Thermal Decarbonization on the Pacific Coast: Reducing Greenhouse Gases from Building Heating and Cooling

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Pacific Coast COLLABORATIVE

To achieve deep decarbonization goals by mid-century, Pacific Coast states, the province of British Columbia, and cities need to significantly reduce greenhouse gas emissions across all economic sectors. PCC jurisdictions are committed to collaborate on ways to lower the carbon intensity of heating fuels in the residential and commercial building sector—known as thermal decarbonization—as a key step on the path to net-zero building energy use.

This policy brief summarizes key solutions and regional principles to guide work in the area of thermal decarbonization. Thermal decarbonization policy development and implementation will play out differently across regional jurisdictions, which represent a diverse array of climates, economic drivers, electricity generation mixes, and renewable energy opportunities. It is important to note that the decarbonization of energy used within buildings takes place in the context of decarbonizing all energy supplies, including pathways for the industrial and transportation sectors. Many of the sectors feature electrification as one strategy for decarbonization. Policy must also ensure that the transition to low-carbon solutions provides new benefits and opportunities for low-income households and communities rather than new burdens.

ABOUT THE PACIFIC COAST COLLABORATIVE

The Pacific Coast of North America represents the world's fifth largest economy, a thriving region of 55 million people with a combined GDP of $3 trillion. Through the Pacific Coast Collaborative (PCC), British Columbia, Washington, Oregon, California, and the cities of Vancouver BC, Seattle, Portland, San Francisco, Oakland, and Los Angeles are working together to build the low carbon economy of the future.

Much of this brief was developed prior to the crisis of COVID-19, and it is being released during the process of ongoing management and recovery. While the crisis does not alter the need for thermal decarbonization to achieve climate goals or the key solutions or principles guiding the work, it does create a new suite of challenges—as well as potential opportunities—as we recover from the economic and social impacts of the crisis. Understanding of these challenges and opportunities will evolve over time (and are beyond the scope of this brief), but we recognize as a region that this crisis may alter the paths we take but not the goals we share.

WHY IS THERMAL DECARBONIZATION IMPORTANT?

Up and down the Pacific Coast, much of the air and water in our buildings is heated and cooled with heating oil, natural gas, and electricity generated from non-renewable resources. The emissions from these fuels make up a significant portion of regional greenhouse gas emissions. Emissions associated with natural gas are likely higher than reflected in inventories because natural gas leaks associated with production, transportation and distribution are not always accounted for.

Pacific Coast Collaborative jurisdictions are committed (and already on a trajectory) to clean up their electrical generation. Simply electrifying thermal loads today would not fully decarbonize building energy uses since the current electricity mix contains varying amounts of fossil-based generation.

Strategies for deep decarbonization primarily focus on the pillars of using less energy, decarbonizing electricity, decarbonizing liquid and gaseous fuels, and switching fuels.[1] These are tightly intertwined parts of an integrated approach, and they present complexities that will have to be addressed in a coordinated and thoughtful manner.

Shifting energy types to facilitate deep decarbonization is a complex undertaking, and understanding the context is important in assisting with decisions and policy making, particularly when focusing on specific sectors. One of the primary approaches being advanced to deeply reduce carbon emissions is electrification of end uses (e.g., transportation and building heating and cooling) coupled with decarbonizing electricity production. End use electrification as a decarbonization strategy significantly increases the quantity of low- or zero-carbon electricity needed and the need for supporting infrastructure to produce, transmit, store and consume it.

Regional differences in how electricity is generated will influence strategies for achieving the Pacific Coast jurisdictions' 2050 deep-decarbonization goals. Achieving these reductions by 2050 will require significant transformations in generation and consumption strategies to be in place more than a decade earlier. A deep decarbonization scenario for Washington State, for example, showed that all sales of new heating equipment would need to be fossil-free by 2035 in order for no fossil-based equipment to still be in operation by 2050.[2] Fossil-fuel based equipment installed before 2035, unless operated using biofuels or renewable hydrogen, will need to be replaced prior to 2050 to assist in fully switching to decarbonized systems. Achieving ambitious interim targets (e.g., 2025–2030) will require even more rapid action.

When focusing on decarbonization of buildings, new policies and market transformations will be needed. Without this transformation, fossil-based fuels may remain the preferred choice in the construction of new buildings and retrofits of existing buildings. Even if new buildings represent net-zero emissions by the 2030s, significant reductions will still be needed from existing buildings, which will require retrofitting and a different set of policies, regulations, programs, and investments.

Policy and programs will also play an important role in ensuring that low-income households and communities have affordable access to clean energy and that their homes and buildings are healthier, safer, and more comfortable with new heating and cooling technologies and fuels. Policies will be needed to ensure that the benefits of this transition don't come at the cost of additional financial burdens, displacement, or other impacts that exacerbate inequities for the most vulnerable populations.

While the challenge is significant, our states, province, and cities can be more successful working as a region within the Pacific Coast Collaborative. The West Coast shares markets for fuels and equipment. Our energy utilities' service and trading areas cross state boundaries and include many cities within each state or province. As the equivalent of the fifth largest economy in the world, we can create substantial scale in new markets and share best practices and tools across the region.

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[1] Clean Energy Transition Institute (2019). *Meeting the Challenge of our Time: Pathways to a clean Energy Future for the Northwest*. Accessed December 14, 2019, https://www.cleanenergytransition.org/meeting-the-challenge.

[2] Evolved Energy Research (2016). *Deep Decarbonization Pathways Analysis for Washington State*. Accessed 25 Jun. 2018, http://www.governor.wa.gov/sites/default/files/Deep_Decarbonization_Pathways_Analysis_for_Washington_State.pdf

We will also go further faster through strong collaboration between cities and the state or province in which they are located. Cities are on the front lines of policies and programs with building owners, operators, and tenants. Pacific Coast cities have been leaders and innovators in this space. This includes advances in building codes in Vancouver BC and San Francisco, Seattle's benchmarking and building tune-up requirements, and general leadership on zero net energy buildings. States and provinces play key roles in creating and enabling environments for cities' efforts, including through utility regulation. Together, these jurisdictions create and implement codes, standards, and incentive programs that influence the technology and practices for building heating and cooling.

WHAT ARE THE POTENTIAL SOLUTIONS?

Primary solutions to achieving thermal decarbonization include improving building efficiency, electrification of heating and cooling in buildings, and decarbonizing liquid and gaseous stationary use fuels. These solutions are inter-related. All of them may be needed to achieve regional decarbonization goals.

Efficiency

In the near-term, energy efficiency may be the most widely available option for reducing greenhouse gasses (GHGs) from thermal uses while new technologies, markets, and strategies are developed for longer-term decarbonization. Many efficiency improvements are currently achievable at low cost. Efficiency measures, including high efficiency gas equipment, can enable transitions that ultimately lead to decarbonization, but shouldn't contribute to locking in carbon emitting technologies that may still be in use in 2050.

Electrification

To achieve thermal decarbonization by 2050, sales of highly efficient electric heat pumps and hot water heaters will need to replace gas-fired equipment sales by the 2030s. There are still substantial challenges and uncertainties to widespread electrification, including cost and equity implications for consumers and the impacts of increased electricity demand on the grid. More analysis, along with consultation with industry, regulators, interest groups, and customers, will be needed to fully understand the local and regional impacts of widespread electrification in the development of targets and strategies.

Significant electrification would result in an increase in electricity demand by end users, but large-scale efficiency improvements and conversion to high-efficiency technologies may reduce or flatten overall consumption.[3] Electrified buildings will also need to be highly efficient, interactive, and intelligent so they can appropriately interact with and respond to grid signals and demands. This highlights the interconnected nature of these approaches and the need to consider both the solutions and possible impacts as they are implemented.

In addition, the current electricity mix on the West Coast still contains significant sources of carbon. Some states have adopted policies that will eventually decarbonize their electricity supply. Increasing production, transmission, and coordination of electricity across the West Coast of North America is a complex but achievable task.

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[3] See, for example, National Renewable Energy Laboratory, *Electrification Futures Study*, https://www.nrel.gov/docs/fy18osti/71500.pdf. The impacts of significant electrification have also been assessed by the Northwest Power and Conservation Council (https://www.nwcouncil.org/) for the Seventh and Eight Power Plan.

Decarbonizing liquid and gaseous stationary use fuels

Fuels like renewable hydrogen and renewable natural gas (RNG) can have lower GHG-intensity than traditional natural gas and may provide some opportunities for decarbonization. One strategy for renewable hydrogen is to use excess renewable electricity (generated by solar, wind, hydro or other zero carbon technologies) to split water with an electrolyzer and distribute the resulting hydrogen in the natural gas pipeline infrastructure. RNG can be produced through anaerobic digestion and may be available through thermal gasification of wood waste. Regulatory change would be required in some PCC jurisdictions to allow RNG to be added to the existing natural gas supply and distribution systems.

Renewable hydrogen and RNG can provide low-carbon transition alternatives when buildings and fuel distribution systems are locked into current gas combustion technologies. However, substitution forecasts need to recognize that regional market dynamics and policies may draw RNG away from buildings into other markets or sectors—such as heavy-duty transportation or industrial applications—especially for uses where electrification is difficult and few other low-GHG options exist.

WHAT ARE THE CHALLENGES?

Meeting deep decarbonization goals for Pacific Coast states, British Columbia, and cities is an achievable, complex, and interconnected task. The report "Meeting the Challenge of our Time: Pathways to a Clean Energy Future for the Northwest"[4] describes it this way:

> *"The low-carbon system of the future must have four primary features: (1) energy must be used more efficiently than it is today; (2) electricity generation must be as clean as possible; (3) liquid fuels must be as low-carbon as technically and economically feasible; and (4) clean electricity must be used for as many purposes as possible."*

The study goes on to further identify that to meet carbon reductions targets,

> *"… the Pacific Northwest would need to have an almost 100% clean electricity grid, transportation would have to shift to fueling 100% light duty vehicles with electricity and medium/heavy-duty vehicles will be powered by synthetic renewable fuels. The electricity grid infrastructure and operation integration would need significant expansion across the west. And new technologies like carbon capture and synthetic liquid fuels production would have to mature to commercial scale."*

All the above-mentioned solutions will be needed for West Coast jurisdictions to decarbonize their fuel supplies. Together, we will have to overcome several key challenges, including economic, technical, and technology barriers, that result from implementing very high levels of efficiency, decarbonizing electricity, and decarbonizing liquid and gaseous stationary-use fuels.

[4] Clean Energy Transition Institute (2019) *Meeting the Challenge of our Time: Pathways to a Clean Energy Future for the Northwest*. Accessed December 14, 2019 at https://www.cleanenergytransition.org/meeting-the-challenge

Efficiency

Cutting building energy use in half will require massive efficiency improvements. Some efficiency strategies face challenges, including whether technology advancements will be enough to ensure widespread adoption and spur building retrofits. There are also customer-focused challenges related to acceptance of highly efficient products, the high cost of new technologies, and split incentives commonly seen in landlord-tenant properties. Current energy efficiency cost-effectiveness analyses also do not fully account for lifecycle GHG implications. This, on top of high costs of newer technologies, can impact the cost-effectiveness of efficiency programs and implementation of specific measures. Achieving massive efficiency improvements in buildings will require improvements in financing, information, supply chains, marketing, and enabling policy.

Decarbonizing electricity

If the emphasis of achieving decarbonization is on switching fuels from natural gas and petroleum to electricity for heating and cooking, this is likely to result in an overall increase in electricity consumption, which will require additional energy generation. The table below summarizes the source mix of electricity generated for each West Coast state and British Columbia.

ELECTRICITY GENERATION SOURCE MIX

State	Year	Coal	Hydro	Natural Gas	Nuclear	Petroleum	Other Fossil Fuels	Solar, Wind and/ or Geothermal	Biomass and Biogenic	Unspecified
CA[5]	2018	3.3%	10.7%	34.9%	9.1%	0.0%	0.2%	29.0%	2.4%	10.4%
OR[6]	2018	2.3%	55.3%	28.0%	0%	0.01%	0.0%	12.8%	1.6%	0.1%
WA[7]	2018	10.2%	59.2%	7.3%	4.8%	0.0%	0.0%	4.9%	0.7%	12.9%
BC[8]	2018	0.0%	89.7%	1.5%	0.0%	0.1%	0.0%	2.5%	6.3%	0.0%

British Columbia's electricity generation is dominated by hydropower, with hydroelectric generation fluctuating year to year based on snowpack and water supply. Hydropower in Oregon and Washington's generation mix is 55% and 59% respectively. Natural gas provides the largest percentage of California's electricity (35%) followed closely by renewables (31%). Over time, trends are shifting toward increasing renewables throughout the region.

Limited options for expanding hydroelectricity generation—along with constraints on storage capacity and transmission and distribution infrastructure for rapidly expanding solar, wind, and other types of renewable energy—represent significant technical and policy challenges. Even though Oregon and Washington have large hydroelectric resources, there is significant social pressure to reduce the number of dams in the Columbia Basin, where many hydroelectric resources are located. Many climate change models predict changes in the hydrograph as well as some level of change in precipitation as snowpack shifts to more rainfall in the Pacific Northwest. This may shift seasonal availability of electricity, with more electricity production in the winter and less in the summer and fall. Social pressure surrounding imperiled salmon populations puts additional constraints on hydroelectric capacity.

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[5] California Total System Electric Generation. Retrieved January 24, 2020 from https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2019-total-system-electric-generation/2016

[6] Electricity Generated in Oregon – 2018 (EIA data). Retrieved January 27, 2020 from https://www.eia.gov/state/index.php?sid=OR.

[7] Washington State Fuel Mix Disclosure Report for 2018. Retrieved January 24, 2020 from https://www.commerce.wa.gov/growing-the-economy/energy/fuel-mix-disclosure/.

[8] The main electricity sources in Canada by Province. Retrieved May 4th, 2020 from Statistics Canada tables 25-10-0020-01 and 25-10-0028-01

The use of coal and petroleum for electric generation is diminishing rapidly, both within the Pacific Northwest and in imported electricity. Solar and wind generation is becoming more affordable, but storage technology still needs to catch up in capacity, duration, and affordability.

In addition to electrifying thermal loads, buildings should be built as grid-interactive with flexible loads and distributed generation and/or storage to reduce, shift, and modulate energy use, which will be increasingly important in the grid of the future with intermittent renewable generation.[9] Utilities and customers will need to expand the use of demand-response agreements to manage supply and demand in real time. The value of energy efficiency, demand response, and other services provided by behind-the-meter distributed energy resources can vary by location, hour, season, and year.[10]

Decarbonizing liquid and gaseous stationary use fuels

Limited production capacity from renewable resources, immature technology for thermal gasification, and associated capital costs are all challenges that would need be overcome to increase the availability of decarbonized liquid and gaseous stationary use fuels. For example studies in Oregon and Washington concluded that RNG has the technical potential to supply between 5% and 20% of natural gas consumption, but the higher end of the range would rely on thermal gasification, which faces economic and technical barriers.[11] Biogas, the precursor to RNG, can be used to produce electricity, but the cost of production is sometimes more than the wholesale price of electricity.[12] Long term contracts for feedstock supplies for forestry and agricultural residuals are elusive.

Economic and financial barriers

Converting buildings to low carbon fuels and technologies may increase energy costs for consumers, hitting hardest those that have benefited from inexpensive fossil fuels or are low-income. Utility investments to meet demand for low-carbon energy may require increased capital expenditure and impact existing assets. Declining energy demand due to efficiency or fuel switching may reduce utilities' customer base and revenue, limiting their ability to make new investments. Sources of funds for new utility investments, like public purpose charges on utility bills, are often constrained by regulation.

Technical and building barriers

Buildings commonly have low and/or unpredictable heating system replacement rates, and replacements are not primarily focused on energy efficiency. Supply chains for alternatives like heat pump systems are not well developed, with limited supply and lack of familiarity among installers, retailers, and others. Addressing these challenges will require more robust supply chains for alternative equipment, marketing to increase familiarity with low-emissions technologies, and addressing bias toward greenhouse gas-intensive fuels and equipment in current building energy codes.

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[9] US DOE Grid-interactive Efficient Buildings. Retrieved May 12, 2020 from https://www.energy.gov/sites/prod/files/2019/04/f62/bto-geb-factsheet-41119.pdf

[10] Grid-interactive Efficient Buildings, Overview, April 2019. Retrieved May 14, 2020 from https://www.energy.gov/sites/prod/files/2019/04/f61/bto-geb_overview-4.15.19.pdf

[11] The 2018 *Biogas and Renewable Natural Gas Inventory* by the Oregon Department of Energy found that Oregon has the technical potential to replace nearly 5% of its natural gas consumption with renewable natural gas (RNG) produced by anaerobic digestion and replace 17.5% of its consumption with RNG produced through thermal gasification once certain economic and technical barriers are overcome (Oregon Department of Energy, 2018, *Biogas and Renewable Natural Gas Inventory*.). A 2017 analysis for Washington State concluded that RNG could substitute for nearly 20% of current direct natural gas use through technologies that include thermal gasification of urban wood waste (Washington State University Energy Program, 2017, *Harnessing Renewable Natural Gas for Low-Carbon Fuel: A Roadmap for Washington State*).

[12] Policies and programs can help reduce cost barriers. For example, California has a program known as BioMAT that provides cost support for electricity made from forestry and agricultural residuals via thermal gasification. Bioenergy Market Adjusting Tariff (BioMAT) Program Review and Staff Proposal. Accessed July 8, 2019 from: https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Electric_Power_Procurement_and_Generation/Renewable_Energy/BioMAT%20Program%20Review%20and%20Staff%20Proposal.pdf

Electrification and fuel technology barriers

Expansion challenges will emerge as all sectors of the economy expand and transition to electricity as the primary fuel. When increased demand for building electrification is coupled with electrification in other end use sectors like transportation, the demand for low carbon electricity is expected to increase significantly. Expanding the production, storage, and transmission of low- or no-carbon electricity is already a major challenge for the power industry. Seasonal demands for power are shifting as climate change progresses, and the increased need for regional coordination and transmission of surplus renewable power between markets is a current and future challenge. Other emerging technologies, like carbon capture and the ability to convert cellulosic biomass to renewable natural gas, are not yet commercially viable and need more time and development to reach maturity.

HOW WILL WE DO THIS WORK?

Efficiency, electrification, and decarbonizing stationary use fuels act as pillars to a broad set of solutions needed to address thermal decarbonization in buildings. The next step will be integrating these solutions into local conditions and regulatory policies in a manner that ensures robust implementation. This ambitious transformation faces several challenges but can benefit from early action and from working together across the region and vertically between cities and their state or province. *To ensure these efforts are consistent, the Pacific Coast Collaborative partners will follow a shared set of principles:*

Ensure affordability and equity. Consistent with PCC agreements expressly valuing climate policy approaches that address socioeconomic inequities by improving access to clean energy technologies and solutions, thermal decarbonization efforts should be available and affordable to low-income households and communities. In the near term, this may be achieved through complementary policies and programs that increase affordability and lower upfront costs. Over the longer term, affordability will be achieved through robust markets that drive innovation, increase availability, lower prices for equipment, and reduce utility bills by increasing efficiency and developing low cost renewable energy resources.

Engage stakeholders. PCC jurisdictions should engage with a broad range of affected stakeholders to understand the implications of market transformations and help design decarbonization policies, programs, and incentives to ameliorate potential adverse impacts. Special emphasis should be placed on obtaining substantive representation and input from low-income and vulnerable communities.

Apply a regional perspective. Consistent with the PCC's recognition that participating jurisdictions can do much individually but can do far more together, thermal decarbonization strategies should embrace regional opportunities created by shared markets and infrastructure. For example, electrification strategies should leverage regional efforts to integrate renewable energy sources into the grid and trade them between utilities.

Account for the carbon content of fuels. Lower carbon content fuels should be prioritized in codes, incentives, and policies. Policies that incentivize higher-GHG thermal fuels should be reformed. Policies that are currently neutral to fuel type should be shifted to those that promote adoption of lower lifecycle carbon intensity GHG fuels.

Account for the costs of carbon. The cost of carbon should be factored into decisions about thermal technology and fuel choices though carbon pricing policies and/or mechanisms that account for the social cost of carbon in utility planning.

Recognize the full range of costs and benefits. Cost-effectiveness methodologies should recognize the full range of lifecycle GHG costs as well as the co-benefits of low-carbon fuels and technologies (e.g., reducing seismic risk related to fuel pipes). Inventory methodologies should also include the upstream leakage from gas production and transmission, using the latest analysis that accurately accounts for all GHG emission impacts.

Take a long-term perspective. Although some solutions may reduce near-term emissions, they will not put the West Coast on the path to long-term decarbonization. PCC partners should avoid locking in durable technologies or infrastructure that will make it difficult or impossible to meet 2050 deep decarbonization goals.

Accelerate market supply and demand. Key markets for low carbon technologies and fuels are in the earliest stages of development and will need to be dramatically transformed to achieve decarbonization goals. Public-private collaboration can help supply chains work more effectively and increase demand by raising public awareness about the benefits of low-carbon alternatives. Market development can increase opportunities for regional investment and job creation.

Leverage information and best practices. Strategies that have proven successful in energy efficiency programs can also be applied to thermal decarbonization. For example, building energy use data collection and benchmarking can motivate behavior change and inform policy and program development.

Understand and mitigate adverse GHG impacts. Thermal decarbonization strategies should recognize and mitigate for potential shifts in emissions to other parts of the energy system. For example, full electrification of heating and cooling can substantially increase peak demand on the electricity grid in winter months, which may encourage long-term investments in fossil fuel-based electricity generation instead of no- or low-carbon resources.

Lead by example. State, provincial, and city agencies should demonstrate the pathways to thermal decarbonization in their own public buildings, campuses, and operations. This includes using building equipment and controls that are intelligent and responsive as a model for buildings providing grid services and emissions reductions through reduced or shifted energy consumption.

Leverage existing long-term assets. Thermal decarbonization strategies should include working with partners to repurpose existing infrastructure, such as using existing natural gas distribution pipelines for RNG and clean hydrogen distribution and storage, to reduce stranded assets and protect consumers from negative cost impacts. This includes working with the natural gas industry to reduce and eliminate fugitive methane emissions, starting at the wellhead and extending all the way through to consumer appliances.

Continue to emphasize efficiency. Energy efficiency is fundamental to other thermal decarbonization strategies. For example, aggressively pursuing building envelope improvements will provide long-range reductions in energy use regardless of the heating and cooling technology used. PCC partners should continue to encourage and incentivize energy and emissions-efficient equipment at time of replacement.