Managing and Accelerating Electrification in Holy Cross Energy

RMI Analysis for Holy Cross Energy

Updated Analysis Submitted to HCE February 9, 2022

Contents

Executive Summary

Holy Cross Energy (HCE) members and communities have committed to climate action. HCE has responded to members by setting a path to 100% clean electricity by 2030. With decarbonized power on the way, electrification is the next key lever for local climate action.

Electrification involves replacing cars, busses, furnaces, and other fossil-fuel burning devices with emissions-free electric devices. Not only will electrification reduce greenhouse gas pollution – electrification can also save households money, reduce health-impacting air pollution, and support local jobs.

Electrification will place large new stresses on the electric grid, which must simultaneously grow and decarbonize at the same time. It will also place added responsibility on electric utilities, who will be asked to provide resilient and reliable power for increased load while keeping rates low.

To better plan for future electrification, HCE asked RMI to assess the potential impact of electrification on HCE members, HCE communities, and the HCE electric system. Using local, state, and national datasets, RMI modeled HCE-specific electrification scenarios to inform HCE's planning efforts.

Key Findings for the HCE system:

- **55% of all cars and 60% of home heating systems could be electric by 2035.** This is based on aggressive, but realistic, assumptions about electric-device adoption.
- **Electrification could avoid 300,000 metric tons of greenhouse gas pollution per year by 2035**. For comparison, a typical passenger vehicle emits around 4.6 metric tons per year.
- **Electricity use could increase 30% by 2035**. HCE may need to expand its resource and procurement plans to meet increased demand.
- **Peak demand could increase 47% by 2035**. Demand increase will be greatest in the winter, when cold-weather heat pump demand will add onto EV and other device loads.
- **Demand flexibility and battery storage can meaningfully reduce peak demand.** Effective deployment of these solutions may avoid some costly infrastructure upgrades.
- **Electrification economics are increasingly attractive.** EVs already provide lifetime savings. Heat pumps provide savings compared to AC and furnace replacements for propane users and some natural gas customers.

Key Recommendations for HCE:

1. Work to ensure new load is also flexible
2. Continue to invest in efficiency
3. Prioritize light duty vehicles, but don't forget heat pumps
4. Educate contractors, members, and community partners
5. Work with large users on electrification planning
6. Track, monitor, and inform local, state, and federal policies
7. Monitor geographic dispersion of electrification and consider targeted interventions
8. Continue to invest in system reliability and community energy resilience

I. Electrification Context: Climate, Tech, and Policy

Electrification is a central pillar of decarbonization

Direct burning of petroleum and natural gas in transportation, buildings, and industry dominate US, regional, and Colorado greenhouse gas (GHG) emissions. In 2019, Colorado buildings (28 million metric tons or MMT), industry (21 MMT), and transportation (25 MMT) were responsible for 74 MMT of the state's 120 MMT emissions[i][1]. The City of Aspen greenhouse gas inventory shows buildings, cars, and trucks created 56% of emissions[ii][2]

For most end uses, electrification is the most efficient and least-cost decarbonization option. Wind, solar, and storage are already cost-effective, widely deployed, and reducing electricity emissions[3]. Electric vehicles and heat pumps are viable options today and rapidly improving and decreasing in cost.

Heat pumps and electric vehicles technology advancement is driving consumer adoption

Technology advancement is creating improved electrification options. Battery-storage costs have declined dramatically over the past decade even as performance has improved. This is helping to drive electric vehicle adoption. Similarly heat pumps, in particular low-temperature heat pumps, have improved significantly over the past five years. The key feature for low-temperature heat pump performance has been advanced variable speed inverter-driven compressor technology[iii]. We're beginning to see more homes go all-electric as a result.

National, state, and local policies are accelerating electrification

For years, the most important national electrification-related policy has been tax credits that reduce the upfront costs for electric vehicles. The November 2021 bipartisan infrastructure bill also introduced important new funding for EV charging, electric buses, and enhanced grid flexibility[4].

On the building side of electrification, the federal government provides incentives for heat pumps[5], and federal building weatherization assistance funds have been used to support building electrification. While federal building electrification incentives have been modest historically, several proposals, including the Build Back Better act include higher levels of building electrification support.

Colorado has passed several laws to accelerate electrification. These policies are motivated by 2019's HB 1261 which sets an ambitious goal to reduce statewide emissions 50% by 2030 and 90% by 2050[6].

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[1] Additional Colorado emissions sources include power generation (23%), oil and gas systems (17%), and agriculture (8.7%)

[2] Not including building and transportation emissions from electricity consumption.

[3] Solar PV and wind are now the lowest cost forms of energy (https://www.lazard.com/perspective/levelized-cost-of-energy-levelized-cost-of-storage-and-levelized-cost-of-hydrogen/) and balancing technologies like battery storage, load flexibility, and clean-firm generation are improving

[4] Bipartisan bill included $7.5B for EV charging, $5B for zero-emission school busses, $5.7B for transit busses, and $3B for enhancing grid flexibility.

[5] Currently $300 for a heat pump (https://www.energystar.gov/about/federal_tax_credits/air_source_heat_pumps)

[6] Compared to 2005 levels

Colorado currently provides a $2,500 tax credit for purchases of light duty EVs, and larger credits for medium and heavy duty vehicles. Other programs including *ReCharge Colorado*, *Charge Ahead*, *EV Fast Charging Corridors*, and *DCFC Plazas* are helping expand charging networks across the state.

In 2021, the Colorado assembly passed four bills focused on building electrification and reducing emissions from buildings[7]. Together these bills direct electric and gas utilities to create plans and introduce incentives to drive building electrification and related building decarbonization strategies. For a list of key Colorado electrification-related policies see **Appendix 1**.

II. Understanding Electrification Options

What electrification options are available to consumers?

At its core, Electrification is about consumer decisions on devices that provide critical services. **Table 1** below lists some of the fossil-fuel and electric devices providing these services

Table 1: Fossil-Fuel and Electric Options for Key End Uses

End Use	Fossil-Fuel Device	Electric Device
Transportation	Internal combustion engine (ICE) car, bus, or truck	Electric vehicle (EV)
Space heating	Natural gas furnace; Propane furnace; Natural gas boiler; Propane boiler	Air source heat-pump; Electric resistance heat; Ground source heat-pump
Hot water heating	Tankless natural gas; Natural gas with storage; Tankless propane; Propane with storage	Electric resistance with storage; Heat pump with storage; Electric tankless
Cooking	Gas stove; Propane stove	Electric resistance stove; Induction stove
Space cooling[8]	Commercial gas absorption chiller	Air source heat pump; Central AC; Room (wall) AC; Commercial chiller
Snowmelt systems	Natural gas boiler	Electric boiler

Consumers make decisions not only about which device to use, but also about when to replace devices. Most device replacements occur at the devices end of life (e.g. when a boiler fails). In our analysis, we focus on the end of life device replacement for the most common devices.

How do electric and non-electric options compare?

Consumers consider multiple factors when they replace devices. These factors include:

- Economics, including upfront cost, ongoing costs, and available incentives
- Environmental attributes, especially greenhouse gas emissions
- Services and features of the device

[7] See https://westernresourceadvocates.org/blog/colorado-legislators-pass-four-bills-to-reduce-building-emissions-cut-utility-costs/

[8] Most homes in HCE rely on passive cooling (windows), and almost all space cooling systems are currently electric. AC demand is increasing driven in part by rising temperatures and poor air quality from forest fires.

- Ease of use and installation

To better understand HCE customer options we analyzed the economic- and environmental-performance of fossil- and non-fossil household devices in HCE service territory. Our results are summarized in **Table 2**.

We started by looking at devices that will perform roughly the same throughout HCE service territory (HCE-all). We then looked at HVAC systems whose performance will vary as a function of climate. We modeled performance in the coldest regions of HCE service territory (Aspen/ Vail) and in more temperate areas (Rifle/ Garfield).

Greenhouse Gas Pollution

Our analysis showed that with a few exceptions, replacing a fossil device with an electric device will result in a significant reduction in greenhouse gas pollution.

First we looked at how much greenhouse gas pollution a fossil device would produce in a year. For example, we found that a typical light duty internal combustion engine car would burn 494 gallons of gas each year, producing 4.2 MT of greenhouse gas pollution.

Next, we looked at how much greenhouse gas pollution would be created to generate the electricity needed to run an electric device given today's blend of fossil-fuel and carbon-free electricity generation. Considering light duty vehicles again, we found that an electric vehicle would consume 4,100 kWh annually and indirectly generate 1.6 MT greenhouse gas pollution with HCE's current generation mix. The net impact is a net emissions reduction of 2.6 MT/yr for an electric vehicle (reflected in the table).

Finally we considered emissions if new load were met entirely by zero-carbon resources. Using this approach, we find an EV would reduce GHG pollution by 4.2 MT/yr compared to an internal combustion light duty vehicle (reflected in table).

In almost all instances we find emissions reductions for electric devices compared to fossil devices. This is because electric devices tend to be significantly more efficient compared to fossil-fuel devices. The one exception is for a natural gas boiler compared to an electric boiler in today's grid mix. This is because an electric boiler is only slightly more efficient than a natural gas boiler[9]. In future lower-carbon grid scenarios, all electric devices provide significant emission reductions.

Economics

Our economic analysis considered upfront cost savings, annual savings, and lifetime cost savings for an electric device compared to a fossil device.

Upfront cost savings include federal, state, and HCE rebates and incentives (e.g. $11,500 total incentive for EV from Colorado and federal credits). In most instances we find that highly efficient electric devices tend to cost more upfront compared to equivalent fossil-fuel burning devices.

[9] We modeled a 99% efficient electric boiler and a 95% efficient gas boiler.

To calculate the annual savings, we compared modeled annual energy consumption and maintenance between devices given current gasoline, natural gas, propane, electricity prices, and assumed maintenance schedules.

Our lifetime savings is based on the expected lifetime for a typical device. We did not discount future costs or savings in our analysis. While our analysis focused only on efficient fossil and electric devices, future analysis could also consider less efficient, but lower upfront cost electric devices like resistance stoves, resistance hot water heaters, and resistance baseboard heaters.

Heat Pump Economics

Electric heat pumps are a key technology driving electrification. Heat pumps are highly efficient and provide both heating and cooling services. Because they work by separating hot and cold air streams, heat pumps can be up to 350% efficient. As comparison, an efficient natural gas furnace can be 95% efficient.

Heat pumps currently cost a premium upfront compared to a furnace replacement. If you are replacing a furnace and an air conditioner, the upfront cost gap will close considerably. Including HCE rebates, we found a heat pump costs $6,800 more upfront than a furnace, but $400 less than a furnace plus an AC unit. Heat pump costs are expected to decline over time as the technology matures.

Heat pumps generally provide annual energy savings compared to furnaces, particularly in mild climates. The story is more complicated in HCE territory where heat pumps must function under very cold temperatures. At low temperatures, a heat pumps efficiency declines and approaches 100%.

Accounting for local climates, we found that heat pumps cost less to operate compared to natural gas furnaces in the Rifle/ Garfield area. Heat pumps will cost less to operate than propane furnaces in all parts of HCE service territory.

Future analysis could also consider the economics of all electric new buildings. RMI analysis shows that new all-electric buildings save money compared to buildings that also use natural gas or propane, even in cold climates.

For more details on modeling assumptions, see Appendix 2.

Table 2: Economic and Emissions Comparison of Select Fossil and Electric Devices[10]

	Service	Fossil Device Replacement	Electric Device Substitution	Upfront Savings (cost)*	Annual Savings (Cost)*	Lifetime Savings*	GHG Reduction (MT/yr) (current grid)	GHG Reduction (MT/yr) (clean grid)
HCE-All	Residential transportation	Light duty vehicle: Internal Combustion	Electric light duty vehicle	($679)	$1,618	$18,736	2.6	4.2
HCE-All	Residential hot water	Natural gas storage hot water	Electric heat pump hot water with storage	($499)	$42	$130	0.2	0.5
HCE-All	Residential cooking	Natural gas stove	Electric induction stove	($986)	($0)	($992)	0.0	0.1
Aspen/ Vail	Residential space heat	Natural Gas Furnace	Air source heat pump (heat)	($6,844)	($30)	($7,298)	0.1	1.2
Aspen/ Vail	Residential space heat	Propane Furnace	Air source heat pump (heat)	($6,694)	$258	($2,831)	0.3	1.5
Aspen/ Vail	Residential space heat	Natural Gas Boiler	Electric Boiler	$3,562	($412)	($2,616)	-1.3	1.2
Aspen/ Vail	Residential space heating and cooling	Natural Gas Furnace + AC Unit	Air source heat pump (heat and cool)	$402	($30)	($52)	0.1	1.3
Aspen/ Vail	Residential space heating and cooling	Propane Furnace + AC Unit	Air source heat pump (heat and cool)	$552	$258	$4,415	0.3	1.5
Rifle/ Garfield	Residential space heat	Natural Gas Furnace	Air source heat pump (heat)	($6,844)	$6	($6,757)	0.2	1.0
Rifle/ Garfield	Residential space heat	Propane Furnace	Air source heat pump (heat)	($6,694)	$239	($3,108)	0.4	1.2
Rifle/ Garfield	Residential space heat	Natural Gas Boiler	Electric Boiler	$3,562	($334)	($1,444)	-1.1	1.0
Rifle/ Garfield	Residential space heating and cooling	Natural Gas Furnace + AC Unit	Air source heat pump (heat and cool)	$402	$6	$489	0.2	1.1
Rifle/ Garfield	Residential space heating and cooling	Propane Furnace + AC Unit	Air source heat pump (heat and cool)	$552	$239	$4,138	0.4	1.3

Key for Colors in Chart

Electric cost 20%+ higher; Emissions increase 20%+	Electric costs 10-20% higher	Electric cost 10% higher to 10% lower	Electric saves 10-20%; Emissions reduction 10-20%	Electric saves 20%+; Emission Reduction 20%+

[10] Upfront costs include device and install costs. Annual building energy use based on NREL ResStock tool for typical 1760 sq ft building in HCE region.

What are the benefits and barriers to electric device adoption?

Dollars and emissions are only part of the story – consumer decisions are also shaped by the comparative services of electric and non-electric devices as well as the ease of adopting the device. **Table 3** below summarizes benefits and barriers to adoption of key electric devices.

Table 3: Benefits and Barriers to Electric Device Adoption

Service	Electric Device	Benefits	Barriers to Adoption
Residential transportation	Electric light duty vehicle (cars and trucks)	- Quick acceleration and high performance - Less maintenance required	- Range declines at low temperatures - Charger access, especially for multi-family homes and renters - May need to upgrade electric panel to install fast charger
Commercial transportation	Electric fleet vehicle	- Decrease total cost of ownership[11] - Opportunity to flexibly charge overnight	- Energy costs may spike on current commercial rate with demand charges
Space heat and cooling	Air source heat pump	- Provides summer air conditioning and winter heating - Modern cold-climate heat pumps operate down to -15°F - Propane customers no longer need to manage delivery and storage - ~2-3X more efficient than furnaces	- May require electric panel upgrade - Supplemental backup power from electric resistance or furnace needed for coldest days - Not all contractors are familiar with heat pump design and installation - Exit air temperature may be lower temperature than for furnace - Need to removing existing gas and duct infrastructure at install
Hot water heating (residential and commercial)	Heat pump water heater	- 2-3X more efficient than gas or electric resistance water heat - Hot water storage can act as a battery for the grid - Can reduce upfront cost with electric resistance hot water heater	- Not all contractors are familiar with hot water heat pump design and installation - Large residential systems may require 3-phase power connection - Additional space needed for large storage tanks - Decreased efficiency on coldest days
Cooking (residential and commercial)	Induction stove	- Eliminate indoor air pollution from gas or propane combustion - Deliver 80% energy to the food in the pan vs 38% for gas - Can reduce upfront cost with electric coil stove	- High demand from induction stove could trigger electric panel upgrade, especially when combined with other electrification upgrades - Higher upfront cost than electric coil, gas, or propane stoves

[11] Analysis shows costs will decrease under volumetric rate (.105$/kwh). Cost impact may be different if business has a significant demand charge. Fleet owners should work with utility to get on the best rate design.

III. Electrification's Impact on the Holy Cross Energy System

In this section, we share our findings of the potential for electrification impacts on Holy Cross's grid. **Appendix 3** provides a detailed explanation of our analytic approach. Briefly, we:

- Assumed electrification adoption rates for each end use based on the Colorado Greenhouse Gas Roadmap and conversations with HCE staff.
- Used a stock rollover model to calculate how the adoption rates increased the fraction of in-use devices that are electric
- Calculated the hourly and annual load from each electrified end use, using the stock rollover outputs and hourly demand profiles from NREL and the RMI mobility team

Stock rollover models calculate how new sales translate into devices in the real world. Because most end use devices are used for many years, even if electric devices sales dominate, it can take a long time for stocks to shift. As an example, in Figure 1, we show light duty vehicle sales and the resulting stocks. In 2035, EV sales are close to 100% but EV stocks are 55%. We use unique stock rollover models, with different adoption rate assumptions and different device lifetimes, for each of the key end uses.

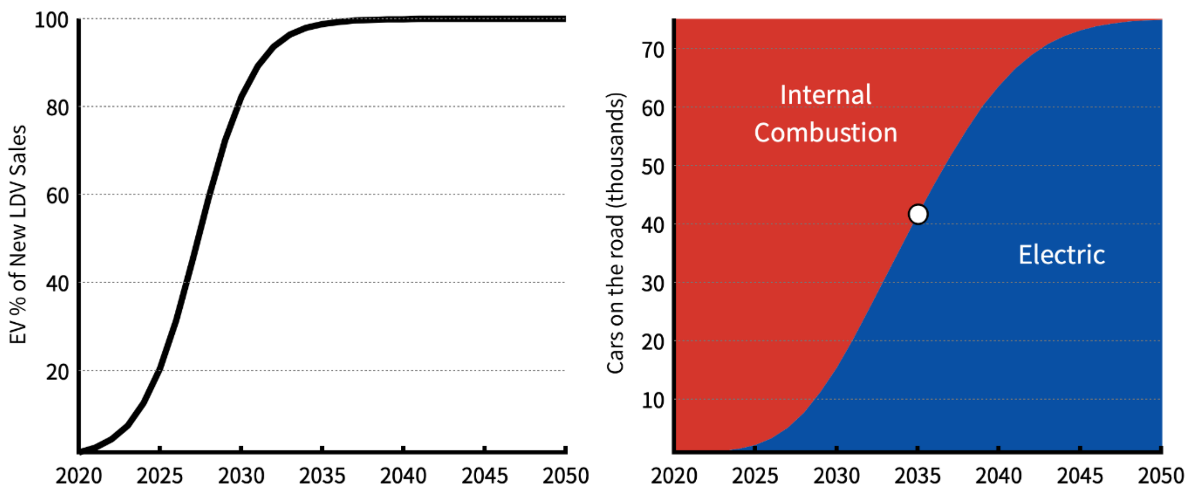

Figure 1. Light Duty Vehicle stock rollover example from our central adoption scenario. In the left panel, we show the fraction of new car sales that are electric. This results in the stocks in the right panel. In the right panel, the white circle indicates the year 2035 which we focus in the hourly load analysis below.

Annual electricity use could increase more than 30% by 2035

Analysis Results

In our central case, we assume that the HCE community electrifies 20% faster than Colorado on average, and Colorado decarbonizes at a rate consistent with HB1261. As shown in Figure 2, this leads to significant load growth starting in the late 2020s, with 33% load increase by 2035 and 63% increase in load by 2050. Note that snowmelt loads are included in the chart but too small to see; while the snowmelt systems can add meaningfully to demand in a given hour, their limited run times make their annual demand small compared to other end uses.

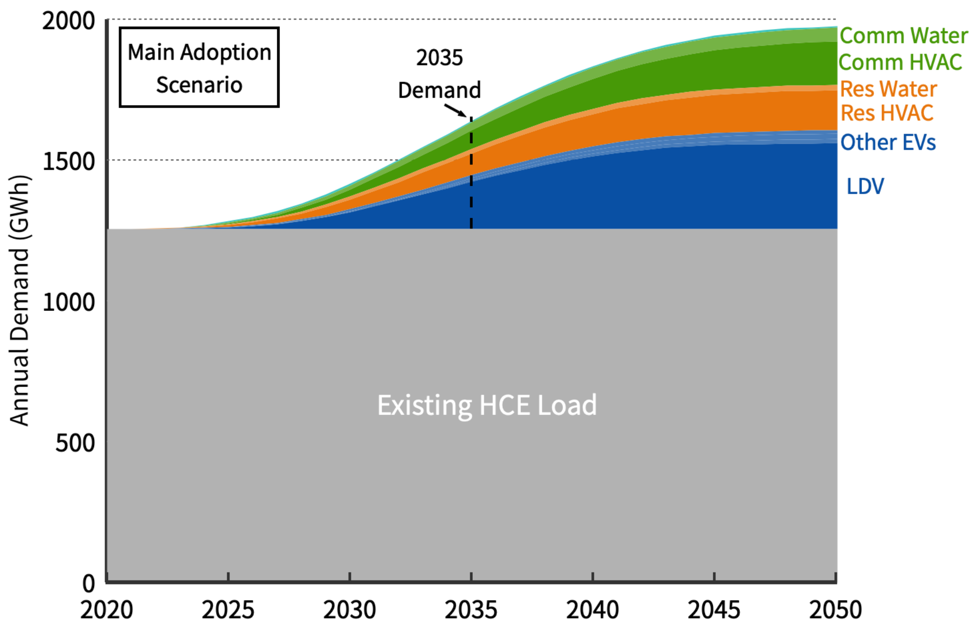

Figure 2. Annual load growth in the central scenario. We indicate 2035 load growth with a dashed line because a lot of our future analysis focuses on 2035. Snowmelt loads are included in the chart but too small to see.

In Figure 3, we show the annual load growth in cases where vehicle or building electrification occurs 50% faster than the Colorado average and Colorado hits the HB 1261 decarbonization target. 2035 and 2050 annual loads are similar across all three scenarios.

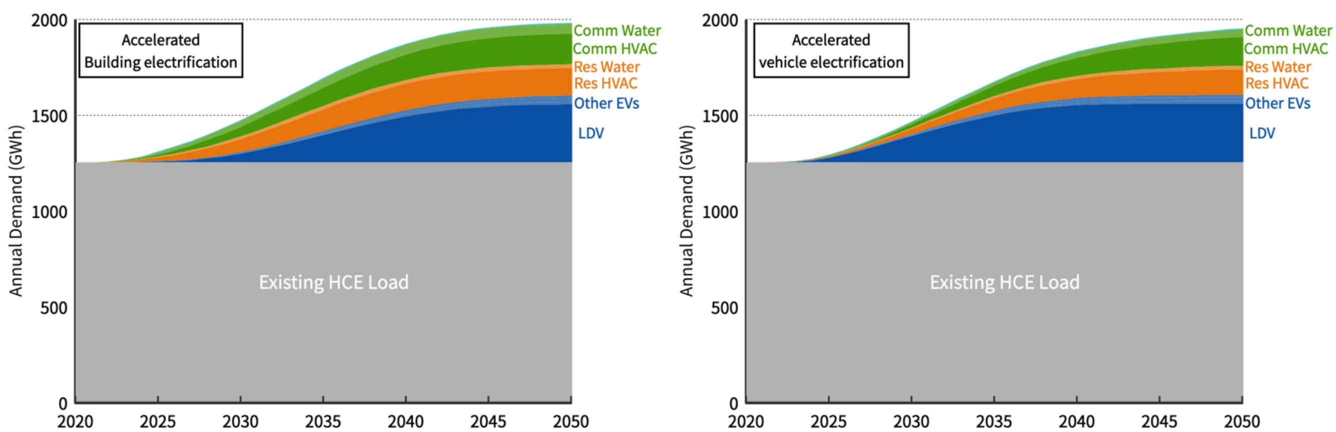

Figure 3. Annual load growth in the accelerated building and vehicle electrification scenarios.

New load will grow the most in the winter, adding to HCE's already high winter energy use. Figure 4 breaks down 2035 electrification load by month for vehicle charging, and electrification-driven commercial, and residential energy use. Residential and commercial electrification loads, which are dominated by heating, peak in the winter. EV load also peaks in the winter, because of decreased EV efficiency during cold weather[12].

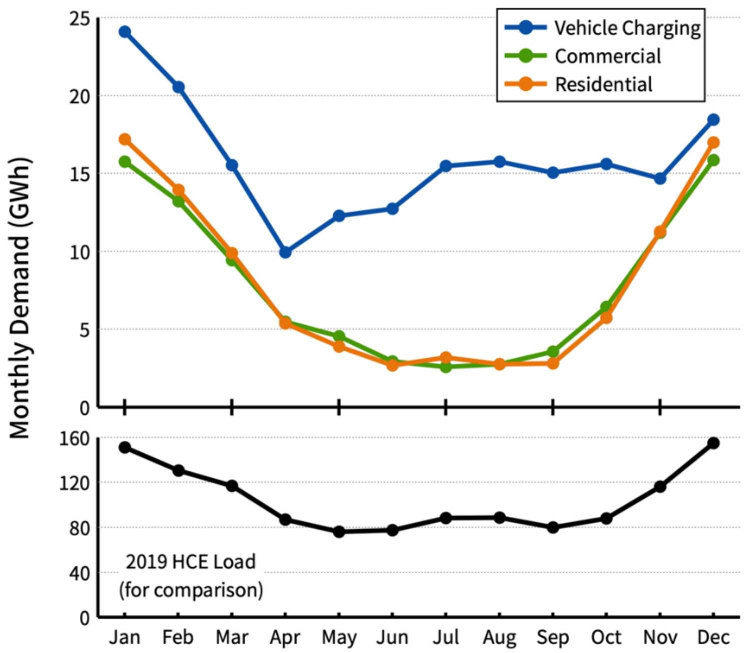

Figure 4. Monthly electric loads by sector in 2035 with the central adoption scenario

Implications for HCE System

Annual and seasonal energy sales will have direct implications on HCE revenue and resource planning. Increased annual energy sales represents increased revenue for HCE. Increased revenue can be invested in infrastructure, invested in customer programs, or returned to customers as lower rates.

HCE will also need to procure energy to meet increased energy demand. Given HCE's commitment to decarbonization, this energy should be met wherever possible by low- and no-carbon resources. Zero-carbon wind and solar are low-cost in Colorado, but their production profile is not a great match with HCE's current and electrification-driven load. While wind production in Colorado is relatively flat with a small peak in the winter, solar production peaks during the late spring and early summer when HCE load is relatively low.

To meet future energy and capacity needs, HCE should consider not only wind, solar, and short-duration battery storage, but also emerging technologies and market solutions. Emerging technologies like long duration storage and hydrogen are promising but still early stage. Market options, including participation in an energy market (i.e. RTO), wholesale power transactions, or bilateral agreements with summer peaking utilities could also be promising.

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[12] We extrapolated EV load from national data. EV miles traveled peak in the summer, but this is more than offset by winter efficiency decreases.

Winter peak demand could increase 47% by 2035

Analysis Results

We also calculate the impact at the hourly level and focus at the HCE peak load before the holidays. Note, that this peak corresponds to data from a "Typical Meteorological Year" but should be representative of the common HCE system peak near the holidays when tourism is high and temperatures are often low. Figure 5 shows the system peak, with new electrification loads broken out by sector.

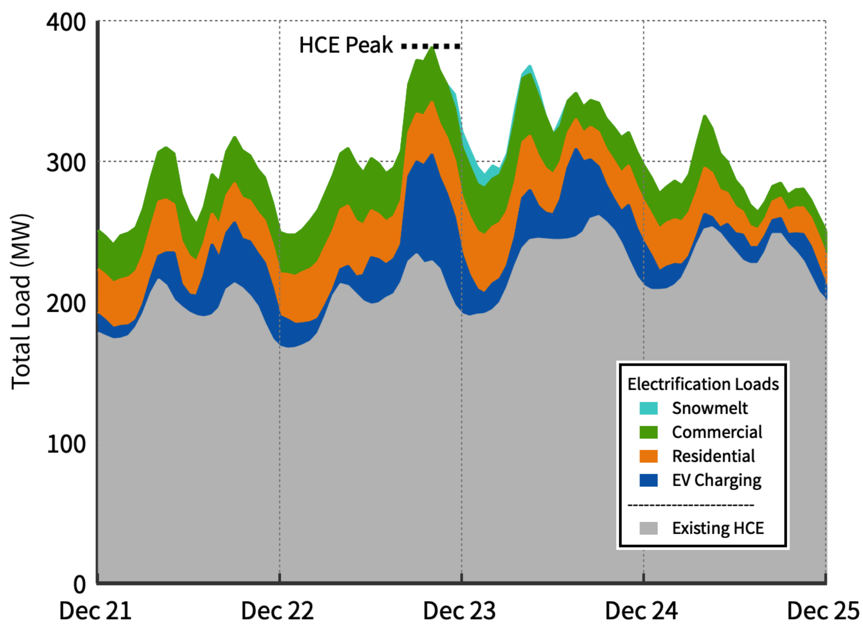

Figure 5. Holy Cross December system demand peak in 2035 (central adoption scenario)

With no effort to manage new loads, peak increases 47%, from 260 MW (on December 23) to 382 MW (on December 22)[13].

[13] Note that while snowmelt has a small impact on the time period modeled above, large snowmelts have a large potential impact. This analysis considered the addition of two large snowmelt systems with maximum output of 26 MW each.

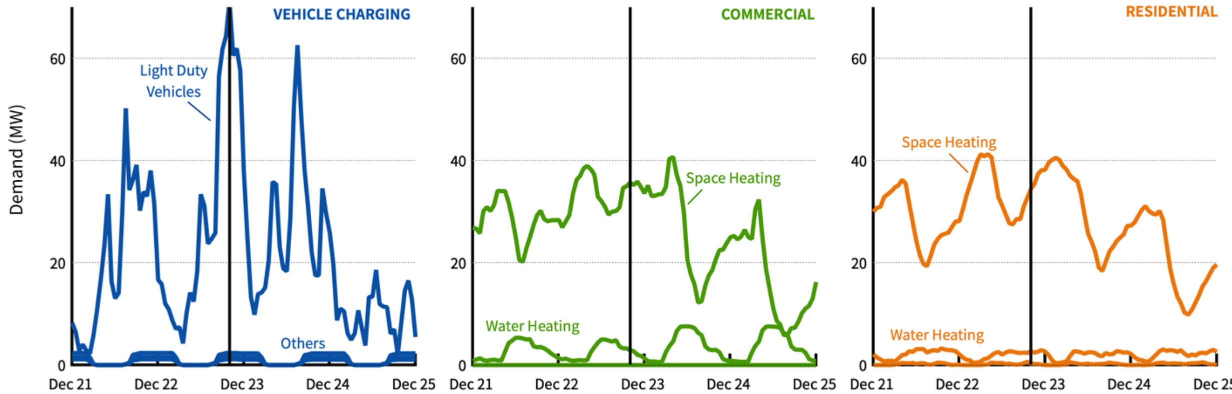

Figure 6. Individual electrification end uses, grouped by sector, contributions to system peak.

In Figure 6, we show the individual technologies contributions to the peak. The time of peak demand is shown in each panel with the vertical black line. Figure 6 shows that LDV charging (over 60 MW) and space heating (~70 MW from combined commercial and residential) are the main electrification contributors to the increased peak load. However, both electric water heating and other vehicle charging also contribute to peak load.

RMI's analysis did not account for the interaction between electrification and seasonal population increases. We know that HCE service territory's population swells during peak tourism times, particularly between Christmas and the New Year. Seasonal population shifts will add to the winter peak described in figures 5 and 6 as more vehicles will be tapping the HCE grid, and residential and commercial load increases with increased occupancy.

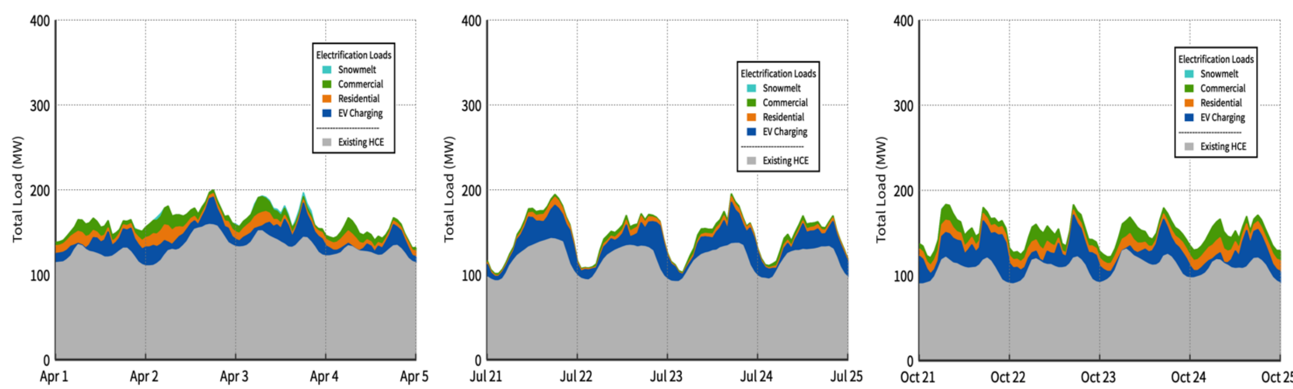

Figure 7. HCE load for sample periods in April, July, and October (2035, base adoption scenario)

In other months, demand is generally lower; we show example 4-day periods in Figure 7. In these months, electrification still adds substantially to load.

Implications for HCE System

Peak demand drives investment across the electric system. Peak demand determines how much contracted generation or storage capacity HCE needs to have in place to serve peak demand and it also will drive investments on the HCE distribution and transmission system.

This analysis shows that peak demand could grow even faster than total energy sales. If electrification-driven load growth triggers major system upgrades, this could mean that rates will increase instead of decrease over time as a result of electrification[14].

Demand flexibility and battery storage can meaningfully reduce peak

Analysis Results

By taking advantage of the ability to manage new loads, it is possible to reduce HCE's system peak or alter its load. As an example, we consider HCE's December system peak (Figure 5 above). Vehicle charging and space heating contribute significantly to this peak. Unfortunately, as shown in Figure 6, the commercial and residential space heating loads are consistently high during the 24 hours before the peak, meaning that it would be challenging to shift those loads. However, vehicle charging is both the largest load and the one with the most flexibility potential.

To show the potential of flexible charging, we shifted 25 MW of the ~70 MW LDV peak by 7 hours. In this case, vehicles that were plugged in during the early evening, would still be charged in the morning. Figure 8 shows the original and managed LDV load profiles and Figure 9 shows the impact on HCE's peak.

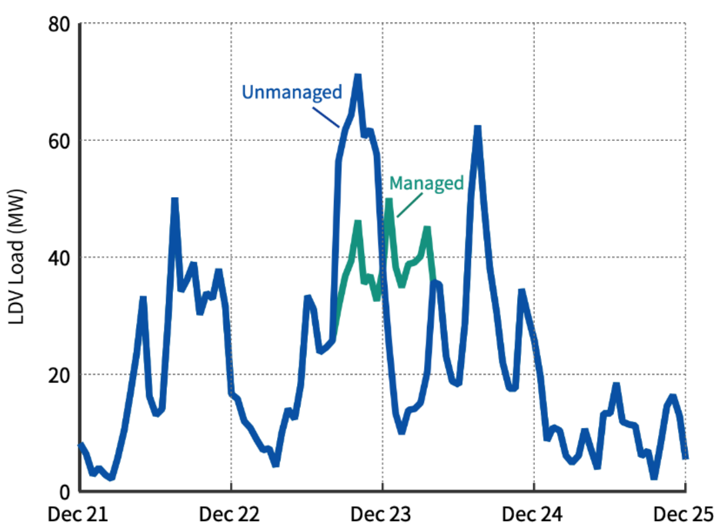

Figure 8. Example managed EV charging load curve during the HCE system peak.

[14] Analysis of distribution and transmission system impacts and required upgrades is out of scope for this analysis, but critical to understanding net economic impacts.

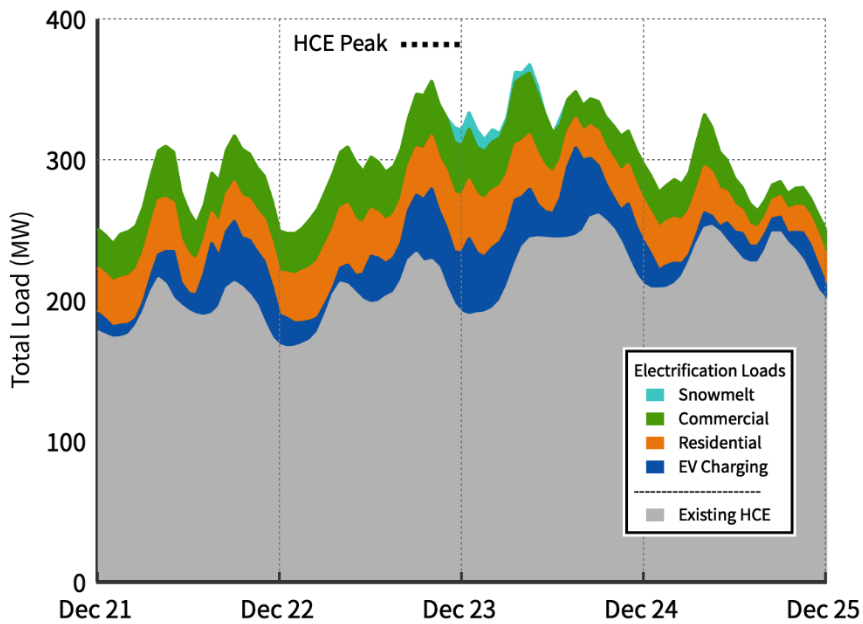

Figure 9. Impact of managed EV charging on HCE system peak.

In addition to EVs, hot water heating and snow melt provide opportunities for load shifting. Electric water heating loads are ~5.5 MW and have the potential for flexibility without influencing end users. Though snow melt loads were modest during the "typical weather year" used in our simulation, peak modeled snow melt demand is 40 MW. If heavy snow coincided with peak, snow melt systems would substantially add to peak demand[15]

In addition to load flexibility, we considered the impact of battery storage. The managed and unmanaged peaks in Figure 5 and Figure 9 are approximately 4 hours in duration and occur during a ~2 day period of sustained high load. This implies that about 30 MW of 4 hour storage (120 MWh) would help reduce and smooth the sustained peak. However, the benefit of energy storage beyond those levels would decrease because to continue bringing down the full system peak further would require spreading new storage energy over greater than one day.

Finally, we evaluated the extent to which variable renewable energy will be available to meet peak demand. In figure 10 we show the combined 2019 PSCO wind and solar output (solar production is stacked on the wind production) together with the HCE holiday peak in Figure 10 We use the managed EV charging profile (from Figure 8) and normalize the PSCO 2019 wind and solar output against their maximum December 2019 production. While there is little wind or solar during the December 22 peak, there was considerable wind and solar in the preceding day and solar generation was significant toward the tail end of the December 23 peak.

[15] It's common for heavy snow to significantly drive-up HCE demand. HCE, therefore, may need to plan for a peak influenced by low temperatures, high community occupancy, and heavy snowfall.

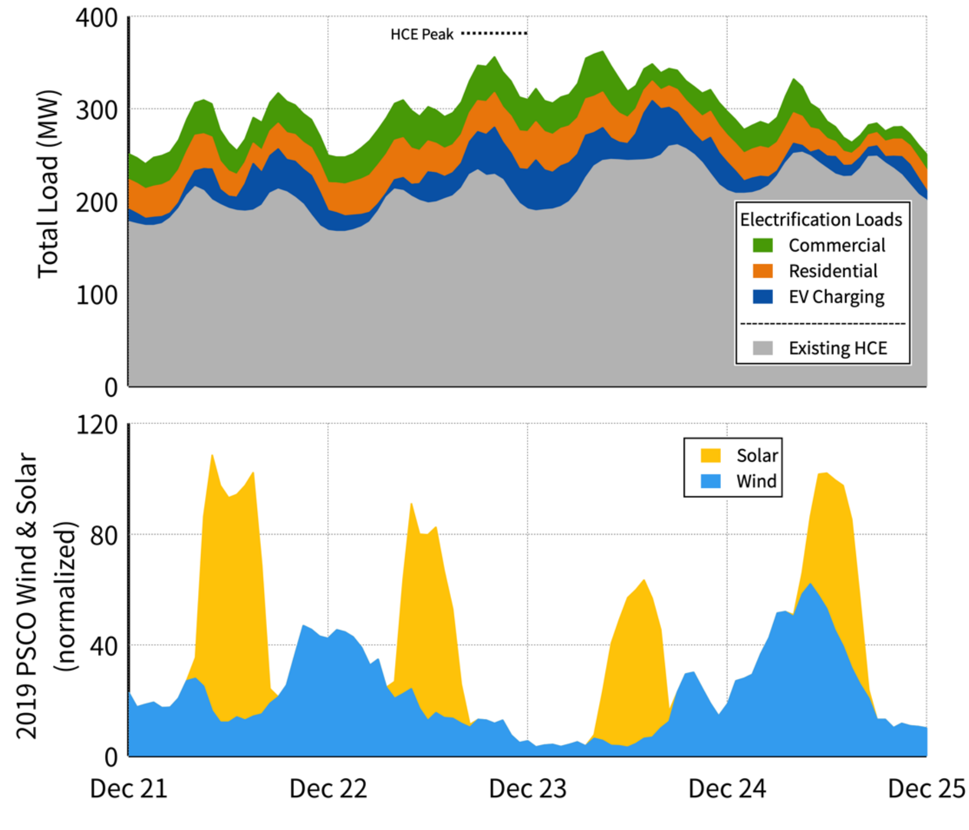

Figure 10. HCE peak load (with managed EV charging) and normalized PSCO 2019 wind and solar output

Implications for HCE System

Managing winter peak is key to controlling costs in high electrification futures. While most electric loads could in theory participate in load flexibility programs, the best candidate devices are EV charging, hot water heating, and snowmelt systems.

In a highly renewable system, peak load management is also connected to solar production, wind production, and battery storage capacity. While wind and solar production are not well correlated with HCE's peak, battery storage can help shift wind and solar output or manage HCE peak demand.

IV. Electrification Impacts on HCE Communities

Electrification could prevent 1.5 Million Tons of greenhouse gas emissions

As shown in Figure 11, electrification reduces end-use emissions significantly. Light duty vehicles are the biggest opportunity for emissions reductions because internal combustion vehicles are inefficient, cars are used year-round, and petroleum is energy intensive compared to natural gas. Electrification could reduce 2035 annual emissions in HCE territory by 300,000 metric tons and cumulative emissions through 2035 by 1.5 million metric tons. This is based on the expectation that new load will be met with zero-carbon electricity, which is consistent with HCE's plans to decarbonize electricity generation.

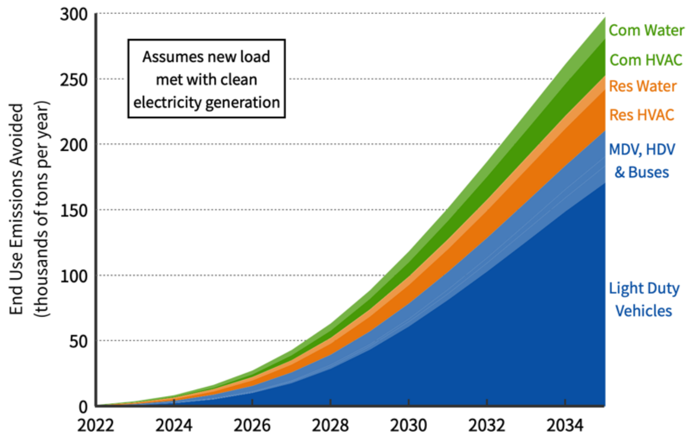

Figure 111. Avoided end-use emissions (neglects emissions associated with electricity generation)

As an extreme, we also calculate the emissions reductions if grid decarbonization stops and future grid emissions intensity (tons per MWh) is frozen at today's levels. This result is shown in Figure 12. Importantly, electrifying all of the end uses that we consider <u>does reduce emissions</u>. Again, vehicle electrification is the most beneficial. In this extreme example, electrification would still reduce 2035 emissions 150,000 metric tons/year and result in a cumulative avoided emissions of 745,000 metric tons.

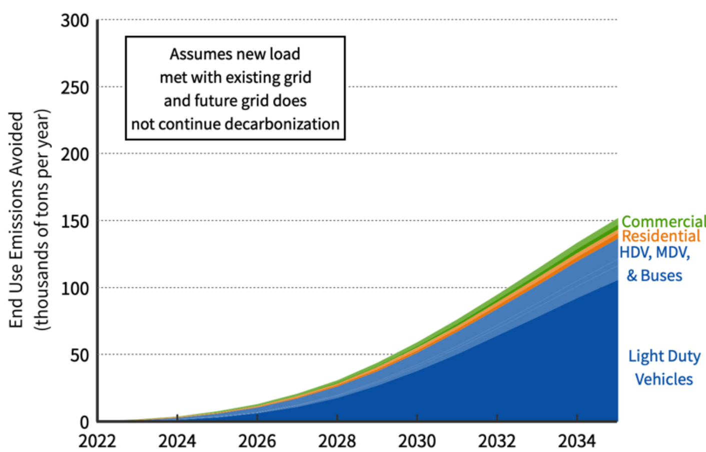

Figure 122. Avoided end-use emissions assuming electricity emissions intensity does not decrease from today.

We believe that the emissions reductions in Figure 11 will be closer to the true benefit for a number of reasons:

- Colorado and HCE have both committed to reducing grid emissions quickly, and have been meeting or exceeding their recent commitments. Nearly all Colorado coal is planned for retirement.
- Clean energy is continuing to decrease in cost.
- The majority of emissions reductions in Figure 11 occur in the late 2020s and 2030s, when the grid is almost certainly going to be much cleaner than it is today.

Electrification will drive net job growth and economic activity

National studies have estimated that electrification could drive the creation of millions of jobs nationally[16]. Job growth and economic activity will be enhanced if electrification is accompanied by investments in energy efficiency and load flexibility.

Local electrification efforts will not directly impact economic oil and gas-related economic activity in Garfield County. In 2020 Garfield County produced 455 billion MCF of natural gas[17][iv]. In comparison, our modeling suggests 1.6 million MCF of natural gas use would be avoided in HCE service territory in 2035. This amount to less than 0.4% of Garfield County's current production.

While a detailed job impact analysis is outside of the scope of the report, most studies suggest that electrification will drive net job growth and economic activity.

Electrification will avoid air quality-related health issues

Internal combustion engine cars produce health-impacting particulate matter (PM), nitrogen oxides, (NOx), and volatile organic compounds (VOCs). The transportation sector is responsible for 55% of NOx emissions nationwide[v].

On the building front, gas stoves have been linked to negative health impacts. Homes with gas stoves can have NOx levels 50-400% higher than homes with electric stoves[vi]. These elevated levels of nitrogen oxides contribute to increased risk of asthma and other respiratory issues.

Replacing fossil-fuel devices with electric devices can help improve indoor and outdoor air quality and avoid pollutants that impact health and views.

VI. Recommendations for Holy Cross Energy

1. Work to ensure new load is also flexible

Electrification benefits will be the greatest if new load is also flexible. Vehicle charging is the best candidate for load flexibility, because it is both a large load and extremely flexible. While some chargers, especially DC fast chargers, are inflexible, most charging is likely to occur at homes and workplaces. If these chargers are installed as connected, Level-2 charging systems, they can shift loads by hours and still ensure that vehicles are charged when drivers need them.

Other end uses also provide opportunities for valuable demand flexibility. Water heating loads are relatively small compared to electric vehicles and building HVAC but they can be flexibly shifted without impacting end users. While only a small portion of any buildings space heating load can be shifted through pre-heating, in aggregate there is an opportunity to help manage peaks by shifting building demand away from critical peak hours. Finally, the large snow melt systems currently being planned should be coordinated with the grid; while these systems do not constitute large loads from a total MWh perspective, they could add large demands, if they turn-on on at critical times.

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[16] For indicative studies, see [16] Rewiring America, the Jobs Report (https://www.rewiringamerica.org/policy/jobs-report) and the 2035 report (https://www.2035report.com/transportation/green-jobs/)

[17] Though gas production far outweighs oil production, Garfield County also produced 1.3 million barrels of oil in 2020

2. Continue to invest in efficiency

Electrified space heating loads will be a major driver of HCE's winter peak (Figure 5 and Figure 6). Because winter peaks are likely to occur during cold spells that last a day or longer, it is difficult to leverage demand flexibility to shift these loads substantially. This impact on peak load adds to the (already strong) justification to continue investing in building efficiency. Tight and efficient buildings reduce upfront[18] and lifetime space heating and cooling costs, are more comfortable, and retain their heat in case of unplanned power outages.[19] Finally, with efficient buildings, it is possible to do some pre-heating to shift peak demand.[vii]

HCE should continue to incentivize and encourage building and mobility efficiency. Future efforts can focus both on building weatherization and efficient devices. Programs should be designed to encourage equitable participation from low- and moderate income households, renters, and households living in multi-family homes.

3. Prioritize light duty vehicles but don't forget heat pumps

As shown in Figure 11, electrifying light duty vehicles present the largest opportunity to reduce HCE emissions (other than electricity generation). This is because vehicles are such a large source of emissions today, electric vehicles are much more efficient than fossil fuel-based vehicles, and petroleum is a carbon-intensive fuel source. Of course, HCE may have limited influence on its customer's car and truck choices.

Heat pump adoption is also critical, but more challenging economically and currently has smaller public "mind share." However, HCE may have more ability to impact customer decisions in this area. This is especially true for customers considering stand-alone air conditioning. Whenever possible, HCE should push heat pumps be installed instead of stand-alone air conditioning because the costs are similar and the heat pump can significantly reduce natural gas use.

4. Educate contractors, members, and community partners

Education can help contractors understand how to specify and install electric building devices. As indicated in Table 3, installers and consumers alike often do not understand heat pumps well.

HCE can directly use its communication channels and work with community partners. Part of HCE's education process should focus on understanding and communicating how EVs and heat pumps perform in cold mountain environments. Education and outreach should include low- and moderate-income members, and the contractors who serve them.

5. Work with large users on electrification planning

While consumer energy demand from buildings and private vehicles is expected to account for 70% of electrification-driven load increase, commercial load is more highly concentrated and may be easier to influence. HCE's largest energy users - including Vail Resorts, Aspen Skiing Company, and local governments – want to make prudent investments that reduce greenhouse gas emissions. Projects from large energy users will have a large direct impact, and highly visible marquis electrification projects will increase awareness among HCE members and visitors to the community.

[18] Building owners can buy smaller and lower cost system sin highly efficient buildings.

[19] See Hours of Safety in Cold Weather (https://rmi.org/insight/hours-of-safety-in-cold-weather/)

In particular, HCE should work with large energy users on fleet electrification, which could provide an attractive payback today, so long as commercial customers are on an appropriate rate plan[20]. HCE should remain in dialogues with large energy users as they plan for electrification.

6. Track, monitor, and inform local, state, and federal policies

Ultimately electrification will be driven by policy drivers, economic trends, and consumer preferences largely out of HCE's control. HCE does, however, have a role in helping local, state, and federal law-makers craft policies that maximize electrification benefits while avoiding drawbacks.

HCE should position itself as a trusted resource for local governments considering changes to codes, as well as state and federal law-makers considering new electrification-related policies. HCE can further amplify its impacts by working with state and federal trade associations (e.g. CREA and NRECA).

7. Monitor geographic dispersion of electrification and consider targeted interventions

Electrification costs and benefits will vary within HCE's service territory. For example, electric heat pumps will be more efficient and cost-effective in warmer (lower elevation) areas, and some distribution circuits have more headroom before they need to be upgraded.

HCE should monitor geographic distribution of electrification and consider targeting electrification-related marketing at specific sub-geographies of its service territory.

8. Continue to invest in system reliability and community energy resilience

Reliability and resilience becomes even more important as heating, transportation, and other critical services become electricity-dependent. HCE should continue to invest in reliability and resilience, with a particular focus on ensuring energy reliability for vulnerable populations[21].

Additional Recommendations

The following recommendations are also critical to maximizing benefits and minimizing drawbacks of electrification.

9. Use rebates and financing to offset upfront costs

10. Prioritize cost-saving options (EVs, new buildings, and propane replacement)

11. Invest in EV charging infrastructure

12. Monitor and anticipate distribution-system impacts

13. Monitor and update projections for electric device adoption

14. Iteratively plan for and procure clean generation additions

[20] While our analysis shows decreased rates for EVs on energy-only charges, rates could increase if the bs

[21] See Working Toward a More Resilient Future (https://www.holycross.com/wp-content/uploads/2020/05/holy-cross-report.pdf) for more details on community energy resilience in the HCE region

Appendix 1: Colorado Electrification Policies

Key Colorado Electrification-Related Policies

- HB 1261 *Climate Action Plan To Reduce Pollution* (2019): Sets a goal to reduce 2025 statewide greenhouse gas emissions by 26%, and 2030 greenhouse gas emissions by 50%, and 2050 emissions by compared to 2005 levels.
- SB-264 *Adopt Programs Reduce Greenhouse Gas Emissions Utilities* (2021): Directs gas utilities to create clean heat plans to reduce the greenhouse gas emissions associated with providing fuel to homes and businesses.
- SB- 246 *Electric Utility Promote Beneficial Electrification* (2021): Directs regulated electric utilities to create incentives for households and businesses to upgrade to efficient electric appliances, heat pumps, and heat pump water heaters.
- HB- 1286 *Energy Performance for Buildings* (2021): Requires owners of large commercial buildings to track and report their energy use over time and comply with performance standards that will require inefficient buildings to cut energy waste and reduce pollution.
- HB – 1238 *Public Utilities Commission Modernize Gas Utility Demand-side Management Standards* (2021): Directs the Public Utilities Commission to establish energy savings targets for gas utility demand-side management programs and updates the methodology used to calculate the costs and benefits to expand energy efficiency programs and help more customers cut energy waste

Appendix 2: Electric and Non-Electric Device Comparison

Heat Pump Efficiency:

Heat pump efficiency will decrease at very high or very low temperatures. Average heating season heat pump efficiency will be higher in the warmer areas of HCE service territory (Garfield/ Rifle) and lower in the coldest areas of HCE service territory (Vail/ Aspen).

We estimated local heat pump performance using an RMI database of modeled heat pump performance in the largest city in each US state. Table 2.1 below summarizes heat pump COP for select cities.

Table 2.1: Heat Pump Coefficient of Performance **in Select US Cities**

City	IECC Zone	Heat Pump COP	HCE Comparable
Fargo, ND	7A	2.06	Aspen
Minneapolis MN	6A	2.34	Aspen
Sioux Falls, SD	6A	2.42	Aspen
Billings, MT	6B	2.53	Garfield
Omaha, NE	5A	2.57	Garfield
Cheyenne, WY	6B	2.58	Garfield
Denver, CO	5B	2.73	Garfield

We compared climate trends from Aspen airport and Garfield County airport to previously modeled to estimate heat pump COP for the HCE region. Table 2.2 below summarizes our assumed heat pump COP.

Table 2.2 Assumed Heat Pump COP.

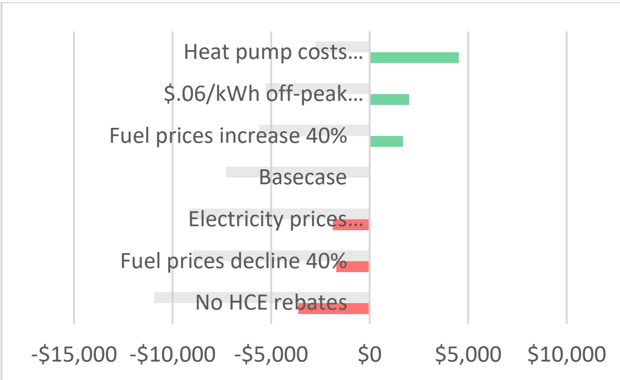
HCE Region	Weather Data Used	Assumed COP
Rifle/ Garfield County	Garfield County Airport	2.20
Aspen/ Vail	Aspen Airport	2.55

Heat Pump vs Furnace Heating Economics Sensitivities

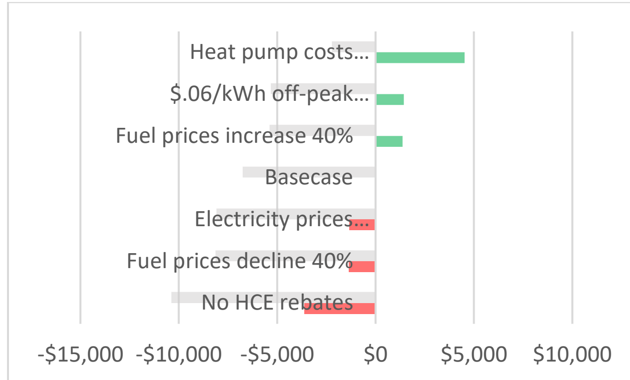
Lifetime savings for electric devices will change in the future and will vary as a function of several key variables. The figures below show how lifetime savings from a heat pump compared to a furnace will change based on set of varying assumptions.

In the figures below, the gray bars show total lifetime savings (positive) or lifetime cost (negative) of a heating heat pump compared to a furnace when the heat pump is only providing heating service. The red and green bars show how each sensitivity will change the lifetime savings.

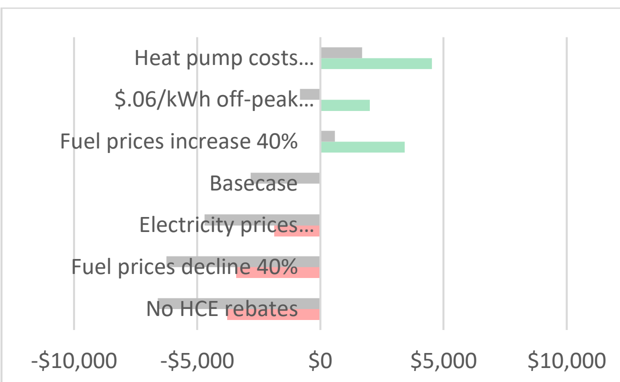
2.1a: Lifetime Savings (Cost): Heat Pump vs. Natural Gas Furnace - Aspen/ Vail



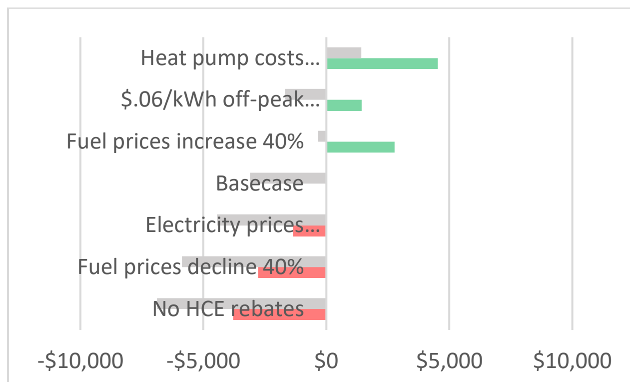
2.1c: Lifetime Savings (Cost): Heat Pump vs. Natural Gas Furnace - Rifle/ Garfield



2.1b: Lifetime Savings (Cost): Heat Pump vs. Propane Furnace - Aspen/ Vail



2.1d: Lifetime Savings (Cost): Heat Pump vs. Propane Furnace - Rifle/ Garfield



Appendix 3: Electric Device Adoption Scenarios

Methodology

Our analysis sources existing stock from the Colorado GHG Roadmap and scales the stock to fit HCE territory depending on end use. For vehicles, stock of EVs and ICE vehicles is scaled by Colorado population. Residential end uses are scaled by the fraction of residential buildings in HCE territory compared to the state at large. Finally, commercial stock numbers are scaled by annual load. Commercial stock is provided in square feet and all other resources are provided by device.

Table 3.1: Technologies analyzed and scalars used to fit Holy Cross territory

Technology	Scaled by	Scalar
Vehicles	Population	1.45%
Residential	Residences	2.28%
Commercial	Annual load	2.12%

To project stock out to 2050, we employ an s-curve function to define the increasing fraction of new sales that are electric. We estimate the vintages of the existing stock using a normal distribution curve with a standard deviation of 3 years. From that starting stock, we calculate the probability of retirement at each vintage based on technology lifetime, and add new stock matching the new sales.

The S-curve shape is defined by the 2030 goals set by the chosen scenario. Therefore, the interim stock numbers are dependent on the scenario chosen. Scenario assumptions can be found in **Table 3.1** below.

Table 3.2: % of Devices Sold in 2030 That are Electric by Scenario

	HB 1261 Scenario	Scenario 1: Modified HB 1261	Scenario 2: Mobility Electrifies Fast	Scenario 3: Buildings Electrify Fast
Description		20% Faster than HB 1261	Mobility 50% faster than HB 1261; buildings same as 1261	Mobility same rate of adoption as HB 1261; buildings 50% faster than 1261
	2030	*2030*	*2030*	*2030*
LDV	69%	82%	99%	69%
MDV	40%	48%	60%	40%
HDV*	40%	48%	60%	40%
Bus	100%	100%	100%	100%
Resi_Heat	70%	82%	70%	100%
Resi_Water Heat	80%	96%	80%	100%
Resi_Cooking	91%	100%	91%	100%
Comm_Heat	71%	85%	71%	100%
Comm_Water Heat	71%	85%	71%	100%

Comm_Cooking	82%	98%	82%	100%

Load data is collected from three sources. RMI's mobility team provided LDV weekly hourly load data based on internal modeling. This hourly data for one week is then scaled by national vehicle gas demand by week to calculate a full year of hourly LDV load data. MDV, HDV, and Bus load data is extracted from researched daily load profiles at truck depots. This demand data is then scaled by national fuel demand to estimate yearly hourly load for all other vehicle technologies. For residential and commercial end use load profiles, we used NREL's recent ResStock and ComStock models with sub-state regional granularity. ResStock load is provided by device and ComStock load is provided by square feet. All building load profiles rely on a typical meteorological year (TMY).

Final estimates are calculated through multiplication of each year's device stock (i.e. the output from the stock rollover model) by the hourly load profiles. This additional load is then stacked on existing HCE load to identify change in load in future years based on electrification scenarios.

[i] Colorado Greenhouse Gas Roadmap (https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap)

[ii] Aspen 2017 Community-wide GHG inventory (https://www.cityofaspen.com/564/Greenhouse-Gas-Reductions)
[iii] https://rmi.org/heat-pumps-a-practical-solution-for-cold-climates/
[iv] https://cogcc.state.co.us/COGCCReports/production.aspx?id=MonthlyOilProdByCounty
[v] https://www.epa.gov/transportation-air-pollution-and-climate-change/smog-soot-and-local-air-pollution
[vi] https://rmi.org/indoor-air-pollution-the-link-between-climate-and-health
[vii] https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf