Electrification, Solar, and Heat Pumps, Oh My!

There is a lot of conversation about electrification, and for good reason. By moving away from burning fossil fuels and towards renewable energy, we can slow and maybe even reverse the effects of climate change. So is now the time to start electrifying our homes? If not now, when? This article will break down electrification as it applies to those who live in the greater St. Louis region. The purpose of this article isn't to tell you what you should do, but rather to give you information and tools to make an educated decision that is right for you.

Electrification

Before we go any further, let's pause and define the term electrification. For this article, electrification will be limited to residential dwelling units and simply means eliminating gas-burning appliances such as stoves/ovens, water heaters, dishwashers, clothes dryers, and furnaces/boilers and replacing them with electric devices. There are a lot of factors that will determine what the best path is for you. So, let's break them down.

Motivations/Priorities

There may be a lot of reasons why someone is thinking about electrification. Folks may want to do it for the environmental benefit. Others may want to eliminate natural gas because they are concerned with adverse health effects, the danger of Carbon Monoxide (CO) poisoning, or fire hazard risks. There are likely a combination of reasons.

Conversely, there may be many reasons to leave a home as it is. For instance, natural gas appliances cost less to operate, some people prefer it for cooking, and changing multiple appliances can quickly become expensive.

As you explore electrification, it is good to understand your reasons to electrify versus not to electrify. Clarity will help you prioritize which options are best for you.

Are electric appliances "greener" than their gas counterparts?

The answer is, "it depends." For people who live in the greater St Louis region in the mid- to late-2020s, gas can be cleaner and less expensive than the equivalent electric appliances. Currently, most electricity still comes from coal-burning power plants[1]. For every unit of electricity used, roughly two units are lost in generation and distribution[2]. Natural gas appliances in your home typically range from 65% to 96% efficient. Furthermore, natural gas emits about 50% less CO^2 than coal.

When we talk about electric appliances there are two main categories. The first is appliances and furnaces that use electric resistance. Think of the little wires in your toaster that get red hot. Those are commonly referred to as "heating elements" (or even just "elements" for short) and they come in many forms depending on the application. There are heating elements in electric furnaces, water heaters, stoves, clothes dryers, hair dryers, dishwashers, etc. These are less expensive and easier

[1] https://www.ameren.com/missouri/company/environment-and-sustainability/integrated-resource-plan
[2] https://www.energy.gov/fecm/transformative-power-systems#:~:text=The%20average%20coal%2Dfired%20power,AI)%20technologies%20within%20existing%20plants.

to install than a comparable natural gas appliance. This is why builders love them. The downside to electric resistance appliances is that they are very expensive to operate compared to natural gas. When we take into consideration our current energy mix, they are more carbon-intensive to operate as well.

The second type of electric appliance uses heat pump technology. These devices move rather than make heat. As a result, they can be very efficient. The type of heat pump that is most common is the Air Source Heat Pump (ASHP). There are also Water Source Heat Pumps and Ground Source Heat Pumps, but those are less common and considerably more expensive to install. For simplicity, this article will focus on ASHPs.

An easy way to compare all these different types of devices is by using the coefficient of performance (COP). In short, this is how much work we get for each unit of energy put in. The COP of an electric resistance device would be 1, for every unit of energy we put in, we get the same out. For a high-efficiency gas appliance that is 96% efficient, the COP would be 0.96. For every unit of energy put in, 4% is lost as exhaust and 96% is turned into useful heat. ASHPs have a COP that typically ranges from 3 – 5 depending on the outside air temperature. However, the COP of electric appliances doesn't take into consideration the losses associated with generation and transmission. When considering these losses, if an ASHP is operating with a COP of 3 it is about equal to a high-efficiency natural gas appliance.

An ASHP is going to be most efficient in the "shoulder seasons," i.e. spring and fall, because the temperatures tend to be milder. During spring and fall, the COP for an ASHP would be closer to 5. During the coldest time of the year, the COP will be closer to 3. During periods of extreme cold, a heat pump typically has backup resistance heat, which as stated above has a COP of 1 or 0.33 after transmission and distribution losses. (Some ASHPs have a backup gas furnace which are called "dual-fuel heat pumps").

To answer the question, are electric appliances cleaner than the equivalent gas appliances, electric resistance appliances are not when we consider the generation and distribution losses. Over a year, an ASHP will likely use less energy and emit less carbon over its useful life than the gas equivalent.

The caveat with ASHPs is they tend to be more expensive to purchase and install. Furthermore, electricity tends to cost more than gas. Thus, while there may be energy savings, there may not be any operational cost savings. Finally, unlike an air conditioner or furnace, an ASHP operates all year. As a result, an ASHP may not last for as many years as an AC unit.

When is the right time to upgrade your equipment?

Most often, equipment is replaced once it fails. The main downside to this approach is there is a rush to get new equipment in as soon as possible. As a result, old equipment is replaced with a newer version of the same thing resulting in a missed opportunity to install equipment that will be more efficient and less harmful to the environment.

The reality is most of us cannot afford to replace all our gas appliances at the same time. Therefore, it is a good plan to identify all the gas-burning appliances in your home. Make a list and evaluate their age and condition. Then make a plan for which appliances you want to replace and when based on their age, condition, and your budget. Planning ensures you make progress towards your goals, allows you time to identify incentives and rebates that may reduce the upfront cost, and helps you realize the savings from more efficient equipment sooner. To learn more about available

incentives, go to dsireusa.org/. Click on your state and you will find a list of federal and state incentives.

If you are planning on replacing a piece of equipment you may want to think about how long that device will last. For example, if we aren't planning to have a clean grid until 2040, most electric appliances, installed today, may reach the end of their useful life just as the grid gets to a place where that equipment could be most beneficial.

Electric Cars

Electric vehicles (EVs) are far more energy efficient than comparable internal combustion engines (ICE). According to fueleconomy.gov, the efficiency of an ICE is at best 30% efficient.[3] Whereas the efficiency of an EV is over 77% efficient.[4] Therefore, even when charging your EV on the conventional electric grid, total emissions are less. To learn more about the life cycle of EVs compared to ICEs check out the International Energy Agency's (IEA) EV lifecycle calculator.[5] Other concerns around EVs are the batteries and what happens at the end of their useful life. EV batteries are over 90% recyclable and the precious metals in the batteries are infinitely recyclable. While this industry is in its infancy, it is a fast-growing market. Furthermore, when EV batteries are no longer suitable for use vehicles, some can be repurposed as backup energy storage for grids and homes.[6]

There are a few downsides to EVs, but perhaps the biggest challenge is the price, followed by range anxiety and gaps in the charging network. Over time, these concerns will lessen as more affordable EVs are released and the charging network expands.

Can our grid even handle electrification?

There is a lot of speculation that our current grid cannot handle mass electrification. To be sure, there is a growing demand on the grid. In addition to electrification, there are many new demands such as electric vehicles and data centers used to power artificial intelligence. So far, utility companies have done a good job keeping up with demand. But there are challenges. For example, the Midcontinent Independent System Operator (MISO) identified a potential generation shortfall for Zone 5 (Missouri).[7] This could lead to the utility companies asking large energy users to switch to backup generators to reduce demand. Fundamentally, a shortage in supply and/or increase in demand results in higher prices.

If electrification seems right for you, concerns over the grid should not be a hindrance. EVs are a flexible load and often charge at night when overall demand is low. Some utilities even see EVs as a potential tool that could help improve grid resiliency.[8] Another consideration is energy efficiency, which is discussed in more detail later.

Solar

There are two main types of solar: solar photovoltaic (PV) and solar collectors. Solar PV is what most people typically think of when they think about solar panels. This is the type of panel that

[3] https://www.fueleconomy.gov/feg/atv.shtml
[4] https://www.fueleconomy.gov/feg/evtech.shtml
[5] https://www.iea.org/data-and-statistics/data-tools/ev-life-cycle-assessment-calculator
[6] https://www.utilitydive.com/news/ev-batteries-repurpose-recycle-grid-storage-microgrid-nrdc/686200/
[7] https://cdn.misoenergy.org/2024%20PRA%20Results%20Posting%2020240425632665.pdf
[8] https://www.nrel.gov/news/program/2023/evs-play-surprising-role-in-supporting-grid-resiliency.html

generates electricity when the sun shines on them. Solar collectors can also be used in residential applications and are typically a part of a solar hot water system. Solar collectors are not very common in cold climates.

Residential solar PV is often located on the roofs of homes and can be a great way to ensure that much of the electricity in your home is renewable. The most significant barrier to solar PV is the large upfront cost of a system. In regions where energy costs tend to be higher, these systems offer a quicker payback. In regions like Missouri, where energy costs are among the lowest in the nation, the payback could be longer than the life of the system. Programs like Solar for All can help reduce the upfront cost by combining your purchasing power with your neighbors.[9] Similarly, a community solar "group buy" program such as Grow Solar[10] is another, typically less expensive, way to purchase solar energy. Both methods allow you and others interested in solar to share the upfront cost of solar.

Alternatives to Electrification

There is a lot we can do for very little to no money that can have a large impact on reducing energy bills and carbon footprint. That's right, we are talking about energy efficiency (EE) and behavior changes! This may not be as exciting as renewable energy and electric cars, but they are the most cost-effective changes you can make and are certainly beneficial to the environment.

Energy efficiency is simply finding ways to do the same work but in a more efficient way. A perfect example is LED lighting. An LED produces the same light but with a fraction of the energy. Other examples of EE include installing storm windows, insulating attics, replacing weather stripping around doors and windows, and more. To learn about other low-cost ways to save energy, visit this link from energystar.gov.[11]

Changing one's behavior is another great way to save energy. For example, choosing to walk or ride a bike instead of driving a few blocks, setting the thermostat down a couple of degrees in the winter, taking shorter showers, and hanging clothes out to dry are just a few examples.

Energy efficiency also pairs well with electrification and renewable energy. When you optimize the energy use of your home, you'll find that you need a much smaller solar array and that you may offset any additional burden electrification may have on the grid.

Conclusion

Hopefully, this article has been helpful and gives a little more perspective on the electrification conversation. The purpose isn't to dissuade you from electrification, but to provide information specific to the St Louis region in the 2020s, that will help you get closer to your environmental goals. To learn about other sustainability topics, visit https://www.ucitymo.org/874/Environment.

[9] https://www.stlouis-mo.gov/government/departments/mayor/news/solar-for-all.cfm
[10] https://www.growsolar.org/
[11] https://www.energystar.gov/products/recent_program_updates/low-no-cost-tips