Electrification and Energy Codes

Background

Because buildings make up almost 40 percent of global greenhouse gas emissions, investing in technologies that decarbonize our building stock can provide a massive opportunity to mitigate the impact of climate change and curb future emissions.

One critical aspect of decarbonization is ensuring all new buildings are prepared to forego fossil fuel combustion equipment and to install electricity-powered equipment, which is often referred to as "electrification" or "building decarbonization". Removing combustion equipment provides many benefits to building occupants such as reducing exposure to harmful pollutants and improving indoor air quality. The concept of electrification is becoming popular in local and state-wide energy codes across the country and will be incorporated into future national model energy codes.

This resource is intended to prepare states for electrifying building codes by sharing the steps to electrification, the components of an all-electric home or building, the challenges associated with electrifying, and national examples of building electrification codes in practice.

Electric "Readiness"

The first step to electrification is becoming "electric ready," meaning that a home or building is wired to accommodate the installation of future electric equipment. This includes having dedicated electric outlets near current water heating, clothes drying, and cooking equipment, as well as having space on an electrical panel to accommodate future loads. Readiness prepares a home or building for further decarbonization by acting as an intermediary between current needs and future electrification. Even if fossil fuel equipment is initially installed in an electric-ready building, wiring it for electric appliances will facilitate the switch in the future. This is important since buildings typically outlast the appliances installed in them by many years, if not decades. Electric readiness also accommodates changes in occupancy and new technologies. Finally, electric readiness offers homeowners protection against costly future electric panel retrofits, which often range from $1,000 to $5,000.[1]

Readiness provisions can also extend to electric vehicle (EV) chargers, renewable energy generation, and on-site energy storage systems. These measures provide additional decarbonization opportunities and can positively impact the transportation sector and electrical grid.

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[1] https://www.energycodes.gov/sites/default/files/2022-02/TechBrief_Factsheet_Electric_Readiness.pdf

The New Building Institute provides model code language for electric readiness for new buildings in Section R404.7 of their Building Decarbonization Code, and has additional model code language for existing buildings in their Existing Building Decarbonization Code.

Beneficial Versus Problematic Electrification

Not all electrification strategies are created equal. "Electrification" can involve installing different types of equipment and technology, not all of which are designed to advance energy efficiency in homes and buildings. For example, electric resistance heating is similar in cost and efficiency to fossil fuel combustion equipment. This resource prioritizes "beneficial electrification", which, according to a June 2018 report from the Regulatory Assistance Project must: *"Achieve one or more of the following goals without adversely affecting the other two: 1. save consumers money, 2. enable better grid management, and 3. reduce negative environmental impacts"*.

Components of a New All-Electric Home or Building

The following is a summary of the components commonly associated with a new all-electric home or building.

Air Source Heat Pumps (ASHPs) for Space Heating and Cooling: Air source heat pumps can be either ducted or ductless systems and can provide both space heating and cooling. "Mini-splits" are a common type of ASHP. These systems operate using electricity instead of fossil fuels[2] such as oil, natural gas or propane. ASHPs can operate efficiently in cold climates and provide a low-carbon alternative to other heating and cooling equipment like furnaces, boilers, and air conditioning.[3] Even the most efficient combustion equipment available on the market doesn't come close to the efficiency of heat pump systems.[4]

ASHPs should be properly sized to ensure that energy isn't being wasted by an oversized or undersized system. Proper sizing and selection of systems improves performance, comfort, and energy efficiency. According to data published by the U.S. Energy Information Administration in the 2020 Residential Energy Consumption Survey, heat pumps represent approximately 4.7 percent of the space heating load in the Northeast,[5] but are likely to become more appealing to the market as consumer and

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[2] There are also dual fuel systems that use electric and natural gas furnaces below a certain temperature, but this is referring to an all-electric ASHP systems

[3] https://www.energypolicy.columbia.edu/wp-content/uploads/2019/12/HeatPump-CGEP_Report_111722.pdf

[4] https://www.pickhvac.com/heat-pump/basics/cop/

[5] https://www.eia.gov/consumption/residential/data/2020/hc/pdf/HC%206.7.pdf

contractor awareness increases, and as energy codes, financial incentives, and other policies embrace decarbonization. Ground source heat pumps, which utilize similar technology, can also provide energy efficient, low-carbon heating and cooling in locations where geothermal energy is viable.

Heat Pump Water Heaters: Electric water heating systems are not all created equal. A heat pump water heater is two to three times more efficient than a conventional electric resistance water heater. Heat pump water heaters are more expensive and cost more to install than conventional water heaters but generally can provide a 20 percent return on investment with a payback of less than five years, and average annual savings of $330.[6] In addition, switching all-electric resistance water heaters to heat pump water heaters could save American consumers $7.8 billion annually in water heating costs, which translates to $182 per household. [7] Energy Star projects that certified heat pump water heaters can save a household of four approximately $550 per year on electric bills and $5,610 over the lifetime of the system, while also saving approximately 3,760 kilowatt hours per year. In addition, they suggest that if all water heaters in the United States were Energy Star-certified heat pump water heaters, there would be approximately 150 billion pounds of prevented annual greenhouse gas emissions, which is equivalent to the emissions of more than 14 million vehicles.[8] In comparison to conventional water heaters using combustion equipment such as natural gas, heat pump water heaters are also much more efficient and don't produce local emissions such as Nitrogen Oxide (NOx)[9]. Heat pump water heaters with grid interactive capabilities-such as demand response controls-can lead to additional savings. New all-electric homes and buildings should include heat pump water heaters whenever feasible to drive efficiency and save money on utility bills.

Electric Clothes Dryers: Electric dryers are usually compared as equals to gas dryers and although they each have benefits, electric dryers are easier to install, cost about $50 to $100 less up-front, and have a longer lifespan.[10] Heat pump dryers, which, according to Energy Star, are 28 percent more energy efficient than standard electric and gas dryers, and don't require ventilation, may present an

[6] https://www.ekotrope.com/blog/why-arent-we-installing-more-heat-pump-water-heaters

[7] https://www.energy.gov/sites/prod/files/2014/01/f7/case_study_hpwh_northeast.pdf

[8] https://www.energystar.gov/products/water_heaters/high_efficiency_electric_storage_water_heaters/benefits_savings

[9] https://www.raponline.org/wp-content/uploads/2023/03/rap-seidman-nox-water-heat-model-rule-tech-support-2023-february.pdf

[10] https://www.angi.com/articles/gas-vs-electric-dryers.htm

even better option. As of 2022, heat pump dryers account for two percent of the market share of dryers in the United States.[11]

Induction Stoves and Cooktops: Induction stoves and cooktops operate differently than traditional electric resistance coils and gas stoves because they operate within an electromagnetic field. As of now, induction stoves and cooktops have higher upfront costs compared to traditional cooking equipment and require certain pots and pans to operate that can also add to the overall cost, but they yield extraordinary benefits for both energy efficiency and health and safety. Induction cooktops are up to three times more energy efficient than gas stoves, and 10 percent more efficient than conventional electric cooking equipment.[12] They also cook faster and can boil water 20-40 percent faster than other equipment.[13] Induction stoves also provide occupant health and safety benefits, because unlike gas stoves, they don't produce harmful chemicals such as nitrous oxide, carbon monoxide, and formaldehyde that could lead to respiratory issues. A recent study has found that 12.7 percent of current childhood asthma rates in the United States are attributed to gas stove use[14].

On-site Renewable Energy or Solar Readiness: Since all-electric homes and buildings use more electricity than mixed fuel homes and buildings, it's important to think about ways to alleviate the costs of utility bills. Installing solar panels or other renewable energy generation systems can reduce electricity costs through net metering, where a home or building owner can sell the energy produced onsite back to the grid and the utility will lower their monthly electricity bills in return.

A common misperception is that some utilities may not accept net metered electricity because too many other homes are already producing enough electricity, and that the current grid can't handle electricity flowing from the home back to the grid. This is a misperception because utilities can invest in energy storage systems that can hold excess energy, which can add more renewable energy to the grid. On-site energy production can also help a home or building become "net zero", where the building produces more energy than it consumes. Solar readiness is also important for those that can't invest in installing solar panels up front but may want to do so in the future. The 2021 International Energy Conservation Code (IECC) has provisions for solar readiness in Appendix CB and Appendix RB.

[11] https://www.familyhandyman.com/article/heat-pump-dryer/

[12] https://www.energystar.gov/partner_resources/brand_owner_resources/spec_dev_effort/2021_residential_induction_cooking_tops

[13] https://www.consumerreports.org/appliances/ranges/guide-to-induction-cooking-a2539860135/

[14] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9819315/

A Dedicated EV Charger or an EV-Ready Parking Space: Buildings aren't the only source of greenhouse gas emissions. The transportation sector makes up 29 percent of total U.S. emissions, which leads consumers to invest in electric vehicles to reduce their personal carbon footprint. The EV market has grown exponentially in the last few years, as a result of reduced costs and greater interest. Equipping new homes and buildings with chargers can have the dual benefit of encouraging future EV purchases and offering an attractive feature to prospective buyers who already own EVs. It also costs about three times less to wire an EV charger during the construction process than it does to install one through a future retrofit.[15]

An On-site Energy Storage System (ESS), or a Dedicated Space and Wiring for a Future System: An on-site energy storage system is essentially a battery that can store the energy produced by a home or building, typically via solar panels. The Tesla Power Wall is a well-known example of an ESS. This system is useful because energy can be used to power a home or building during an outage and can supply energy back to the grid when needed. The more buildings that have ESS, the more resilient communities can become when faced with storms or other natural disasters.

A Properly Sized Electrical Panel That Can Accommodate a Fully Electric Home or Building: The electrical panels of older homes and buildings may not be sized appropriately to service an all-electric one, so panels in newly built homes and buildings must be properly sized to accommodate the additional load needed to power them. The up-front cost of installing a new panel is lower than a subsequent retrofit because it can be done before the walls are finished, so installation takes less time.[16]

Tight Thermal Envelope That Can Support Space Heating Equipment: Although investing in a building's thermal envelope isn't directly related to electrification, improving the envelope can reduce energy load and costs, as well as improve occupant safety and comfort.[17] Minimized air infiltration and added insulation are important considerations when thinking about the building thermal envelope. For an average US home, even modest weatherization measures can reliably reduce energy use by 12-18 percent and can help the grid by reducing peak electric loads by approximately 7-10 percent. In

[15] https://www.energycodes.gov/sites/default/files/2021-07/TechBrief_EV_Charging_July2021.pdf

[16] https://homeguide.com/costs/cost-to-replace-electrical-panel

[17] https://www.aceee.org/sites/default/files/pdfs/b2201.pdf

addition, residential customers can save between $150 and $1,200 in operational costs per year, with the average home saving $500 to $800 per year.[18]

Challenges and Barriers

Grid Capacity: As more homes embrace electrification, it's important to make sure the electric grid has the capacity to handle additional load necessary to power these homes. New technologies are emerging that reduce the strain on the grid, such as demand responsive controls and on-site energy production and storage. It's also important to recognize that the energy used to power the grid varies by location but comes primarily from fossil fuel sources. Utilities will need to transition to using renewable sources moving forward in the efforts to decarbonize. This brief focuses primarily on the direct impacts of electrifying new buildings but recognizes that steps must also be taken to transition the electric grid away from fossil fuel use as well.

Grid Resilience and Disaster Preparedness: As extreme weather events become more common, it's also important to think about how to protect occupants of all-electric homes during power outages and emergencies since they rely on electricity for space heating, water heating and cooking. It's important to prepare for these challenges ahead of time. Installing emergency back-up generators can support these communities in times of crisis. According to a recent study, building to the latest model energy codes and above code measures like passive house can increase the number of days of safety in a home during an extreme weather event.[19]

Equity: Energy codes only impact existing buildings when a significant change occurs, such as an addition or alteration, so another important consideration is how to electrify our existing building stock when energy codes are not triggered in a way that doesn't add undue burden and costs to vulnerable communities. When installing heat pumps in an existing home, it's important to make sure that the home is properly weatherized to accommodate the new system so that energy isn't being wasted. It's also important to prioritize electrification measures that improve health and safety first – such as replacing a gas stove with an electric one – to make sure that vulnerable communities aren't being left behind in the transition to a clean energy future.

Initial Costs: Perceived higher upfront costs may discourage building professionals from considering electrification in their projects. However, a study from the Rocky Mountain Institute found that an all-

[18] https://www.aceee.org/topic-brief/2023/07/empowering-electrification-through-building-envelope-improvements

[19] https://www.energycodes.gov/sites/default/files/2023-07/Efficiency_for_Building_Resilience_PNNL-32727_Rev1.pdf

electric new single-family home costs less to build and operate than the new mixed-fuel home.[20] Additionally, there is less variability in electricity costs compared to natural gas, propane, and oil as well as a more reliable supply.

There are considerable incentives available to build all-electric homes at both the state and federal level. In Massachusetts, the All-Electric Home Incentive program from Mass Saves provides $15,000 to $25,000 to a single-family home that achieves a certain level of above code energy savings. The Energize Connecticut Residential New Construction All-Electric Home Incentive has a similar program that provides $7,500 to $10,000 to single-family home applicants. The federal Inflation Reduction Act (IRA) also extended the 45L Tax Credit through 2030, which provides $5,000 to a single-family home that achieves the Department of Energy (DOE) Zero Energy Ready Homes Program requirements. Other states and jurisdictions can design similar programs that provide monetary incentives that will expand the number of all-electric homes built.

Split Incentives: Another challenge is how benefits from electrification incentive programs are allocated, where property owners and developers are responsible for electrifying, but renters are the ones who see the changes to their utility bills. This could negatively impact both parties if they are not on the same page. If property owners want to electrify buildings to receive incentives, but don't invest in weatherization, tenants would pay more for electricity bills. On the flip side, if property owners pay upfront cost of electrifying and weatherization, they wouldn't benefit from lower utility bills that are passed on to tenants. It's important to find ways to ensure equitable outcomes that benefit both occupants and property owners when making decisions on incentive programs.

Examples of Electrification in Practice

Several states have already incorporated electrification provisions into their base or stretch energy codes. This section highlights several examples.

Massachusetts currently has two stretch codes, one of which has been adopted by approximately 300 communities, and a new Municipal Opt-In Specialized Code that, as of July 2023, has been adopted by 18 communities representing 18 percent of the state population. The Municipal Opt-In Specialized Code has three pathways to compliance: Zero Energy, All Electric, and Mixed Fuel. If following the Mixed Fuel Pathway, Section RC104.3[21] has requirements for electric readiness for residential

[20] https://rmi.org/insight/the-economics-of-electrifying-buildings-residential-new-construction/

[21] Found on Page 18 of 225 CMR 22: Massachusetts Residential Stretch Energy Code and Municipal Opt-In Specialized Code 2023

buildings, and Section CC106[22] has requirements for electric readiness for commercial buildings, specifically for space and water heating, cooking, and clothes drying. The state has also developed a 10-community Municipal Fossil Fuel Free Building Demonstration Program that bans new fossil fuel hookups. To participate, a community must adopt the Municipal Opt-In Specialized Code without the Mixed Fuel Pathway, requiring, at minimum, all-electric new construction.

California has mandatory electric readiness requirements in its 2022 Building Energy Efficiency Standards. Sections 150.0[23] (n), (s), (t), (u), and (v) require single-family homes to be electric-ready for water heating, energy storage systems, heat pump space heating, electric cooktops, and electric dryers respectively. Section 160.4 (a)[24] requires multifamily buildings to be electric-ready for water heating and Section 160.9[25] requires multifamily buildings to be electric-ready for space heating, cooking and clothes drying.

Colorado developed a Model Electric Ready and Solar Ready Code because of legislation passed in May 2022. Section 104.2.3 of the Model Electric Ready and Solar Ready Code requires electric readiness for wiring for future electric equipment, a designated space on the electric panel for future electric equipment and physical space on site for the installation of a future system.

New York and Rhode Island have decided to skip the 2021 IECC in favor of adopting the 2024 IECC when it becomes available, which is likely to include electrification-ready provisions that are based on a national model code. In the 2024 International Energy Conservation Code (IECC) Residential draft[26] Section R404.5 requires "electric readiness," but these requirements do not extend to space heating. Section R404.6 requires solar readiness, and Section R404.7 requires EV readiness. In the Commercial Draft of the 2024 IECC Section C405.14 requires EV readiness, Section C405.15 requires on-site energy generation, and Section C405.16 requires energy storage system readiness.

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[22] Found on Page 37-39 of 225 CMR 23: Massachusetts Commercial Stretch Energy Code and Municipal Opt-In Specialized Code 2023

[23] Section 150.0 starts on page 307 of the 2022 California Building Energy Efficiency Standards (which is page 323 of PDF)

[24] Section 160.4 starts on Page 397 of the 2022 California Building Energy Standards (which is page 413 of PDF)

[25] Section 160.9 is on Page 418 of the 2022 California Building Energy Efficiency Standards (which is page 434 of PDF)

[26] The 2024 IECC is currently under development and the provisions within the current draft are not finalized and subject to change

Washington has provisions in the Residential 2021 Washington State Energy Code in Section R403.5.7[27] requiring heat pump water heaters and Section R403.13[28] requiring heat pumps for space heating. In the Commercial 2021 Washington State Energy Code, Section C403.1.4[29] requires that *"heating energy shall not be provided by electric resistance or fossil fuel combustion appliances,"* and C404.2.1[30] also requires the use of a heat pump water heater. Each of these requirements include exceptions, but unlike in other state codes, Washington directly requires the use of electric space and water heating equipment, instead of just including readiness provisions. A Ninth Circuit Court decision in California Restaurant Association v. City of Berkeley led the Washington State Building Code Council to delay the implementation of the updated building code for 120 days, which was initially intended to take effect July 1, 2023. On July 18, 2023 a federal judge denied a request from the natural gas industry to vacate the code requirements for heat pumps, which led to a lawsuit being dropped against the adoption of the code, which provided a major victory to the state's ability to keep these provisions in the code.

Conclusion

It is expected that more states will adopt electrification provisions in their energy code in the coming years as funding from the IRA becomes available. In addition to the extension of the 45L Tax Credit for building DOE Zero Energy Ready Homes, Section 50131 of the IRA specifically allocates $670 million to adopting net zero codes, and the first step to achieving net zero is becoming all electric. State incentives can also prioritize building decarbonization and offer additional incentives to new all-electric homes and buildings. This resource presents concrete examples of electrification codes in practice and can serve as a guide for other states that are looking to adopt all-electric building code provisions in the next few years. By examining the steps to achieve electrification, the specific components of new all-electric homes or buildings, and the challenges associated with decarbonization, communities can better understand the opportunities ahead and make more informed decisions when updating their energy code.

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[27] Section R403.5.7 is found on Page RE-34 of the 2021 Washington State Energy Code (which is page 40 of PDF)

[28] Section R403.13 is found on Page RE36-RE37 of the Washington State Energy Code (which is page 42-43 of PDF)

[29] Section C403.1.4 is found on Page CE48-CE50 of the Washington State Energy Code (which is page 54-56 of PDF)

[30] Section C404.2.1 is found on Page CE-116 of the Washington State Energy Code (which is page 122 of PDF)