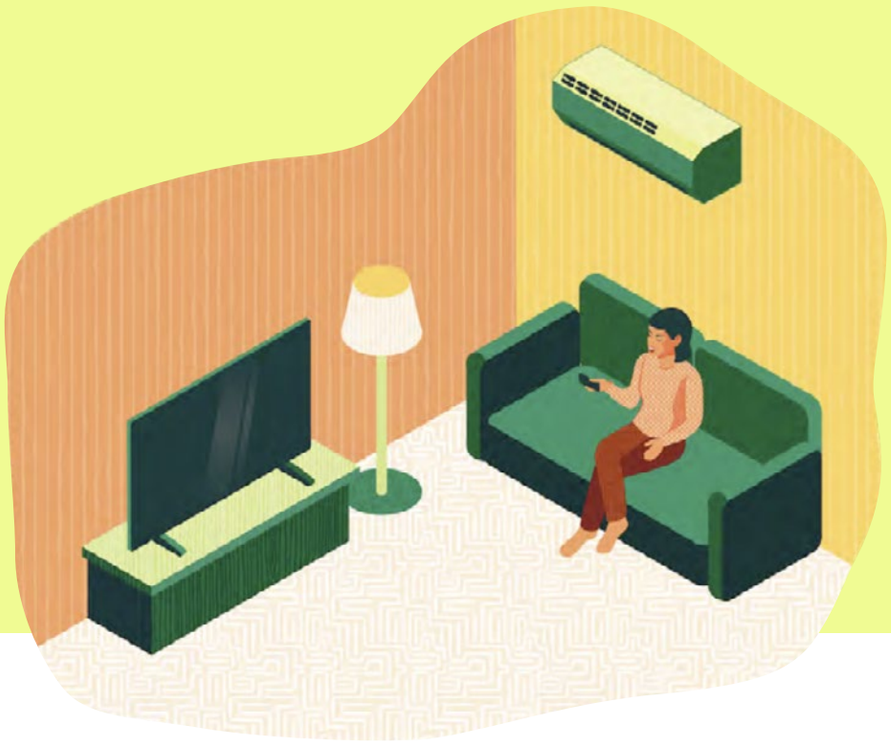
REWIRING AMERICA



Electrify Everything: Heat Pump: Heating and Cooling

By Joel Rosenberg, Rewiring America

Version 2.0, released May 2023

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REWIRING AMERICA

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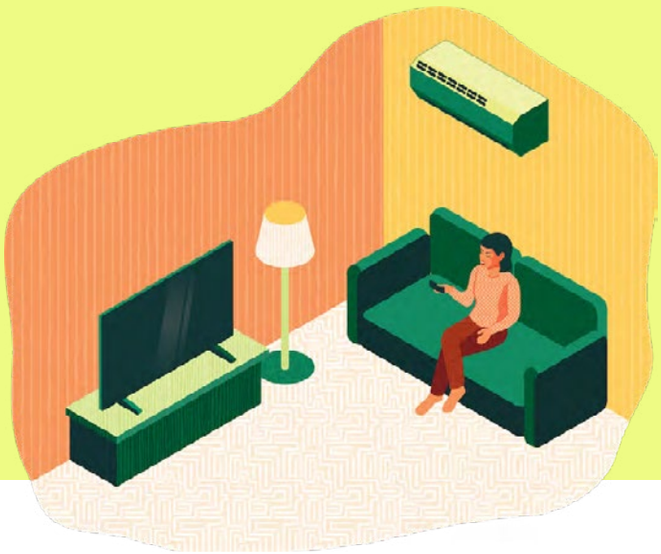
Heat Pump Space Heating & Cooling



DIFFICULTY:	HARDER
UPFRONT COST:	$1,000 (DIY) to $30,000
IMPACT:	High
CONTRACTORS:	HVAC Contractor
DO NOW:	Get a "home energy audit" or "home energy assessment" (including a blower door test), and/or schedule at least one heat pump contractor to come to your home and give you an initial quote/proposal.
RENTER:	Get a window unit or portable heat pump.

RECOMMENDATIONS

ALL CLIMATES: Inverter-driven, HSPF of 10.5 and SEER 20 or higher (COP of 3 or better). The higher your electric rate is, the better your savings from higher efficiency.

COLD CLIMATE: Get a cold climate heat pump that works well down to -5°F or lower. The technology has improved dramatically for cold climates.

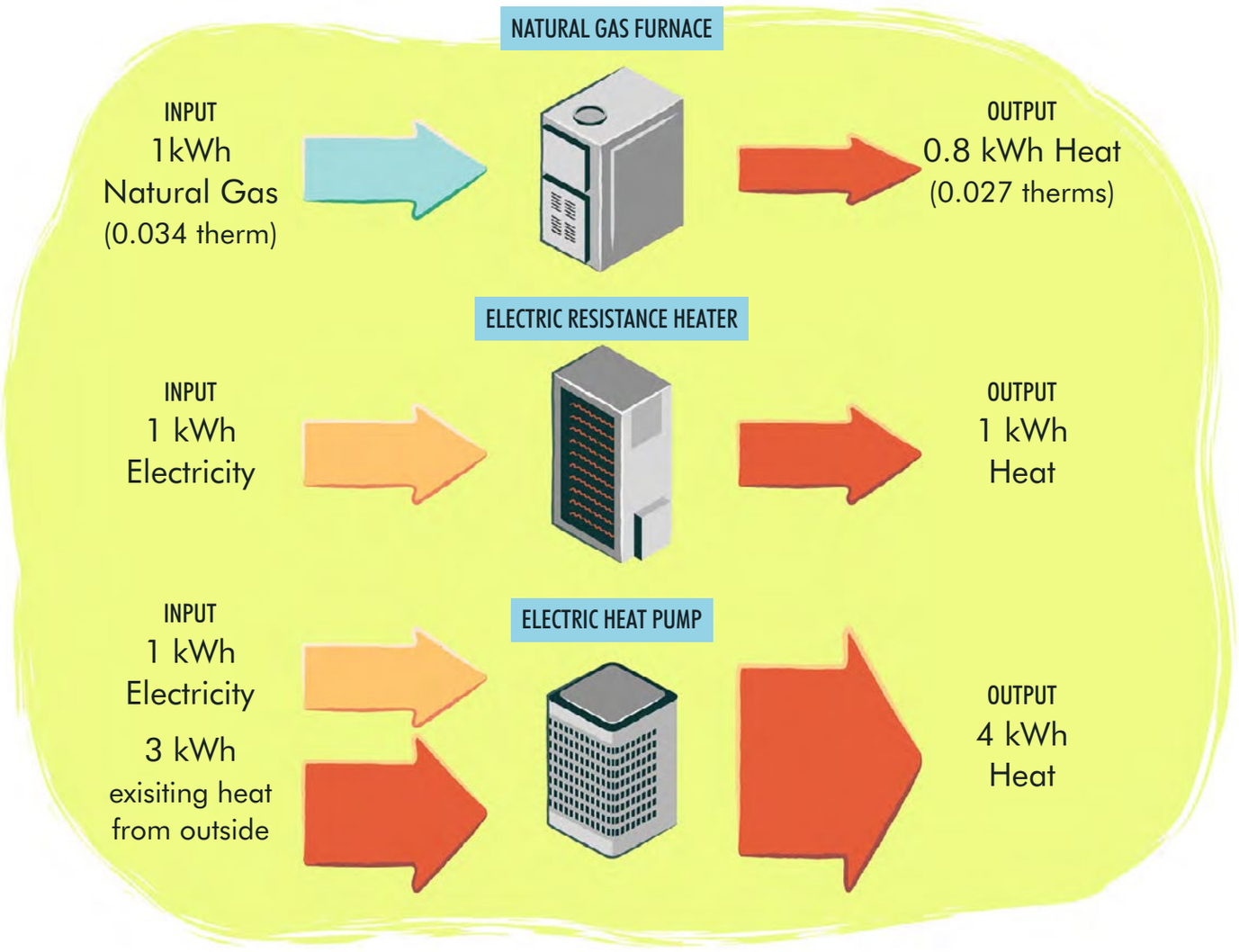
WARM CLIMATE & DRY CLIMATE (WESTERN U.S.): Avoid or downsize backup resistance strip heaters if possible.

DISTRIBUTION: Choosing ductless can help you abandon ducts you no longer want. Ducts in an attic lose more energy than ducts in a basement or crawlspace.

AVOID: Don't buy a stand-alone Air Conditioner. Most major AC brands make a Heat Pump version that both heats and cool. Demand this of your contractor, spend an extra $100-$400, and you can stop using your inefficient gas furnace. And don't buy a new natural gas furnace!

If you've never heard of a heat pump before, it might be because they go by many names, such as "refrigerator" and "air conditioner." If you feel the back of your refrigerator, it's warm because heat is being pumped out of the fridge, leaving it colder inside. An air conditioner is very similar, pumping heat out of your home. A heat pump is like a reversed air conditioner, where heat is pumped from outside air *into* your home (and leaving it slightly colder outside).

The amazing thing about this is that even freezing cold air contains heat that can be pumped inside, and it's much more efficient to move heat than to create it. So while a natural gas furnace might deliver 80% of the heat produced from burning the gas, and an electric resistance heater can use 100% of the electrical energy to produce heat, a heat pump can pump 300-450% worth of heat into your home for the same electrical energy input! The height of each arrow in the image below visually represents the amount of energy input and output for these devices. The colors are: blue for natural gas, yellow for electricity, red for heat. The heat pump takes existing heat from outside as an input, which is why it's such a huge improvement over a natural gas furnace or an electric resistance heater.



DO NOW: START PREPARING FOR YOUR HEAT PUMP

Upgrading to a heat pump is more complex than the rest of the things in this guide, in large part because it's not just swapping out an appliance like your gas stove for an electric, but instead designing the heat pump to work well with your existing home. For that, you're going to need an HVAC (Heating, Ventilation, Air Conditioning) contractor. Three things you can do now to start planning for a heat pump are:

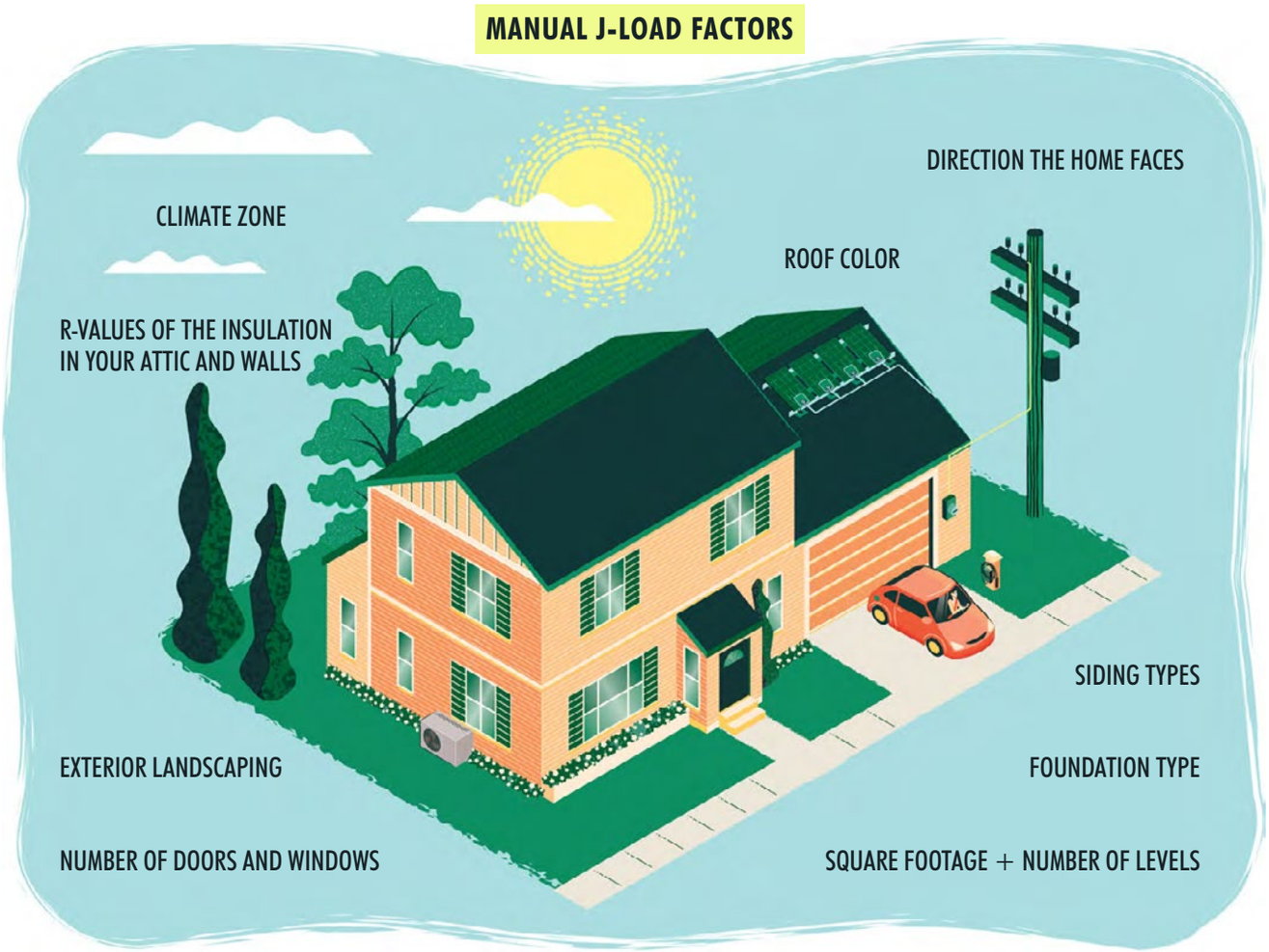
1. **Get a home energy assessment (aka home energy audit):** This can be very helpful if you live in a cold climate, but it's also useful in a warm climate. It involves someone coming to your home to perform some tests to see how well your home is insulated and sealed against air leaks and drafts. The Department of Energy has a video on what to expect from an audit — **energy.gov/energysaver/weatherize/home-energy-audits**. It can cost between $100-$300, but check with your local utility to see if there are programs to make it cheaper, or free. You should also check with your utility, or your state or local energy/weatherization office, for a list of certified energy auditors in your area. Make sure your audit will include a blower door test, where a fan blows air through your front door to measure your home for air leaks.

2. **Pre-contractor prep:** Before you start finding contractors for quotes, make a list of any places in your home that are uncomfortable because they're too hot or cold. Based on your home energy audit results, consider if you want to seal leaks or better insulate your home (see "Weatherizing your home" section below). And be sure to read through the "Understanding Your Heat Pump Options" section below to get a sense of what you're looking for, so you can request quotes on similar units from multiple contractors.

3. **Get quotes for inverter-driven heat pumps:** This might be done by your home energy auditor if they're also an HVAC contractor, or by a separate contractor. By getting initial quotes, you'll get suggestions for what options can work in your home. Check with your state or utility to see if there is a list of contractors who regularly install heat pumps. Working with a state-certified contractor might also help unlock additional state and local rebates. And make sure you ask for quotes on "inverter-driven" heat pumps (see "Variable capacity" section below).

Your contractor has to know how to properly size your heat pump, which requires knowing how much energy your home gains and loses over the course of a day — known as the "load calculation." This calculation has been standardized as "Manual J," and the graphic below shows the standard inputs

such as your climate and home position, the quality of the insulation, and the size and number of openings.[1] You might ask any potential contractor what software program they use for their Manual J calculation, since it will give you an idea of how seriously they take this step.[2] See "Finding and working with a contractor" section below.



"WEATHERIZING" YOUR HOME

The blower door test from your energy assessment will give you a sense of how much air your home leaks. Ideally, your blower door number will be either similar to or less than the square footage of your home.[3] If it's higher than that, you should consider sealing your home, which is an affordable step you could even do yourself — see the Department of Energy's "A Do-it-yourself Guide to Sealing and Insulating with Energy Star" —**energystar.gov/ia/partners/publications/pubdocs DIY_Guide_May_2008.pdf**.

Beyond sealing leaks, you can also add insulation to your home, but it might not be necessary. Talk to your HVAC contractor about where to focus — your walls, attic, floors, or windows.

If you are interested in continuing to use your existing ducting, it may only perform well with a smaller unit (maximum size around 3 tons, or 36 kBtu/h). Air sealing and insulation will allow you to install a smaller unit.

FINDING AND WORKING WITH A CONTRACTOR

To help you engage a contractor, below is a collection of recommendations from several different sources:[4]

To find a contractor:

- → Ask for suggestions and referrals from your friends, neighbors, co-workers, and local trade organizations. Aim to get proposals from at least three contractors.
- → For central heat pumps, consider reaching out to a local HVAC distributor for major brands (such as Carrier, Bryant, Mitsubishi, Fujitsu, Trane, and American Standard) and asking which contractors buy a lot of "inverter-driven heat pumps."
- → Before calling for quotes, know the model of your current system and maintenance history, and note any uncomfortable rooms.

QUESTIONS TO ASK A CONTRACTOR WHEN ENGAGING:

- ☐ Make sure they're licensed in your state, and that you verify it with the state license board. Also make sure they have insurance — both general liability and worker's comp. This might be a requirement for a state license.
- ☐ Do you install inverter-driven air source heat pumps? What percentage of your business are they?
- ☐ Do you use a computer program to do load calculations? Which one? (Good contractors will use WrightSoft, EDS, or CoolCalc.)
- ☐ Will you do a home evaluation with a blower door?
- ☐ Have you participated in manufacturer training for the systems you would install?
- ☐ Do you know about available incentives or rebates, and will you provide assistance in applying for them?
- ☐ Where will you mount the outdoor unit(s), and how? (Brackets bolted to an exterior wall may create unwanted noise in a sensitive area like a bedroom; ground-mounted units should always be on a stand to keep them above the normal snow line. Units should

also be shielded from rain and snowmelt dripping off the roof.)

- ☐ If exterior "line sets" (piping) will be visible, where will they be placed?
- ☐ What type of indoor units are you recommending, where will they be located, and why?
- ☐ Do you recommend a wall-mounted thermostat or control? (This is needed for ducted systems. For ductless units serving larger spaces, it can enhance comfort by sensing the temperature in a central location.)
- ☐ Do you always perform a triple evacuation before charging the refrigerant lines?
- ☐ Will I need to hire my own electrician to provide the electrical work? Will I need any electrical service upgrade to accommodate the heat pumps? (This is not unusual in older homes.)
- ☐ Will you use any subcontractors in the process? If so, who are they and what jobs will they do?
- ☐ Will you provide training on how to properly operate and maintain the system?
- ☐ Do you provide a warranty for the systems you install, and how long is it?
- ☐ Can you provide references from previous customers with similar systems?
- ☐ If in a cold climate, do you use the NEEP Sizing and Selecting Guide and Cold Climate Installation Guide[5] to inform your work? Will you choose equipment from the NEEP cold-climate air source heat pump list,[6] and use the information in the listing to help size the system properly?
- ☐ Do you recommend I add Heat Recovery Ventilation (HRV) or Energy Recovery Ventilation (ERV)?

GETTING PROPOSALS FROM A CONTRACTOR, AND SIGNING A CONTRACT:

- ☐ Call the contractor's references to ask about their installation and service performance, and whether the job was done on time and within budget.
- ☐ Get written, itemized estimates. Ask for options for two or three alternatives from each contractor, along with an explanation of the differences and benefits of each alternative.
- ☐ Proposals should include:
  - specific brands, manufacturer's model numbers and all relevant specs;
  - itemized lists of any other parts and accessories that you'll be charged for;
  - planned date of completion (including any subcontractors);

- a schedule of payments for the complete job — in dollars and cents and NOT percentages;
- a down payment (if any) doesn't exceed $1,000 or 10% of the contract, whichever is less.

☐ Sign a written proposal with a contractor before work gets started. It'll protect you by specifying project costs, model numbers, job schedule and warranty information.

WORKING WITH YOUR CONTRACTOR:

☐ Treat your contractors well.

- Have drinks and snacks handy, and tell them which bathroom they can use.
- If there is something you want to incentivize, tell them up front rather than as an end-of-job bonus.
- Only pay for work that's been performed — never in advance.

☐ Make sure all contract changes are in writing and signed by the contractor.

☐ Don't make final payments until you have seen receipts for bills paid by the contractor to any subcontractors and suppliers, or written waivers proving they've paid for materials and labor on the completed job.

☐ Make sure the system is set up well, you're trained in how to properly operate and maintain it, and clear on if and when they'll be back for inspection or service.

UNDERSTANDING YOUR HEAT PUMP OPTIONS

To retrofit a n e xisting h ome, most people will get an air-source heat pump that extracts heat from the air. There are also ground-source heat pumps with pipes buried near the home to get heat from the ground, and water-source heat pumps if your home happens to be close to water, but these are less common.[7] And if you have radiant floor heating or another type of forced hot water heating, there are hydronic heat pumps that transfer heat from the air to water, which can also be used for heating swimming pools and hot tubs.

Check out Redwood Energy's "Pocket Guide to All-Electric Retrofits of Single-Family Homes" for many different heat pump product options — **redwoodenergy.net/research**.

AIR SOURCE HEAT PUMPS

There are a number of different configurations for air source heat pumps, and it can be a little confusing to understand the differences. New York State's "Heat Pump Planner" is a useful reference for understanding your options beyond what's below — **nyserda.ny.gov/All-Programs/Programs/Heat-Pump-Program/Heat-Pump-Planner**.

To start, let's look at how a refrigerator works as a kind of "air conditioner" for the inside of the fridge.

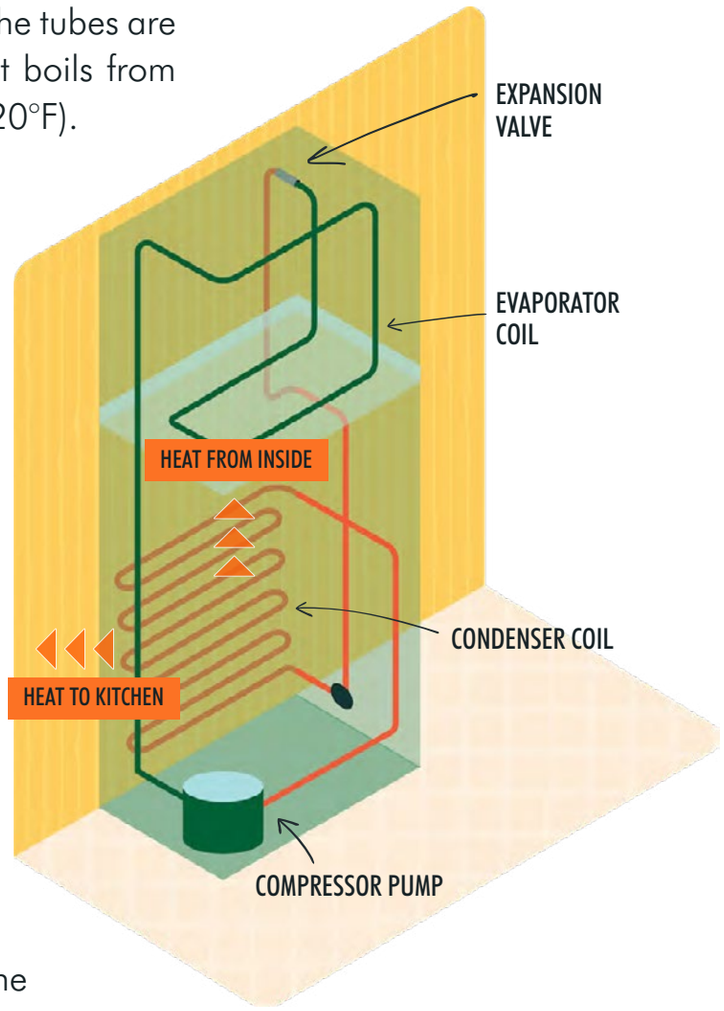
A refrigerator "pumps" heat out

Two coiled tubes are connected together, one running inside the fridge, one outside on the back. The tubes are filled with a fluid called a "refrigerant" that boils from liquid into gas at a low temperature (e.g. -20°F).

Inside the fridge, heat is absorbed by liquid refrigerant in the "Evaporator" coil, and the heat boils the liquid into gas. The refrigerant gas carries more heat than the liquid, the same way steam carries more heat than water.

The "hot" refrigerant gas is then squeezed by a compressor, which heats it even more. The gas then moves to the "Condenser" coil behind the fridge, where it dumps the heat to the kitchen. The refrigerant gas cools down enough to condense back into liquid.

Every refrigerator, air conditioner, and heat pump has these two parts — the Evaporator and Condenser. Where they're located is key to understanding the differences between heat pump configurations.



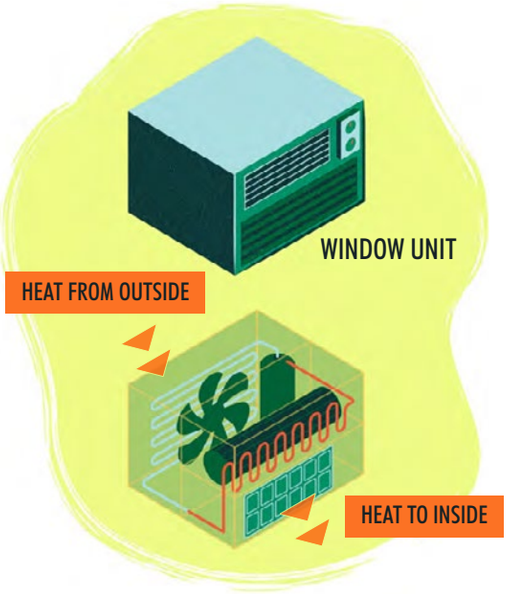
A. Packaged Heat Pumps—A packaged heat pump is an all-in-one unit, with the Evaporator and Condenser coils in the same "package."

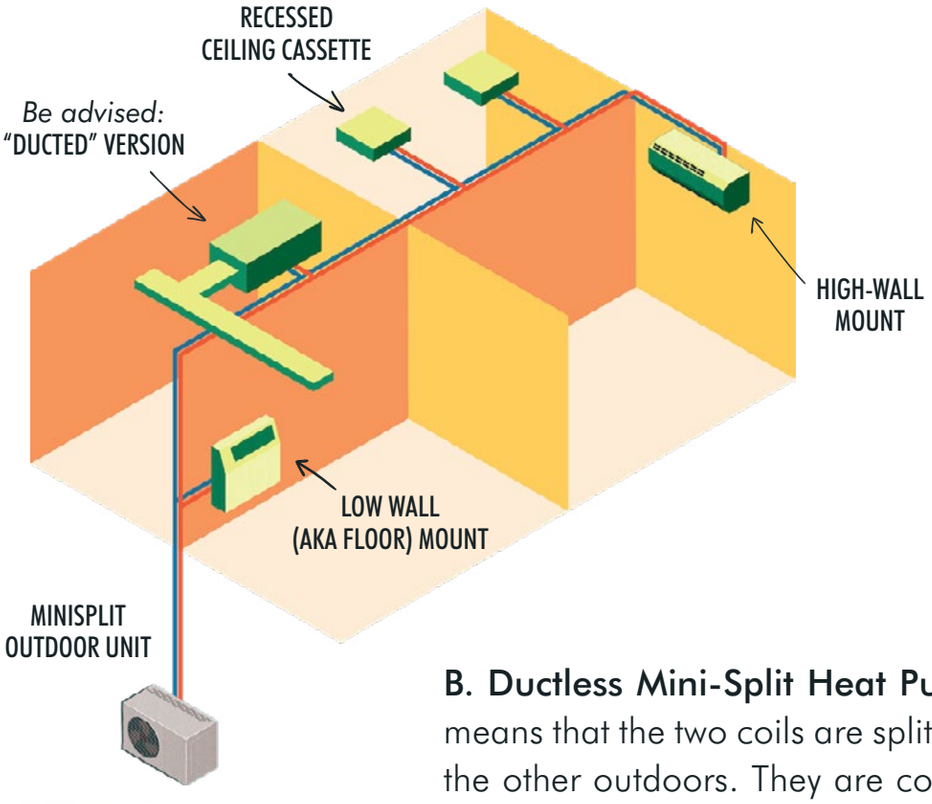
It can look like a window air conditioner. The main difference between an air conditioner and a heat pump is that the heat pump can reverse direction, and either

coil can act as the Evaporator or Condenser.

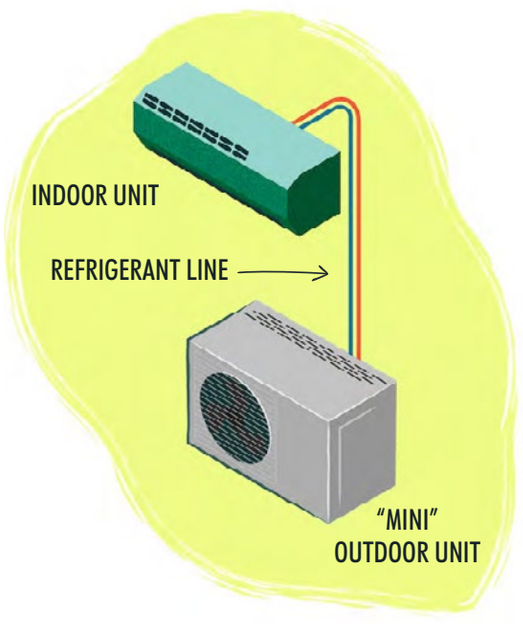
Besides window units, there are also portable stand-alone units (often with hoses that mount in your window), and through-wall mounted units. They cost between $500-$2,000, and can usually be self-installed.

Be advised: There are also larger "packaged" units that could replace your outdoor central air conditioning unit, and even run multi-family homes. This can be confusing, since it's not a window unit. See below on ducted split heat pumps.





MINI-SPLIT HEAT PUMP

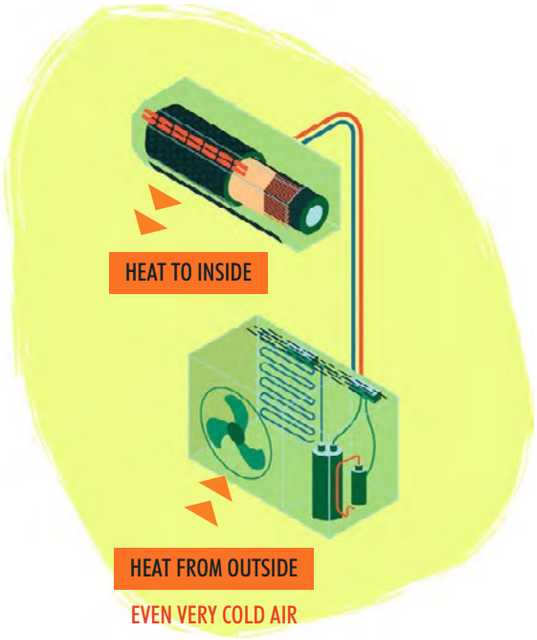


B. Ductless Mini-Split Heat Pump—The term "split" means that the two coils are split, with one indoors and the other outdoors. They are connected together by a refrigerant line that passes through the wall. The term "mini" refers to the outdoor unit, which is the size of a suitcase.

They are called "ductless" because they don't use air ducts to move heated and cooled air around the home.

Consider a mini-split if your home uses:

- baseboard heaters,
- wall or floor heater,
- portable heater,
- window air-conditioner,
- wood stove,
- nothing in a cold space (garage, attic).[8]



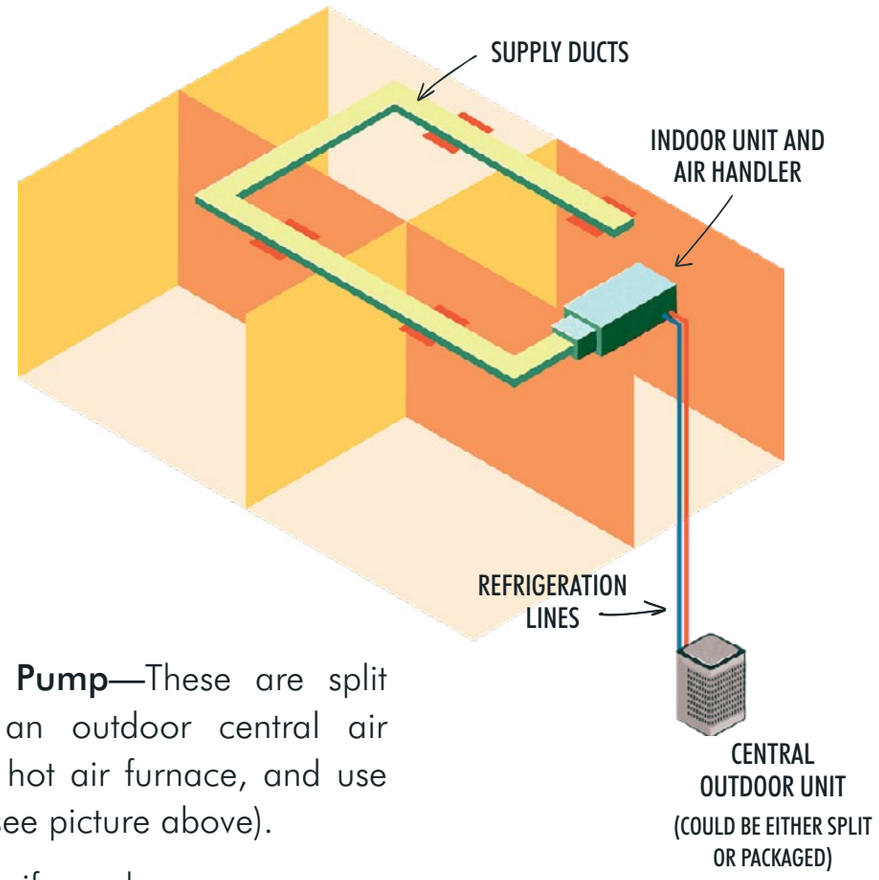
Each room or heating zone needs its own indoor unit, and multi-zone indoor units can share one outdoor unit.

Different brands might have multiple options for indoor units, including high wall mount, low-wall (aka floor) mount, and recessed ceiling cassette (see picture on previous page). Be sure to ask your contractor about which options best fit your situation. You might be able to mix and match.

Be advised: You can also have a "ducted" mini-split that uses air ducts to share a single indoor unit among a few rooms (also in picture on previous page).

Do-It-Yourself (DIY): If you're handy, you might consider installing a "retrofit-ready" mini-split yourself from brands like Pioneer, Gree, and MRCOOL. They work with 120V outlets and come with pre-charged refrigerant lines. Check the manual to see if you need an inspection to get the warranty.[9]

DUCTED CENTRAL HEAT PUMP



C. Ducted Central Heat Pump—These are split systems that can replace an outdoor central air conditioning unit, or central hot air furnace, and use existing ducts in your home (see picture above).

Consider a central heat pump if your home uses:

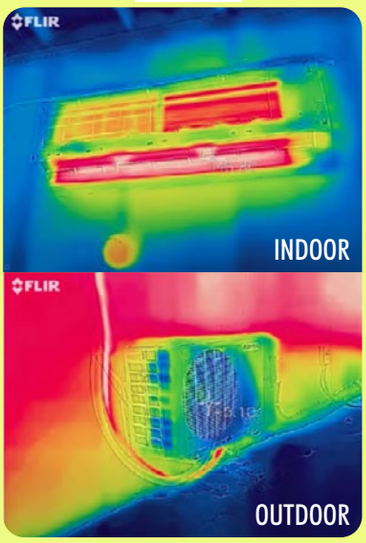
- Ducted furnace / air conditioner (forced air)
- Boiler / radiant heating (forced hot water).

It is important for your contractor to check your existing ducts to see if they'll work well with a heat pump. They

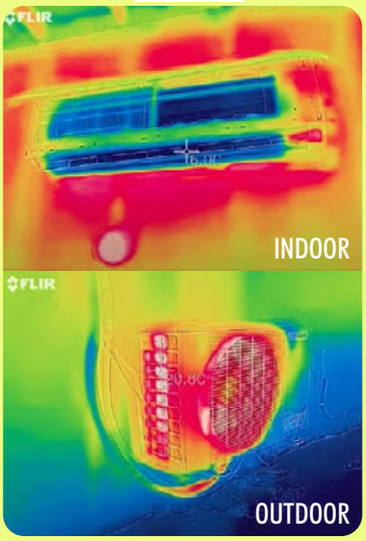
might be: poorly designed (lots of bends), undersized, oversized, dirty, leak air, run through cold spaces (like an attic), under-insulated, or some combo.

Central heat pumps also need an air handler, and those are typically 240V. Your current furnace has an air handler, and it's 120V. Request a model that has an electric line from the outdoor unit that powers the indoor unit, which also frees up your old furnace air handler circuit for other electrification projects.

HEATING



COOLING



REVERSIBLE HEATING & COOLING

To make the reversible operation of a heat pump clearer, to the right are thermal camera images of the indoor and outdoor units of a mini-split system, taken from Technology Connection's fun video, "Heat Pumps: the Future of Home Heating" — **youtube.com/watch?v=7J52mDjZzto**. In the top pair of pictures, it's working as a heater — the indoor unit is warm (red) and the outdoor unit is cool (blue). In the bottom pair of pictures, it's working as an air conditioner, and now the indoor unit is cool (blue) while the heat is pumped outdoors (red).

COLD CLIMATES

There is an outdated misconception that air-source heat pumps only work well in warmer climates. That is no longer the case — recent advances have made them very suitable for cold climates too. NEEP has a list of cold-climate air source heat pumps — **ashp.neep.org**, and a buying guide — **neep.org/air-source-heat-pump-buying-guide**. One manufacturer has a video showing their heat pump working well in winter in the coldest continental U.S. town of Grand Forks, North Dakota — **youtube.com/watch?v=_v8vizQXwss**.

SIZING

The first recommendation your contractor might give is for the size of the unit you'll need, in units of "tons" or BTU/hour.[10] For a mild climate, here are unit size estimates based on floor area:[11]

- → 500 square feet: 1 ton (12,000 BTU/hour)
- → 1,000 square feet: 2 tons (24,000 BTU/hour)
- → 1,500 square feet: 3 tons (36,000 BTU/hour)

These sizes might be much lower than your current furnace, because the furnace has to turn on at 3,000°F and then turn off before it melts. This "cycle" happens three to eight times an hour, even when it's working well. Variable speed (inverter driven) heat pumps put out constant heat at about 120-130°F, so they can be right-sized to stay on and operate quietly. They adjust their fan speed and compressor speed to keep the home temperature stable, which is much more energy efficient, and also makes the space feel more comfortable than with a furnace that keeps turning on and off.

If you have central air conditioning, you can use its capacity as a guide to what you'll need in a heat pump (which is just a reversible air conditioner). So if you need 3 tons of cooling, you need 3 tons of heating too.

Note that the size of the furnace will depend on the Manual J calculations done by your contractor (see the "Do Now" section above). Your contractor should also consider using Manual S (for sizing) and Manual D (for ductwork) calculations when recommending a system.

VARIABLE CAPACITY

You have several options for the amount of control over the heat pump's output. More control can be more energy efficient and thus less expensive to run, but it might be more expensive up front. Here are the main variations:

- → **Single-stage:** This is the simplest and least expensive type of heat pump, and it's either turned on at 100% capacity, or turned off, making it the cheapest but least efficient.
- → **Two-stage:** This heat pump uses a compressor that can run at either 70% or 100% capacity, depending on what your home requires. Better than single-stage.
- → **RECOMMENDED — Inverter-driven (aka "Variable speed" or "Modulating"):** The best heat pumps use an electrical device called an "inverter" to enable variable speed of the compressor, which in turn varies (or "modulates") the capacity between 20% and 100%.[12] This is the most efficient option, and is worth requesting for its operating cost savings and comfort. Ask for quotes on "inverter-driven" heat pumps.

SURGE PROTECTOR FOR INVERTER-DRIVEN COMPRESSOR

Nate Adams notes that power fluctuations can kill an inverter compressor, and recommends using an ICM493 surge protector on outdoor units to protect your investment. Ask your contractors about including one in their proposals.

"HYBRID" RESISTANCE BACKUP

Some heat pumps are called "hybrid" because they come with resistance heating elements that turn on when the temperature drops below a certain threshold. In general, the performance of heat pumps decreases with falling temperature, but some newer heat pumps rated for cold climates eliminate the need for this backup. Even though resistance heating uses a lot more energy than the heat pump itself in cold climates, it can make sense to get this as backup.

FURNACE BACKUP

Some heat pumps can also be installed so that they use an existing fossil-fuel furnace as backup. This might only make sense in severe cold climates with fluctuating electric rates, and the Massachusetts Clean Energy Center, for example, is no longer recommending fossil fueled backups after an extended study of whole home heat pumps.[13]

If you keep a fossil fueled furnace backup, your installer should help you set it up — with either a new thermostat, or a second thermostat — so that the furnace backup only comes on when the heat pump can no longer comfortably heat your home because it's too cold outside to provide enough heat. If the heat pump and furnace are controlled by separate thermostats, they should be set at least several degrees apart so that they don't overlap.

If you want to stick with a furnace backup in other climates, you can add a mini-split heat pump for much of the year, and use the furnace only on a few cold mornings. You can later add additional mini-splits or a central heat pump to replace the furnace entirely.

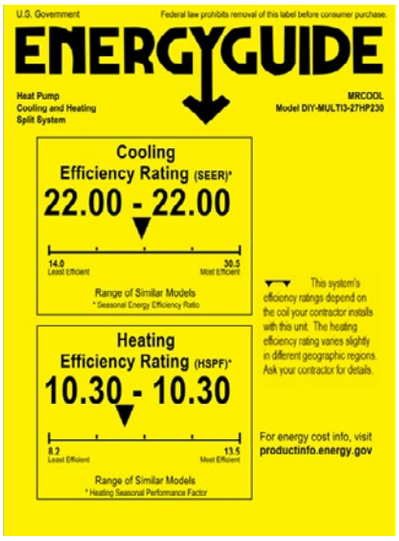
PERFORMANCE

Heat pump performance is measured with two numbers — SEER (Seasonal Energy Efficiency Rating) for cooling in summer, and HSPF (Heating Seasonal Performance Factor) for heating in winter. These are the measures that appear on each appliance's yellow Energy Guide label required by the U.S. Government.

In the label to the right, the SEER is 22.0 and the HSPF is 10.3, which is an average device, as indicated by the mid-range arrows on the scale below the big bold numbers.

When shopping for a high-performance heat pump:

- **GOOD** heat pumps have SEER above 20, and HSPF above 10.5.
- The current **BEST** heat pumps available in the U.S. are mini-split systems that have SEER of 30, and HSPF of 15.2.
- For reference, an electric resistance heater might have an HSPF of 3.4, which is **MUCH WORSE** than the heat pump.



REFRIGERANTS

It's worth knowing that refrigerants — the stuff moving between the Evaporator and Condenser to transport heat — can themselves be contributors to climate change. Make sure that you don't vent your refrigerants when it's time for maintenance.

LOOKING UP HEAT PUMP UNITS

CEE (Consortium for Energy Efficiency) maintains a Directory of Efficient Equipment. You can search for heat pump units by brand and model number, as well as a number of other criteria including SEER.

If you live in a cold climate, you should also check NEEP's (Northwest Energy Efficiency Partnerships) Cold Climate Air Source Heat Pump List — **ashp.neep.org**.

VENTILATION

Having a well-sealed home is great for keeping heat in (or out), but you still want to be able to let in fresh air, while also filtering out pollen, smoke, and germs. Ask your contractor about two specific types of ventilation — Heat Recovery Ventilation (HRV) and Energy Recovery Ventilation (ERV). The main difference is that an ERV will make your home less humid in summer and more humid in winter, compared with an HRV. See Redwood Energy's "Pocket Guide to All-Electric Retrofits of Single Family Homes" for more info — **redwoodenergy.net/research**.

COST FOR EQUIPMENT AND INSTALLATION

Most heat pumps are purchased through a contractor, who includes the equipment and installation costs together. The cost for an installed air-source 1-ton heat pump with a single zone is around $4,000, and a 2-ton is around $5,000. The cost can be lower for a multi-family home, and can be much higher for larger units, multiple zones, and high quality brands. Additional costs can include:[14]

- → Sealing your home for air leaks.
- → Duct installation or repair ($2,000 - $4,000).
- → A new hybrid furnace ($2,000 - $6,000).
- → A replacement air handler ($2,000 - $3,500).

Again, the best thing to do is to get quotes for recommended systems from a few different contractors, so you can further research and compare what your next steps should be.

INSTALLATION, SETTINGS, & MAINTENANCE

It should take an experienced contractor 2-4 hours to install a 1-ton ductless heat pump. It will take longer to install a central heat pump.

Before the contractor leaves, make sure they explain to you how it's set up, and how to operate and maintain it. You should read about the settings in your owner's manual. Here are some suggestions for getting the most out of your heat pump:[15]

1. Use your heat pump year-round — even on the coldest days if you have a cold-climate heat pump.

2. Set it and forget it — don't try to turn it up and down throughout the day and night (though you can make it cooler at night if that's more comfortable).

3. Minimize thermostat changes. Pick a comfortable temperature, even if it needs to be warmer than your old furnace setting.

4. Give your heat pump its own zone. Close non-heat pump dampers/radiators in spaces heated by the heat pump, and if you have a backup boiler/furnace, move the thermostat out of the heat pump zone.

5. Maximize the heating zone by opening doors between rooms the heat pump can reach (and closing off doors to rooms you don't need to heat).

6. Prioritize your heat pump over another heating system by setting your backup boiler/furnace thermostat at least several degrees below the heat pump's.

7. Avoid "auto" mode for heating and cooling — set it to "Heat" in winter and "Cool" in summer.

8. But do use "auto" mode for fan speed. If that doesn't spread the heated or cooled air far enough, set the speed to the lowest fixed speed that will meet your needs.

9. Optimize air flow direction by pointing the vents towards the open space that is the farthest away from the indoor unit, and away from any obstructions. Warm air should be directed down towards the floor, away from occupants, and cool air directed up, or at occupants.

10. Expect new sounds. Heat pumps are mostly silent, but sometimes make quiet gurgling and clicking noises as they cycle through their settings.

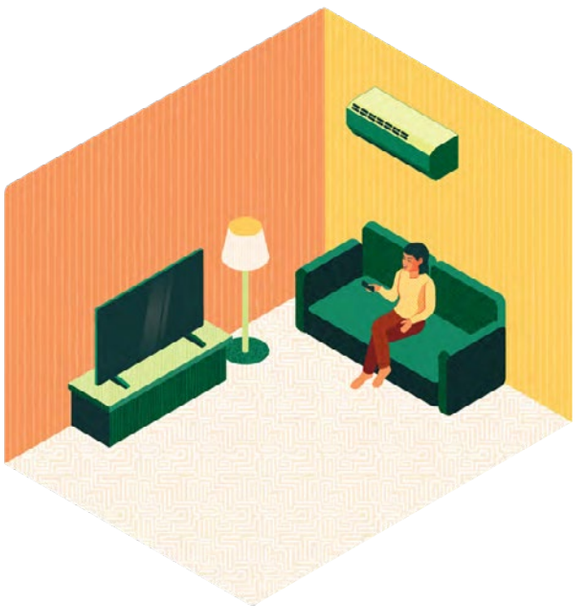
11. Watch for indicator lights, and check the user manual for their meanings.

12. Clean your dust filters by vacuuming or rinsing and drying them every few weeks to months, according to the user manual (and how dirty they get). Also pay attention to the allergen filter if your unit has one.

13. Check on your system once a season. Keep your outdoor unit clear of shrubs, leaves, ice, and snow drifts.

14. If you are in a coastal climate, rinse off your outdoor unit every few months to remove saltwater.

15. Have your heat pump serviced professionally every year or two. Follow the manufacturer's recommendations, and ask your contractor if they include service. Under normal use, modern heat pumps need very little service.



Endnotes

1. You can also learn about load calculation from an episode of This Old House, from 6:40-14:10: https://www.thisoldhouse.com/ jamestown-net-zero-house/21053794/hvac-of-the-future-the-jamestown-net-zero-house

2. This is just one question in Nate's useful "Electrify Everything/HVAC 2.0 Contractor Interview Form.": https://docs.google.com/ forms/d/e/1FAIpQLSdqkjs2joY2XVtu89gRu8 PtQ7BU9l21c1IU6pguiPOlmTNiPA/viewform

3. http://www.natethehousewhisperer.com/home-comfort-101.html

4. NEEP: https://neep.org/sites/default/files/resources/ASHP_buyingguide_5.pdf, Department of Energy: https://www.energystar.gov/campaign/heating_cooling/10_tips_hiring, So-Cal Gas: https://www.socalgas.com/save-money-and-energy/energy-saving-tips-tools/hiring-a-contractor, Finding a Contractor, https:// www.youtube.com/watch?v=nQuwkcZP-dLY, and https://docs.google.com/forms/d/e/1F AIpQLSdqkjs2joY2XVtu-89gRu8PtQ7BU9l21c 1IU6pguiPOlmTNi-PA/viewform

5. https://neep.org/guide-sizing-selecting-ashps-cold-climates and

6. https://ashp.neep.org/

7. Watch two entertaining videos to learn more about heat pumps: "Heat Pumps: The Future of Home Heating" and "The Future of Heat Pumps is Underground (and other places, too!): https://www.youtube.com/watch?v=7J52mDjZzto and https://www.youtube.com/watch?v=7zrx-b2sLUs

8. From https://www.switchison.org/how-it-works

9. For example, The Heat Pump Store in Portland, Oregon provides this service: https://www.theheatpumpstore.com/diy-with-assistance/

10. "One ton" of cooling capacity, historically, referred to the amount of heat energy absorbed in the melting of one ton of ice over 24 hours, which is 288,000 British Thermal Units (BTU), or 12,000 BTU/hour. From https://inspectapedia.com/heat/Tons-Cooling-Capacity.php

11. https://www.heatpumpshq.com/heat-pump-sizing.html

12. https://en.wikipedia.org/wiki/Inverter_compressor

13. https://www.youtube.com/watch?v=b-7cghS1G_Wc

14. https://www.masscec.com/ blog/2021/09/13/masscec-pilot-showcases-success-whole-home-heat-pumps

15. https://homeguide.com/costs/heat-pump-cost