Electrification as a Strategy for Decarbonization

DUQUESNE LIGHT CO.

Contents

Produced by Duquesne Light Company

Electric generation and greenhouse gas analysis completed by KeyLogic Systems, LLC.

Duquesne Light Company acknowledges SmithGroup for their contributions to earlier work on this topic.

Introduction

One of the most critical issues facing society today is global climate change. The primary human contribution to global climate change is the increased emission of greenhouse gases (GHG), including carbon dioxide (CO_2) and methane (CH_4). These GHGs trap the sun's heat in the atmosphere, causing what is known as "the greenhouse effect." Increased concentrations of GHGs over the past century have largely been the result of the production and use of fossil fuels, contributing to warming and other impacts on the global climate.

According to the International Panel on Climate Change report released in 2021, global temperatures are expected to increase by at least 1.5 degrees Celsius by mid-century unless deep, immediate emissions reductions occur.[1] This level of warming will alter the state of Earth's systems and present challenges to human life.

According to the Department of Environmental Protection's Pennsylvania Climate Impacts Assessment 2021 report, this means southwestern Pennsylvania will face an increase in frequency and intensity of heat events and heavier rainfall, leading to more flooding and susceptibility to landslides.[2]

To confront climate change and prevent further warming, society must change the way energy is produced and used. Any viable solution must also strengthen the economy and improve environmental and human health and safety. One viable solution that can contribute to emissions reductions and economic and societal enhancement is beneficial electrification. This white paper seeks to explore the topic of beneficial electrification and its potential in the Greater Pittsburgh region.

Global temperatures are more than likely expected to increase by at least **1.5 degrees Celsius** by mid-century.

[1] *AR6 Climate Change 2021: The Physical Science Basis. www.ipcc.ch/report/ar6/wg1/*
[2] *Pennsylvania Climate Impacts Assessment 2021. www.dep.pa.gov/Citizens/climate/Pages/impacts.aspx#:~:text=As%20with%20previous%20Impacts%20Assessments,by%20mid%2Dcentury%20from%20the*

Electrification as a Strategy for Decarbonization

Electrification is a means of powering end-uses of energy with electricity. Electrification can be part of a decarbonization[3] strategy when electrification results in emission reductions. The American Council for an Energy-Efficient Economy defines beneficial electrification as a strategy that provides three forms of societal benefits: reduced energy consumption (total source BTUs), lower consumer costs, and reduced greenhouse gas emissions.[4] It is important to note there are certain instances when switching from direct fossil fuel combustion to an electric option is not beneficial. For example, by this definition, if a customer switched from a high-efficiency natural gas boiler to electric space heaters, they would likely use more energy, resulting in increased emissions and higher energy bills. Beneficial electrification, in contrast, will result in energy savings, reduced emissions, cost savings, and other societal benefits; for example, electrifying public transportation that is currently fueled by diesel will result in zero tail-pipe emissions, improvements to local air quality, and reduced operating expenses.

According to the Regulatory Assistance Project,

> **“mounting research suggests that aggressive electrification of energy end uses – such as space heating, water heating, and transportation – is needed if the United States and the world are to achieve ambitious emission reduction goals for carbon dioxide.”[5]**

Electrification is an essential strategy to reduce emissions, in tandem with decarbonizing electricity generation.

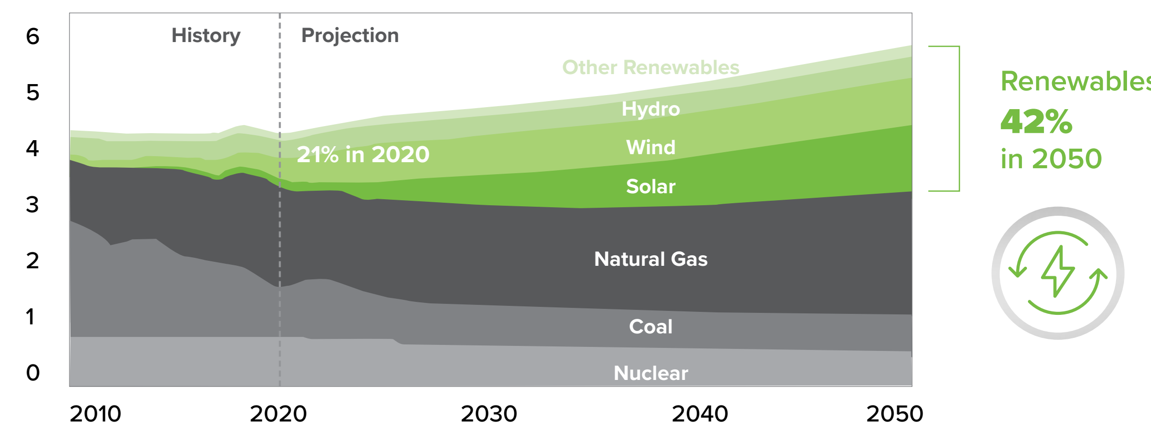
For more information on other decarbonization strategies that highlight electrification as a key component, see Appendix A.

[3] *Decarbonization can be defined as the transition to a low- or zero-carbon economy. Decarbonization strategies, for example the United States Mid-Century Strategy, typically focus on transitioning to a low-carbon energy system that reduces wasted energy, sequestration of carbon, and reductions in other heat-trapping gases.*
[4] *Beneficial Electrification and Energy Efficiency Policy. www.aceee.org/sites/default/files/electrification-dc.pdf*
[5] *Environmentally Beneficial Electrification: The Dawn of 'Emissions Efficiency'. www.raponline.org/knowledge-center/environmentally-beneficial-electrification-dawn-emissions-efficiency/*

While Pennsylvania's grid electricity was historically produced from coal, today it includes a less polluting mix of natural gas, nuclear, coal, and a small but growing portion of renewable energy. This lower-emission grid mix means Pennsylvania residents and businesses can reduce their environmental footprint with beneficial electrification, including the use of efficient electric heating and cooling systems, electric vehicles (EVs), and electric appliances. Converting these end-uses to electricity has the potential to reduce GHG emissions today. Further, forecasts project this future load growth will largely be met with increasing renewable energy generation (Figure 1).

Figure 1: U.S. Forecasted Electricity Generation[6]

U.S. Electricity Generation, AEO2021 Reference Case (2021-2050)
trillion kilowatthours



Source: U.S. Energy Information Administration, *Annual Energy Outook 2021* (AEO2021)

[6] *EIA projects renewables share of U.S. electricity generation mix will double by 2050. www.eia.gov/todayinenergy/detail.php?id=46676*

How Electric Utilities Purchase Electricity

It is important to consider how electric utilities purchase electricity in Pennsylvania, and how that differs from "vertically-integrated" states, where utilities own and operate the entire delivery chain, from generation to the end-user.

Following the adoption of the Electricity Generation Customer Choice and Competition Act in 1996,[7] Pennsylvania electric utilities were required to "unbundle" their electricity generation and delivery services, in part to allow for competition among electric generation suppliers. Electric distribution companies (EDCs) do not own generation and remain solely responsible for delivering electricity to customers in their respective service territories, but customers now have the option to choose the entity that supplies their electric generation. Customers who do not choose an alternative supplier will have their energy procured by their EDC through a competitive bid process. This is referred to as "default service." EDCs do not earn any profit on the electricity supply provided to customers.

EDCs, such as Duquesne Light Company (DLC), procure electricity for default service customers through processes that are regulated by the Pennsylvania Public Utility Commission. By law, default electricity supply must be procured through a "prudent mix" of contracts that yield the "least cost to customers over time," and must include a minimum percentage of renewable generation and other alternative sources as required under the Alternative Energy Portfolio Standards Act (AEPS Act) of 2004. These requirements tend to make EDCs neutral to the source of default electricity supply generation (other than their AEPS Act requirements) and may restrict opportunities to establish other generation source targets (such as a carbon-free target).

The information contained in this white paper regarding the emissions associated with the electricity generation mix is not synonymous with the carbon footprint of the electricity purchased by DLC to serve customers, under existing default service rules, but rather shows the generation mix that is located within the region.

Because Pennsylvania utility customers can choose their electricity supplier, they can elect to purchase renewable energy. While this does not necessarily change the source of electricity that is delivered to the customer, the grid operator ensures a balance of energy purchased to energy consumed, so that demand for renewable energy has the potential to displace traditional generation sources on the grid over time.

[7] Some Pennsylvania EDCs have parent companies that continue to own generation. However, these are operated as separate legal entities. DLC's parent company, Duquesne Light Holdings, does not own electricity generation.

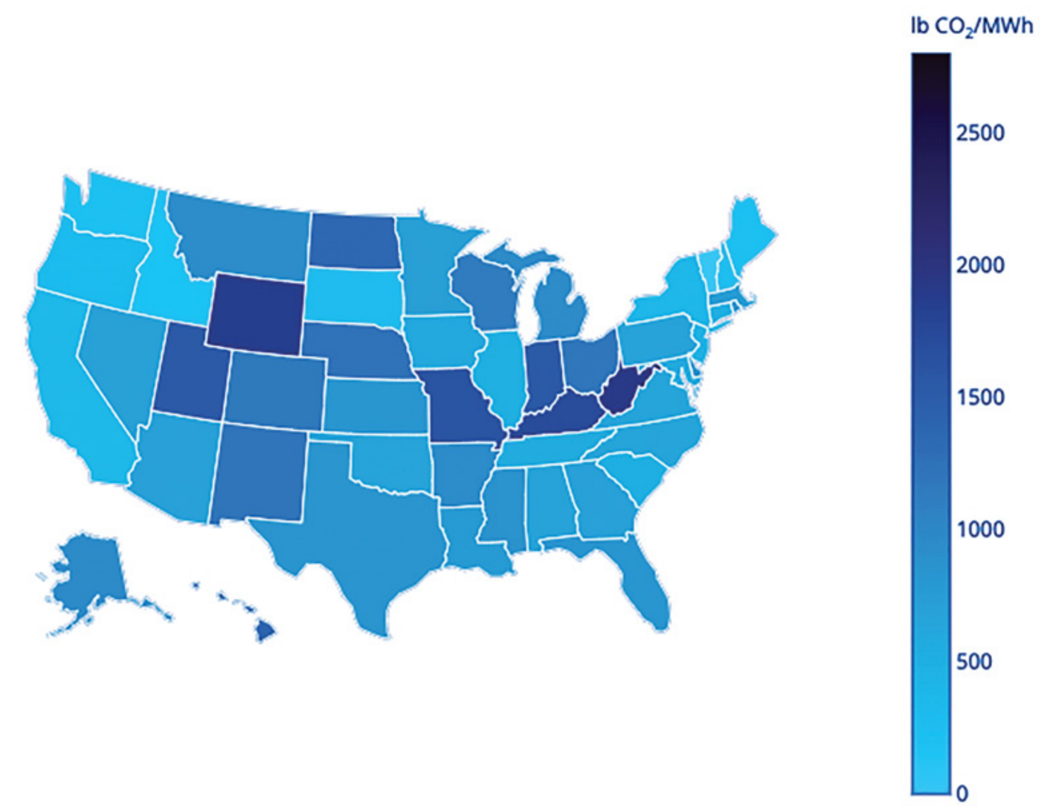
Electricity Emissions Implications

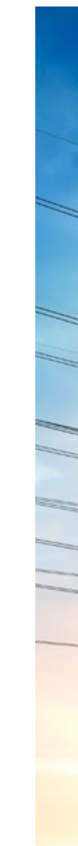
Emissions From Electricity Generation

Electrification is only beneficial if it also results in emissions reductions.

This depends greatly on how the electricity is generated. Emissions related to electricity generation can vary depending on the region and the generators located there. The figure below shows the average carbon intensity of electricity by state (Figure 2).

Figure 2: U.S. State Power Sector Carbon Index for 2020[8]





[8] Power Sector Carbon Index. www.emissionsindex.org/

Various sources of publicly available energy and emissions data, such as eGrid, Energy Information Administration (EIA), and S&P Global provide data based on geographic regions and generating facilities within those regions. Depending on how the boundaries of these regions are drawn, emissions may differ. For instance, DLC's service territory sits within the eGrid RFC West (RFCW) region, which includes Ohio, Indiana, and parts of the surrounding region (Figure 3). The rest of Pennsylvania sits within the RFC East (RFCE) region. eGrid and EIA both provide data for the state of Pennsylvania. Further, PJM also provides electricity emissions data for the state of Pennsylvania. Each of these sources reflect a different electricity emissions value, based on the boundaries of the region that are used.

DLC frequently receives inquiries from environmental organizations and other interested stakeholders regarding the sources of the electricity and associated emissions in its service territory and surrounding area. There is a misconception that this electricity is generated predominately from coal-fired power plants. Recognizing that calculating emissions based on purchased energy is the standard method of greenhouse gas accounting, as an illustrative exercise, DLC sought to understand what the likely generation sources were for the electrons in its service territory.

It is impossible to track where an individual electron was generated because the grid is an interconnected system, but it is understood that electricity is generally consumed closest to the area where it is generated, and typically, power flows across PJM transmission lines from west to east.[9] Electricity generated by facilities interconnected to the transmission system west of the DLC service territory follow the path of least resistance to higher population centers, such as the Pittsburgh region.[10,11] To further explore the carbon footprint of the DLC electric grid, transmission line topology in the region was reviewed to identify and assess the transmission lines that were running into and out of the DLC service territory (Figure 5). This information, along with hourly demand, was used to determine the most likely generation sources of electricity flowing across DLC's grid.[12,13]

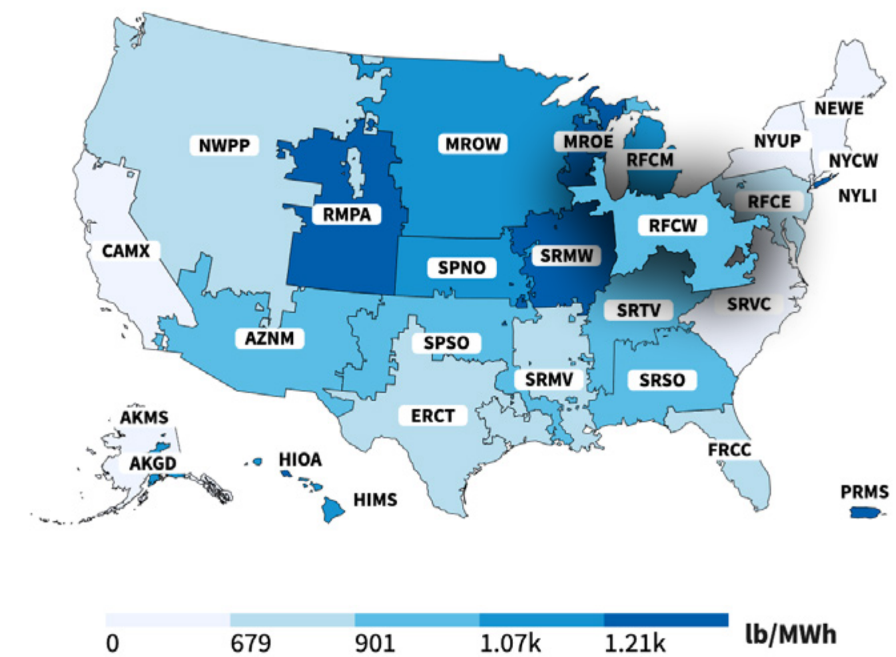
DLC's service territory and the surrounding area currently host a large percentage of low-carbon electricity generation sources. In 2020, the large majority of electricity produced within DLC's service territory was the product of carbon-free nuclear generation, making it cleaner than the statewide average and RFC West. The capacity of the nuclear facility generally exceeds the electric demand of the service territory from mid-September through May. When the electric demand exceeds the capacity of the nuclear facility, electricity is pulled in from other, likely coal and natural gas, facilities in the service territory and surrounding area (Appendix B).

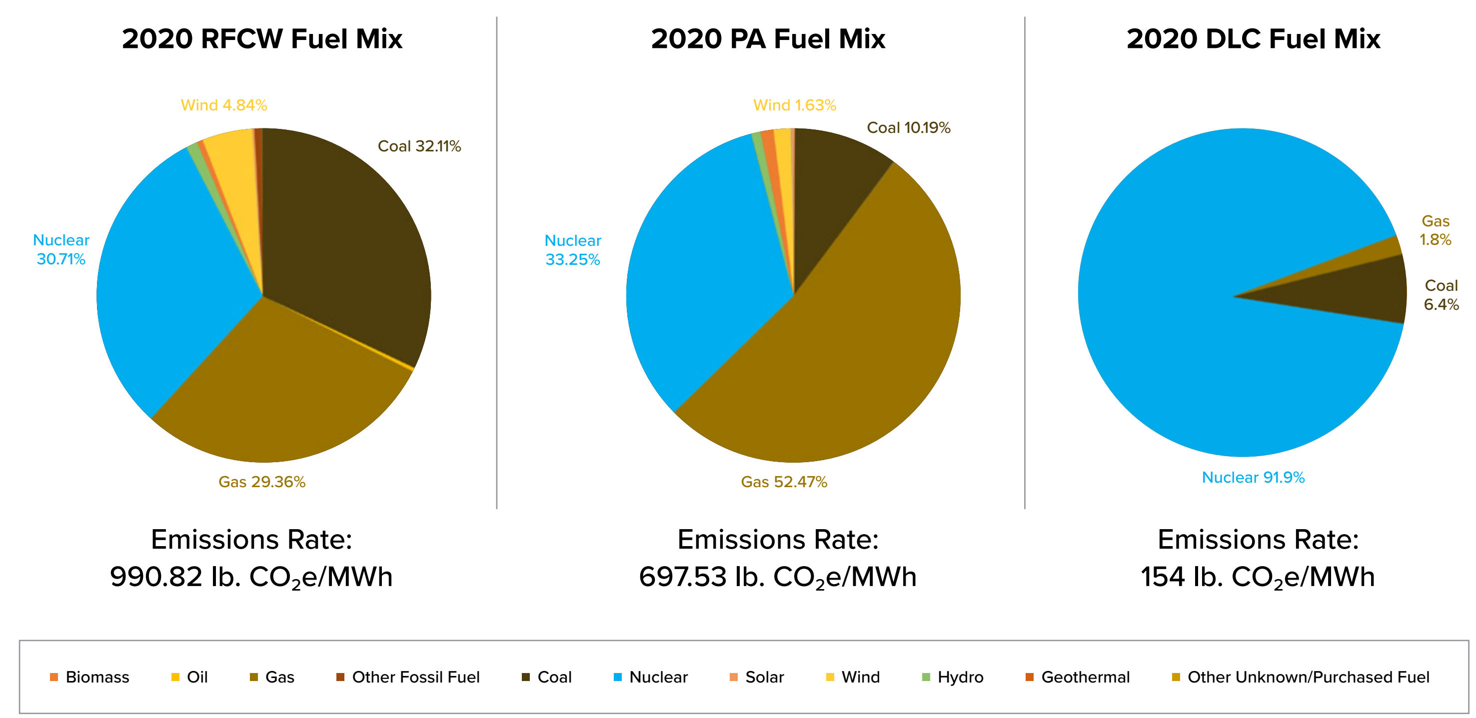
In the future, market conditions or commitments to specific customers may impact the availability of the carbon-free attributes of clean energy generation in PJM.

[9] "PJM is the regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia." DLC is part of PJM. (Who We Are. https://www.pjm.com/about-pjm/who-we-are.aspx)
[10] Managing Heavy Electricity Use Areas. learn.pjm.com/three-priorities/keeping-the-lights-on/managing-heavy-electricity-use
[11] The Benefits of the PJM Transmission System. www.pjm.com/-/media/library/reports-notices/special-reports/2019/the-benefits-of-the-pjm-transmission-system.pdf
[12] DLC's service territory encompasses a majority of Allegheny and Beaver counties.
[13] DLC Contractor KeyLogic utilized S&P Global's S&P Capital IQ Pro to identify transmission lines topology and generating facilities likely responsible for the electricity flowing across DLC's grid. It was determined that these facilities likely include Beaver Valley (nuclear), Cheswick (coal), Brunot Island (natural gas), Cardinal (coal), and Lordstown (natural gas). For a complete and detailed explanation of how this mix and the emissions rate was determined see Appendix B.

Figure 3: Fuel Mix Comparisons in eGrid Subregions, Pennsylvania, and DLC Service Territory[14, 15]

CO_2 total output emission rate (lb/MWh) by eGRID subregion, 2019





[14] eGRID Data Explorer. www.epa.gov/egrid/data-explorer/
[15] eGRID uses data from the Energy Information Administration (EIA) Forms EIA-860 and EIA-923 and EPA's Clean Air Markets Program Data. eGRID data reflects MWhs produced by powerplants, whereas AEPS compliance occurs through RECs that could come from smaller distributed sources not counted in eGRID data.

Sustainable Energy Solutions

Most Pennsylvanians think society should be doing more to address climate change.[16] Pennsylvanians do not have to wait for the state's generation mix to change to support more sustainable energy solutions. Electrifying today presents opportunities to achieve sustainability goals. As the generation mix continues to decarbonize, these benefits will be amplified.

Beneficial electrification is directly linked to advancing sustainability for local communities. The impacts of beneficial electrification projects result in local benefits. Sustainability is traditionally defined as having three pillars: environment, economy, and society. Electrification can help strengthen all these pillars today.

Environmental benefits: Electrification reduces the region's reliance on fossil fuels while lowering energy use intensity (EUI) in buildings and significantly improving vehicle fuel economy, helping to achieve regional emission reduction goals.

Economic benefits: Electrification generates new economic activity and opportunity that supports business and job growth. In a 2020 report released by Rewiring America, it is estimated that electrifying the United States economy would result in 25 million American jobs in the next 15 years and 5 million sustained jobs by 2050.[17] Beneficial electrification of heating and cooling systems and electric vehicles also has the potential to save customers money.

Societal benefits: Electrification improves the region's air quality by removing fossil fuel combustion from homes, buildings, and transportation sources. Reducing fossil fuel combustion inside of buildings improves indoor air quality and safety, while electric vehicles reduce criteria pollutants, improving outdoor air quality.

[16] *Yale Climate Opinion Maps 2021. https://climatecommunication.yale.edu/visualizations-data/ycom-us/*
[17] *Mobilizing for a zero carbon America: Jobs, jobs, jobs, and more jobs – A Jobs and Employment Study Report. https://content.rewiringamerica.org/reports/mobilizing-for-a-zero-carbon-america-technical-whitepaper.pdf*

Implementing Electrification Now

An Equitable Energy Future

Most importantly, all sustainable energy solutions should be considered through an equity lens. An equitable energy future is one that is affordable, clean, and benefits all communities.

It is critical that strategies for an electrified future are developed in ways that give access to communities that have historically been left behind. This group includes low income individuals, legacy business employees, rural residents, under educated persons, and traditional diversity community members to name a few. This energy future can be realized for the Pittsburgh region and help grow the local economy, improve the lives of DLC's customers, and make our communities healthier and safer places to live, work, and play.

Transition Towards Electric Mobility

Compared to conventional internal combustion engine (ICE) vehicles, EVs in Pennsylvania produce about 2/3s fewer emissions that contribute to climate change and smog.[18] With transportation accounting for 17% of greenhouse gas emissions in Pittsburgh,[19] switching to EVs reduces nearly 2/3s of CO_2 equivalent emissions for every mile traveled.[20] Electrifying transportation can reduce fine particulate matter and other criteria pollutant concentrations in Pittsburgh's air, which contributes to negative health impacts like asthma.[21] The environmental benefits can be amplified if the electricity source comes from a low-carbon grid.

Electric vehicles also offer lower operation and maintenance costs. On average the cost of electric fuel is less than half of petroleum fuel to power a vehicle in Pennsylvania.[22] Over the lifespan of the vehicle, all-electric vehicles require less maintenance due to fewer moving parts compared to ICE vehicles. It has been found that over the lifetime of ownership, most EVs offer savings between $6,000 and $10,000 compared to ICE vehicles.[23] Driving electric can put money directly back into consumers' pockets.

The transition to electric transportation also brings economic benefits to the region. Because Pennsylvania's supply chain is strong in electronic component, motor, and generator manufacturing industries, the growth of electric transportation is expected to create new jobs. As of 2019, there were 4,400 jobs involved in the electric transportation supply chain in Pennsylvania with 24% growth expected by 2024, while overall statewide employment is only projected to grow 3%.[24]

Switching to EVs reduces **nearly 2/3s of CO_2** equivalent emissions for every mile traveled.

All Electric Building Systems

Heating and Cooling

Heating and cooling contribute to more than 50% of emissions from commercial buildings and almost 80% of residential emissions in Pittsburgh.[25] Electrifying heating can lead to reduced carbon emissions due to the overall lower energy use intensity and cleaner fuel source from the grid.[26] In addition to potential climate benefits, removing on-site fossil fuel combustion sources, such as gas furnaces and appliances, improves indoor air quality and reduces the risk of fires and explosions. According to a 2017 study by UC Berkeley, household electrification leads to a significant reduction in indoor pollutant concentrations. The study found that electrified homes experienced a drop in acute respiratory infections in children under six years of age.[27]

[18] U.S. Department of Energy. Emissions from Hybrid and Plug-In Electric Vehicles. www.afdc.energy.gov/vehicles/electric_emissions.html
[19] The City of Pittsburgh Climate Action Plan Version 3.0. https://apps.pittsburghpa.gov/redtail/images/7101_Pittsburgh_Climate_Action_Plan_3.0.pdf
[20] A Technology Roadmap for Pittsburgh: Linking Climate and Innovation, 2019. assets.new.siemens.com/siemens/assets/public.1561154658.a31d7c2c-8c2c-4836-998a-097fe3e10bf0.2019-cypt-report-pittsburgh-lowres.pdf
[21] Alternative Fuels Data Center. https://afdc.energy.gov/vehicles/electric_emissions.html
[22] eGallon: Compare the costs of driving with electricity. www.energy.gov/maps/egallon
[23] Electric Vehicle Ownership Costs: Today's Electric Vehicles Offer Big Savings for Consumers. October 2020. advocacy.consumerreports.org/wp-content/uploads/2020/10/EV-Ownership-Cost-Final-Report-1.pdf
[24] Electric Transportation Supply Chain in Pennsylvania. info.aee.net/hubfs/AEE_BW_PA%20EV%20Report_5.28.20.pdf

[25] A Technology Roadmap for Pittsburgh: Linking Climate and Innovation. 2019. assets.new.siemens.com/siemens/assets/api/uuid:a31d7c2c-8c2c-4836-998a-097fe3e10bf0/version:1561154658/2019-cypt-report-pittsburgh-lowres.pdf
[26] All-Electric New Homes: A Win for the Climate and the Economy. rmi.org/all-electric-new-homes-a-win-for-the-climate-and-the-economy/
[27] Household electrification and indoor air pollution, 2017. www.sciencedirect.com/science/article/abs/pii/S0095069617304825

Heating and Cooling *(continued)*

Electric heating technology exists today that can accommodate both residential and commercial spaces and benefit consumers. The type of electric heating technology that will best suit a building's needs depends on the building type, size, design, and climate. Electric heat pumps do not generate heat; instead, they transfer it from one space to another. Because of this, they are especially efficient in moderate climates. For locations that experience colder climates during parts of the year, like Pennsylvania, heat pumps can still be an effective system when they are sized properly and balanced with other heating technology, such as radiant heating or electric furnaces.[28] Radiant heating supplies heat directly to the floors or wall panels in a building, which heat the air in the room. Because these systems are ductless, they reduce allergens distributed in the air and do not experience duct losses, causing greater efficiencies and more comfort.

Electric boilers are another option for heating homes and commercial buildings. For heating larger commercial spaces, electric boilers can be paired with add-on heat pumps to distribute the heat throughout the building. Electric boilers are more efficient, quieter to operate, compact, require less maintenance, and eliminate the combustion of fossil fuels indoors, eliminating the need for a flue or gas exhaust pipe.

Although there are challenges in implementing wide-scale adoption of electric heating systems, there are opportunities to overcome these barriers (Figure 4). The most cost-effective time to adopt electrification in buildings is during initial construction, especially for heating systems. A 2020 study performed by Rocky Mountain Institute for Columbus, Ohio showed an "all-electric home saves $3,900 in net present costs[29] [...] over a 15-year period."[30] While electric heating systems, such as electric boilers, have less expensive installation, maintenance, and equipment costs than gas-fired boilers, retrofitting existing buildings to an electric heating system can be more costly. This points to the importance of utilizing state and federal financial incentives for customers wanting to switch from dated heating systems.

An all electric home has the potential to **save $3,900** in net present costs over a 15-year period.

[28] *Electric Resistance Heating. energy.gov/energysaver/home-heating-systems/electric-resistance-heating*
[29] *Net present cost calculation incorporates upfront costs and bill impacts, discount rate of 7%, and 15-year assumed equipment lifetime.*
[30] *The New Economics of Electrifying Buildings: An Analysis of Seven Cities. rmi.org/insight/the-new-economics-of-electrifying-buildings?submitted=1983dhtw8*

Figure 4: Barriers to Adopting Electric Heating and Cooling[31]

	Challenge
Infrastructure	Existing buildings designed for gas may require more expensive ductwork and/or retrofits.
Stock turnover	Gas furnaces and boilers can last for decades, locking customers in long-term.
Status quo bias	Homeowners often only replace gas furnaces and boilers when they fail, leaving little time for decision-making about an electrified option.
Short-term thinking	Consumers often only weigh upfront costs vs. lifetime costs and benefits.
Builder bias	Builders are not always incentivized to pay higher upfront costs for energy efficiency; requires an understanding of tax financing. Upfront costs can also make homes more expensive.
Contractor familiarity	Lack of training or installation and maintenance familiarity in the market.
Awareness	Electric heating has a reputation for not working in colder climates when large-scale heating supplies are needed. Heat pumps, waste heat recovery, and energy efficiency are all options for making electrification possible at all scales, but they require specific installer familiarity.

Solutions

- Develop incentives and financing to increase the affordability of equipment and retrofits, encouraging adoption.
- Increase customer education in the marketplace about electric heating options and long-term benefits, so they are prepared to make fully informed decisions.
- Educate developers on electric heating solutions for all building types and how to communicate the benefits to buyers.
- Create training programs to better familiarize contractors with electric heating equipment, installation, and maintenance.
- Develop pilot projects that show the effectiveness of technologies and applications in the Pittsburgh region.

[31] *Adapted from Kaufman, Sandalow, Di Schio, and Higdon, "Decarbonizing space heating with air-source heat pumps", Columbia Center on Global Energy Policy, 2019 and The Rocky Mountain Institute, "The Economics of Electrification", 2020*

Other Electric Appliances

Developing a home or building that runs on all-electric is possible today. As previously mentioned, there are benefits to indoor air quality, safety, and health that accompany removing fossil fuel combustion indoors. Studies have shown that, when burning, a gas range can increase nitrogen dioxide (NO_2), carbon monoxide (CO), and formaldehyde (HCHO) up to five times the outdoor air quality limits. Exposure to these pollutants is linked to symptoms like wheezing, coughing, and colds and can lead to long-term health issues such as asthma, cancer, and more, with children and the elderly at a higher risk of illness.[32]

Electric cooking has come a long way from the radiant electric coils that were available decades ago. Today, the safest and most efficient electric cooking option is induction cooking. Induction cooking uses electromagnetism to heat the cookware on the stove, all while keeping the surface of the cooktop cool, increasing safety and efficiency.[33] There is less residual heat because the induction process is heating the cookware itself, rather than transferring heat to the cookware with an open flame. It also improves cooking time, in some instances cutting it in half. Induction cooking is safer for your health and more efficient.

Another opportunity to electrify appliances is through electric hot water heating. There are different technologies available, such as electric tankless hot water heaters and electric heat pump hot water heaters. Tankless hot water heaters can typically run for more than 20 years and are cheaper to operate and maintain.[34] An additional option, heat pump hot water heaters can operate as an efficient standalone option, or there is opportunity to marry heating for your building and your hot water needs to increase efficiency. This can be done with heat pump hot water heaters and has been proven successful in multifamily buildings when the investment can be spread among multiple units and sized appropriately.[35] These systems can alleviate the need for more expensive gas infrastructure.

[32] *Gas Stoves: Health and Air Quality Impacts and Solutions. rmi.org/insight/gas-stoves-pollution-health*
[33] *Kitchen Appliances. www.energy.gov/energysaver/kitchen-appliances*
[34] *Tankless or Demand-Type Water Heaters. www.energy.gov/energysaver/tankless-or-demand-type-water-heaters*
[35] *Heat Pumps for Hot Water: Installed Costs in New Homes. rmi.org/insight/heat-pump-hot-water-cost/*

Electrification of Manufacturing and Industrial Processes

Industrial operations consume more energy than any other sector, and in 2019, it accounted for 23% of total U.S. GHG emissions.[36] However, electricity represents only about 20% of industrial energy use and is often only used for buildings or simple processes/machines, such as conveyor belts. Of all the fuel that industrial companies use for energy, it is estimated that almost 50% could be replaced with electricity using available technology.[37]

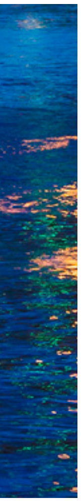
Electricity represents **only about 20%** of industrial energy use

There is a long-held perception that electrification cannot support the intense heating demands required by certain industrial processes. However, newer electrified technologies are available today with the capacity to supply heating demands ranging from 400 to 1000 degrees Celsius, like those used in the petrochemical industry for cracking.[38]

While the opportunities for significant industrial electrification exist, they are not as well researched, understood, or incentivized. Compared to buildings and transportation, there are even fewer policies in place that motivate the industrial sector to electrify. The data and tools needed to effectively prioritize and support industrial electrification are also lagging.

The Pittsburgh region can help lead the way with targeted research partnerships and pilot efforts. Pittsburgh-based research institutions, such as the National Energy Technology Laboratory (NETL), the University of Pittsburgh's GRID Institute, and Carnegie Mellon University's Scott Institute for Energy Innovation, provide leadership on next-generation grid solutions and can help realize the benefits of electrification for industrial processes through further research and development.

[36] *Sources of Greenhouse Gas Emissions. www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions*
[37] *Plugging in: What electrification can do for industry. www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/plugging-in-what-electrification-can-do-for-industry*
[38] *Plugging in: What electrification can do for industry. www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/plugging-in-what-electrification-can-do-for-industry*



Conclusion

Building an Equitable Energy Future Through Beneficial Electrification

Beneficial electrification presents an opportunity for the Pittsburgh region to significantly impact GHG emissions, improve air quality and health, and strengthen its economy. A transition to electrification will require collaboration among key stakeholders across the region, with a focus on making sure solutions and their benefits reach all communities.

Opportunities to Support Electrification:

- Ensure that electrification occurs in ways that benefit all communities and that policy incentives are equitable.
- Establish targets for electrification of buildings and transportation as part of local climate action planning.
- Develop a cross-sector strategy around beneficial electrification that includes outreach and education, workforce development, and policy targets.
- Engage with national organizations and programs to better understand the opportunities for electrification for decarbonization.
- Coordinate the strength of local universities, industry partners, and the national labs to establish Pittsburgh as a hub for innovation in electrification.

The Pittsburgh region has a rich history of energy innovation. Today, the region's strong industry, trades, and first-class institutions position Pittsburgh to be a leader in an energy transition that benefits all communities.

Appendix A

Deep Decarbonization Pathways Reports

Many researchers have concluded that electrification is an essential part of any deep decarbonization strategy that will result in meaningful reductions in GHG emissions and other positive climate impacts. For more information on other deep decarbonization strategies that highlight electrification as a key component, refer to the resources below.

- The White House: United States Mid-Century Strategy for Deep Decarbonization
- United States Department of State and the United States Executive Office of the President: The Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050
- IPCC Special Report: Global Warming of 1.5°C. Ch. 2 Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development
- Great Plains Institute: The Road Map to Decarbonization
- International Energy Agency: Net Zero by 2050: A Roadmap for the Global Energy Sector
- Sustainable Development Solutions Network and Institute for Sustainable Development and International Relations: Pathways to Deep Decarbonization in the United States
- EPRI: Strategies and Actions for Achieving a 50% Reduction in U.S. Greenhouse Gas Emissions by 2030
- Clean Energy Transition Institute: Five Deep Decarbonization Strategies

Appendix B

2020 DLC Fuel Mix Methodology

KeyLogic Systems, LLC performed calculations to determine the most likely generation sources and emissions footprint of electricity flowing across DLC's grid. The methodology provided herein describes their work.

For this white paper, data on generation and load was collected from two key data sources, S&P Global's S&P Capital IQ Pro Service (S&P CIQP) and U.S. EPA's eGRID. Both data sources attempt to aggregate publicly available information from U.S. Department of Energy's Energy Information Administration (EIA) Form 860s (and other sources) into useful and actionable formats. Both data sources can provide information for a given year that is useful for a study of this kind.

- S&P Capital IQ Pro Service is a specific data service of S&P Global that DLC subscribes to and therefore, the KeyLogic team had access. S&P CIQP collects general power plant data from EIA Form 860, as well as data from EPA, and condenses it for user convenience in spreadsheet and mapping formats. S&P CIQP also is a source of hourly load and generation data and plant-level CO_2 emissions. Data is available for years 2019 and 2020.

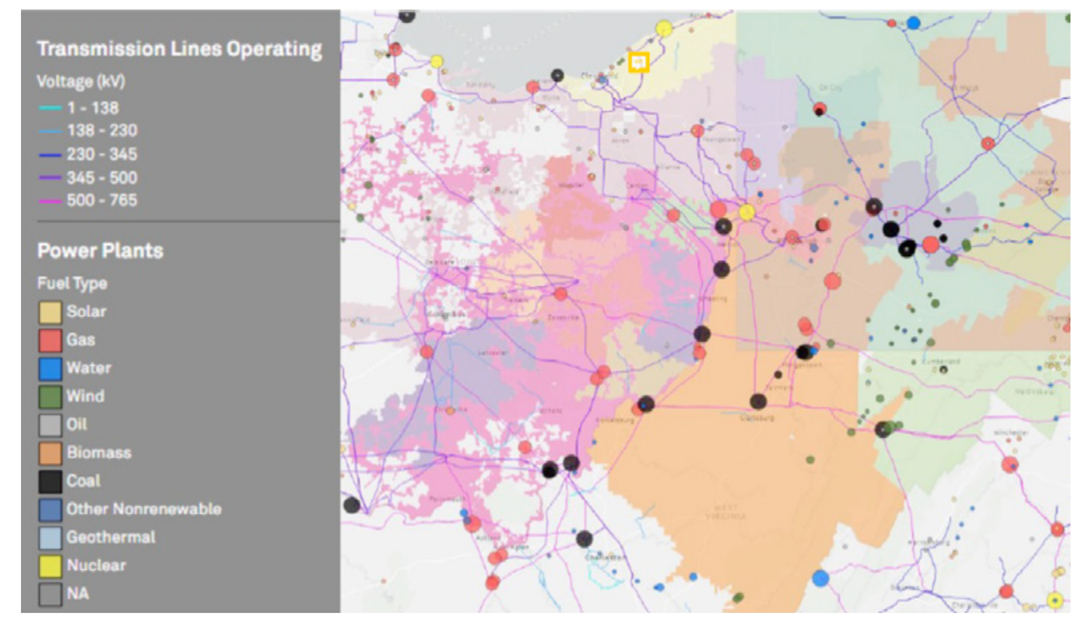
- eGRID is a publicly available database of annual information from the U.S. EPA that aggregates information beginning at the electricity generating unit level, up to plant level, and then to balancing authority and state levels. It includes information for multiple greenhouse gases. At the time this study was performed, the latest year for which eGrid data was available was 2019.

Prior to using the S&P CIQP data for 2020, a study of the differences in results across the two data sources and a correlation analysis of various parameters for the year 2019 was performed.[39] The results presented a correlation of these values to be extremely high – 96% for annual generation and 99% for carbon dioxide emissions. This gives a high degree of confidence in the reliability of the two data sets (which is perhaps not surprising given that they both use EIA data as their sources). Given the high correlation between the data sources, and the goal of using the most recent data possible, S&P CIQP data was used for 2020, with the presumption that the eGRID data for 2020 (which was not yet available at the time of this study) would likely look very similar.

[39] The correlation analysis between S&P CIQP and eGrid data sets was performed using 2019 data, because at the time of the analysis, 2019 was the most recent eGrid data available.

Information from these data sources was used to create aggregated summaries of generation for each power plant in the region as well as for the whole DLC service territory. The network of transmission lines into and out of DLC, and within DLC borders were studied as well, to better understand which generators were supplying power to the DLC service territory (Figure 5), understanding that electricity generally flows from west to east in PJM. In summary, understanding the locations of generators and their connections to the DLC territory (and others) can help to narrow and explain the generators that are likely to be part of the mix that enters the DLC service territory.

Figure 5: Generators and Transmission Lines in the PJM Region

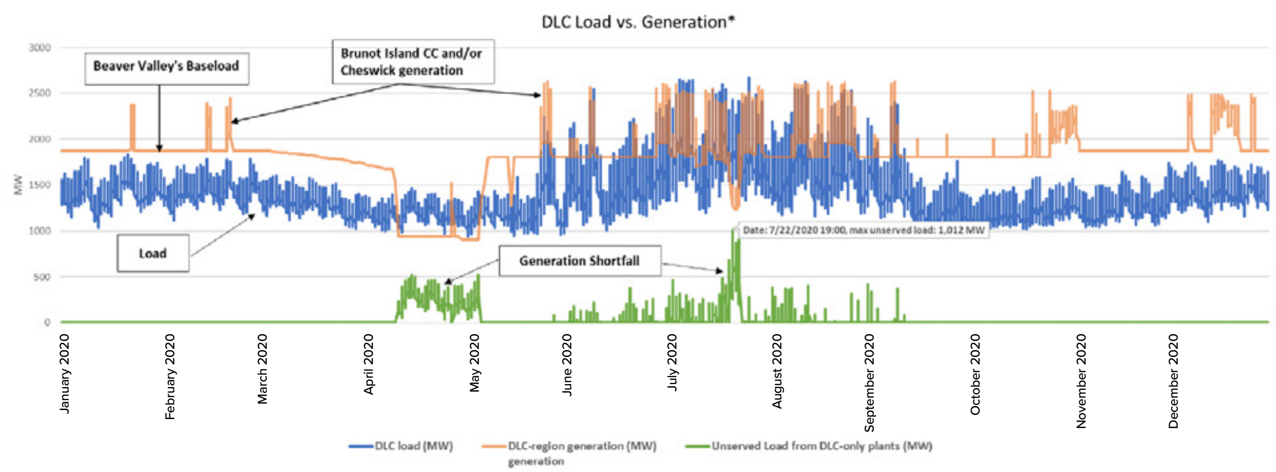


Regional production and load were analyzed for the DLC region and regions surrounding DLC throughout PJM. Additionally, hourly data on demand/load was collected from S&P CIQP for DLC demand, and production from Beaver Valley (nuclear), Brunot Island (natural gas), and Cheswick (coal) power stations.[40]

These data were then compared to understand how the power generation within DLC's boundaries compared to the demand in the region using DLC hourly data (Figure 6).

[40] Cheswick power station was closed on April 1, 2022. This was the only remaining coal electricity generation station in the DLC service territory.

Figure 6: Summary of Generation Load in the DLC Region



Given findings about the size and transmission constraints in the greater DLC region, the results estimate that three plants within the DLC territory serve the load for most of the year. Beaver Valley is the predominant source of electricity in the region for most of the year. The facility is able to supply the load in the DLC service territory a majority of the time between mid-September through May. During the summer peaks and/or when there is a shutdown of the Beaver Valley facility, the Cheswick and Brunot Island facilities help serve the portion of load that Beaver Valley cannot meet.

Outside of the DLC region, it is estimated that the Cardinal and Lordstown plants are most likely the generators supporting DLC load during the summer peaks as well due to their transmission line connections and capacity. Lordstown (940 MW) is a natural gas combined cycle plant while Cardinal (1,810 MW) is a coal-fired generator. The 2020 capacity factor for Lordstown was 75% and 57% for Cardinal, meaning that KeyLogic estimated that 38% of the supplemental electricity coming into DLC was from gas, and 62% was from coal. Figure 7 details the generators supporting DLC's load along with the emissions associated with each.

2020 DLC Electricity Emissions Rate Methodology

Given the generation and load data above, and the identification of specific sources associated with DLC's load, the greenhouse gas emissions were also estimated. Both S&P CIQP and eGRID provide estimates of CO_2 emissions and as noted are highly correlated. As the 2020 S&P CIQP data was already being used to estimate the generation of each power plant, the 2020 CO_2 emissions from S&P CIQP were used.

Each facility estimated to be delivering electricity in the DLC service territory has an overall emissions intensity that is provided by S&P CIQP, which is the ratio of CO_2 emissions to generation (tons CO_2/MWh). Using this ratio, and the mix of generation found from the results of our analysis, hourly carbon emissions were first estimated and then aggregated for annual and seasonal values. Using the MWh and emissions totals for each generating facility that is estimated to be serving the DLC service territory, the annual and seasonal emissions factor for meeting DLC load was estimated by dividing tons CO_2 by generation.

Since not available from S&P CIQP, the emissions of CH_4 and N_2O were also estimated and added to the values described above. eGRID estimates emissions of the GHGs methane (CH_4) and nitrous oxide (N_2O), using EPA emissions factors for fossil fuel combustion specific to a fuel (currently 0.011 kg CH_4/mmBtu for coal, 0.001 CH_4/mmBtu for natural gas, and 0.001 kg N_2O/mmBTU for coal). They were also converted into equivalent emissions of CO_2 (CO_2e) using the IPCC AR5 method.

Overall, it is estimated that the GHG intensity of electricity supplied in the DLC region is 0.077 tons CO_2e/MWh annually.

Figure 7: Summary of Generation Sources Supporting DLC Load in 2020

		January 1 - March 31		April 1 - June 14		June 15 - September 14		September 15 - December 31		Annual	
Generator	**Fuel Type**	**MWh**	**CO_2 (tons)**	**MWh**	**CO_2 (tons)**	**MWh**	**CO_2 (tons)**	**MWh**	**CO_2 (tons)**	**MWh**	**CO_2 (tons)**
Within DLC											
Beaver Valley	Nuclear	3,130,478		2,122,334		3,357,710		3,265,443		11,875,965	
Brunot Island	Natural Gas			11,198	7,303	93,705	61,927	16,809	10,610	121,712	79,840
Cheswick	Coal	37,919	41,937	49,949	55,097	342,783	358,032	214,205	210,409	644,856	665,475
Outside DLC											
Lordstown	Natural Gas			66,455	26,595	42,250	16,909			108,705	43,504
Cardinal	Coal			108,638	120,979	69,069	76,915			177,707	197,894
Total		3,168,397	41,937	2,358,574	209,974	3,905,517	513,783	3,496,457	221,019	12,928,945	986,713

If you would like to be engaged in these conversations moving forward, please reach out to us at **CleanEnergy@duqlight.com**.

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