ELECTRIC HOME CHEAT SHEET

INTRODUCTION

This guide contains background information for converting homes in the northern US to be all-electric. All-electric homes and buildings are key to combat global warming. Even though most electricity generation is currently from fossil fuels, we cannot wait until the grid is completely converted, if we want to avoid the most dire effects of climate change.

Being all-electric means not burning oil, gas, or propane in your home. Once you accomplish this, you will have a home that's carbon free, if you also get your electricity from a renewable supplier. Eliminating your home's effect on climate change does not require local generation, such as rooftop solar panels.

One of the advantages of electricity is that solar panels can help offset some of your HVAC, but solar is a topic unto itself, not covered by this guide.

LOW-COST PRELIMINARY STEPS

If you're not quite ready to begin converting your home to be all-electric, there are several preliminary steps that you can take right away to help with climate change. Not only are these steps quick and easy, but they cost very little or nothing at all, and will actually save money right away.

Get an Energy Audit

Many states have arrangements for a free or very low-cost energy assessment. Assessments check for energy safety and efficiency. Plus, the auditor may fill air leaks on-the-spot at no cost, and may bring you free stuff, like energy-saving light bulbs and water-saving shower heads.

If the auditor recommends work such as additional insulation, it's often very heavily subsidized by state governments. Assessments have numerous financial benefits. Some states require that you complete an assessment in order to be eligible for incentives or loan programs. Look for an energy audit program on the home page of your electric utility.

Change Your Electricity to a Renewable Supplier

The biggest and quickest thing that you can do to combat climate change is to change your electricity supplier to one that provides 100% renewable power. Many states require the company that supplies your power be separate from the company that delivers your power. You don't get a choice about the company delivering your power, but you can select the supplier. There is a default supplier, if you don't select one.

For example, in Massachusetts, the government site https://energyswitchma.gov can get you started. https://electricityrates.com/massachusetts/massachusetts-electricity-providers has some ratings on power suppliers.

Power suppliers can be generators themselves, for example wind farms owner/operators, or they can be aggregators, that is, they buy power from a variety of renewable generators. Some localities make it easy to select a green supplier, because they have contracted for a municipality-wide option. In Acton, Massachusetts for example, https://www.masspowerchoice.com/acton offers several community options, including 100% green.

If possible, select a power supplier that uses regional power. As compared with importing green power from elsewhere, regional power is more likely to drive replacement of fossil fuel generation, thus having a greater benefit against climate change.

Renewable electricity is not necessarily more expensive than fossil-fuel generated. Sometimes the difference is a fraction of a cent per kilowatt-hour to a maximum of a few cents. Suppliers offer a large variety of plans with different pricing.

Lower Water Temperature (forced-water boilers)

If you have a forced hot water heating system, the temperature of the water is typically set to a range like 160-180°F. For each 10°F that you reduce the temperature, you can see a 3% reduction in fuel use. That's because the lower water temperature extracts more heat from the burning fuel. It's also a bit quieter – less pipe banging.

Consider reducing the temperature to 140°F, or a range such as 125-145°F. If you also heat domestic (tap) hot water from your boiler, you probably don't want to go lower than 130°F. If you have radiant ceilings or floors, your water temperature is likely already at a lower temperature.

The only disadvantage to making this change is that it will take a bit longer to raise the temperature of your home. So, you might need to change the timing of your set-back thermostats to be a bit earlier. For example, if you lower the temperature of your home overnight, and raise it back up a half hour before you typically wake, you might have to change that to a full hour before you wake. (Smart thermostats make this calculation automatically.)

If you find that your system cannot heat the home on extremely cold days, you can set the temperature back up in 10°F increments. For optimum efficiency, you want the system to operate continuously on the coldest nights of the year.

Not only does lowering the temperature reduce fuel use and save money, but it gets ready for conversion to a heat pump, which operate at lower temperatures – typically around 125°F. When designing a heat pump system, insufficient capacity to transfer enough heat into the home on extremely cold days at lower water temperatures is an important consideration.

Reduce Nozzle Size (oil burner)

If you have an oil-burner furnace or boiler, consider asking the technician to reduce the size of the nozzle, when you get your annual burner service. Nozzles are sized in the gallons-per-hour that they spray oil to burn. Ask the technician to reduce the nozzle by .1gph. So, if you currently have a .95gph nozzle, reduce it to .85.

When it's off, the furnace or boiler continues to lose heat up the chimney, even though it's not creating more heat. Some systems have an automatic damper to lessen this, but heat is still lost. It may seem counter-intuitive, but it's more efficient when it's running more at a lower rate. Ideally, you want the oil burner to run constantly on the coldest nights of the year. If the oil burner is still not running a lot, you can ask the technician to reduce the nozzle size by .1gph again next year.

HEAT PUMPS

Heat pumps move heat from one place to the other, like a refrigerator that moves heat from the inside of the refrigerator to the outside. Because of their huge energy savings, heat pumps are becoming ubiquitous – in domestic hot water heaters, in clothes dryers, for home heating and cooling, etc.

HVAC heat pumps can move heat either way, from the inside the home to the outside for air-conditioning, or from the outside to the inside for heating. The effectiveness of a heat pump is measured with the Coefficient of Performance (COP), which is the amount of energy (heat) moved divided by the amount of energy (electricity) used. If 3 watts of heat can be moved with 1 watt of energy, then the heat pump is operating with a COP of 3.0. A typical home heat pump can have a Seasonal (average) Coefficient of Performance (SCOP) of more than 3.0, which is the equivalent of being more than 300% efficient. COPs greater than 1.0 are possible, because heat pumps only move heat, instead of creating it. Burning fossil fuels can never have a COP greater than 1.0.

Heat pumps come in several varieties:

- Air to air (similar to traditional central air conditioning)
- Air to water (can replace a boiler)
- Water to air (geothermal)
- Water to water (geothermal)

Heat pumps have made fantastic strides in efficiency in the past decade, especially at low temperatures. Heat pumps in northern climates can now pull heat from air colder than -10°F at full rated capacity. They can operate with a COP greater than 2.0 at very low temperatures. Modern heat pumps are variable speed – sometimes called inverter heat pumps. Inverter heat pumps are more efficient, because the variable speed allows them to adapt to the required load without cycling on and off, which also avoids temperature swings. (There second generation Heat Seasonal Performance Factor (HSPF2) comparison rating upcoming. Essentially, it's the number of BTUs a heat pump generates under specific test conditions, per 10kWh of electricity.)

Heat pumps used to require electric resistance auxiliary heat for very cold temperatures, but modern units don't need that. While whole-house systems can still include an electric coil heater, it's often not used, except for emergency backup.

Heat-pump heating is less expensive to operate than oil or propane heat. Although it may currently be more expensive to operate than gas heat, the differences are slight. Because electricity is generated from a variety of sources, prices tend to be more stable than an individual fossil fuel.

Heat pumps do not work in a black-out, but nor do air conditioners or fossil-fuel heating systems. Heat pumps can be serviced by many refrigeration technicians who also service central air conditioning.

Weather and Sizing

In northern North America, heating is the primary consideration when designing an HVAC system – not cooling. For a given area, the ambient temperature warmer than the design temperature 99% of the time, e.g. if it's warmer than 5°F 99% of the time, that's the design temperature.

Heat pumps do not operate efficiently if they only operate intermittently. So, it's important not to oversize the total capacity for your home. Correctly sized capacity may cause the interior temperature to drop a few degrees on the coldest night of the year, but it won't stop. If you're concerned, you can add an electric coil heater to whole-house systems, or add some resistance electric baseboard – just in case. Although resistance heating is expensive to operate, the overall system will operate more efficiently, if it's right-sized.

To make sure that a heat pump will operate efficiently, mostly without the need for a supplemental resistance heater, be sure to select a heat pump that is intended for use in extremely cold weather. Some traditional brands that work well in the southern US, don't have the cold-weather capacity to work up north. Make sure that the specification indicates that the heat pump provides 100% of rated capacity below 0°F, and still operate with a COP of about 2.0 below -10°F. For heating, heat pumps are extremely efficient in the 20-40°F – the most common winter temperatures.

STRATEGY

It no longer makes economic or environmental sense to install fossil-fueled anything. To avoid the most dire effects of climate change, anything installed now, would need to be replaced again before the end of its useful life. If you are building something new, it makes the most economic sense to go with electric power. There are two practical implications of this:

- If you are building a new structure, like an addition or new home, go with all electric from the start. An upgrade later is more expensive than an initial install.
- If something breaks, replace it with an electric replacement. So, if your gas water heater, clothes dryer, range/cooktop, etc. needs to be replaced, replace it with an electric model. The money that you would have put into a fossil fuel replacement, can be leveraged to help you get closer to net zero.

To develop a strategy, you need to decide how far and how quickly you want to proceed. For example:

- Do you want to move to a whole-house heat pump soon, or go with a partial solution that leaves your existing heating system in place?
- How soon will you be getting electric cars that will need a place to charge?
- How long will you be in your home (noting an all-electric home is likely to be a sales advantage)? A decade from now no one is going to be seeking homes that burn fossil fuels.

Financing with Rebates and Incentives

Be sure to check out the rebates and incentives offered by your state. In addition to cash incentives, some states have low or no interest loans allowing you to spread the costs over years. For example, in Massachusetts:

- https://www.masssave.com/saving/residential-rebates lists the rebates and incentives.
- https://www.masssave.com/saving/residential-rebates/heat-loan-program has information about the loan programs.

It may be possible to get a zero-interest loan to finance the remainder of the system after government incentives, which would mean very little cash outlay up front.

When your project is completed, it's very important to get the paperwork required to apply for rebates and incentives from your contractor. Typically, you will need a paid-in-full receipt listing the model and serial numbers from all the installed equipment, plus an AHRI Certificate showing the efficiency ratings of the installed equipment. Sometimes rebates are time-limited, so don't delay submitting your application!

Retrofit Design Alternatives

For existing homes, the layout of the home, the condition and capacity of existing ductwork or baseboard, etc., cause every situation to be unique. Sometime hybrid situations work best, for example, use ductless systems on the first floor, where space is more open and it would be difficult to run ducts, and then adding ducts through the attic to the second floor, where individual rooms make a ductless system impractical.

If you don't currently have air conditioning, another important consideration is whether you want to add it, and whether you want to add central air-conditioning or only air condition certain areas.

It's important to select a contractor that is responsive, and with whom you feel comfortable discussing design alternatives.

Auxiliary and Emergency Heater

Auxiliary and emergency heaters are separate concepts, but are often provided by the same electric resistance coil or similar. Resistance heaters can be part of a whole-house system, but not stand-alone mini-splits.

An auxiliary heater provides assistance to the heat pump, when the heat pump is slow to increase temperature, or falls behind in bitter cold weather. The auxiliary heater is sometimes called heating stages, where the primary stage is the heat pump and the secondary stage is resistance heater.

Since the electric resistance heater is expensive to operate, you'll want to be conscious of how often it runs. In some situations, it can be shut off at the thermostat, or disabled at the unit. Without the auxiliary heater, the temperature of the home may drop slightly on the coldest nights of the year. There are different algorithms for when auxiliary heat mixes in, e.g.

- When the system runs continuously for too long (What is too long may be fixed, settable, or algorithmically determined.);
- When the inside temperature falls a few degrees below the set point;
- When the outdoor temperature drops below a specific temperature.

The emergency heater provides replacement heat, if the heat pump is not operating properly. Modern heat pumps are extremely reliable. Still, it's good to have some backup, especially in areas that have sustained periods of sub-freezing temperatures. In general, there are two ways to achieve redundancy:

- Use multiple heat pumps. For example, you may have a whole-house heat pump with a mini-split in one area, or you may have ductless mini-splits on the first floor, and a ducted system on the second floor.
- Use an electric resistance emergency heater as part of a whole-house system. As stated previously, modern heat pumps designed for cold climates often do not require an auxiliary electric resistance heater. However, including an electric resistance coil in a whole-house system provides emergency heat, just in case. Often emergency heat is enabled manually, on the controller or thermostat.

Just to confuse things, the terminology isn't consistent. Some thermostats call auxiliary heat Boost Mode and emergency heat Aux Mode.

Be careful not to enable the aux or emergency heater by mistake. Since it's less efficient, you don't want to be surprised by a large electric bill. There are often several ways to turn on the aux or emergency heater, making it ridiculously easy to turn it on accidently:

- There is usually a button to always use the emergency heater, when heating. This should normally be off.

- There can be a setting to reverse the primary/secondary heat source. Make sure that the heat pump is primary and the aux heater is secondary.
- Aux heating setting can be misconfigured. If properly configured, it can be left enable to only operate when needed. Be sure to understand the optimum settings.

Resistance heating is not typically needed for modern heat pumps, unless you want backup for a single ducted heat pump. If you do get resistance heating, usually the smallest available unit will suffice.

Thermostats and Controllers

Mini-spilt systems include a thermostat controller as part of the indoor unit, but multiple mini-splits can be controlled with a common external controller. Whole-house heat pumps often come with a dedicated controller, which often serves as the thermostat. To make sure that you understand the operation, review the controller with your contractor after installation.

Systems that have their own controller can usually support a traditional thermostat, but it's best to use the controller. Dedicated controllers communicate with both the indoor and outdoor units for optimum efficiency – especially inverter (variable speed) heat pumps. Plus, controllers often have monitoring and diagnostic features, in case problems come up down the line. Sometimes, the settings and diagnostics are done from a separate panel.

Controllers for whole-house heat pumps will have many settings related to configuration and operation. Since controllers and their many settings are constantly evolving, it's often difficult for even the contractors to keep up. When the heat pump installation is finished, it's essential and that the contractor review all the settings to assure that they are properly set for your installation. Also make sure that you receive complete documentation.

If a heat pump system doesn't come with its own controller, you'll want to make sure that you have smart thermostats that understand heat pumps, auxiliary heat, emergency heat, set-back schedules, and remote access. There are good choices from companies that do not share your data.

Whether you use a controller or thermostat, consider having on-line access. You will be able to control the system and check the temperature of your home when you're away. Many systems require a separate Wi-Fi module for connectivity. If remote access is important to you, be sure to ask about connectivity, when you're designing the system with the contractor.

Temperature Control

You should avoid manually futzing too much with the temperature setting on the controller. If you change it more than a degree or two, you can make the system waste energy, as it works harder to raise the temperature. If you want to set back the temperature overnight, it's best to use the timer settings that are part of the controller, rather than to manually change the thermostat.

With a whole-house heat pump, it will definitely cost more to raise the temperature back up after a set-back, if an auxiliary heater kicks in. To assure that auxiliary heat does not come into play, you might want to limit the set-back to just 2-3 degrees. However, if you know that auxiliary heat won't come on, you could set back 4-5 degrees. Set-back schedules larger than that offer diminishing returns.

Reducing the temperature, while you're away on vacation is fine. Also, hydronics system with traditional thermostats work better with set-backs, than air-to-air heat pumps.

For optimal efficiency, avoid using auto mode that switches between heating and air-conditioning. Use heat mode in the winter, and cool mode or dry mode in the summer. Using auto fan-speed mode is best all the time.

Oddities of Set-backs with Heat Pumps

If you're used to turning up the heat, when someone is in a room, then turning it back down, when they leave, you're going to need to develop new habits for heat pumps. The difference with heat pumps is that the efficiency varies a lot, depending on the ambient temperature, e.g. the efficiency of a typical air-to-air heat pump might be 400% at 40F and 200% at 5F.

Let's say that you typically turn up the heat, when you move to the family room after dinner to watch TV. With a heat pump, that's likely going to make your energy bill higher – not lower. That's because you'd be turning up the heat just as the outside temperatures are falling. So, the heat pump is not only going to have to work harder to catch up, because you turned up the temperature. It's also going to have to work harder, because the outside temperature is lower.

The bottom line is that if you want to set back the temperature overnight several degrees, when it's colder outside, that's fine. But, it doesn't make sense to turn down the temperature during the day. If you're going to set back, you should turn up the temperature as late in the morning as is practical for you, and turn it down by several degrees, when you got to bed. However, you can skip the setbacks, and just set the temperature and leave it.

Choosing a Whole-House System

If you want to convert your whole-house HVAC, there is no need to keep around your old system for backup. Only systems that are not appropriate for northern climates, require backup. There are several different approaches.

- If you already have ductwork in your home, a ducted mini-split heat pump is likely the best choice, as long as the ductwork is in good shape.
- If your home is currently heated by water, but you want to add central air conditioning, it's likely best to add ductwork or indoor units to your home, even if you have to abandon the existing baseboard. A plumber could cut the pipes to the old baseboard, so that you could remove them the next time that you paint each room. Or, you could have the baseboard removed as part of the project.
- If ductwork is not easily added to your home, you should consider mini-splits with multiple indoor units. Note that it's often the case the different solutions are used on different floors in the home.
- If mini-split wall or console units aren't practical, and central air conditioning isn't required, an air-to-water heat pump may be the easiest choice, even though it's more expensive than air-to-air. An air-to-water heat pump can support wall-mounted cooling units in specific areas of your home.

Each are discussed in more detail later.

Making Safe the Old Fuel

When you get an oil burner heating system removed, it's a good idea to include the removal and making-safe the oil tank as part of the job.

When the final use of gas is removed, have the plumber disconnect the home pipe from the meter. Then you'll need to call the gas company to get the meter removed, which is usually an easy process. However, they may need to come back at a later time to shut off the gas at the street and remove the regulator and meter bracket at your home. The dead gas line from the street will likely remain in the ground.

ELECTRIC SERVICE

As part of home electrification, you'll be wiring new things into your electric panel. Depending on what you intend to stall, you may have to upgrade your panel or electric service. The big breaker at the top of your electric panel will have an amperage rating for your service, typically 100, 200, or 400.

- If you currently have 100/150A service, you will very likely need to upgrade.
- If you have 200A service, you're likely OK. 200A service is usually enough for a whole-house heat pump, plus a single Level 2 electric car charger. If you need multiple heat pumps or multiple Level 2 car chargers, you might need 320/400A service, but it depends on what you currently have.
- If you already have 320/400A service, you won't need to upgrade.

A second consideration is how many free slots you have in your panel for additional circuit breakers, noting that most electric-conversion items are 230V, requiring two slots. If your panel is short just a small number of slots, the electrician may be able to free up a couple slots by using double-breakers for some of the lighter circuits. If you need additional slots and your service is not overloaded amperage-wise, an electrician can put in a secondar subpanel. The subpanel can be located next to the original panel, or close to where the HVAC or car charger connections are going to be.

Obviously, you'll need to consult with an electrician, but here are some general guidelines:

- If you have 200A service, and you are only going to be adding a couple things, for example an HVAC heat pump and a car charger, you probably don't need to upgrade your service or panel. You may need to add a sub panel, if you don't have enough room in the main panel.
- If you have a particularly large house and you plan to add multiple car chargers, you may need to upgrade to 320/400A service, and also upgrade to a panel that is large enough to accommodate future needs. (If you're starting with 100A service, consider upgrading directly to 320/400A. If you upgrade to 200A and then to 320/400A later, you'll pay twice.)

Other notes:

- If you are tight on amperage capacity, you can install NEMA 14-30 outlets for a 20-30A Level 2 car charger, instead of a NEMA 14-50 outlet for a 40-50A Level 2 charger. Your car will still completely charge overnight.

- If you replace a conventional electric water heater with a heat-pump model (You can get some models that do not have electric resistance backup), or replace a conventional electric dryer with a heat-pump condensing model, the new heat-pump appliances will have a significantly lower electricity usage than the conventional models.

The list below can help you figure out how many additional circuit breaker slots that you'll need for your electric conversions. Note that upgrading from an existing electric hot water heater, electric dryer, or central air conditioning does not require additional panel capacity.

- +4 (30-50A)x2 for upgrading a fossil fuel boiler/furnace to a whole-house heat pump, including electric resistance coil
- +2 (20-30A) for each supplemental mini-split heat pump
- +2 (20-50A) for each Level 2 electric car charger
- +2 (20-30A) for upgrading a gas dryer to electric
- +2 (30-50A) for upgrading a gas stove/oven/range to electric
- +2 (20-30A) for upgrading a gas water heater to electric

The electrical work can cost hundreds to thousands of dollars, depending on what's required. It's easier if you can include the electrical work as part of the heat pump contract, but be sure to consider capacity for everything.

Finally, if you bring in an electrician for one thing, consider prepping for future changes at the same time. For example, if you are replacing a gas water heater with electric, you can ask the electrician to install outlets near your gas range/cooktop and gas clothes dryer. Plus, don't forget plugs where you park for Level 2 car chargers. When you go to upgrade later, the process will be much quicker and less costly.

PARTIAL SOLUTION

If converting your whole-house HVAC system to a heat pump is too much to consider logistically or financially, you and make a significant impact with a partial solution. For example, you can add one or two mini-split units, leaving your existing heating system in place for the very coldest times. If you rely mostly on the mini-splits, your old heating system will rarely be used.

Ductless mini-splits have an outside compressor unit and an interior wall-mounted ventilation unit – thus the split. The outdoor and indoor units are connected by refrigeration lines – thus the ductless. The indoor units come with a remote control.

They are highly flexible with regard to air movement. Mini-splits provide both heating and cooling.

Some mini-splits allow multiple indoor units for a single outdoor unit. Installed mini-split units cost $5K+, before rebates or incentives, and not including electrical work, if required.

If you have a large mini-split in one spot, the heat in the home may be uneven – like a central wood stove. That's fine for some people. If you actually have a wood stove, locate the mini-split on the other side of the home. To completely remove fossil fuels from your home, you can add a small amount of electric resistance baseboard for limited use in bedrooms or other remote rooms with closed doors.

Be careful if your heat pump is so good that you almost never use your old heating system. If your old system is forced-water, rarely used pipes may freeze. For oil heat, the contents of the tank may jell over time. Monitor your old system closely the first winter, and if it's really not needed, remove it next summer, possibly adding some resistance electric baseboard for supplemental comfort.

REPLACEMENT WITH (MOSTLY) "DUCTLESS"

Mini-split heat pumps provide a revolutionary approach to home HVAC. They use components, assembled into a complete solution in an a la carte fashion.

The outdoor (compressor) units in systems support 1-4 indoor units. The indoor units include the normal wall-mounted style of a mini-split, but also low-wall console units, ceiling units, etc. Ductless interior and outdoor units are connected by refrigerant lines. The heating and cooling is immediate and direct.

Interior air-handlers are available, allowing them to be ducted as well. In addition to whole-house air handlers, which are used for conversion of force-air systems, there are air handlers that can be placed in an attic or even inside ducts. Refrigerant is run to the air handler, and then conditioned air goes from the air handler through ducts to room grates.

Using a ductless system for a two-story home for example, there could be wall or console units at several places on the first floor, plus an air handler in the attic to service the second story rooms through ducts. Multiple first floor wall units could share one exterior heat pump, and the second floor could use another. There are endless combinations to adapt to the unique situations in existing homes.

Fewer units can cause temperature variations from one part of the home to another, like with a wood stove. Sometimes bypass fans are used to even the temperature between rooms with closed doors. Each unit can be separately controlled, or the controllers can be wired together for common control.

The big advantage that (mostly) ductless system have is price. Installing ductwork in forced-air systems and plumbing in forced-water systems is labor intensive. The amount of labor required is usually the biggest cost driver.

Bathrooms are way too small to have their own indoor unit. To make sure that they are warm enough, use an overhead light/fan/heater combo, or add a bit of electric baseboard.

CONVERSION OF FORCED-AIR SYSTEM

If your home already has air ducts for heating and/or central air conditioning, the conversion to use a heat pump instead is often straightforward. The fossil fuel furnace, plus any central air conditioning, can be replaced by a single heat pump, which will provide both heating and cooling.

A technician will need to confirm that the existing ductwork is sufficient for the heat pump. Zones in existing ducts can complicate matters. There will usually be some sheet-metal changes required around the heat exchanger. The heat exchanger may contain an electric resistance coil for backup. Typically, the coil can be shut off, if not desired.

Some whole-house air-to-air heat pumps use a special thermostat controller, which communicates directly with the compressor unit. The compressor unit uses temperature differentials to operate most efficiently.

Conversion of a forced-air system to a heat pump can cost $20-25K+, before rebates and incentives. Significant electrical work may add to the cost. Alternatively, forced-air systems can use hydronics (See below.) by using the heated or cooled water in the heat exchanger. Hydronics systems can be more expensive, but can help provide domestic hot water.

CONVERSION OF FORCED-WATER HEATING

Hydronics

In recent years, air-to-water heat pumps, a.k.a. hydronics, have made the conversion of a forced-water heating system to a heat pump possible. Hydronics systems heat or cool water in a self-contained outdoor unit. Then, that water is plumbed into the home. The is no refrigerant in the home. In addition to forced-water conversions, hydronics systems are a very good choice for new construction, because the plumbing is easy to route and doesn't take as much room as ducts.

For forced water systems, heated water is pumped through the radiators to heat the home. While existing water radiators can work with an air-to-water heat pump, steam radiators may not be compatible. Typically, the hot water accumulates in a buffer tank to raise the temperature by passing it through the heat pump multiple times. The buffer tank also can contain electric resistance heating elements to provide backup heat, which is rarely needed.

Unlike ducted systems, conversion of a boiler to a heat pump works better if the existing system has multiple zones. The conversion can cost $40K+, before rebates and incentives, and not including any electrical work.

Supplementing Existing Radiators

The hot water from hydronics systems is not as hot as from a fossil fuel boiler. Radiant ceilings or floors will be OK, but in some rooms traditional radiators or baseboard may not be sufficient to keep the room warm. Normally it's fine, but if there is a room which was typically cool with the fossil fuel boiler, it can be even cooler with a hydronics system. There are two ways to address this:

- Some radiators or baseboard in cool rooms can be replaced with higher efficiency radiators or radiant panels.
- A mini-split system can be added to the cool room. Not only does this provide supplemental heat to the cool room, but it also provides air conditioning in the summer. The mini-split system can be sized to handle an adjacent room as well.

Hot Water Boost

Heat from the hydronics system can be used to help heat domestic hot water, even during air-conditioning season. This can be somewhat cheaper to install and operate than a stand-alone heat-pump water heater.

Using the hydronics system for hot water boost in this way is especially advantageous if there is no basement or other appropriate location for a stand-alone heat-pump water heater. (See below.)

Air Conditioning

Air-to-water heat pumps can provide cool water for air conditioning, when used in a forced-air system. However, baseboard radiators in a forced-water system cannot be used for cooling. Instead, the water can be plumbed to an air handler, and then ducted to the rooms.

Alternatively, wall-mounted ventilation units are available, which use the conditioned hydronics water supply to provide air conditioning and heating. The indoor units look similar to the indoor unit of a mini-split system. If supplemental air-conditioning is desired, the interior hydronics units can be less expensive than adding mini-splits for cooling.

As with mini-split components discussed above, the design of a hydronics system is very flexible. It just uses water to move the heating/cooling around instead of refrigerant.

GEOTHERMAL

Geothermal (water-sourced) obtain heat and cold from the ground. A fluid is pumped thorough the ground and up to the heat pump. Because the ground temperature is stable, geothermal heat pumps are usually more efficient than air-sourced with SCOPs of about 4.0 as opposed to 3.0 for air-sourced.

The pipes in the ground can be vertical (drilled) or horizontal, but in either case outside land area is required. The heat pump compressor is usually located in the basement of the home. Sometimes the refrigerant from a geothermal heat pump is routed directly to an air handler, but that's less common. Usually, the output from the heat pump goes into water, so that it can be used in various ways for heating, cooling, and hot water, like other hydronics systems. (See above.)

At $60K+, geothermal systems are much more expensive to install, because you have to drill wells or lay pipe in the ground. So, they are often not cost-effective for single-family homes. However, there is a 30% federal tax credit for geothermal system, which can make them cost-effective if there is significant plumbing, ductwork, or other installation expense.

Geothermal systems are advantageous if outdoor aesthetics are important, for example in an historic district, because there is nothing visible above ground outside. Geothermal systems can often be better multi-family dwellings or other large buildings. Not only can geothermal be more cost-effective for larger buildings, but they can be more practical, when large air-sourced systems require a large area for outdoor heat exchangers.

APPLIANCES AND OTHER NON-HVAC ELECTRIFICATION

Domestic Hot Water Heater

Heat pump water heaters are much less expensive to operate than conventional electric, propane, or fossil gas water heaters. However, they are expensive to install, especially if converting from gas, when the electrical wiring must be added. Make sure that the size of the heat pump water heater qualifies for any incentives that your state may have.

Most heat-pump water heaters have resistance electric backup elements. These can be shut off, if not desired.

Heat-pump water heaters take heat from the environment that they are in, i.e. they cool the environment that they are in. The best place for a heat-pump water-heater is in the basement, where heat is convected from the underground walls. It is inherently less efficient to locate the heat-pump water heater in a heated space.

If the basement space is heated, it's OK, because much of the heat will still come from the underground walls. It helps to keep the heating thermostat low, when the basement is not occupied.

If the hot water heater is located in a closet, or other space in the living area of the home, a conventional electric water heater is more appropriate. Alternatively, there are water heaters with remote fins that can be mounted on an outside wall. Or, hydronics system can heat domestic hot water too.

Clothes Dryer

A clothes dryer can be one of the biggest energy consumers in your home. The most efficient clothes dryers have a heat pump, as a replacement for, or in addition to, electric resistance heating. They use the cooling side of the heat pump to condense out the water, and to return the air closer to its original temperature. Be careful, because not all condensing dryers are heat-pump dryers. Heat pump dryers consume less than half the energy of a conventional resistance electric dryer.

Condensing dryers don't have to be vented to the outside, which means they can be located in the center of the home. Usually, they are connected to a drain – the same drain that the washer uses or a nearby sink or floor drain. When you're looking at specific heat pump dryers, make sure that their drain specifications will work with the drain that you have. If you don't have access to a drain, select a heat pump dryer with a removable water tank that you can empty every couple of loads.

Heat pump dryers come in smaller European-sized models, and larger North American-sized models. The

North American-sized models often include optional resistance heating. Heat pump dryers cost more to buy, but cost much less to operate. , They plug into a conventional 230V dryer outlet.

Be sure to check for rebates or incentives on appliances from your state or electric utility.

Range/cooktop

The best electric ranges are induction cooktops. They heat the pan directly with magnetism, while the surface only gets warm. Cooks like them, because they heat amazingly quickly, and you can reduce the heat instantly.

However, induction cooktops only work with cookware that is flat-bottomed and has sufficient iron to attract a magnet. You can test your cookware with a refrigerator magnet. If it's not attracted, you need to replace that item to use an induction cooktop.

Induction cooktops are 15% more efficient than conventional electric ranges. However, conventional electric ranges are much faster and twice as efficient as gas stoves, which are better at heating the air than the pan. The important thing is to get an electric range, either induction or conventional.

Outdoor Tools

Battery operated lawn mowers, leaf blowers, string trimmers, etc. are just as good or better than their gasoline equivalents, and they are competitively priced. In addition to not adding greenhouse gases to the atmosphere, they are quiet and don't spew smoke for you to inhale.

If you have 2 batteries and a fast charger, the spare battery will charge about as fast as the battery that you're using discharges, so the tool can be used continuously. You should consider a tool brand that allows you to share batteries across tools, so that you don't have to buy spares for each one.

Tools such as chain saws work acceptably well, but are maybe not quite as good as their gasoline counterparts. They are more convenient to use, however.

Large tools such as snow blowers and riding lawn mowers have advantages over their gasoline counterparts, but consume enough power that the batteries required make them more expensive.

Be sure to check for rebates or incentives on outdoor tools from your state or electric utility.