Opinion **Dynamics**

RESIDENTIAL BUILDING DECARBONIZATION TECHNOLOGY AND POLICY BRIEF

THIS IS THE SECOND IN A SERIES OF BRIEFS DESIGNED TO SUMMARIZE AND SYNTHESIZE MARKET TRENDS

JUNE 2025

The information presented herein is part of the BUILD Program and TECH Initiative Evaluations currently underway in CA on behalf of SCE and the CPUC.

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3 Major end-uses of focus this update:

- Space Conditioning Heat Pumps
- Heat Pump Water Heaters
- Induction cooktops

This brief is a follow-up to the first issue, published in January 2022. It can be considered a "201" level brief. Basic information about technologies can be found here in the previous edition. This edition will focus on updates and newer technologies that are coming to the fore in the areas of residential space and water heating and cooking. The intended audience for this edition is broad, inclusive of efficiency and electrification practitioners, stakeholders, and implementers. Anyone interested in electrification and "what's next" in terms of technology and policy developments may wish to bookmark this resource.

HEADLINES:

Policy – The Inflation Reduction Act (IRA) of 2022 is widely regarded as a catalyst for U.S. decarbonization, primarily through its expansive use of grants, incentives, and updated tax credits. However, recent messaging from the current federal administration has raised uncertainty about the continued implementation of these initiatives. In contrast, many states—most notably California—are advancing their own ambitious decarbonization agendas, signaling that state-level momentum remains strong regardless of federal direction.

Technology – The heat pump space conditioning market continues to face significant challenges due to persistent supply chain disruptions, inflationary pressures, trade policy uncertainty, and evolving environmental regulations. These factors have created headwinds for manufacturers, distributors, and installers, impacting product availability, pricing, and deployment timelines. As of December 2024, air-source heat pump shipments saw a year-to-date growth of 14% over December 2023 shipments.[1,2] Combined shipments of central ACs and heat pumps rose by 11.8% year-to-date, highlighting overall HVAC market growth. However, the faster growth rate for heat pumps compared to central ACs (+14.0% vs. +10.3%) suggests increased prioritization of electrified, energy-efficient solutions, driven by federal/state incentives, rising gas prices, and climate policies. Meanwhile, heat pump water heaters (HPWHs) are seeing slow but consistent growth in adoption. In response to both market and regulatory pressures, manufacturers are advancing innovation on multiple fronts: integrating demand flexibility capabilities, improving cold-climate performance, developing new form factors to serve diverse building types and customer segments, and preparing for compliance with newly finalized refrigerant regulations.

GENERAL UPDATES:

Before delving into individual technologies, the following are developments that defy easy categorization or that apply across multiple product types.

Supply chain issues and inflationary pressure: Broader economic challenges—particularly persistent supply chain disruptions and inflation—have impacted the technologies discussed in this brief. Key contributing factors over the past two years include the drought-induced slowdown at the Panama Canal, the collapse of the Francis Scott Key Bridge in Baltimore, and labor negotiations in the shipping sector. These events have strained the availability of materials and equipment, creating additional hurdles for manufacturers and project deployment.

1 Air-Conditioning, Heating, and Refrigeration Institute December 2024 https://www.ahrinet.org/news-events/news/ahri-releases-december-2024-us-heating-and-cooling-equipment-shipment-data

2 Shipment data refers to the number of units of HVAC equipment (e.g., furnaces, central ACs, heat pumps, water heaters) that manufacturers report as having left their factories/warehouses and been shipped to distributors, wholesalers, or retailers during a given period.

Refrigerant Regulations: As of January 1, 2025, key provisions of the American Innovation and Manufacturing (AIM) Act have taken effect, significantly impacting products and systems that use refrigerants. The Act authorizes the U.S. Environmental Protection Agency (EPA) to phase down the production of hydrofluorocarbons (HFCs), promulgate regulations, and enact sector-based restrictions. The final rule, signed in late 2023, restricts HFCs above certain global warming potential limits in new aerosol, foam, refrigeration, air conditioning, and heat pump products and equipment. Among the first to be affected are new Refrigeration, Air-Conditioning, and Heat Pump (RACHP) systems, which must comply with product-specific restriction dates beginning January 1, 2025. Notably, these restrictions do not apply to components used for servicing or repairing existing systems that use higher-GWP refrigerants. For residential RACHP systems, only refrigerants with a GWP of 700 or lower, meaning 700 times the warming potential of carbon dioxide (GWP of 1), are permitted going forward.[5]

Refrigerant	GWP	Notes[6]
R-410A	2,088	Commonly used refrigerant in many new residential and commercial AC systems pre 2025
R-407C	1,774	Commonly used refrigerant in many new residential and commercial AC systems pre 2025
HFC-32 (same as R-32)	675	Commonly available in at least 30 countries and is an acceptable substitute (with caveats) in room AC units under U.S. EPA Significant New Alternatives Policy (SNAP) program. Expected efficiency and performance are thought equal or better than R-410A. As of 2021, this refrigerant was the only currently available lower-GWP alternative for small split system AC. Not a drop-in replacement for R-410A.
R-290	3	This is propane. Acceptable substitute (with caveats) in room AC units under U.S. EPA SNAP program. Expected efficiency and performance are thought equal or better than R-410A
R-441A	<5	Acceptable substitute (with caveats) in room AC units under U.S. EPA SNAP program. Expected efficiency and performance are thought equal or better than R-410A.
R-454B	466[7]	Newer option considered a substitute for R-410A in new equipment, although it cannot be used as a drop-in replacement but is expected to be more efficient.[8,9] It is a blend of R-32 and R-1234yf.[10] Rheem® has chosen this as its primary refrigerant although mini-splits will likely use R-32[11] Trane® began a transition to R-454B in 2024 starting with its residential products.[12]
R-744	1	R-744 is the technical designation for carbon dioxide (CO2) used as a refrigerant. It is non-flammable, non-toxic, but operates at very high pressures. It is often used in commercial, industrial, and transport refrigeration.

CARB has also established restrictions on refrigerants with a GWP of 750 or greater and considers a high-GWP refrigerant as one with a GWP of 150 or higher.[13,14] As of January 1, 2025, bulk refrigerants in excess of 2,200 GWP were no longer allowed to be sold in California. The refrigerant R-410A, which is slightly below that threshold, has a sell-through date of January 1, 2030, when bulk refrigerants above 1,500 GWP are phased out. Servicing equipment that requires any refrigerant in excess of the 2,200 GWP limit will require contractors to rely upon reclaimed refrigerant. Also, as of January 1, 2025, any equipment owned or operated by the state must be serviced with either reclaimed refrigerants or virgin refrigerants of 750 GWP or less.[15]

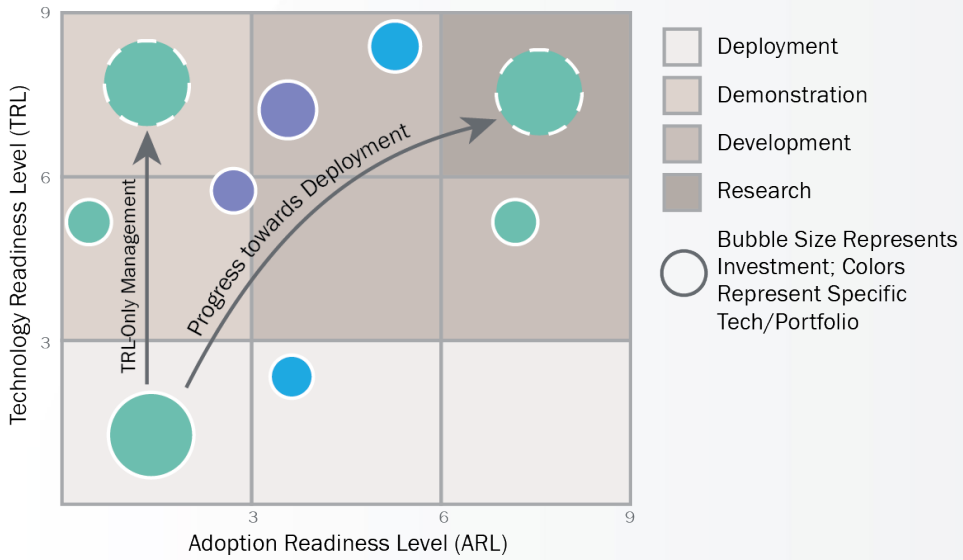
5 https://www.epa.gov/system/files/documents/2023-10/technology-transitions-final-rule-fact-sheet-2023.pdf
6 https://www.epa.gov/sites/default/files/2021-02/documents/transitioning_to_low-gwp_alternatives_in_res_and_com_ac_chillers.pdf
7 https://www.opteon.com/en/products/refrigerants/xl41
8 https://www.nwshvac.com/blog/new-hvac-refrigerant-in-2025-big-changes-are-coming-for-hvac-coolants/
9 https://www.hvac.com/expert-advice/2025-refrigerant-change/
10 https://www.trane.com/residential/en/resources/glossary/what-is-r454b-refrigerant/
11 https://www.rheem.com/air-conditioning/articles/what-to-know-about-the-2025-hvac-refrigerant-change/
12 https://www.trane.com/residential/en/resources/glossary/what-is-r454b-refrigerant/
13 https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/frorevised.pdf
14 https://ww2.arb.ca.gov/resources/documents/high-gwp-refrigerants
15 https://ww2.arb.ca.gov/2022-sb-1206-skinner-nancy-hydrofluorocarbon-gases-sale-or-distribution-chaptered

Total GWP impacts are dependent on several factors, among them the leak rate of various types of equipment and the average end of life loss rates. The current (as of 1/1/2025) Refrigerant Avoided Cost Calculator[16] expresses the following statistics, as maintained by CARB:

Equipment Type	Average Charge (Pounds of Refrigerant)	Percent Loss Per Year	Total Lifetime Pounds Lost	Percent Lifetime Loss
Portable AC	1.54	1.0%	1.52	98.7%
Residential Heat Pumps	8.20	5.3%	12.04	146.8%
Residential Unitary AC	7.50	5.0%	10.73	143.0%
Window/Room AC and Packaged Terminal AC Units	1.54	2.0%	1.52	98.9%

As new technologies enter the market, some developers are prioritizing not only the global warming potential (GWP) of their chosen refrigerants but also system-level strategies to reduce climate impact. As noted in interviews with companies such as 2040 Energy and Aris, this includes designing systems to minimize refrigerant leakage and reduce the overall volume of refrigerant required from the outset.

Moving Away from Technology Readiness Level (TRL) and towards Adoption Readiness Level (ARL): Recognizing that successful technology deployment depends on overcoming both technical challenges and ecosystem adoption barriers, the Department of Energy's Office of Technology Transitions has introduced an Adoption Readiness Level (ARL) framework alongside the traditional Technology Readiness Level (TRL) framework.[17] The ARL is assessed through a comprehensive risk evaluation across 17 dimensions, grouped into four key categories: value proposition, market acceptance, resource maturity, and license to operate. [18]



16 DEER_Supporting_Files_racc-fsc_v3_2024111_RACC-FSC_v3.1
17 https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-04a-admchg1/@@images/file
18 https://www.energy.gov/sites/default/files/2024-10/ARL%20Assessment%2010-10-24.pdf

Focus on Workforce: There is growing recognition of a significant gap between the current trades workforce and the scale of labor needed to transform the heating and cooling markets. In California alone, decarbonizing 14 million homes and over eight billion square feet of commercial space will demand vast numbers of skilled workers across clean energy trades such as HVAC, plumbing, and electrical. Workforce shortages are already a concern, as many experienced workers are nearing retirement. Meanwhile, Generation X, the workforce segment just below the Baby Boomers, is the smallest generation of American workers, and without sufficient new entrants from Millennials and younger generations, the trades will struggle to fill this gap. Finally, there is growing recognition that decarbonization goals will only be equitably met by increasing diverse representation in the workforce.[19] A 2024 study conducted by Opinion Dynamics found high variability in workforce growth across California's regions and the trades, including a notable decrease in plumbing employees between 2018 and 2023 and proportionally fewer contractors in disadvantaged communities.[20] A number of efforts exist to smooth the path to certification and market entry for contractor businesses and employees and to assist customers in finding and selecting contractors to perform work. One notable example: The U.S. Department of Energy and Google® announced a partnership at the end of 2024 whereby contractors with a workforce credential that is recognized as "Energy Skilled" by DOE will sport a badge on their business profile on Google.[21]

Technology Highlights: Since our first brief, several features have emerged as ways to drive adoption and minimize climate impacts.

- **Lower-GWP Refrigerant Usage** as described above
- **Water heating grid flexibility options.** EcoPort® is, for instance, incorporated into the NEEA residential HPWH qualified product list as a key evaluation criterion and serves as a certification mark verifying a unit's ability to connect via the CTA-2045 communication interface. Air-source heat pump units are also expanding their presence in the grid flexibility arena, as demonstrated by companies like Stash Energy, Steffes, and Qvantum. Notably, Steffes recently launched its Origin system, specifically designed to support decarbonization of multifamily central heating systems. Additionally, Cala Systems and Harvest Thermal®—both discussed below—highlight their advanced integrated intelligence capabilities that enhance grid interaction and operational efficiency.
- **Thermal storage technologies** are playing an increasingly important role in enhancing grid flexibility across multiple sectors. In the residential sector, water heating equipment—such as heat pump water heaters with smart controls—can store thermal energy during off-peak periods and shift energy use to balance grid demand. Meanwhile, in commercial and industrial settings, more advanced thermal storage solutions are being deployed, including phase change materials that store and release heat at specific temperatures, and super hot brick thermal batteries that can retain high levels of thermal energy for extended periods. These technologies help decouple energy consumption from real-time demand, providing utilities and grid operators with valuable flexibility to integrate variable renewable energy sources and improve overall system reliability and efficiency.
- **Compatibility with 120V wiring** is increasingly seen as a crucial feature for technologies such as water heating and cooking appliances. By enabling these units to operate on standard residential electrical circuits, installers can significantly reduce the time and complexity associated with rewiring or upgrading electrical systems. This compatibility not only lowers installation costs but also broadens the potential for adoption by simplifying the retrofit process in existing homes. As a result, manufacturers focusing on 120V-compatible designs are helping to accelerate deployment and support wider market acceptance of energy-efficient technologies.
- In recent years, several companies have begun **developing integrated systems designed to efficiently meet a home's heating, cooling, and domestic hot water needs**. Although most of these all-in-one systems remain in the pre-commercial stage, they represent a promising new category for building decarbonization. Notable innovators in this space include Harvest Thermal®, Aris Hydronics®, and Qvantum. As reported by ACEEE, air-to-water heat pumps are already well-known outside of the United States, and companies like Enertech®, Chilltrix, LG®, SpacePak, and Viessmann® have been in the market for some time now. Production of such systems has reached the United States. U.S. Boiler Company, Copeland®, and Daikin® have all made moves to produce such units domestically, some benefitting from U.S. Department of Energy support.

19 https://www.calmac.org/publications/FuelSubstitutionWorkforceReadiness_Report_9_27_2024_Final.pdf
20 https://www.calmac.org/publications/FuelSubstitutionWorkforceReadiness_Report_9_27_2024_Final.pdf
21 https://www.energy.gov/eere/articles/doe-google-collaboration-will-help-consumers-identify-qualified-technicians-home; https://bsesc.energy.gov/recognition/energy-skilled

PROCESS HIGHLIGHT:

With the advent of funding from the Bipartisan Infrastructure Law and the Inflation Reduction Act in addition to existing and emerging programs, several entities have designed their services to help demystify the process of building decarbonization. Sometimes referring to this approach as a "concierge model," such companies work at different points along the supply chain and in different ways to present a kind of hand-holding one-stop-shop to residents eager to upgrade their homes. Among these entities are the following:

- Sealed: "Simplifying rebates, empowering contractors"
- Elephant: "Confidently upgrade to a climate-friendly home"
- Eli: "Making the clean, electric future accessible – for everyone"
- Pearl Edison: "Electrify and save"
- QuitCarbon: "Upgrade your home with free expert guidance and contractors you can trust"
- Node Collective: "Powering Electrification through open data and collaboration"
- Rock Rabbit: "Incentives make home electrification affordable. We make incentives easy."
- Laminar Collective: "Open pricing research & heat pump bulk deals for the community."
- Zero Homes: "Get off gas and electrify your home"

SPACE HEATING AND COOLING

Single family segment compound annual growth rate (CAGR) over 10%

Installed base for cooling in CA is roughly 28% heat pumps and 72% one-way AC.

Anticipated CAGR for residential heat pumps: >9% through 2034

Residential air to water HP in North America expected CAGR of 18.1% through 2032

Cold climate heat pumps in North America (U.S. plus Canada) expected CAGR of 9.8% through 2034

US Residential air source heat pump market is anticipated to be ~$12b in 2032

US Residential heat pump market represents 14.9% of global market and is anticipated to shrink to 10.6% by 2032 meaning - global growth will be faster than US.

Sources: https://www.gminsights.com/industry-analysis/north-america-residential-heat-pump-market; https://rmi.org/now-is-the-time-to-go-all-in-on-heat-pumps/#:~:text=A%20new%20RMI%20analysis%20shows,by%20up%20to%2093%20percent.&text=Replacing%20fossil%20fuel%2Dburning%20appliances,%2C%20health%2C%20and%20economic%20goals;

Heat pumps **outsold** furnaces in CA for the first time in 2020 and continues today.

PERFORMANCE:

In 2024, the Consortium for Energy Efficiency (CEE) released updated specifications for residential electric HVAC and water heating systems, aimed at better informing customers about how equipment performs under varying conditions.[23] These specifications incorporate revised efficiency metrics: SEER2 (Seasonal Energy Efficiency Ratio, measuring cooling efficiency over a season), EER2 (Energy Efficiency Ratio, gauging cooling efficiency at peak load), and HSPF2 (Heating Seasonal Performance Factor, measuring seasonal heating efficiency).[24] These updates replace the earlier SEER, EER, and HSPF metrics with testing procedures designed to more accurately reflect real-world performance.

According to CEE, the updated specifications "reflect market advancements in efficiency, heating capacity, and the ability for equipment with embedded demand response capabilities to support grid reliability." The goal is to ensure that CEE-recognized products deliver meaningful, cost-effective energy savings while maintaining consumer comfort and lowering utility bills.

The updates also help align the requirements for federal incentive and tax credit programs, which had previously been misaligned—some relying on ENERGY STAR® certification, while others, like the 25C tax credit, were based on CEE tiered performance levels.[25] The revised CEE specifications took effect January 1, 2025, and now form the basis for determining eligibility for the 25C residential energy efficiency tax credit. Notably, CEE also introduced the first-ever performance specification for room heat pumps, targeting emerging products from manufacturers like Gradient and Midea. These units, often used in multifamily and retrofit applications, are now held to a standardized benchmark for performance, also effective January 1, 2025.[26]

23 https://cee1.org/news/details/2025-cee-performance-requirements-for-hvac-and-water-heaters-integrate-federal-and-utility-incentives-to-increase-adoption-of-high-performing-heat-pumps
24 https://indoortemp.com/resources/SEER2-EER2-HSPF2-New-Energy-Efficiency-Standards and https://hvactraining101.com/ac/seer/vs-hspf/ and https://hvactraining101.com/ac/seer/vs-eer/
25 https://cee1.org/program-resources/cee-and-the-inflation-reduction-act/
26 https://cee1.my.site.com/s/resources?id=a0VTR000003DmoH

The conversion crosswalk is as follows:

System Type	Equation
Split System Air Conditioner and Heat Pump	SEER = SEER2 X 1.05
Split System Air Conditioner and Heat Pump	EER = EER2 X 1.04
Split System Heat Pump	HSPF = HSPF2 X 1.18
Packaged Air Conditioner and Heat Pump	SEER = SEER2 X 1.04
Packaged Air Conditioner and Heat Pump	EER = EER2 X 1.04
Packaged Heat Pump	HSPF = HSPF2 X 1.18
Ductless Heat Pump	HSPF = HSPF2 X 1.12
Space Constrained System	SEER = SEER2 X 1.01
Space Constrained System	HSPF = HSPF2 X 1.17
Small Duct High Velocity System	SEER = SEER2 X 1.00
Small Duct High Velocity System	HSPF = HSPF2 X 1.17

As of late October 2024, eight manufacturers passed DOE's testing process as part of the Cold Climate Heat Pump Challenge. The eight manufacturers were Bosch®, Carrier®, Daikin®, Johnson Controls®, Lennox®, Midea®, Rheem®, and Trane®.

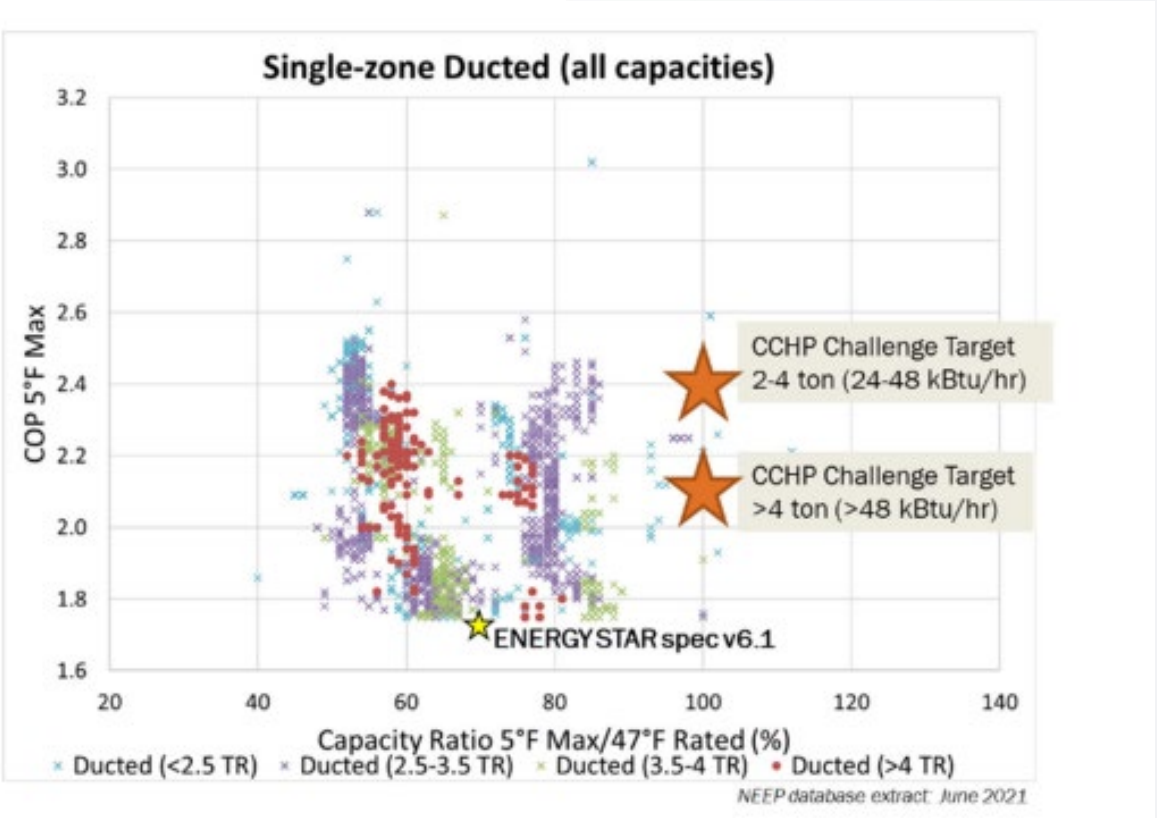


Figure 1. Challenge Specification Compared to Commercially Available Cold Climate Heat Pumps as of June 2021

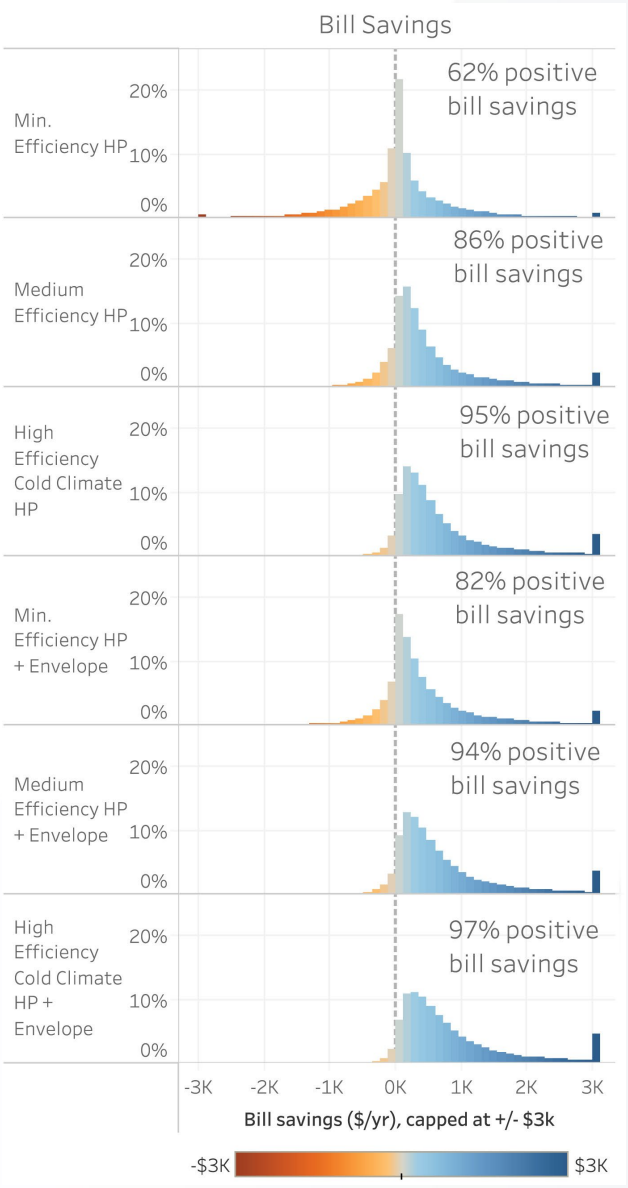
Source: ACEEE

COST:

Various market factors have influenced the cost of heat pump equipment over the past few years. Anecdotal market feedback points to inflationary pressure, including rising refrigerant costs, as a factor in decisions to raise prices. One manufacturer cited such factors in a decision to raise residential equipment prices by up to ten percent at the outset of 2024.

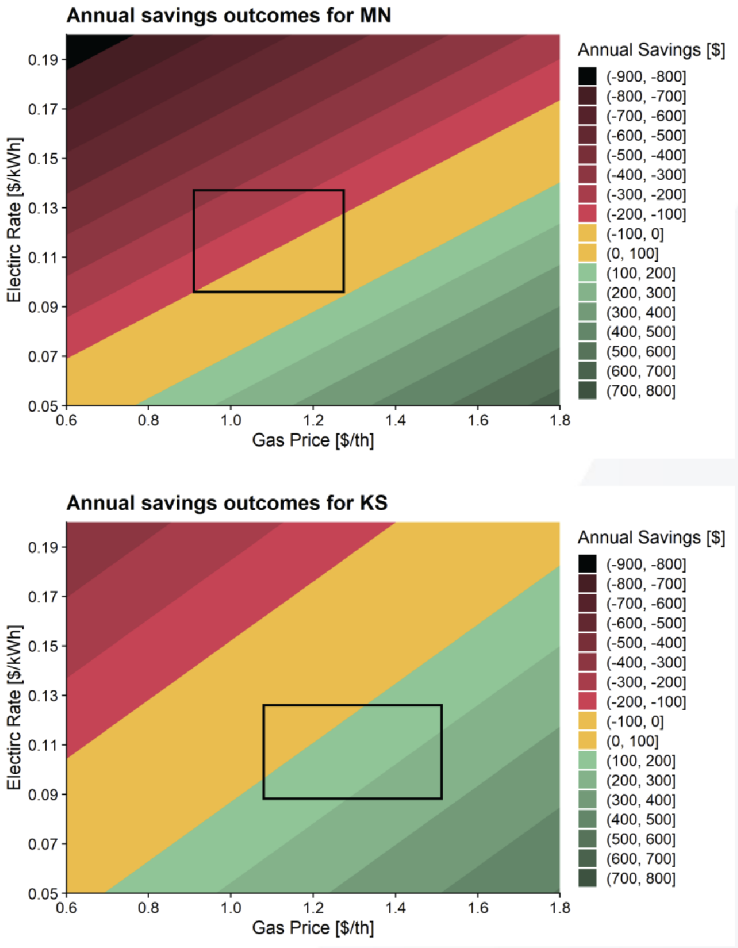
The median cost per residence for all TECH space conditioning heat pump projects that began installation by mid-November 2024 was $19,144. That is up from the median cost of $16,681 for projects begun by mid-November 2022. Projects began in 2024 and experienced a median cost of $20,415 per residence.

The phrases “spark gap” and “spark spread” have begun entering the vernacular as ways to describe the ratio between prices for electricity and for fossil fuels. Even with more efficient operation, if an area experiences a high spark spread, heat pumps have difficulty competing on an operational cost basis. There is evidence that the larger the spark spread, the fewer heat pumps sold. The figure below illustrates a distribution of energy bill savings “relative to the reference scenario, using energy prices from winter 2021 to 2022.”



Source: Wilson, Eric J.H. et al. Joule, Volume 8, Issue 4, 1000 - 1035

Bill savings are highly contextual and depend on a number of factors beyond the spark gap. As can be seen below, Minnesota and Kansas may experience different savings outcomes due to these contextual factors:



Source: CEE Report

In Opinion Dynamics' TECH Population-Based Pathway Impact Report, we assessed bill impacts. The average annual net energy bill impact is estimated to be - $11. In a normal weather year, the average participant experiences a substantial decrease in natural gas bills and a significant decrease in electric bills but does not experience a statistically significant change in their combined energy bills. The average participant does experience an increase in their winter energy bills, but this is offset by decreases in the summer and shoulder season bills.

Change in customer energy bills by fuel and season

Season	Electric Estimate	Natural Gas Estimate	Net Change		
			Annual Change	Lower CI	Upper CI
Winter	$316	-$222	$94*	$79	$108
Summer	-$33	-$24	-$56*	-$74	-$39
Shoulder	$50	-$99	-$49*	-$62	-$36
Overall	$333	-$344	-$11	-$37	$15

*Results are statistically significant at 95% confidence level.
Note: Normal weather estimates based on fixed-effects D-in-D panel regression analysis of TECH participant and matched nonparticipant monthly natural gas consumption data and interval electricity consumption data, combined with utility rates. Summer is defined as June through September, winter as December through March, and shoulder as April, May, October, and November.

When we looked closer, we found important variation by geography, measure type, and customer segments in the energy and bill impacts. All groups achieve statistically significant increases in electric consumption and reductions in gas consumption, but bill impacts range from neutral to a significant energy bill increase or decrease, depending on the segment.

Annual energy and bill impacts by subgroup

Group	Modeled Sites (Electric/Gas)	Electric Consumption		Natural Gas Consumption		Combined Energy Bills ($)
		kWh Baseline	kWh Impact (%)	Therms Baseline	Therms Impact (%)	
Overall	4,129 / 3,684	8,421	1,451 (17.2%)*	432	-165 (-38.2%)*	-$11
Geography						
CZ2 (northern)	235 / 205	6,509	2,769 (42.5%)*	506	-210 (-41.5%)*	+$242*
CZ4 (central)	154 / 120	5,797	1,583 (27.3%)*	452	-201 (-44.5%)*	-$57
CZ10 (southern)	340 / 250	9,045	619 (6.8%)*	424	-172 (-40.6%)*	-$30
Measure						
Central Heat Pump	2,528 / 2,483	9,480	1,064 (11.2%)*	422	-154 (-36.6%)*	-$25
Ductless Heat Pump	936 / 765	7,392	2,123 (28.7%)*	433	-180 (-41.4%)*	+$72*
HPWH	644 / 424	6,681	1,845 (27.6%)*	466	-164 (-35.1%)*	-$184*
Customer Segments						
Low-income	472 / 349	9,409	861 (9.2%)*	369	-120 (-32.6%)*	-$109*
Not Low-income	3,657 / 3,335	8,281	1,514 (18.3%)*	438	-170 (-38.7%)*	-$34*
Net Metered [a]	1,193	4,079	1,081 (26.5%)*	N/A	N/A	-$76*
Not Net Metered	2,936	10,340	1,544 (14.9%)*	N/A	N/A	-$28*

*Results are statistically significant at 95% confidence level.
[a] Net metering status could only be identified for the electric analysis.
Note: Normal weather estimates based on fixed-effects D-in-D panel regression analysis of TECH participant and matched nonparticipant monthly natural gas consumption data and interval electricity consumption data, combined with utility rates. Summer is defined as June through September, winter as December through March, and shoulder as April, May, October, and November.

TECHNOLOGY UPDATES:

Batteries on Board: As described above, Carrier® announced in the fall of 2024 that the next generation of its residential heat pumps would tap into battery storage and grid-interactive features, which were further elucidated in the March 2025 press release in coordination with Google® Cloud.

Betting on beauty: Startup Quilt is betting that more customers will be interested in installing mini splits if they are more integrated into the existing aesthetics of their homes. The system additionally uses an app or dial and occupancy sensors to optimize its performance. The company integrates the process in a way that enables upfront pricing, which results in an upfront price of $6,499 per room before incentives, which the company applies to the cost at the point of sale.

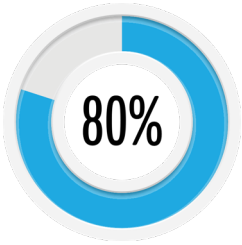
Solid-state: Mimic touts its solid-state heating and cooling systems, explaining that this "means no refrigerants, no moving parts, and fewer greenhouse gas emissions." The modular units are designed for various uses focused on personalized comfort.

Commercial and Industrial systems: Flow Environment Systems' ANSWR, which uses CO2 as refrigerant.

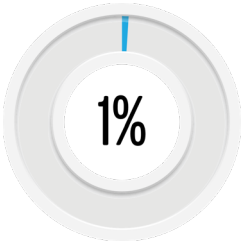
International companies of note:

- Sweden's Qvantum has a line of residential heat pumps that feature unified heating and hot water, with some featuring cooling capabilities as well.
- China's AUX launched in the United States in late 2024 with a line of mini-splits. One feature of note is voice control.

WATER HEATING



80% of homes in CA have gas-fired water heaters



1% have heat pump water heaters

Approx. 721,000 water heaters replaced each year in CA single-family homes

Approx 1.1 million water heaters were sold in California as of 2020

Almost 400,000 new housing units constructed each year

75% of replacements are on an emergency or near-emergency basis in existing homes

The growth of the segment in the U.S., which was sized at $3.17B in 2022 is anticipated to come largely from gas units

In the United States, the residential heat pump water heater market is expected to experience a CAGR of 5.9% between 2023 and 2030.

Sources:
https://www.gminsights.com/industry-analysis/north-america-residential-water-heater-market
https://www.fortunebusinessinsights.com/u-s-heat-pump-water-heater-market-108864

Almost **400k** new housing units constructed each year

Roughly **1/6** of those new units had a heat pump water heater installed over a recent five-year period

PERFORMANCE:

As described above, CEE has released updated specifications effective January 1, 2025

In April 2024, the DOE released a finalized efficiency standard update with compliance starting in 2029. The standards are anticipated to increase the share of electric storage water heaters that feature heat pump technology from 3% to over 50%. While the Trump administration and Congress has moved to delay or reverse certain equipment standards, including reversing the 2024 standard on instantaneous gas-fired water heaters, the electric storage water heater standard seems to stand as of this writing.[28]

COST:

As of the end of 2024, the median gas storage water heater replacement cost through the TECH program was $5,016, encompassing a median cost of $6,800 for single-family and $4,909 for multi-family.

A recent study of 120V HPWHs in California with CTA-2045-enabled modules found that load shift led to "average utility bill savings of 24.2% of HPWH electricity costs."

TECHNOLOGY UPDATES:

The advent of 120V units: Rheem introduced the first 120V plug-in model in July of 2022 with their ProTerra model, addressing a key barrier to adoption by eliminating the need for costly 240-volt electrical upgrades. A.O. Smith followed in October 2023 with the SMART Voltex, introducing small electric resistance elements, making it suitable for colder climates, unlike Rheem's model. In February 2024, GE Appliances, a Haier company, announced the 120-volt GeoSpring heat pump water heater utilizing low GWP refrigerants, further diversifying offerings.

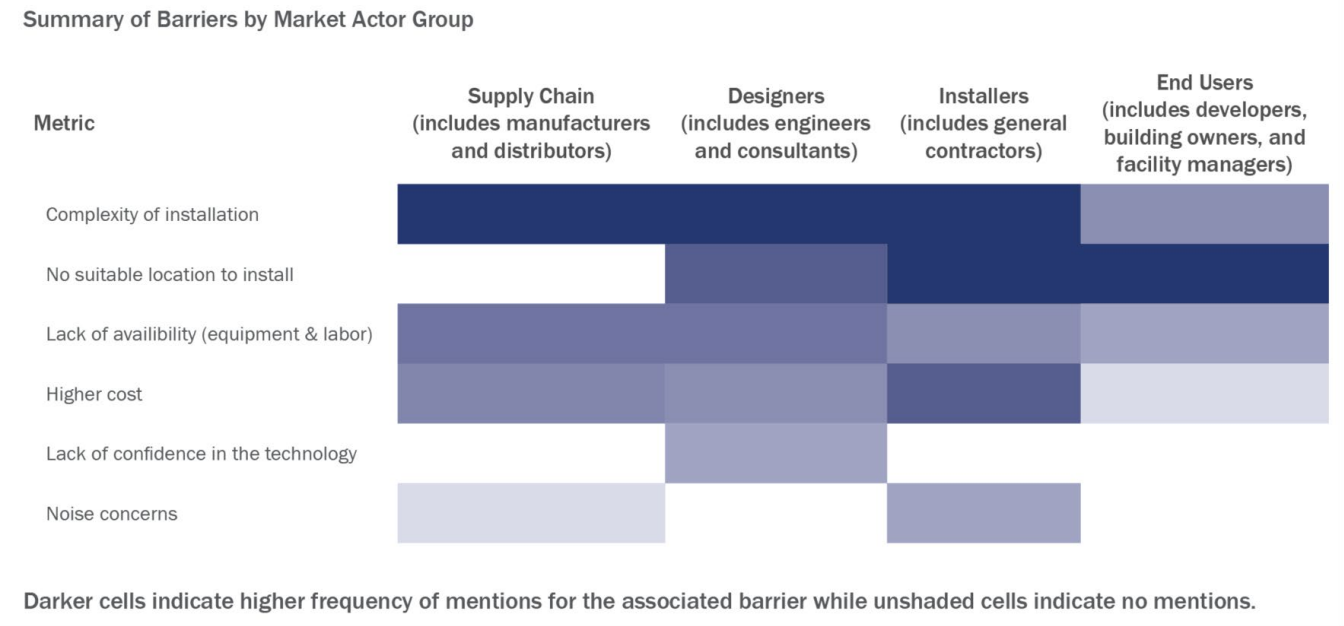
23 https://cee1.org/news/details/2025-cee-performance-requirements-for-hvac-and-water-heaters-integrate-federal-and-utility-incentives-to-increase-adoption-of-high-performing-heat-pumps
24 https://indoortemp.com/resources/SEER2-EER2-HSPF2-New-Energy-Efficiency-Standards and https://hvactraining101.com/ac/seer/

In 2023, HPWHs accounted for 4% of residential water heater sales in the U.S. Specific data on the market share of 120V plug-in models remains scarce. However, early adoption trends suggest growing interest. These plug-in models are gaining traction due to their compatibility with standard outlets, lower installation costs, and suitability for retrofits. They are particularly well-suited for smaller households (1-4 people) replacing gas water heaters, but careful sizing is crucial to address slower heating and reduced or absent backup heating elements. Larger storage tanks are often required for optimal performance. Their ability to avoid electrical infrastructure upgrades makes them especially appealing to low-income households. However, they also face higher costs due to low production volumes and space constraints. Recent statistics from the TECH program show that 120V HPWHs accounted for 15% of all HPWH installations and 22% of emergency replacements, even though emergency replacements made up only 9% of total TECH HPWH installations.

AI-assisted water heating: Startup Cala Systems promotes its heat pump water heater as the first to feature built-in intelligence that adjusts heating speed based on forecasted demand, using inputs such as household usage patterns and weather data. Cala's advertised smart capabilities closely resemble those of the integrated system developed by Harvest Thermal, profiled below.

Solar assist: In January 2024, a solar-assisted HPWH from Smart Solar was certified by ENERGY STAR®. The unit requires only a 120V wall plug for basic operation but can handle higher usage with a double-pole 30A circuit.

Central HPWHs for Multifamily: This product category includes several units using CO_2 as a refrigerant (R-744), a feature that is especially important for decarbonizing multifamily buildings. CO_2 systems can reliably deliver high-temperature water at scale, making them well-suited to serving the large, continuous hot water loads typical of multifamily settings. It was the subject of a 2023 study published by NEEA. Several barriers were identified:



INDUCTION COOKTOPS

CGR of 7.2% from 2024 to 2030 in North America

In 2023, the global induction cooktop market was valued at approximately $102.29 billion in 2023 and is to grow at a compound annual growth rate (CAGR) of 7.8% from 2024 to 2030.

Projected revenue of $35,434 million by 2030 in North America

Approx 3% of U.S. consumers use induction cooktops

In terms of revenue, the North America region accounted for 21.3% of the global induction cooktops market in 2023.

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Momentum in the US induction cooktop market is increasingly influenced by energy-forward building codes and electrification policies at the state and local levels

U.S. market is witnessing the launch of more sophisticated, high-quality induction models that offer advanced features such as precise temperature control, built-in smart technology, and visually appealing designs. These premium products attract consumers interested in luxury kitchen appliances, further enhancing sales trends

Sources: https://www.forbes.com/sites/jamiegold/2022/08/23/new-legislation-offers-wellness-and-climate-benefits/ https://www.pge.com/en/newsroom/currents/energy-savings/weigh-the-pros-and-cons-of-induction-cooking.html
https://www.grandviewresearch.com/horizon/outlook/induction-cooktops-market/north-america#:~:text=The%20induction%20cooktops%20market%20in,market%20from%202024%20to%202030.
https://www.grandviewresearch.com/industry-analysis/cooktop-market-report
https://www.nrdc.org/stories/what-induction-cooktop

Only **3%** market penetration of induction cooktops for both single- and multi-family households.

Induction Cooking:

Induction cooking was nascent in the United States at the time of the previous brief but has advanced in the interim, with around 38 induction models listed on V1 of the ENERGY STAR ® Residential Electric Cooking Products Qualified Product List as of August 2024. The specification itself was released in October 2023.[29]

In October 2024, the California Market Transformation Administrator released a market characterization report for the product category, which noted slow adoption of induction cooktops by home builders and remodelers as well as underrepresentation at retail locations. The report showed only 3% market penetration in both single family and multifamily households.[30] Loaner programs are increasingly recognized as an effective way to build consumer confidence by offering first-hand experience with unfamiliar technologies. At the same time, a growing body of research underscores not only the energy savings but also the significant health and safety advantages of transitioning away from fossil-fuel-based cooking.

As of 2020, natural gas remained the primary cooking fuel for 70% of California single-family households. [31] Currently, most induction cooktops require a 240V connection, which can increase the cost of adoption and make switching from gas more expensive. In response to these barriers, two companies—Copper Home (with its Charlie range) and Impulse (offering a drop-in cooktop)—have introduced battery-assisted 120V models. Copper's product is the focus of a December 2024 CalNEXT report.[32] According to this 2024 market characterization report, when questioned, three major manufacturers of 240V induction equipment stated they did not plan to develop 120V models.[33] Additionally, neither Copper nor Impulse currently offers an integrated outlet for powering other appliances during power outages. However, Impulse's system can be configured to connect to a 240V circuit and includes an optional bidirectional inverter, enabling the appliance to supply power back to the home. [34]

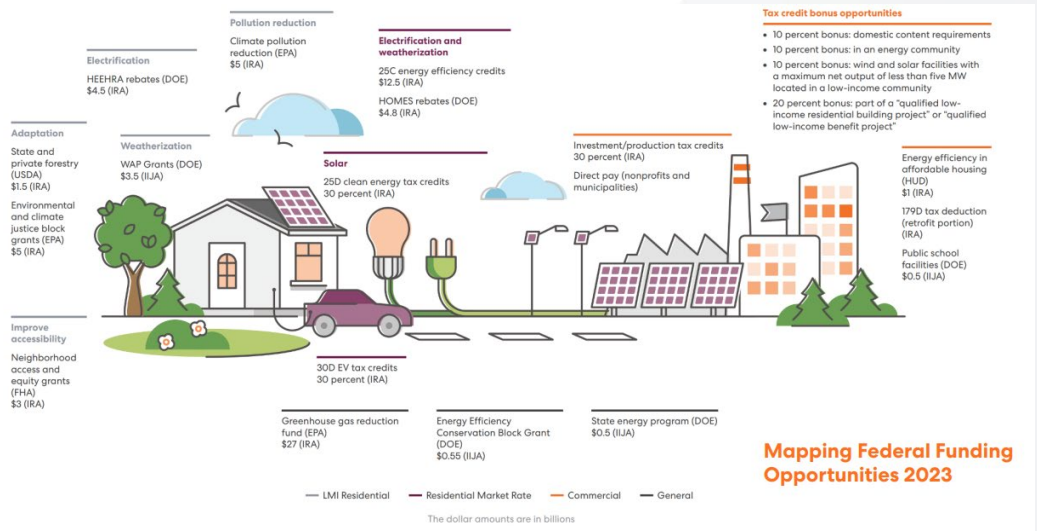
Induction cooktops in the United States require the use of compatible cookware (although adapters are available on the market), but a model that touted compatibility with all types of metal cookware was launched for commercial applications in 2017.[35] Such technology does not appear to be available in the U.S. however, the U.S. DOE released a peer review of such technology in 2024, perhaps indicating a renewed interest in that functionality.[36]

29 https://calmta.org/wp-content/uploads/sites/263/Market-Characterization-Report-Induction.pdf
30 https://calmta.org/wp-content/uploads/sites/263/Market-Characterization-Report-Induction.pdf
31 https://www.eia.gov/todayinenergy/detail.php?id=53439
32 https://www.redwoodenergy.net/research/120v-induction-stoves-with-battery-backup
33 https://calmta.org/wp-content/uploads/sites/263/Market-Characterization-Report-Induction.pdf
34 Personal exchange with an Impulse representative.
35 https://www.prnewswire.com/news-releases/panasonic-introduces-groundbreaking-new-induction-cooktop-providing-extraordinary-commercial-cooking-performance-with-all-kinds-of-metal-cookware-300404902.html
36 https://www.energy.gov/sites/default/files/2024-11/bto-peer-2024-32274-all-metal-induction-cooking-rallabandi.pdf

Expanding the use of heat pumps is anticipated to save **$4.8 billion** in energy costs

Federal:

Federal policy pertaining to the clean energy industry over the last three years has been a rollercoaster. The two most significant actions at the federal level for the clean energy industry during the Biden administration were the passage of the Bipartisan Infrastructure Law (BIL), or Infrastructure Investment and Jobs Act (IIJA), and the Inflation Reduction Act (IRA). Funding from these two bills was designed to touch a vast swath of the clean energy landscape, as pictured below, and programs were to be executed by the federal, state, regional, and local governments, as well as tribes. RMI keeps a useful breakdown of the IRA by program and tax incentive.



Source: MichiganSaves.org, Implementing the Greenhouse Gas Reduction Fund in Michigan, Slide 5.

After initial planning stages, several of these funding opportunities are now open for applications and beginning to flow into the market. For instance, as of June 2025, the Energy Efficiency and Conservation Block Grant (EECBG) Program funded by the BIL, is actively supporting state, local, and tribal governments in implementing energy efficiency and conservation projects, although recent shifts in federal policy may impact the ultimate spend and longevity of these programs. A number of California cities, counties, and tribes have been awarded thousands to millions of dollars through these grants, and the state of California was awarded over $4 million to create a Local Government Building Decarbonization Challenge, which is a competitive grant program aimed at assisting local governments in developing and implementing strategies for building decarbonization. SCEP is also the office responsible for administering the billions of dollars available via the IRA Home Energy Rebate programs. California, via the CEC, has integrated the initial tranche of Home Electrification Appliance Rebates while the CEC is additionally exploring how to integrate Home Efficiency Rebate (or HOMES) funding into the existing Equitable Building Decarbonization program. Of additional note is the multi-billion-dollar EPA-administered Climate Pollution Reduction Grant (CPRG) process, which has led to CARB's Priority Climate Action Plan as well as similar plans undertaken by the ten Metropolitan Statistical Areas in California and tribal entities overlaid with California's geography that were awarded CPRG planning grants. The one CPRG implementation grant awarded within California was to the South Coast Air Quality Management District.

to the tune of nearly half a billion dollars for decarbonized transportation infrastructure. The proposal was created in alignment with state goals, and execution will undoubtedly require state-level coordination.

Federal clean energy policy has taken a significant swing in direction from the Biden to Trump administrations. On his first day in office, President Trump signed several executive orders related to energy policy, including the notable "Unleashing American Energy" order, which partially revoked several Biden-era energy and climate directives. Since then, his administration and supportive members of Congress have continued to shape energy policy in line with his vision.

The administration has moved to pause or revoke much of the funding allocated or planned under the Bipartisan Infrastructure Law (BIL) and the Inflation Reduction Act (IRA). Governments at various levels are currently assessing which specific programs may be impacted. In April 2025, the Trump administration issued Executive Order 14260, Protecting American Energy from State Overreach, which extends beyond federal funding issues and directly challenges state-level climate policies.

State:

In the wake of the federal retreat from climate action, many states, including California, have reasserted their intentions to continue progress and assert their ability to do so. In 2024, California, along with officials from eight additional states, led by the Northeast States for Coordinated Air Use Management (NESCAUM), agreed to a goal of heat pumps constituting 65% of residential HVAC and water heating shipments by 2030 and 90% by 2040. The year before, ten manufacturers agreed to support California's six million by 2030 heat pump goal, and that consortium has issued a Blueprint for achieving that goal.

In November 2024, California voters approved Proposition 4, a $10 billion *Climate Bond* (the Safe Drinking Water, Wildfire Prevention, Drought Preparedness, and Clean Air Bond Act of 2024), which will fund a broad suite of climate resilience and environmental projects.[37] These funds are earmarked for categories including safe drinking water, coastal and flood resilience, wildfire prevention, nature-based climate solutions, clean energy, extreme heat mitigation, park creation, and climate-smart agriculture. The Governor's initial 2025-26 spending plan proposes allocating about $2.7 billion in that year alone, with about one-third of the "clean energy" slice ($275 million) going toward enabling clean energy infrastructure and demand-side grid support. The bond also includes strong equity priorities (disadvantaged and severely disadvantaged communities), annual audits, and a legislature-oversight process. Meanwhile, the updated 2025 California Energy Code—adopted by the California Energy Commission in September 2024 and set to take effect on January 1, 2026—prioritizes the expanded use of heat pumps and is projected to save $4.8 billion in energy costs.[38]

It remains to be seen how the divergence of federal and California climate and energy policy will evolve through the end of the current federal administration.

37 https://www.latimes.com/california/story/2024-11-05/california-election-night-proposition-4 and https://lao.ca.gov/ballot/2024/prop4-110524.pdf
38 https://www.energy.ca.gov/news/2024-09/energy-commission-adopts-updated-building-standards-expanding-requirements-heat and

THE FOLLOWING INSIGHTS ARE PRIMARILY GATHERED FROM PERSONAL COMMUNICATION WITH THE RESPECTIVE COMPANIES. NOT ALL STATEMENTS HAVE BEEN INDEPENDENTLY VERIFIED.

HARVEST THERMAL

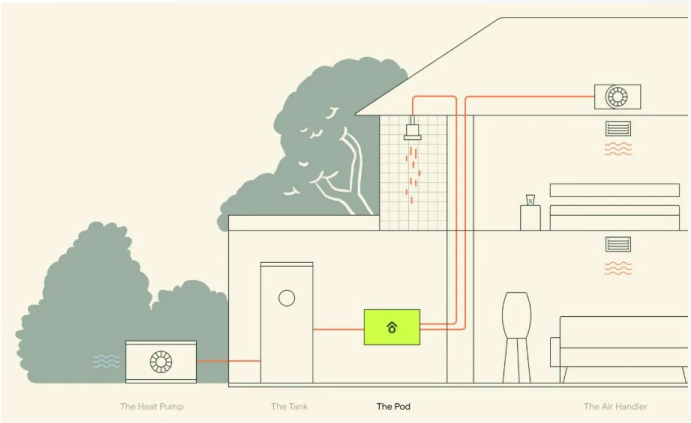
What: A "smart thermal battery" with all-in-one heat, hot water, and air conditioning that uses a CO2 refrigerant heat pump for hydronic heat and an air-to-air A/C or heat pump for cooling and supplemental heat. Currently sized up to 4 tons.

When: Founded 2019

Where: Currently in California and the Pacific Northwest, with nationwide ambitions. Two system installations were recently underway in Canada. The systems are mostly installed in single-family homes under retrofit conditions triggered by gas furnace or gas water heater replacement. Single-family new construction and multifamily are less common.

Why: Storing heat when it is cheaper and using it when it is more expensive. Harvest claims a 30% savings over average CA prices based on the natural gas price mix in 2022. They also aim to minimize grid costs by shifting usage away from peak periods, helping to defer the need for costly grid infrastructure upgrades.

How: Harvest is perhaps best thought of as a system, not a piece of equipment. The Harvest Pod® (the Pod) is the brains of the operation for this system, and Harvest is configurable to work with (Harvest Open) or without AC (Harvest Classic) and can integrate with an existing AC system if desired. The Pod monitors usage patterns in the home and can also correlate usage with weather or home orientation (e.g., In west-facing homes, space conditioning demand may increase in the afternoon due to greater solar heat gain). Weather forecasts and price signals are all factored into the operation of the Pod and, therefore, the system as a whole. The system's tank is sized larger than typical, allowing for greater storage capacity—though the absence of a tank-top condenser keeps the 119-gallon tank comparable in size to a conventional heat pump water heater. This design enables the system to maintain sufficient hot water reserves and adjust operation based on real-time usage patterns. The tank is also well-insulated, needing limited heating and providing a more extended supply of hot water during power outages.



The path to program acceptance: To date, eligibility for both water heating and space conditioning (air) incentives, rather than just one or the other, has been determined on a program-by-program basis. In other words, whether a customer can receive incentives for both a heat pump water heater and a heat pump for space heating and cooling depends on the specific rules and design of each incentive program. Some California programs (through Silicon Valley Clean Energy and Peninsula Clean Energy, for instance) provide both incentives, while others, like TECH Clean California, cover the system as an air-to-water heat pump. However, while Harvest has not yet been listed in any technical reference manuals (although as of April 2025, a workpaper for approval by the California Technical Forum is under development), the system has been incorporated into the CBEC-RES (residential code compliance software) after PG&E and the California Energy Commission put the system through its paces in a testing facility. Meanwhile, the system is eligible for a 30% uncapped 25D federal tax credit.[39] Harvest has also forged ahead through partnership with WattCarbon to value the decarbonization attributes of the technology, resulting in an initial round of installations in Truckee, California.

DANDELION ENERGY

What: Residential geothermal system provider

When: Founded in 2017 after spinning out from X, the Google "moonshot factory" [40]

Where: Nationwide, historically with most installations in the Northeast (retrofit focused) and more recently in Colorado and nationwide for new construction. Maryland and DC are other big areas due to favorable economics, but they have projects in other states as well.

Why: Geothermal heat pump systems typically offer very low operating costs but come with high upfront installation expenses. This creates a classic split incentive problem: while the long-term utility savings benefit the homeowner, the initial costs are often borne by the builder or seller, who may not remain in the home long enough to realize those savings. Dandelion Energy believes it can address this split incentive issue. The company argues that geothermal systems provide significant value to the electric grid due to their lack of "peakiness"—in other words, they place minimal demand on the grid during peak times. According to Dandelion, quantifying the value of this reduced peak demand is critical to establishing appropriate incentive levels for geothermal adoption.
In Colorado, Dandelion's work demonstrated the grid benefits of geothermal compared to air-source heat pumps (ASHPs), helping to make the case for utility support. The company suggests that states like California could similarly benefit by deploying ground loops at scale—reducing both grid stress during peak periods and homeowners' long-term energy costs.
Dandelion frames this as a policy conversation; While California is aggressively pursuing building electrification, it also faces equity challenges. Geothermal, Dandelion argues, can help address the operational cost burdens of electrification and alleviate peak demand concerns. Dandelion's partner in their Colorado venture, Lennar (described below), is (according to Dandelion) eager to adopt geothermal and build homes in CA, but current incentive structures remain insufficient to support widespread adoption.[41]

How: Dandelion's system pairs a ground loop with a high-efficiency geothermal heat pump. The company claims the system delivers twice the efficiency of a standard air-source heat pump (ASHP), with a coefficient of performance (COP) of up to 5.2. It can heat air to 120°F, approximately 20°F higher than typical ASHPs—an advantage for maintaining comfort in colder climates.[42] Dandelion's geothermal rig is track-mounted and can squeeze into spaces six feet wide or greater.[43]

New Construction in Colorado: A flagship project partnership with Lennar in Colorado will consist of 1500-1700 new construction homes, which should create cost efficiency due to scale. Supply chain costs will be 30% less for the Lennar project than the norm for Dandelion.

40 https://x.company/projects/dandelion/
41 https://dandelionenergy.com/dandelion-energy-and-lennar-announce-one-of-the-largest-residential-geothermal-deployments-in-us-history
42 https://dandelionenergy.com/technology
43 https://dandelionenergy.com/drilling

Incentives and tax credits: According to Dandelion, its geothermal systems currently qualify for two federal tax credits: the Residential Clean Energy Credit (Section 25D), which offers a 30% tax credit to homeowners, and the Investment Tax Credit (Section 48), which applies to commercial property owners. However, homebuilders do not qualify for either credit, as they do not retain ownership of the property nor meet the definition of a homeowner. In practice, this means that in projects like those in Colorado, Lennar—Dandelion's homebuilder partner—is ineligible for these tax credits, although individual homebuyers may qualify for the 25D credit once they purchase the homes. Dandelion is currently having an internal debate about whether to market around these tax credits given the uncertainty of their continuation. Dandelion identifies that the biggest beneficial policy for the company would be a simple, flat, and not income-qualified (as income qualification might essentially invalidate a new construction incentive) geothermal-specific incentive for both new construction and retrofit. Dandelion cites a geothermal kicker of $5k in Colorado, which names geothermal specifically, not just performance level. In Maryland there is a GREC – a geothermal renewable energy credit.[44] According to Dandelion, rather than a flat incentive, this is determined based on the efficiency of the system and the leakiness of the home.

44 https://www.psc.state.md.us/electricity/description-documents-maryland-renewable-energy-portfolio-standard-program/geothermal-rec-frequently-asked-questions/

GRADIENT

What: A 120V plug-in window-hung space conditioning heat pump

When: Founded 2017

Where: Started in California and is widely available, but focused particularly on the large multifamily market in New York and other cold climates.

Why: Window-hung form factor and the ability to plug into a standard wall outlet minimize installation costs and impact to the existing structure

How: Gradient produces an All-Weather, 120V cold-climate-capable window heat pump, building on its first-generation moderate-climate model. The unit weighs 140 pounds and has a list price of $3,800. It can heat and cool and pair with the Gradient app for remote operation. The unit also has onboard controls and includes a remote to control the system. The All-Weather 120V unit touts a rating of 5,400 BTU/hr down to 5°F and is capable of operating down to -13°F. The unit plugs directly into a standard 120V outlet, limiting the need for panel or service upgrades to the building. There's also no need to plumb condensate or alter the building envelope since it installs through a window, and the condensate is atomized into the air. According to Gradient, installation takes about 30 minutes for two laypeople and does not require a licensed HVAC technician to install.

The path to program acceptance: The All-Weather 120V model has been certified by the Consortium of Energy Efficiency (CEE) as of March 2025.

Suitability: Gradient is focused on advancing electrification in multifamily buildings, emphasizing the suitability of its system—which functions like a mini-split but uses a saddleback design that mounts over the window sill, preserving full window operability. According to Gradient, the amount of space these units can condition depends on climate and building characteristics, but they can generally heat and cool 250-500 sq ft per unit. The units can be scheduled and controlled via an app, and in 2025, they plan to roll out the capability to control through the building automation and control communication protocol BACnet. This capability has been sought by large multifamily owners, in particular. A touted benefit of these units is the integrated filter for air purification and the option to upgrade the air filter from a MERV2 to a MERV13 for added air purification benefits.

Regarding refrigerant: The Gradient units use R-32 refrigerant, but the company is considering ultra-low-GWP options in the future. The units are hermetically sealed at the factory, so they do not require specialized licenses for in-field refrigerant charging during installation. According to Gradient, the units are expected to see less leakage over their life than a mini split by a factor of eight.

Condensate management: Rather than requiring a condensate drain, Gradient uses atomizers on the external portion of the unit to dispose of condensate. While the expected life of the unit is around 15 years, the atomizer technology is fairly new, and the component life is not yet fully understood. The company has ongoing "accelerated life testing" underway, with 25 years of equivalent operation demonstrated as of April 2025. In addition, the meltwater subassembly is designed to be swappable in under an hour if it were to break in the field.

RENEWABOILER BY 2040 ENERGY

What: A heat pump boiler for homes with radiators. The product's launch aligns with growing market demand for electrification solutions that can seamlessly replace fossil-fuel-based systems, supporting policy goals for clean energy and climate mitigation.

When: The 2040 Energy initiative began in 2018 with the goal of advancing sustainable energy solutions. As part of this effort, the company plans to release the RenewaBoiler—a next-generation heating system designed for improved efficiency and reduced emissions—targeted for launch in 2025.

Where: Based in Minnesota

Why: RenewaBoiler is intended to be a 1:1 replacement for an existing gas or oil boiler that can handle the hot water required for radiators and function in very cold temperatures.

How: The RenewaBoiler is intended to replace an existing fossil-fired boiler fully, but sits outside the building envelope rather than inside. Existing fossil-fired boilers are designed to run with a 180-degree intake and 160-degree output, but according to 2040 Energy, most other air-to-water manufacturers are designing for 140 degrees. RenewaBoiler is aiming for a maximum of 175 degrees with a maximum return temperature threshold of 140 degrees. The system is intended to serve a home's domestic hot water if combined with an indirect water tank.

ARIS HYDRONICS

What: Aris Hydronics is actively developing and testing its **ARIS Home Comfort System**, which integrates heating, cooling, and hot water into a single modular, hydronic system.

When: Launched in early 2022

Where: Based in Oregon, it has been piloting for the past two years, primarily in the Pacific Northwest. Plans are for pilots in California and Minnesota for the single-family system.

Why: Aris is a Hydronics-based solution intended to provide heat, cooling, and hot water through one system without running refrigerant line sets through the building envelope.

How: To paraphrase Aris, "The solution is not hardware – hardware is the result of designing a system that works." Intended to address both single-family and multi-family uses, the heat pump for this system is exterior to the building, and the heat transfer is to water. This enables the heat pump to come pre-charged with refrigerant and sealed at the factory. The Aris Home Energy system (a combi system for single-family homes) is made to be as modular as possible so that it doesn't require as much on-the-ground engineering and is intended to be a replacement for any system, not just an existing hydronic system.

The path to program acceptance: Testing and certification have posed significant challenges for this air-to-water technology, which provides both heating and cooling. According to Aris Hydronics, sufficient understanding existed during the most recent building code revision in Washington state to include language specific to air-to-water systems. However, other regulatory and incentive frameworks reveal gaps between existing requirements and the full capabilities of this combined heating and cooling technology. For example, while ASHRAE's chiller certification enables Aris to obtain product listings, it does not fully capture the system's dual-function (combi) nature. Additionally, many incentive programs rely heavily on heating seasonal performance metrics, which are incompatible with the ASHRAE chiller certification. Aris notes that several European manufacturers are similarly advocating for updated testing and certification standards that align with comprehensive performance measures, such as the Seasonal Coefficient of Performance (SCOP) outlined in BS EN 14825.

Temperature considerations: Since the heat exchanger for this unit sits outside the building envelope (in the outdoor unit) with water running from the outdoors to the indoor components, certain modifications are required to resist freezing in very cold climates. Where freezing is a concern, Aris mixes glycol into the lines. Blending is not the default, given the added cost of glycol and an energy penalty resulting from the mixture.

Regarding refrigerant: Aris uses R-32 for its system but is working on incorporating R-290 into their next-generation product. According to Aris, this is because R-290 is adaptable for systems that are reversible, while CO2 struggles with going from cooling to heating and requires higher pressure. In their system, Aris aspires not only to minimize the global warming potential of the refrigerant used but also to minimize the amount of refrigerant the system requires in the first place.

Recognition: In September 2024, Aris Hydronics was awarded the U.S. Department of Energy's EAS-E Prize, recognizing their innovative approach to home electrification and energy-efficient heating and cooling.

COPPER HOME

What: A 120V battery-assisted induction range

When: Founded in 2022

Where: Headquartered in Berkeley, CA with shipping currently available anywhere in the United States. In late 2024, Copper was selected to supply 10,000 stoves to the New York City Housing Authority.

Why: Switching from fossil-fired cooking to a full-size electric option has, until recently, required wiring a 240V outlet, which is not always feasible or affordable. Copper Home is one of a couple of companies that have introduced a 120V compatible induction cooking option. The company touts the ease of installation as well as environmental, health, and safety benefits of induction.

How: The core innovation of Copper Home's Charlie range is its battery system. Initially tested with a 4 kW battery, the company has since upgraded to a 5 kW battery that has successfully passed the UL runaway thermal test. The battery uses lithium iron phosphate chemistry, selected for its enhanced stability compared to other lithium-ion variants. To ensure safety, the system includes an integrated thermal kill switch that activates if temperatures rise to dangerous levels. Copper Home markets the Charlie range to both single-family and multifamily customers. The multifamily housing sector is particularly attractive because individual units can be linked and managed collectively, allowing for optimized performance across an entire building or portfolio. Additionally, Copper Home emphasizes the significant health and safety benefits of replacing fossil-fuel appliances in lower-income multifamily housing, where smaller, less ventilated units often exacerbate indoor air quality issues.

The path to program acceptance: While ENERGY STAR® is often a precondition for programs, the way that the battery for the Charlie charges has prevented it from attaining that certification. The company does assert that the Charlie unit is eligible for a 30% tax credit due to its storage capabilities.

What's next: Copper Home is in the process of developing at least one other iteration of the Charlie stove to suit different market segments and has its eyes on other appliance end uses in the future.

Opinion **Dynamics**