerant Management Program) requirements; Moderate = enacted state SNAP-style controls; Limited = primarily federal AIM/Section 608.

Getting both transitions right

Building electrification and refrigerant transitions are essential climate strategies. They should reinforce one another, not compete against each other. GWP_{100} remains the most consistent basis for inventories, net-zero frameworks, whole-life-carbon analysis, and refrigerant regulation. It also preserves the central climate signal across the scenarios examined here: efficient heat pumps remain a preferred building decarbonization solution even when methane leakage and refrigerant emissions are included. GWP_{20} can supplement this framework by highlighting near-term warming, but changing the accounting horizon does not change the underlying need to electrify buildings, improve heat-pump efficiency, decarbonize the grid, reduce methane leakage, and manage refrigerants responsibly.

Refrigerants, methane, and operational carbon are interconnected components of the same climate challenge. We are not short of solutions, whether it is aggressively electrifying buildings while continuing to decarbonize the electricity grid, targeting the largest sources of methane leakage across the natural gas supply chain, or embedding

refrigerant management into electrification strategies. However, more solutions do not necessarily yield better outcomes if we cannot determine where each solution can deliver the greatest climate benefit, and if we do not sequence implementation accordingly based on the best available evidence.

The first phase—from R-410A toward substantially lower-GWP alternatives—is well underway. The next phase, toward ultra-low-GWP refrigerants, requires coordination among manufacturers, safety standards, building and fire codes, contractors, permitting authorities, utilities, and policymakers.

The comparisons in this brief are intentionally simplified and should not be treated as a full life cycle assessment or a prediction for every system. They do not capture the efficiency differences among system configurations or the performance effects of different refrigerants, compressors, controls, climates, installation practices, backup-heat strategies, or distribution systems. These factors can materially affect total emissions and should be evaluated in application-specific policy analysis. System-level efficiency is not simply about using less energy; it also reduces electricity demand during periods when the grid is constrained—this supports total carbon reduction and lower system costs.

Even with these limitations, our analysis clearly shows why policymakers should evaluate refrigerant emissions, operational efficiency, and heat-pump adoption together rather than using refrigerant GWP alone as a proxy for climate impact. Where ultra-low-GWP technologies are commercially available, cost-effective, code-ready, and safe, policy should accelerate deployment. Where those conditions are not yet in place, policymakers can continue reducing emissions through lower-GWP refrigerants, smaller charges, leak prevention, recovery and reclamation, and deliberate preparation for the next transition.

There is no perfect refrigerant or technology that will immediately resolve an accumulated global warming problem that took more than a century to develop. Refrigerant GWP is one component of our climate strategy and outcome; it is not an end in itself. If a policy reduces refrigerant emissions but materially increases equipment costs, reduces efficiency, constrains product availability, or slows electrification, it can worsen overall climate results. Policymakers should evaluate life cycle climate performance considering direct refrigerant emissions together with energy-related emissions, equipment efficiency, leakage, servicing, recovery, and end-of-life management.

Overall, the goal is not simply to install the heat pump with the lowest-GWP refrigerant. It is to achieve the lowest emission heating transition - and to get as many buildings there as possible.

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