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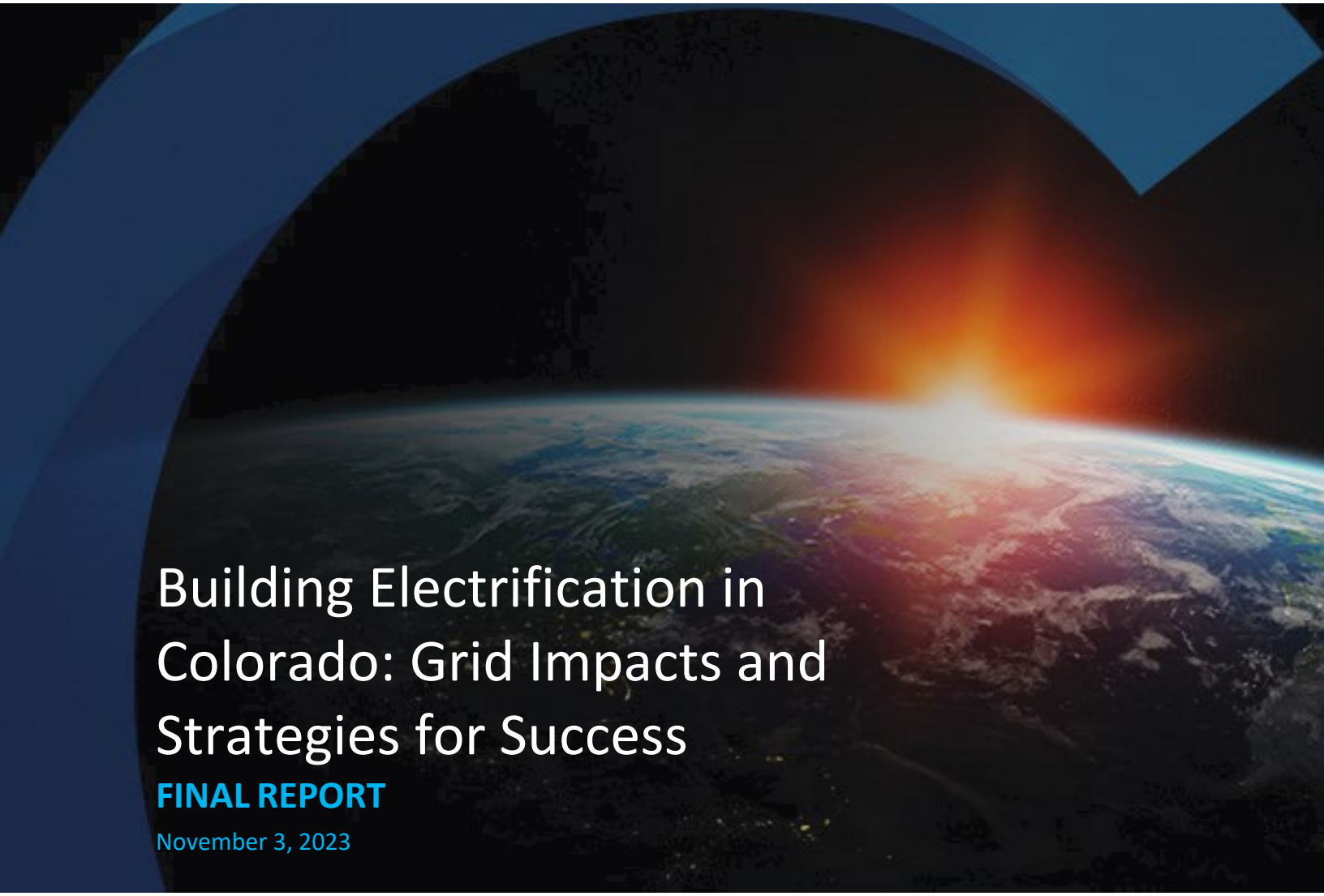

Building Electrification in Colorado: Grid Impacts and Strategies for Success

FINAL REPORT

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Executive Summary

Faced with a statewide push towards building sector electrification, some of the Beneficial Electrification League of Colorado's (BEL-CO) stakeholders have raised concerns about the ability of grid operators to keep up with increased power demand. While the risks posed to customer bills and grid reliability by hasty electrification demand attention, they are also well understood by utilities and regulatory bodies.

Existing literature on building electrification in Colorado was reviewed to determine how utilities are planning for an all-electric future. This research found that Colorado utilities have robust analyses and planning underway, and this report outlines the plans and tools used by the utilities to keep ratepayers safe and deliver affordable electricity even as demand grows. It also reviews best practices and critical technologies such as building weatherization and load shifting.

This report provides a snapshot of how experts view the shift from a summer-peaking grid to a winter-peaking one. That shift will not happen in the near term, and there are various timelines and methods for addressing this transition as electricity demands evolve. This study highlights key trends in building and transportation electrification, the quality of plans to address it, and the best tools that exist to ensure this transition is smooth, safe, and affordable. Here are those five conclusions:

1. The rate of market adoption of electric appliances, influenced by incentives and policies, will drive electrification's impact on electricity prices and grid upgrade requirements.
2. Utilities are carefully planning for a variety of electrification scenarios and pathways.
3. Careful management of electrification can lead to more affordable energy delivery in the short and long term by consolidating infrastructure needs.
4. Energy efficiency, energy storage, and building envelope upgrades will reduce energy bills and reduce the need for costly grid infrastructure upgrades.
5. Colorado's power demand will likely shift to winter peaks by 2040, but it could happen earlier if more aggressive decarbonization policies are pursued.

Introduction

Colorado is positioning itself as a leader in decarbonization. In 2021, the State adopted ambitious greenhouse gas (GHG) emissions reduction goals of 50% below 2005 levels by 2030 and 90% below 2005 levels by 2050,[1] and mandated that Colorado utilities set their own GHG emissions reduction targets.[2]

As of 2019, fuel burned in residential, commercial, and industrial buildings accounted for 22% of the State's GHG emissions.[3] Electrifying the built environment, primarily by replacing fossil-fuel-fired heating systems with electrical appliances, is necessary to meet state GHG reduction goals alongside robust development of renewable generation. Sourcing clean power for those appliances is another necessary action that can be done in parallel with electrification.

Colorado regulators and utilities are taking concerted action to reduce building sector emissions via electrification. In June 2023 Xcel Energy, Colorado's largest public utility, adopted a budget of over $360 million for building electrification and energy efficiency projects, representing 84% of its overall budget for 2024-2026. Xcel will sunset all financial incentives for residential air-conditioning systems in 2024 and natural gas appliances by 2027.[4]

These rapid timelines, and the emergence of heat pumps as an affordable alternative to natural gas HVAC systems, have given rise to concerns from stakeholders about the potential impacts of an electrified future on energy affordability and reliability. Fossil fuels, though polluting, have the benefit of being reliable from a supply perspective: a coal or oil generation plant or a natural gas furnace can be turned on at a moment's notice, ensuring that all end-use demand can be met at all times. Demand in excess of supply results in power failures, which are at best disruptive and at worst dangerous. Can an electrified grid fueled by renewable sources meet the needs of an electrified society?

To answer these questions, the Cadmus team conducted a literature review of four sources identified by BEL-CO as primary material of interest for this study, as shown in Table 1, as well as various other resources regarding utility planning processes, electrification forecasts, heat pump technology, and best practices for a stable transition away from fossil fuels (Appendix B.a.i.1.a.Appendix C).

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1 Colorado Energy Office. 2021. *GHG Pollution Reduction Roadmap 2.0.* https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap-20

2 Colorado General Assembly. 2021. *SB21-264: Adopt Programs Reduce Greenhouse Gas Emissions Utilities.* https://leg.colorado.gov/bills/sb21-264

3 Colorado Air Pollution Control Division. 2021. *Colorado 2021 Greenhouse Gas Inventory Update,* pg. 16. *https://cdphe.colorado.gov/environment/air-pollution/climate-change#inventory*

4 Natural Resources Defense Council. 2023. "Colorado Adopts Historic Goals for Building Electrification." https://www.nrdc.org/bio/claire-lang-ree/colorado-adopts-historic-goals-building-electrification

Table 1. Primary Sources

Author	Title	Year Published	Link
City and County of Denver Office of Climate Action, Sustainability, and Resiliency	City of Denver Renewable Heating and Cooling Plan	2021	PDF
Xcel Energy	Technical Appendix to the 2021 Electric Resource and Clean Energy Plan	2021	PDF
RMI	Managing and Accelerating Electrification in Holy Cross Energy	2022	PDF
Platte River Power Authority	Platte River Building Electrification Forecast	2022	Not published

Utility Plans and Forecasts

Utility planning and demand modeling processes are extremely detailed and prioritize safety and redundancy. Xcel and HCE have incorporated rapid electrification into their medium-term plans and are working to ensure that their territories continue to receive reliable electricity. Capacity requirements and planned additional capacity account for the 18% reserve margin as required by the Colorado Public Utilities Commission, meaning that all utility plans have a built-in and statutorily required safety buffer.

Xcel Energy in particular demonstrates a methodical and meticulous approach to planning for electrification. Among the tools detailed in the *Technical Appendix to the 2021 Electric Resource and Clean Energy Plan* are:

- Forecasting scenarios to capture the possible pathways grid electrification might take. It is intuitive that the speed of electrification will determine the type and magnitude of impacts that Colorado residents will see on reliability and energy prices. By defining these pathways and calculating their costs and impacts, utilities and regulators can use them as benchmarks to better understand the future of the grid.
- This sophisticated model allows the utility to plan for even very unlikely weather patterns and extreme temperatures or events. Understanding the greatest likely demand over the planning period allows Xcel to acquire the resources necessary to meet that demand.
- Detailed modeling of the costs of every step in the energy generation, transmission, and consumption process, from the capital structure of resource acquisitions to the prices of non-renewable fuels to inflation rates and the costs of upgrading transmission capacity. Each of these components is subject to rigorous testing. Furthermore, the granular nature of this modeling approach allows any given component to be adjusted as real-world data becomes available, further refining the model and driving predicted results closer to actual outcomes.

Xcel's current predicted additional capacity needed by 2030 is 1,747 megawatts (MW), though it is possible that extreme weather patterns may increase the need for additional electrical capacity. Under Portfolio 3 (No New Coal), Xcel plans to acquire a total of 8,692 MW in generation resources compared

to 7,075 MW of predicted peak demand. The utility is also planning $2.32 billion worth of infrastructure upgrades in order to meet these requirements. Appendix C contains tables detailing predicted peak demand and total consumption by year for both the Base and Roadmap scenarios, with building electrification and electric vehicle (EV) split out.

Utilities must continue to develop detailed plans and forecasts for the adoption of electrified appliances and must ensure that they have access to both renewable generation sources and the distribution infrastructure required to meet the needs of Colorado residents.

Best Practices and Tools

Electrified technology is often the focus of discussions about grid electrification, but there is a suite of largely non-technical tools and practices that are crucial for a safe and smooth transition away from fossil fuels. Interviews that our team has conducted with subject matter experts reveal that, although many state agencies and utilities are focused on advanced technology, it is imperative that the core tools of energy efficiency and demand-side management not be ignored.

Energy efficiency practices and peak load management/load-shifting can significantly reduce the amount of additional generation and transmission resources required to electrify the grid. Efficient building envelope improvements keep indoor climate stable and reduce total heating demand of an enclosure.[5] Efficiency and management changes are based on customer decisions, educated customers, those who know of all options available to them, are able to make informed decisions about building upgrades and feel secure about their choices. One way that customers gain the necessary information is through informed contractors. Contractors can help guide their clients towards the building upgrades and technology improvements that would be best suited for their clients. These contractors can also help in facilitating customer access to rebates and other incentives in order to help save their clients valuable time and money.

Demand management is a critical method of reducing peak demand, and can refer to load shifting (i.e. moving load from peak demand hours to less congested times), behavioral adjustment, distributed battery storage, managed EV charging, and pre-heating and cooling buildings to reduce demand on the grid at the busiest times. The studies from HCE and the City of Denver agree that shifting space heating load (the largest contributor to increased electricity demand from buildings) is difficult for a variety of reasons, including high usage in the 24 hours leading up to typical peak events and the inflexible nature of some heating load. Heat pump water heating has some potential for load shifting with the ability to pre-heat water before the typical peak takes place, such as the hours before the typical population wakes each morning. While the current summer peak does not occur during this time frame, when the winter peak shift occurs, it may be during the early hours of the morning.

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[5] City of Denver. June 2021. *Renewable Heating and Cooling Plan.* https://www.denvergov.org/files/assets/public/climate-action/documents/hpbh/renewable-hampc/denver-renewable-heating-and-cooling-plan_june-2021.pdf

Snapshot: Winter Peaking

Since many cooling systems are already electric, grid demand from new all-electric heating systems will add to winter electric demand. As this differential between heating and cooling loads decreases, eventually a tipping point will be reached when maximum annual demand occurs in the winter, rather than in the summer as is the case today. This represents a paradigm shift and is viewed by Colorado utilities and regulators as a watershed moment for electrification. The flip from a summer peak to a winter peak would involve significant changes in the sources and patterns of power supply and demand. As such, it is used as a threshold in many utility plans: how can they account for power needs during winter peaking?

Many recent utility clean energy plans, along with some reports from the City of Denver, predict that the state and its capital will be summer peaking until around 2040. At this point Colorado is forecast to have over 60% heat pump adoption in both the residential and commercial sector.[6] This timeline may be shifted due to certain policies and may occur sooner or later depending on the area: the Platte River Power Authority is expecting to become winter peaking sometime after 2035, but they are acutely aware that the timeline may shift with the introduction of all-electric new construction policies, which would shift expected winter peak five to ten years earlier.[7] If this shift occurs too quickly and without adequate resource planning, it could have serious impacts on the electrical grid's integrity overall. While most stakeholders are not concerned with immediate impacts due to the predicted winter peak not occurring for a decade or more, it is still important to consider the potential impacts, including costly grid upgrades, that a too-rapid transition might have.[8]

Winter peaking is not only a challenge in Colorado, and other regions are taking steps to address the issue. New England has a similar timeline and strategy to Colorado and are expecting winter peak demand to increase about 3% each year for the next ten years until it will exceed summer demand. Utilities in those states are making incremental changes and upgrades to the electrical grid in order to keep up and prepare for this shift in the coming years. Although heating electrification is often considered a large component of winter peaking, the New England Independent System Operator's calculations put vehicle electrification as having a greater impact on demand.[9] New York City has completed similar studies. In 2021 the Urban Green Council found that, due to the massive cooling load of the city, there is no immediate risk of heating electrification causing a winter peak. For New York to become winter peaking they would need 30-40% of the buildings to install heat pumps, a benchmark not expected until between 2035 and 2040.[10] However, there are pockets of residential areas in New York City's outer boroughs that could require grid upgrades sooner because of lower current power

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[6] City of Denver. *Renewable Heating and Cooling Plan.*

[7] Apex Analytics. March 2022. *Platte River Building Electrification Forecast*. No public link available.

[8] City of Denver. *Renewable Heating and Cooling Plan.*

[9] ISO New England. 2023. *New England's Electricity Use.* https://www.iso-ne.com/about/key-stats/electricity-use

[10] Urban Green. 2021. *Grid Ready: Powering NYC's All-Electric Buildings.* https://www.urbangreencouncil.org/grid-ready-powering-nycs-all-electric-buildings/

capacity. With this distant deadline in place, New York is continuing to add capacity in the coming years to ensure a smooth transition to a winter peaking system.

The early implementation of dual-fuel systems (that is, electric heat pumps with natural gas backups that activate during periods of extreme cold) and a phased approach to electrification would reduce immediate grid impacts and can help push back costly grid upgrades.[11] These systems help reduce demand and are much easier to implement, since many homes already have usable furnaces in place. These systems increase the expected lifespan of both the furnace and the heat pump and require fewer electrical upgrades, making them cost-effective and easy to install.

Conclusions

The Cadmus team concludes that utilities are planning for the grid capacity upgrades that will be necessary to supply an electrified building sector, and that these utilities do not anticipate having trouble acquiring adequate generation and transmission resources.

Speed of adoption drives impact

The pace of the transition to an electrified grid will be one of the main determinants of the quantity and timing of additional grid resources that utilities will need to acquire. The aggressive pathway outlined by HCE would necessitate rapid investment of large sums to contract the generation sources and build out the transmission and distribution capacity required to satisfy a sharp increase in electrical demand. Even if generation and transmission resources are adequately secured, such short-term, high-magnitude investment in grid resources would likely put upward pressure on electricity prices.

However, Xcel Energy's more moderate adoption scenarios provide more time for utilities, regulators, contractors, and others to acclimate to the new normal. This will allow for any growing pains to be eased in the early stages of the transition and will provide a solid foundation for the kind of rapid decarbonization that the state of Colorado and its utilities are aiming for in the coming decades.

Careful planning is underway

From a distance, it may seem that Colorado's state government and utilities are rushing headlong into unknown territory. However, examining the technical resource acquisition plans published by these utilities reveals a meticulous approach to the development of grid resources. The utilities are continuing to monitor the adoption rates for electrification and develop detailed medium and long-term scenarios to inform resource acquisition planning.

Careful management can lead to positive impacts

While HCE's aggressive scenario would likely increase energy bills, a properly managed "phased transition" may actually reduce energy prices, at least in the short-term, due to improvements in the utilization rates of existing resources. Electricity utilities are more profitable when generation resources can be utilized more evenly throughout the year. This includes maximizing the use of renewable

[11] City of Denver. *Renewable Heating and Cooling Plan.*

resources, which have zero fuel and low maintenance costs and can easily operate whenever their fuel source (i.e. sun or wind) is available.

This conclusion is supported by Denver's study, which found that at least in the short-term, building electrification will put downward pressure on Xcel Energy rates.[12] However, it is unclear what will happen to Xcel electricity rates after 2040, when it predicts that winter-peaking may begin.

Best practices can reduce grid impacts

Energy efficiency and building envelope upgrades are one key to preventing more quick and expensive grid upgrades in response to building electrification. In some cases, electric resistance heat may be needed to supplement heat pumps, but building efficiency upgrades reduce that need. Less resistance heat also means less power generation and transmission resources needed during the winter.

For newly constructed all-electric homes, it is best practice is to install efficient cold-climate heat pumps without electric resistance backup. Heat pumps can meet home heating demands in Colorado's Front Range, but some supplemental heat may be needed in the mountains. Installing dual-fuel heat pump systems in residential buildings also helps reduce immediate grid impacts.

Educating contractors and customers on efficiency and electrification best practices is also important. Contractors that are knowledgeable of the technologies and best practices will be able to inform their customers of such practices.

Peak power demand could occur in Winter by 2040

Xcel Energy's system is expecting to be summer peaking until around 2040, based on Colorado's GHG Roadmap scenario. There are some Colorado utility service territories that may be winter peaking as early as 2035. This early peaking will be due to more aggressive electrification policies, such as more generous heat pump rebates or possible requirements for all-electric new homes/buildings.

Colorado is not the only state that is expecting a shift to winter-peaking. States such as New York and Massachusetts are expecting similar scenarios and are working to make any needed upgrades to their grid in response to building and vehicle electrification.

[12] City of Denver. *Renewable Heating and Cooling Plan.*

Appendix A. Glossary

EV – Electric Vehicle

GHG – Greenhouse Gas

HCE – Holy Cross Energy

MW – Megawatt

GWh – Gigawatt-hour

Appendix B. Xcel Energy Demand & Consumption Growth Forecasts

Table 2 and Table 3 show Xcel's projections of peak energy demand and total energy consumption at five-year intervals. The tables are reproduced from Xcel Energy's *Technical Appendix to the 2021 Electric Resource Plan and Clean Energy Plan, Volume 2,* Table 2-2.10. In both tables, the middle columns show the projected added demand (MW) and consumption (GWh) due to building electrification and electric vehicles (EVs) for each year shown, under the GHG Roadmap scenario. The last column shows the sum of the 'Base Scenario,' 'building electrification,' and 'EV' projections for each year, which is the total for the 'GHG roadmap scenario'.

Table 2. Peak Demand (MW)

Year	Base Scenario	Building Electrification	Electric Vehicles	GHG Roadmap
2025	7,031	32	57	7,120
2030	7,219	90	133	7,441
2035	7,665	223	179	8,067
2040	8,159	455	226	8,840

Table 3. Total Consumption (GWh)

Year	Base Scenario	Building Electrification	Electric Vehicles	GHG Roadmap
2025	34,170	450	832	35,452
2030	35,627	1,274	1,925	38,826
2035	38,899	3,584	2,756	45,238
2040	42,823	7,474	3,679	53,976

Appendix C. Sources

Apex Analytics. March 2022. *Platte River Building Electrification Forecast*. No public link available.

City of Denver. June 2021. *Renewable Heating and Cooling Plan.* https://www.denvergov.org/files/assets/public/climate-action/documents/hpbh/renewable-hampc/denver-renewable-heating-and-cooling-plan_june-2021.pdf

Colorado Air Pollution Control Division. 2021. *Colorado 2021 Greenhouse Gas Inventory Update,* pg. 16*. https://cdphe.colorado.gov/environment/air-pollution/climate-change#inventory*

Colorado Energy Office. 2021. *GHG Pollution Reduction Roadmap 2.0.* https://energyoffice.colorado.gov/climate-energy/ghg-pollution-reduction-roadmap-20

Colorado Energy Office. July 2020. *Beneficial Electrification Potential in Colorado: Market Potential 2021-2030,* pg. 8. https://energyoffice.colorado.gov/press-releases/colorado-energy-office-releases-research-on-beneficial-electrification-potential-in

Colorado General Assembly. 2021. *SB21-264: Adopt Programs Reduce Greenhouse Gas Emissions Utilities.* https://leg.colorado.gov/bills/sb21-264

ISO New England. 2023. *New England's Electricity Use.* https://www.iso-ne.com/about/key-stats/electricity-use

Natural Resources Defense Council. 2023. "Colorado Adopts Historic Goals for Building Electrification." https://www.nrdc.org/bio/claire-lang-ree/colorado-adopts-historic-goals-building-electrification

Urban Green. 2021. *Grid Ready: Powering NYC's All-Electric Buildings.* https://www.urbangreencouncil.org/grid-ready-powering-nycs-all-electric-buildings/