MARYLAND COMMISSION
on **CLIMATE CHANGE**

Ben Grumbles, Chair

DECARBONIZING BUILDINGS IN MARYLAND

BUILDINGS SUBGROUP REPORT TO THE MITIGATION WORK GROUP

SEPTEMBER 21, 2020

Disclaimer

In April 2020, the Maryland Climate Change Commission's (MCCC) Mitigation Work Group (MWG) agreed to create an ad hoc group of volunteers, both members and non-members of the MWG, focused on developing recommendations for decarbonizing buildings in Maryland. This report summarizes topics explored by the Buildings Subgroup between June and September, 2020, including content presented by subgroup participants and expert panelists. A brief literature review to intends to fill in knowledge gaps. Recommendations included herein are generally supported by subgroup participants, however, **this is not a consensus report**. A number of the subgroup's 55 regular participants (see Appendix A) oppose some or all of the recommendations. See the *discussion* following each recommendation for a brief summary of opposition and support.

A few participants also voiced concern for the overall process, raising legitimate concern that the subgroup did not have enough time or analytical support to fully deliberate the implications of the subgroup's recommendations. The authors of this report agree that more time and analytical support would have been beneficial. Several of the recommendations included herein lack the detail that may be needed to implement the recommended changes. Readers of this report should note that this subgroup nor the Mitigation Work Group nor the Commission on Climate Change have decision-making power over State statute, policy, or programs. If the Administration, General Assembly, or other entities pursue any of these recommendations, then separate public processes would be initiated to fully vet these issues.

Lastly, most energy cost figures included in this report are based on historical energy rates and **do not include a social cost of carbon, projected carbon pricing,** or other measures of societal, economic, or environmental benefits of reducing greenhouse gas emissions or other pollutants. However, the EmPOWER Maryland Energy Efficiency Act process does include some of these measures in its cost-benefit analysis.

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Executive Summary

Direct fuel use in residential, commercial, and industrial (RCI) buildings accounted for 18% of Maryland's gross greenhouse gas emissions in 2017 and is projected to become the second largest source of emissions, behind transportation, within 10 years as emissions from electricity generation continue to decline. The State's 2019 Greenhouse Gas Reduction Act (GGRA) Draft Plan includes few measures for decreasing direct emissions from buildings. For Maryland to meet its target of an 80-95% reduction in gross emissions by 2050, it will need to achieve deep emissions reductions from its buildings sector. Residential and commercial buildings in Maryland produced 77% of RCI emissions in 2017 and are the focus of this report. Almost all fossil fuel use in homes and businesses serve just three end-uses – space heating, water heating, and cooking. A literature review shows a common approach to decarbonizing buildings focusing on at least two, if not all three, of the following core strategies:

> **Efficiency** – Improving the thermal performance of building shells and the efficiency of fossil fuel heaters can reduce emissions but efficiency alone would not likely reduce emissions enough to achieve GGRA targets. An 80-95% reduction in the heating energy use of the entire building stock would be needed to achieve a roughly 80-95% reduction in direct emissions from buildings without additional strategies. Efficiency is a critical component of decarbonizing buildings but must be coupled with electrification and, to a smaller degree, renewable fuels.
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> **Electrification** – Electrifying fossil fuel end-uses is a critical part of decarbonizing buildings. Electric heat pumps can be cost effective for new construction and for some building retrofits. The most efficient air source heat pumps installed in 2021 can eliminate direct emissions and reduce total emissions (including emissions from the electric grid) 63% compared with the most efficient gas furnaces and 76% compared with the most efficient oil boilers over 15 years of operation. Emissions reductions are even greater with ground source heat pumps. Analysis by the U.S. Department of Energy finds that it is currently cost effective in Maryland for 99% homes with propane, 95% of homes with oil, and 20% of homes with natural gas space heating systems to switch to an efficient air source heat pump at the point of replacement for the air conditioner. Heat pump water heaters and induction cooktops are proven replacements for combustion alternatives and round out the equipment selection for most all-electric buildings.
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> **Renewable Fuels** – The potential supply of renewable natural gas (RNG), power-to-gas, hydrogen, and other fossil gas alternatives (FGAs) is limited and expensive. RNG, which has the greatest supply potential of the FGAs, could replace only 10% of Maryland's current natural gas consumption in buildings by 2050 and is expected to remain at least three times as expensive as fossil gas for at least the next 30 years. FGAs could be useful for decarbonizing the hardest to electrify sources such as heavy transport, industrial processes, and combined heat and power but are likely too limited and expensive to be a significant factor in decarbonizing typical low-temperature heating needs including space and water heating.

Several states including Washington, Oregon, California, and New Jersey recently published results from studies on decarbonizing buildings and generally found that electrification-focused scenarios offer the lowest cost and lowest risk pathways for achieving those states' emission reduction goals. A few states found that building electrification presents various benefits: reduced stranded assets of infrastructure, increased energy efficiency, increased financial savings, and increased flexibility to achieve emissions goals.

New Jersey, with climate conditions and energy rates similar to Maryland's, offers valuable insights in their recent Energy Master Plan. New Jersey found that "electrification reduces annual costs by 50% in 2050, compared to retaining gas use in buildings" if the state is to meet its emissions target (80% below 2006 levels by 2050) and that "electrification is the most cost-effective path to achieving further emissions reductions" beyond the 80% reduction target. The state's strategy for decarbonizing buildings is summarized this way:

> *The building sector should be largely decarbonized and electrified by 2050 with an early focus on new construction and the electrification of oil- and propane-fueled buildings. New Jersey must electrify its state facilities, partner with private industry to establish electrified building demonstration projects, expand and accelerate the current statewide net zero carbon homes incentive programs for both new construction and existing homes… The state must also develop a transition plan to a fully electrified building sector, including incentivizing appliances like electrified heat pumps and hot water heaters.*

Using the literature, including New Jersey's Energy Master Plan, as a guide, the Buildings Subgroup deliberated over three months and developed, with broad but varying levels of support, the following recommendations:

Goal 1: Adapt EmPOWER for Beneficial Electrification

Recommendation 1: Enable Fuel-Switching to let Marylanders Choose Lowest Cost and Lowest Carbon Energy Systems

Recommendation 2: Let EmPOWER Facilitate Beneficial Electrification and Greater Energy Efficiency

Recommendation 3 [Option A]: Target 50% of Space Heater Sales to be Electric Heat Pumps by 2025

Recommendation 3 [Option B]: Establish Residential Heat Pump Retrofit Goals

Goal 2: Construct Carbon Neutral New Buildings

Recommendation 4 [Option A]: Require All-Electric and Energy Efficient New Homes by 2025 and New Commercial Buildings by 2026 with Cost Controls

Recommendation 4 [Option B]: Require All-Electric and Energy Efficient New Homes by 2025

Recommendation 5: Incentivize Net-Zero Energy, Energy Efficient, All-Electric New Buildings

Goal 3: Develop an Energy Transition Plan

Recommendation 6: Produce an Energy Transition Plan by the end of 2021

Goal 4: Prioritize Benefits to Underserved and Limited-Income Consumers and Households

Recommendation 7: Prioritize an Equitable Level of Benefits for all Marylanders

Recommendation 8: Improve Interagency Coordination for Wholistic Building Retrofits

Introduction

Maryland Department of the Environment's (MDE's) greenhouse gas inventories[1] show that direct fuel use in residential, commercial, and industrial (RCI) buildings accounted for 18% of Maryland's gross greenhouse gas emissions in 2017 and was the third largest source of emissions behind transportation and electricity use. Between 2006 and 2017, direct emissions from Maryland's buildings decreased 18% due to a halving in emissions from Maryland's industrial sector. Modest emissions reductions in residential buildings were counteracted by emissions increases in commercial buildings. On net, direct emissions from residential and commercial buildings increased 2% during this period.

The 2019 Greenhouse Gas Reduction Act (GGRA) Draft Plan[2] includes few measures for decreasing direct emissions from buildings. The Draft Plan currently estimates that emissions from buildings would remain flat through 2050 and become the second largest source of emissions around 2030 as electricity use emissions continue to decline. For Maryland to meet its target of an 80-95% reduction in gross emissions by 2050, it will need to achieve deep emissions reductions from its buildings sector.[3] Studies show that decarbonizing buildings is more cost effective than mitigating or sequestering emissions from other sectors,[4] so the State should aim to achieve buildings sector reductions at least on pace with statewide emissions reduction targets.

Table 1: Direct Emissions from Buildings in Maryland (MMtCO2e)

	2006 Emissions (baseline)	2017 Emissions (latest inventory)	Change, 2006-2017	2050 Target (80-95% reduction)
Residential	6.0	5.4	- 10%	
Commercial	4.5	5.3	+18%	
Industrial	6.4	3.2	- 50%	
Total	**16.9**	**13.9**	**- 18%**	**0.8 - 3.4**

As of 2017, direct emissions from buildings resulted from the combustion of natural gas (70%), heating oil (9%), coal (5%), wood (5%), liquefied petroleum gas (LPG)/propane (4%), and various other fuels (7%).[5] Coal and heating oil (also called distillate fuel) have the highest carbon intensity among these fuels and should be replaced, when cost effective and with assistance from State programs, with cleaner sources. However, because natural gas combustion causes 70% of total RCI fuel use emissions and represents 80% of direct emissions within the residential and commercial sectors,[6] it must be a focal point of the State's decarbonization plan.

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[1] MDE. Greenhouse Gas Inventories for 2006 and 2017. https://mde.maryland.gov/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx

[2] MDE. 2019 GGRA Draft Plan. October 2019. https://mde.maryland.gov/programs/Air/ClimateChange/Pages/Greenhouse-Gas-Emissions-Reduction-Act-(GGRA)--Draft-Plan.aspx

[3] The 2019 GGRA Draft Plan shows that only one of four modeled policy scenarios would come close to achieving the State's minimum emissions reduction target for 2050. The three policy scenarios that exclude deep decarbonization of the building sector do not reach the target.

[4] Global Commission on the Economy and Climate. New Climate Economy technical note: Quantifying the multiple benefits from low-carbon actions in a greenhouse gas abatement cost curve framework. January 2015.

[5] MDE. Greenhouse Gas Inventories for 2006 and 2017.

[6] ibid

Deep Decarbonization Pathway for Buildings

Several federal and state agencies, nongovernmental organizations, and research groups have published studies and reports on measures for decarbonizing buildings. A literature review shows a common approach that focuses on at least two, if not all three, of the following core strategies: Efficiency, Electrification, and Renewable Fuels. This section briefly describes the potential opportunities and limitations of each strategy and ends with conclusions that other states reached when these strategies were evaluated synergistically.

Efficiency

Energy efficiency should be a primary goal for any emissions reduction plan, especially since it represents a suite of measures that typically reduce costs while reducing emissions.[7] Theoretically, Maryland could reach its 2050 emissions target through efficiency alone without electrifying fossil fuel end-uses or utilizing renewable fuels; logic suggests that an 80-95% reduction in the heating energy use of the entire building stock would roughly translate to an 80-95% reduction in direct emissions from buildings. Of course, there are cost effectiveness limitations for efficiency measures, so the lowest cost deep decarbonization pathway for buildings is likely balanced between efficiency, electrification, and, possibly, renewable fuels.

EmPOWER: Success Story and Market Capacity Builder

Maryland has a proud history of running efficiency programs that provide financial benefits for ratepayers and participating utility companies. EmPOWER has often been recognized as a top energy efficiency program in the country, repeatedly ranking in the top ten most energy-efficient states in the nation according to ACEEE annual scorecards.[8] The EmPOWER Maryland Energy Efficiency Act (Maryland Public Utilities § 7-211) requires Maryland's largest electric utility companies to develop programs that achieve an annual energy savings goal of 2% of gross energy sales through 2023 by providing customers with energy efficient options. In enacting the EmPOWER Maryland Energy Efficiency Act in 2008, the Maryland General Assembly noted that "energy efficiency is among the least expensive ways to meet the growing electricity demands of the State" (*Id*.§ 7-211(b)). EmPOWER programs are administered by the Maryland Public Service Commission (PSC) with consultation by the Maryland Energy Administration (MEA) and Office of People's Council (OPC).[9]

Residential, commercial, and industrial customers can find financial incentives under EmPOWER program offerings.[10] Programs include lighting and appliance rebates for homeowners, Home Performance with ENERGY STAR, commercial lighting rebates, and energy efficiency services for industrial facilities. EmPOWER programs are managed by the following utility companies: Baltimore Gas and Electric Company (BGE), Potomac Edison Company, Delmarva Power & Light, Potomac Electric Power Company (PEPCO), Southern Maryland Electric Cooperative, and Washington Gas Light Company

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[7] Global Commission on the Economy and Climate. New Climate Economy technical note: Quantifying the multiple benefits from low-carbon actions in a greenhouse gas abatement cost curve framework. January 2015.

[8] ACEEE. Maryland EmPOWER. 2017. ttps://www.aceee.org/press/2017/01/empower-maryland-will-save-customers

[9] PSC EmPOWER, https://www.psc.state.md.us/electricity/empower-maryland/

[10] Maryland Public Service Commission. EmPOWER Maryland Report. 2019.

(WGL). The Department of Housing and Community Development (DHCD) oversees the two limited income programs. There is a Low-Income Energy Efficiency Program (LIEEP), a weatherization program in which qualifying participants receive no cost direct install, health and safety, and weatherization measures. There is also a Multifamily Energy Efficiency and Housing Affordability Program (MEEHA), a financing mechanism for the installation of qualifying energy efficiency measures in both the residential and commercial spaces of housing developments.

EmPOWER is successful at what it was mainly designed to do: reduce per capita electricity consumption and peak demand. By 2020, EmPOWER saved a total of 10,670,600 MWh and 2,571 MW of peak demand while generating $10.6 billion in savings over the life of installed energy efficiency measures.[11] EmPOWER programs have provided cost-effective and long-term benefits, including reduced energy consumption and rates, avoided investments in energy transmission and distribution, and some indirect improvements to the environment. EmPOWER also has a unique capacity to support new job creation, improve overall customer health and comfort, provide training and workforce opportunities for contractors, and increase demand and capacity for the adoption of energy-efficient appliances.

EmPOWER: Opportunities for Emissions Reductions and Equity Considerations

Despite EmPOWER's ability to decrease indirect emissions from electricity consumption, it does not seem to have a spillover effect of decreasing direct emissions from buildings. As seen in the following table, fossil fuel consumption *increased* in both the residential and commercial building sectors from 2006 to 2017 while EmPOWER was active.[12] Again, this is no fault of the program, which was not designed to reduce direct use of fossil fuels or total energy costs. Ratepayers with fossil fuel heating systems are not eligible for incentives for upgrading to high efficiency electrified systems since that type of replacement would increase electricity consumption, which works against EmPOWER's current objectives. Changing the goals of EmPOWER would be necessary to make it effective at decreasing direct fuel use in buildings and helping ratepayers reduce total energy consumption.

Table 2: Direct Fuel Use in Residential and Commercial Buildings in Maryland (Billion Btu)

	Residential			**Commercial**		
	2006	2017	Change	2006	2017	Change
Natural Gas	73,811	79,376	+8%	65,041	75,700	+16%
Heating Oil	19,719	10,426	- 47%	10,494	5,563	- 47%
LPG	6,645	6,277	+6%	1,173	3,078	+162%
Total	**93,530**	**96,079**	**+3%**	**76,708**	**84,341**	**+10%**

The 2019 GGRA Draft Plan[13] acknowledges this issue and proposes adapting EmPOWER to give ratepayers greater access to incentives for replacing fossil fuel heating systems and lowering total energy use (excerpt below). The Buildings Subgroup endorses the State's proposal and offers a few recommendations at the end of this report for achieving the desired outcomes.

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[11] Best, Amanda. EmPOWER Maryland. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. August 2020.

[12] MDE. Greenhouse Gas Inventories for 2006 and 2017. https://mde.maryland.gov/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx

[13] MDE. 2019 GGRA Draft Plan. October 2019.

The current EmPOWER statute requires the utilities to continue programs focusing on the efficient use and conservation of energy, subject to the review and approval of the PSC, after 2023. Without prejudice toward the PSC's process, the 2019 GGRA Draft Plan proposes that the state continue to invest in energy efficiency through EmPOWER beyond 2023, at levels of effort roughly consistent with those required to achieve the current program cycle goals. The 2019 GGRA Draft Plan also proposes to begin incentivizing increased deployment of efficient electric heat pumps to heat homes in Maryland, including in homes that currently use a different fuel for heat, in order to improve the efficiency of residential heating systems, and to transition the energy source for home heating toward increasingly clean electricity.

Additionally, although EmPOWER has programs in place to specifically target program availability for low-income customers, many low and middle-income customers are continuing to be disproportionally impacted by environmental harms and risks, many of which are associated with energy production. The EPA states that defines overburdened communities as the following: [14]

Minority, low-income, tribal, or indigenous populations or geographic locations in the United States that potentially experience disproportionate environmental harms and risks. This disproportionality can be a result of greater vulnerability to environmental hazards, lack of opportunity for public participation, or other factors. Increased vulnerability may be attributable to an accumulation of negative or lack of positive environmental, health, economic, or social conditions within these populations or places. The term describes situations where multiple factors, including both environmental and socioeconomic stressors, may act cumulatively to affect health and the environment and contribute to persistent environmental health disparities.

There is a long history of inequitable access to clean energy, safe indoor air quality conditions, and overall energy-related comfort. Many states have begun to consider targeted efforts to increase participation in energy efficiency programs by low- and middle-income customers. There is a great opportunity for EmPOWER programs, as well as other energy-related programs regulated by state entities, to ensure and prioritize incentives and long-term benefits are also available to overburdened communities. For example, the Maryland Energy Administration manages millions of dollars in proceeds from the Regional Greenhouse Gas Initiative (RGGI) to create energy programs that also provide incentives.[15] These programs already provide around $6 million annually to retrofit low to moderate income homes but there may be room to better align programs with emissions reductions and equity considerations. Additionally, the Maryland Department of Housing and Community Development (DHCD) has a Net Zero Loan Program in place for homeowners, builders, and developers, and could provide useful insights on program design and existing market gaps to increase the reach of other incentive efforts.[16]

Notably, the Maryland Green and Healthy Homes Initiative prepared a gap analysis report for the Maryland Lead Poisoning Prevention Commission and recommended that weatherization programs be aligned with lead prevention efforts.[17] The report highlights the need for health and safety considerations in programmatic design and incentive allowances. Many programs have already begun integrating health and housing services programs to better align with environmental remediation efforts, such as by the U.S. Department of Energy Weatherization Assistance Program (WAP). In 2013, the Maryland Public Service Commission awarded $19.0 million for use by the Maryland Department of

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[14] EPA. Environmental Justice Glossary for 2020. https://www.epa.gov/environmentaljustice/ej-2020-glossary

[15] MEA Incentives. https://energy.maryland.gov/Pages/all-incentives.aspx

[16] DHCD. https://dhcd.maryland.gov/Pages/NetZero/default.aspx

[17] Green & Healthy Homes Initiative. Maryland Lead Poisoning Prevention Asset and Gap Analysis Report: Prepared for the Maryland Lead Poisoning Prevention Commission. May 2020.

Housing and Community Development in seven counties and $19.8 million to the Baltimore City Department of Housing and Community Development for use on Consumer Investment Funds (CIF) for program interventions in low income homes that included energy efficiency, lead hazard reduction, health and safety and housing rehabilitation.

Overall, there is a great opportunity to design EmPOWER programs with the state's broader policy goals, including decarbonization and equity considerations. For example, cost-effectiveness considerations could follow the National Standard Practice Manual and encourage new pilot programs.[18] Some potential approaches include: A) alignment with other like health and safety upgrades; B) measurable outcomes for which low- income households are better off after participation in programs including metrics to ensure benefits are flowing to increase equity and equitable outcomes, and is triaged by known disparities and gaps; and C) retrofit implementation at no cost for the state's most financially vulnerable consumers.

Bottom line: Adapting EmPOWER to work for reducing direct emissions and lowering total energy costs for ratepayers could be the single most important mechanism for decarbonizing existing buildings in Maryland. This change would incentivize ratepayers to install systems that can provide the lowest total costs and emissions for homes and businesses, which is implicitly prohibited in EmPOWER's current program structure by not allowing ratepayers with fossil fuel heating systems to receive incentives for replace those systems with efficient electric alternatives. It would expand the utilization of electric heat pumps, which have zero direct emissions and lower total emissions than alternative energy systems (analysis below). It would also increase incentives for shell improvements (such as insulation and air sealing) to reduce total energy costs and improve occupant comfort.

Electrification

Replacing fossil fuel heating systems with electric systems is widely recognized as a critical component of deep decarbonization of buildings.[19] In Maryland, approximately 95% of fuel use in homes and 76% of fuel use in commercial buildings serve just two end-uses – space heating and water heating – with space heating being the dominant end-use.[20] Electric heat pumps (air source or ground source), which efficiently move heat from one place to another instead of combusting fuel to make heat, are commonly used for space heating and water heating, produce zero direct emissions, and have lower total emissions than other heating equipment. Air source heat pumps (ASHPs) are more common than ground source heat pumps (GSHPs) because they cost less to install and can operate at high efficiency levels, though not as high as GSHPs. ASHPs can also cost less to install and operate than separate natural gas furnaces and electric air conditioning (AC) systems, which is why ASHPs are the focus of several reports and studies on buildings decarbonization[21] including this one.

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[18] National Efficiency Screening Project (NESP). 2020. The National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources. 2020.

[19] MDE. 2019 GGRA Draft Plan. October 2019; New Jersey. Energy Master Plan. 2019; NREL. Electrification Futures Study. 2017; RMI. The Economics of Electrifying Buildings. June 2018; NEEP. Building Decarbonization Public Policy Framework. 2019; NEEP. Strategic Electrification Regional Assessment. 2017; The Brattle Group. Heating Sector Transformation in Rhode Island. 2020.

[20] Based on natural gas end-use in residential (EIA RECS 2015) and commercial (EIA CBECS 2012) buildings, averaged for the South Atlantic and Middle Atlantic regions.

[21] New Jersey. Energy Master Plan. 2019; NREL. Electrification Futures Study. 2017; RMI. The Economics of Electrifying Buildings. June 2018; NEEP. Building Decarbonization Public Policy Framework. 2019; NEEP. Strategic Electrification Regional Assessment. 2017; The Brattle Group. Heating Sector Transformation in Rhode Island. 2020.

Emissions from Space Heating Systems

The most efficient ASHPs installed in 2021 can eliminate direct emissions and reduce total emissions (including emissions from the electric grid) 63% compared with the most efficient gas furnaces and 76% compared with the most efficient oil boilers over 15 years of operation. The following table compares emissions between several residential heating systems. Emissions savings (as percentages) would be similar between different types of commercial heating equipment with the same levels of efficiency. Emissions associated with ASHPs (and GSPHs) would further improve if the electricity grid decarbonizes faster than projected or if the equipment is powered by renewable electricity sources.

Table 3: Estimated 15-Year Emissions from Highest Efficiency Residential Heating Systems

	Heating Efficiency[22]	Annual Heating Demand (MMBtu)	Annual Heating Energy Use (MMBtu)	15-year Emissions[23] (MtCO2e)
Ground Source Heat Pump	500%	50	10	**11**
Air Source Heat Pump	370%	50	14	**15**
Natural Gas Heat Pump	140%	50	36	**28**
Natural Gas Furnace	98%	50	51	**41**
Oil Boiler	90%	50	56	**62**

ASHP Cost Effectiveness in Homes

ASHPs are already widely used in Maryland and are the most common space heating system for homes in the Census region that includes Maryland. Among new single-family homes that started construction in the South Atlantic region in 2018, 76% were built with heat pumps as the primary space heating system.[24] Although Maryland experiences colder wintertime temperatures than other states in its Census region, its climate is rapidly shifting to more closely resemble the current climate of states farther to its south. Research by faculty at the University of Maryland Center for Environmental Science found that Maryland's climate will continue to shift to resemble the climate of Arkansas (moderate emissions scenario) or Mississippi (high emissions scenario) over the next 60 years.[25] As Maryland's climate continues to warm, ASHPs will be increasingly cost effective solutions for heating and cooling.

ASHPs can provide the lowest installation and operating costs compared with other systems, which is why they are the most commonly installed space heating system in homes in the South Atlantic region, but a recent study by the Rocky Mountain Institute (RMI)[26] found that ASHPs are also cost effective in a wide range of climates, for new construction or retrofit:

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[22] Based on highest efficiency equipment available in 2020. The highest efficiency ASHP in 2020 has a HSPF rating of 14.2 (SCOP 4.2) but efficiency is decreased in this analysis to SCOP 3.7 based on study (https://conduitnw.org/Pages/File.aspx?rid=4967) results showing that efficient ASHPs perform about 12% below their HSPF/SCOP rated values in mixed-humid climates.

[23] Assuming a natural gas emissions factor of 0.0532 MtCO2e/MMBtu, oil emissions factor of 0.0744 MtCO2e/MMBtu, and electricity emissions factor of 0.0743 MtCO2e/MMBtu based on projected grid emissions in Maryland from 2021 to 2035.

[24] National Association of Home Builders. Air Conditioning and Heating Systems in New Homes. December 2019. http://eyeonhousing.org/2019/12/air-conditioning-and-heating-systems-in-new-homes-4/

[25] Fitzpatrick, M. & Dunn, R. Contemporary climatic analogs for 540 North American urban areas in the late 21st century. Nature Communications. February 2019.

[26] RMI. The Economics of Electrifying Buildings. June 2018.

In many scenarios, notably for most new home construction, we find electrification of space and water heating and air conditioning reduces the homeowner's costs over the lifetime of the appliances when compared with performing the same functions with fossil fuels. Costs are also reduced for customers in several retrofit scenarios: for customers switching away from propane or heating oil, for gas customers who would otherwise need to replace both a furnace and air conditioner simultaneously, and for customers who bundle rooftop solar with electrification. New homes and homes currently lacking natural gas service also avoid the cost of gas mains, services, and meters not needed in all-electric neighborhoods.

The following table summarizes total installed costs and total energy costs in single-family homes for standard ASHP space conditioners and water heaters compared with standard natural gas space and water heaters with separate AC systems, averaged across RMI's study sites:

Table 4: Average 15-Year Net Present Cost of Water and Space Conditioning in new Single-Family Homes in Four U.S. Cities[27]

	New Construction			**Retrofit**		
	Energy Cost	Fixed Cost	Total Cost	Energy Cost	Fixed Cost	Total Cost
ASHP Space Conditioner and ASHP Water Heater	$4,850	$6,850	$11,700	$11,175	$10,550	$21,725
Gas Space Heater, Gas Water Heater, and Electric AC	$5,475	$9,300	$14,775	$10,575	$11,625	$22,200
Difference	**($625)**	**($2,450)**	**($3,075)**	**$600**	**($1,075)**	**($475)**

The data show that energy cost differences between the two different system packages are marginal: +/- $600 over 15 years, which equates to +/- $40 per year or +/- $3 per month. However, the installation cost savings are significant. The all-electric package is $2,450 less expensive to install than the gas heating with AC package in new homes and $1,075 less expensive in a retrofit. Local labor, equipment, energy rates, and site conditions will, of course, influence costs but the RMI study is a good benchmark since it carefully considered these factors for each of its study sites.[28]

A separate study[29] by the U.S. Department of Energy (DOE) shows further evidence of the cost effectiveness of replacing existing heating systems with ASHPs. As seen in the following figure, the study found that it is cost effective for the majority of homes that use oil or propane for heating to switch to an ASHP space conditioner when the existing AC system wears out. For homes with natural gas furnaces, it is cost effective to replace the existing gas furnace with an ASHP at the time of AC replacement for about 25% of homes nationally.

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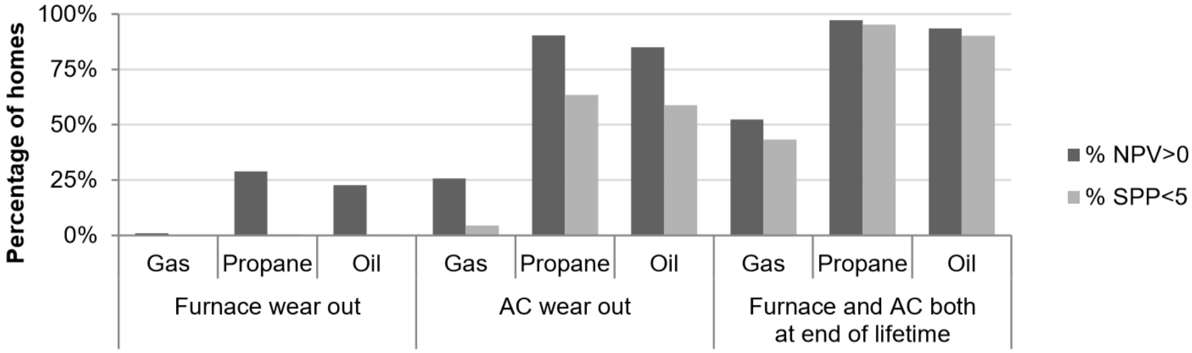
[27] ibid

[28] ibid

[29] U.S. DOE. Energy Efficiency Potential in the U.S. Single-Family Housing Stock. December 2017.

Figure 1: National Percentage of Homes Passing Cost-Effectiveness Thresholds for Replacement of Furnace/Air Conditioner with Variable-Speed Heat Pump, Under Three Wear-Out Scenarios[30]



Jack Mayernik from the U.S. DOE presented[31] to the Buildings Subgroup and said that the DOE is currently working on state-level analyses of the data shown above. Although the results are not yet published, DOE was able to share estimates for Maryland. A forthcoming report finds that it is currently cost effective (NPV>0) in Maryland for 99% homes with propane, 95% of homes with oil, and 20% of homes with natural gas space heating systems to switch to an efficient ASHP at the point of AC replacement. In other words, DOE's state-level analysis shows that Maryland's data resembles the data from their national assessment, which suggests that for around half of Maryland homes with both AC units and gas furnaces near the end of their lives, switching to an ASHP would be cost effective.

Mr. Mayernik presented[32] other reasons why ASHPs may become increasingly cost effective in the future. First, analysis shows that ASHPs in Maryland need a seasonal coefficient of performance (SCOP), which is a measure of average energy efficiency throughout a typical heating season, of 3.1 to break even on the annual cost of heating compared with an Energy Star compliant natural gas furnace with a heating efficiency (AFUE) of 90%. Mid-tier ASHPs currently have a SCOP around 3.0 but around 7% of ASHPs available today have SCOP ratings of at least 3.81. DOE reports that with continued advancements in technology, typical residential ASHPs could achieve SCOP ratings of 3.75-4.0 by 2030,[33] which would result in significant energy cost savings compared with natural gas furnaces.

Second, natural gas rates are projected to increase faster than electricity rates for residential (and non-residential) customers.[34] As seen in the following figure, the U.S. Energy Information Administration's (EIA's) reference case scenario anticipates that natural gas rates could increase around 20-25% by 2050 while electricity rates remain relatively flat.[35] As the efficiency of ASHPs improves and/or natural gas rates increase faster than electricity rates, then ASHPs could become the most cost effective space heating systems for the majority of homes in Maryland.

[30] ibid

[31] Mayernik, J. Cost Effectiveness of Electrification with Air-Source Heat Pumps. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. August 2020.

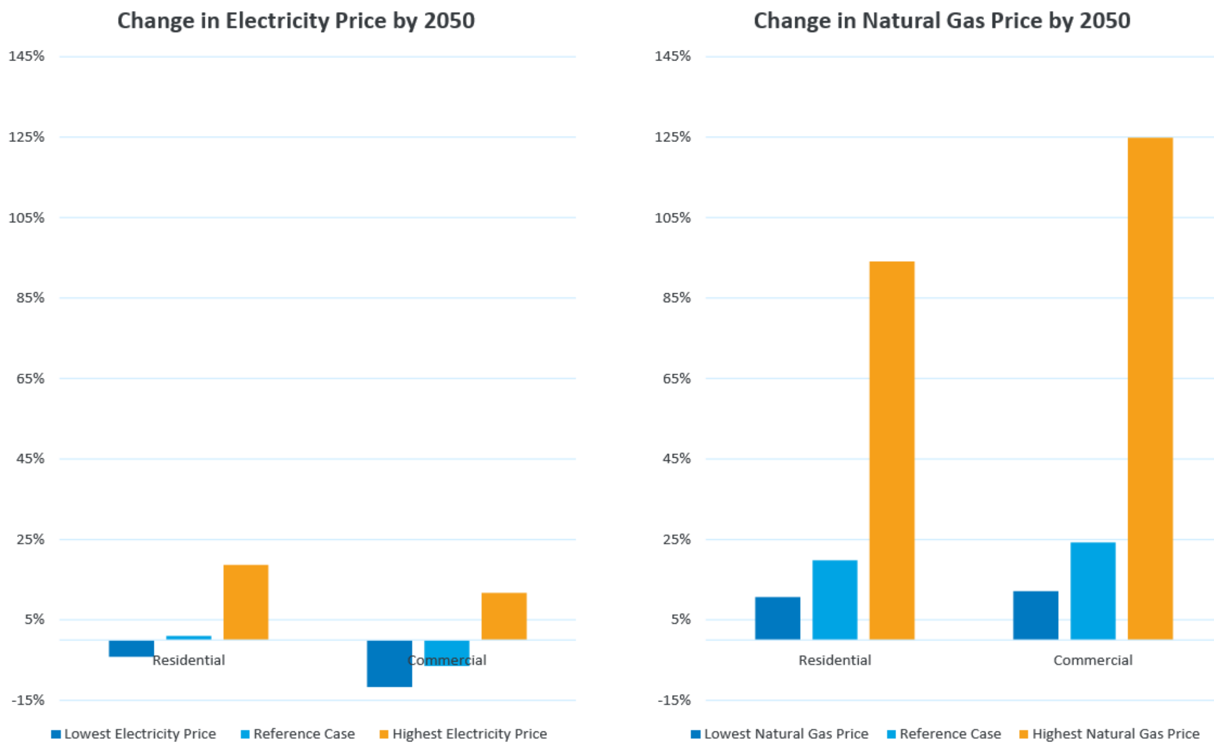
[32] ibid

[33] NREL. Electrification Futures Study. 2017.

[34] U.S. EIA. Annual Energy Outlook 2020.

[35] ibid

Figure 2: Change in Electricity and Natural Gas Rates by 2050[36]



ASHP Cost Effectiveness in Commercial Buildings

The cost effectiveness of ASHPs in commercial buildings is hard to determine because it seems to be less studied than ASHP application in the residential sector. Commercial buildings cover a wide range of building types and uses, which makes it difficult to generalize the performance of any type of energy system across such a diverse sector. Still, ASHPs including variable refrigerant flow (VRF) systems are not uncommon in commercial buildings and there is reason to believe they, like their residential counterparts, can deliver annual energy costs on par with energy costs of mixed-fuel systems in many applications.

Mr. Mayernik noted in his presentation[37] that commercial ASHPs can be more efficient than residential ASHPs and typically exceed the efficiency rating necessary to provide lower heating costs than natural gas systems in Maryland. As seen in the figure below, typical commercial ASHPs installed in 2020 achieve a SCOP of 3.4-4.0.[38] These efficiency ratings are for International Energy Conservation Code (IECC) Climate Zone 5, which is slightly colder than Maryland's climate (IECC Climate Zone 4; see Appendix B).[39] Thus, ASHP performance in Maryland should, on average, meet or exceed the performance ratings of ASHPs in this study. The figure below also shows that commercial ASHPs are expected to continue to increase in efficiency and decrease in cost over the next three decades. The study found that commercial ASHPs would likely achieve a SCOP of 3.5-4.5 by 2030.

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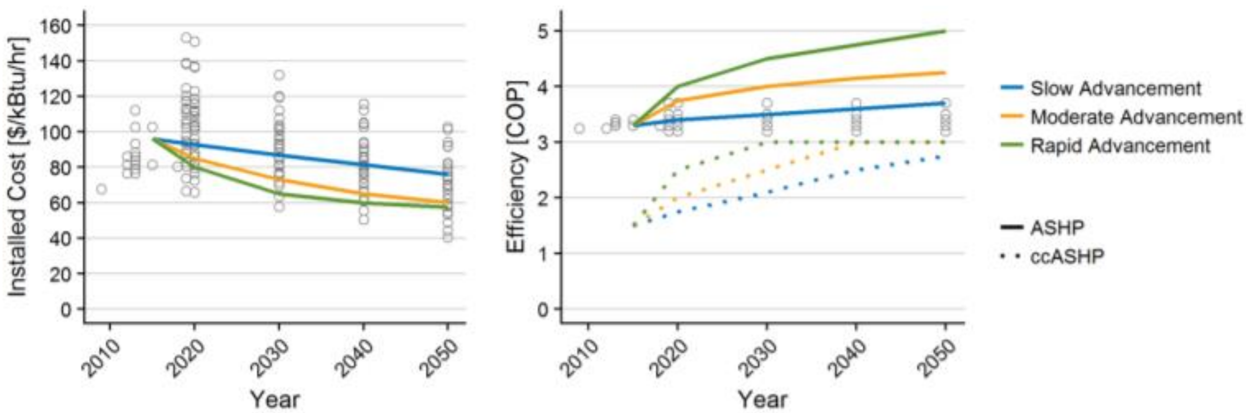
[36] Mayernik, J. Cost Effectiveness of Electrification with Air-Source Heat Pumps. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. August 2020.

[37] ibid

[38] NREL. Electrification Futures Study. 2017.

[39] ibid

Figure 3: Installed Unit Costs (left) and Performance Projections (right) for Commercial ASHPs[40]



The following table examines the SCOP needed by ASHPs to match the heating cost of natural gas furnaces for residential, commercial, and industrial customers in Maryland. For every customer class, the highest efficiency ASHPs have lower heating costs than the highest efficiency gas furnaces based on ratings. Standard efficiency ASHPs roughly breakeven on heating costs compared with standard efficiency furnaces based on ratings. Cost savings potential is greatest for commercial and industrial customers who pay relatively lower rates for electricity than for natural gas as compared with residential customers. It is important to note, however, that ASHP ratings are not always an accurate predictor of real-world performance (see next sections).

Table 5: Heating Cost Parity Point for ASHPs and Natural Gas Furnaces in Maryland[41]

	Residential	**Commercial**	**Industrial**
Electricity rate	$39.01/MMBtu	$30.59/MMBtu	$24.14/MMBtu
Natural gas rate	$11.38/MMBtu	$9.24/MMBtu	$8.21/MMBtu
ASHP SCOP needed for heating cost parity with:			
Standard efficiency (80% AFUE) gas furnace	2.7	2.6	2.4
Highest efficiency (98% AFUE) gas furnace	3.4	3.2	2.9
Current ASHP SCOP ratings:			
Standard efficiency (HSPF 8.2) ASHP	2.4	2.4	2.4
Highest efficiency (HSPF 14.2) ASHP	4.2	4.2	4.2

[40] NREL. Electrification Futures Study. 2017.

[41] Electricity and natural gas rates from EIA data for 2018 converted to $/MMBtu. HSPF 8.2 is the current federal minimum rating for residential ASHPs sold in most states including Maryland. The residential ASHP recognized on the ENERGY STAR Most Efficient list as of April 2020 has a HSPF of 14.2. SCOP = HSPF x 3.412. Commercial ASHPs do not receive a HSPF/SCOP rating but are considered to be at least as efficient as residential systems. Industrial buildings assumed to use residential or commercial systems for space conditioning.

Caution on Commercial and Industrial Building Diversity

Any application of general cost and performance estimates to commercial and industrial buildings needs to consider the diversity of building sizes, uses, and energy needs. Multiple participants noted that, while general studies described here may indicate ASHPs could often cost less to install and operate than other systems, there are many commercial and industrial building applications where that is not the case, and where some use of combustion, for primary heating, secondary heating, or backup electricity generation, would be more cost-effective,[42] and there are opportunities for substantial efficiency gains through the use of combined heat and power and district energy systems.

Caution on HSPF/SCOP Ratings

Ideally, the heating season performance factor (HSPF) or seasonal coefficient of performance (SCOP) rating would accurately reflect the actual heating performance of an ASHP. Unfortunately, real world performance can stray from the rated values. Early results from an ongoing study by the Northwest Energy Efficiency Alliance[43] show that for 13 ASHPs tested with an average HSPF of 12 (SCOP 3.5), their performance in a mixed-humid climate like Maryland's was around 12% lower than their ratings, achieving a SCOP 3.1 on average instead of 3.5. If the study results were applied to all ASHPs in Maryland, then standard efficiency ASHPs would have higher heating costs than standard efficiency natural gas furnaces and only high efficiency ASHPs would offer lower heating costs than high efficiency gas furnaces.

Although it is noteworthy that heating costs could be higher than suggested by an ASHP's rating, the RMI study mentioned previously is a reminder that heating costs are just one factor to consider. Comparing ASHPs with natural gas furnaces makes sense in the context of this report, which aims to find solutions for decreasing direct use of fossil fuels (primarily natural gas) in Maryland's buildings. However, ASHPs provide heating *and* cooling and are often more efficient than dedicated AC systems, so cooling cost savings should be considered, too, along with potentially lower installation costs. RMI found that even when energy costs increased with an ASHP in homes, the increase (an average of $3/month in retrofit jobs) was more than offset by installation cost savings.[44]

ASHP Water Heaters

Water heating gets less attention in the literature than space heating but it is a significant source of emissions representing around 25% of natural gas use in Maryland's buildings.[45] Studies show that residential ASHP water heaters are already cost effective compared with natural gas water heaters.[46] RMI's The Economics of Electrifying Buildings[47] study found that ASHP water heaters save an average of $70 per year in energy costs compared with natural gas water heaters but cost around $400 more to install. The simple payback period for the cost premium was around six years. However, these cost/savings figures may mask the greatest value of heat pump water heaters: they can be used as

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[42]Carrier. Evaluating Variable Air Volume (VAV) Packaged Rooftop Systems for use in High Performance Environments. *Carrier Engineering Newsletter*. Volume 6, Issue 2; RMI. Value Potential for Grid-Interactive Efficient Buildings in the GSA Portfolio: A Cost-Benefit Analysis. 2019.

[43] NEEA. EXP-07 Preliminary Results: A new load-based test procedure - variable capacity heat pumps. November 2019.

[44] RMI. The Economics of Electrifying Buildings. June 2018.

[45] Based on natural gas end-use in residential (EIA RECS 2015) and commercial (EIA CBECS 2012) buildings, averaged for the South Atlantic and Middle Atlantic regions.

[46] NREL. Electrification Futures Study. 2017; RMI. The Economics of Electrifying Buildings. June 2018.

[47] RMI. The Economics of Electrifying Buildings. June 2018.

energy storage devices, which could have significant benefits to the electric utility companies and ratepayers as explained in RMI's report:

> *Water heaters can generally provide more load shifting than space heating, without impacting individual comfort. This is especially true when water can be preheated to very high temperatures (e.g., 150– 160°F) and provide hot water to the user for many hours without the need for additional energy use. In our Houston Free Nights scenario, for instance, this strategy shifts the large majority of energy use to nighttime and reduces annual energy costs for water heating from $154 to $48. The same strategy for space heating provides only a few dollars per year of savings, as the building cannot be comfortably heated so high or cooled so low outside normal temperatures, and does not retain heat as well as a water tank.*[48]

Induction Cooking

Although space heating and water heating are the focal points for decarbonizing buildings, cooking is another important consideration. An estimated 3% of natural gas used in homes and 19% of gas used in commercial buildings in Maryland is for cooking.[49] A recent study[50] comparing electric induction, electric resistance, and natural gas cooktops found that induction units boiled water faster and heated more evenly than electric resistance or gas units. Induction cooktops also had the lowest cooking surface temperature, making them the safest with regard to burn prevention. However, induction cooktops are currently more expensive to purchase than alternatives and cost about $1 more per month (under typical residential cooking usage) to operate than gas cooktops. The table below summarizes results from the cited study. From a cost perspective, installing induction cooktops might be cost effective in new buildings where all-electric construction results in a lower net cost than mixed-fuel construction but it is not currently cost effective, without accounting for climate or public health benefits, as a replacement to an existing cooktop without incentives.

Table 6: Residential Cooktop Energy Cost Comparison[51]

Cooktop	Induction A (Frigidaire)	Induction B (GE)	Induction C (Samsung)	Resistance Ceramic (Whirlpool)	Resistance Coil (Frigidaire)	Gas Burner (Samsung)
Total Energy Per Day	970 Wh	996 Wh	1013 Wh	1050 Wh	1088 Wh	8,150 Btu
Total Energy Per Year	252 kWh	259 kWh	263 kWh	273 kWh	283 kWh	21.19 therms
Energy Cost Per Year	$40.55	$41.62	$42.35	$43.89	$45.48	$33.06
Annual Cooling Costs*	$4.62	$4.74	$4.82	$5.00	$5.18	$9.10
Annual Heating Savings*	$6.23	$6.39	$6.50	$6.74	$6.99	$12.27
Total Annual Costs	$38.94	$39.97	$40.66	$42.15	$43.68	$29.89

[48] ibid

[49] Based on natural gas end-use in residential (EIA RECS 2015) and commercial (EIA CBECS 2012) buildings, averaged for the South Atlantic and Middle Atlantic regions.

[50] Frontier Energy. Residential Cooktop Performance and Energy Comparison Study. July 2019.

[51] ibid

Electrification Emissions Modelling

Electrifying fossil fuel end-uses may already be cost effective for many builders and building owners but a recent analysis[52] by MDE's greenhouse gas modelling consultant, Energy and Environmental Economics (E3), showed that significant levels of electrification might also be necessary for achieving Maryland's GGRA target for 2050. At the request of the Mitigation Work Group, E3 modelled a policy scenario with the following assumptions for buildings:

- Increase EmPOWER efficiency goals to 3% annual reduction by 2023 and beyond
- All-electric new construction beginning in 2025
- 1.3 million electric heat pump retrofits in existing buildings by 2050
- 50% of space heater sales in 2030 and 90% in 2050 are electric heat pumps

E3 estimates that these measures would reduce direct emissions from buildings 41% by 2050 and, along with other measures including 100% zero-emissions electricity by 2040 and aggressive zero-emissions vehicle sales, Maryland would still fall about 9 MMtCO2e short of its minimum target (80% reduction in gross emissions) in 2050.[53] In other words, it may be necessary to exceed the measures modelled in this policy scenario for the State to meet its GGRA goal.

Electricity Grid Implications from Electrification

Electrifying fossil fuel end-uses will increase electrical load onto the grid, so should be paired with measures to manage that additional load to maximize the economic and emissions benefits, and to avoid incurring costly upgrades to the transmission and distribution systems. Analyses indicate that Maryland could achieve substantial levels of heating system electrification before those challenges arise, and even under ambitious electrification scenarios those challenges would be decades away, providing time to plan for and mitigate them. E3's recent analysis of an emissions reduction pathway that included ambitious electrification efforts in both the buildings and transportation sectors estimated that, when paired with continued and improved investment in energy efficiency, Maryland's total electricity demand would be declining or flat through the mid-2030s.[54]

Maryland electric utilities are required to annually report on system reliability to the Public Service Commission, who then evaluates whether the utilities are meeting system-wide reliability standards. In its most recent report, PSC found that "all of the Electric Companies met their system-wide reliability standards."[55]

Like most other states, Maryland is a "summer peaking" state, meaning the time of highest electricity demand is on hot summer days. As a general matter, the capacity of the electrical system to deliver electricity to buildings is built to accommodate that time of highest demand with a reserve margin. Substantial grid-related costs of heating system electrification would arise if enough building systems are electrified for the winter peak to approach or overtake the summer peak. The NREL Electrification Futures Study evaluated the balance between summer peaks and winter peaks under a variety of electrification scenarios. In their most ambitious "high electrification" scenario, Maryland remained a

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[52] E3. Building Electrification in Maryland. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. July 2020.

[53] ibid

[54] ibid

[55] MD Public Service Commission. Order Number 89260. Order on Electric Reliability Performance Reports. September 2019. https://www.psc.state.md.us/wp-content/uploads/Order-No.-89260-Case-No.-9353-Order-on-Electric-Reliability-Performance-Reports.pdf

summer peaking state through 2050,[56] meaning that the additional electrical load from heating system electrification would increase utilization of the existing system more than it would require expanded system capacity.

Bottom line: Electrifying fossil fuel end-uses is a critical part of decarbonizing buildings. Studies show that electric ASHPs can be cost effective for new construction and for some building retrofits. Several residential and commercial ASHPs available today can provide lower heating costs than natural gas furnaces and lower cooling costs than typical AC units, however, more study may be needed on the cost effectiveness of ASHPs in the commercial buildings sector. Analysis by the U.S. DOE finds that it is currently cost effective in Maryland for 99% homes with propane, 95% of homes with oil, and 20% of homes with natural gas space heating systems to switch to an efficient ASHP at the point of AC replacement. ASHP water heaters cost more to install than natural gas water heaters but achieve energy cost savings that payback the additional upfront cost. Cost effectiveness of ASHPs will improve steadily as Maryland's climate warms, ASHP performance improves, and/or natural gas rates increase faster than electricity rates.

Renewable Fuels

E3 recently evaluated the potential to replace fossil fuel use in Maryland with renewable fuels.[57] E3's analysis, based on data from the U.S. DOE,[58] shows that Maryland's population-proportional share of potential national production of renewable natural gas (RNG) and biodiesel would be 17 trillion British thermal units (tBtu) and 56 tBtu, respectively. That means the potential supply of RNG in 2050 could replace approximately 10% of Maryland's current RCI natural gas use. Meanwhile, the potential supply of biodiesel could more than replace all heating oil use in buildings, however, biodiesel supply may be better directed to decarbonizing heavy transport. From a technical standpoint, it appears that RNG and biodiesel could contribute, at least partially, to decreasing emissions associated with the two most commonly used fuels in buildings. However, costs of these renewable fuels must be weighed against their alternatives.

According to E3's Biofuels Modeling and Assumptions,[59] the average price of biodiesel in 2050 is projected to be $42.80 per million Btu (MMBtu), 52% more than the projected price of fossil diesel. The average price of RNG in 2050 is projected to be $16.50 per MMBtu, 324% more than the projected price of fossil gas. A recent report by ICF,[60] which was commissioned by Washington Gas/AltaGas, corroborates E3's RNG pricing analysis. ICF anticipates that the average price of RNG would be around $15 per MMBtu from 2023 to 2050, where the incremental cost of RNG compared with fossil gas would average around $12 per MMBtu. In the same report, ICF also evaluated the potential for other fossil gas alternatives (FGAs), including power-to-gas (methane produced using renewable electricity) and hydrogen, to replace fossil gas but found that those fuels will probably be available in lower volumes and higher prices than RNG. ICF found that the price of power-to-gas is estimated to be $25-40 per MMBtu today but could become less expensive over the coming decades, possibly matching RNG pricing

[56] NREL. Electrification Futures Study. 2017.

[57] E3. Biofuels Modeling and Assumptions. Presentation to MDE. November 2019.

[58] U.S. DOE. 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy. July 2016.

[59] ibid

[60] ICF. Opportunities for Evolving the Natural Gas Distribution Business to Support the District of Columbia's Climate Goals. April 2020.

by 2050. However, within the next 30 years, the prices of RNG and other FGAs are expected to be at least three times the price of fossil gas.

Bottom line: The potential supply of RNG, power-to-gas, hydrogen, and other FGAs is limited and expensive. RNG, which has the greatest supply potential of the FGAs, could replace only 10% of Maryland's current natural gas consumption in buildings by 2050 based on federal estimates. Given their limited supply, FGAs should only be considered as a possible solution for decarbonizing *existing* gas systems; gas infrastructure should not be expanded with the hope that FGAs can be used to achieve deep decarbonization for both new and existing buildings. Potential supply does not meet potential demand. Further, FGA pricing is expected to be at least three times greater than fossil gas pricing for the next 30 years, which further improves the relative cost effectiveness of efficiency and electrification as decarbonization measures. Biodiesel supply potential, on the other hand, could exceed demand but since heat pumps already offer much lower energy costs than oil heaters, it is unlikely biodiesel will play a significant role in the decarbonization of buildings.

Lowest Cost Pathway – Findings from Other States

Several states commissioned studies to find the lowest cost pathways for decarbonizing buildings at rates necessary to meet those states' emissions reduction goals. Each study essentially evaluated how efficiency, electrification, and renewable fuels could be used to reduce emissions, minimize net economic impacts, and minimize costs for ratepayers. Notably, many studies also looked at the long-term effects of various policy scenarios, including grid impact and energy reliability. A few states have found that building electrification presents various benefits: reduced stranded assets of infrastructure, increased energy efficiency, increased financial savings, and increased flexibility to achieve emissions goals. This section briefly summarizes key findings from a few of those studies.

California

Deep Decarbonization in a High Renewables Future[61] examined 10 mitigation scenarios to reach California's 2030 and 2050 climate goals. The study found the high electrification scenario to be "one of the lower-cost and lower-risk mitigation scenarios." The study also found the cost of the high electrification scenario relative to a reference case (which does not meet climate goals) yields anywhere from a $2 billion savings to a net cost that is less than 0.5% of the state's GSP.

Washington

Deep Decarbonization Pathways Analysis for Washington State[62] found that a high electrification scenario would cost about $0.1 billion, which is less than 0.1% of GSP, whereas a renewable fuels scenario would cost $6.1 billion by 2050.

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[61] California Energy Commission. Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model. June 2018.

[62] Evolved Energy Research. Deep Decarbonization Pathways Analysis for Washington State. December 2016.

Oregon

Exploring Pathways to Deep Decarbonization for the Portland General Electric Service Territory[63] found the high electrification scenario is the cheapest "across a range of alternative fossil fuel price and end-use electric technology cost projections." For the average household, this looks like a reduction in monthly energy costs of around $50 by 2050 (in 2016 dollars).

New Jersey

New Jersey's Energy Master Plan[64] finds that "electrification reduces annual costs by 50% in 2050, compared to retaining gas use in buildings" if the state is to meet its emissions target (80% below 2006 levels by 2050). New Jersey also found that "electrification is the most cost-effective path to achieving further emissions reductions" beyond the 80% reduction target. New Jersey's climate and utility rates are similar to Maryland's, so its Energy Master Plan may be a good guide to follow. The state's buildings strategy is summarized this way:

> *The building sector should be largely decarbonized and electrified by 2050 with an early focus on new construction and the electrification of oil- and propane-fueled buildings. New Jersey must electrify its state facilities, partner with private industry to establish electrified building demonstration projects, expand and accelerate the current statewide net zero carbon homes incentive programs for both new construction and existing homes… The state must also develop a transition plan to a fully electrified building sector, including incentivizing appliances like electrified heat pumps and hot water heaters.*[65]

Notably, the report includes "Strategy 6: Support Community Energy Planning and Action with an Emphasis on Encouraging and Supporting Participation by Low- and Moderate-Income and Environmental Justice Communities." This strategy encourages municipalities to enact Community Energy Plans, encourages more robust public participation and outreach strategies, and encourages targeted educational efforts for overburdened communities. Additionally, the report includes "Strategy 7: Expand the Clean Energy Innovation Economy." This strategy encourages workforce training programs, including through a workforce needs assessment and support for vocational training. The strategy also encourages the exploration to establish "a Clean Buildings Hub to develop workforce training, awareness, and education for builders, architects, contractors, engineers, real estate agents, and code enforcers in the most efficient electrification, construction, and retrofit building techniques."

While costs in Maryland may vary from other states, these state-level analyses suggest that an electrification-focused pathway is more cost effective than alternative pathways for decarbonization. Studies more specific to Maryland may be helpful but some no-regret actions that move towards electrification can be taken now, such as the recommendations provided below.

[63] Evolved Energy Research. Exploring Pathways to Deep Decarbonization in Portland General Electric Service Territory. April 2018.

[64] New Jersey. Energy Master Plan. 2019

[65] ibid

Recommendations

In order to reach Maryland's Greenhouse Gas Reduction Act (GGRA) goals, including reducing emissions to protect people and places from the effects of climate change, the buildings sector must substantially reduce its direct use of fossil fuels in conjunction with electric grid decarbonization. The Buildings Subgroup recommends the Administration, General Assembly, Public Service Commission, State Agencies, and other relevant stakeholders take the following immediate actions to begin reducing emissions from buildings in Maryland while the Commission on Climate Change coordinate the development of a long-range energy transition plan.

Discussion on Recommendations: Each of the following recommendations includes a discussion section that describes the degree of support and opposition among buildings sub-group participants, including concerns expressed about the recommendations and reasons not to adopt them. Some participants do not support the recommendations and conclusions of this report overall, including some participants from affected industries.

Goal 1: Adapt EmPOWER for Beneficial Electrification

Recommendation 1: Enable Fuel-Switching to let Marylanders Choose Lowest Cost and Lowest Carbon Energy Systems

Analysis by the U.S. Department of Energy (DOE)[66] found that it is currently less expensive for 99% of homes with propane, 95% of homes with oil, and 20% of homes with natural gas space heating systems in Maryland to switch to an efficient air source heat pump (ASHP) at the point of air conditioning (AC) system replacement. DOE analysis[67] also suggests that for roughly half of Maryland homes with both an AC unit and natural gas furnace near the end of their lives, switching to an ASHP would be cost effective. Ground source heat pumps (GSHPs) are generally more expensive to install than ASHPs but are more efficient to operate. Considering their eligibility for existing subsidies, GSHPs can be more cost effective than ASHPs in some cases. Currently, EmPOWER Maryland incentives for installing electric heat pumps are only available to ratepayers who replace existing electric heating systems, consistent with EmPOWER's original mandate to reduce electricity use. Ratepayers with fossil fuel heating systems cannot access incentives to replace their systems with electric heat pumps that could lower their energy costs and reduce emissions. Several states already provide guidelines for fuel-switching, including Alaska, California, Vermont, and New York.[68]

The General Assembly should amend the Public Utilities Article (PUA) section §7-211 to allow electrification of existing fossil fuel systems through EmPOWER and direct the Public Service Commission to require the electric utilities to proactively encourage customers with propane or oil heating systems to replace those systems with electric heat pumps, especially for homes with central air conditioning, especially for low-income households and consumers. State agencies should also modify programs they manage to facilitate fuel-switching if not already allowed. Enabling electrification also means EmPOWER needs the flexibility to allow some buildings to increase electricity consumption in

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[66] Mayernik, J. Cost Effectiveness of Electrification with Air-Source Heat Pumps. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. August 2020.

[67] ibid

[68] ACEEE. State Policies and Rules to Enable Beneficial Electrification in Buildings through Fuel Switching. April 2020.

order to reduce total energy consumption, emissions, and costs. For this reason, this recommendation is linked with Recommendation 2.

The amendment should require a review to determine the appropriate cost recovery for electrification programs. Utilities are currently allowed to recover the cost of investments in energy efficiency at the approved Weighted Average Cost of Capital via the EmPOWER surcharge. Investments in energy efficiency and electrification should be on par with grid investments, incentivizing utilities to increase strategic focus on carbon reduction programs to meet the goals of the state. Appropriate cost recovery should be determined by the Public Service Commission.

Discussion on Recommendation 1: Subgroup participants generally support this recommendation, with a few participants expressing concerns/opposition based on impacts to the fossil fuel industry, the long-term potential for escalating system maintenance costs for remaining natural gas customers under high degrees of electrification, and the challenge of modifying EmPOWER to allow fuel-switching.

Recommendation 2: Let EmPOWER Facilitate Beneficial Electrification and Greater Energy Efficiency

Electrifying fossil fuel end-uses in buildings is necessary for achieving Maryland's long-term emissions reduction targets,[69] electrified systems can offer the most cost effective solutions for space heating and water heating,[70] and several other states found that electrification-focused scenarios are the lowest cost options for achieving those states' emissions reduction targets.[71] Electrification of buildings and transportation in Maryland is already called for in the State's GGRA Draft Plan.[72] Although EmPOWER's original focus on reducing electricity consumption and peak demand made sense when enacted and served the State well for more than a decade, it is time to adapt EmPOWER to align with the State's many energy related goals, including its GGRA emissions reduction goals.

The General Assembly should amend the PUA section §7-211 to change the core objective of EmPOWER from electricity reduction to a portfolio of mutually reinforcing goals, including greenhouse gas emissions reduction, energy savings, net customer benefits, and reaching underserved customers. Massachusetts and New York have taken this approach. In so doing, the PUA should allow for beneficial electrification, which is when electrification meets one or more of the following conditions without adversely affecting the other two: 1) saves consumers money; 2) enables better grid management; and 3) reduces negative environmental impacts.[73] Beneficial electrification programs should be prioritized first for low-income households and consumers and should be aligned with other health and safety upgrades to consider a whole-home or whole-building retrofit approach to ensure cost effectiveness and a focus on benefitting underserved homes and businesses first.

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[69] E3. Building Electrification in Maryland. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. July 2020.

[70] Mayernik, J. Cost Effectiveness of Electrification with Air-Source Heat Pumps. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. August 2020; NREL. Electrification Futures Study. 2017; RMI. The Economics of Electrifying Buildings. June 2018; U.S. DOE. Energy Efficiency Potential in the U.S. Single-Family Housing Stock. December 2017.

[71] California Energy Commission. Deep Decarbonization in a High Renewables Future: Updated Results from the California PATHWAYS Model. June 2018; Evolved Energy Research. Deep Decarbonization Pathways Analysis for Washington State. December 2016; Evolved Energy Research. Exploring Pathways to Deep Decarbonization in Portland General Electric Service Territory. April 2018; New Jersey. Energy Master Plan. 2019.

[72] MDE. 2019 GGRA Draft Plan. October 2019.

[73] Regulatory Assistance Project. Beneficial Electrification: Ensuring Electrification in the Public Interest. June 2018. https://www.raponline.org/knowledge-center/beneficial-electrification-ensuring-electrification-public-interest/

The General Assembly should also direct the Public Service Commission to pursue all cost effective energy efficiency and electrification measures based on the value of avoided carbon, along with other avoided criteria pollutants and other societal benefits of efficiency, and on a schedule that meets GGRA emissions reduction targets.

In the meantime, starting with the 2021-2023 EmPOWER program cycle, the Public Service Commission should:

- Require participating utilities to report avoided carbon based on a methodology sanctioned by the independent evaluator.
- Include more stringent environmental and health cost considerations in cost-benefit analysis.
- Maximize efficient retrofit of existing electric end-uses, including by providing higher incentivization for the retirement of electric resistance space heating and hot water heating systems, combined with shell efficiency to reduce loads and improve comfort and satisfaction.
- Authorize technical trainings on electrification technology and design.
- Authorize demonstration projects and pilot programs for all-electric buildings of various types, including in the residential and commercial areas.
- Authorize, to the maximum allowable limit of the existing statute, utilities to incentivize replacement of existing oil and propane heaters with electric heat pumps.
- Ensure that low to moderate income Maryland residents receive benefits from these programs that are equal to or greater than the average benefit to Maryland residents. Develop all-electric new construction and renovation tiers.
- Recognize the need to electrify fossil fuel end-uses in order to meet the State's GGRA goals and prohibit incentives or subsidies for new fossil fuel infrastructure.
- Recalculate climate benefits so they are consistent with GGRA goals.

Discussion on Recommendation 2: Subgroup participants generally support this recommendation, with a few participants expressing concerns/opposition based on impacts to the fossil fuel industry and the challenge of modifying EmPOWER to change its core objective from electricity reduction to a portfolio of goals. A few participants (including a member of the General Assembly) suggest that since electrifying fossil fuel end-uses in buildings is a key strategy for achieving GGRA targets, the State should not support projects that would expand any type of natural gas infrastructure to new or existing buildings since those projects are counterproductive to the State's climate goals and increase risk of stranded assets.

Recommendation 3 [Option A]: Target 50% of Space Heater Sales to be Electric Heat Pumps by 2025

Maryland Department of the Environment's (MDE's) greenhouse gas modeling consultant, E3, estimates that even if all new buildings were all-electric by 2025, energy efficiency targets were increased, and space heater sales reached 50% heat pumps in 2030 and 90% in 2050, then Maryland's building sector emissions would decrease only 41% by 2050.[74] Faster adoption of electric heat pumps is necessary for the buildings sector to achieve deep decarbonization in line with Maryland's GGRA targets. Currently,

[74] E3. Building Electrification in Maryland. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. July 2020.

around 20% of space heater sales are electric heat pumps (air source or ground source).[75] Enabling fuel-switching and beneficial electrification (Recommendations 1 and 2) should improve that rate. Incentivizing builders to install heat pumps in new buildings (Recommendation 4) would further improve it. Still, a sales target alongside stronger financial incentives would help ensure that incentives are sufficient to encourage building owners and HVAC installers to accept heat pump technology and would help the State achieve its emissions reduction targets. Aggressive adoption of heat pumps could also help more Marylanders save money. As noted above, DOE analysis suggests that for roughly half of Maryland homes with both an AC unit and natural gas furnace near the end of their lives, switching to an ASHP would be cost effective.

The General Assembly should direct the Public Service Commission to ensure that EmPOWER programs, incentives, and implementation plans are sufficient to for 50% of space heater sales to be electric heat pumps (air source or ground source) by 2025.

Recommendation 3 [Option B]: Establish Residential Heat Pump Retrofit Goals

[Same first paragraph as the recommendation above. Replace subsequent text with:]

The Mitigation Work Group should establish annual heat pump retrofit targets for existing buildings sufficient to meet Maryland's 2050 decarbonization goals as part of an Energy Transition Plan described in Recommendation 6.

Discussion on Recommendation 3: Nonprofit organizations including the Sierra Club, Nature Conservancy, Natural Resources Defense Council, League of Conservation Voters, Climate Law and Policy Project, and Earth Justice are in "strong support" of option A. Several subgroup participants representing state and county agencies and the Green and Healthy Homes Initiative also support option A. Several other participants are neutral on either option or do not indicate a position. Representatives of fossil fuel companies indicate opposition to the recommendation (option A or B) and prefer that the State be fuel-neutral in its energy policy.

Goal 2: Construct Carbon Neutral New Buildings

Recommendation 4 [Option A]: Require All-Electric and Energy Efficient New Homes by 2025 and New Commercial Buildings by 2026 with Cost Controls

Maryland should continue to be a national leader in adopting the newest construction codes, including appendices for net zero energy/carbon pathways, to ensure that all new buildings meet stringent energy efficiency standards and have low energy costs. However, installation of new fossil fuel infrastructure is counterproductive to meeting GGRA targets and creates significant risk of increased cost and stranded assets, especially when natural gas rates are expected to increase faster than electricity rates[76] and fossil fuel alternatives (such as renewable natural gas, power-to-gas, and biodiesel) are in limited supply and

[75] ibid

[76] Mayernik, J. Cost Effectiveness of Electrification with Air-Source Heat Pumps. Presentation to the Maryland Commission on Climate Change's Buildings Subgroup. August 2020.

much more expensive than their fossil fuel counterparts.[77] There is now evidence that all-electric new buildings can have lower or equivalent capital and operating costs compared with mixed-fuel buildings.[78] In fact, 76% of new homes in the Census region that includes Maryland were built with electric heat pumps as their primary heating systems in 2018.[79] Maryland should join the other jurisdictions that are requiring all-electric standards for new buildings.[80]

The Maryland Building Codes Administration should require additional energy use reductions relative to the current code, require that "on-site combustion of fossil fuels shall not be permitted for the provision of thermal energy to the building."[81] and determine if any other parts of the codes would need to change in response to this amendment. Compliance with the all-electric requirement should begin by 2025 for new single-family homes and 2026 for new commercial buildings but publicly-owned buildings should meet the standard earlier to save taxpayers money and have Maryland government lead by example. The General Assembly or Administration should adopt requirements for all-electric and energy-efficient new buildings for state funded facilities including requirement to ensure that fossil fuel equipment at the end of its useful life is replaced with cost effective electric heating and cooling options. Electric vehicle charging, solar-ready, smart grid, and demand response-ready amendments should also be added to codes as soon as possible.

While the all-electric code amendment is meant to encourage builders to pursue design choices that reduce capital costs, energy costs, and emissions for new buildings, there should be flexibility to allow builders to install combustion equipment when the elimination of that equipment would unnecessarily increase costs. As such, the Maryland Building Codes Administration should allow on-site combustion of fossil fuels if energy models, specific to the project, show that an all-electric building would have a significantly higher lifecycle cost than a mixed-fuel building.

A. If the lifecycle cost of the all-electric option is **less than or equal to** the lifecycle cost of the mixed-fuel option without subsidies, then the all-electric requirement would be upheld.

B. If the lifecycle cost of the all-electric option is **up to X% greater than** the lifecycle cost of the mixed-fuel option without subsidies, then funding from EmPOWER, tax credits, or other sources should be available (without delaying the project schedule) to reach lifecycle cost parity between the all-electric and mixed-fuel options and uphold the all-electric requirement.

C. If the lifecycle cost of the all-electric option is **X% greater than** the lifecycle cost of the mixed-fuel option without subsidies, then the all-electric requirement may be waived.

Life cycle cost analysis should be part of the Energy Code development process when the State considers future versions of IECC, including 2021 IECC, which will come before the State in 12 to 18 months. Reasonably foreseeable future costs of combustion, such as costs resulting from stranded fossil fuel assets or carbon pricing, should be considered when calculating lifecycle costs.

Buildings that have uninterruptible energy needs that cannot be met cost effectively with on-site battery storage (using the rules and incentives listed in this recommendation) and buildings that include

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[77] E3. Biofuels Modeling and Assumptions. Presentation to MDE. November 2019.

[78] RMI. The Economics of Electrifying Buildings. June 2018.

[79] National Association of Home Builders. Air Conditioning and Heating Systems in New Homes. December 2019. http://eyeonhousing.org/2019/12/air-conditioning-and-heating-systems-in-new-homes-4/

[80] Henchen, M. Why States Need to Ban New Gas Hookups in Buildings (in 5 Charts). February 2020. https://www.greentechmedia.com/articles/read/5-charts-that-show-why-states-need-to-eliminate-fossil-fuels-from-buildings

[81] Based on District of Columbia's Construction Codes Supplement of 2017, 12-I[CE] and 12-I[RE] DCMR - Energy Conservation Codes Supplement of 2017. Appendix Z. 2017.

combined heat and power systems would be exempt from the all-electric requirement. New buildings connected to an existing district energy system would follow the all-electric requirement but the energy source for that district energy system could use fuels other than electricity. New energy sources for new or existing district energy systems should evaluate the lifecycle costs and emissions of alternative designs including an all-electric system.

Recommendation 4 [Option B]: Require All-Electric and Energy Efficient New Homes by 2025

[Same first paragraph as the recommendation above. Replace subsequent text with:]

The Maryland Building Codes Administration should, for new homes, require additional energy use reductions relative to the current code, require that "on-site combustion of fossil fuels shall not be permitted for the provision of thermal energy to the building,"[82] and determine if any other parts of the codes would need to change in response to this amendment. Compliance with the all-electric requirement should begin by 2025.

Concurrent with an all-electric requirement for new homes, Maryland should take measures to advance all-electric new buildings of other types. Publicly-owned buildings should meet an all-electric standard earlier to save taxpayers money and have Maryland government lead by example. The General Assembly or Administration should adopt requirements for all-electric and energy-efficient new buildings for state funded facilities including requirement to ensure that fossil fuel equipment at the end of its useful life is replaced with cost effective electric heating and cooling options. Electric vehicle charging, solar-ready, smart grid, and demand response-ready amendments should also be added to codes as soon as possible. Life cycle cost analysis should be part of the Energy Code development process when the State considers future versions of IECC, including 2021 IECC, which will come before the State in 12 to 18 months.

In developing the Energy Transition Plan described in Recommendation 6, the Mitigation Work Group should consider adoption of a broader all-electric requirement for all new buildings with accommodation for the diversity of commercial, industrial, and institutional buildings, and including appropriate exclusions for buildings utilizing district energy systems and combined heat and power system, for buildings with overriding need for uninterruptable energy needs, and for cases where additional costs of all-electric construction would be unacceptably high.

Discussion on Recommendation 4: Nonprofit organizations including the Sierra Club, Nature Conservancy, Natural Resources Defense Council, League of Conservation Voters, Climate Law and Policy Project, and Earth Justice are in "strong support" of option A. Several subgroup participants representing state and county agencies also support option A. Representatives of home builders and commercial real estate oppose the recommendation (option A or B) citing: lack of detailed cost and performance studies specific to Maryland; concerns about increasing construction and energy costs for residential and commercial buildings; preference for achieving emissions reductions through the code development process, LEED standards, and Energy STAR standards, all of which have achieved substantial gains and will continue to do so; concerns with a lay body creating requirements rather than established expert and stakeholder proceedings like those used for code development; and concerns with establishing new requirements for construction while multiple previously established requirements are being phased in. Home builder representatives also note consumer preference for natural gas appliances.

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[82] ibid

Recommendation 5: Incentivize Net-Zero Energy, Energy Efficient, All-Electric New Buildings

All-electric buildings produce zero direct emissions but still have some indirect emissions from conventional electricity supplies until the grid becomes carbon neutral, which could take another 20 years or more in Maryland.[83] All-electric net-zero energy buildings, on the other hand, are carbon neutral immediately because they produce 100% of their annual electricity demand from on-site or, potentially, near-site zero-carbon renewable energy systems. It is also possible that net-zero energy all-electric homes are more cost effective than all-electric homes. A recent study examining the cost of building net-zero energy all-electric new homes in Montgomery County, in response to the County's initiative for new single-family residential construction to include rooftop solar starting in 2022, found that "new net-zero-energy detached homes with rooftop solar – which annually generate as much electricity as they consume – are more economical than conventional homes. Annual average savings over the life of a 30-year mortgage would be about $1,100 per year relative to a gas-heated house built to the same overall standards."[84] More study might be needed to further evaluate the cost effectiveness of net-zero energy all-electric buildings (residential and commercial), which is why this recommendation is suggesting incentives for early adoption.

The Maryland Building Codes Administration should develop optional codes and standards for all-electric net-zero energy buildings, including allowance of near-site renewable energy systems such as community solar projects, and determine how to incentivize builders to design to those standards. This work should be coordinated with the Maryland Department of Housing and Community Development (DHCD) in shaping incentive offerings since DHCD already has a Net Zero Loan Program in place and could provide useful insights on program design and existing market gaps to increase the reach of other incentive efforts.

Discussion on Recommendation 5: Subgroup participants generally support this recommendation, with a few participants remaining neutral and at least one opposed. Some participants suggested that the state should pilot all-electric net-zero energy construction in state buildings, and some expressed concern over differing definitions of "net-zero" adopted by different stakeholders and by different localities.

Goal 3: Develop an Energy Transition Plan

Recommendation 6: Produce an Energy Transition Plan by the end of 2021

The immediate steps in the prior recommendations would begin a 30-year transition toward a decarbonized buildings sector. As those steps begin, the State should develop an Energy Transition Plan to coordinate long-term activities and ensure that the overall buildings sector strategy achieves equitable benefits for disadvantaged communities, anticipates and prevents escalating distribution system costs for shrinking pools of natural gas customers, and takes advantage of opportunities for economic growth, including for the agricultural community from renewable fuel development and EmPOWER market optimization.

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[83] MDE. 2019 GGRA Draft Plan. October 2019.

[84] IEER. Gold on the Roof: The Economics of a Net-Zero-Energy Rooftop Solar Mandate for Detached Housing in Montgomery County, Maryland. September 2020.

In 2021, the Mitigation Work Group should coordinate a research and planning process that:

- Dovetails with the Public Service Commission's work on Transforming Maryland's Electric Grid (PC44) and related work.
- Evaluates the diversity of commercial, industrial, and institutional buildings and their uses in order to develop a carbon reduction strategy to replace on-site combustion sources with electrification, combined heat and power, and connections to district energy systems where electrification is not feasible or significantly less cost-effective.
- Evaluates cost effectiveness and incentives for renewable fuels in applications requiring sources of combustion.
- Evaluates carbon capture utilization and storage (CCUS) and bioenergy with carbon capture and storage (BECCS) opportunities for medium to large stationary point-sources of emissions including CHPs and industrial facilities.
- Evaluates benefits to Maryland's agricultural community from renewable fuel development and infrastructure gaps for bringing renewable fuel to market.
- Identify the best uses for renewable fuels and identify policy and regulatory structures to incentivize targeting renewable fuels to those uses that are hardest to electrify. Evaluates exit strategies for gas utilities, heating oil, and propane distributors and their customers, especially LMI customers, including quantification of the impacts to customers from changes in natural gas volume due to electrification.
- Identifies measures to manage increased electricity use from electrification to minimize impacts on the electricity distribution system, including demand response and integration with distributed generation and energy storage.
- Evaluates statewide targets for building sector greenhouse gas reductions (e.g. X% by 2050) and identifies the most cost-effective mix of reduction measures to achieve those targets.
- Identifies measures to manage increased electricity use from electrification to minimize impacts on the electricity distribution system, including demand response and integration with distributed generation and energy storage.
- Creates a training and workforce needs assessment report that considers both business and governmental needs, as well as consideration for targeted low-income and middle-income workforce development
- Supports local government building decarbonization efforts wherever possible, such as the Montgomery Energy Connection, which provides local residents with energy-saving resources.
- Evaluates policies and programs that will foster the creation of high-quality, family-supporting, and union jobs in the building electrification sector.
- Identifies known gaps in the equitable distribution of housing and housing programs to better inform proposed action steps.
- Evaluates the role of ground source heat pumps for decarbonizing buildings and district energy systems.

- Evaluate impacts through reduced natural gas availability to support back-up generation for vulnerable populations, critical infrastructure, central plants and other key uses.
- Identify funding sources to support Energy Transition Plan recommendations.

Discussion on Recommendation 6: Subgroup participants generally support this recommendation, with a few participants remaining neutral. Some participants expressed concern with developing this plan under the Mitigation Working Group instead of relying on other electricity and energy processes managed by the Public Service Commission and Power Plant Research Program.

Goal 4: Prioritize Benefits to Underserved and Limited-Income Consumers and Households

Recommendation 7: Prioritize an Equitable Level of Benefits for all Marylanders

The Governor, State Agencies, Commissions, and General Assembly should ensure that all policy decisions to reduce greenhouse gas emissions from the building sector in Maryland, including those within these recommendations, prioritize an equitable level of benefits to limited income households, the state's affordable and multi-family housing stock, and low income ratepayers, and concurrently with the benefits provided to others. This includes policies and programs that prioritize A) alignment with other building retrofit programs, like health and safety upgrades; B) measurable outcomes for which low-income households are better off after participation in programs including metrics to ensure benefits are flowing to increase equity and equitable outcomes, and is triaged by known disparities and gaps; and C) retrofit implementation at no cost for the state's most financially vulnerable consumers. Furthermore, the MWG should commission a study to determine the impacts on limited income households and small businesses of the electrification programs recommended above.

Recommendation 8: Improve Interagency Coordination for Wholistic Building Retrofits

The Governor, via Executive Order, or General Assembly, via legislation, should revive an Interagency Task Force with the goal of increased and consistent coordination across programs, policies, and funding streams to retrofit the state's existing building stock to achieve healthier, safer, more efficient, and climate-friendly homes and businesses. This Green and Healthy Task Force would identify opportunities to align lead, mold, asbestos, and indoor air quality remediation intervention schedules and programs with energy efficiency upgrades and electrification retrofit programs to ensure a more cost-effective, whole-building retrofit program that meets the state's various health, safety, affordability, and climate action goals. Progress should be tracked and measured through a public state dashboard.

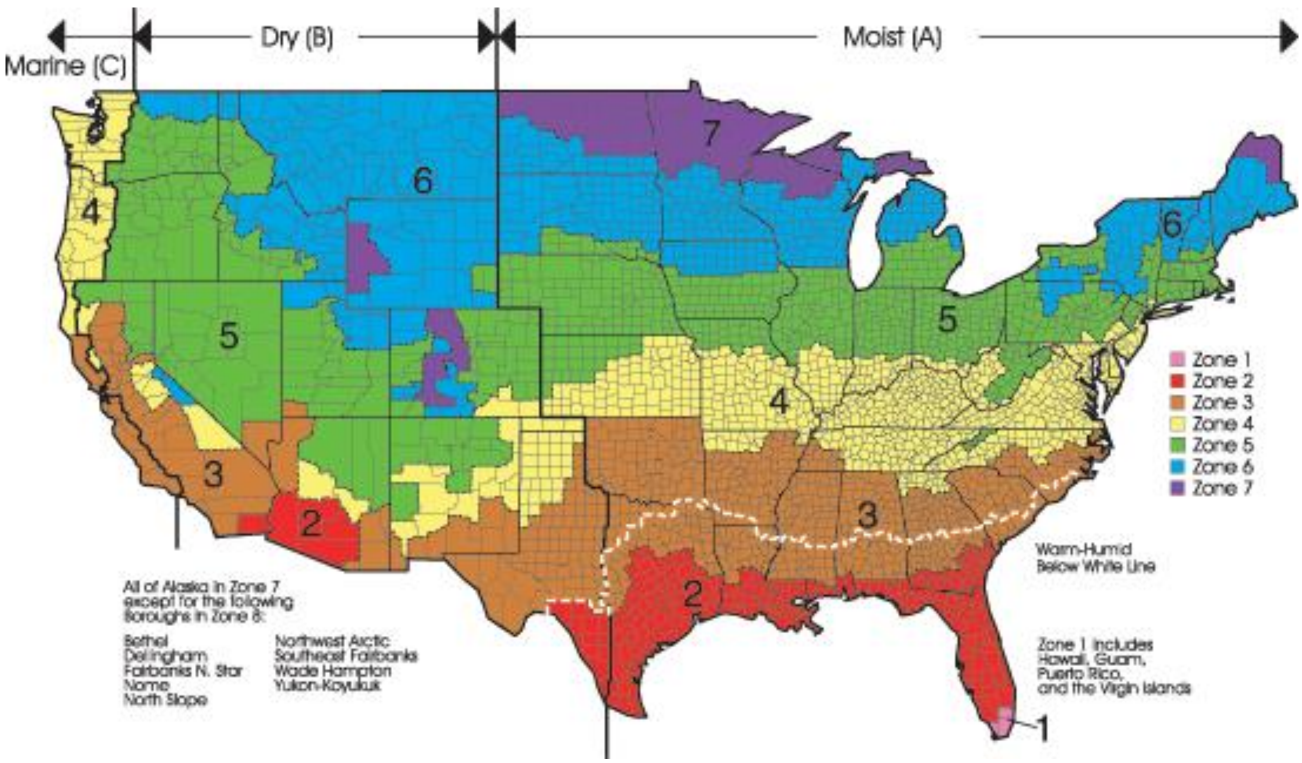
Discussion on Recommendations 7 and 8: The vast majority of subgroup participants generally support this recommendation, with a few participants remaining neutral.

Appendix A – Buildings Subgroup Participants

Name	Title	Organization
Mark Stewart	Sustainability Manager	University of Maryland
John O'Neill	Graduate Student	University of Maryland
Mike Powell	Attorney	Gordon Feinblatt Attorneys at Law
Tom Ballentine	Vice President for Policy and Government Relations	NAIOP
William Ellis	Director of External Affairs	Pepco Holdings
Lori Graf	CEO	MBIA
John Quinn	Director of State Affairs	BGE
Samuel DuPont	Principal of Strategy and Regulatory Affairs	BGE
Maria Frazzini	Director of Sales and Energy Efficiency Team	WGL
Nicholas Umosella	Development Manager	Bozzuto
Drew Cobbs	Executive Director	Maryland Petroleum Council
Thomas Marston	Regional Manager at Energy Services Group	MBIA
Donald Goldberg	Founder and Executive Director	Climate Law and Policy Project
Peter Trufahnestock	Director of Governmental Affairs	Columbia Gas of Pennsylvania and Maryland
Ellen Vallentino	Lobbyist	Mid-Atlantic Petroleum Distributors Association
John Fiastro	Lobbyist	Fiastro Consulting (representing Vicinity Energy and Schneider Electric)
Kenneth Schisler	Vice President for Governmental Affairs	Vicinity Energy
Patrick Roddy	Lobbyist	Rifkin Weiner Livingston Law Firm (represents Columbia Pipeline Group)
Brian Smith	State Government Relations and Public Policy Manager	WGL
Alex Butler	Policy Associate in Energy and Environment	Maryland Association of Counties
Emily Curley	Commercial Energy Program Manager	Montgomery County's Department of Environmental Protection
Christopher Beck	Climate Change Division Chief	MDE
Christopher Hoagland	Climate Change Program Manager	MDE
Cindy Osorto	Legislative and Policy Analyst	MDE
Erick Thunell	Natural Resources Planner	MDE
Kim Drake	Natural Resources Planner	MDE
Susan Casey	Communications Manager	MDE
Laura Armstrong	Director of Maryland Green Registry	MDE
Abdul Mohammed	Climate Program Analyst	MDE

David Smedick	Sr. Campaign Representative on Beyond Coal and Dirty Fuels Campaigns	Sierra Club
Jim Grevatt	Managing Consultant	Energy Futures Group
Kim Coble	Executive Director	Maryland League of Conservation Voters
Susan Stevens Miller	Attorney	Earth Justice
Ruth Alice White	Activist	Sierra Club
Bryan Howard	Director, State Policy	ACEEE
Amanda Best	ex officio	PSC
David St. Jean	Director for the Office of Energy and Sustainability	DGS
Eric Coffman	Energy Programs Director	MEA
Tom Walz	Multi Family Energy Production Manager	DHCD
Steven Lauria	Facilities Planning	DGS
Richard Louis	Facilities Planning	DGS
Kirsten Jackson	Environmental Literacy Specialist	MSDE
Ryan Opsal	Director of Policy	MEA
Christopher Russell	Energy Program Manager, State Buildings & State Agency Loan Program, Building Codes	MEA
Jennifer Gallicchio	Assistant Division Director	MEA
David Giusti	Energy Program Manager, Data Center & Lawton Loans	MEA
Dean Fisher	Energy Program Manager, Low to Moderate Income	MEA
Caitlin Madera	Energy Program Manager, Commercial, Industrial & Agricultural	MEA
Ron Kaltenbaugh	Chair of the Energy, Transportation, and Buildings subgroup	Frederick County
Julian Varo	Senior Sales Engineer	WGL
Bryan Howard	Director	ACEEE
Jamal Lewis	Policy and Technical Assistance Specialist	Green & Healthy Homes Initiative
Lorig Charkoudian	Delegate (District 20)	Maryland General Assembly
Allison Magino	Senior Director, Government Relations	AHRI
Nick Harbeck	Industry Analyst	AHRI

Appendix B – IECC Climate Zone Map



Each state has their own regulations pertaining to how the climate zone map and international building codes are followed.