Equity Considerations in Minnesota's Electrification Policies

09/30/2021
Contract 196786

Conservation Applied Research and Development (CARD) FINAL Report

Prepared for: Minnesota Department of Commerce, Division of Energy Resources
Prepared by: Midwest Energy Efficiency Alliance

Prepared by:
Maddie Wazowicz

Midwest Energy Efficiency Alliance
20 N. Wacker Drive, Suite 1301
Chicago, IL 60606
(312) 587-8390
mwalliance.org

Contract Number: 196786

Prepared for Minnesota Department of Commerce, Division of Energy Resources:
Grace Arnold, Commissioner, Department of Commerce
Aditya Ranade, Deputy Commissioner, Department of Commerce, Division of Energy Resources

Anthony Fryer, Project Manager, Department of Commerce, Division of Energy Resources
Phone: 651.539.1858
Email: anthony.fryer@state.mn.us

ACKNOWLEDGEMENTS

This project was supported by a grant from the Minnesota Department of Commerce, Division of Energy Resources, through funding secured from the U.S. Department of Energy's State Energy Program competitive grant process.

The authors would also like to acknowledge and thank Nick Dreher and Reine Rambert from the Midwest Energy Efficiency Alliance for their reviewing and editing.

DISCLAIMER

Table of Contents

List of Figures 2
Acronyms 3
Executive Summary 5
Introduction 6
Electrification 6
Residential Buildings 7
Commercial Buildings and Industrial Processes 8
Transportation 9
Equity 9
Electrification Action Plan 11
Discussions of Equity within the TAC 11
Metrics 11
Grid Impacts 12
Technology 12
Legal Framework of Electrification 13
Working Framework of Equity 15
Current Barriers to Electrification 17
Climate 17
Upfront Costs 18
Education and Outreach 19
Benefits of Electrification 21
Health Benefits 21
Equity Considerations 21
Bill Savings 22
Equity Considerations 23
Grid Flexibility 24
Equity Considerations 24
Unintended Consequences of Electrification 26
Stranded Assets 26
Increased Demand 27
Conclusions and Recommendations 29
Leading Practices 29
Conclusion 31
References 32

List of Figures

Figure 1. Carbon Intensity of U.S. Electric Generation 7

Figure 2. The Importance of Deep Energy Retrofits 21

Figure 3. Energy Burden in Minnesota 22

Figure 4. Utility Bills Rise Non-Linearly with Customer Exit 25

Figure 5. Minnesota’s Average Hourly Demand, 2017 to 2050 Comparison 26

Acronyms

CIP: Conservation Improvement Program

DOC: Minnesota Department of Commerce

ECO: Energy Conservation and Optimization Act of 2021

EJ: environmental justice

EV: electric vehicle

GHG: greenhouse gas emissions

IOU: investor-owned utility

LEV: low-emission vehicle

MPCA: Minnesota Pollution Control Agency

PUC: Minnesota Public Utilities Commission

TAC: Technical Advisory Committee of the Electrification Action Plan

TOU: time of use rates

ZEV: zero-emission vehicle

[This page intentionally left blank]

Executive Summary

Over the last decade or so, many states, utilities, and advocates have been planning for a decarbonized future. Electrification has recently come forth as a potential avenue to contribute to decarbonization. Minnesota has emerged as a regional leader on this topic, becoming the first state in the Midwest to pass legislation that allows utilities to operate beneficial fuel-switching programs with the passing of the Energy Conservation and Optimization Act of 2021. Electrification programs are likely coming, so it is an ideal time for Minnesota regulators and decision makers to understand the benefits and risks of electrification. Without careful planning, electrification measures have the potential to exacerbate grid strain and energy burden. However, by centering impacted communities in the process and committing to equitable outcomes, electrification can improve air quality, reduce energy burden, and offer grid flexibility while prioritizing communities that have suffered from previous compounded inequities. Minnesota's distinct characteristics (e.g., demographic, geographic, climatic, economic, etc.) need to be comprehensively assessed in the context of increased electrification initiatives in order to ensure that the potential benefits of electrification are equitably shared amongst the population and the potential risks or downsides are mitigated to prevent inequitable harm on vulnerable populations.

This paper aims to assess the current energy landscape, review statewide policies on electrification, summarize major takeaways from Minnesota's recent Electrification Action Plan Technical Advisory Committee, and offer a potential framework for incorporating equity into the design, implementation, and evaluation of electrification initiatives for the state.

Introduction

Electrification

Electrification, as defined by the Lawrence Berkeley National Laboratory, is "the process through which end uses such as heating and cooling appliances that are currently directly powered by solid, liquid, or gaseous fossil fuels (e.g., natural gas or fuel oil) are powered by electricity instead."[1] A movement for greater electrification is gaining traction as the country makes progress in transitioning away from fossil fuel generation to renewable energy generation. Notably, in 2018, the Electric Power Research Institute conducted a U.S. National Electrification Assessment and highlighted key benefits of different electrification scenarios and the potential policy and regulatory frameworks that could help facilitate the transition. The report, amongst other recommendations, makes clear that meticulous planning, as well as inter- and intra-governmental coordination, is needed to ensure access to affordable, reliable, and secure energy as electrification increases.[2]

Currently, it may not make sense to electrify each and every end use in Minnesota considering the challenges of Minnesota's cold climate, current technological constraints, and the financial costs of retrofits. Recently, beneficial electrification and efficient electrification have emerged as terms to describe when an electrification measure's benefits outweigh its costs. Minnesota's Energy Conservation and Optimization (ECO) Act, the law that enables utility electrification programs, defines an efficient fuel-switching improvement as one that:

- results in a net reduction in the amount of source energy consumed for a particular use, measured on a fuel-neutral basis;
- results in a net reduction of statewide greenhouse gas emissions over the lifetime of the improvement;
- is cost-effective, considering the costs and benefits from the perspective of the utility, participants, and society; and
- is installed and operated in a manner that improves the utility's system load factor.[3]

These factors need to be included when deciding if and when it is appropriate to switch to an electric end use. It is likely that more electrification measures will be considered beneficial and efficient as technologies advance and the grid becomes cleaner, as the Electric Power Research Institute and other research entities predict.[4]

---

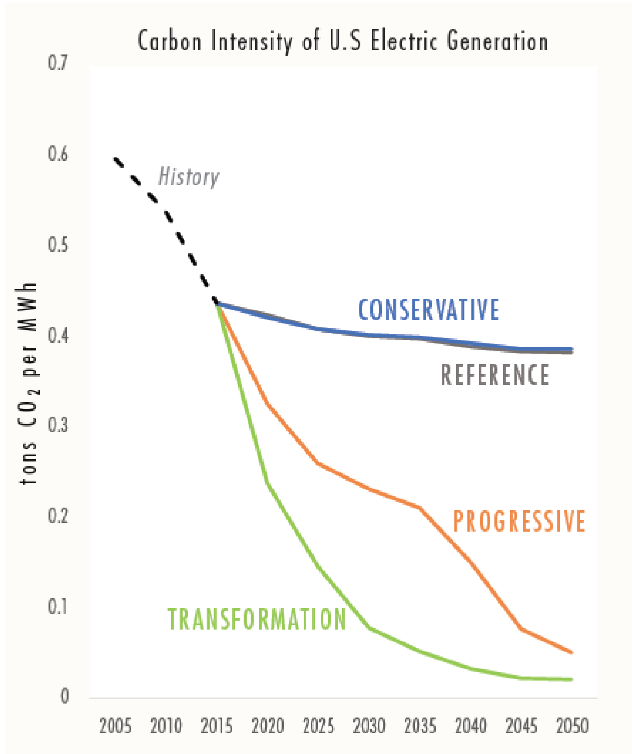
[1] Lawrence Berkeley National Laboratory, Electrification of Buildings and Industry in the United States 2018, eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

[2] Electric Power Research Institute, U.S. Electrification Assessment, ipu.msu.edu/wp-content/uploads/2018/04/EPRI-Electrification-Report-2018.pdf

[3] Energy Conservation and Optimization Act, revisor.mn.gov/laws/2021/0/Session+Law/Chapter/29/

[4] Electric Power Research Institute, U.S. Electrification Assessment, ipu.msu.edu/wp-content/uploads/2018/04/EPRI-Electrification-Report-2018.pdf

Figure 1. Carbon Intensity of U.S. Electric Generation (EPRI)[5]



This paper presumes that building end-use electrification will start to happen, pursuant to the limitations on efficient fuel-switching in the ECO Act. Electrification offers utilities a way to contribute toward their energy savings requirements under the Conservation Improvement Program and to meet consumer demand, so it is likely that some will begin to offer electrification programming. This paper is not meant to argue for or against electrification; rather, it acknowledges that the recently passed ECO Act enables electrification programs and that now is the appropriate time to make the resulting electrification programs and policies equitable.

Residential Buildings

In the residential buildings sector, space heating, water heating, and kitchen and laundry appliances are the most common gas end uses that will be targeted for electrification. In 2019, the U.S. Energy Information Administration found that 66.2% of Minnesota's home heating systems were direct combustion natural gas systems, which is significantly higher than the U.S. average of 47.8%.[6] The majority of the remaining systems use propane/fuel oil (12.7%) or electricity (17.3%).[7] Considering these percentages, Minnesota has extensive opportunities to electrify heating systems, in addition to electrifying other end uses, like appliances or water heating. Additionally, a large percentage of the state's homes that use electricity for heating have electric resistance heating systems, which are significantly less efficient than newer heat pump technologies. While modernizing these systems would

[5] Ibid.

[6] U.S. Energy Information Administration, Minnesota State Energy Profile, eia.gov/state/print.php?sid=MN

[7] Ibid.

not require switching the source fuel, increasing the efficiency of existing electric heat systems could also lead to economic and environmental benefits. Importantly, the residential housing sector is expanding rapidly in Minnesota. Minnesota led all Midwestern states with over 28,000 permits for new housing units in both 2019 and 2020.[8] Thus, electrification policies and programs for new residential buildings have the potential to be especially impactful.

Commercial Buildings and Industrial Processes

The industrial and commercial sectors have failed thus far to meet the goals set in the 2007 Next Generation Climate Act, which aimed to reduce the state's greenhouse gas (GHG) emissions by 15% from 2005 levels by 2015, with that goal increasing to 30% by 2025 and 80% by 2050.[9] Analysis of emissions data through the end of 2018 showed that the industrial sector increased its GHG emissions by 18% and the commercial sector increased its GHG by 15%.[10] Electrifying these sectors does present some challenges, especially since many energy intensive industries like oil and gas refining, bulk chemicals production, iron and steel production, and food production rely heavily on non-electricity fuel use.[11] Per a Lawrence Berkeley National Laboratory report on electrification potential, while there is high overall potential for electrification of industry, there is also a need for significant technological advances to overcome the engineering and cost barriers of electrifying certain processes, especially those that require extremely high temperatures.[12] Minnesota does not have as much heavy industry as many other Midwestern states. The state's total industrial fuel consumption in 2019 was 622.2 trillion BTU, which is considerably less than Illinois (1,170.7 trillion BTU), Indiana (1,301.6 trillion BTU), and Ohio (1,186.8 trillion BTU).[13]

On the commercial side, Minnesota's 356.8 trillion BTU of consumption substantially trails Illinois (808.9 trillion BTU), Michigan (612.4 trillion BTU), and Ohio (678.3 trillion BTU).[14] The technological barriers that are currently preventing mass electrification of industry do not stand in the way of commercial electrification. The vast majority of non-electricity fuel use in the commercial sector is for space heating, water heating, and cooking, which makes this sector more akin to the residential sector as opposed to the industrial sector.[15] The technical potential of electrification in the commercial sector is very high. The main barriers in Minnesota are the upfront costs of the electric technologies and the performance of these technologies in Minnesota's cold climate.

Ultimately, electrifying these sectors is critical for the state to reach its carbon reduction goals, and the potential is high. Due to the technological difficulties of electrifying, it is unlikely that mass electrification of energy intensive industries will occur before the residential building and transportation sectors.

---

[8] U.S. Census Bureau, Building Permits Survey, census.gov/construction/bps/stateannual.html

[9] Minnesota Pollution Control Agency, Greenhouse Gas Emissions Inventory 2005-2018, pca.state.mn.us/sites/default/files/lraq-1sy21.pdf

[10] Ibid.

[11] Lawrence Berkeley National Laboratory, Electrification of Buildings and Industry in the United States 2018, eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

[12] Ibid.

[13] U.S. Energy Information Administration, Total Energy Consumption, Price, and Expenditure Estimates, 2019, eia.gov/state/seds/sep_fuel/html/pdf/fuel_te.pdf

[14] Ibid.

[15] Lawrence Berkeley National Laboratory, Electrification of Buildings and Industry in the United States 2018, eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

Transportation

With the state's Clean Cars policy, Minnesota has begun to address electrifying transportation, the state's largest emitting sector. Governor Tim Walz initiated this process in fall of 2019 when he directed the Minnesota Pollution Control Agency (MPCA) to start the process for creating new vehicle emission standards. The Clean Cars initiative encapsulates two separate measures: the low-emission vehicle (LEV) and zero-emission vehicle (ZEV) standards. LEV standards are no different than what has been in place in Minnesota since 2012 and simply continue the requirement for tailpipe pollution limits on new cars delivered to the state. ZEV standards require auto manufacturers to provide a certain number of new vehicles with zero tailpipe emissions at an increasing annual rate.[16] With its official adoption on July 26, 2021, Minnesota became the 13th state to enact both standards.[17]

Additionally, the state has set a goal of reaching 20% electric vehicle (EV) penetration by 2030. As of June 2021, the state has 10,380 electric vehicle registrations.[18] Using historical data from 2010-2020, it is estimated that the state will need to have 777,307 passenger EVs on the road in 2030 statewide in order to reach this penetration goal. This value represents a 7,389% increase from the current quantity of EVs registered in Minnesota. Between these policy goals and shifting consumer patterns, it is inevitable that the state will see increased EV purchases and registrations. The state's 20% EV penetration goal does not include non-passenger EVs. Electric buses, municipal fleets, and trucks are starting to come as well, especially with the MPCA's focus on these categories with its share of the Volkswagen settlement funds.[19] As EV adoption rates increase, the demand for charging stations will follow. Minnesota currently has 1,115 EV charging stations.[20] Walz and the MPCA have prioritized funding EV charging corridors to ensure EV drivers can utilize the state's highways, though additional work needs to be done on this front in the coming decade if the state nears its 20% adoption goal.

Equity

Simply put, equity is the quality of being fair and impartial. Equity is not equality, where each person is treated the same with no regard for their differences. Rather, equity considers the barriers that prevent a person from succeeding, even if allocated the same amount of resources as another. Equity requires tailored solutions to understand and remedy the deficiencies. It is critical that equitable processes/outcomes reflect the intersectionality of individuals and communities. True equity requires an understanding of how race, gender, income, disability, age, housing status, and more can factor into a person's position in the world. It is impossible to utilize a one size fits all approach when all of these factors impact individuals differently.

[16] Minnesota Pollution Control Agency, About Clean Cars Minnesota, pca.state.mn.us/air/about-clean-cars-minnesota

[17] Ibid.

[18] Office of Renewable Energy & Energy Efficiency, Electric Vehicle Registrations by State, afdc.energy.gov/data/10962

[19] Minnesota Pollution Control Agency, Volkswagen Settlement: Minnesota's Plan, pca.state.mn.us/air/minnesotas-plan

[20] Office of Renewable Energy & Energy Efficiency, Electric Vehicle Charging Station Locations, afdc.energy.gov/fuels/electricity_locations.html#/analyze?region=US-MN

There are many examples of policy implementation that has resulted in inequities. Examples of historic exclusion, discrimination, inequitable processes, and inequitable dispersion of costs and benefits include: the buildout of America's highway system, which disproportionately displaced people of color; the placement of hazardous waste facilities, landfills, and other toxic polluting facilities, which are disproportionately located in communities of color and low-income communities; and redlining and restrictive covenants, which have prevented people of color from living in certain neighborhoods, accessing mortgages, and building generational wealth.

In fact, without equitable design and decision-making processes, any new policy or program rollout could exacerbate existing discriminatory systems, further harming or excluding targeted or otherwise vulnerable groups. Perhaps this is obvious when looking at examples like segregating public schools or redlining, where the federal government, local governments, and banks refused to offer lending opportunities to areas deemed to be a financial risk. But the legacy of inequitable processes and outcomes persists and can be exacerbated by decisions made in energy and energy-adjacent sectors. Energy access, energy affordability, health impacts from nearby industrial facilities, and utility service disruption caused by weather events overlap with existing under-resourced and historically excluded community boundaries.

For example, a study by the National Center for Children in Poverty shows that 44% of low-income households (under 200% of the federal poverty level) are energy insecure, or unable to meet their basic household heating, cooling and energy needs, compared to 2% of above low-income households.[21] 35% of Black households are energy insecure and 21% of Latino households, compared to 14% of white households. Renters are two and a half times more likely to be energy insecure than homeowners.

Additional research shows that low-income households in Minnesota use less energy but have a higher energy use intensity, which essentially is energy use by square foot. Researchers tracked household energy usage in St. Paul and found that the lowest-income households used 24 to 45% less energy but had a 27% higher energy use intensity.[22] Furthermore, the research team saw that an increase in non-white population is significantly correlated to higher energy use intensity.[23] This demonstrates that low-income households are doing all they can to use less energy and lower their utility bills, even to the point of sacrificing comfort, but the substandard quality of housing means these inefficient structures are leaking energy. Ultimately, the residents of St. Paul who are suffering most are people of color and low-income families, which directly demonstrates how equity and energy intersect in Minnesota.

Energy insecurity is not a siloed issue. Instead, a family's ability or inability to pay their energy bills is dependent on family income, housing quality, and access to energy efficiency and energy assistance, which in turn are shaped by job opportunities, educational opportunities, homeownership access, and more. The interconnection of these issues needs to be recognized by those who are designing policies. The energy system is not responsible for all of the root causes of all of these inequities, but those designing it and its evolution have a duty to be cognizant of the factors that have put some customers behind, in order to counteract or otherwise not exacerbate existing inequitable forces where possible.

---

[21] National Center for Children in Poverty, Energy Insecurity among Families with Children, academiccommons.columbia.edu/doi/10.7916/D89G5JX8

[22] Proceedings of the National Academy of Sciences, Measuring Social Equity in Urban Energy Use and Interventions Using Fine-scale Data, https://www.pnas.org/content/118/24/e2023554118

[23] Ibid.

Prioritizing equity in the beginning of electrification discussions enables us to learn from community members, avoid repeating past mistakes while ensuring people eventually subjected to the new policies and programs have a hand in designing them. The legacy of persisting structural racism and socioeconomic biases has created numerous inequities, many of which have continued to affect customers' interaction and participation in the energy system. Decisions made today will impact generations to come, especially in the energy sector where infrastructure and grid buildout and management require years of planning and decades of cost recovery. All should be able to access a clean, reliable, and resilient grid. Electrification is an opportunity to make progress toward that vision, and can potentially provide economic, environmental, and health benefits as well. But without consideration of how these benefits could equitably be deployed, it's possible that electrification can negatively impact communities that have already been left behind.

Electrification Action Plan

This paper emerged from the work of the Minnesota Electrification Action Plan, which was funded through a U.S. Department of Energy grant in the State Energy Program. The Action Plan, convened by the Minnesota Department of Commerce and their contractor, Michaels Energy, sought to study Minnesota's regulatory framework on electrification, as well as determine how electrification could contribute toward the state's carbon-reduction goals. Much of this work occurred through the Plan's Technical Advisory Committee (TAC). The TAC consisted of three workgroups: Metrics, Grid Impacts, and Technology. Equity was not the focus of any one workgroup, though participants in each group did articulate that equity needed to be a factor in electrification policies and outcomes.

Discussions of Equity within the TAC[24]

Metrics

The Metrics workgroup was tasked with determining how electrification's benefits and costs would fit into the state's current cost-effectiveness regulatory framework. The group coalesced around the idea that Minnesota's priorities in elevating electrification as a policy could guide the cost-effectiveness testing framework.

- If equity is a priority, there are ways to elevate equity in cost-effectiveness testing.
- Regulators can set up specific metrics that align with equity goals to track progress and focus efforts.
- Though more challenging to quantify, non-energy impacts (both costs and benefits) are important and warrant further research, especially if those impacts affect the low-income sector.
- Additional research is needed to understand and quantify non-energy impacts when considering the nexus of equity and affordability.

[24] Taken from a variety of presentations to the full TAC and its three workgroups. While some conversations happened informally in the workgroups, some presentations can be found here: michaelsenergy.com/electrification-action-plan/resources/

Grid Impacts

The Grid Impacts workgroup focused its conversations on how electrification will affect the grid. While mass electrification will add a considerable amount of demand to the grid, electrification can also bring flexibility and dispatchability. Ultimately load shifting, grid reliability, and pricing controls can have seen and unforeseen impacts on equity.

- Minnesota needs to have clear goals when it comes to electrification. If the state's goal is to reduce carbon (versus a goal of reducing peak demand or increasing indoor air quality), that goal will have unique impacts on the grid and equity.
- A wide array of grid-related decisions impact energy rates and costs for customers.
- Electrification will impact distribution systems (on both the electric and natural gas sides) which will have associated costs.
- It is critical to avoid creating under-investment in areas that are not electrifying first. For example, neighborhoods with high EV adoption rates may require additional substation upgrades, while electric infrastructure in under-resourced communities falls behind.

Technology

Lastly, the Technology workgroup discussed what electrification technologies are in the market, as well as what could be done to increase market share of these technologies. The workgroup acknowledged that equitable adoption of electrification technologies will require different strategies and approaches to help under-resourced communities access these technologies.

- Combining electrification technologies with other initiatives may help increase adoption.
- It is important to not add undue burdens, such as complicated participation requirements, to programs.
- Electrification does not guarantee cheaper costs. For under-resourced households, it will be important to consider reducing total operating costs as opposed to simply shifting the same costs.
- The clean energy workforce will need to adapt and grow in order to produce and disseminate these technologies. Policies and programs to stimulate this workforce can infuse equity into their deliverables.

While each workgroup touched on electrification's potential impact on equity, the workgroups did not solely focus on equitable processes and outcomes within an electrification framework. Creating an equitable pathway will require centering and prioritizing equity as opposed to siloing it. This paper hopes to present policymakers with considerations and recommendations on equitable electrification policies, but it is only meant to start the process. Reaching equitable outcomes will require continued and concerted efforts from lawmakers, regulators, utilities, and advocates.

Legal Framework of Electrification

Over the last few years, both customers and utilities have begun to explore how electrification programs can fit into their future plans. Each state has addressed electrification and fuel-switching differently: some states have passed laws to encourage (like Connecticut, with Public Act 18-50) or ban (South Carolina state code bans electrification through its energy efficiency programs, unless the customer receives their natural gas and electricity from the same provider) electrification, while others have relied on regulators to address the issue as it has arisen.[25] Michigan and Wisconsin have granted approval to individual utilities seeking to implement fuel-switching measures. Illinois' Technical Reference Manual, the document that codifies allowable energy savings measures, includes regulations for utilities to use if they use fuel-switching technologies like geothermal heat pumps, ductless heat pumps, and combined heat and power.[26,27] Other municipalities and states have considered outright bans on new natural gas infrastructure, with Berkeley, California being the first city to pass this regulation. The policy would expedite electrification by mandating new buildings be built all-electric. This kind of policy has received some traction in California and the Northeast, but it has also inspired some state legislatures to preemptively ban municipalities from banning new natural gas infrastructure.

Per a 2003 Department of Commerce (DOC) order, Minnesota utilities were not allowed to fuel-switch under the Conservation Improvement Program (CIP), which is the state's framework that guides utility energy efficiency programs.[28] Commerce issued this order to ensure CIP funds would be spent to advance energy efficiency as opposed to being used by utilities to build their customer and load base. A 2012 DOC order reaffirmed this regulation but allowed one exception: utilities could offer energy-saving fuel switching measures to low-income customers using CIP-exempt fuels, like those who use delivered fuels or are members of small municipal gas utilities.[29]

Despite none of the states in the Midwest having passed legislation to encourage electrification within the energy efficiency planning context prior to Minnesota, the Minnesota legislature worked for several years to find a legislative fix to this regulation for a few reasons. First, some legislators and advocates viewed the ban on fuel-switching (and therefor electrification) as an obstacle toward reducing emissions. And second, municipal and cooperative utilities had expressed challenges in meeting the required energy savings and asked for CIP to expand what programs and measures could count toward these requirements.

Seeking to resolve these issues, the Energy Conservation and Optimization (ECO) Act was first introduced in 2019 and passed and signed into law in May 2021. The ECO Act expands and modernizes the CIP framework to allow beneficial electrification in some situations. While ECO would allow electrification, it does not go so far as to incentivize it as the law prohibits the Public Utilities Commission (PUC) from approving a financial mechanism for electric utilities to encourage fuel-

---

[25] ACEEE, State Policies and Rules to Enable Beneficial Electrification in Buildings through Fuel Switching, aceee.org/sites/default/files/pdfs/fuel_switch_revised_5-14-20.pdf
[26] Ibid.
[27] In September 2021, Illinois passed legislation (SB2408) allowing electric utilities to offer customer electrification measures as part of their energy efficiency planning. The Climate and Equitable Jobs Act, at page 600-602.
[28] Division of Energy Resources, BTU Comparison in Cost-Benefit Analysis for the Conservation Improvement Program, Docket No. G008/CIP-00-864.07.
[29] Division of Energy Resources, CIP Policy Guidelines: Energy Savings from Delivered Fuels, mn.gov/commerce-stat/pdfs/conserve-prog-delivered-fuels.pdf

switching. But, ECO does grant regulatory flexibility to the state's consumer-owned utilities. Municipal and cooperative utilities still have to reach 1.5% in annual energy savings, but only .95% needs to come from traditional utility energy efficiency programs. The remaining .55% can come from energy savings achieved from beneficial electrification, which allows these municipal and cooperative utilities to find savings from more measures that were previously disallowed under CIP. On the investor-owned utility (IOU) side, gas IOUs can count energy savings from electrification programs to reach their 1% energy savings goal. Electric IOUs can only count savings from fuel-switching above their mandated 1.75% energy savings goal.

With the inclusion of electrification under ECO, it is likely that the state's utilities will begin to roll out electrification measures and programs. However, it is likely to start slowly, as ECO put guardrails in place to prevent a rush of electrification from happening immediately. Investor-owned utilities can only spend up to .35% of their gross operating revenue and consumer-owned utilities can spend up to .55% per year on fuel-switching improvements.

The ECO Act tasks the Department of Commerce with providing technical guidance on electrification measures. DOC will need to work with stakeholders to determine what kind of fuel-switching measures will be allowable under this new statutory framework. Additionally, DOC will need to determine baseline energy savings and cost-effectiveness scores that come from these fuel-switching measures that utilities can reference in future filings. Minnesota's legal framework on electrification is somewhat dependent on these forthcoming rules and guidelines, which are expected to be finalized in spring of 2022.

Working Framework of Equity

When considering how electrification policies should be grounded in equity, it's important to decide what an equitable vision looks like. Since 2000, the National Academy of Public Administration has defined social equity as: "The fair, just and equitable management of all institutions serving the public directly or by contract, and the fair and equitable distribution of public services, and implementation of public policy, and the commitment to promote fairness, justice, and equity in the formation of public policy."[30]

The New York City Panel on Climate Change sorts equity into three branches:

- **Distributive equity:** Emphasizes disparities across social groups, neighborhoods, and communities in vulnerability, adaptive capacity, and the outcomes of adaptation actions
- **Contextual equity:** Emphasizes social, economic, and political factors and processes that contribute to uneven vulnerability and shape adaptive capacity
- **Procedural equity:** Emphasizes the extent and robustness of public and community participation in planning and decision making[31]

And, in Minnesota, Fresh Energy, a St. Paul-based energy nonprofit, defines equity as elimination of barriers to full participation in the process, and access to the full benefits of the outcome.[32]

When considering equity in decisions and processes, it is especially important to lift up voices from communities that have historically been marginalized. In the energy and environmental spaces that includes environmental justice (EJ), low-income and rural communities.

The California Public Utilities Commission uses the following definition for environmental and social justice communities:

- Predominantly people of color or low-income
- Underrepresented in the policy-setting or decision-making process
- Subject to disproportionate impact from one or more environmental hazards
- Likely to experience disparate implementation of environmental regulations and socioeconomic investments in their communities.[33]

In the energy space, there are several metrics one could look at to determine if a person qualifies as low-income. Qualification for low-income programs may look at income compared to area median income or state median income. Per census data, 8.9% (approximately 500,000) of Minnesotans fall under the federal poverty line.[34] However, poverty is an imperfect definition that does not capture all

---

[30] National Academy of Public Administration, Standing Panel on Social Equity in Governance Issue Paper and Work Plan, napawash.org/aa_social_equity/papers_publications.html

[31] Annals of the New York Academy of Sciences, New York City Panel on Climate Change 2019 Report, Chapter 6: Community-Based Assessments of Adaption and Equity, https://doi.org/10.1111/nyas.14009

[32] Fresh Energy, Advancing Equity through Electrification [PowerPoint slides], michaelsenergy.com/wp-content/uploads/2020/09/Presentations-from-August-27-2020.pdf

[33] California Public Utilities Commission, Environmental and Social Justice Action Plan, cpuc.ca.gov/news-and-updates/newsroom/environmental-and-social-justice-action-plan

[34] U.S. Census Bureau, SAIPE State and County Estimates for 2019, census.gov/data/datasets/2019/demo/saipe/2019-state-and-county.html

populations that are struggling. The Regulatory Assistance Project takes a holistic look for their definition that is specifically relevant to this paper: "'Low income' may have a variety of meanings, but it is likely to describe consumers who lack the means — because of cost, access or other circumstances — to consider energy improvements such as electrified space and water heating."[35]

According to the Minnesota State Demographic Center, approximately 15% of Minnesotans live in small towns (with a population under 10,000) and remote rural areas, which equates to about 820,000 people.[36] The state's rural population has some overlap with its low-income population, as urban Minnesotans make on average $10,000 more annually than their rural, small town, and large town counterparts, and rural Minnesotans are more likely to live in poverty.[37] Importantly, many of the state's rural counties are losing population, as evident by the 2020 Census results.[38] That means rural electric cooperatives and small town municipal utilities are experiencing a reduction of its customer base which has ramifications on utility rates, infrastructure build-out, and more.

Collectively, these definitions provide a framework to help regulators, lawmakers, and advocates in prioritizing equity in policy making. Equity should not be a buzzword, nor should it be siloed within one department. Rather, equity requires continued and dedicated efforts from all to ensure those who will be impacted by a decision—especially when they are people who have historically been disenfranchised or have suffered from procedural, distributive, or contextual inequities in the past—can participate in the decision-making process and can reap the benefits from the process.

Efforts need to be made to recognize the compound factors of these inequities. While utilities and regulators will need to consider how to equitably deploy electrified technologies to EJ and low-income communities, one policy or program may not be the answer for all.

---

[35] Regulatory Assistance Project & Synapse, Renovating Regulation to Electrify Buildings: A Guide for the Handy Regulator, raponline.org/wp-content/uploads/2021/01/rap-shipley-hopkins-takahashi-farnsworth-renovating-regulation-electrify-buildings-2021-january.pdf

[36] Minnesota State Demographic Center, Greater Minnesota: Refined and Revisited, mn.gov/admin/assets/greater-mn-refined-and-revisited-msdc-jan2017_tcm36-273216.pdf

[37] Ibid.

[38] Minnesota State Demographic Center, State Demographic Center Data, mn.gov/admin/demography/data-by-topic/population-data/2020-decennial-census/redistricting/

Current Barriers to Electrification

Climate

Minnesota's cold climate is a factor in electrification. EV range has been found to be reduced in extreme temperatures, especially when the driver is utilizing either the air conditioning or heating functions. A recent study by the Norwegian Automobile Federation determined the average range loss due to cold weather, denoted below 32°F for this analysis, was about 20%.[39] Additionally, AAA determined that hot weather range loss, denoted above 90°F, averages around 17%.[40] By those metrics, Minnesota EV drivers would have approximately 181 days--170 cold, 11 hot--where they would see diminished range. Lower range means EVs would need more charges to reach the same amount of miles traveled. Those extra charges mean more electricity pulled from the grid and more operational costs for the drivers.

Additionally, air source heat pumps have historically lost efficiency once the temperature reaches extreme cold. This is especially relevant in Minnesota, which is mostly split between Climate Zone 6 (cold) and Climate Zone 7 (very cold).[41] Some recent research has demonstrated that the technology has matured and that heat pumps have the ability to perform in very cold temperatures, while other data has demonstrated the value of heat pumps even if a back-up system is required. RMI has collected research from a variety of field tests demonstrating that heat pumps, especially ground source heat pumps, can work in very cold temperatures.[42] Research from the Center for Energy and Environment shows that cold-climate air source heat pumps would especially make sense in Minnesota for delivered fuels customers, as they could maintain their propane furnaces for back-up heat. Propane customers could cut their energy costs in half and the state could see upwards of 2,600 GWh of fuel savings.[43] Additionally, heat pumps could also substantially benefit customers with inefficient electric resistance heating systems. However, most Minnesotans use natural gas systems for heating. Maintaining a natural gas furnace as back up would reduce the emissions and financial benefits heat pumps provide.

The cold climate also means weatherization of homes is critical, as poorly insulated homes will reduce the economic and environmental benefits of heat pumps. Low-income households tend to live in less efficient housing. Research shows that low-income households in St. Paul wait longer in the cold season to turn on their heating systems compared to the city's highest-income households.[44] Despite this, lower-income households in St. Paul have a considerably higher energy use intensity, using up to twice as much energy per square foot as high-income households.[45] Weatherization is a critical first step to

---

[39] Norwegian Automobile Federation, 20 Popular EVs Tested in Norwegian Winter Conditions, naf.no/elbil/aktuelt/elbiltest/ev-winter-range-test-2020/#qbrickVideo1a0723c0-00090201-04b09b31

[40] American Automobile Association, AAA Electric Vehicle Range Testing, aaa.com/AAA/common/AAR/files/AAA-Electric-Vehicle-Range-Testing-Report.pdf

[41] Office of Renewable Energy & Energy Efficiency, Climate Zone Map from IECC 2021, basc.pnnl.gov/images/climate-zone-map-iecc-2021

[42] RMI, Heat Pumps: A Practical Solution for Cold Climates, rmi.org/heat-pumps-a-practical-solution-for-cold-climates/

[43] Center for Energy and Environment, Turning Up the Heat on Cold Climate Heat Pumps: A Statewide Approach, mncee.org/sites/default/files/report-files/ACEEEccHP%20%282%29.pdf

[44] Proceedings of the National Academy of Sciences, Measuring Social Equity in Urban Energy Use and Interventions Using Fine-scale Data, https://www.pnas.org/content/118/24/e2023554118

[45] Ibid.

electrification, and it also will help make these homes safer and more comfortable in the extreme cold that Minnesota's winters can bring.

While Minnesota's cold climate will continue to be a factor in electrification deployment, ultimately many field tests demonstrate that heat pump technology is maturing and their ability to perform efficiently in cold climates will likely become less of an issue as time goes on. Colorado, Maine, and Massachusetts all consider heat pumps to be valuable toward achieving the climate goals,[46] and all three of those states have territory in Climate Zones 5, 6, or 7.[47] It is important to ensure heat pumps' effectiveness prior to installing them in Minnesota's most vulnerable communities, as low-income households have the least financial flexibility to pay for repairs if the heat pump were to fail.

Upfront Costs

Ultimately, the upfront cost of electrification technologies is currently too high for many, despite rebate programs offered outside the Midwest. In order to reduce the state's rural reliance on expensive and dirty fuel oil, Maine issued a statewide goal of installing 100,000 high-performance air source heat pumps by 2025.[48] Efficiency Maine estimates that after rebates, one indoor unit would cost $2,950 or $1,750 for an income-qualified home.[49] Using Efficiency Maine's loan option would mean those units cost $31 or $19 a month respectively. While that is relatively affordable, some homes will require two or more heat pumps, which could end up costing the customer between $6,300-6,500. The upfront costs to electrify may make more financial sense when a customer is replacing an appliance upon its failure, which is when the majority of consumers buy new furnaces and other appliances. Additionally, air source heat pumps have the ability to heat a home in the winter and cool a home in the summer, so cost comparisons should be between a heat pump and a furnace and air conditioner, which could further benefit the upfront cost calculus.

Electric vehicles are also considerably more expensive than gasoline-powered vehicles. While costs have come down in recent years, the average sticker price of an EV was $19,000 more than gasoline-powered vehicles as recently as mid-2020.[50] The promise of reduced operating and repair costs may not matter to a consumer if they cannot afford the monthly car payment. Acknowledging the more expensive sticker price, California's Clean Cars 4 All initiative has tried to make the upfront costs more manageable by targeting residents with low-incomes who are living in disadvantaged communities with rebates of up to $9,500 to purchase a new or used EV when the customer turns in their older gasoline-powered vehicle, though it's likely the upfront costs of EVs still may be too high for many families.[51]

High upfront costs mean that not everyone can be an early adopter of new technologies without targeted utility programming. Utilities and regulators need to work together to create programs that

---

[46] RMI, Heat Pumps: A Practical Solution for Cold Climates, rmi.org/heat-pumps-a-practical-solution-for-cold-climates/

[47] Office of Renewable Energy & Energy Efficiency, Climate Zone Map from IECC 2021, basc.pnnl.gov/images/climate-zone-map-iecc-2021

[48] An Act to Transform Maine's Heat Pump Market to Advance Economic Security and Climate Objectives, mainelegislature.org/legis/bills/bills_129th/billtexts/SP059701.asp

[49] Efficiency Maine, Heat Pumps, efficiencymaine.com/heat-pumps/

[50] Natural Resources Defense Council, Electric vs. Gas: Is It Cheaper to Drive an EV?, https://www.nrdc.org/stories/electric-vs-gas-it-cheaper-drive-ev

[51] California Air Resources Board, Clean Cars 4 All, https://ww3.arb.ca.gov/msprog/lct/vehiclescrap.htm

limit upfront costs so they are accessible and manageable for customers in all income classes. While long term bill savings are attractive, it is for naught if the upfront costs are high enough to turn away entire customer classes. Cost saving, not cost shifting, should be a paramount consideration. Additionally, electrification end uses like heat pumps require a home to be relatively efficient in order to reap the benefits of the efficient heat pump system. If it is up to customers to pay the upfront costs of those efficiency upgrades, those additional costs could push an electrified upgrade to unaffordable.

Education and Outreach

Electrification is a confusing and complicated topic that requires customer education. Electric vehicles have been in motion for decades, and customers have been able to see the transition from combustion engines to hybrids to zero emissions electric vehicles. Even with that, there is still anxiety and lack of awareness on EV range, charging infrastructure costs, and more. That uncertainty and confusion is even more apparent in residential, commercial, and industrial electrification. The average utility customer has likely not heard of electrification or seriously considered it for their property. Until 2021, it was not even an option for Minnesota utilities to encourage fuel switching in their CIP programs. Now that utilities are allowed to promote electrification programs, there will be a need to reach out and educate customers, which is important with any new technological advancement.

There is also an additional barrier for Minnesotans who rent: renters, who tend to be lower income and more often people of color than those who own their homes, often cannot access energy efficiency upgrades or electrification programs since they do not own their property or their unit's appliances and equipment. Property owners may not want to go through with the hassle of upgrades if they do not pay the utility bills and, thus, would not experience the financial benefit. This split incentive has complicated the delivery and access of energy efficiency programs and will continue to be a likely barrier for electrification.

Utilities and program implementers will also need to come to terms with customer preferences. Many customers like their gas appliances, especially gas ranges where customers value the control and speed of heat.[52] When municipalities in California were considering a ban on natural gas hookups, some of the opposition came from Asian communities who consider gas stoves critical for their impact on food's taste and texture.[53] Commercial and industrial customers may, too, be rooted in their current way of doing things. Even when the economics work out, industrial customers are inherently risk averse with tight profit margins and focus on operational safety and may be hesitant to switch fuels when there is a learning curve in operating and repairing the new equipment.[54]

That outreach and education is important for those who are responsible for marketing and installing the technologies. Contractors have been hesitant to recommend heat pumps to customers, or even present them as an option.[55] It will be critical for utilities to employ contractors who are knowledgeable about

---

[52] Lawrence Berkeley National Laboratory, Electrification of Buildings and Industry in the United States 2018, https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

[53] Marketplace, Chinese Restaurant Owners in California Fight for Gas Stoves, https://www.marketplace.org/2019/10/24/chinese-restaurant-owners-in-california-fight-for-gas-stoves/

[54] Lawrence Berkeley National Laboratory, Electrification of Buildings and Industry in the United States 2018, https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

[55] Center for Energy and Environment, Turning Up the Heat on Cold Climate Heat Pumps: A Statewide Approach, mncee.org/sites/default/files/report-files/ACEEEccHP%20%282%29.pdf

the technology when it makes sense for the customer. The energy efficiency industry has experienced some of these challenges. The average consumer does not think about energy efficiency, and many consumers may not see how energy efficiency can positively impact them. Minnesota utilities should take lessons learned through their low-income energy efficiency programs and apply them to future electrification programs. Partnering with community action agencies, demonstrating the programs' value to trusted community partners, lifting up success stories, and employing a workforce that is reflective of the community can help bridge the education gap and build trust between the utilities, contractors, and community members.

Benefits of Electrification

Health Benefits

Gas end uses emit toxic particles and contribute to poor indoor air quality. Roasting meat in a gas oven, for example, can emit 300 ppb of nitrogen dioxide (NO_2), far above the World Health Organization's recommended maximum of 106 ppb (over a one hour average).[56] Exposure to elevated levels of NO_2 can contribute to many negative health outcomes, especially in children, such as aggravated respiratory symptoms, changed lung function, increased risk of asthma, and cardiovascular effects.[57] In addition to NO_2, gas stoves can also release pollutants like particulate matter, carbon monoxide, and formaldehyde. Electrification of end uses can reduce the presence of these harmful pollutants and improve indoor air quality, so much so that a California study estimated that replacing all residential gas appliances would result in 354 less deaths and 900 less cases of acute and chronic bronchitis annually, equating to over $3.5 billion in health benefits.[58] Furthermore, lessening gas consumption would, in turn, lead to less gas production and distribution. Reducing these processes could lead to fewer methane leaks in the natural gas supply chain, which contribute to poor outdoor air quality and worsened lung function.

Equity Considerations

UCLA researchers have found that CO and NO_2 from gas cooking are found in higher concentrations in apartments, in part due to their smaller square footage and poorer ventilation.[59] It's known that renters are disproportionately low-income and people of color, so these populations are thus even more affected by the harmful pollutants from gas cooking. Additionally, the UCLA researchers pointed out that renters have less control over the type or quality of their appliances, meaning they may be using old, broken, or poorly maintained appliances that can intensify the problem.[60]

In addition to indoor air quality, a 2019 MPCA study showed that low-income and Black, Indigenous, and People of Color are disproportionately more likely to be near higher levels of air pollution. While 32% of Minnesota residents experience poor air quality, 46% of low-income Minnesotans and 91% of Black, Indigenous, and People of Color communities are above the risk guidelines for exposure.[61] Many of the sources that contribute toward the state's air pollutants—on road vehicles, industrial facilities, and home heating—are processes that can eventually be electrified. Electrifying end uses has environmental justice impacts (like improving said indoor and outdoor air quality) for communities who have long borne the brunt of the negative consequences of our industrial progress.

---

[56] RMI, Gas Stoves: Health and Air Quality Impacts and Solutions, rmi.org/insight/gas-stoves-pollution-health/

[57] Ibid.

[58] UCLA Fielding School of Public Health and Sierra Club, Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California, ucla.app.box.com/s/xyzt8jc1ixnetiv0269qe704wu0ihif7

[59] Ibid.

[60] Ibid.

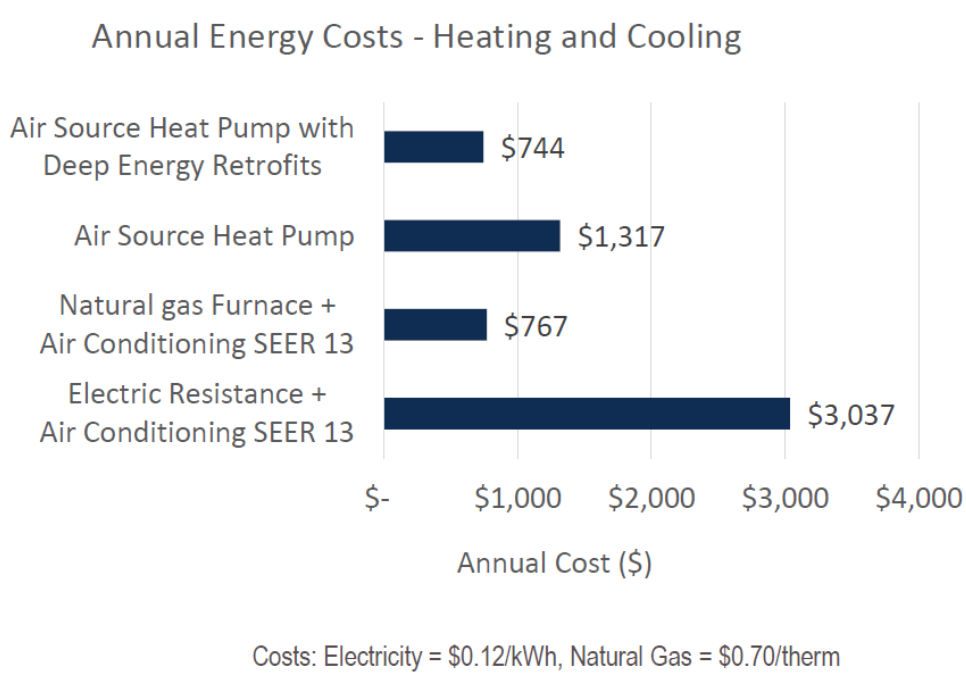
[61] Minnesota Pollution Control Agency, The Air We Breathe: The State of Minnesota's Air Quality 2019, pca.state.mn.us/sites/default/files/lraq-1sy19.pdf

Bill Savings

Saving money will be one primary reason customers seek to electrify end uses. It is important to note that not all electrification technologies will make financial sense in all situations. As discussed, Minnesota's cold climate could present challenges to electrifying space heating. As technologies mature, it is likely that electrification of more end uses in more situations will save customers money. Initial research demonstrates the cost-benefit analysis of electrification is improved when electrification is paired with energy efficiency retrofits.[62] Together with efficiency, electrification could be used as a tool to mitigate energy burden for households most negatively impacted by it.

As mentioned, the upfront costs of purchasing electrified technologies can be out of reach for many customers. However, when installed, heat pumps and other electrified appliances have the ability to reduce customer bills, especially when they are replacing inefficient technologies. Figure 2 shows data from the Center for Energy and Environment. Upgrading to an air source heat pump will cost more to run on an annual basis when compared to a natural gas furnace with a SEER 13 air conditioner. However, there are substantial energy savings to be had when upgrading from an electric resistance heating system or when pairing a heat pump with deep energy retrofits, though deep energy retrofits would also increase the efficiency of a natural gas furnace as well.

Figure 2. The Importance of Deep Energy Retrofits (CEE)[63]



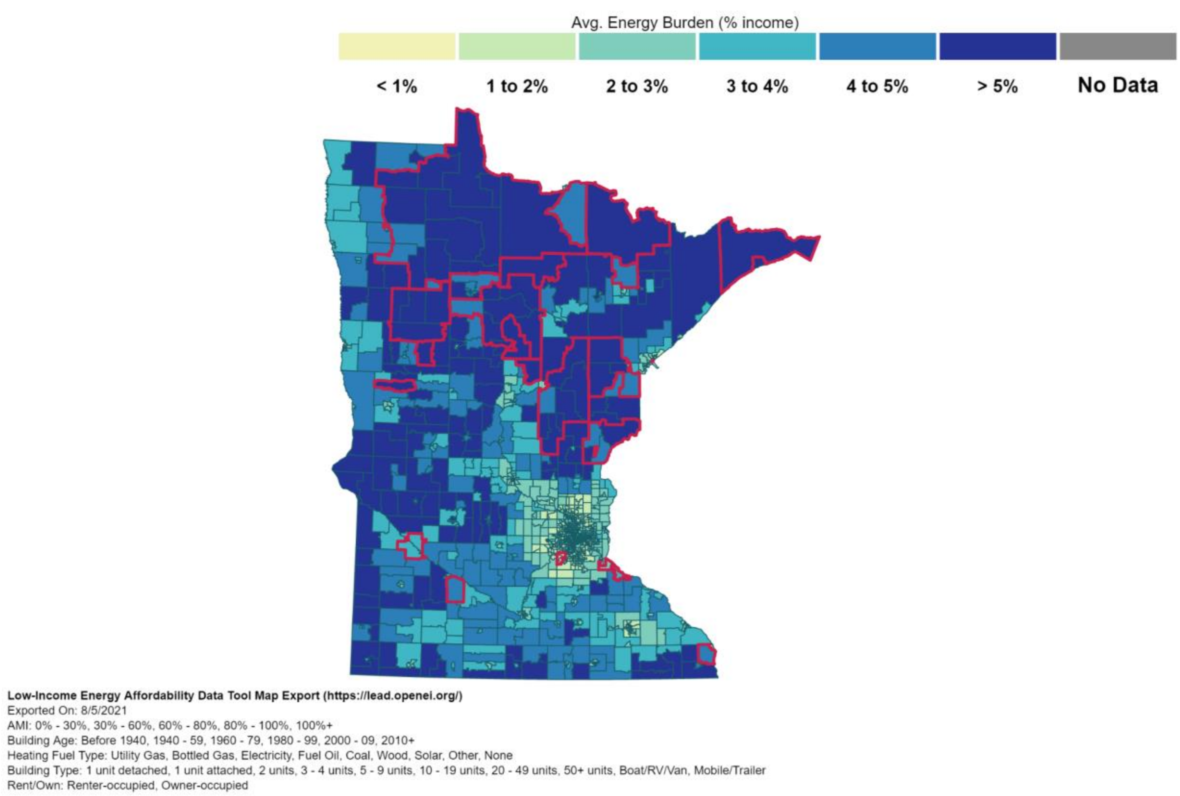
[62] Center for Energy and Environment, Minnesota's Electrification Action Plan [PowerPoint slides], michaelsenergy.com/wp-content/uploads/2020/09/Presentations-from-August-27-2020.pdf

[63] Ibid.

Equity Considerations

Electrification's potential as a tool to help save customers money on their utility bills could positively impact families that are struggling with energy burden. ACEEE defines households with high energy burden as those who spend more than 6% of their income on their electricity and heating costs.[64] Figure 3 shows the average energy burden in Minnesota as a percentage of income. The areas outlined in red are tribal areas. The map demonstrates that customers in much of the state are burdened by high energy bills. The ACEEE report finds that there are many households in Minneapolis that are suffering from high energy bills: 50% of low-income households in Minneapolis have an energy burden greater than 6.6% and 25% of low-income households have a burden greater than 12.2%.[65] Figure 3 demonstrates that energy burden is truly a statewide issue. Many rural customers in Greater Minnesota suffer from high energy burdens, and nearly all of the tribal areas have average energy burdens greater than 5%.

Figure 3. Energy Burden in Minnesota (LEAD Tool)[66]



Families who are suffering from high energy burden disproportionately live in substandard housing and older buildings. Weatherization and energy efficiency measures are two ways to help families substantially alleviate their burden. The ACEEE report makes three key recommendations to improve

[64] American Council for an Energy Efficient Economy, How High are Residential Energy Burdens?, aceee.org/sites/default/files/pdfs/u2006.pdf

[65] Ibid.

[66] Office of Renewable Energy & Energy Efficiency, Low-Income Energy Affordability Data (LEAD) Tool, energy.gov/eere/slsc/maps/lead-tool

these programs to better serve the most burdened families: design programs to meet the needs of highly burdened communities, ramp-up investment in low-income housing retrofits, energy efficiency and weatherization, and improve program design, delivery, and evaluation through best practices and community engagement.[67] Electrification could be a part of the solution if paired with additional programs to help low-income families. As Figure 2 demonstrates, electrification has the potential to save customers money when it is paired with deep energy efficiency.

The ECO Act presents an opportunity for utilities. Not only does the Act allow for efficient fuel-switching as previously discussed, it also increases the amount of money utilities must spend on low-income energy efficiency programming. Additionally, ECO allows utilities to spend up to 15% of their low-income energy efficiency budget on pre-weatherization measures, to address health and safety walk away issues. This new regulatory framework could be an opportunity for utilities to braid their programs and target low-income households with pre-weatherization, energy efficiency, and electrification when the situations are cost-effective and save customers money.

Grid Flexibility

While mass electrification will require additional load to meet the forecasted increased electric demand, electric end uses will also provide benefits to both the customer and the utility if the flexibility of these end uses is harnessed effectively. Encouraging usage of electric end uses in low demand periods or in periods with high renewable generation can intensify the economic and environmental benefits of the fuel-switching measure. An electric water heater, for example, could be programmed to heat water in off-peak times as opposed to high demand periods, which would provide customers with bill savings and utilities with load-shifting flexibility. Utilizing electric end uses as storage can potentially help prevent or ease grid stress during a peak demand time or outage.[68] As extreme weather events become more common and intense, the grid is likely to experience more strain. While reducing usage cannot remedy all of the energy system's vulnerabilities in the face of climate change, the ability to shift usage of electrified end uses to off peak times can relieve grid strain and, in turn, build resiliency.[69]

Equity Considerations

Equity needs to be considered in order for all customers to be able to reap the benefits, not just regulators and utilities. A *Nature Energy* study conducted by Lee V. White and Nicole D. Sintov found that when a Southwestern utility implemented time-of-use (TOU) rates, certain vulnerable communities suffered from higher bills than their non-vulnerable counterparts.[70] In this study, households were considered vulnerable if their residents were low-income, elderly, young children, disabled, Hispanic, or African American. The study concluded that vulnerable households, especially disabled and elderly households, had a statistically significant increase in bills during the time of use pilot, in part because

[67] American Council for an Energy Efficient Economy, How High are Residential Energy Burdens?, aceee.org/sites/default/files/pdfs/u2006.pdf

[68] Lawrence Berkeley National Laboratory, Electrification of Buildings and Industry in the United States 2018, https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

[69] U.S. Department of Energy, U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather, energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf

[70] Nature Energy, Varied Health and Financial Impacts of Time-of-use Energy Rates across Sociodemographic Groups Raise Equity Concerns, nature.com/articles/s41560-019-0515-y.pdf

those vulnerable households are less able to change when they consume energy. The authors conclude that: “These results suggest that time-of-use rates may increase hardships faced by some groups already more likely to face energy poverty, but impacts vary by sociodemographic group and rate design.”[71]

The Environmental Defense Fund believes there is a way for a utility to implement a TOU while considering the unique needs of its varied customer base. In a blog post, the organization recommends that utilities consider:

- Bill protection- guarantee that customers in TOU programs don’t pay more than they would have under their normal rate by instituting refunds if they pay more
- Weatherization- ensure that customers entering in TOU rates have access to weatherization and other energy efficiency programs in order to help customers not waste energy during peak hours under their TOU rates
- Marketing, education, and outreach- educate customers on what TOU rates are and how they can use them to their benefit prior to enrolling customers
- Rates and times- make off-peak prices substantially lower than peak prices to motivate customers to shift behaviors, and ensure that off-peak windows are wide enough to be used
- Opt-Out- allow customers to opt-out if they find that the program does not work for them[72]

TOU rates are not the only regulatory mechanism that will see increased adoption in an electrified world, but these considerations should serve as examples to regulators and utility policymakers on how equity should fit into the conversation. Electrification has potential to help alleviate stress in the energy system, and those who electrify end uses should access the benefits of that.

[71] Ibid.
[72] Environmental Defense Fund, How We Can Make Time of Use Pricing Work for Everyone, blogs.edf.org/markets/2020/03/09/how-we-can-make-time-of-use-pricing-work-for-everyone/

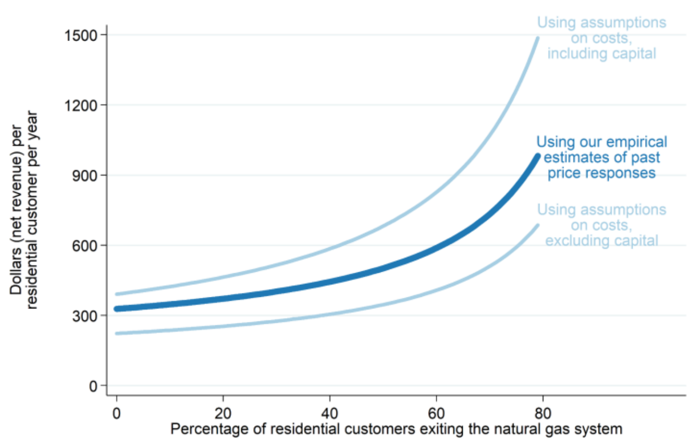
Unintended Consequences of Electrification

Stranded Assets

While some advocates have used the future expansion of electrification as an argument against expanding natural gas infrastructure, the fact remains that a significant amount of natural gas infrastructure has been built out in the 21st century, and the cost of those capital improvements will continue to be paid for by ratepayers. Over the last two decades, states and municipalities have begun committing to greenhouse gas reduction goals, many of which aim to reach carbon neutrality by mid-century. As mentioned, Minnesota's Next Generation Climate Act of 2007 seeks to reduce the state's GHG emissions by 80% between 2005 and 2050. However, natural gas utilities throughout the country have continued to upgrade or build out new gas infrastructure like replacement mains and service extension lines. This infrastructure is built to last upwards of several decades, and regulators and natural gas utilities have historically spread out the costs of these investments over decades to make the upgrades affordable for customers.[73] Considering Minnesota's climate goals, it is possible, if not likely, that recent and future natural gas infrastructure will become stranded assets prior to the state's mid-century decarbonization goals.

Advocates fear that electrification can bring on the so-called "death spiral" in which a portion of customers electrify and leave the rolls of the natural gas utility and then the natural gas utility raises rates in response to compensate for this customer loss. Thus, higher rates motivate more customers to leave the natural gas utility and fewer customers are left to pay higher and higher rates. A recent working paper from the Energy Institute at Haas determined that a 15% reduction in natural gas customers would lead to an approximate $30 annual increase in bills for the remaining utility customers. However, if that jumped to a 90% reduction in customers, the remaining customers could see a $1,500 increase in their annual bills.[74]

Figure 4. Utility Bills Rise Non-Linearly with Customer Exit (Energy Institute at Haas)[75]



[73] Gridworks, California Gas System in Transition: Equitable, Affordable, Decarbonized and Smaller, gridworks.org/wp-content/uploads/2019/09/CA_Gas_System_in_Transition.pdf

[74] Energy Institute at Haas, Who Will Pay for Legacy Utility Costs?, haas.berkeley.edu/wp-content/uploads/WP317.pdf

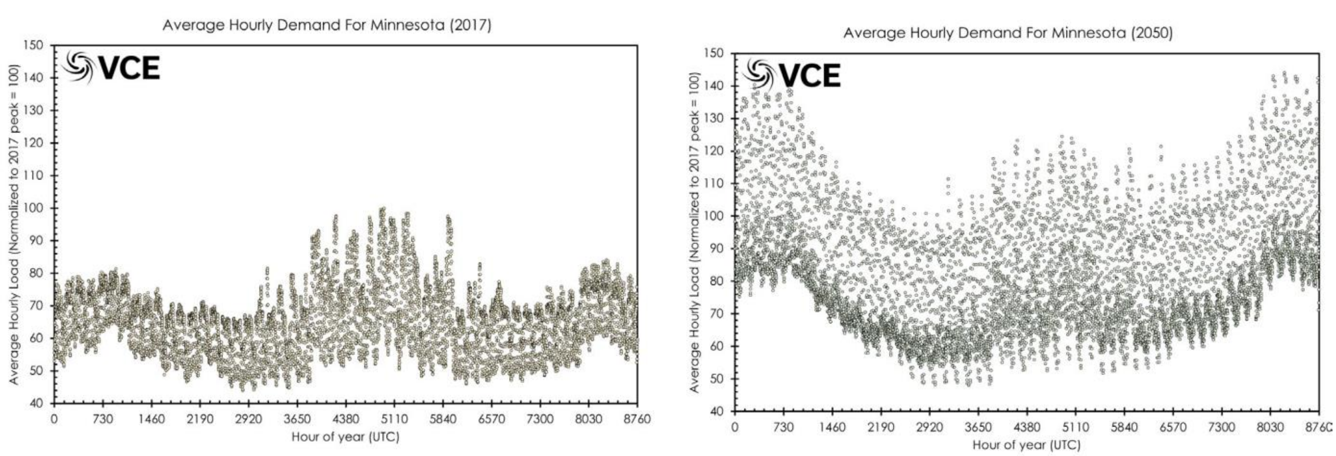
[75] Ibid.

This, of course, has tremendous implications on equity, as those customers who are left on the natural gas rolls are those who cannot afford to electrify, and, in turn, are the least likely to be able to absorb rate increases. Minimizing new natural gas infrastructure, allowing for securitization, and adjusting depreciation schedules for gas infrastructure are possible considerations for regulators as this issue begins to arise. The Energy Institute at Haas paper lists a few more potential policies to consider: electrify entire communities that are in the priority queue for infrastructure replacement to reduce capital costs, consider charging exit fees for customers leaving the natural gas utility, and/or shift costs to shareholders or the entire taxpayer base.[76] Ultimately, the goal should be preventing the most vulnerable communities from bearing the costs of electrification. Special attention needs to be paid to improve access to electrification programs to those who cannot afford the upfront costs and to consider how future gas rate hikes impact the most vulnerable communities.

Increased Demand

As more Minnesotans electrify end uses, the state's electricity demand will also increase. With natural gas and other non-electric fuel usage lessening as electrification increases, electricity's share of total energy usage will grow from 21% in 2015 to potentially 47% in 2050.[77] Put another way, widespread electrification of industry, buildings and transportation could push electricity demand up by 52% come 2050, even when including substantial energy efficiency in the model.[78] Minnesota's peak electricity usage is currently slightly higher in the summer than in the winter. However, widespread electrification would change that. In large part due to grid demands from electric heating systems, Minnesota would experience a winter peak, which could be approximately double Minnesota's current summer peak according to estimates from the Electric Power Research Institute.[79] Figure 5 is from a 2018 Vibrant Clean Energy report that demonstrates what usage could look like come 2050.

Figure 5. Minnesota's Average Hourly Demand, 2017 to 2050 Comparison (VCE)[80]



[76] Ibid.

[77] Electric Power Research Institute, Efficient Electrification: Opportunities and Challenges [PowerPoint slides], michaelsenergy.com/wp-content/uploads/2020/01/Keynote-Tom-Wilson-EPRI.pdf

[78] Ibid.

[79] Ibid.

[80] Vibrant Clean Energy, Minnesota's Smarter Grid, mcknight.org/wp-content/uploads/Minnesotas-SmarterGrid_FullReport_NewFormat.pdf

Minnesota needs to begin preparing for this tremendous amount of load growth that electrification will demand of the grid. Additionally, regulators and utilities need to prepare for this grid strain in light of a changing climate where Minnesota is more likely to experience extreme weather that could lead to power outages. While many natural gas-powered furnaces require electricity to start, converting the 1.47 million residential housing units[81] to all electric furnaces will require a great deal more electric demand than the current demand of natural gas-powered furnaces. Texas, where 61% of households use electricity for home heating, saw a peak demand of 69 gigawatts[82] during the record-breaking cold snap of 2021, which led to forced outages of 28 gigawatts.[83] While high demand was not the only contributing factor, power outages led to millions of households without heat, with hundreds of people dying in the extreme temperatures.

Electrifying more end uses means that people will rely upon the electricity system even more and stand to be more negatively impacted by outages. A recent analysis of the Texas freeze using satellite data of the census block groups showed that areas with a high share of minority populations were more than four times as likely to experience a blackout than majority white populations.[84] Power outages, along with supply issues and shut-offs, are a component of energy insecurity.[85] Energy insecurity disproportionately affects low-income families, people of color, people in poor health, and families in substandard housing.[86] These are also the populations who are the least able to weather power outages: people in poor health are disproportionately reliant on electricity for medical equipment and medication storage, and low-income families are the least able to afford new food or alternative housing costs. And, most consequentially, power outages historically have led to higher rates of mortality.[87] Causes of death range from hypothermia due to lack of heat, food poisoning from spoiled unrefrigerated food, and carbon monoxide poisoning from incorrect usage of generators or other equipment.[88] Analysis by the *Houston Chronicle* showed that 74% of the deaths from the Texas freeze and blackout were people of color.[89]

Building resiliency into the energy system is critical in order to avoid these negative outcomes. Between a massive ramp up in grid demand and the increase of extreme weather events, Minnesota regulators and utilities need to be prepared to mitigate outages and energy insecurity that has been proven to disproportionately affect people of color, low-income families, the elderly, and people in poor health.

---

[81] U.S. Census Bureau, House Heating Fuel, data.census.gov/cedsci/table?q=house%20heating%20fuel&g=0100000US.04000.001&tid=ACSDT1Y2019.B25040&hidePreview=false

[82] Electric Reliability Council of Texas, 2021 ERCOT Hourly Load Data, ercot.com/gridinfo/load/load_hist

[83] Energy Institute at Haas, The Texas Power Crisis, New Home Construction, and Electric Heating, energyathaas.wordpress.com/2021/02/22/the-texas-power-crisis-new-home-construction-and-electric-heating/

[84] Rockefeller Foundation, Frozen Out in Texas: Blackouts and Inequity, rockefellerfoundation.org/case-study/frozen-out-in-texas-blackouts-and-inequity/

[85] Frontiers in Public Health, Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature, frontiersin.org/articles/10.3389/fpubh.2019.00357/full

[86] Ibid.

[87] Epidemiology, Lights Out: Impact of the August 2003 Power Outage, journals.lww.com/epidem/Fulltext/2012/03000Lights_Out__Impact_of_the_August_2003_Power_Outage.3.aspx

[88] Ibid.

[89] Houston Chronicle, Analysis Reveals Nearly 200 Died in Texas Cold Storm and Blackouts, Almost Double the Official Count, houstonchronicle.com/news/houston-texas/houston/article/texas-cold-storm-200-died-analysis-winter-freeze-16070470.php

Conclusions and Recommendations

Leading Practices

Impacted communities and advocates have been thinking for years about the opportunities and challenges electrification may bring. For policymakers, ensuring an equitable process begins with learning from and listening to the community.

The Greenlining Institute and Energy Efficiency For All released a report, "Equitable Building Electrification: A Framework for Powering Resilient Communities," in September 2019 which sought to study the potential impacts electrification could have on environmental and social justice communities in California. In this report, the writers establish a framework to center impacted communities in the electrification process and its outcome:

- Assess community needs, identify indicators and set goals
- Establish community-led decision making
- Develop metrics and plan for tracking
- Ensure funding and program leveraging
- Improve outcomes[90]

Gridworks' 2019 paper, "California Gas System in Transition: Equitable, Affordable, Decarbonized and Smaller," studied California's current gas system and tried to understand how this system will be impacted by the state's decarbonization goals. Electrification and decarbonization will bring challenges: without careful planning, natural gas rates can increase from the current $1.50 per therm to $19 per therm, further exacerbating energy burden for the state's poorest.[91] The paper's authors then describe the "prudent path," laying out the following recommendations for policymakers to consider to ensure equity is a part of electrification decisions:

- Initiate interagency, integrated long-term planning for gas demand, infrastructure, and the transition of the delivery system.
- Consider requiring all new residential and commercial construction to be all-electric as quickly as possible, to mitigate future stranded gas infrastructure costs and to avoid committing to decades of future GHG emissions from gas combustion in buildings. Consider elimination of gas line extension allowances as a first step in that direction.
- Identify alternatives to significant new investments in the gas delivery system, not otherwise needed to maintain system safety and reliability, such as electrifying neighborhoods to avoid replacing aging gas infrastructure or downrating local transmission lines to distribution by reducing the pressure.
- Anticipate and organize a just transition for the gas delivery system workforce and any corresponding support services, such as customer service center staff and "call before you dig" workers.

---

[90] The Greenlining Institute and Energy Efficiency for All, Equitable Building Electrification: A Framework for Powering Resilient Communities, greenlining.org/wp-content/uploads/2019/10/Greenlining_EquitableElectrification_Report_2019_WEB.pdf

[91] Gridworks, California Gas System in Transition: Equitable, Affordable, Decarbonized and Smaller, gridworks.org/wp-content/uploads/2019/09/CA_Gas_System_in_Transition.pdf

- Develop a comprehensive strategy to ensure low-income and disadvantaged communities are empowered through, benefit from, and are not left behind in the transition
- Clarify that a gas utility's "obligation to serve" could be met with alternative fuels when doing so would avoid significant future investments in the gas system, reducing costs for all gas customers.
- Consider aligning financial recovery of new gas infrastructure investments with the time horizons determined in the integrated long-term gas infrastructure plan, and adjust depreciation schedules for existing assets to better reflect actual "useful life" in light of changes resulting from California's decarbonization goals. Consider securitization to mitigate the upfront rate impacts of faster depreciation schedules and ultimate decommissioning costs. These financial tools should include protections that ensure that the bills of low-income customers will not increase.
- Consider ratemaking adjustments such as the following to cushion the impact of the transition on customers, particularly low-income customers
- Explore external funding sources to recover gas transition costs from sources beyond gas utility customers, such as the electric customers who benefit from increased electric load and taxpayers more broadly.[92]

And, the Urban Sustainability Directors Network, in collaboration with the Emerald Cities Collaborative, the American Climate Cities Challenge and Upright Consulting, released a set of guiding principles for equitable electrification in its 2021 report, "Equity and Buildings: A Practical Framework for Local Government Decision Makers." These principles were informed by the authors' advisory committee, which included local governments, NAACP, Partnership for Southern Equity and many more organizations. The twelve principles of practice include:

- Make impacted communities central to planning and projects.
- Collaborate across departments and disciplines to produce policies and programs that better address equity issues.
- Shift funding and financing structures to directly support increased capacity in impacted communities.
- Prioritize making economic opportunities work for marginalized communities- policies or programs should set job creation and wealth building as explicit goals.
- Lay a foundation of equitable decision-making processes and transparent accountability measures.
- Tie success directly to equity- develop and track meaningful equity metrics to be used alongside traditional environmental indicators.[93]

Collectively these authors' recommendations can give decision makers a roadmap on how to equitably approach decisions on electrification.

[92] Ibid.

[93] Urban Sustainability Directors Network, Equity and Buildings: A Practical Framework for Local Government Decision Makers, usdn.org/uploads/cms/documents/usdn_equity_and_buildings_framework_-_june_2021.pdf

Conclusion

Referring back to the New York City Panel on Climate Change, it could be useful to consider how decisions around electrification could be rooted in distributive, contextual and procedural equity. Distributive equity asks us to think about how resources have and will be allocated. Using this lens, it is necessary for energy sector policymakers recognize the historical inequities in the system. It is imperative that electrification measures do not further burden people of color, low-income communities, the elderly, or people in poor health. Understanding how grid demand can lead to outages in areas with poor energy infrastructure or how rate design can exacerbate energy burden for low-income families are ways for those in power to apply distributive equity. Contextual equity challenges us to understand how socioeconomic and political factors have led to existing inequity. It is paramount to utilize this understanding to ensure that these mistakes are not repeated. Ultimately, those factors contributed to past inequity, and we need to consider that context going forward. Procedural equity requires us to think about how we can infuse equity into the process, not just the outcome. In electrification policy decisions, it will be important to educate and then hear from the community to understand how decisions could impact vulnerable and disadvantaged communities. This will require upfront education, expansion of access to processes like stakeholder meetings and utility dockets, and engagement with community leaders. Equity should not be a buzzword; rather, procedural equity should push us to holistically understand existing disparity and engage the community to prevent further inequity.

Utilities, regulators, and policymakers must ensure the planning for an electrified future is equitable. That means we must assess potential impacts, undo inequities when possible and center the solutions and concerns of communities in policies and programs. At the very least, it is our duty to do no further harm and exacerbate existing inequities. But with thoughtful planning, it is possible to utilize electrification as a way to create a more equitable energy system.

References

American Automotive Association. (2019, February). *AAA Electric Vehicle Range Testing.* https://www.aaa.com/AAA/common/AAR/files/AAA-Electric-Vehicle-Range-Testing-Report.pdf

American Council for an Energy-Efficient Economy. (2020, May 14). *Policy Brief: State Policies and Rules to Enable Beneficial Electrification in Buildings through Fuel Switching.* https://www.aceee.org/sites/default/files/pdfs/fuel_switch_revised_5-14-20.pdf

An Act To Transform Maine's Heat Pump Market To Advance Economic Security and Climate Objectives. Sec. 6. 35-A Maine Revised Statutes §10119 (2019). https://www.mainelegislature.org/legis/bills/bills_129th/billtexts/SP059701.asp

Anderson, G.B. & Bell, M.L. (2012, March). Lights Out: Impact of the August 2003 Power Outage on Mortality in New York, NY. *Epidemiology, 23*(2), 189-193. https://journals.lww.com/epidem/Fulltext/2012/03000/Lights_Out__Impact_of_the_August_2003_Power_Outage.3.aspx

California Air Resources Board. (2019). *Clean Cars 4 All.* https://ww3.arb.ca.gov/msprog/lct/vehiclescrap.htm

California Public Utilities Commission. (2019, February 21). *Environmental and Social Justice Action Plan (version 1.0).* https://www.cpuc.ca.gov/news-and-updates/newsroom/environmental-and-social-justice-action-plan

Carvallo, J.P., Hsu, F.C., Shah, Z., & Taneja, J. (2021, April 14). *Frozen Out in Texas: Blackouts and Inequity.* The Rockefeller Foundation. https://www.rockefellerfoundation.org/case-study/frozen-out-in-texas-blackouts-and-inequity/

Char, F., Hawkins, A., & Sullivan, D. (2021, March 17). *Greenhouse Gas Emissions Inventory 2005-2018* (Document No. lraq-1sy21). Minnesota Pollution Control Agency and Department of Commerce. https://www.pca.state.mn.us/sites/default/files/lraq-1sy21.pdf

Davis, L. (2021, February 22). *The Texas Power Crisis, New Home Construction, and Electric Heating*. Energy Institute at Haas School of Business at University of California, Berkeley. https://energyathaas.wordpress.com/2021/02/22/the-texas-power-crisis-new-home-construction-and-electric-heating/

Davis, L. & Hausman, C. (2021, July). *Who Will Pay for Legacy Utility Costs?*. Energy Institute at Haas School of Business at University of California, Berkeley. https://haas.berkeley.edu/wp-content/uploads/WP317.pdf

Deason, J., Wei, M., Leventis, G., Smith, S., & Schwartz, L. (2018, March). *Electrification of Buildings and Industry in the United States: Drivers, Barriers, Prospects, and Policy Approaches.* Lawrence Berkeley National Laboratory. https://eta-publications.lbl.gov/sites/default/files/electrification_of_buildings_and_industry_final_0.pdf

Despart, Z., Serrano, A., & Lamm, S. (2021, April 1). Analysis Reveals Nearly 200 Died in Texas Cold Storm and Blackouts, Almost Double the Official Count. *Houston Chronicle.*

https://www.houstonchronicle.com/news/houston-texas/houston/article/texas-cold-storm-200-died-analysis-winter-freeze-16070470.php

Division of Energy Resources. (2012, August 3). *CIP Policy Guidelines: Energy Savings from Delivered Fuels.* Minnesota Department of Commerce. https://mn.gov/commerce-stat/pdfs/conserve-prog-delivered-fuels.pdf

Division of Energy Resources. (2003, October 29). *BTU Comparison in Cost-Benefit Analysis for the Conservation Improvement Program.* Docket No. G008/CIP-00-864.07. Minnesota Department of Commerce. https://www.edockets.state.mn.us/EFiling/edockets/searchDocuments.do?method=eDocketsResult&userType=public#{91D0666E-94D4-4118-B337-00C07DD4FA9F}

Drehobl, A., Ross, L., & Ayala, R. (2020). *How High are Household Energy Burdens?.* American Council for an Energy-Efficient Economy. https://www.aceee.org/research-report/u2006

Edwards, Jenny. (2020, August 27). *Minnesota's Electrification Action Plan* [PowerPoint slides]. Center for Energy and Environment. https://michaelsenergy.com/wp-content/uploads/2020/09/Presentations-from-August-27-2020.pdf

Efficiency Maine. (2021). *Heat Pumps.* https://www.efficiencymaine.com/heat-pumps/

Electric Power Research Institute. (2018, April). *U.S. National Electrification Assessment.* https://ipu.msu.edu/wp-content/uploads/2018/04/EPRI-Electrification-Report-2018.pdf

Electric Reliability Council of Texas. (2021, July 9). *2021 Hourly Load Data.* http://www.ercot.com/gridinfo/load/load_hist

Energy Conservation and Optimization Act of 2021. Sec. 2. Minnesota Statutes §216B.2401 *et seq.* (2021). https://www.revisor.mn.gov/laws/2021/0/Session+Law/Chapter/29/

Foster, S., Leichenko, R., Nguyen, K.H., Blake, R., Kunreuther, H., Madajewicz, M., Petkova, E.P., Zimmerman, R., Corbin-Mark, C., Yeampierre, E., Tovar, A., Herrera, C., & Ravenborg, D. (2019, March). New York City Panel on Climate Change 2019 Report, Chapter 6: Community-Based Assessments of Adaptation and Equity. *Annals of the New York Academy of Sciences 1439* (1), 126-173. https://doi.org/10.1111/nyas.14009

Gartman, M. & Shah, A. (2020, December 10). *Heat Pumps: A Practical Solution for Cold Climates*. RMI. https://rmi.org/heat-pumps-a-practical-solution-for-cold-climates/

Gridworks. (2019, September). *California's Gas System in Transition: Equitable, Affordable, Decarbonized, and Smaller.* https://gridworks.org/wp-content/uploads/2019/09/CA_Gas_System_in_Transition.pdf

Hays, J., Toloui, M., Rattu, M., & Wright, K. (2021, June). *Equity and Buildings: A Practical Framework for Local Government Decision Makers.* Urban Sustainability Directors Network, American Cities Climate Challenge, Emerald Cities Collaborative, & Upright Consulting Services. https://www.usdn.org/uploads/cms/documents/usdn_equity_and_buildings_framework_-_june_2021.pdf

Hernandez, D., Aratani, Y., & Jiang Y. (2014, June 13). *Energy Insecurity among Families with Children.* National Center for Children in Poverty, Columbia University. https://academiccommons.columbia.edu/doi/10.7916/D89G5JX8

Huang, J. (2019, October 24). *Chinese Restaurant Owners in California Fight for Gas Stoves*. Marketplace. https://www.marketplace.org/2019/10/24/chinese-restaurant-owners-in-california-fight-for-gas-stoves/

Jessel, S., Sawyer, S., & Hernandez, D. (2019, December 12). Energy, Poverty, and Health in Climate Change: A Comprehensive Review of an Emerging Literature. *Frontiers in Public Health 7* (1). https://www.frontiersin.org/articles/10.3389/fpubh.2019.00357/full#h1

McPherson, E., Smith, I., & Nelson, C. (2020, August 24). *Turning Up the Heat on Cold Climate Heat Pumps: A Statewide Approach.* Center for Energy and Environment. https://www.mncee.org/sites/default/files/report-files/ACEEEccHP%20%282%29.pdf

Miller, C., Chen, S., Hu, L., & Sevier, I. (2019, September 30). *Equitable Building Electrification: A Framework for Powering Resilient Communities.* The Greenlining Institute and Energy Efficiency For All. https://greenlining.org/wp-content/uploads/2019/10/Greenlining_EquitableElectrification_Report_2019_WEB.pdf

Minnesota Pollution Control Agency. (2020). *Volkswagen settlement: Minnesota's plan.* https://www.pca.state.mn.us/air/minnesotas-plan

Minnesota Pollution Control Agency. (2020). *About Clean Cars Minnesota.* https://www.pca.state.mn.us/air/about-clean-cars-minnesota

Minnesota Pollution Control Agency. (2019, September 30). *Request for Comments On Planned New Rules Governing Passenger Vehicle Greenhouse Gas Emissions, Minnesota Rules, chapter 7023; Revisor's ID Number 04626*. https://www.pca.state.mn.us/sites/default/files/aq-rule4-10a.pdf

Minnesota State Demographic Center. (2017, January). *Greater Minnesota: Refined and Revisited.* Minnesota Department of Administration. https://mn.gov/admin/assets/greater-mn-refined-and-revisited-msdc-jan2017_tcm36-273216.pdf

Minnesota State Demographic Center. (2021). *State Demographic Center Data*. Minnesota Department of Administration. https://mn.gov/admin/demography/data-by-topic/population-data/2020-decennial-census/redistricting

National Academy of Public Administration. (2000, November). *Standing Panel on Social Equity in Governance issue paper and work plan*. www.napawash.org/aa_social_equity/papers_publications.html

Norwegian Automobile Federation. (2020, March 12). *20 Popular EVs Tested in Norwegian Winter Conditions. https://www.naf.no/elbil/aktuelt/elbiltest/ev-winter-range-test-2020/#qbrickVideo1a0723c0-00090201-04b09b31*

Office of Energy Efficiency & Renewable Energy. (2018). *Low-Income Energy Affordability Data (LEAD) Tool.* U.S. Department of Energy. https://www.energy.gov/eere/slsc/maps/lead-tool

Office of Energy Efficiency & Renewable Energy. (2021). *Electric Vehicle Charging Station Locations.* U.S. Department of Energy. https://afdc.energy.gov/fuels/electricity_locations.html#/analyze?fuel=ELEC

Office of Energy Efficiency & Renewable Energy. (2021). *Alternative Fuels Data Center: Electric Vehicle Registrations by State*. U.S. Department of Energy. https://afdc.energy.gov/data/10962

Office of Energy Efficiency & Renewable Energy. (2021). *Climate Zone Map from IECC 2021.* U.S. Department of Energy. https://basc.pnnl.gov/images/climate-zone-map-iecc-2021

Office of Policy and International Affairs & the National Renewable Energy Lab. (2013, July). *U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather*. U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf

Palmer, B. (2020, July 31). *Electric Vs. Gas: Is It Cheaper to Drive an EV?*. Natural Resources Defense Council. https://www.nrdc.org/stories/electric-vs-gas-it-cheaper-drive-ev

Passer, Ben. (2020, August 27). *Advancing Equity through Electrification* [PowerPoint slides]. Fresh Energy. https://michaelsenergy.com/wp-content/uploads/2020/09/Presentations-from-August-27-2020.pdf

Seals, B.A. & Krasner, A. (2020). *Health Effects from Gas Stove Pollution*. Rocky Mountain Institute, Physicians for Social Responsibility, Mothers Out Front, and Sierra Club. https://rmi.org/insight/gas-stoves-pollution-health/

Shipley, J., Hopkins, A., Takahashi, K., & Farnsworth, D. (2021, January). *Renovating Regulation to Electrify Buildings: A Guide for the Handy Regulator.* Regulatory Assistance Project and Synapse. https://www.raponline.org/wp-content/uploads/2021/01/rap-shipley-hopkins-takahashi-farnsworth-renovating-regulation-electrify-buildings-2021-january.pdf

Smith, A.J., Pribble, R., & Steinward, F. (2019). *The Air We Breathe: The State of Minnesota's Air Quality*. Minnesota Pollution Control Agency. https://www.pca.state.mn.us/sites/default/files/lraq-1sy19.pdf

Spiller, Beia. (2020, March 9). *How We Can Make Time of Use Pricing Work for Everyone*. Environmental Defense Fund. http://blogs.edf.org/markets/2020/03/09/how-we-can-make-time-of-use-pricing-work-for-everyone/

Tong, K., Ramaswami, A., Xu, C., Feiock, R., Schmitz, P., & Olhsen, M. (2021, June). Measuring Social Equity in Urban Energy Use and Interventions Using Fine-Scale Data. *Proceedings of the National Academy of Sciences 118* (24). https://www.pnas.org/content/118/24/e2023554118

U.S. Census Bureau. (2021, May 3). *Building Permits Survey.* https://www.census.gov/construction/bps/stateannual.html

U.S. Census Bureau. (2020). *Home Heating Fuel* (Table ID: B25040). https://data.census.gov/cedsci/table?q=house%20heating%20fuel&g=0100000US.04000.001&tid=ACSDT1Y2019.B25040&hidePreview=false

U.S. Census Bureau. (2020, December). *SAIPE State and County Estimates for 2019.* https://www.census.gov/data/datasets/2019/demo/saipe/2019-state-and-county.html

U.S. Energy Information Administration. (2021, June 17). *Minnesota State Energy Profile.* https://www.eia.gov/state/print.php?sid=MN

U.S. Energy Information Administration. (2019). *Total Energy Consumption, Price, and Expenditure Estimates, 2019* (Table F33). https://www.eia.gov/state/seds/sep_fuel/html/pdf/fuel_te.pdf

Vibrant Clean Energy. (2018, July 31). *Minnesota's Smarter Grid*. McKnight Foundation & Gridlab. https://www.mcknight.org/wp-content/uploads/Minnesotas-SmarterGrid_FullReport_NewFormat.pdf

White, L.V. & Sintov, N.D. (2019, December 16). Health and Financial Impacts of Demand-side Response Measures Differ Across Sociodemographic Groups. *Nature Energy 5,* 50-60. https://www.nature.com/articles/s41560-019-0507-y

Wilson, Tom. (2019, January 7). *Efficient Electrification: Opportunities and Challenges* [PowerPoint slides]. Electric Power Research Institute. https://michaelsenergy.com/wp-content/uploads/2020/01/Keynote-Tom-Wilson-EPRI.pdf

Zhu, Y., Connolly, R., Lin, Y., Mathews, T., & Wang, Z. (2020, April). *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California.* UCLA Fielding School of Public Health and Sierra Club. https://ucla.app.box.com/s/xyzt8jc1ixnetiv0269qe704wu0ihif7