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REGULATORY ASSISTANCE PROJECT

Meeting the Thermal Challenge: A Clean Heat Standard for Maryland

Prepared for the Maryland Department of the Environment

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Contents

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Executive Summary

The burning of fossil fuels for heat creates cost burdens across Maryland, particularly for low-income households and struggling small businesses, while harming residents' health and the environment. Importing those fuels imposes a drain on the broader economy.

Maryland has ambitious goals to reduce climate pollution and to improve energy equity. Commercial and residential heating is one of the state's largest sources of climate pollution, accounting for about 14% of statewide direct emissions. Heating and cooling are essential services, and lower-income families and overburdened communities face higher energy burdens than other consumers. A clean heat standard can be a powerful tool toward meeting both those goals.

A **clean heat standard** is a performance standard that would apply to providers of fossil-fuel heating energy in Maryland, notably gas utilities and importers of heating oil and propane. These obligated parties would be required to serve Maryland's residential and commercial customers with gradually increasing percentages of clean heat services so that sales of fossil fuels are phased down.

Just as renewable portfolio standards require electricity providers to replace coal- and gas-fired generation with wind, solar and other clean electricity generation, the clean heat standard would replace pipeline gas, fuel oil and propane heat with weatherization improvements, heat pumps, clean district energy and other verified low-carbon options.

As a performance standard, a clean heat standard works differently than a carbon price or carbon cap to drive down greenhouse gas emissions. Instead of directly taxing or limiting fossil fuels used for heating, a clean heat standard requires measured additions to the clean heat side of the ledger. The standard's main advantage and key attribute is that it focuses on concrete, delivered clean heating solutions. The standard would replace fossil-fuel heat with clean heat to reduce carbon pollution from the thermal sector at the pace required by Maryland's Climate Solutions Now Act of 2022 (CSNA).

This climate law commits the state to steep reductions in greenhouse gas emissions:

- By 2031, economywide greenhouse gas emissions must be reduced at least 60% from 2006 levels.
- By 2045, statewide greenhouse gas emissions must be net zero.

Over time, meeting the CSNA targets would require reducing greenhouse gas emissions from heating by about 5% to 7% each year.

Many policy options besides the clean heat standard are available in pursuit of these reductions. However, evidence from many jurisdictions reveals that:

- Just offering incentives to building owners does not enlist customers quickly enough.
- Relying on carbon taxes alone raises prices but with relatively small reductions in heating demand, and other public funds are too limited and often too variable to meet the scale of the climate challenge.

- Building codes and fossil-fuel equipment standards usually cover only new construction and new heating equipment and by themselves would not be fast enough to meet the state's climate goals.
- Mandatory energy improvements for existing buildings can be a tool to reduce emissions, but such standards are usually imposed only on the largest commercial buildings. Householders and small businesses often need financial and technical help to make long-term improvements in their homes and businesses.

To deliver large greenhouse gas savings from residential and commercial buildings on the time frame required by the CSNA, communities need a positive policy driver to help building owners improve building shells and change heating systems in the existing building stock. The clean heat standard can be that policy driver and amplify the beneficial impacts of complementary policies such as incentives, codes and standards.

Technology Options for Clean Heat

A clean heat standard can be designed to promote a variety of heating technologies and fuels, in line with state policies. Clean heating choices can include:

- Weatherization and building improvements.
- Electrification for space and water heating and cooling, particularly heat pumps.
- Certain biofuels and renewable gases meeting greenhouse gas reduction and sustainability standards.
- Low-carbon district heating and geothermal systems.
- Solar thermal and advanced wood heating.
- Green hydrogen.

Because the main goal is to reduce climate pollution, the performance standard itself and the clean heat options are all measured in tons of greenhouse gas emissions reduced.

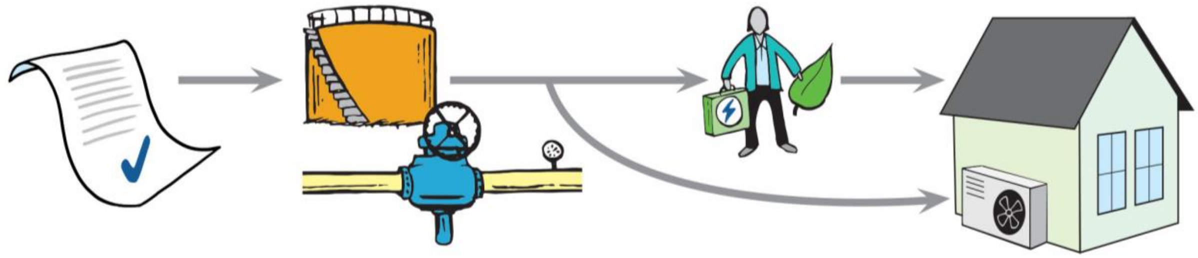
Decisions in Designing a Clean Heat Standard

The main advantage and key attribute of a clean heat standard is that it focuses on the delivery of concrete, clean solutions to drive down consumption of fossil fuels on a schedule that aligns with the state's greenhouse gas reduction and social equity goals. Within that framework, there are many ways to design and implement a clean heat standard. This paper takes up the major architectural elements of any clean heat standard, along with some of the options open to decision-makers.

The first steps in creating a clean heat standard are to determine the pace of emissions reductions needed in the thermal sector and to identify the parties that would be obligated to deliver those reductions. The CSNA sets benchmarks for emissions reductions in 2031 and 2045, but it will be necessary for the clean heat standard program administrator to set annual reduction goals to ensure continuous improvement and to appropriately pace the work required to transform heating fuels and systems.

A clean heat standard gives energy suppliers a broad range of options for meeting their obligation, but the logic of the standard is straightforward, as illustrated in Figure ES-1.

Figure ES-1. Elements of a clean heat standard



The obligated parties would include pipeline gas utilities and companies that import or sell liquid fossil heating fuels in Maryland. Fossil-fuel sales for transportation, off-road vehicles and industrial heating would not be covered by the performance standard. Because electric utilities are already lowering their emissions through renewable energy and efficiency mandates, and because electricity will be increasingly fossil-free, the clean heat standard focuses responsibility on providers of fossil-fuel heat.

Each year, the obligated parties would need to demonstrate that they have earned or acquired enough clean heat credits to meet their annual responsibilities to reduce greenhouse gas emissions. They can meet their obligation by delivering cleaner fuels, helping customers install qualified clean heat measures, or purchasing clean heat credits from others who have delivered those solutions.

A wide range of eligible service providers — not just obligated parties — can earn clean heat credits. This is an important feature of the clean heat standard, given the magnitude of the thermal challenge, and it allows a market for clean heat credits to evolve. Thus, weatherization providers, EmPOWER, HVAC contractors, housing authorities, utilities and fuel dealers can all earn credits if they deliver verifiable greenhouse gas reductions through approved clean heat measures. Obligated parties also can earn credits by delivering savings to any end-use customer, not just their existing customers.

Importantly, the clean heat standard does not require homeowners or businesses to make any particular clean heat choices. While customers will likely receive incentives, information and support, they will have flexibility on choosing their heating options and the timing for making switches and upgrading their buildings.

Building In Equity and Environmental Guardrails

One advantage of a performance standard like the clean heat standard is that provisions to promote equity and environmental sustainability can be built into its architecture from the outset. To ensure that lower-income households and energy-burdened communities are not left behind, the clean heat standard should involve those communities in program design from the start and require that a substantial fraction of clean heat credits each year be secured by delivering services to those customers.

Environmental guidelines are also important. The standard should not credit emissions reductions in buildings in Maryland if they are achieved via measures that just shift emissions elsewhere, such as switching to cleaner-burning fuels whose production emissions occurred in other states. For this reason, certain clean heat solutions, particularly fuel substitutions, should be tested on a life-cycle basis. The program administrator would, by rule, adopt a process for assessing different clean heat measures so they would earn credits only for their verifiable life-cycle greenhouse gas emissions reductions. This is similar to the process used to award credits under low-carbon fuel standards in other states.

Clean Heat Standards in the Broader Policy Context

It's going to take a suite of complementary policies to transform the heating sector in Maryland. Other policies could include energy-saving programs from EmPOWER, weatherization programs, fossil-fuel equipment standards and building codes, the tax credits and grants from state programs and the new federal Inflation Reduction Act. Maryland's Building Energy Performance Standards will also encourage building owners to improve their energy use. The clean heat standard is designed to work with all these other programs. Clean heat measures that are delivered by any of these programs could also earn clean heat credits, which can be sold to obligated parties to satisfy their annual obligations. Such an umbrella approach creates a broader array of ways to reach and assist customers and would speed up the heating transition required by the CSNA.

In developing a clean heat standard, Maryland can look to experience with other performance standards and to developments in other states. Although the clean heat standard is a relatively new policy tool, energy performance standards are common in the United States and elsewhere. Roughly 30 states have renewable portfolio standards for electricity, and 25 states have energy efficiency performance standards. Many of these measures have been in place for decades. Clean fuel standards for transportation fuels are well tested in the western United States. More recently, Colorado has adopted a clean heat requirement for pipeline gas companies. Vermont has adopted a clean heat standard for both its gas utility and providers of delivered heating fuels. Oregon and Massachusetts are considering clean heat rules for all fossil-fuel heat providers. Maryland can find insights and experience from these jurisdictions as it develops a clean heat standard tailored to the state's heating markets, climate and policy goals.

This paper highlights notable features of the Colorado and Vermont legislation and surveys Maryland's policy history on greenhouse gas emissions reduction approaches. In the final section, we present design options for a clean heat standard. Although in some cases RAP's preferences and recommendations are set out, we emphasize that different arrangements are feasible. Clean heat standards can be tailored to a state's building stock, energy markets, climate conditions and policy preferences.

Introduction

Maryland has ambitious goals to reduce climate pollution and to improve energy equity. Commercial and residential heating is one of the state's largest sources of climate pollution, accounting for about 14% of statewide direct emissions.[1] Heating and cooling are essential services, and lower-income families and overburdened communities face higher energy burdens than other consumers. A clean heat standard can be a powerful tool toward meeting both those goals.

This paper addresses the problem that RAP calls fossil heat. Fossil heating fuels include pipeline gas, fuel oil, liquid propane and smaller amounts of kerosene and coal. Although heating buildings (space heating) is the largest use of fossil heating fuels, these fuels are also burned for water heating, clothes drying, cooking, municipal and commercial operations, and important industrial processes.[2] In recent years, families and businesses in Maryland have spent $2.8 billion annually[3] to purchase fossil heating fuels across these end uses, even before recent price spikes.

Across all sectors, fossil heat accounted for 18% of Maryland's climate pollution in 2020[4] and was the third-largest source of greenhouse gas emissions, after transportation and electricity consumption.[5] Figure 1 on the next page provides a breakdown of greenhouse gas emissions from fossil fuels in Maryland's thermal sector in 2020.[6] Pipeline gas combustion emissions made up just over two-thirds of those emissions, and emissions from burning delivered fossil fuels (propane, fuel oil and kerosene) were approximately one-quarter. The remaining 6% came from industrial coal combustion.

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[1] Percentage calculated from Maryland Department of the Environment. (n.d.-a). *Greenhouse gas inventory*. https://mde.maryland.gov/programs/air/climatechange/pages/greenhousegasinventory.aspx

[2] This paper adopts the convention that the full range of heating applications for fossil fuels is called the thermal sector or thermal fossil-fuel usage. The thermal sector excludes fossil-fuel combustion for major electric generation facilities, but certain data may include fossil-fuel electric generation at building and industrial sites, such as combined heat and power. Subsets of the thermal sector include the buildings sector, which is principally residential, and commercial combustion of these fossil fuels, as well as the industrial sector. Manufacturing is a subset of the industrial sector and has special treatment under the relevant Maryland statutes for greenhouse gas emissions reductions.

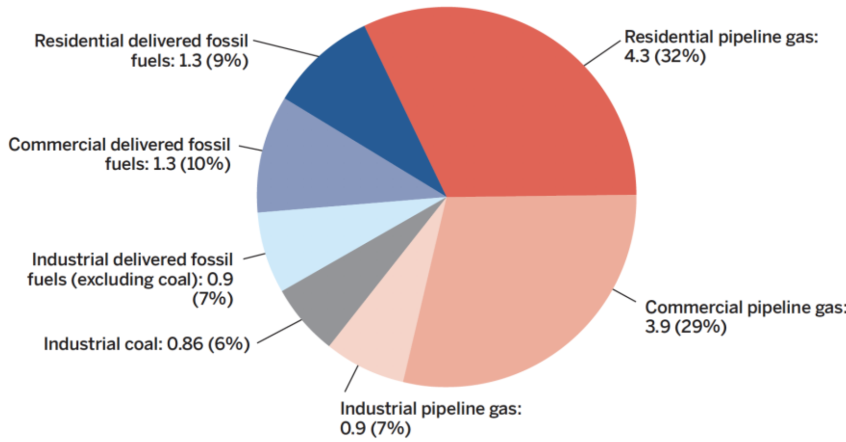
[3] For example, in 2019, the residential, commercial and industrial sectors in Maryland spent $2.76 billion on thermal fossil fuels — specifically, $445 million on fuel oil, $298 million on propane and $1.98 billion on pipeline gas. Averaged from 2010 to 2020, thermal fossil-fuel spending was $2.8 billion per year. Data are from the U.S. Energy Information Administration State Energy Data System. https://www.eia.gov/state/seds/seds-data-complete.php?sid=MD#PricesExpenditures

[4] Percentage calculated using gross greenhouse gas emissions, including agriculture, fossil-fuel extraction, land use, industrial processes and waste management. Maryland Department of the Environment, n.d.-a.

[5] Maryland uses the following definition: "'Greenhouse gas' includes carbon dioxide, methane, nitrous oxide, hydro-fluorocarbons, perfluorocarbons, and sulfur hexafluoride." Md. Code Ann., Environment §2-1202 — Definitions. https://mgaleg.maryland.gov/mgawebsite/laws/StatuteText?article=gen&section=2-1202&enactments=false. In this paper we focus on those emissions related to space and water heating in the residential and commercial sectors. Industrial process heat is treated separately under Maryland law and would not be subject to the clean heat policies discussed herein.

[6] Maryland Department of the Environment, n.d.-a.

Figure 1. Maryland 2020 greenhouse gas emissions from fossil-fuel heat (million metric tons CO_2)



Data source: Maryland Department of the Environment. (n.d.). *Greenhouse Gas Inventory*

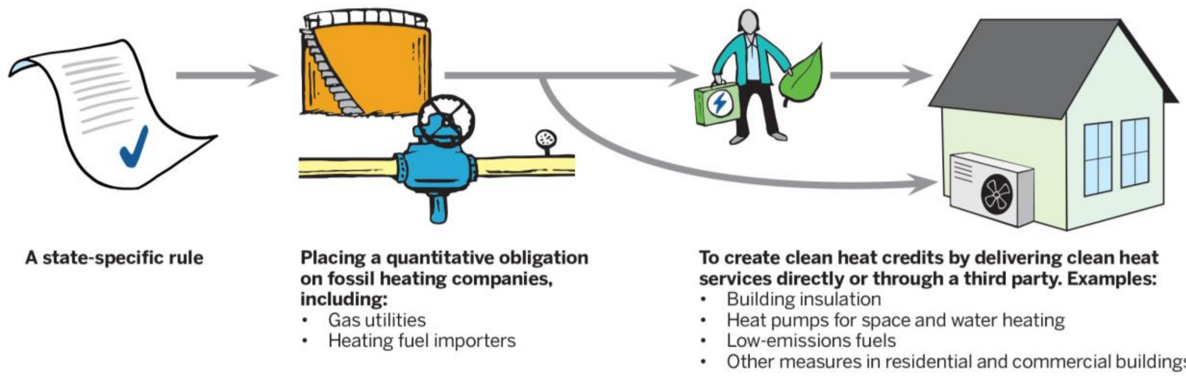
State law requires Maryland to reduce greenhouse gas emissions, including those from space heating and other thermal uses. Cleaner heating systems can also reduce local air pollution and improve indoor air quality. Of course, heat will always be an essential service — for health, comfort and a viable economy. Similarly, thermal processes are essential to many commercial and industrial operations. As a result, Maryland must find effective, affordable and equitable pathways to rapidly revamp its thermal sector. In this paper, the authors describe the concept of a new requirement on heating energy providers that works to phase down sales of fossil fuels. RAP calls this concept a **clean heat standard**. Several major design choices are necessary to implement it, and numerous additional details can affect the operation of the program.

At the highest level, a clean heat standard is a credit-based performance standard that would be applied to suppliers of heating energy in Maryland, notably gas utilities and providers of heating oil and propane. These parties would be obligated to serve their customers with gradually increasing percentages of low- or zero-emissions heat. Just as a renewable portfolio standard (RPS) requires electricity providers to replace coal- and gas-fired generation with wind, solar and other clean electricity generation, the clean heat standard would replace fuel oil, propane and fossil gas heat with weatherization and energy efficiency improvements, heat pumps, clean district energy and other verified low-carbon options, potentially including biomethane, green hydrogen, biodiesel, renewable diesel and advanced wood heat.[7]

A clean heat standard gives energy suppliers a broad range of options for meeting their obligation, but the logic of the standard is straightforward, as illustrated in Figure 2 on the next page.

[7] See the section Technology Options for Clean Heat on Page 13, where we define and describe these fuel options.

Figure 2. Elements of a clean heat standard



Each year, the obligated parties would need to earn or acquire enough clean heat credits to meet their annual responsibilities to reduce greenhouse gas emissions through additions to the clean heat resources serving homes and commercial buildings in Maryland. Credits are retired once they have been applied to fulfill a party's obligation.

Energy providers would not be alone in this effort to reduce emissions, although only they would face an annual obligation under the standard. Actions by a wide range of service providers — such as weatherization specialists, heating system contractors and housing authorities — can also yield clean heat credits. For some end uses, it will be more difficult to substitute low-emitting heat sources. However, because the design of the standard includes credit trading and other compliance flexibility measures, greenhouse gas reductions from various heat end uses can help with compliance. For example, credits earned for upgrading buildings can be sold to obligated parties, thus helping to defray the cost of upgrades while providing a path to compliance.

A key feature of the standard is that it does not require homeowners or businesses to make any particular clean heat choices. Also importantly, a clean heat standard can work alongside many other policies to reduce thermal emissions.

The Challenge and Opportunity of Decarbonizing Heating in Maryland

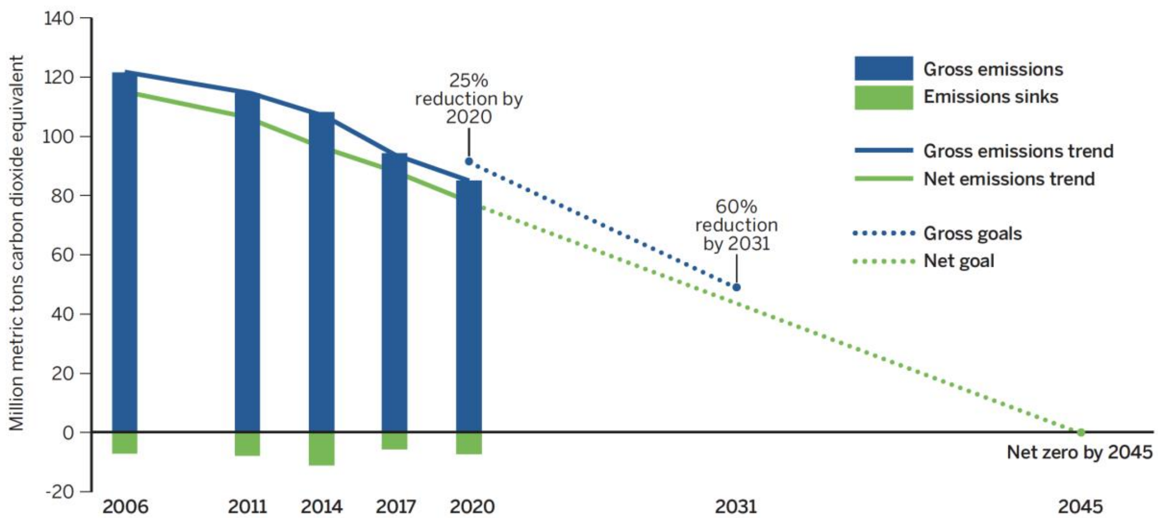
Maryland has ambitious goals to reduce climate pollution and to improve energy equity. Legislation and an advisory commission provide guidance as the state charts a path to meeting these dual goals.

In 2022, the Maryland General Assembly passed the Climate Solutions Now Act (CSNA), which included an overarching framework for reducing greenhouse gas emissions in Maryland substantially over time.[8] Those updated statutory requirements include:

- By 2031, economywide greenhouse gas emissions must be reduced at least 60% from 2006 levels.
- By 2045, statewide greenhouse gas emissions must be net zero.

Figure 3 shows the historical greenhouse gas emissions and future statutory requirements for Maryland.[9]

Figure 3. Economywide historic greenhouse gas emissions and future limits in Maryland



Source: Maryland Commission on Climate Change. (2022). *2022 Annual Report*

Of particular relevance to this paper, the Department of the Environment is required to adopt regulations and implement programs to reduce statewide greenhouse gas emissions in accordance with the law.

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[8] Climate Solutions Now Act, ch. 38, S.B. 528, Gen. Assemb., Reg. Sess. (Md. 2002) (enacted). https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/sb0528?ys=2022RS. The legislation updated the previous requirements from the Greenhouse Gas Reduction Act of 2016 and the earlier Greenhouse Gas Reduction Act of 2009.

[9] Maryland Commission on Climate Change. (2022). *2022 annual report.* https://mde.maryland.gov/programs/air/ClimateChange/MCCC/Pages/MCCCReports.aspx

Equity is a key concern in writing these regulations. The department must ensure that the emissions reduction measures it adopts do not "disproportionately impact rural or low-income, low- to moderate-income, or minority communities or any other particular class of electricity ratepayers," among other requirements.[10] The Climate Solutions Now Act set a deadline of June 30, 2023, for the Department of the Environment to submit a proposed plan to meet the 2031 emissions limit. After a public process, the department must adopt a final plan by December 31, 2023. The final plan must include regulations to implement plan measures for which Maryland agencies have existing statutory authority, as well as a summary of any new legislative authority needed.

The department received a recommendation for a program similar to a clean heat standard from the Maryland Commission on Climate Change (MCCC), which was created by law to advise the General Assembly and the executive branch on efforts to fight climate change. The MCCC has several formal working groups, including the Mitigation Working Group, as well as a steering committee working on climate justice.

In 2021, the MCCC mapped a path for building decarbonization, based on findings that all-electric buildings are the least costly to construct and operate and that building electrification can greatly reduce gas consumption.[11] Taking a broader view, the MCCC's *2022 Annual Report* made 34 recommendations, including that the state reform its thermal renewable energy credit program and develop a new "climate-aligned renewable thermal energy program."[12] The clean heat standard is given as an example of such a policy being developed in other states. This paper is designed to advance this MCCC recommendation.

Reducing emissions from the thermal sector presents serious challenges. Clean heating solutions must be delivered to a multitude of end-use locations and typically require decisions and investments to be made by millions of individual building owners. The building stock is long lived, and the rates of replacement and new construction are much slower than needed to meet today's climate goals through new standards alone. Heating and cooling are essential services that must be delivered reliably and equitably across society. And incumbent fossil heat suppliers will face a growing economic challenge of

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[10] Md. Code Ann., Environment §2-1206.

[11] Maryland Commission on Climate Change. (2021, November). *Building energy transition plan: A roadmap for decarbonizing the residential and commercial building sectors in Maryland.* https://mde.maryland.gov/programs/air/ClimateChange/MCCC/Documents/2021%20Annual%20Report%20Appendices%20FINAL.pdf

[12] "The State should develop a new climate-aligned, renewable thermal energy program to facilitate the decarbonization of the building sector. The new program would absorb the state's existing Thermal Renewable Energy Credits (TRECs) from the Renewable Portfolio Standard (RPS) electricity program and allow for various clean heat solutions to compete for renewable energy credits, with a prioritization of clean heating solutions that are not associated with on-site emissions. Credits in this expanded program should be made available to support measures that decarbonize heating fuel supplies, reduce methane leaks from natural gas distribution systems, improve the energy efficiency of homes/buildings, install a thermal or combined heat and power system that runs on qualifying biomass fuels, replace equipment that runs on fossil fuels with equipment that runs on qualifying biomass fuels, and replace equipment that runs on fossil fuels with efficient electric alternatives such as heat pumps. Examples of this type of 'Clean Heat Standard' program are under development in other states. Moving the existing TRECs to the new program would also return the state's RPS to its original intent of increasing the share of renewable energy in Maryland's electricity supply. Further, the program should prioritize the delivery of clean heating solutions, and associated climate, economic, and air quality benefits to low-income and environmental justice communities, particularly improvements to energy efficiency of homes/buildings and deployment of efficient, electric equipment such as heat pumps. The General Assembly should also modify requirements for woody biomass-to-energy systems to qualify for TRECs during the time before the new renewable thermal energy program takes effect. Low-value woody material from a forest management action with a net positive carbon benefit should be included to support healthy and climate-adapted forest composition and sustainable urban tree management." Maryland Commission on Climate Change, 2022, p. 19.

providing service to a shrinking customer base as cleaner heating services expand. Multiple policies are needed to work in tandem to address these and other implementation challenges.

At the same time, though, the heating transformation also presents new opportunities because, in addition to meeting CSNA mandates, clean heating options give the state of Maryland the chance to:

- Improve public health with cleaner air indoors and outdoors.
- Stimulate the economy with reduced expenditures on fossil fuels imported from other regions and overseas.
- Create new local industries and jobs.
- Make homes and businesses more comfortable year-round.

Technology Options for Clean Heat

A variety of heating technologies and fuels are available as alternatives to fossil fuels. Because the clean heat standard leaves this choice up to homeowners and businesses, it supports greenhouse gas reductions from various heating options.

Regardless of the underlying technologies involved, however, heating is cleaner when less energy is required. As a priority, Maryland will need to evaluate investments in weatherization and end-use efficiency to reduce thermal needs. Efficiency options include improved insulation and windows, air sealing and automated temperature controls. Efficiency measures should be delivered where they are most cost-effective, taking into account their contribution to bill reductions for the most energy-burdened households and their contribution to lowering peak demand for electricity on the hottest and coldest days of the year.

Measures for managing electricity usage (such as controlling water heaters and air-conditioning during spikes in demand) will be increasingly important as electrification of end uses expands, to better match thermal electric demands with the capacity and energy available from renewable electricity sources.

Nearly every modern fossil-fueled heating unit also requires electricity for some part of its operation, including ignition, control technologies, pumps to circulate hot water from boilers and fans to circulate warm air from furnaces. As a result, losing electric service for any significant period will prevent the operation of the fossil-fueled heating system in most houses.

Advances in technology over time have led to more efficient versions of fossil-fueled heating equipment. But there are now a substantial number of heating options that are cleaner than fossil-fueled technologies, with lower greenhouse gas emissions[13] and no

[13] In a region dominated by high-emitting electric generation resources such as coal, less-efficient electric heating technologies (e.g., electric resistance space heating) can still be responsible for substantial greenhouse gas emissions. However, greenhouse gas emissions from the electricity grid in the PJM Interconnection region have decreased significantly over the past two decades and are projected to continue decreasing in the coming decades.

on-site combustion that affects indoor air quality or local air pollution. Chief among those are electric heating technologies, including:

- **Electric resistance.** Running an electric current through metal can be used to heat air or water. This is a relatively inefficient technology for space heating but is a common water heating technology.
- **Air-source heat pumps.** Typically using an outdoor compressor and an indoor unit, an air-source heat pump uses the inherent energy in the outdoor air with a refrigerant to either heat or cool the indoor air. Ductless indoor units directly heat or cool the room where they are located, but indoor units can also be connected to air ducts to transport the conditioned air, like a traditional furnace or cooling system. Both ductless and central air-source heat pumps also provide cooling in summer.
- **Heat pump water heaters.** This technology is similar to an air-source heat pump with a simpler, single-unit arrangement, but it directly heats water instead of air. There is no outdoor condenser, as these units take heat from the air in the space where they are located, often a basement or cool storage space.[14]
- **Geothermal heat pumps.** Also known as ground-source heat pumps, these use the consistent temperature of the earth (instead of ambient air) to provide very efficient heat or cooling to a building through a heat exchanger using loops of refrigerant-filled pipe buried in the ground.
- **Geothermal district energy, using heat pumps within buildings**. This uses a system of networked ground-source heat pumps to serve multiple homes or businesses at a time.

Other clean heat alternatives:

- **Solar thermal.** Flat plates or evacuated tube collectors can be used to heat water, which can either be used for space heating or water heating.
- **District energy using low- to zero-greenhouse-gas inputs.** This includes combined heat and power facilities that use renewable electricity sources to create steam, which can be distributed to heat one or more buildings.

There are a range of other heating fuels (solids, liquids and gases) that are not derived from fossil fuels and may have the potential to provide clean heat in Maryland. Importantly, there are many variations in how these fuels are created, collected or combusted, which leads to different kinds of upstream and downstream environmental impacts.

The primary alternatives for clean solid fuels are various forms of advanced wood heating, typically using wood pellets. Some sources of woody biomass could be considered to have zero or low greenhouse gas emissions when evaluated on a life-cycle basis — for example,

[14] Although air-source heat pumps for domestic hot water are common, they are not often used in the United States for hydronic space heating systems (those relying on circulating fluids via radiators or baseboard pipes), which require higher-temperature fluids. This could change as heat pump technologies improve.

if pellets are made from sawmill residue or other waste products. Newer combustion technologies for wood fuels are much cleaner and more efficient than those of the past.

In addition, at least two kinds of liquid fuels can substitute for fossil heating oil[15] as a blend or sometimes as a full replacement:

- **Biodiesel.** This can be derived from vegetable oils, soybeans or other food byproducts and in some cases from nonfood crops and residues. Biodiesel can be used as a blend, but pure biodiesel is hard to store and may require modifications to typical heating equipment.
- **Renewable diesel.** Renewable diesel can be derived from the same feedstocks as biodiesel but is further refined into the same chemical form as fossil diesel fuel. As a result, renewable diesel can be used as a blend or a replacement for fossil heating oil.

Potentially cleaner forms of gaseous fuels are:

- **Biomethane, sometimes called renewable natural gas.** There are several different collection sources for forms of methane that could be considered renewable. Potentially valuable sources include those that recapture methane that would otherwise be vented into the atmosphere. Those include collection at landfills, livestock operations, wastewater treatment plants, coal mine mouths and anaerobic digestion, but not synthetic methane created from other fossil fuels. Most forms of biomethane contain contaminants that have health impacts and that interfere with combustion control technologies for reducing other pollutants, such as nitrogen oxides (NOx).
- **Green hydrogen.** Today, nearly all hydrogen is created using steam-methane reforming, which typically has significant greenhouse gas emissions from the energy input needed and the chemical process itself. This is known as gray hydrogen. However, green hydrogen, created from the electrolysis of a water molecule using zero-greenhouse-gas electricity, has no greenhouse gas emissions associated directly with its production. Several other hydrogen creation methods are being explored across the globe, and each has its unique features. Although many analysts support the use of green hydrogen on a limited basis as a replacement for gray hydrogen and in high-temperature applications that are not easily electrified, a much wider use of hydrogen as a replacement for pipeline gas raises many issues. A principal concern is system efficiency. A given quantity of renewable electricity can deliver much more heat at end uses via heat pumps than it can by first creating and then burning hydrogen.[16] Hydrogen also poses challenges for existing gas pipeline infrastructure because of its chemical and physical properties, and substantial investments to carry significant

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[15] Fossil heating oil is also known as distillate fuel oil and is chemically identical to stationary and mobile diesel fuel.

[16] Rosenow, J. (2022, September 27). Is heating homes with hydrogen all but a pipe dream? An evidence review. *Joule*, *6*(10), 2225-2228. https://doi.org/10.1016/j.joule.2022.08.015. While green hydrogen is not well suited to widespread use in pipeline systems for conventional heating, it may provide a storage option for meeting peak electricity demands and could be needed to provide high-temperature heat in industrial applications that are hard to electrify using current technology. See: Lowes, R. (2023). *Regret-ready: A briefing on United Kingdom proposals for the mandating of 'hydrogen-ready' gas boilers.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/regret-ready-briefing-on-united-kingdom-proposals-for-mandating-hydrogen-ready-gas-boilers/

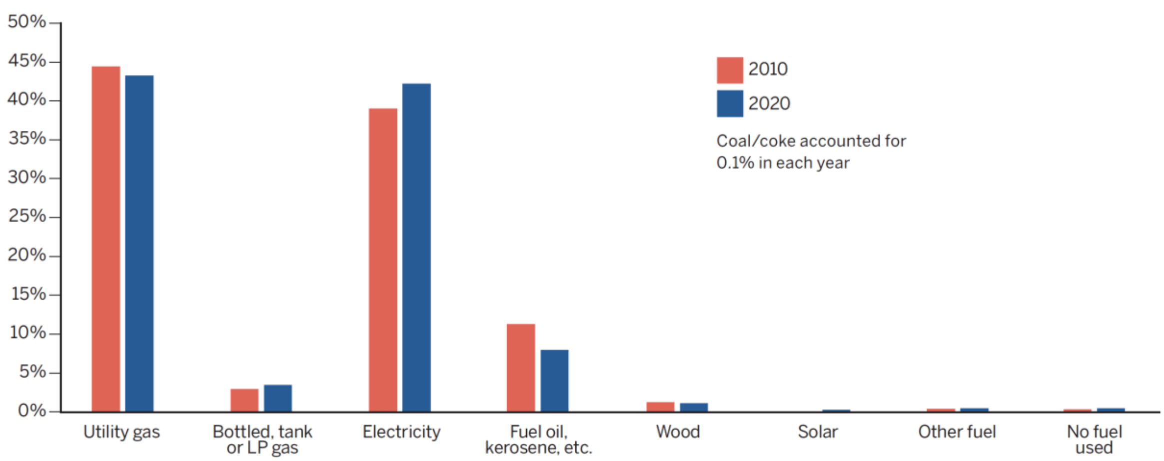
percentages of hydrogen would be needed. Combustion of hydrogen can also have significant nitrogen oxide emissions.

Judgments about these alternative combustion fuels, whether solid, liquid or gaseous, are required for a sensible thermal decarbonization policy. The necessary judgments may depend on the exact architecture of the clean heat standard, as discussed below. However, those judgments likely include life-cycle greenhouse gas emissions, infrastructure retrofit needs, conventional air pollutants, and sustainable forestry and agricultural practices.

An Evolving Thermal Sector in Maryland

Data from the previous decade show that fuel-switching is already occurring in Maryland homes, and over 40% of homes in the state are primarily heated without on-site combustion of fossil fuels, mostly by electricity. Still, the majority of the roughly 2.45 million housing units in Maryland in 2020 were heated primarily by fossil fuels, although the share had declined 4 percentage points since 2010, as shown in Figure 4.[17] In this time, the percentage of homes heated primarily by fuel oil and kerosene declined from 11% to 8%, and the percentage heated by propane increased slightly. The percentage of homes heated by gas from utilities declined slightly, although the absolute number of homes heated by gas increased. Over this period, there was a 3 percentage point increase in the proportion of homes that reported electricity as their primary heating fuel. While the existing level of electrification in Maryland is encouraging, the slow pace of change from 2010 to 2020 suggests that significant additional policies will be needed to meet the goals of the CSNA.

Figure 4. Maryland housing units by primary heating types

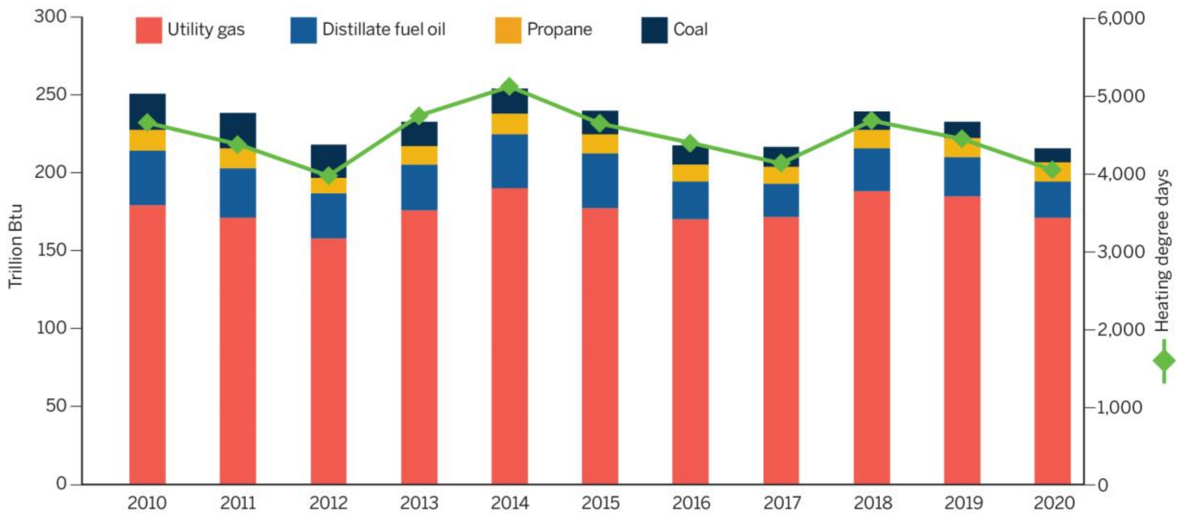


Data source: U.S. Census Bureau. (n.d.). *American Community Survey: DP04 Selected Housing Characteristics*

[17] U.S. Census Bureau. (n.d.). *American Community Survey: DP04 Selected housing characteristics* [Maryland 2010 and 2020 tables]. https://data.census.gov/table?g=DP04&g=040XX00US24&y=2010 and https://data.census.gov/table?g=DP04&g=040XX00US24&y=2020

Utility gas was by far the highest usage fossil heating fuel in Maryland every year from 2010 to 2020, followed by heating oil and propane (see Figure 5).[18] Industrial coal usage remained significant but decreased substantially over this time period. Consumption can vary quite a bit from year to year. Weather is a significant variable, as shown by the heating degree days data (cold winters require more energy for space heating).

Figure 5. Maryland fossil-fuel consumption for heating (residential, commercial and industrial) varies with heating degree days



Note: Consumption of kerosene and residual fuel oil was too low to represent effectively in this chart.

Data source: U.S. Energy Information Administration State Energy Data System

Comparing Pathways for the Transition

Moving Maryland's buildings off fossil fuels will require a multipronged approach. The Maryland Commission on Climate Change in 2021 considered four scenarios for achieving net zero emissions in the buildings sector by 2045 using different levels of electrification and fuel-switching. In November 2021, the MCCC issued its *Building Energy Transition Plan: A Roadmap for Decarbonizing the Residential and Commercial Building Sectors in Maryland*.[19] This plan included the results of modeling of the four scenarios by the consulting firm Energy + Environmental Economics (E3). The conclusion was that adopting a combination of decarbonization policies for new and existing buildings, while centering equity and justice, would be the lowest-cost approach.

The four scenarios were:

- **High electrification.** Almost all buildings adopt heat pumps and improve shell performance by 2045. New construction is all-electric starting in 2025.

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[18] U.S. Energy Information Administration State Energy Data System. https://www.eia.gov/state/seds/seds-data-complete.php?sid=MD#Consumption

[19] Maryland Commission on Climate Change, 2021. Although still relevant in many respects, this report was issued before the passage of the Climate Solutions Now Act of 2022.

- **Electrification with fuel backup.** Existing buildings adopt and use heat pumps for most of their annual heating needs by 2045, but existing furnaces and boilers provide backup heating in the coldest hours of the year. Fossil fuels are replaced with low-carbon renewable fuels by 2045. New construction is all-electric starting in 2025.
- **High decarbonized methane.** Most buildings use fuel for heating and improve shell performance by 2045. Fossil fuels are replaced with low-carbon renewable fuels by 2045.
- **MWG policy.** After reviewing the results of the other three scenarios, the Mitigation Working Group of the MCCC crafted a specific policy package.

Benefiting from the previous analysis of the other three scenarios, the MWG policy scenario was found to have the lowest total cost of the four scenarios. The four core concepts for the MWG policy scenario were:

- Ensure an equitable and just transition, especially for low-income households.
- Construct new buildings to meet space and water heating demand without fossil fuels.
- Replace almost all fossil-fuel heaters with heat pumps in existing homes by 2045.
- Implement a flexible building emissions standard for commercial buildings.[20]

One key distinction among the scenarios is that the MWG policy scenario has high electrification in the residential sector, which was found to have small impacts on peak electricity demand, and modest electrification in the commercial sector, which had been found to have significant impacts on peak electricity demand in the high electrification scenario.

Designing to Meet Policy Goals

There are many ways to approach the thermal decarbonization challenge, so it is vital to keep in mind a few guiding principles to test decision-making as policymakers consider various aspects of the clean heat standard program. A successful set of policies will:

- **Meet Maryland's climate goals.** Reduce local air pollution and global greenhouse gas emissions and be expected to meet the thermal sector's share of emissions reductions called for in the CSNA.
- **Enhance social equity.** Build social equity into the architecture of the program and, particularly, minimize adverse impacts on low-income households and those most burdened by high energy bills and high levels of indoor air pollution.
- **Secure physical delivery in Maryland.** Provide real and verified emissions reductions, delivered via cleaner heating services at end-use locations in the state.

[20] Maryland Commission on Climate Change, 2021.

- **Provide customer flexibility.** Give individual homeowners, building owners and other consumers a range of low-emissions heating choices, as well as the ability to decide whether and when to make changes in response to market offerings.
- **Promote supplier flexibility.** Offer multiple pathways for obligated parties to meet their obligations under the standard.
- **Minimize cost.** Provide flexibility to enable emissions reductions to be achieved at the lowest possible cost.
- **Maintain resource diversity.** Retain Maryland's ability to provide affordable heating services despite changing global energy prices and supply conditions.
- **Minimize negative side effects.** These include environmental harms from measures whose emissions occur elsewhere, such as switching to cleaner-burning fuels whose production emissions occurred in other states.
- **Scale over time.** Grow in scale gradually to provide opportunities to benefit from new technology, capture economies of scale, and provide certainty to market participants that the market for clean heat solutions will continue and grow.
- **Be as simple as possible.** Minimize complexity of administration while maintaining enough regulatory rigor to ensure that emissions reductions are real and are consistent with state requirements.
- **Work well with other policies.** Be mutually reinforcing with Maryland's weatherization programs, utility efficiency and fossil-fuel reduction programs and other greenhouse gas reduction initiatives. A set of policies should work with existing Maryland policies and institutions to boost progress, ensure consistency across policies and avoid re-creating the wheel.
- **Enhance economic development.** Replace expensive and price-volatile fossil fuels with efficiency investments and cleaner and more affordable energy carriers. This conversion will support growth in the economy, including new jobs and job training opportunities, and fuel providers' ability to transition to new and economically sustainable business models.

Policy Options for Decarbonizing Heat

In the main body of this paper, we focus on the principal design options for a clean heat standard to deliver essential emissions reductions from the thermal sector in Maryland. But a clean heat standard is not the only policy option available to reduce emissions from burning fossil fuels for heat. Building technologies are rapidly advancing, and a clean heat standard is a relatively new idea. Therefore, the pros and cons of a clean heat standard should be compared against other policy options, and decision-makers should consider how different policies can work together to deliver on Maryland's established goals.

In concluding this review, we wish to emphasize a key observation: Each of these policy options has merit, and most of them could be adopted to work in tandem with a clean heat standard. To the degree that any of these parallel strategies lowers demand for fossil heat, or lowers the cost of delivering clean heat solutions, they make it easier to deliver cleaner fuels and heating conversions, speeding up the transition to clean heat in Maryland. **A clean heat standard is an overarching strategy that can work with and tie together complementary approaches to advance clean heat**.

RAP has considered several alternatives to a clean heat standard to reduce emissions. This section explores four options:

- Carbon pricing, such as taxes and cap-and-invest programs.
- Fuel-blending requirements and the use of renewable fuels.
- Energy efficiency programs that could include efforts in gas efficiency.
- Building codes and heating equipment standards.

In the sections below we briefly discuss some of the major program options for reducing emissions and transforming the thermal sector. We touch briefly on the pros and cons of these options, before turning our attention to the clean heat standard as a central element in a comprehensive clean heat strategy for Maryland.

Carbon Pricing: Two Models for Curbing Emissions

Although the variations in carbon pricing policies are numerous, two models have been discussed in Maryland in recent years. One is putting a price on greenhouse gas emissions directly to a regulated sector, typically called a carbon tax. The other — often called a cap-and-invest program — involves setting a cap on the greenhouse gas emissions of the relevant sector, requiring the purchase of allowances for emissions in that sector, and using revenues from those purchases to fund programs that assist in meeting the state's goal.

Carbon Tax

Placing a tax per ton on the greenhouse gas emissions of a particular sector has been discussed recently in Maryland. A 2022 report commissioned by the Maryland Energy Administration[21] was designed to provide background on policy options and initial quantification of the impacts of a carbon tax, including on Maryland's ability to meet earlier goals of state legislation (e.g., the 2030 goals of the 2016 Greenhouse Gas

[21] Maryland Energy Administration. (2022, February). *Carbon pricing in Maryland: An initial analysis*. https://energy.maryland.gov/Reports/MEA%20Carbon%20Pricing%20Report%20Final.pdf

Reduction Act, which were superseded by the 2022 CSNA legislation). It did not discuss how revenues from the tax might be used.

While theoretically attractive, a carbon tax by itself will not be the best means to drive change in the buildings sector, where actions must be taken by individual building owners facing significant barriers to change. There is strong evidence that pricing carbon alone would not drive down fossil heat emissions meaningfully unless it were set at unrealistically high rates. Looking at consumption data over many decades, economists conclude that demand for heating fuels is strongly inelastic — that is, consumption changes very little in relation to the price of fuel.[22]

One concrete example comes from a study commissioned by the Vermont Legislature in 2019. Following extensive economic modeling, Resources for the Future found that even if carbon prices were set as high as $100 per ton, the achieved reduction in carbon emissions statewide would be only about 10% below the expected business as usual case.[23]

Maryland residents know the truth of this conclusion, having lived through large swings in the prices of fossil fuels in recent years, with little sustained impact on overall fossil-fuel demand.

However, if a carbon tax can raise a predictable revenue stream for clean heat programs, it could be useful where funds are directed to driving change and providing incentives in the buildings sector. Carbon revenues can be especially useful in delivering clean heat benefits to energy-burdened and lower-income households and other priority consumers.

Cap-and-Invest Programs

Cap-and-invest programs could help speed up the transition to low-emissions heating, particularly if used as a complementary program. The Regional Greenhouse Gas Initiative (RGGI) program has demonstrated the value of cap-and-invest programs in reducing emissions and reinvesting proceeds in areas important to states. In Maryland more than "half of the funds collected through RGGI auctions are invested in energy assistance for low-income households and energy efficiency in low- to moderate-income homes and communities. Other investments include grants for residential and commercial solar arrays and electric vehicles."[24]

The main benefit of a cap-and-invest program is that the cap ensures reductions in emissions. On the other hand, cap-and-invest programs lead to uncertainty in the revenue stream that is essential to driving change in the thermal sector. When carbon allowance revenues and demand levels are uncertain, it is harder to build and maintain continuity

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[22] The price elasticity of demand for electricity and for heating fuels has been measured many times and is usually found to be between -0.2 and -0.3. This means that it would take a 100% increase in the cost of heating fuels over an extended period to incentivize a 20% to 30% reduction in consumption. For example, in one study, researchers from the Rand Corporation found that the price elasticity for pipeline gas in the Northeastern United States was -0.1 in the short term and -0.3 in the long term. Bernstein, M., & Griffin, J. (2006). *Regional differences in the price-elasticity of demand for energy* (NREL/SR-620-39512), p. 35. National Renewable Energy Laboratory. https://doi.org/10.2172/877655

[23] Hafstead, M. A. C., Look, W., Keyes, A., Linn, J., Burtraw, D., & Williams III, R. C. (2019). *An analysis of decarbonization methods in Vermont*, p. 2. Resources for the Future. https://www.rff.org/publications/reports/an-analysis-of-decarbonization-methods-in-vermont/

[24] Maryland Department of the Environment. (2022, December 12). *Maryland raises a billion dollars for climate progress and energy efficiency* [Press release]. https://news.maryland.gov/mde/2022/12/12/maryland-raises-a-billion-dollars-for-climate-progress-and-energy-efficiency/

in ongoing programs and harder to recruit and train the workforce that is needed to install measures. And these issues may be exacerbated if the revenues are considered public tax receipts and must be appropriated each budget cycle. We have seen this problem in the RGGI program. Some of the RGGI states have included the purposes for revenue use in their enabling legislation but that has still led to funding levels being adjusted by legislatures.

A significant program element from RGGI that merits inclusion in a clean heat standard is the requirement that the program be reviewed every three years. Improvements to the RGGI program are still merited (e.g., to reduce inequitable impacts from power plants), and the states have successfully made improvements in two prior reviews of the program. A third program review is underway in 2023 with a focus on improving equitable outcomes from the program.

Fuel-Blending Requirements and Use of Renewable Fuels

Maryland has limited requirements for fuel blending, and there is some interest in nonfossil fuels, including woody biomass, biomethane, synthetic gas and hydrogen. The E3 study completed for the MCCC and the Mitigation Working Group developed scenarios with opportunities for using a variety of renewable fuels, particularly to assist with phasing out methane.[25]

One fuel-blending requirement applies to the state's vehicle fleet and offers ideas that could be considered for a clean heat standard. Maryland has a requirement that at least 50% of the state's vehicles using diesel fuel use a minimum of 5% biodiesel.[26] And for fleets, the Maryland Energy Administration administers the Clean Fuels Incentive Program to encourage fleet operators to procure alternatively fueled vehicles. The grants cover electric, hydrogen, propane, methane and biodiesel vehicles. There are other programs that assist municipalities in purchasing electric vehicles and installing electric vehicle charging infrastructure.[27] While these programs do not directly support a clean heat standard, they demonstrate Maryland's interest in developing the use of alternative fuels. This could be extended to heating system fuels — for example, requiring or crediting biodiesel blends in heating fuels.[28]

The E3 building decarbonization study for the Maryland Department of the Environment[29] explored a scenario for blending gaseous heating fuels. The study included a "high decarbonized methane" scenario involving renewable natural gas supplied by biomethane and synthetic gas; a 7% hydrogen blend in the renewable natural gas; and high energy

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[25] Clark, T., Aas, D., Li, C., de Villier, J., Levine, M., & Landsman, J. (2021, October). *Maryland building decarbonization study: Final report.* Energy + Environmental Economics. https://mde.maryland.gov/programs/Air/ClimateChange/MCCC/Documents/MWG_Buildings%20Ad%20Hoc%20Group/E3%20Maryland%20Building%20Decarbonization%20Study%20-%20Final%20Report.pdf

[26] U.S. Department of Energy Vehicle Technologies Office. (n.d.). *Biodiesel laws and incentives in Maryland*. Alternative Fuels Data Center. https://afdc.energy.gov/fuels/laws/BIOD?state=MD

[27] Maryland Energy Administration. (n.d.). *FY23 Clean Fuels Incentive Program (CFIP).* https://energy.maryland.gov/transportation/Pages/Clean-Fuels-Incentive-Program.aspx

[28] Three Northeastern states — New York, Connecticut and Rhode Island — have adopted mandatory biofuels blending requirements for fuel oil suppliers.

[29] Clark et al., 2021, p. 13.

efficiency levels through deep building retrofits. The scenarios looked at using all available biomethane from within Maryland as well as the state's share of national biomethane resources. Due to its greenhouse gas accounting rules, Maryland would prefer to use only in-state resources, which would limit the availability of biomethane to a few trillion Btu of gas. E3's more inclusive scenario assumed at least a doubling of biomethane (from national sources) and much more synthetic gas. This was not the most cost-effective strategy that E3 modeled; that distinction goes to a strategy developed in consultation with the Mitigation Working Group.

Two options are available for gas fuel blending that could be done by gas utilities (including competitive gas suppliers): biomethane and hydrogen.

In the first case, biomethane captured from landfills or produced from food and animal waste can be blended with fossil methane and delivered in existing pipelines or used on-site for electric generation. There are wide-ranging estimates for the potential for producing biomethane based on assumptions about the generation of gas from landfills over time, and the amount of food waste that can be diverted from disposal and converted to methane through anaerobic digestion. The MCCC's *2022 Annual Report* includes a recommendation for funding to support methane capture from landfills and wastewater treatment facilities and to use that methane for on-site power generation.[30] The appendix to the 2022 report includes more specific recommendations on biomass-to-energy opportunities, such as using more wood waste for combined heat and power systems or thermal systems.

Maryland has acted to improve the supply of biomethane from food waste. As of January 1, 2023, the state has banned food waste from disposal for facilities that produce over 2 tons per week, such as supermarkets, schools and institutions.[31] The requirement drops to 1 ton per week in 2024.[32] The requirements apply to facilities within 30 miles of an organics recycling facility that has capacity and is willing to take additional waste.

The generation of methane from either source leads to concerns about contamination from other chemicals, particularly siloaxanes in food waste that make cleaning up the gas to pipeline-quality methane difficult and costly.[33] Also, any use of biomethane should be regulated to ensure good combustion of the gas, particularly to avoid undue increases in nitrogen oxide emissions.

Hydrogen can also be blended with methane, perhaps up to 20%, but is usually done at a much lower percentage — around 7% — due to concerns about leakage and pipeline

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[30] Maryland Commission on Climate Change, 2022, recommendation 23, p. 18.

[31] BioCycle. (2021, June 1). *Food waste disposal ban in Maryland now law*. https://www.biocycle.net/food-waste-disposal-ban-in-maryland-now-law/. See also applicable regulations in Md. Code Regs. 26.04.13 (December 2022). https://mde.maryland.gov/programs/land/RecyclingandOperationsprogram/Documents/COMAR%2026.04.13%20Food%20Residuals%20Recycling%20%26%20Diversion_Adopted.pdf

[32] Maryland Department of the Environment. (2023, March). *Determination of applicability of the food residuals diversion requirement under 2021 House Bill 264/Senate Bill 483.* https://mde.maryland.gov/programs/land/RecyclingandOperationsprogram/Documents/26.04.13PersonAssessment_withAppendixDocChecklist.pdf

[33] Shen, M., Zhang, Y., Hu, D., Fan, J., & Zeng, G. (2018, September 5). A review on removal of siloxanes from biogas: With a special focus on volatile methylsiloxanes. *Environmental Science and Pollution Research, 25*, 30847–30862. https://link.springer.com/article/10.1007/s11356-018-3000-4

embrittlement and safety. This was the fraction used in the building decarbonization modeling. A fundamental question for the use of hydrogen in a clean heat standard would be how the hydrogen was produced, since it can be accomplished with varying levels of greenhouse gas emissions. Those levels depend on the process used — for example, electrolysis or steam-reforming methane — and the energy used to complete the chemical process. Technologies that provide a greenhouse gas benefit (e.g., by using renewable energy to produce hydrogen) could be a viable option for credits in a clean heat standard. However, steam-reforming methane typically releases greenhouse gases from energy usage and from the chemical process. As with methane, hydrogen production brings concerns about increases in other pollutants that result from the chemical process, such as nitrogen oxides, and should be monitored so life-cycle reductions in greenhouse gases are not offset by increases in nitrogen oxides.

Advances in technologies for hydrogen, biomethane and biodiesel may make it possible to increase their use in the thermal sector. While supplies of low-emissions renewable gas are likely to be quite limited, liquid biofuels may be more plentiful. Since many of these are relatively new technologies and they are evolving quickly, their life-cycle emissions should be calculated carefully and updated regularly. Clean heat policies should be designed to test fuel pathways to see whether their reductions in greenhouse gas pollutants merit their inclusion in a clean heat program, or whether their overall impacts should require their exclusion.

In any case, an analysis conducted by the Energy Futures Group in conjunction with this paper shows that even in the most expansive scenario for the use of biofuels, they will account for no more than 20% of the emissions reductions needed in Maryland.[34] Therefore, under any scenario, we expect electrification options will provide the vast majority of heating conversions needed.

Under any scenario, we expect electrification options will provide the vast majority of heating conversions needed.

Although the use of woody biomass is not as common in Maryland as in some other parts of the country, it could have a place in Maryland, as does the forestry industry, which is an important part of the economy in western Maryland. The Maryland greenhouse gas inventory includes a significant biomass sink offsetting other greenhouse gas emissions. Maryland assumes that any woody biomass produced and used in the state is carbon neutral, but life-cycle emissions can vary greatly across fuel sources, timber management practices and ecosystem regimes. Biomass represents a small part of the energy resources, yet the 2022 annual MCCC report includes the use of "qualifying" biomass fuels as part of a thermal sector program like the clean heat standard. That report also recommends supporting the forest product industry in Maryland to maximize carbon sequestration.[35]

Maryland does not expect to import significant quantities of renewable fuels like biomass or biomethane to meet its greenhouse gas goals but plans to promote in-state resources.[36]

[34] For a more detailed summary of the findings, see the text box on Page 56.

[35] Maryland Commission on Climate Change, 2022, recommendations 24 and 25, pp. 19-20.

[36] States may, of course, promote in-state resources in a variety of ways, but care must be taken in the design of a clean heat program to avoid program elements that would violate constitutional provisions governing interstate commerce.

For example, biomethane could be used as backup fuel for some heating and industrial applications, assuming a life-cycle analysis of emissions of those fuels shows reductions compared to other sources. The Department of the Environment has requested that the MCCC's Scientific and Technical Working Group review the department's methodologies for tracking greenhouse gas emissions associated with the use of biofuels.

Building Codes and Heating Equipment Standards

Building codes and equipment standards are often used to promote energy efficiency and reduce emissions, and Maryland is including them in climate planning in at least three ways. Adopting new and improved building codes is part of Maryland's climate strategy. The state has also been active in developing performance standards for existing buildings as part of investigating options for transforming its buildings sector. Maryland policymakers are also interested in improving the use of zero-emissions heating equipment as per the recommendation of the MCCC.

Improvements in New and Existing Construction

Every building built today is likely to be in operation for 75 to 100 years. Building new structures to very high standards that leads to near-zero or net-zero emissions is possible. Maryland is taking steps to improve building codes in line with stringent international standards so that new buildings are much more efficient, healthier and less polluting than historically buildings have been. But building codes for new buildings cannot come close to addressing the climate challenge posed by the existing building stock. The rate of new additions, replacements and deep renovations is too slow. The majority of the buildings that will be in use in 2050 are already built and not likely to be replaced soon. To widen the opportunity to realize essential emissions reductions, the state is developing performance standards for existing large buildings.

The *Building Energy Transition Plan* from the Mitigation Working Group of the MCCC includes important findings for transforming Maryland's buildings sector.[37] Some are:

- All-electric homes have low construction and operating costs, which supports Maryland's effort to update its building codes.
- Gas consumption in buildings can be reduced 62% to 95%, depending on success with electrification.

The report also provides a roadmap for building decarbonization. E3's analysis found that implementing the plan would:

- Reduce emissions from residential and commercial buildings by 95% by 2045.
- Reduce construction and energy costs for most building types.[38]

Maryland's efforts to update its building codes include adoption of the 2021 International Energy Conservation Code for residential and commercial buildings in May 2023. State legislation requires adoption within 18 months of a new version of the International

[37] Maryland Commission on Climate Change, 2021.

[38] Maryland Commission on Climate Change, 2021, p. 4.

Code; municipalities have an additional 12 months to adopt the code once the state has adopted it.[39]

But the pace of new construction in Maryland, less than 1% per year with around 10,000 new units added per year, and the expected percentage improvement in equipment efficiencies alone are too low and too slow to deliver the reductions needed in fossil heat consumption in coming decades.[40]

Under the Climate Solutions Now Act, the Maryland Department of the Environment is responsible for developing regulations for building energy performance standards. These will require annual reporting of energy use and emissions for buildings 35,000 square feet or larger beginning in 2025 and lead to building standards with net-zero direct greenhouse gas emissions by January 2040 (with an interim 20% reduction by January 2030).[41] The department can include an alternative compliance fee that is at least as high as the social cost of greenhouse gas adopted in Maryland or by the federal government. Regulations are under development.[42] The department notes that around 9,000 buildings would be covered by the regulations. It expects to use the U.S. Environmental Protection Agency's Energy Star Portfolio Manager for the annual reporting, which many U.S. jurisdictions use. The energy performance standards cover larger residential buildings (e.g., multifamily) as well as commercial buildings. The clean heat standard could synchronize with the energy performance standards and help address the thermal needs of smaller buildings.

Equipment Standards to Promote Energy Efficiency and Improve Air Quality

In May 2022, Maryland adopted new appliance efficiency standards with enactment of H.B. 722.[43] The legislation establishes minimum energy efficiency standards for additional products (not covered by federal standards) sold or installed in Maryland, including commercial dishwashers and steam cookers. The legislation also requires procedures for testing, certification, inspection and enforcement to ensure compliance with the standards. Regulations pertaining to these standards were out for comment as of October 1, 2023.[44]

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[39] Northeast Energy Efficiency Partnerships. (n.d.). *Building energy codes.* https://neep.org/efficient-resilient-buildings-and-communities/energy-codes. The 2022 climate legislation also requires a report from the Maryland Department of Labor on electrification of buildings, which has been released in draft and includes support for electrification of residential buildings. The final report is due in December 2023.

[40] This is because (1) only a small fraction of existing building energy use is affected by codes each year; and (2) building energy codes typically establish a "floor" for efficiency, not efficiency levels that are optimal in the context of aggressive climate policy.

[41] Maryland Department of the Environment. (n.d.-b). *Building energy performance standards.* https://mde.maryland.gov/programs/air/ClimateChange/Pages/BEPS.aspx

[42] Maryland Department of the Environment. (2022). *Building energy performance standards* [Presentation]. https://mde.maryland.gov/programs/workwithmde/Documents/AQCAC/2022MeetingMaterials/BEPS%20MDE%20Overview%20Fall%202022.pdf

[43] An Act Concerning Maryland Energy Administration — Energy and Water Efficiency Standards — Alterations, ch. 564, H.B. 772, Gen. Assemb. (Md. 2022). https://mgaleg.maryland.gov/2022RS/Chapters_noln/CH_564_hb0772t.pdf

[44] Maryland Energy Administration. (n.d.). *Title 14: Independent agencies. Subtitle 26: Maryland Energy Administration. Notice of proposed action.* https://energy.maryland.gov/SiteAssets/Pages/ProposedRegulatoryChanges/Regulations%202022%20-%20Appliance%20Standards.docx.pdf

In addition to these new standards, Maryland could provide incentives for phasing out existing fossil-fueled equipment.

The heating equipment in buildings has a shorter lifespan than the buildings themselves. Around 8% of Maryland homes heat with oil,[45] and the life of an average oil furnace is likely more than 20 years. A lower percentage (about 4%) heats their homes with propane. Both are typically costly fuels. Unfortunately, most heating and cooling equipment, including water heaters, is replaced on an emergency basis when it fails, which typically precludes simultaneously reconsidering the heating system as a whole or renovating and upgrading the building. As a result, owners rarely have the time or inclination to switch to an entirely new system, even one that would be less polluting and less expensive to run in the long term.[46] For these reasons, many experts have advocated raising the minimum performance standards for heating and cooling equipment so that the choices available at the time of sale, including replacement, are altogether more efficient.

On emissions standards, the MCCC in its *2022 Annual Report*[47] recommended that Maryland adopt zero-emissions standards for water and space heating. This would allow Maryland to align efficient equipment standards with its climate and clean air goals by adding standards for pollutants like nitrogen oxides for water heaters. There is precedent for state emissions standards for heating equipment. For example, Utah[48] and air districts in California[49] currently require low NOx water heaters, and in mid-March 2023 the Bay Area Air Quality Management District promulgated zero NOx emissions water heater and furnace standards, set to take effect in 2027 for small water heaters, 2027 for furnaces and 2031 for large water heaters.[50] Those standards are based on state and federal authority derived from the Clean Air Act and state environmental legislation. Maryland's authority is similar.

The Regulatory Assistance Project developed a model rule for regulating NOx emissions from water heaters with input from a number of Northeast states.[51] RAP has been working with a regional association of state air quality agencies, NESCAUM, discussing equipment emissions standards under the broader umbrella of building electrification options, considering options for lowering greenhouse gases and NOx. The RAP model rule proposes to require cleaner equipment in the late 2020s and zero-emissions equipment around 2030.

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45 U.S. Census Bureau, n.d.

46 Malinowski, M., Dupuy, M., Farnsworth, D., & Torre, D. (2022). *Combating high fuel prices with hybrid heating: The case for swapping air conditioners for heat pumps.* CLASP. https://www.clasp.ngo/research/all/ac-to-heat-pumps/

47 Maryland Commission on Climate Change, 2022, recommendation 21, p. 17.

48 Utah Admin. Code, R307-230 — NO[x] emission limits for natural gas-fired water heaters. https://casetext.com/regulation/utah-administrative-code/environmental-quality/title-r307-air-quality/rule-r307-230-nox-emission-limits-for-natural-gas-fired-water-heaters

49 See, for example: South Coast Air Quality Management District. (n.d.). *Rule 1121 — Control of nitrogen oxides from residential-type, natural gas-fired water heaters.* https://www.aqmd.gov/home/rules-compliance/rules/support-documents/rule-1121

50 Bay Area Air Quality Management District. (2022, January 21). *Rules 9-4 and 9-6 building appliances.* https://www.baaqmd.gov/rules-and-compliance/rule-development/building-appliances. See also: Balaraman, K. (2023, March 20). *Bay Area regulators opt to phase out NOx emissions from furnaces, water heaters, prepare for grid impacts*. Utility Dive. https://www.utilitydive.com/news/bay-area-regulators-opt-to-phase-out-nox-emissions-from-furnaces-water-hea/645387/

51 Regulatory Assistance Project. (2023, February 7). *Model rule: NOx standards for water heaters*. https://www.raponline.org/knowledge-center/model-rule-nox-standards-for-water-heaters/

However efficient the new heating equipment standards might be, it will still take a long time for all the water heaters and furnaces to turn over in Maryland, 20 years or longer. Nevertheless, heating equipment standards and the clean heat standard could be combined in a policy package that could improve delivery of both policies. Equipment standards provide a clear market signal to the supply chain and installers that the market will be transformed over time. Delivering a portion of the clean heat obligation through equipment mandates will lower the cost of clean heat credits, while providing some financial support for replacements. The clean heat standard also provides an opportunity for installers to help customers plan and replace aging equipment before it fails and to earn credits for doing so.[52]

The addition of zero-emissions equipment standards provides the Maryland Department of the Environment with an additional tool to lower building greenhouse gas emissions and achieve other pollutant emissions reductions that can be credited to state implementation plans for ozone, fine particles and regional haze. The implementation timeline would overlap with that of the clean heat standard as existing fossil equipment is replaced with zero-emissions versions in the next 20 years (i.e., water heaters and furnaces). If appliance emissions standards were promulgated quickly, those emissions reductions would begin sooner, and they could deliver a clear message that these technologies will be the new norm.

Lowering emissions of pollutants other than greenhouse gases through equipment replacements can lead to measurably cleaner air, support equity and assist with climate mitigation, as the recent regulations of the Bay Area Air Quality Management District have shown.[53] The Bay Area zero-emissions appliance rule approved in March 2023 was founded on the public health improvements that will result from reducing NOx and fine particles (direct fine particles and secondary particles formed by NOx). The Bay Area district completed health modeling demonstrating expected improvements in air quality, particularly in environmental justice areas.[54]

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52 In *California Restaurant Association v. Berkeley,* the Ninth Circuit Court of Appeals ruled that an outright ban on gas appliances in new construction was preempted by the federal Energy Policy and Conservation Act (EPCA). This decision may be reconsidered by the court in an *en banc* proceeding. Because the clean heat standard does not attempt to set standards for individual appliances and allows obligated parties multiple pathways to compliance, we judge that it does not conflict with EPCA. Similarly, we conclude that a heating equipment standard is not preempted by EPCA if it focuses on the criteria pollutant air emissions of the equipment, as permitted under the Clean Air Act and many state implementation plans.

53 Colorado also offers support for this approach, having adopted legislation to require NOx regulation of gas water heaters and some furnaces starting with the levels currently regulated in other states such as California. The Colorado equipment standards become enforceable on January 1, 2026. See: Environmental Standards for Appliances, H.B. 23-1161, 74th Gen. Assemb., Reg. Sess. (Colo. 2023). https://www.leg.colorado.gov/bills/hb23-1161

54 Bay Area Air Quality Management District, 2022. For a summary of the Bay Area rule, see Martien, P., & Elwell, J. (2023, March 15). *Proposed amendments to Rules 9-4 and 9-6* [Presentation]. https://www.baaqmd.gov/~/media/files/board-of-directors/2023/bod_presentation_031523_v2_final_op-pdf.pdf?la=en&rev=31d959e50a20499eb034ee7e8d1f3997. The modeling on public health impacts is on slides 11-20.

Energy Efficiency Programs and Incentives

The building transition pathways modeled by E3 assume high levels of building efficiency to reduce increases in peak electricity demand.[55]

Maryland has delivered successful energy efficiency programs for many years as demonstrated by its ranking of No. 7 in the 2022 state scorecard from the American Council for an Energy-Efficient Economy.[56] The utilities'[57] programs are overseen by the Maryland Public Service Commission with input from the Maryland Energy Administration (MEA) and the Office of People's Counsel. MEA says of the programs that the goal is to "promote affordable, reliable and cleaner energy that benefits all Marylanders. MEA's programs and policies help lower energy bills, support business energy upgrades and a cleaner environment while promoting energy independence for Maryland."[58] MEA's responsibilities extend beyond energy efficiency to advising the governor and Legislature on how energy affects all aspects of Maryland's economy. The Office of People's Counsel advocates for residential utility customers by supporting utility service that is "reliable, safe, reasonably priced, and supportive of the State's environmental and climate goals."[59]

Maryland has important energy efficiency programs that benefit low-income consumers under the Department of Housing and Community Development. EmPOWER Maryland began in 2008[60] and was established by the Legislature in recognition that "energy efficiency is among the least expensive ways to meet the growing electricity demands of the State."[61] Legislation in 2023 (H.B. 169) affirmed the state's interest in ensuring low-income households are served with efficiency programs.

EmPOWER has a successful history within Maryland with good name recognition and is an accepted brand among consumers. In 2023, EmPOWER is planning a transition in its programs to focus more on electrification and greenhouse gas reductions, in part based on MCCC recommendations. In 2020, the Public Service Commission issued an order that established the Future Programming Working Group to evaluate future potential paths of the EmPOWER programs. The working group concluded that there was consensus support for moving away from energy savings goals toward greenhouse gas abatement goals.[62] The 2022 MCCC annual report[63] also recommended that EmPOWER consider changes to

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[55] Clark et al., 2021.

[56] American Council for an Energy-Efficient Economy. (2022, December). *Maryland*: *State and local policy database.* https://database.aceee.org/state/maryland

[57] Baltimore Gas and Electric Company, Potomac Edison Company, Delmarva Power & Light, Potomac Electric Power Company, Southern Maryland Electric Cooperative, Inc. and Washington Gas Light Company.

[58] Maryland Energy Administration. (2022, March). *Incentive and technical assistance programs at a glance*. https://energy.maryland.gov/Reports/_Updated%20MEA%20General%20Grants%20Flyer%203.7%20(1).pdf

[59] Maryland Office of People's Counsel. (n.d.) *What we do*. https://opc.maryland.gov/Our-Office/What-We-Do

[60] Md. Code Ann., Public Utilities §7-211.

[61] Maryland Energy Administration. (n.d.). *EmPOWER Maryland*. https://energy.maryland.gov/pages/facts/empower.aspx

[62] Maryland Public Service Commission. (2022). *Recommendations on the future of EmPOWER Maryland*. https://www.psc.state.md.us/wp-content/uploads/EmPOWER-Recommendations-to-General-Assembly_Final.pdf

[63] Maryland Commission on Climate Change, 2022.

ensure that the program equitably serves all Maryland residents and include goals to that end. The next three-year efficiency plans from the utilities are due by the end of 2023. These revisions are well timed to assist with meeting Maryland's ambitious climate goals.

Thermal energy efficiency programs are essential to delivering equitable and effective heating solutions in Maryland and can complement other efforts like the new building performance standards and reporting. Weatherization, expanded heat pump deployment and clean heat can work together to cut fossil heat pollution, but it will still be challenging to reach the net-zero greenhouse gas goal for buildings by 2040 as specified in the 2022 CSNA legislation.

As a practical matter, efficiency programs do not eliminate the need for a clean heat program. Weatherization experts agree that thermal retrofits — even so-called deep retrofits — can be counted on to reduce the heating needs of Maryland buildings often in the range of 20% to 30%. Most of the heat requirements in most buildings will still need to be met through thermal inputs of some kind. To meet climate goals, those inputs will need to come from low- and zero-emissions sources — those that would be promoted by a clean heat standard.

A clean heat standard can also create and support a proactive approach to challenges that may come with changing heating systems. To accommodate some electric heat pumps, internal house systems (pipes or ducts) to which they would be connected[64] may need to be changed. Some homes may also require modifications to existing electrical systems for heat pumps, which can create timing challenges in the context of emergency replacements. Designing programs to avoid the small crises that occur when units fail can be accomplished by enlisting the expertise of furnace technicians to warn customers that their unit will soon be at the end of its life and to offer advice on how to install a clean heat alternative proactively, rather than waiting until the unit fails. Programs that offer loans of equipment like water heaters are being designed — for example, by VEIC[65] — so that consumers have time to consider options before replacing a failed water heater. This forward-looking approach is best coupled with incentives to encourage changing out equipment before end of life and emergency situations.

Addressing the Gap: The Clean Heat Standard

A clean heat standard is by no means the only policy option available to reduce fossil heat consumption and greenhouse gas emissions. In the preceding section, we have considered several other options, including carbon pricing, thermal energy efficiency programs, building codes and heating equipment standards. All of these approaches have some merit, and any or all of them could be adopted to work in tandem with a clean heat standard. To the degree that any of these parallel strategies lowers demand for fossil heat, or lowers the cost of delivering clean heat solutions, they only make it easier to deliver

64 Most furnaces and gas boilers are connected to networks of pipes or ducts that last much longer and are more complicated and more expensive to reengineer when a heating system is changed. Depending on existing heating system designs and which new clean heat technology is being considered, such changes may or may not be needed.

65 Chris Badger, VEIC, Hot Water Forum of the American Council for an Energy-Efficient Economy, personal communication, March 2023.

cleaner fuels and heating conversions, speeding up the transition to clean heat in Maryland.

However, we conclude that none of these other options is likely to succeed on its own, and none would be as singularly effective as a clean heat standard in delivering tangible progress. There are several reasons for this, easily summarized.

We begin with **carbon pricing**. While many analysts have suggested that putting a price on carbon could be the driver for clean heat, there is strong evidence that pricing carbon, by itself, would not drive down fossil heat emissions meaningfully unless it were set at unrealistically high rates. Maryland's demand for these fuels has not been appreciably affected by changes in fuel prices in recent years.

As noted in the previous section, **thermal efficiency programs** are critical to meeting Maryland's energy needs at least cost, but, in the absence of complementary policies to dramatically reduce fossil-fuel usage, efficiency will not produce the kinds of emissions reductions that the CSNA calls for. EmPOWER and other programs have generated large savings, and expanding them would enable even more benefits. Even in a decarbonized heating sector, building efficiency will be a low-cost resource — and an important contributor to improved public health.

However, as a practical matter, thermal efficiency does not eliminate the need for thermal inputs of some kind to meet the large majority of heating requirements in most buildings. To meet the state's climate goals, those inputs will need to come from low- and zero-emissions sources — that is, those that would be promoted by a clean heat standard.

The same is true of **building codes**. There are important reasons to improve building codes in Maryland so that new buildings are much more efficient, healthier and less polluting than the current stock. But building codes cannot come close to addressing the climate challenge posed by existing buildings. Replacement rates and new additions are far too low.

Nor is it likely that **heating equipment standards** by themselves will drive the transition to nonfossil systems quickly enough to achieve the thermal sector's share of emissions reductions in the time frame envisioned by the CSNA. In contrast to the building stock, heating equipment in buildings tends to have shorter lifespans, but the turnover rate is still too slow to deliver the pace of reductions required. As noted above, most heating equipment, including water heaters, is replaced on an emergency basis when it fails. As a result, owners rarely have the time or inclination to switch to an entirely new system, even one that would be less polluting and less expensive in the long run. A clean heat standard would create and support a proactive approach to enlist a variety of market actors — from fuel suppliers to heating, ventilation and air-conditioning (HVAC) contractors and programs like EmPOWER — to work with customers before units fail and to offer advice and financial assistance to install a clean heat alternative.

How the Clean Heat Standard Links With Complementary Programs

As the previous section makes clear, a clean heat standard is not a replacement for the host of complementary policies that are driving emissions and cost reductions in Maryland's use of energy. Rather, it can be an overarching strategy that will work with and tie together those policies. Most importantly, it will accelerate achievement of the emissions reduction goals in the CSNA, which the current policies will fall short of reaching. The collective impact of the broad suite of programs can ensure an adequate rate of progress over time, while simultaneously advancing other policy goals.

The way a clean heat standard interacts with the array of complementary policies depends on which of two approaches policymakers adopt in the design of the standard. We explore that fundamental design decision and others in the next section, but here we will consider the implications of the two options in the context of other programs.

The umbrella approach. Under this design, any program-qualified action that reduces greenhouse gas emissions in the thermal sector would earn credits, whether or not the action was uniquely "caused" by the clean heat standard or by an obligated party. Under this umbrella approach, regulators would just ask, "Is it a qualified clean heat measure?" and "How much will it reduce greenhouse gas emissions?" This way of constructing the program has financial implications, in most cases deliberately. Credits generated by upgrading buildings can be sold to obligated parties, thus defraying the cost to the builder or developer.

Direct attribution approach. This approach gives credits to clean heat measures only if they are solely the result of the clean heat standard obligation and not caused by other public policies or even private individual choice. Regulators would add up the quantity and pace of greenhouse gas reductions that are estimated to come from all of the state's thermal policies, including building codes, equipment standards, carbon pricing and weatherization and efficiency programs. They would subtract those expected gains from the total greenhouse gas reductions needed, yielding a remaining requirement for the obligated parties to deliver. It is also possible to design a clean heat standard that would subtract only the savings from certain complementary policies (e.g., equipment standards for end-of-life replacements) but not for all.

Although a clean heat standard can be designed either as an umbrella program or a direct attribution program, complementary policies will be essential in either case. Other programs can be modified to coordinate with it, similar to the ways that energy efficiency, buildings programs and renewable energy program have been designed to work together in many states in recent years.

Performance Standards in Other Contexts

The clean heat standard would not be the first time that performance obligations have been placed on energy providers. In Maryland, across the United States and in many other countries, there are decades of experience with clean energy performance standards applied to the electric power sector and, in some cases, to regulated pipeline gas companies and suppliers of liquid fuels. Some of these policies, such as renewable portfolio standards, apply to both fully regulated and less-regulated competitive electricity providers. The clean heat standard is similarly comprehensive in its sector in that it would apply a performance standard to energy providers across regulated and non-utility energy companies in the same program.

At least four types of programs set up across the country provide potential lessons for the design of a clean heat standard:

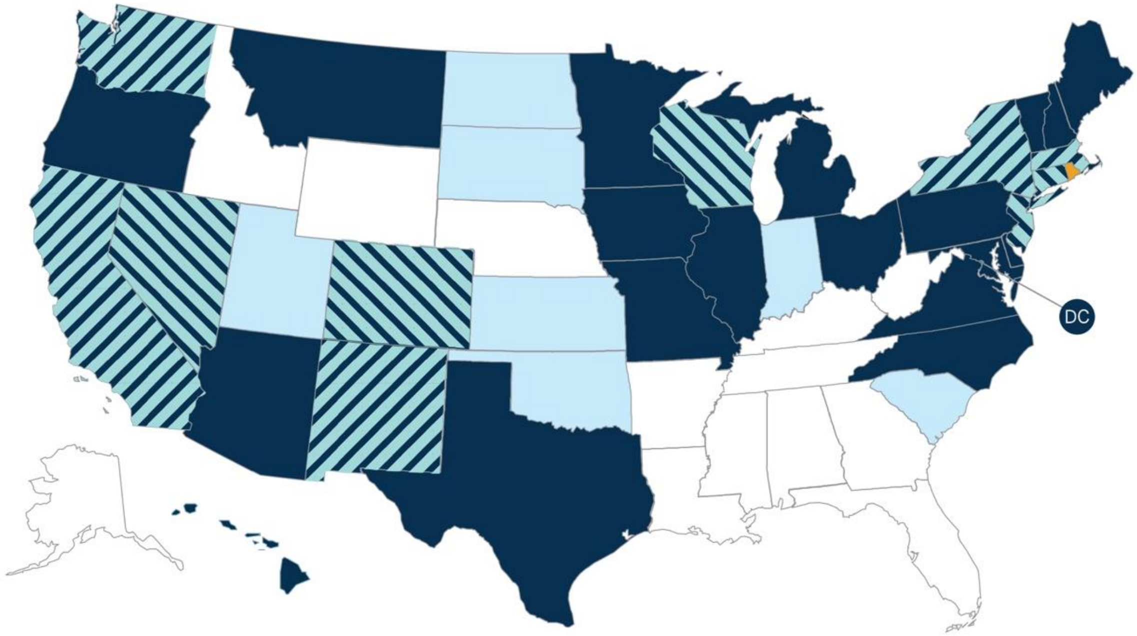
- Renewable portfolio standards.
- Low-carbon fuel standards.
- Energy efficiency obligations.
- Other states' clean heat policies.

Renewable Portfolio Standards

The most widely known examples of clean energy performance standards are the electric renewable portfolio standards in many jurisdictions, which mandate continuing increases in the shares of renewable energy generation in the portfolios of electric power that utilities provide to end-use customers. More than two dozen U.S. states have electric portfolio standards in place. Several states have clean energy standards that include a broader range of eligible generator types (e.g., large hydro is excluded from Massachusetts' RPS but included in its clean energy standard). Figure 6 on the next page shows a snapshot of this evolving policy landscape.[66]

[66] Based on North Carolina Clean Energy Technology Center. (2020, September). *Renewable & clean energy standards* [Figure]. Database of State Incentives for Renewables & Efficiency. http://www.dsireusa.org/resources/detailed-summary-maps/. Updated maps are available from the same source.

Figure 6. State renewable portfolio and clean energy standards (September 2020)



Renewable portfolio standard plus (amounts in parentheses):

- Renewable portfolio standard
- Renewable portfolio goal
- Clean energy standard
- Clean energy goal
- Renewable portfolio goal and clean energy goal (Rhode Island)

Arizona: 15% by 2025*
California: 60% by 2030 *(100% by 2045)*
Colorado: 30% by 2020 (IOUs)*† *(100% by 2050)*
Connecticut: 40% by 2030 *(100% by 2040)*
Delaware: 25% by 2026*
Hawaii: 100% by 2045
Illinois: 25% by 2026
Indiana: 10% by 2025†
Iowa: 105 MW
Kansas: 20% by 2020
Maine: 100% by 2050
Maryland: 50% by 2030
Massachusetts: 35% by 2030 and 1% each year thereafter (new resources); 6.7% by 2020 (existing resources) *(80% by 2050)*
Michigan: 15% by 2021*†
Minnesota: 26.5% by 2025 (IOUs) 31.5% by 2020 (Xcel)
Missouri: 15% by 2021
Montana: 15% by 2015
Nevada: 50% by 2030 *(100% by 2050)*
New Hampshire: 25.2% by 2025
New Jersey: 50% by 2030 *(100% by 2050)*
New Mexico: 80% by 2040 (IOUs) *(100% by 2045 [IOUs])*
New York: 70% by 2030 *(100% by 2040)*
North Carolina: 12.5% by 2021 (IOUs)
North Dakota: 10% by 2015
Ohio: 8.5% by 2026
Oklahoma: 15% by 2015
Oregon: 50% by 2040* (large utilities)
Pennsylvania: 18% by 2021†
Rhode Island: 38.5% by 2035 *(100% by 2030 goal)*
South Carolina: 2% by 2021
South Dakota: 10% by 2015
Texas: 5,880 MW by 2015*
Utah: 20% by 2025*†
Vermont: 75% by 2032
Virginia: 100% by 2045/2050
Washington: 15% by 2020* *(100% by 2045)*
Washington, D.C.: 100% by 2032
Wisconsin: 10% by 2015 *(100% by 2050)*

U.S. territories

- Puerto Rico: 100% by 2050
- Guam: 25% by 2035
- U.S. Virgin Islands: 30% by 2025
- Northern Mariana Islands: 20% by 2016

IOUs = investor-owned utilities

* Extra credit for solar or customer-sited renewables
† Includes nonrenewable alternative resources

Source: Based on North Carolina Clean Energy Technology Center. (2020, September). *Renewable & Clean Energy Standards*

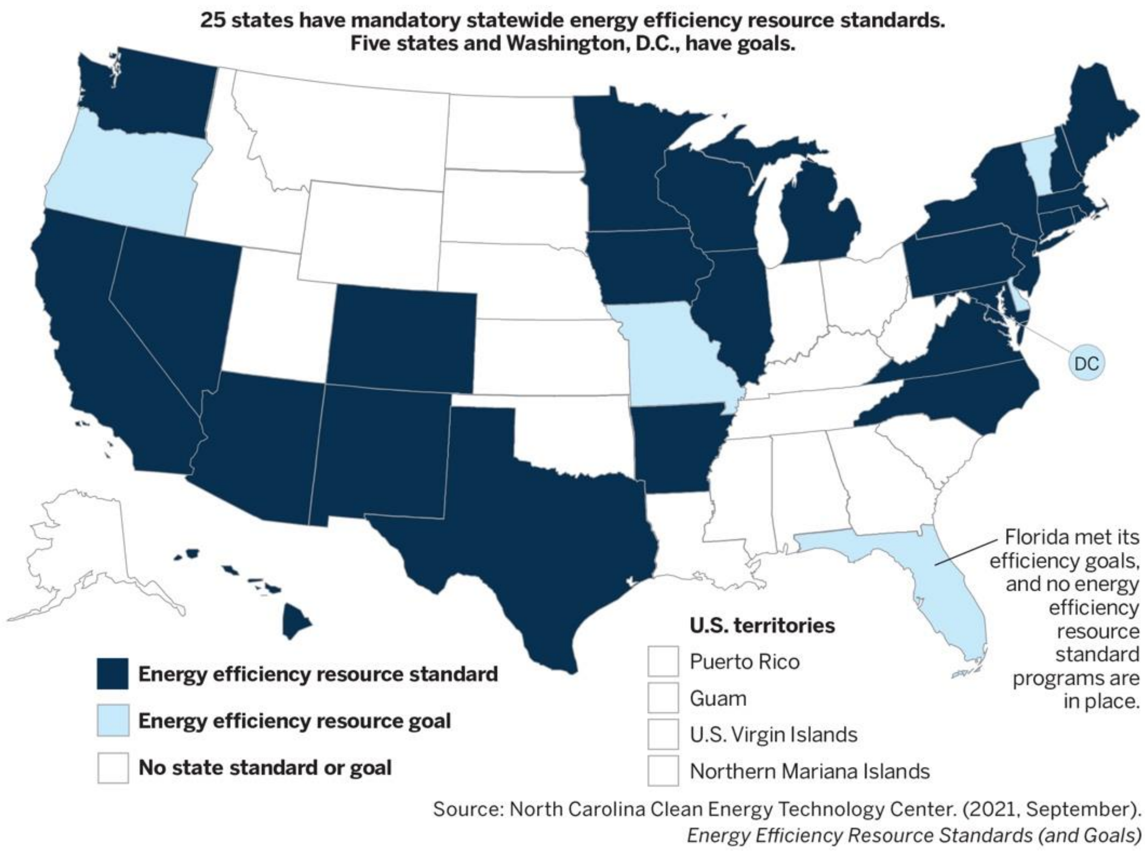
Low-Carbon Fuel Standards

The low-carbon fuel standards in California, Oregon, Washington and British Columbia are designed to decrease the carbon intensity of transportation fuels on a life-cycle basis, as measured by metric tons of greenhouse gas emissions. Although the transportation and thermal sectors are quite different, the California program has two elements that can be useful in the design of a clean heat standard. First, the low-carbon fuel standard includes electricity as a creditable resource in meeting the standard. Second, the program uses life-cycle emissions across all eligible fuel types, which offer good analytical examples that can be drawn on, or improved, for a clean heat standard in Maryland.[67]

Energy Efficiency Obligations

At least 31 states have an energy efficiency resource standard or similar obligations in place, requiring regulated utilities or retail electricity suppliers to deliver energy efficiency savings to and with their end-use customers (see Figure 7[68]). These too rely on performance standards to reduce consumption, total energy costs and emissions.

Figure 7. State energy efficiency resource standards and goals (September 2021)



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67 For specifics on widely used emissions modeling systems, see the section on Life-Cycle Accounting for Clean Heat Measures on Page 52.

68 North Carolina Clean Energy Technology Center. (2021, September). *Energy efficiency resource standards (and goals)* [Figure]. Database of State Incentives for Renewables & Efficiency. http://www.dsireusa.org/resources/detailed-summary-maps/

Important lessons can be taken from the experience gained by Maryland and other states in the delivery of end-use energy efficiency measures. First, although it is challenging to overcome the consumer barriers to efficiency, good program design can succeed in enrolling customers in changing the technologies they use in their homes and businesses. Second, there has been a great deal of experience in measuring and verifying consumption savings from long-lived measures. As this paper discusses later, these two topics are quite important in the design of a clean heat standard, which relies in large measure on enrolling customers to change their heating systems and on measuring and crediting greenhouse gas savings from those systems over multiyear periods.

Other States' Experience With Clean Heat Policies

Experience in two states, Colorado and Vermont, can provide some guidance for Maryland. In 2021, Colorado adopted legislation requiring its largest pipeline gas utilities to create clean heat plans that would reduce emissions by 22% by 2030.[69] Gas distribution utilities can choose from a range of "clean heat resources" to meet the emissions reduction requirements, including electrification, efficiency, green hydrogen and a limited fraction of recovered methane and methane leakage reductions.

In December 2021, the Vermont Climate Council recommended adopting a broader clean heat standard for both pipeline and delivered fuels.[70] The Vermont General Assembly adopted detailed legislation to implement that recommendation, but the governor vetoed it at the end of the 2022 legislative session.[71] The legislation became law in 2023, modified in several respects to address concerns raised by the administration and various stakeholders.[72] The overall structure of what is now called the Affordable Heat Act remains intact; guardrails on cost impacts and opportunities for further legislative review are the primary focus of the revisions.

Decision-makers and stakeholders in Maryland will be able to learn from the legislative and regulatory processes in those states as they develop a clean heat standard for the state.

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[69] Clean Heat Targets — Legislative Declaration, S.B. 21-264, Rev. Stat. 40-3.2-108, Gen. Assemb., Reg. Sess. (Colo. 2021) (enacted). See also: Henchen, M., & Overturf, E. (2021, August 11). *Policy win: Colorado's innovative Clean Heat Standard will force gas utilities to clean up their act.* Canary Media. https://www.canarymedia.com/articles/policy-regulation/policy-win-colorados-innovative-clean-heat-standard

[70] Vermont Climate Council. (2021). *Initial Vermont Climate Action Plan*, pp. 97-101. https://climatechange.vermont.gov/sites/climatecouncilsandbox/files/2021-12/Initial%20Climate%20Action%20Plan%20-%20Final%20-%2012-1-21.pdf

[71] An Act Relating to the Clean Heat Standard, H.B. 715, Gen. Assemb. (Vt. 2022). https://legislature.vermont.gov/Documents/2022/Docs/BILLS/H-0715/H-0715%20As%20Passed%20by%20Both%20House%20and%20Senate%20Official.pdf

[72] Affordable Heat Act, Act 18, 30 V.S.A. §§ 8121-8131, Gen. Assemb. (Vt. 2023) (enacted). https://legislature.vermont.gov/Documents/2024/Docs/ACTS/ACT018/ACT018%20As%20Enacted.pdf

Architecture of a Clean Heat Standard

The essential characteristics of a clean heat standard are these: (1) It's a performance obligation, (2) requiring delivery of qualified clean heat fuels and measures, (3) on a schedule that aligns with the state's greenhouse gas reduction and social equity goals.

Within those essential criteria there are many ways to design and implement a clean heat standard. The discussion below takes up the major architectural elements of any clean heat standard, along with some of the options open to decision-makers. While in some cases RAP's preferences and recommendations are set out, we emphasize that different arrangements are feasible. Moreover, structural decisions within the clean heat standard may well change, depending on decisions in Maryland on the structure of companion policies such as carbon pricing and energy efficiency programs.

This section explores design decisions for a clean heat standard:

- The nature of the obligation.
- Obligated parties.
- Linking with other thermal programs.
- Annual obligation and compliance periods.
- What actions or fuels earn clean heat credits.
- How to ensure equity.
- Creation, ownership and transfer of credits.
- Managing credits from long-lived measures.
- Credit trading and compliance options.
- Establishing default delivery agents.
- Program administration and evaluation.

Decision Point: The Nature of the Obligation

Recommendation: Focus the clean heat obligation and the crediting system on measures that deliver tons of greenhouse gas emissions reductions — in terms of carbon dioxide equivalents — to ensure that reductions are prioritized and quantified.

The main advantage and key attribute of the clean heat standard is that it focuses on the delivery of concrete, delivered clean solutions to drive down consumption of fossil fuels. A key goal of the standard is to stimulate suppliers of clean heat alternatives to deliver clean heat solutions to their customers. As a credit-based system it must, however, take care to measure the right accomplishments. For example, a clean heat standard that requires installation of X number of heat pumps or weatherization of Y square feet of building space could be based on good estimates of the greenhouse gas results but would be measuring inputs rather than measuring the outputs (greenhouse gas reductions) that really matter. Therefore, we recommend that the crediting systems focus on counting tons of greenhouse gas reductions to ensure that emissions reductions are prioritized and quantified.

Carbon Dioxide Equivalents as the Clean Heat Credit Yardstick

A clean heat standard is an earned-credit system, akin to the RPS for electricity. Such a program would require obligated parties to deliver annually a gradually increasing quantity of heating services through approved clean heat measures. As these measures replace fossil heat services, greenhouse gas emissions will decline in sync with the state's climate mandates. Like other performance standards, the clean heat standard would provide a clear picture of the rate of change required. The program would create a commercial value for each heat pump installed, each customer served with an approved alternative, the square feet of homes weatherized and other complementary measures the state wants to support.

That, in turn, could help gas utilities, efficiency providers, fuel dealers, HVAC contractors and others to transition their businesses to selling such products and services.

In electricity performance standards, performance is normally counted in kWh. Since the principal goal of a clean heat standard to deliver the emissions reductions required by the 2022 CSNA, clean heat credits should be measured in terms of carbon dioxide equivalents (CO_2e), which would give credit for the CO_2 emissions avoided by the addition of a variety of clean heat solutions. Using CO_2e also allows a variety of clean heat options, from weatherization and heat pumps to approved clean fuels, to be compared on a quantitative basis.

Because the clean heat standard would award credits for actions taken in the form of CO_2e avoided, it would be critical to establish standards to quantify the performance of different types of clean heat measures over time. This type of problem has been addressed in other performance-based systems, including energy efficiency program targets and low-carbon fuel standards.[73]

Energy efficiency programs have well-established protocols for quantifying the energy, capacity and environmental benefits of different types of efficiency measures, from light bulbs to weatherization to equipment replacements. So-called deemed savings rates are based on field measurements and are updated over time. A clean heat standard would require a similar manual and a process to create it and update it over time.[74]

Decision Point: Obligated Parties

Recommendation: The obligation to lower greenhouse gas emissions should be applied on a competitively neutral basis across all fossil heating fuels, including gaseous fuels supplied via pipelines and distribution networks and delivered fuels.

A majority of U.S. states have adopted performance standards, including renewable portfolio standards and efficiency obligations, that have the effect of lowering the greenhouse gas emissions of the regulated electric utilities and promoting preferred technologies. A few states have efficiency obligations that apply to pipeline gas utilities, and a few states have renewable fuel-blending requirements that apply to delivered fuels. On the whole, however, performance standards for renewable energy and energy efficiency

[73] A low-carbon fuel standard measures the average greenhouse gas intensity of fuels used, rather than the quantity of emissions from the sector. Because the CSNA mandates are set in terms of total greenhouse gas emissions, the clean heat standard is designed to measure and credit CO_2e in the quantity of tons emitted and avoided. However, both systems can use the same methods for quantifying the life-cycle emissions rates of various fuel pathways, so the existing body of work that has been done to develop life-cycle analyses for the low-carbon fuel standard can serve as a guide for the clean heat standard as well. See the section on Life-Cycle Accounting for Clean Heat Measures on Page 52 for a discussion of widely used models and the variables they consider.

[74] Life-cycle CO_2e analysis would also be required if renewable fuels or biofuels were included in a clean heat standard. There are scientifically determined values assessing the life-cycle emissions of different types of fuel, differentiated by feedstock, location and other variables. Modeling systems already in use by the California Air Resources Board and the EPA could help to assign life-cycle emissions values for any fuels deemed creditable under a clean heat standard in Maryland.

are much better developed and more widely applied to electricity sales than to sales of fossil heating fuels.

The clean heat standard is intended to fill that gap and level the playing field to some degree between the performance burdens on electricity and on fossil fuels. For these reasons, the obligation to lower the greenhouse gas emissions of fossil-fuel heating fuels should be applied on a competitively neutral basis across all fossil heating fuels, including gaseous fuels delivered by pipelines and distribution networks (termed natural gas, fossil gas or pipeline gas) and delivered fuels (fuel oil, propane, kerosene and coal). The standard would apply to all substantial fossil-fuel sales from any of these sources. All of these fuels contribute to the thermal sector's climate pollution, and it makes little sense to excuse any major fuel source while applying a performance standard to its competitors.

While coverage of the standard should be inclusive, the question remains: Who should be the obligated parties to ensure that this responsibility is carried out?

Maryland does not produce fossil fuels. The state depends on imports of petroleum and diesel. In recent years, Maryland residents and businesses have spent $2.8 billion annually to import fuels to heat buildings and hot water, to cook and to run industrial processes.

A variety of enterprises are involved in this large, critical sector. Some, including some very large interstate fuel providers, import fossil fuels into Maryland. Maryland wholesalers and retailers also operate bulk storage facilities for propane or distillate products in the state. At the retail level, Maryland is served by regulated and competitive suppliers of pipeline gas and a variety of retail providers of fuel oil and propane. These entities range in size from very large corporations to local, family-owned fuel dealers.

Within this chain of commerce we can find the following options for designating obligated parties in Maryland:

- Pipeline gas distribution utilities, investor-owned or municipally operated.
- Fuel providers of delivered fuels, with the point of regulation applying at the point of importation, or earlier in the wholesale chain of commerce.
- Fuel providers of all fossil fuels at the retail level.
- Electricity suppliers, either on their own or together with other heating suppliers.

Beyond the fuel supply chain, other categories that may warrant consideration include:

- Large commercial properties above a set threshold of fuel usage (to prevent individual homeowners from an individual obligation).
- Municipalities.
- Landlords with real estate above a set threshold of square footage.
- Other options that could be raised through public input

As the list above reveals, a clean heat standard in Maryland could be applied in many ways. The most straightforward approach is to impose the obligation on the providers of fossil heating fuels, including pipeline gas and delivered fuels. The next most direct option is to include electric utilities as obligated parties, either in proportion to their total sales, or in proportion to the fraction of their sales related to heating services. We address these options in turn in the sections below.

At a very practical level, meeting the 2022 CSNA goals for the thermal sector will require millions of building owners to make major changes to existing heating systems. Maryland's building codes are not likely to include a thermal conversion mandate directly on end users, requiring individuals to replace their existing heating systems,[75] so how can building owners be supported to make those changes? A principal reason to place a clean heat obligation on energy providers is that they have commercial relationships with end-use customers and thus can work with their customers on choices for heating that will reduce emissions. In addition, in the long run, clean heat services will be a business opportunity in Maryland, and the state's economic goals are served by developing expertise in-house and in-state, as we have for energy efficiency and solar power. Placing an obligation on existing heating providers on a competitively neutral basis might well provide a needed boost in that direction.

Obligations on Pipeline Gas Providers

Recommendation: Apply the obligation on the regulated local distribution companies.

With respect to pipeline gas, the obligation should cover all deliveries in Maryland. This can be accomplished by imposing the obligation on all pipeline gas retailers, both regulated and competitive,[76] or on the local distribution pipeline companies that deliver the fuel. Due to more direct regulatory oversight, and for ease of administration, we recommend applying the obligation on the regulated local distribution companies, but either choice could work.[77] The Colorado Clean Heat Standard applies the obligation only to the larger pipeline gas companies, excluding municipal distribution companies and investor-owned pipeline gas companies with fewer than 90,000 customers. Vermont applies the obligation both to the state's regulated gas utility and to the largely unregulated providers of delivered fuels.

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[75] However, as discussed in the section on complementary policies, it would be feasible to combine a clean heat standard with a set of equipment standards for new construction and for replacement of HVAC and water heating equipment in existing buildings. Building codes and equipment standards by themselves would not deliver emissions reductions fast enough to meet the state's greenhouse gas requirements, but they would provide a fraction of the clean heat resources needed, and that fraction would grow over time.

[76] For information on competitive gas suppliers in Maryland see: Maryland Public Service Commission. (n.d.) *The Gas Division*. https://www.psc.state.md.us/gas/

[77] Fossil heating fuels are delivered in a variety of ways, including directly from interstate pipelines to larger industrial users. Municipalities also deliver fossil gas to end users through public systems. As a general matter, RAP recommends including all thermal sales in the clean heat standard, in order to achieve the state's climate goals and to avoid creating bypass incentives. However, decisions on scope involve other statewide public policy choices that decision-makers will need to weigh in the balance.

Obligations on Delivered Fuel Providers

Recommendation: The clean heat standard obligation should apply to the providers of delivered fuel oil, propane and other fossil fuels, at either the retail level or the jurisdictional point of importation. Whether the obligation is on retail or wholesale fuel providers, provide ample opportunity for regional and state-based fuel dealers and energy companies to develop new lines of business.

The discussion below touches on how the standard should be applied to delivered fuels, such as distillate heating oil and propane.

A basic question to address is: Should the clean heat standard obligation for delivered fuels be imposed downstream, on retail delivery companies, or upstream, on wholesale providers?

As noted above, a major reason to assign the clean obligation to retail fossil-fuel companies is their direct relationships with end-use customers. These companies employ technicians and delivery staff members who could be trained to work with customers on heat pump options and other cleaner heating solutions. These companies could develop new business models to succeed under a clean heat mandate.

While the state clearly has jurisdiction to place the obligation at the retail level, upstream wholesalers may have greater financial and management capacity, are less numerous and have the opportunity to acquire and blend renewable fuels into the system, which could quickly deliver at least some carbon savings without requiring actions by end users.[78] Wholesalers could also meet their clean heat obligations by purchasing credits from others or contracting with a range of delivery entities, including fuel dealers, heat pump contractors and statewide delivery organizations. Finally, wholesale providers might wish to use this opportunity to build up a clean heat line of business, akin to the work that many traditional power companies have been doing in transitioning to renewable electricity. An upstream obligation would still give retail fuel dealers the opportunity, but not the direct obligation, to deliver fuel-switching services to their customers. They could be working with the wholesalers to identify customers who are good candidates for upgrades.

If an upstream approach is taken, legal research is required to determine the best way to apply an obligation at the wholesale level. Some wholesale transactions occur outside of the state (e.g., filling a tanker truck at a fuel storage depot in another state). At the wholesale level, the obligation to meet a clean heat standard could be attached to the wholesale seller at the time a tanker truck is filled for sale, even if that happens out of state, if the fuel is destined for sale in Maryland as per a bill of lading.[79] Alternatively, the obligation could be attached to the owner of the fuel at the point and time that the fuel enters the state. This is the approach taken in the 2023 Vermont legislation, which has the

[78] Fossil-fuel wholesalers include in-state and out-of-state entities and out-of-state entities with in-state facilities and operations. Intermediate shipment points are also commonly used, as in the numerous bulk storage tanks that store fuel for later loading onto local delivery trucks. Classifications can be misleading, since some importers are also retailers and some retailers are large corporations, while some importers are small family-owned operators. The policy goals are to ensure a level playing field for all fossil sales and to avoid undue administrative burdens on smaller operators.

[79] A variety of legal options have been developed to ensure regulatory coverage of interstate fossil-fuel sales. If obligations are placed on multistate wholesale operators, Maryland would need to evaluate how those methods could be applied to a clean heat standard and how reliable the reporting and compliance pathways would be.

effect of placing some of the obligation on wholesalers and some on importer-retailers. If the obligation is not imposed at the retail level, we recommend that it be imposed on the first jurisdictional provider of fossil heating fuels destined for consumption in Maryland.

Since either an upstream or retailer obligation could work, the choice might come down to the practical preferences of the state and stakeholders including energy service providers. Whichever way the clean heat standard is designed, it should provide ample opportunity for both regional and state-based fuel dealers and energy companies to develop new lines of business and to thrive in a low-carbon energy environment.

Obligations on Electricity Providers

Recommendation: If applying the clean heat standard to electricity utilities, they should not be alone among energy providers in facing an annual obligation, particularly at the start of the program.

Maryland is among a handful of states that have gotten a start on thermal efficiency and cleaner heat by extending electric utility energy efficiency or renewable energy programs to at least some fossil-fuel uses.

Massachusetts, which is considering a clean heat standard, and Vermont also have policies directing electric utilities to devote some resources toward reducing emissions in the thermal sector. Massachusetts has adopted an alternative energy portfolio standard (APS), under which electric load-serving entities are obliged to purchase alternative energy credits equal to a certain percentage of their retail sales in a given year. That percentage requirement, 5.5% in 2022, has been rising at the rate of 0.25 percentage point each year. Initially, the program was designed to promote combined heat and power (CHP) installations, and over the years the largest fraction of the alternative energy credits has come from fossil-gas-fired CHP operations. Much smaller fractions have been delivered by renewable thermal measures, including heat pumps, and by liquid biofuels and fuel cells.

The APS has been revised several times, enlarging the categories of technologies that can earn alternative energy credits. Studies of the APS and stakeholder reviews of its implementation have crystallized a set of conclusions and recommendations that are quite relevant to the design of a clean heat standard. The APS experience shows that a performance standard can permit a range of technologies to compete in lowering emissions. It is also apparent, however, that an effective clean heat standard would need to be much larger than the APS program has been to date. Moreover, because the program's energy-based credits are earned on a MWh basis, the program has tended to reward gas-fired CHP rather than rewarding renewable energy solutions more in line with the greenhouse gas reduction goals of the state's Global Warming Solutions Act.

Vermont has also imposed an obligation on regulated utilities, both gas and electric, to reduce fossil-fuel emissions among their customers. The Vermont program, called Tier III of the Renewable Energy Standard, requires utilities to secure distributed renewable electricity generation or fossil-fuel emissions savings equal to 2% (in 2017) rising to 12% (in 2032) of the utility's retail electricity sales. A number of potential thermal actions are permitted. Most of the savings have come from the installation of heat pumps, but a number of other measures have earned credits, including installation of advanced wood heating systems, weatherization projects, transportation measures and substitution of electric motors and heating technologies for fossil-fuel equipment in commercial and industrial settings.[80] Vermont's experience with Tier III demonstrates that a nonfossil performance standard on electric utilities can support a range of end-use measures, and it has been estimated that Tier III projects at current rates could deliver about 7% of the 40% emissions reduction called for by 2030 in Vermont's Global Warming Solutions Act.[81]

Maryland could impose a thermal obligation on electric utilities or could place the clean heat requirements solely on fossil-fuel suppliers, or on both fossil-fuel and electricity providers. The merits of these choices are sketched out below.

A leading factor in this choice is that electric utilities and electric rates are already bearing most of the cost of addressing climate change in energy in Maryland and the region. Electric rates have supported renewables additions, grid upgrades and electric efficiency programs. Carbon costs are also reflected to some degree in power costs through the Regional Greenhouse Gas Initiative. Yet, clean and affordable electricity will be needed to help transform the other sectors of the economy, including heating. In contrast, pipeline gas utilities and their rates bear fewer costs for energy efficiency; face no renewable fuels mandates; and have no regional carbon emissions reduction requirements. Delivered fuel companies and their customers have even lower climate obligations.

As a result, progress has been very slow in the thermal sector, and we have created a situation in which the cleanest energy source (electricity) is paying extra costs to address climate change, while the higher-emitting fossil fuels are paying much less. The resulting relative prices are sending the wrong signals to consumers and making it that much harder to clean up our energy mix. Putting a clean heat obligation on the fossil-fuel suppliers is appropriate on the merits, and it also helps to rebalance the scales so that a greater share of the emissions reduction costs is reflected on consumers' fossil heating fuel bills instead of their electric bills.[82]

If we assume that Maryland does not plan to impose a clean heat obligation directly on most end-use consumers,[83] almost all consumers will need to make heating choices on an individual basis. Consumers naturally compare the total cost of heating with one system against the total cost with another system when they are renovating a building or replacing a failed furnace or boiler. Incentive awards can make a big difference at that time, but comparative fuel costs matter as well. So even if "all customers will pay" one way or another, it matters how they pay.

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[80] Vermont Public Service Department. (2020). *RES Tier III verification report — 2019*. https://publicservice.vermont.gov/sites/dps/files/documents/2019_Tier_III_Report_20-0644-INV.pdf

[81] Cowart, R., & Neme, C. (2021). *The clean heat standard*, p. 34. Energy Action Network. https://www.raponline.org/knowledge-center/the-clean-heat-standard/

[82] There is certainly logic to the argument that the cost of decarbonizing the electric system should be borne in the electricity sector, and the cost of decarbonizing fossil heat should be borne in the thermal sector. In line with this thinking, the MCCC has recommended that a clean heat standard be designed to replace the existing program for thermal renewable energy credits. The Vermont legislation, in contrast, seeks to retain the savings being delivered by the existing electricity-supported thermal obligation, but allows those savings to earn some compensation from the obligated fossil-fuel providers.

[83] The state made a similar choice with its recently enacted building energy performance standard. That legislation applies only to buildings 35,000 square feet or larger, of which there are about 9,000 in Maryland. By comparison there are about 2.5 million housing units.

A diversity of solutions to reduce emissions from the heating sector will also be important, especially during the transition period. We can expect that fuel suppliers, electricity suppliers and a pipeline gas utility will each take different approaches to the solutions offered to customers and how they will be marketed. Electric utilities, for example, are likely to focus on delivering heat pumps. However, particularly in the short run, Maryland may need more than heat pumps to meet its climate and equity goals. Fossil-fuel providers have proposed a number of options to deliver cleaner heat solutions, and some of them might be needed to deliver near-term reductions, particularly in a transition period.

In the longer run, a broad conversion away from pipeline gas will require either phased decommissioning of parts of the gas grid or planned provision of hybrid electric-gas heating or both. If gas utilities are involved in delivering the solution, they can help to deliver heating system changes to customers in geographically targeted areas, so as to avoid customer confusion, lower future stranded costs and minimize the total cost of the system conversion.[84] In addition, particularly in rural areas served by delivered fuels, choice is important to consumers due to personal preferences and the nature of the building stock.[85]

Finally, if the clean heat obligation is placed on fossil-fuel providers in proportion to their annual sales of fossil fuels, it creates a continuous incentive for those providers to reduce their fossil sales every year. When each year's clean heat obligations are keyed to current or recent fossil sales, actions that reduce fossil sales will both (1) earn clean heat credits in the present year and (2) reduce the size of the obligation in future years. This creates an incentive for continuous decarbonization by obligated fossil-fuel providers.

To deliver the depth and pace of change required, it is at least useful and probably necessary to engage the existing fossil industry in its own transition to a clean thermal sector. For these reasons, we do not recommend placing the obligation entirely on electricity providers, particularly at the start of the program.

Phased Approach

Recommendation: Analyze efficiency and equity impacts to help decide whether the clean heat obligation should shift across different heating providers over time.

As the discussion above makes clear, there are several reasons to impose a clean heat standard obligation on fossil-fuel providers and some potential to impose the obligation on electricity providers. A third option is to adopt a phased approach, including electricity suppliers as obligated parties in the standard over the longer term when Maryland expects to have largely reduced the use of fossil fuels for heating. Reasons for taking this phased approach include:

- Over time, as electrification proceeds in powering heating and transportation needs, electricity suppliers' financial strength is likely to increase along with their capacity to

[84] Where parts of the gas grid are to be decommissioned, it will be essential to offer heat pumps, district heating services or other options to those customers on a geographically targeted basis. Gas utilities will have to be involved in this new type of planning process.

[85] For example, some rural buildings may be ready for conversion to heat pumps almost immediately, but many will require efficiency renovations first. Some customers may be ready and willing and financially able to do those renovations; others will want or need to wait.

purchase compliance credits and hedge risks associated with weather and fuel price variability.

- Maryland transition pathways analysis and the text of recent climate legislation identify electrification as a necessary component of decarbonization, and electric utilities are likely to be more supportive of electrification than other potential compliance entities.
- Electricity customers include virtually all residences and businesses in Maryland. Placing the obligations on electricity providers would spread the costs of the transition more broadly, particularly in the later years when gas companies and delivered fuel suppliers have seen their customer bases shrink.

Considering these factors, it would be useful to study how the mix of obligated parties might evolve over time. If assigning clean heat obligations to both fossil-fuel providers and electric utilities, the assignments could be in proportion to their total thermal sales, the relative costs incurred to reduce greenhouse gas emissions, their customer bases or some other ratio to meet public policy goals.[86] If the obligation were only on fossil providers, the obligation would be placed on a declining number of users, whereas if the latter, all heat customers would be paying for the transition.[87]

Shifting the burden to electricity customers would avoid some of the rate impacts on a declining base of fossil heat customers but would shift the program away from one based on the "polluter pays" principle. Carbon cap-and-trade systems are based on the expectation that as the cap declines, prices will increase for fossil fuels. Electric utilities participating in RGGI will be exposed to those higher allowance prices, so it's a fair question whether fossil heat providers should be shielded from increased compliance costs under a clean heat standard. On the other hand, the equity impacts of leaving the entire burden on fossil providers will be a critical issue. Decision-makers should examine whether the Maryland clean heat obligation should be designed to shift the compliance obligation across different heating providers over time. This design question will require additional analysis and a careful review of both efficiency and equity impacts of the options.

Decision Point: Linking With Other Thermal Programs

Recommendation: Use an umbrella approach that counts all qualifying efforts to reduce fossil-fuel use. Emissions standards for fossil heating equipment are highly compatible with a clean heat standard.

Policymakers need to make an overarching decision about how to set the annual obligation for the clean heat standard. As a general matter, the standard can be designed either as an umbrella policy that takes into account all qualified clean heat fuels and measures delivered in the jurisdiction, or as an additional policy that requires the obligated parties

[86] Another option would be to place certain costs on electricity and other costs on fossil-fuel providers. For example, the cost of building retrofits and weatherization as part of a clean heat standard could be placed on electricity providers, since these measures will lower the cost of meeting total power system demand peaks in the future.

[87] Putting the obligation on providers with a shrinking quantity of fossil-fuel sales is difficult but achievable. If the annual obligation is proportional to an obligated party's fossil-fuel sales, as those sales go down, so does the obligation in quantitative terms.

only to deliver enough clean heat resources to meet an anticipated clean heat gap but requires each obligated party to demonstrate that its claimed actions are *additional* to those that would have been delivered in the market or by complementary programs. Maryland could opt for either policy design. We discuss each of the two options in turn.

Regardless of which option Maryland chooses, promulgating emissions standards for equipment (e.g., furnaces and water heaters) provides important opportunities to increase the rate of reduction in greenhouse gas and other pollutant emissions, encourages market transformation for the equipment regulated and improves energy efficiency efforts, which can enhance equity. Although the turnover time for equipment may be long, the combined benefits of having equipment standards as well as a clean heat standard are worth the effort.

Option 1: Umbrella policy. Any qualified measure earns credits, and obligated parties can look to a wide market to purchase credits to satisfy the total thermal mandate.

One of the most attractive features of the clean heat standard is that it can recognize credits for the delivery of clean heat solutions without needing to consider which program or entity (or combination thereof) “caused” the solution to be delivered. The 2022 CSNA requires specific levels of emissions reduction at multiple points between today and 2050. A clean heat standard can be an overarching policy tool for ensuring that those reductions are achieved in the state’s thermal sector. Thus, what matters is whether emissions go down and the correct number of clean heat credits have been generated and retired. In this respect the clean heat standard can be seen as a measuring device to ensure that clean heat measures are delivered in Maryland; the standard need not be the sole driver of those changes.

It is important that programs and actors who deliver clean heat savings can be paid in credits for those actions. However, for the main purpose of the law, it does not matter who generates those credits or why they were generated. If many of the credits would have been generated through complementary programs such as weatherization programs or through natural evolution of the market (e.g., customers buying heat pumps or weatherizing on their own, without any programmatic inducement), that would simply mean that the level of effort required by obligated parties to acquire the right number of credits — and cost they would need to incur to do so — will be lower than if natural market forces would not produce much change on their own.

This is akin to how most electricity renewables mandates work. Electric utilities must show that a certain percentage of their electric portfolio each year comes from wind, solar and other renewable energy sources. It does not matter whether a customer would have put photovoltaic panels on their roof without a utility program or whether a wind turbine would have been built without any utility support. As long as the utility acquires the renewable attributes of such resources, the utility can use them to demonstrate compliance with its renewable portfolio obligation.

One advantage of this approach is that it minimizes disputes over additionality. If a qualified measure is installed, or if a qualified low-carbon fuel is delivered, it can count as a contribution to statewide thermal progress. Independent actors of all kinds, including

HVAC contractors, weatherization programs and efficiency programs, can create clean heat credits and sell them to obligated parties. Of course, obligated parties can take these actions as well. Ideally, the diversity of actors and measures available will encourage efficiency and innovation in program delivery. Obligated parties do not have an obligation to prove that their additional action caused or precipitated a particular measure, so they will have every reason to support complementary programs and innovative marketing by anyone in the market who could generate credits. Clean heat measures would be creditable only if they meet the program standards and are real, verifiable and counted only once toward meeting the state's overall goals for thermal sector emissions.

Option 2: Additional policy. Obligated parties must deliver just enough greenhouse gas savings to reduce the clean heat gap but must demonstrate that their actions are additional to savings from other policy and market actions.

Maryland, like many states, already has a variety of programs and policies that have the effect of reducing emissions in the thermal sector. Additional programs, including revisions to the mandate of EmPOWER and the possible creation of an economywide greenhouse gas cap-and-invest program, could be adopted in coming months. Those programs might or might not be designed to deliver all the thermal sector emissions reductions required by the 2022 CSNA. If a projected gap remains, the state could choose to design the clean heat standard to require the obligated parties to deliver only enough measures to fill that clean heat gap. However, the dimensions of the gap — and thus the collective obligation that could be assigned under the clean heat standard — would depend on the design of the other programs and on policymakers' choices about how much of the clean heat work they wish to assign to obligated parties rather than other policies and actors. To illustrate how this balance between the clean heat standard and complementary policies might be established, we consider the following two situations.

Situation A: Existing or expanded roles for EmPOWER and other programs

Complementary policies might be maintained or enhanced to require delivery of some types of clean heat measures through means other than the standard. Complementary programs include thermal efficiency and heat-switching programs run by EmPOWER, emissions standards for equipment replacements and codes for new construction. If decision-makers wanted to require obligated parties only to add to the impacts of those programs, the agency responsible for the clean heat program would need to estimate the pace of expected deliveries under these efforts, and then set the clean heat standard obligation at the level needed to meet any remaining thermal performance gap. Credits would be given only for measures that were additional to savings delivered by the other policies and programs. A routine true-up every year or two might be needed to make sure estimates and deliveries across all programs line up with overall greenhouse gas goals.

This program design is compatible with the general structure of the clean heat standard as outlined in this paper, simply with a smaller performance rate on obligated parties.

An expanded scale of operations and broader authority for EmPOWER and other programs could also be folded in under the umbrella clean heat standard option described above. The expansion itself does not drive the decision on how to deal with inclusion versus additionality for the standard.

Situation B: In the context of a broader carbon cap

If Maryland were to create an economywide carbon cap-and-invest program, some observers would likely argue that a performance standard such as a clean heat standard would not be needed in the thermal sector. However, as discussed earlier in this paper, imposing a carbon price on thermal fuels is not a very effective tool to drive clean heat solutions unless the price is quite high. On the optimistic side, the fact that heat pumps are increasingly available, more affordable and better performing and can serve both heating and cooling needs should reduce the historically high market barriers to switching heating systems in homes. This means that the price effect of carbon charges can be greater, especially if carbon revenues are recycled to deliver clean heat measures at scale. On the other hand, delivering building renovations will remain a tough challenge and will require customer assistance, marketing, financing options and more, in addition to the signals provided by carbon pricing. This will be especially true with respect to lower-income housing and multifamily housing and in environmental justice communities. Moreover, an economywide cap-and-invest system may not deliver the level of greenhouse gas reduction needed in the thermal sector if it is easier or more cost-effective to capture savings in other sectors.[88]

These factors suggest that there could still be a role for a clean heat standard in the thermal sector even within a greenhouse gas cap-and-invest regime, similar to the situation we have seen for the electricity RPS and energy efficiency programs within the carbon cap system set up in RGGI. There will still be a need for heat service providers to work directly with end-use customers to accelerate the delivery of cleaner heating solutions in over 2 million buildings across Maryland.

A key variable in the case of a carbon cap plus clean heat standard obligation would be how the revenue from allowance sales would be distributed and invested. It would be important to ensure that those funds are spent to leverage investments in clean heat solutions, especially in low- and moderate-income households, in hard-to-serve housing types and in environmental justice communities.

Although a clean heat standard can be an effective complement to existing policies, RAP recommends adopting an umbrella approach. This allows greater flexibility for obligated parties, since there are a greater number of pathways to satisfy the obligation, and it creates the possibility of a payment stream from those selling polluting fuels to those who are reducing their emissions.

[88] For this reason, even in an economywide cap regime, many observers recommend having separate cap-and-trade segments for transportation, electricity, thermal and industrial sectors.

Decision Point: Size of the Annual Obligation and Length of the Compliance Periods

Recommendations: Size the annual obligation to match the pace of decarbonization required to meet CSNA mandates for the thermal sector. Establish three-year compliance periods and annual reporting periods.

The size of the annual obligation to reduce greenhouse gas emissions could be configured in a straight-line format (the same percentage of reductions required per year) or with a ramp up (more aggressive as time goes on, based on the time needed to develop some of the options that will yield a high level of annual greenhouse gas reductions later in the program, such as electrification of large apartment buildings). Deciding which to use will depend on how fast the regulating state agency feels various options can be developed and implemented in consultation with stakeholders, including the obligated parties and those who will need assistance, such as financing for electrification.

As the program progresses, adjustments will be needed since it is likely that credits will be harder to obtain and a percentage reduction more difficult to achieve. On the other hand, as technology improves (e.g., the availability of 120V heat pump water heaters), some options like retrofitting heat pump water heaters into existing homes will be more fruitful in a few years.

A compliance period is the amount of time that an obligated party has to demonstrate that it has fulfilled its obligation to meet the clean heat standard. The length of time for the compliance period is usually chosen to reflect how frequently the agency tracking compliance wants to see progress, balanced with a need for the obligated parties to have sufficient time to develop and implement projects and demonstrate progress toward the goal. Most RPS programs have annual compliance obligations, but energy efficiency programs often permit multiyear averaging.

In many environmental regulatory programs, annual compliance of some sort is required to demonstrate progress even though penalties may not be assigned. For example, monitored data might be submitted annually to demonstrate the emissions released, but some averaging may be allowed over multiple years so no penalties are issued on an annual basis. The RGGI program has a compliance period of three years for surrendering allowances to offset emissions over that time period. It also requires an annual demonstration showing that at least 50% of the allowances required during that year have been surrendered, so that a regulated facility doesn't end up with a large obligation at the end of three years, when penalties may be assessed for noncompliance.

Since the clean heat standard is designed to tackle a long-term cumulative problem, and since customer-facing programs take time to develop and implement, we conclude that three-year compliance periods and annual reporting periods would be appropriate.

Decision Point: What Actions or Fuels Earn Clean Heat Credits

Recommendation: Permit a range of technologies and fuels to compete to earn clean heat credits, based on life-cycle greenhouse gas emissions, but only if they directly reduce combustion of fossil fuels in Maryland homes and businesses.

The clean heat standard is a performance standard, not a technology mandate. One of the central ideas of the program is to enable a variety of pathways to decarbonize heating, instead of overly narrowing choices by having regulators require certain heating solutions rather than others. This is important for at least three reasons:

1. Ultimately, end-use customers need to install their own heating equipment and choose their energy suppliers. Buildings differ, consumer preferences differ, and even the same consumers will choose different heating systems as their budgets and preferences change over time. The case for beneficial electrification is strong, and it's realistic to project that electric heat pumps will play a dominant role in the thermal transition in Maryland, but some other resource options may turn out to be useful in particular applications or for particular end users.
2. A performance standard creates competitive pressure across technologies and fuels, which will lower the total costs of the heating transition and help to drive innovation, both in technology and in service delivery pathways.
3. The fundamental purpose of the clean heat standard is to reduce emissions, not to promote certain technologies for extrinsic reasons. The standard needs to include guardrails to ensure that unsustainable or clearly undesirable choices are not rewarded. But within a range of solutions, the standard allows customers, providers and markets to choose clean heat paths.

We recommend that the clean heat standard should permit a range of technologies and fuels to compete for the ability to earn clean heat credits. The standard could be met in multiple ways, combining different numbers of weatherization jobs, heat pumps, district heating, advanced wood heat systems and/or different blends of renewable pipeline gas, perhaps green hydrogen, and approved biofuels. We do not have a crystal ball to determine at this point what the ideal mix of resources should be or will be.

The one thing we do know — whatever the future clean heat mix turns out to be — is that Maryland will need very substantial increases in clean heat investments and fuels through a variety of means. And climate science tells us that early actions to reduce emissions are particularly valuable. In general, diversity in creditable clean heat measures will promote a quicker and less expensive transition.

In the discussion below we address some of the major policy choices regarding eligible clean heat options for Maryland and, where appropriate, RAP's recommendations regarding them. In summary:

- Award clean heat credits only for measures that directly reduce combustion of fossil fuels in Maryland homes and businesses.

- Biofuels and renewable gases would be eligible for clean heat credits on a limited basis and only if delivered and used in Maryland.
- Clean heat credits need to account for life-cycle greenhouse gas emissions of the fuel(s) used.
- Exclusions: Certain measures — including pure offsets, fossil-fuel fugitive emissions reductions and switching from one fossil fuel to another — should not earn clean heat credits.

The reasoning behind each of these recommendations follows.

Credits Conditioned on Direct Reductions in Fossil-Fuel Combustion in Maryland

Although it would be possible to create a clean heat performance standard that could be satisfied by emissions offsets in any sector, anywhere in the world, such a standard would not satisfy the requirements of Maryland law. Nor would it help us to deliver the physical changes needed in Maryland to transition away from reliance on fossil fuels. The 2022 CSNA clearly articulates a preference for direct reductions in Maryland's gross greenhouse gas emissions. In addition, to reduce the state's reliance on expensive and price-volatile fossil fuels, the clean heat standard would need to focus on the direct delivery of building upgrades and clean heat solutions in Maryland homes and businesses.

Direct reductions from in-state homes and businesses are also much easier to document as being real (i.e., actually occurring) and legitimate (e.g., relative to an appropriate baseline) and not being double-counted (e.g., relative to emissions reduction requirements in other sectors or in other jurisdictions).[89] For example, it would be very challenging to verify whether investments in tree planting, especially in another country, effectively achieved the level of greenhouse gas emissions reduction assumed. Similarly, it would be challenging to determine whether greenhouse gas emissions reductions at an industrial facility in another state were both (1) attributable to the actions or payment of an obligated party in Maryland and (2) not also being counted toward other emissions reduction requirements in another state.

Deliverability Requirement for Biofuels

The requirement that any biofuels substituted for fossil fuels be delivered to Maryland homes and businesses is consistent with the principle of focusing on curbing emissions within the state. For biodiesel and other biofuels displacing fuel oil, propane, or kerosene, this requirement means that clean heat credits can be earned only for biofuel physically delivered and used in Maryland. Biomethane that is trucked to an in-state home or business would also be an eligible measure. Giving credits simply for the creation of biofuels anywhere in the world — or even anywhere in the North America or the United States — would overwhelm the clean heat standard and undermine its fundamental goal to

[89] A concern about offsets is ensuring that reductions occurred, proper baselines reductions are measured and the reductions are not credited for multiple purposes (or in multiple jurisdictions). Some of these concerns are applicable to biofuels. However, when and if biofuels are used in Maryland, their life-cycle greenhouse gas emissions can be assessed and measured against the fossil fuels they displace in Maryland homes and businesses.

change the nature of heating in the state. Put simply, the standard should be a clean heat program for Maryland, not an offsets support system.

The concept of deliverability is a little more complicated in the context of the pipeline delivery system for methane gas and hydrogen because it is not possible to trace which molecules of methane or hydrogen are burned in which homes and businesses. Thus, for pipeline biomethane, deliverability could be satisfied by purchase and sale of what gas utilities call a bundled product. Specifically, the obligated gas supplier must purchase the biomethane itself (including its greenhouse gas emissions reduction attributes) and have a contractual pathway for physical delivery of the gas from the point at which it is injected into a pipeline all the way to a distribution system in Maryland.

The standard should be a clean heat program for Maryland, not an offsets support system.

This concept is geographically consistent with the way renewable energy certificates are credited in the electric RPS, where renewable generation in other states is eligible to count when the power is delivered to the power grids and markets that directly serve Maryland. Renewable generation cannot earn portfolio standard credits in Maryland, on the other hand, when the generator is located on a remote power grid and sold in a remote power market (e.g., in California or Georgia) that does not deliver electricity in Maryland's region. However, the clean heat standard could be more stringent than the RPS with respect to environmental attributes, if the clean heat standard is set to allow crediting only on a life-cycle impacts basis or otherwise restricts eligibility for alternative gases in the program.[90]

Life-Cycle Accounting for Clean Heat Measures

Discussions about complex comparisons in the energy world inevitably end up in a discussion of "compared to what?" The combustion of biofuels typically produces the same amount of CO_2 emissions at the burner tip as combustion of the fossil fuels they are displacing. The difference is that, compared with geologic fuels, biofuels can provide life-cycle greenhouse gas emissions reduction benefits — either eliminating emissions of other greenhouse gases (e.g., methane from landfills and sewage treatment plants) or removing CO_2 from the atmosphere before being burned (e.g., woody biomass harvested from sustainably managed forests).

When calculating the carbon reduction benefits of various biologic fuel types, two opposing and somewhat simplistic approaches are often mentioned. On one end of the spectrum is the view that biologic sources are by definition zero-emitting on a life-cycle basis, so their use would offset 100% of the greenhouse gas emissions of the fossil fuel they displace. The opposing view looks only at the emissions at the burner tip and concludes that renewable fuels avoid 0% of the previous emissions from fossil fuel. For a clean heat program that is focused on reducing greenhouse gas emissions, a more balanced approach

[90] The Vermont Clean Heat Standard, for example, allows credits for hydrogen only if it is green hydrogen, and for renewable natural gas only when based on the recovery of methane that would exist and would otherwise be vented in the absence of the program. Moreover, clean heat credits for alternative fuels are earned only for the net life-cycle improvement offered by those fuels when compared to the fossil fuels they replace. 30 V.S.A. § 8127(d)-(f).

is required. To estimate that net effect one must compare the life-cycle emissions of the fossil fuel avoided to the life-cycle emissions of the cleaner fuel or measure being used instead.

Maryland does not have to invent a new system of greenhouse gas accounting to provide reasonably accurate life-cycle measurements for the various fuel pathways that might be followed under a clean heat standard. While there are robust debates about the life-cycle impacts of almost every fuel type, well-established low-carbon fuel programs have relied upon a set of analyses developed by the Argonne National Laboratory, called the GREET model.[91] Low-carbon fuel standards in California, Oregon and Washington have used this model, sometimes on a modified basis, to characterize hundreds of specific fuel pathways and to assign carbon intensity scores to them. These models assign emissions rates to different types of fuels taking into account the energy inputs to recovering or creating them, refining them and transporting them to market, as well as their sequestration rates and burner tip emission rates. Some models also consider indirect effects of different fuel pathways, including indirect land use effects from land dedicated to growing biofuels.

Similar models of adequate rigor, developed by the EPA, the Intergovernmental Panel on Climate Change and others, could also be used in Maryland. To avoid endless disputes over life-cycle impacts of different fuel choices, it will be important for regulators to create a framework for analysis, such as GREET or a Maryland-modified version of GREET, and then to set up a process for characterizing different fuel pathways upon request. This is the approach taken in Vermont.[92]

To avoid endless disputes over life-cycle impacts of different fuel choices, it will be important for regulators to create a framework for analysis.

A clean heat standard in Maryland should avoid giving excess credits for emissions impacts that are merely exported from the burner tip to another location, whether that location is inside Maryland or in another jurisdiction. Thus, credits for biofuels need to be based on their net effect on greenhouse gas emissions, including indirect effects. The same logic can apply to the replacement of fossil-fuel heat by electric heat pumps, using appropriate average emissions rates for the electricity that will be used to power the heat pump. This logic applies to all creditable actions but is most appropriate for measures based on fuel substitutions, such as biofuels, advanced wood heat and electricity-driven heat. [93]

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[91] For a thorough description of the model, see: Argonne National Laboratory. (n.d.). *GREET model: The Greenhouse gases, Regulated Emissions, and Energy use in Technologies model*. https://greet.es.anl.gov/

[92] The Vermont law states: "To promote certainty for obligated parties and clean heat providers, the Commission shall ... establish a schedule of lifecycle emission rates. ... The schedule shall be based on transparent, verifiable, and accurate emissions accounting adopting the Argonne National Laboratory GREET Model, Intergovernmental Panel on Climate Change (IPCC) modeling, or an alternative of comparable analytical rigor." 30 V.S.A. § 8127(g)(1).

[93] Complex life-cycle analyses are typically and appropriately moderated by establishing "boundaries of analysis," which allow decision-makers to focus on the most important impacts and to avoid ever-deeper assessments of the remote impacts of the actions in question. Protocols for life-cycle assessments reflect judgments about the appropriate boundaries in particular cases.

Exclusions: Actions That Do Not Earn Clean Heat Credits

A comprehensive climate program will necessarily offer a world of opportunities to reduce emissions in different places and across many sectors. An economywide cap-and-invest program might try to cover them all. For reasons explained earlier in this paper, even though a clean heat standard addresses a major portion of the state's emissions, it focuses on a narrower goal: decarbonizing heating operations at the end-user level in the state. Awarding credits for actions not closely linked to that goal would undermine its effectiveness and slow the pace of the thermal energy transition we need.

Decision-makers in Maryland can consider a range of resource options in the design of a clean heat standard that will drive its greenhouse gas and other environmental impacts, its costs, its ability to meet the 2022 CSNA mandates and its openness to a variety of clean heat resource options. Program design will reflect not only which clean heat resources are encouraged, but also which potentially deliverable resources should be excluded. The most likely candidates for exclusion are discussed briefly below.

Upstream fossil-fuel emissions reductions. Arguments can be made as to whether reductions in fugitive fossil-fuel emissions upstream from homes and businesses (e.g., from storage systems, pipeline gas distribution systems and shared propane facilities) should be eligible. This issue has arisen in other states. Fossil-fuel providers sometimes argue that reducing upstream emissions should be creditable since the total emissions associated with delivering fuels is being reduced, while environmental advocates assert that such reductions should be regarded as simply mandatory in the usual course of business. Vermont does not include upstream fossil-fuel reductions as creditable measures.[94] The Colorado Clean Heat Plan law, on the other hand, permits a small fraction of the total obligation to come from a range of methane-reducing actions, including reducing methane leaks on the pipeline system.

Fossil-fuel substitutions. We do not recommend giving clean heat credits to actions that merely substitute one fossil fuel for another, even if emissions are temporarily reduced by the switch. For example, hooking up a building that currently heats with fuel oil to the pipeline gas grid might reduce emissions somewhat in the short run. However, the ultimate goal of the clean heat program is to reduce greenhouse gas emissions altogether, and that new pipeline connection both adds to the fixed costs of the pipeline grid and delays the ultimate conversion of the building away from fossil fuels. For these reasons, the Vermont statute does not give clean heat credits for "switching from one fossil fuel use to another fossil fuel use."[95]

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[94] See 30 V.S.A. § 8127(d) for a list of eligible clean heat measures.

[95] 30 V.S.A. § 8123(3).

Fossil-fuel efficiency measures. A closely related question is whether clean heat credits should be earned when old and perhaps outdated fossil equipment is replaced with newer and more efficient equipment. Historically, utility energy efficiency programs have encouraged this behavior alongside non-equipment efficiency measures such as building retrofits. However, as jurisdictions come to grips with climate imperatives, efficiency programs must now consider the long-term greenhouse gas impacts of equipment substitutions and recognize the “lock in” effect of installing new fossil thermal equipment even when it is better than the equipment being replaced. Some efficiency programs are now moving to exclude such measures, and clean heat program designers should also consider this issue carefully.[96]

Secondary life-cycle effects. We recommend that the agencies establish a process to consider whether eligibility to earn clean heat credits should be further restricted to protect against secondary undesirable environmental and social impacts of switching thermal heat sources from fossil sources to alternatives. In particular, some biofuels have been shown to have serious negative impacts and should not be awarded credits under the clean heat standard, regardless of the calculated greenhouse gas savings (if any).

Carbon intensity thresholds and percentage caps. In addition, a threshold percentage standard of improvement might also be employed to discourage fuel substitutions that may only marginally improve emissions.[97] It would also be possible to design upper limits on the total contribution that could be credited from particular clean heat fuels or technologies — for example, an upper limit on the total quantity or fraction of biofuels that have nonzero life-cycle greenhouse gas emissions. It is also important to consider the long-term goals of decarbonizing heating when assessing the potential short-term costs of switching to one technology or fuel versus another.

A clean heat standard can be designed in many ways, and particular resource choices can be included, limited or required to meet the state’s policy goals. These choices deserve careful attention because limiting options will reduce the range of market-based consumer choice, may raise overall compliance costs and could slow the pace of greenhouse gas reductions. These tradeoffs are issues that need to be handled carefully, but the public and regulatory processes available in Maryland can address them.

[96] Recent legislation in Maryland requires an examination of EmPOWER’s efficiency programs to ensure they are focused on greenhouse gas reduction as well as their historic efficiency and bill-savings goals.

[97] The Vermont law includes a requirement to ensure that biofuels can earn credits only when they are meaningfully less emitting than the fossil fuels they replace, on a life-cycle basis. The required level of improvement rises over time. 30 V.S.A. § 8127(f).

How could the clean heat standard be achieved?

Analysis of potential compliance paths for buildings in Maryland

Maryland's Climate Solutions Now Act has established goals reducing the state's greenhouse gas emissions, relative to a 2006 baseline, by 60% by 2031 and 100% by 2045. The Regulatory Assistance Project asked Energy Futures Group (EFG) to review recent trends in greenhouse gas emissions from the burning of fossil fuels in Maryland's residential and commercial buildings and to identify potential combinations of clean heat measures that would be needed for the state to meet its climate goals. EFG's study, *Maryland Building Decarbonization Pathways*, was conducted as a companion assessment to this RAP paper.

EFG estimates that the burning of fossil fuels in Maryland's residential and commercial buildings resulted in approximately 10.5 million metric tons of carbon dioxide equivalents (CO_2e) in 2006. The burning of fossil gas accounted for about 70% of the total, with burning of fuel oil accounting for a little over 20%. Residential emissions were slightly greater than commercial sector emissions. Nearly three-quarters of residential and commercial fossil-fuel consumption is for space heating. Though there were modest shifts in the mix of fossil fuels used in buildings between 2006 and 2021 — most notably a 30% decrease in fuel oil consumption and a 9% increase in fossil gas consumption — total emissions changed little. As a result, a rapid ramping up of substantial investment in clean heat measures will be necessary for the Maryland buildings sector to achieve its proportional share of the state's goal of 60% emissions reduction by 2031.

Many clean heat measures could contribute to achieving the 2031 and 2045 emissions reduction goals for buildings. These measures include electrifying space and water heating (with heat pumps), cooking and drying; using geothermal networks; weatherizing buildings to reduce heating loads; and substituting biofuels such as biomethane for fossil gas and biodiesel for fuel oil.

Although having a range of options may be helpful, especially during the heating transition, EFG finds that pathways to decarbonizing Maryland's buildings will be dominated by electrification, which could contribute 75% to 90% or more of emissions reductions in 2031 and 80% to 100% in 2045. Weatherization of buildings can contribute a little less than 10% emissions reductions needed to meet Maryland's 2031 goal. By 2045, as the building stock must be fully fuel-switched to electricity or biofuels, building envelop efficiency upgrades no longer provide direct emissions reductions but will likely be critical to keeping the cost of the energy transition affordable, particularly for lower-income households. Though biofuels can play a role in reducing emissions, that role is modest, primarily because of limited availability of biomethane. Even under generous assumptions about the availability of biofuels, no more than about 20% of emissions reductions would be achieved through biofuels in 2031 and 2045 — and that projection may be high if life-cycle emissions accounting is used, as EFG and RAP recommend.

Decision Point: How to Ensure Equity

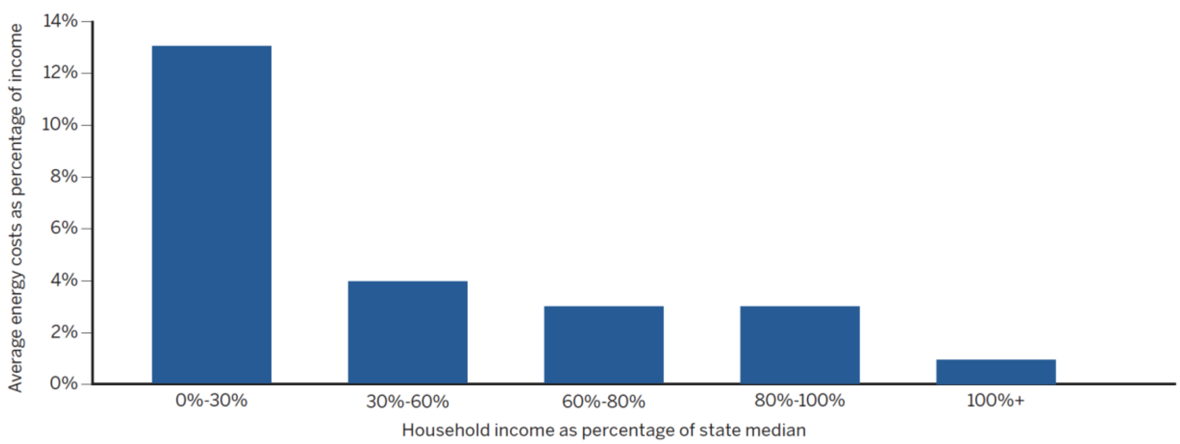
Recommendation: The principles of equity and environmental justice should be built into the design of the clean heat standard, with respect to public processes, key design features and, over the life of the program, tested outcomes.

Equity and environmental justice have long been goals of Maryland's energy and environmental policy. And now, in the state's effort to meet its aggressive climate goals, it has an explicit statutory requirement for greenhouse gas policies and regulations to rigorously address these important issues.[98] In designing policies such as a clean heat standard, the equity objective has both process and substance components.

As a matter of procedural equity, significant efforts must be undertaken in the initial program design stage to obtain input from low-income residents of the state and from environmental justice communities. Input from housing agencies, weatherization and efficiency practitioners and finance experts should support this engagement. The design process must be open to ideas from energy-burdened communities, housing providers and others with lived experience and professional expertise delivering weatherization and heating solutions. This process includes important roles for community organizations.

As for substance, studies reveal that, as a general matter, low-income populations spend a disproportionately high fraction of their income on household energy, despite consuming less energy overall. And this is true of Maryland. Figure 8 shows how the energy burden is significantly higher for the state's low-income residents. [99]

Figure 8. Energy burden in Maryland



Data source: U.S. Department of Energy. (n.d.). *Low-Income Energy Affordability Data Tool*

[98] See generally the Climate Solutions Now Act of 2022. The act identifies parts of the population (e.g., low- to moderate-income households, underserved communities and overburdened communities) that bear a disproportionate share of the state's energy costs (on a household or per-capita basis) and who are more likely to suffer the environmental harms of energy production, and it directs the relevant governmental agencies to design and implement programs pursuant to the act so as to mitigate those burdens as much as possible.

[99] U.S. Department of Energy. (n.d.). *Low-Income Energy Affordability Data Tool*. https://www.energy.gov/eere/slsc/maps/lead-tool

Several elements of a clean heat standard should be designed with equity in mind. For example, the standard can be developed with an equity carve-out that requires that a high fraction of clean heat credits be acquired from measures in low- and moderate-income households. In the alternative, regulated parties can be awarded a credit bonus, reducing their overall obligation, if a certain equity threshold is reached. In addition, the standard can cooperate with equity-focused goals in other programs, such as community outreach programs, means-tested energy rate tiers and end-use efficiency programs dedicated to low- and moderate-income consumers.

One example of how to design an equity carve-out is contained in the Vermont Clean Heat Standard, as enacted in 2023. It requires that 16% of the *total* quantity of clean heat measures be delivered to low-income residences and an additional 16% be delivered to either low- or moderate-income residences. Since only about half of the total energy savings and credits that the clean heat standard will produce will come from Vermont's residential customers, this means that more than three-fifths of residential installations will benefit low- and moderate-income households. Moreover, the Vermont law requires that at least 50% of those measures qualify as long lived — that is, measures such as heat pumps and weatherization jobs that will deliver cost savings for the residents in the long term.

Low-income households and environmental justice communities often have the highest greenhouse gas-emitting building stock. Decarbonizing this share of the housing stock will make the greatest proportional contribution to reducing energy burdens, improving health outcomes and ensuring transitional equity. Building-shell improvements and heating conversions will be necessary to improve this portion of the housing stock. Since the financial resources of low-income occupants are by definition limited, public policies are needed to make it happen. Those strategies should be built into the clean heat standard program design from the beginning.[100]

Decision Point: Creation, Ownership and Transfer of Clean Heat Credits

Recommendation: Clearly define in program rules the pathways for ownership of credits and give obligated parties flexibility to acquire credits through at least five nonexclusive options.

Customers Could Own Their Clean Heat Credits

When a clean heat measure is purchased or installed, who owns the associated clean heat credits? This question can be answered in a variety of ways, but the main point is that the rules of the road should be clear to obligated parties, clean heat providers and end-use

[100] There is, on the surface, tension in program design between dedicating efficiency and heat-switching resources to consumers with the highest energy burdens on the one hand and maximizing early pollution reductions by focusing on the quickest reductions from anywhere on the other. A just transition requires both justice and an effective transition, so multiple objectives must be served. At this point, RAP judges that the balance should favor early action to improve heating systems for those who bear the greatest energy burdens. Ultimately, clean heat solutions will have to be delivered to most homes and businesses across Maryland, so almost everyone will ultimately be served. RAP believes it is equitable and ultimately cost-effective to provide clean heat solutions to the most energy-burdened households disproportionately earlier in the process than would be the case if the distribution of benefits were left to market forces alone.

customers. The program regulator will need to address this issue, perhaps with the assistance of an appropriate stakeholder advisory group.

One possibility is to assign ownership of clean heat credits initially to the end-use customer[101] whose fossil heat consumption has been reduced. That customer can decide whether to transfer the credits to the contractor, installer or fuel supplier who provided the clean heat services; sell them in the market; or hold them for future use. In many, if not most, cases we can expect the provider of the service to contract with the customer for ownership of any credits and would likely offer an incentive payment or discount on the service provided. There is a great deal of experience in marketing energy efficiency and other energy services to demonstrate that the flexible use of discounts and incentives can spur customer uptake of the measures in question.

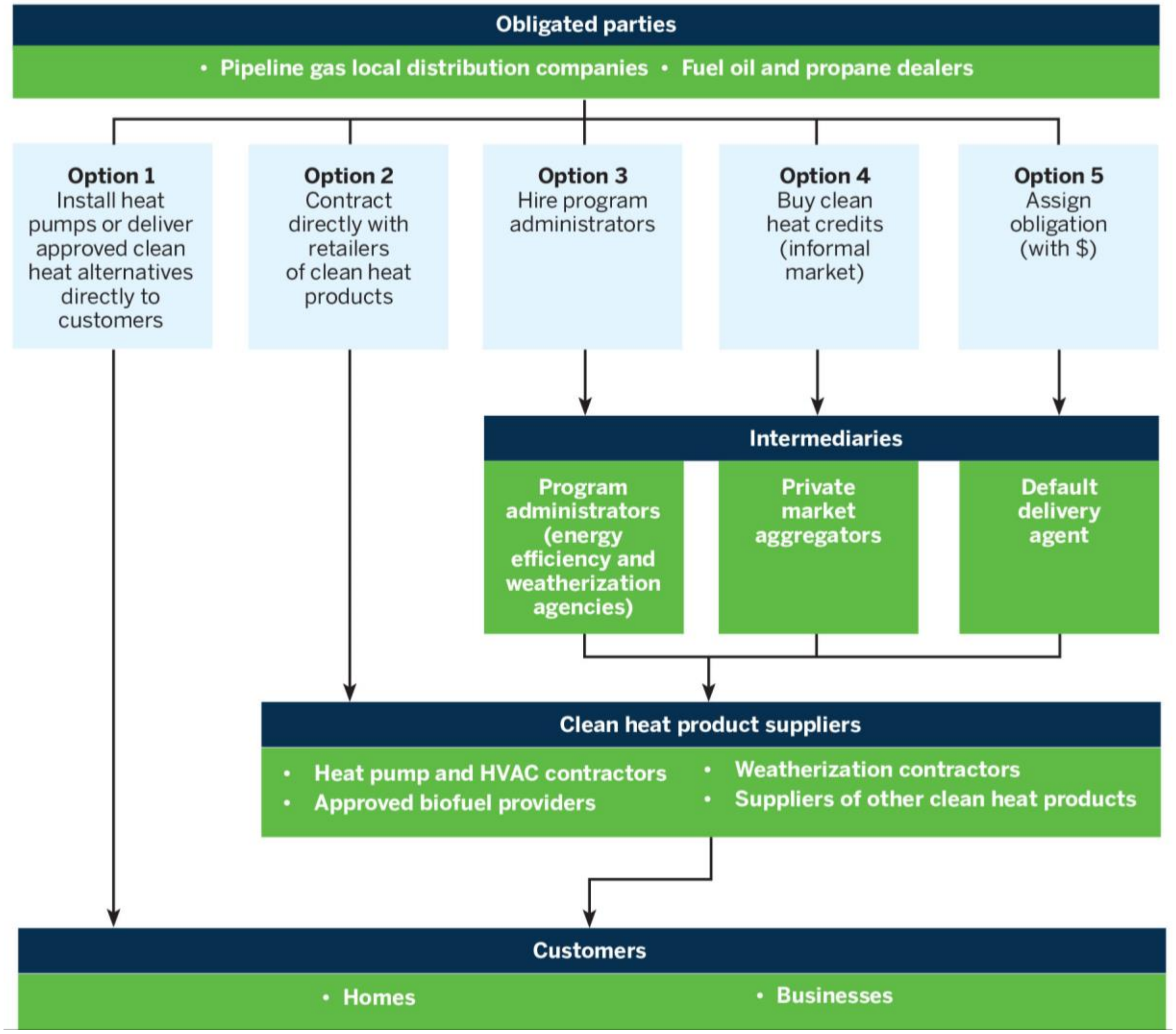
If this path is chosen, it could create greater competition in the market, lowering the cost of compliance with the clean heat standard. It should also make it easier for businesses selling clean heat products and services — for example, HVAC contractors selling heat pumps, vendors of pellet stoves and weatherization contractors — to find markets and the best prices for the credits they could generate.

Many Ways to Acquire Credits

Flexibility will be essential to minimizing the costs of compliance with the clean heat standard. It may also be essential to enabling the standard to be met, as different obligated parties will have different levels of capacity and interest in the way credits are developed or acquired. The system should offer at least five nonexclusive options to obligated parties, as seen in Figure 9 on the next page.

[101] Additional nuances will be needed for landlord-tenant arrangements and related business arrangements where the occupier and operator of a building space is different from the owner of the property or the owner of the thermal equipment. For long-lived measures (e.g., new air-source heat pumps), our recommendation would be that the person or entity that owns the newly installed equipment would be the initial owner of the clean heat credits.

Figure 9. Potential paths for acquiring clean heat credits



1. Obligated parties should have the option to **generate credits directly**, by helping customers to install different emissions reduction measures (e.g., heat pumps and weatherization of buildings) or by purchasing and selling low- or zero-carbon fuels to customers, as this is the simplest way to comply with the clean heat standard.
2. If an obligated party does not want to work with customers directly, it could **hire contractors to install** clean heat measures on its behalf. This is analogous to how many utility efficiency programs operate in Maryland and across the country.
3. An obligated party could hire a more broad-based **third-party program administrator**, who might earn credits through a range of services and might deliver them on behalf of multiple obligated parties. For example, a fuel dealers association could offer to deliver clean heat services on behalf of some or all of its members.
4. The obligated party could **buy credits on the open market**, which allows a variety of private sector businesses to use the clean heat standard as a vehicle to advance existing or new business models. For example, a current fuel oil dealer or an HVAC

contractor could decide to diversify its business by selling heat pumps, generating credits that could then be sold to any obligated party. When an obligated party buys those credits, it would defray the cost of making the heat pump sales, ultimately lowering costs to customers or increasing the profitability of the business selling the clean heat products.

5. The final option would be making a payment to assign emissions reduction obligations to one or more **default delivery agents** designated by the lead agency implementing the clean heat standard. This option is further developed in a separate section below.

Another important aspect of flexibility is the ability of an obligated party to acquire clean heat credits not just from its own customers, but also for measures installed in any Maryland home or business. That would include customers who buy fossil fuels from other obligated parties. For example, pipeline gas retailer A could acquire credits resulting from installing heat pumps in homes served by pipeline gas retailer B, or by weatherizing a home. Or fuel oil company A could acquire credits from an HVAC company that originally came from the installation of a heat pump in a home that had bought fuel oil from provider B.

Regardless of which of these options or combinations of options are utilized, a mechanism would be needed to register credits when they are claimed and track them when they are sold, to create a strong credits market and to avoid double-counting of credits. This is not a new challenge. Credit registration and transfer recording systems exist in many environmental credit markets, in renewables obligation programs, utility capacity and demand management markets.

Decision Point: Managing Credits from Long-Lived Measures

Some clean heat measures have a one-year life. For example, a gallon of zero- or low-emissions clean fuel reduces greenhouse gas emissions only in the year in which it is burned. Other clean heat measures — such as heat pumps and home weatherization projects — provide greenhouse gas emissions reductions for 15 years, 20 years or even longer. The clean heat standard needs to ensure that these long-lived measures are adequately supported and needs to assign emissions reduction credit values over the course of years. Such support is also appropriate because these measures cannot easily be reversed.

Recommendation: Award lifetime clean heat credits for long-lived measures.

There are, broadly, two ways to ensure that long-lived clean heat measures receive credits in proportion to the emissions they will avoid over their useful lives.

1. One option is to credit a multiyear measure with its full lifetime emissions reductions in the year it is installed. For example, if a heat pump had a 15-year life and produced 10 clean heat credits per year, one could assign 150 credits to that heat pump in year one. Thus, a heat pump installed in 2024 would provide 150 credits toward an obligated party's 2024 credit obligation (but no credits in subsequent years).

2. The second option is to time-stamp a multiyear "strip" of credits for that measure. In this case, a heat pump installed in 2024 would earn 10 credits with a 2024 time stamp, another 10 credits with a 2025 time stamp, another 10 credits with a 2026 time stamp and so on through 2038 (the 15th year of its life). There may be other gradations of these two choices.

The first option — capturing the lifetime emissions reductions in the year a measure is installed — is simpler and helps support installations by providing credits at the time that the investment expense is incurred. However, retiring a lifetime's worth of credits in the first year is inconsistent with the statutory requirements to achieve defined levels of greenhouse gas emissions reductions in specific years. It would result in substantially lower levels of emissions reductions in any given target year than required by the 2022 CSNA. In addition, fully accelerating lifetime emissions reductions into the early years of the program would add substantially to the supply of credits in those years, reducing credit prices and weakening the price signal that the program is intended to deliver to ensure substantial reductions.[102]

Recommendation: Protect the number of credits for long-term measures, once awarded.

Regulatory agencies will, after appropriate public processes, establish clean heat credit values for a range of approved actions. These credit values will need to change over time as technologies and situations change and as everyone learns how particular measures work in practice. That is expected and necessary. It will be important, however, to not alter the number of credits originally awarded at the time a long-lived measure was installed. For example, if in the fall of 2025 the regulatory agency approves an assumption that a 3-ton centrally ducted heat pump provides a defined stream of clean heat credits across the 15 years of its assumed life, any heat pump installed in 2026 would earn those credits in 2026 and each year thereafter through 2040 (its 15th year). Those credits would remain as assigned in 2026, even if a future evaluation suggests that such heat pumps reduce greenhouse gas emissions more or less than the quantity assigned in 2025.

This approach provides certainty for obligated parties regarding the number of credits they can earn for different measures. The market value of credits in each of those future years may, however, be higher or lower than the market value of credits in the year the heat pump was installed. This result is similar to the risk that renewable energy providers face with respect to the value of renewable energy credits over the lifetime of a wind turbine or solar farm, and it is the primary reason states have chosen to augment the broader RPS requirements with policies such as carve-outs and long-term contracting requirements. Therefore, the decision-makers need to be conscious of the potential impact of price volatility on the ability for the clean heat credits to attract a sufficient amount of clean heat investments. Options to address this issue are discussed next.

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[102] This is akin to the problem faced in some greenhouse gas cap-and-trade programs, including the European Trading System, which created a large "overhang" of excess credits due to generous crediting of offsets and early actions. See, for example, Cowart, R., Buck, M., & Carp, S. (2017). *Aligning Europe's policies for carbon, efficiency, and renewables: Creating a "virtuous cycle" of performance and emissions reduction.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/aligning-europes-policies-for-carbon-efficiency-and-renewables-creating-a-virtuous-cycle-of-performance-and-emissions-reduction/. A more detailed discussion of this point with respect to the clean heat standard, with an arithmetic example, is included in Cowart & Neme, 2021.

Recommendation: Consider program options to encourage investments in long-lived measures that support other policy objectives.

All policy options aimed at transforming the heating sector must overcome the slow turnover rates in buildings and heating systems and the high up-front costs of making long-term changes. The clean heat standard is not unique in this regard, but it does offer some unique approaches to the problem. We recommend that policymakers consider a variety of options that could accelerate investments in long-lived measures under the clean heat standard, without undermining the emissions reduction goals the program needs to meet. These options are especially important to spur investments in weatherization (particularly low-income weatherization), heat pumps and renewable district heat systems. Among options to consider:

- Securitizing or contracting for the credits earned by long-lived measures. An alternative to putting a lifetime of credits into the market in year one of the measure's life is to securitize their value. Maryland could create or commission a patient lender or buyer of clean heat credits, which could pay for them at the time of installation and release them into the credit market in the years the measure is operating. This could be paid for in a number of ways, including green bonds, housing finance tools, loans secured by tariffed on-bill financing and other environmental finance tools.
- Using carbon revenues to finance clean heat investments, either as part of a securitization package or directly, as an element of a cap-and-invest program that could operate in tandem with the clean heat standard.
- Adapting utility regulation to support these outcomes. Regulated fossil gas utilities could be required, as part of their clean heat standard obligation, to deliver a set fraction of clean heat credits from qualified long-lived measures. Alternatively, or in combination, regulated electric utilities could be directed to provide financial assurances that would encourage installation of qualified measures. In the case of weatherization, heat pumps and heat pump water heaters, financial tools such as on-bill tariffed financing could help to overcome the price barriers that customers face in installing the measures. The utility could purchase and hold the clean heat credits as part of that financing package.
- Designing the clean heat standard to ensure that an adequate fraction of all clean heat measures is derived from long-lived measures or those measures that are especially valued for public policy reasons (e.g., low-income weatherization, heat pumps, renewable district heating). This could be done through a credit carve-out or tiered credit system, as was done for solar electricity under various renewable portfolio requirements. Carve-outs are similar to the time-stamped credit approach in that the energy is counted on par with other options in calculating compliance with the broader annual standard, but it is different in that it can be used to require (versus encourage) particular project categories.

The list above is by no means exhaustive. Whatever path is chosen, we recommend that policymakers consider the tradeoffs between a clean heat standard that leaves the mix of qualified solutions entirely to the market, as chosen by providers and customers, and a program that affirmatively promotes selected solutions that may also advance other public policy objectives.[103]

Decision Point: Credit Trading and Compliance Options

Recommendation: Enable banking of clean heat credits to meet future obligations, but not borrowing.

Several compliance flexibility mechanisms are typically offered in programs of this type. It is not expected that each individual fossil-fuel provider acquires sufficient credits directly in a given year to satisfy its compliance obligation.

First, the most straightforward flexibility mechanism is credit transfer, which in most cases will be structured as a purchase and sale in exchange for other valuable consideration. This requires a system for credits to be transferred to other parties, and appropriate security measures are necessary to ensure that credits are not transferred without the proper permission from the current owner. With these basic administrative structures, an informal credit market could arise, but there are also more formal markets and exchanges that could be set up by the state agency in charge.

Second, obligated parties may acquire more clean heat credits than they need to meet their obligation for a given year and may bank those credits for use in a later year. Some amount of "overshooting" is highly likely to occur in many years if obligated parties see the cost of modest overcompliance to be lower than the cost of falling short of their obligations and having to make a noncompliance payment. Allowing any such excess credits to be applied to a future year's obligation will lower the cost of meeting the state's emissions reduction goals. It will also likely enhance the likelihood of meeting annual goals by lowering the cost of overcompliance (since, from the perspective of the obligated parties, the credits from overcompliance are still useful and not wasted). Regulators will need to establish a system for tracking banked credits, but that should be relatively easy to implement. Any minted credit that has not yet been retired should continue to be registered in the system and thus can be used for compliance in the future.

We recommend, however, that the reverse option, known as borrowing, should not be allowed. Borrowing credits from planned, future clean heat actions is not consistent with the goals of the 2022 CSNA to physically deliver defined emissions reductions in specific years. Borrowing creates the risk that the borrowing entity will fail to perform in the future or even go out of business. These are unacceptable risks in an essential emissions reduction program, particularly since climate science tells us that near-term reductions are especially important to forestall the worst impacts of climate change. Although we do not recommend it, we do acknowledge that limited borrowing might be an option for addressing short-term market volatility, such as might be caused by abnormal variations in the weather or relative fuel prices.

Instead of borrowing, an alternative compliance payment is a typical feature of an RPS and can be determined in a clean heat standard. This means that if an obligated party has not

[103] For example, to promote delivery of long-lived clean heat measures to low- and moderate income households, the Vermont Affordable Heat Act states that at least half of the clean heat credits in those households must come from long-lived measures that are expected to lower household heating bills on a continuing basis. 30 V.S.A. § 8124(d)(2).

otherwise acquired sufficient credits to meet its obligation, then the party can pay a predetermined dollar amount per unit of undercompliance to satisfy the regulation. Of course, this does lead to physical undercompliance in a given year, but the payment should be set at a level high enough to pay for near-term delivery of savings by other means. A good alternative compliance payment can provide a level of cost certainty for obligated parties and can lower the risk of the program driving higher-than-expected overall compliance costs. It will be important to create a mechanism in advance that could ensure that all alternative compliance payments are invested efficiently in qualifying clean heat measures that advance the equity and environmental goals of the standard.

Decision Point: Establishing Default Delivery Agents

Recommendation: Create one or more default delivery agents that would deliver clean heat measures on behalf of obligated parties that choose this option.

Among the fundamental drivers for creating a clean heat standard are two plain facts: (1) progress in the thermal sector requires decisions, actions and investments by millions of building owners, and (2) most fossil-fuel providers have very limited experience in helping their customers to make the clean heat decisions that are now needed. The clean heat standard is designed to offer historic fossil heat providers paths to new business models. The largest pipeline gas utilities in Maryland may choose to play a leading role in delivering clean heat measures. However, it's realistic to appreciate that some obligated parties might have little interest in pursuing new lines of business, and others might not have the ability to do so in the near term. Moreover, some obligated parties might be interested in delivering some solutions, such as heat pumps or perhaps biofuels, but lack the ability and special expertise to deliver weatherization assistance or to serve low-income households or multifamily housing sites.

In addition, we know from the experience of delivering energy efficiency programs in Maryland and many other places that change can be accelerated through market transformation and that market transformation can be accelerated through large-scale programs with broad geographic scope and wide customer awareness.

To take advantage of market scale, ensure that significant performance gaps do not arise and offer a straightforward compliance option to obligated parties, we recommend the creation of one or more default delivery agents to deliver clean heat measures on behalf of obligated parties.

Maryland could adopt either an opt-in or opt-out policy with regard to the default delivery agent option. Under the opt-in approach, the law would begin with the assumption that obligated parties would normally fulfill their obligations on their own, or through buying credits in the market. But they would have the option, under appropriate timing and quantity constraints, to transfer all or a portion of their obligation to the default delivery agent. Under the opt-out approach, the law would begin with the assumption that each obligated party's obligation would be performed by the default delivery agent, under a fee schedule set by the regulator. If an obligated party wanted to avoid using the default delivery agent, it could file a declaration that it intends to fulfill the obligation in whole or in part, on its own.

Vermont has adopted the opt-out approach.[104] This approach is intended to reduce administrative burdens on obligated parties, particularly the state's many small dealers in delivered fuel. It also allows the default delivery agent to benefit from economies of scale and sufficient lead time to develop and deliver a suite of thermal programs that meet the environmental and equity goals of the clean heat standard.[105] Policymakers do not, however, expect that Vermont's one pipeline gas utility would seek to rely on a default delivery agent.

Whether on an opt-in or opt-out basis, the default delivery agent provides a performance option for any obligated party that prefers making a payment to having to deal with the planning and management of efforts to acquire credits in some other way. The default delivery agent would then be required to use the funds to deliver clean heat savings to consumers in a manner consistent with the requirements it has undertaken on behalf of obligated parties.

Decision Point: Program Administration and Evaluation

There are several administrative functions that one of the Maryland regulatory agencies would likely need to perform to establish and operate a clean heat standard, such as preparing and promulgating regulations. Per Maryland law, the implementing agency would need to seek stakeholder input and initiate a public comment process. These processes should emphasize input from environmental justice and overburdened communities. The stakeholder process would serve as the foundation for the systems that follow to administer the program. The guiding principles offered early in this paper can serve as a starting point for considering the process and areas for focus as the regulatory agencies begin their work and as touchstones to ensuring that the program design will meet the aims of Maryland. The state has a good structure established through the Maryland Commission on Climate Change that could provide some of the needed structure to assist the agencies in developing the program.

Administrative functions include areas such as the following.

Registering credits. This requires a system that provides for the serialization of unique credits that can be used in a data system to track who buys, sells or owns them. The system also needs a mechanism that allows for banking credits for future use and a function to retire credits that are used to meet compliance obligations.

Reporting by obligated parties and amendment or revision processes. The data system needs to have functions that enable the obligated parties to demonstrate how they have met their compliance obligations and provide the regulatory agencies with the ability to amend, review or update these parties on at least an annual basis or perhaps more frequently, or even on demand (as businesses are sold and ownership changes).

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[104] The Vermont law includes provisions for selection and supervision of one or more default delivery agents by the Public Utility Commission, requires a public planning process for the work it would do, and includes multiyear notice and payment obligations on obligated parties to ensure that any default delivery agent will have the time and resources needed to perform the obligations it assumes on behalf of the statutory obligated providers.

[105] Timing, funding, planning and programmatic requirements to support an effective default delivery agent option are similar to those that have been developed for statewide energy efficiency programs, including Efficiency Vermont and Efficiency Maine. For more information on these issues, see 30 V.S.A. § 8125.

Enforcement, fines, penalties and corrective action. The regulatory agencies need authority to enforce the program if obligated parties do not meet their obligations. This needs to include fines and penalties that are significant enough to promote compliance, and the regulatory agencies need to be able to request any corrective action deemed necessary to discourage a repeat of noncompliance. For example, in the RGGI program if the surrendered allowances are not sufficient to meet a compliance obligation, the offending party must then surrender three allowances for every allowance it did not submit (a 3:1 penalty). That is in addition to paying a monetary penalty.

Program reviews and updates. A program review every few years (RGGI's requirement is every three years) can ensure that adjustments and improvements are made in the program and its governing regulations over time as issues arise. It also provides an excellent mechanism for updating areas, such as:

- What options are creditable for compliance and how various options are valued in greenhouse gas emissions reductions (or other program metrics).
- How life-cycle emissions are calculated as that science evolves.
- Whether the annual compliance obligation needs to be increased to ensure that greenhouse gas emissions reduction goals are being met.

Centralized procurement mechanisms or default delivery agent structures. These concepts envision a mechanism (not necessarily a regulatory provision of the state agencies) by which, for example, a fuel dealer association could serve as a joint purchasing agent of credits (or an agent for developing credits) on behalf of its members.

The regulatory agencies will need to evaluate whether to undertake the tasks noted above themselves or set up other mechanisms through contracts. For example, the analysis of life-cycle emissions could be undertaken by one of the national laboratories, a Maryland university or a contractor familiar with GREET.

Other administrative functions may arise as the public process of implementing the program begins to be developed. The list above is not intended to be exhaustive.

Conclusion

Performance Standards Can Drive Thermal Decarbonization

Renewable energy standards and other performance standards have worked well to drive change in the electricity sector. In some jurisdictions, performance standards also apply to the regulated pipeline gas utilities successfully. National and local experience with these performance standards reveals six broad observations.

1. **Performance standards can achieve change at scale.** Renewable portfolio standards and energy efficiency resource standards are responsible for a large fraction of the renewable energy and energy efficiency services received by end-use customers in the states that have enacted them.

2. **Performance standards can keep costs lower.** These programs have delivered clean energy improvements largely in the absence of carbon taxes or cap-and-trade regimes. They can bring about systemic changes without relying on higher prices as the main tool to change consumer behavior. Carbon revenues can be quite helpful, but carbon taxes are not required to deliver renewable energy or energy efficiency to replace fossil energy.

3. **It's important to focus on adding "good" resources, not just on limiting "bad" resources.** In many states the renewable portfolio standard and efficiency mandates have been designed to require the addition of desirable resources to energy systems, rather than imposing a cap or a penalty on the production or consumption of less-desirable resources. Even so, by adding low-emissions resources to energy systems, they have displaced higher-carbon energy sources and substantially reduced environmental harms, including greenhouse gases. Of course, the strategies can also be combined — a cap on "bad" resources and a performance standard for "good" resources can work together to ensure that the energy transition delivers the desired mix of resources while serving equity goals.

4. **Performance standards can elevate resources that are most needed and most desirable.** Many states have adopted portfolio standards with tiers or set-asides for resources that were especially desired or needed additional assistance, especially in the early years. Distributed resources, solar generation and other preferred resources can be called out in a performance standard to ensure delivery in the program. Efficiency programs have taken a similar approach, especially to ensure service delivery to low-income customers or in underserved communities.

5. **Regulators know how to administer them.** Performance standards require ways to measure and count performance, and states across the country have decades of successful experience. The details can be complicated, but across all these programs, utilities, governmental regulators and stakeholders have developed the procedures and verification methods to implement them successfully.

6. **Competition lowers costs and drives innovation.** To the degree that performance standards permit flexibility in resources and delivery methods, they can promote new ideas and uncover cost-savings opportunities. For example, spurred by

renewable portfolio standards, many utilities have conducted competitive solicitations for renewable supplies from independent producers, leading to rapid reductions in the cost of solar and wind power.

A clean heat standard shares many of the characteristics that have made other performance standards successful.

Like the RPS and energy efficiency programs, a clean heat standard is not a fee-based system or a tax. Its continued success does not depend on annual governmental appropriations.

Designing the standard to focus on the delivery of low-emissions thermal solutions avoids arguments over whether and how to limit the use of fossil resources that most people and businesses have long relied upon. The clean heat standard would provide opportunities and incentives for consumers to switch away from fossil heat systems, but it does not require any individual end user to make that choice.

As with numerous energy efficiency programs, clean heat standard success requires finding ways to work with both upstream vendors and end-use customers to deliver solutions in millions of distributed locations.

As with RPS and efficiency programs, a clean heat standard can be designed with special tiers or set-asides for minimum and maximum percentages of resources in order to meet public policy goals. This could include positive assurance percentages for desired resources (e.g., beneficial electrification, service to lower-income households and communities), along with caps on resources that are deemed less desirable in the long run. The clean heat standard would be a performance-based obligation, without needing detailed prescriptions, imposed on fossil-fuel sellers (or all heating energy providers) on a competitively neutral basis. Competition among obligated providers creates incentives for innovation and better customer service while lowering costs over time.

Finally, the electricity RPS has guided numerous electricity providers to new business models that work sustainably in the emerging low-carbon economy. In like manner, the clean heat standard would be designed to help Maryland's heating enterprises, providers of fossil gas and delivered fuel, and possibly its electricity companies to become clean heat suppliers, while helping their customers to switch to cleaner, sustainable heating choices. These changes have not yet occurred at scale and are unlikely to occur through the actions of a few early adopters and the public programs now operating in Maryland. To meet Maryland's climate objectives, a much larger driver is required. A clean heat standard, operating in combination with a strong suite of complementary policies, could provide that framework.

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Maryland Building Decarbonization Pathways

Final Report

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Introduction

Maryland's Climate Solutions Now Act (CSNA) has established goals of reducing the state's greenhouse gas (GHG) emissions 60% from 2006 levels by 2031 and 100% by 2045.[1] Achieving emissions reductions from the residential and commercial building sector will be important in meeting these ambitious goals.

One policy available to Maryland to address emissions from the building sector is a clean heat standard. This is a performance-based standard intended to reduce emissions from fossil fuels used in homes and businesses. A clean heat standard would be applied to the fossil heating fuel providers in the state and would require them to deliver a gradually increasing percentage of low-emission heating services to customers.[2]

Given the potential of a clean heat standard to reduce emissions in the state, the Maryland Department of the Environment (MDE) is interested in understanding the impacts of the policy for the buildings sector. To that end, Energy Futures Group (EFG) has undertaken an analysis to identify and quantify illustrative mixes of clean heat measures that could be installed under the auspices of a clean heat standard designed to meet the building sector's proportional contribution to Maryland's 2031 and 2045 emissions goals.

This is a high-level analysis, meant to provide a directional sense of what will be required for the building sector. We have not done detailed modeling of every end use, every fuel type, or every potential clean heat measure. Instead, we focused on the most important fuels, end uses, and measures. We also focus on what it would take to reduce emissions, basing our scenarios on insights from our own work and other studies on the clean heat measures likely to have the biggest impacts. We have not assessed the costs of the scenarios we developed and have therefore not attempted to develop economically optimized scenarios.

[1] https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/sb0528?ys=2022RS

[2] Cowart, Richard and Chris Neme, *The Clean Heat Standard,* an Energy Action Network (EAN) white paper, December 2021.

Maryland Building Energy Use and Emissions Trends

Changes Since 2006

Maryland relies on fossil fuels to meet a significant portion of its residential and commercial building energy needs for space heating, water heating and select other end uses. For example, as Table 1 shows, approximately 54% of all housing units in the state use fossil fuels to heat their homes. The use of fossil fuels is greatest in single family detached housing.

Table 1: Maryland Primary Residential Space Heating Fuels by Building Type (Housing Units)[3]

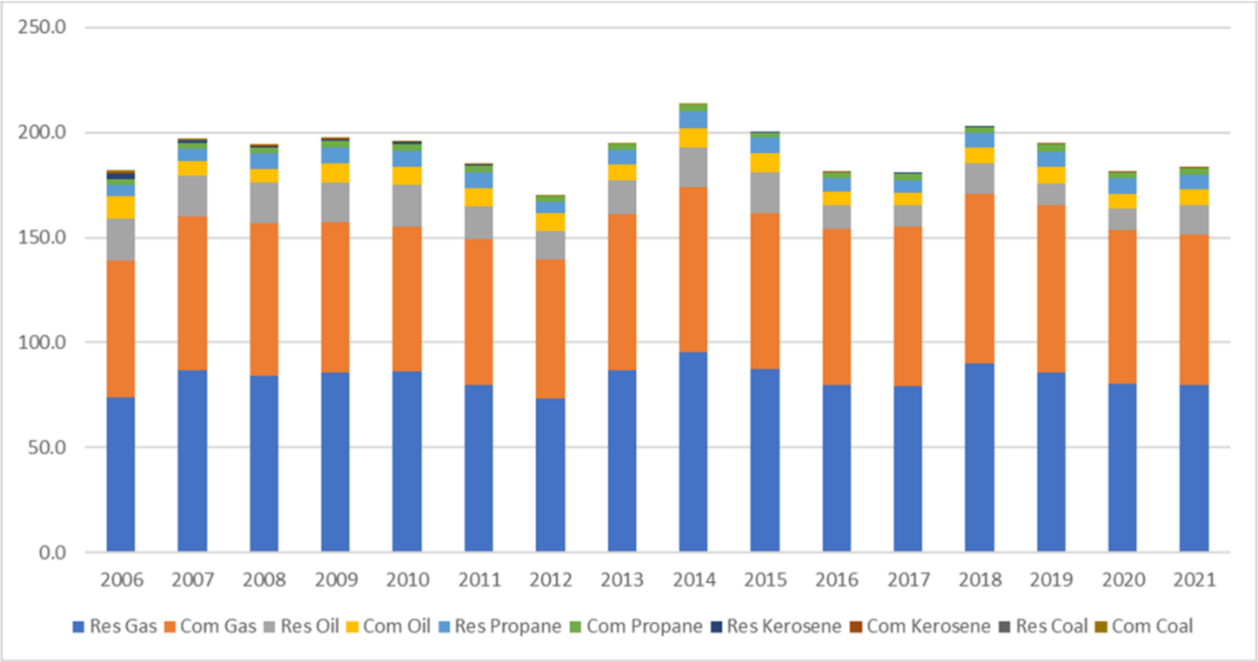
					Apartments							
Fuel Type	Mobile Home or Trailer	One-family house detached	One-family house attached	Duplex	3-4 Units	5-9 Units	10-19 Units	20-49 Units	50+ Units	Boat, RV, van, etc.	Total	Total %
Gas	2,812	532,076	251,045	12,981	18,284	48,916	69,801	16,883	47,961	546	1,001,305	43%
Propane	7,245	65,996	4,925	1,145	1,106	1,525	1,878	1,404	776	-	86,000	4%
Electricity	7,793	464,692	217,523	14,011	25,045	64,746	94,750	30,620	117,465	139	1,036,784	44%
Fuel Oil	3,677	152,933	10,887	1,538	1,361	497	616	60	354	442	172,365	7%
Coal	-	1,209	52	108	38	-	25	115	-	-	1,547	0%
Wood	970	18,876	219	-	-	-	-	110	102	-	20,277	1%
Solar	46	5,771	925	-	73	61	-	-	147	-	7,023	0%
Other	1,168	8,003	1,590	115	-	260	119	44	1,436	11	12,746	1%
None	496	5,808	3,915	708	736	859	1,263	555	2,749	515	17,604	1%
Total	24,207	1,255,364	491,081	30,606	46,643	116,864	168,452	49,791	170,990	1,653	2,355,651	100%
Fossil Fuel %	57%	60%	54%	52%	45%	44%	43%	37%	29%	60%	54%	54%
Electric %	32%	37%	44%	46%	54%	55%	56%	61%	69%	8%	44%	44%

Figure 1 shows the trend in fossil fuel consumption from Maryland buildings from the base year of 2006 to 2021. Total fossil fuel consumption changed very little over that 15-year period. Indeed, the 2021 consumption of 183.4 TBtus is less than one percent higher than the 2006 consumption of 181.9 TBtus.[4] The modest variations from year to year may be attributable to changes in severity of winters. The majority of building energy needs served by fossil fuels – both residential and commercial – is currently and has historically been met by fossil gas (also commonly called natural gas or fossil methane).

[3] U.S. Census, 2021 American Community Survey.

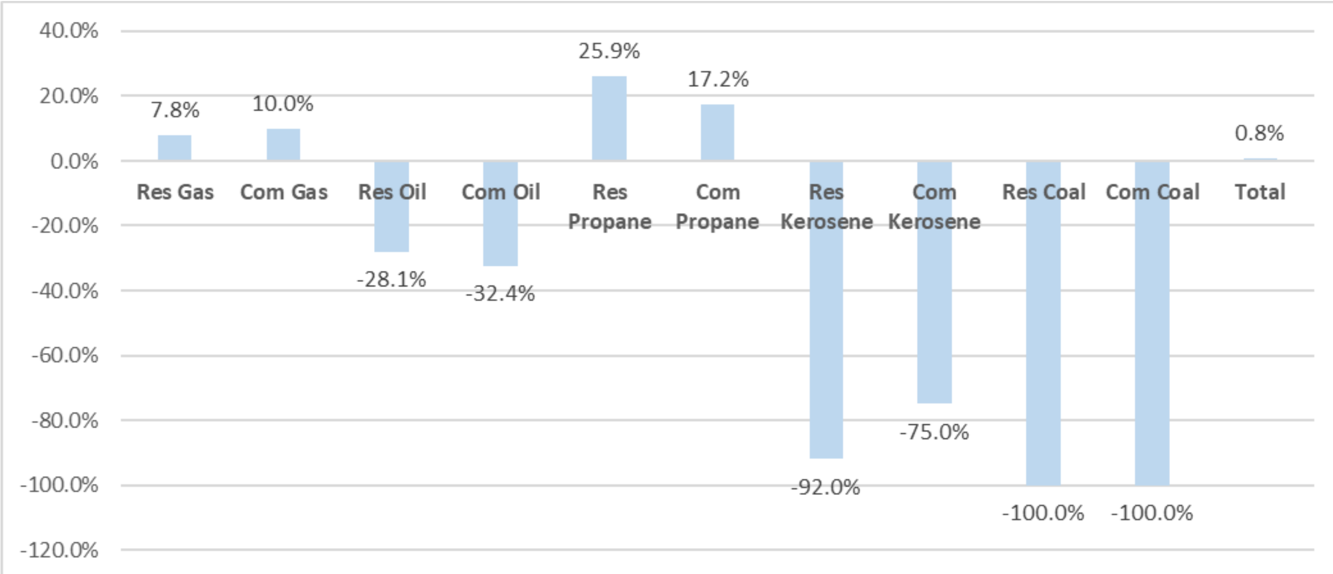
[4] Over the same 15 year period, Maryland's population increased by nearly 10% (https://www.macrotrends.net/states/maryland/population) and the state's gross domestic product increased by a little more than 20% (https://www.statista.com/statistics/187897/gdp-of-the-us-federal-state-of-maryland-since-1997/), so consumption per capita and per unit of economic output actually declined.

Figure 1: Fossil Fuel Consumption in Maryland Buildings from 2006 through 2021 (TBtus)



Though total consumption of fossil fuels has remained relatively steady, there have been notable changes by fuel. For example, as Figure 2 shows, fossil gas consumption increased by nearly 8% in the residential sector and 10% in commercial buildings. Propane use also increased. On the other hand, there have been substantial reductions in fuel oil consumption, elimination of what were small amounts of coal burning, and near elimination of small amounts of kerosene use.

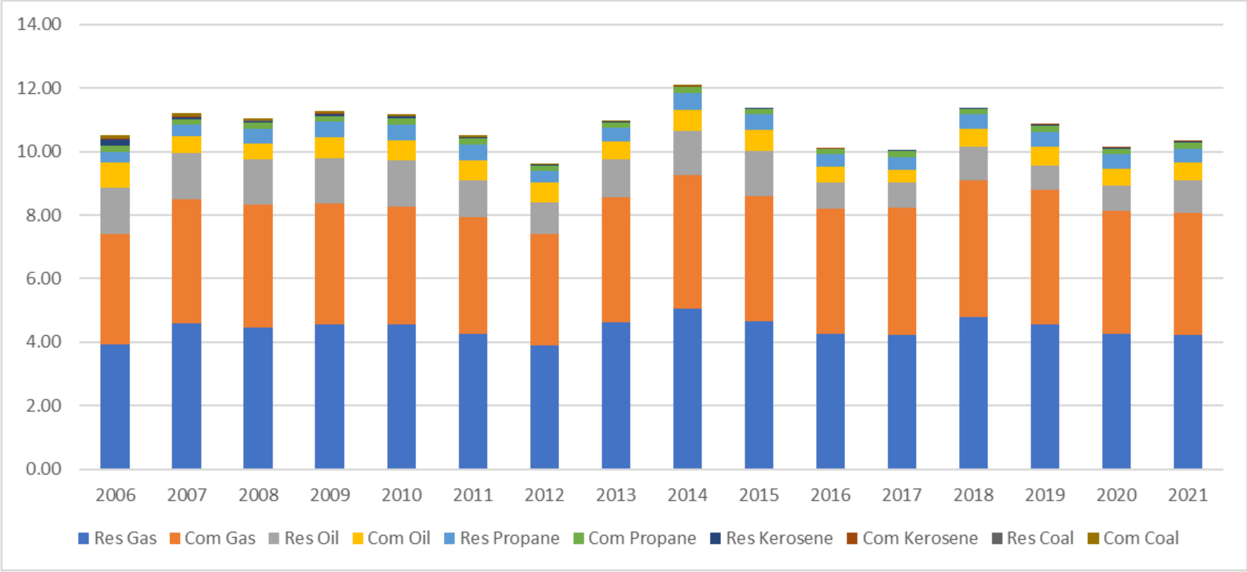
Figure 2: Change in Consumption of Different Fossil Fuels in Maryland Building (2006 to 2021)



The trend in historic emissions from buildings in Maryland follows a pattern similar to the pattern of fossil fuel consumption. Figure 3 shows emissions from residential and commercial buildings measured in million metric tons of CO2e (MMTCO2e). In 2006, the base year from which the CSNA goals will be measured, building emissions in the state were about 10.51 MMTCO2e. In 2021, building emissions in the state were 10.31 MMTCO2e, an approximately 2% drop in emissions from the base year.[5]

[5] As previously noted, fossil fuel consumption increased by nearly 1%. The 2% decline in emissions appears to have occurred because the fossil fuels whose consumption increased (e.g., fossil gas and propane) have a lower combustion emissions profile than the fossil fuels whose consumption decreased (e.g., fuel oil, kerosene and coal).

Figure 3: Trends in Maryland Building Emissions (MMTCO2e)



The gap between existing building emissions trends and the proportional reductions from the building sector necessary to meet the CSNA goals is very large. Achieving a 60% emissions reduction from 2006 levels by 2031 from buildings would require emissions to be reduced by 6.31 MMTCO2e. And a 100% reduction in building emissions (meaning zero emissions) by 2045 means a reduction of 10.51 MMTCO2e. Closing the gap between existing building emissions trends and achieving the 2031 and 2045 CSNA goals will require significant and rapid investment and action by the state.

GHG emissions from Maryland buildings have not change appreciably since 2006. Thus, meeting the 2031 and 2045 CSNA goals will require significant and rapid investment and action by the state.

Methodology for Developing Building Emission Reduction Pathways

Pathways Analyzed

In order to illustrate the possible building emissions reduction options in Maryland, we developed two pathways to achieving the CSNA goals. These two pathways are:

1. **An all-electrification scenario**, in which all emissions reductions come from electrifying building end uses along with some energy efficiency investments; and
2. **A biofuels-inclusive scenario**, which is based on a realistic estimate of the maximum amount of biofuels that could be deployed to reduce emissions in buildings in the state, but which still relies primarily on electrification and energy efficiency because of limited availability and cost of biofuel alternatives.[6]

These pathways represent the outer bounds of what we consider to be the likely mix of measures that would be deployed in the state and are useful in understanding the scale at which clean heat standard measures must be implemented to achieve CSNA goals. We would expect a realistic outcome of a clean heat standard to fall in between these two bounds.

The outcomes of the two pathways represent two possible combinations of credit-generating measures that could be installed to achieve CSNA goals.

Overview of Analytical Approach

In order to build the pathways to achieve CSNA goals, we developed an analysis based in an Excel calculator which estimates the emissions reductions that are possible through different combinations of clean heat standard measures. The approach to this analysis included the following steps:

1. Estimate baseline fossil fuel consumption by sector and end use
2. Identify primary clean heat measures applicable to each major sectoral end use
3. Estimate biofuels potential (i.e., measures applicable to all major sectoral end uses)
4. Develop calculator to estimate emissions reduction per measure
5. Develop clean heat measure packages that meet 2031 and 2045 goals

Baseline Fossil Fuel Consumption

The analysis of emissions reduction potential in Maryland is based on building fossil fuel consumption by end use. This allows us to understand what is currently emitted from fossil fuel-burning equipment serving each end use – and then the emissions reduction potential of

[6] Even with maximum achievable potential of biofuels, this pathway achieves about 80% of emissions reductions from electrification and about 20% of emissions from biofuels.

switching to an electric appliance (and for heating, building envelop efficiency improvements) to serve that end use.

In order to establish baseline fossil fuel consumption for buildings in the state, we used the Energy Information Administration's (EIA) State Energy Data System (SEDS) for energy consumption by fuel for residential and commercial buildings in Maryland. [7] We then referenced the EIA's Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS) to determine the proportion of energy by fuel that can be attributed to each end use.[8]

We focused on clean heat measures that would address only fossil gas, fuel oil, and propane, which account for the vast majority of consumption. We also focused only on the most important end uses, including heating, water heating, cooking, and drying.[9] Focusing on these fossil fuels and end uses meant that the analysis accounts for 96% of total emissions. We implicitly assume that the additional emission reductions necessary from other fossil fuels and from miscellaneous end uses would be comparable to those addressed in the analysis. Table 2 displays the baseline fossil fuel consumption for buildings by sector by end use used in the analysis.

[7] https://www.eia.gov/state/seds/seds-data-complete.php?sid=MD#Consumption

[8] While Maryland is included in the South Atlantic region for the RECS and CBECS datasets, we utilized the consumption data for the Mid-Atlantic region to represent Maryland allocations between end uses. This is because Maryland energy consumption per household, which we derived from EIA's SEDS and census data on housing units, was much closer to the RBES Mid-Atlantic region's energy consumption per household. Also, Maryland's climate is much closer to that of the RECS Mid-Atlantic states than to most parts of the RECS South Atlantic region, which extends all the way down to Florida.

[9] We only addressed drying in residential buildings.

Table 2: Maryland Buildings Fossil Fuel Consumption by End Use (TBtu).

Sector	Fuel	Total	Heating	Water Heating	Cooking	Other	Total %
Residential	Natural Gas	79.8	54.9	18.9	0.9	5.1	43.5%
Residential	Fuel Oil	14.1	10.8	2.2	0.0	1.1	7.7%
Residential	Propane	6.8	4.7	1.2	0.3	0.7	3.7%
Residential	Kerosene	0.2	data not available				0.1%
Commercial	Natural Gas	71.7	55.5	4.6	8.1	3.5	39.1%
Commercial	Fuel Oil	7.3	6.3	0.3	0.0	0.7	4.0%
Commercial	Propane	3.4	2.6	0.2	0.4	0.2	1.9%
Commercial	Kerosene	0.1	data not available				0.1%
Total	All	183.4	134.9	27.3	9.6	11.3	
Total %	All		74%	15%	5%	6%	

Our analysis addresses existing buildings and does not account for any increase in emissions from new construction. However, any increase in emissions from new construction is likely to be modest, at least in the short-term, particularly if an all-electric building energy code is adopted. Additionally, our analysis of changes in emissions from existing buildings is based entirely on 2021 consumption levels. We have not adjusted for potential declines in energy consumption due to gradual efficiency improvements in stock of heating, water heating, or other fossil fuel burning equipment. We do not expect those impacts to be significant because times at which existing fossil fuel equipment would naturally turnover or be replaced is also the most natural time for electrification to occur. That limits opportunities for replacing existing fossil equipment with more efficient new fossil equipment.

Per guidance from MDE,[10] increased emissions from electrification are assumed to be addressed in the electric sector. Thus, assumptions about the efficiency of electrification measures do not affect our calculations of building emission reductions. However, the efficiency of electrification measures would affect the amount of load added to and emissions produced by the electric grid,

Any increase in emissions from electrification is assumed to be addressed in the electric sector.

[10] Personal communication with Mark Stewart, June 2023.

as well as customer cost. In that broader, economy-wide context, there would be significant advantages to ensuring that electrification was very efficient – by both promoting the purchase of the most efficient electric appliances and making major investments in improving the efficiency of building envelopes (e.g., insulation upgrades and air sealing).

Clean Heat Measures

The next step in the analysis was to identify a list of measures that could be included in the Maryland clean heat standard. Table 3 displays the measures included in the analysis, broken out by end use. The two pathways include a combination of these measures to attain emissions reductions.

Table 3: Clean Heat Measures Included in Decarbonization Pathways

End Use	Clean Heat Standard Measure
Heating	• Electrification with central air source heat pump (ASHP) • Electrification with ground source heat pump (GSHP) • Weatherization achieving 10% energy reduction (Wx Lite) • Comprehensive weatherization achieving 25% energy reduction (Wx Comprehensive)
Water Heating	• Electrification with heat pump water heater (HPWH)
Cooking	• Residential electrification with induction stoves • Commercial electrification with various electric appliances
Drying	• Residential electrification with Energy Star dryer
All End Uses	• Renewable natural gas (RNG) displacing fossil gas • Biodiesel displacing fuel oil[11]

Regarding electrification via heat pump installations, most Maryland buildings already have forced air heating and/or cooling. We are implicitly assuming that buildings that do not have existing ductwork would add it to enable use of centrally ducted heat pumps. We readily

[11] Note that biodiesel can replace 100% of fuel oil (i.e., a one-for-one replacement) or can be blended with fuel oil (e.g., 20% biodiesel blended with 80% fuel oil – or what is commonly called b20). The number of clean heat credits that could be earned by biodiesel would be a function of how much fossil fuel they displace. A 100% displacement would earn five times as many credits as b20.

acknowledge that is an over-simplification of how electrification would occur. Some Maryland buildings that currently do not have ductwork (e.g., those heated with boilers and hydronic distribution systems and with only window air conditioning) would undoubtedly find it more practical or economic to electrify using ductless mini-split heat pumps, new window heat pumps, air-to-water heat pumps and/or networked geothermal systems. However, those alternatives to centrally ducted heat pumps are likely to be deployed in relatively modest numbers. Moreover, accounting for that diversity of heating electrification options would not significantly change the nature of our decarbonization pathways.[12]

Additionally, some buildings will not be able to easily accommodate heat pump water heaters, because of space or other constraints, and would instead require electric resistance water heaters if they were to electrify. This would not affect our estimates of the number of homes or businesses that would need to electrify their water heating to meet the state's emission reduction goals. However, it would have a small effect on the magnitude of the increase in grid emissions and customer energy costs.[13]

Biofuels Potential

For the pathway that includes biofuels, EFG estimated potential for biomethane to displace fossil gas and for biodiesel to displace fuel oil. Though it may be possible for a biofuel alternative to propane to emerge, we did not address that potential.

Biomethane

We based our estimate of the annual potential for biomethane on a 2019 study by ICF for the American Gas Foundation.[14] That study provided low and high estimates of potential future biogas production from eight different sources, four from anaerobic digestion (landfill gas, animal manure, water resource recovery facilities and food waste) and four via thermal

[12] One possible exception would be in a scenario in which there is significant commitment to and investment in roll-out of networked geothermal systems.

[13] Consider a scenario in which all of the ~1.1 million Maryland households that burn fossil fuels for water heating were to electrify that end use by 2045. Annual electricity sales in the state would be about 340 GWh greater if 10% of those homes had to install an electric resistance water heater instead of a much more efficient heat pump water heater. That 340 GWh increase is less than 1% of Maryland's current annual electricity sales.

[14] ICF, Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment, prepared for the American Gas Foundation, December 2019.

gasification (agriculture residue, forest residue, energy crops and municipal solid waste). The study provided national and state-by-state estimates of potential.

We based our estimates of potential available RNG to Maryland on the state's biogas production potential. ICF estimated that Maryland's annual production potential could be between 17.6 and 35.1 TBtus by 2040. We then assume that since industrial customers use 9% of the fossil gas currently consumed by residential, commercial and industrial customers in the state,[15] only 91% of the Maryland biogas production potential would be available for use in the residential and commercial sectors. That translates to a range of 16.0 to 31.9 Tbtu/year in 2040. We use the average of those two values, or 24.0 Tbtus, for estimated potential for 2045. That is equivalent to 15.8% of the 151.5 Tbtus of fossil gas that was consumed in the residential and commercial sectors in Maryland in 2021. The ICF study did not provide state-by-state biogas potential estimates for any years other than 2040. However, it did estimate that the national potential in 2030 would be 55-60% of 2040 potential in the low resource potential scenario and 40-45% of 2040 potential in the high resource potential scenario. We applied those ratios to the 2040 production potential for Maryland to estimated annual biogas potential of 11.3 Tbtu in 2031 – equivalent to 7.4% of 2021 fossil gas consumption in Maryland buildings.

We assume the maximum potential of RNG to be 7.4% of current fossil gas use in Maryland's residential and commercial buildings by 2031 and 15.8% by 2045.

There are several important caveats to note about these estimates:

- **Biogas sales will not be constrained by state borders**. Maryland could potentially access biogas produced in other states. The "flip side" of that point is that other states could also access biogas produced in Maryland. Thus, we have used Maryland biogas production potential as a simple *proxy* for the total amount of biogas that the state could access. We also considered an alternative approach of basing Maryland's future access to biogas on the state's share of national biogas potential, with the state's share based on its portion (i.e., a little more than 1%) of national gas consumption by

[15] Based on U.S. Energy Information Administration data.

residential, commercial and industrial customers. The result of that approach is an estimate of biogas assumed to be available to Maryland residential and commercial customers that is equal to about 6.8% of current natural consumption by 2031 and 15.0% by 2045 – both only slightly lower than the estimates based just on Maryland biogas production potential. This gave us comfort that our estimates are at least within a reasonable range.

- **The industrial sector may need more than its proportional share of biogas**. One could reasonably argue that the industrial sector should be assumed to be allocated more than its proportional share of available biogas because it is much more difficult (if not impractical) to electrify portions of the industrial sector than to electrify residential and commercial buildings. In that regard, our estimates of biogas available to Maryland buildings could be considered to be high.
- **ICF study estimates of biogas potential have been critiqued for being unreasonably high**. Much of the concern focuses on the potential for some of the sources of biogas to create other environmental or social harms. For example, accessing forest product residues for thermal gasification can itself be energy intensive. Growing energy crops can drive up prices for food by competing for good land. There are also potential concerns that markets for RNG from livestock manure could increase the economic viability of concentrated animal feeding operations (CAFOs), which often create water pollution problems. One analysis that highlights these concerns suggested that only about 60% of the RNG potential identified in the ICF study is appropriate to use.[16]

In sum, our estimate of potential future Maryland biogas consumption potential is likely to be optimistic, even though we based our estimates of biogas potential on the average of ICF's low and high resource potential scenarios (rather than just the high estimate). However, we are comfortable using those estimates in the context of an analysis of two pathways that are designed to represent opposite ends of the spectrum of what is possible.

Biodiesel

We are unaware of any basis for a limiting assumption about the potential availability of biodiesel to displace use of fuel oil in residential and commercial buildings. However, our past

[16] Borgeson, M. (June 2020). A Pipe Dream or Climate Solution? The Opportunities and Limits of Biogas and Synthetic Gas to Replace Fossil Gas. Natural Resources Defense Council. https://www.nrdc.org/sites/default/files/pipe-dream-climate-solution-bio-synthetic-gas-ib.pdf

analyses suggest that it is likely to be very cost-effective for fuel oil customers to electrify. That, in turn, led us to conclude that it would be reasonable to define a more biofuel focused pathway as displacing no more than 25% of current fuel oil consumption with biodiesel by 2031 and no more than 50% by 2045.[17]

Biofuels Emissions Profiles

There are compelling reasons to require consideration of lifecycle emissions from biofuels under a Clean Heat Standard, even if state policy focuses on reducing combustion emissions from fossil fuels. First, biofuels do not actually reduce GHG emissions from combustion. A molecule of biomethane burned in a furnace produces the same amount of carbon dioxide as a molecule of fossil methane burned in the same furnace. Biofuels only reduce emissions to the extent that their combustion avoids other greenhouse gas emissions (e.g., methane that would otherwise be released to the atmosphere). Second, the lifecycle emissions of biofuels can vary considerably. For example, some biogas, such as dairy farm methane, produces "negative" lifecycle emissions when burned as a fuel. That is, the lifecycle emission reductions resulting from the capture of dairy farm methane have a greater beneficial impact than the complete elimination of combustion emissions of the fossil methane it displaces. Other biofuels (e.g., thermal gasification of agriculture residues, forest produce residues and energy crops) can have lifecycle emissions rates that effectively offset only half (or worse) of the greenhouse gas emissions from burning fossil fuels. Thus, policies that ignore lifecycle emissions and treat all sources of biofuels as zero-emitting may not only fail to achieve desired impacts on the global climate, but will also fail to recognize important

> *There are compelling reasons to require consideration of lifecycle emissions from biofuels under a Clean Heat Standard, even if state policy focuses on reducing combustion emissions from fossil fuels.*

[17] We make no assumptions about how this biodiesel might be deployed – e.g., whether it is used to completely displace fossil fuel oil in some buildings (b100), used to displace 5% of fuel oil use in some buildings when burned as a 5% blend with 95% fossil fuel oil (b5), or used in any other blending ratios (b10, b20, b50, etc.) in some buildings. We simply identify the total amount of biodiesel that is assumed to be burned in a clean heat scenario. As noted above, the number of clean heat credits that could be earned from biodiesel would be a function of how much fossil fuel oil it displaces (as well as its own emissions profile). Selling b100 to a home or business would generate more clean heat credits than burning b5, b10 or b20.

emissions differences between biofuel sources and therefore fail to more heavily promote those that are best for the climate.[18]

That all said, our analysis addresses only combustion emissions from fossil fuels and the biofuels that could replace them. The reason is three-fold: (1) the goal of our analysis was to provide only a high-level assessment of building emission reduction needs and pathways; (2) estimating lifecycle emissions is complicated; and (3) since the role biofuels can play in reducing building emissions is modest even under optimistic assumptions, the added value associated with estimating lifecycle emissions for the purpose of this study was limited. Lifecycle emissions can vary considerably not only based on the type of resource, but also on the distance the biofuel must be moved and even the details of the specific facility from which it is produced. Thus, a lifecycle emissions assessment would involve considerably more time and effort than was possible within the scope of work for this project. If Maryland adopts a lifecycle emissions accounting approach to crediting biofuels for GHG reductions, a modest increase in the amount electrification than we have included in our analysis of the biofuels-inclusive pathway would likely be required in order to achieve the state's emission reduction goals.[19]

Emissions Reduction Calculator

We developed an Excel calculator to estimate the emissions reductions that are possible through different combinations of clean heat standard measures in the two pathways. The calculator uses the baseline consumption for each measure for each of the ends uses for each of the three fossil fuels incorporated in the analysis. We were then able to calculate an estimate of the emissions reduction that each of the clean heat measures would produce.

For the residential sector, we estimated emissions reductions per measure per average Maryland housing unit. We were then able to estimate the number of units of equipment needing to be installed to hit the CNSA goals. For the commercial sector, our analysis was a top-

[18] This discussion addressed only greenhouse gases. Burning of biofuels also produces emissions of other pollutants such as nitrous oxides (NOx), particulates, and hydrocarbons other than carbon dioxide. Thus, even if lifecycle GHG emissions accounting is used to ensure an "apples-to-apples" treatment of contributions to climate goals by biofuels and electrification, there may be disparities in other environmental attributes of these two sets of potential clean heat measures.

[19] We would expect the average lifecycle emission reductions from biofuels to be less than complete offsetting of emissions from the fossil fuels that they would displace. It is difficult to say how much less. The answer will ultimately depend on the mix of sources of RNG and biodiesel.

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down approach. We used the total statewide commercial energy consumption per end use, by fuel, and calculated total emissions attributable to each end use. Instead of estimating the number of units of equipment (as in the residential sector), we calculated the percentage of energy – for each end use for each fuel – that would need to be converted to each clean heat measure to hit the CNSA goals.

We then included an adjustment in the calculator to address interactive effects between measures so as not to double-count emissions reductions. For example, we accounted for the interaction between weatherization, which would reduce energy needs – and therefore emissions reduction potential – and electrification equipment, so that the same emissions reductions were not counted in both measures. We also adjusted for interactions between weatherization and biofuels.[20]

Emissions calculated in the analysis were carbon dioxide equivalent (CO2e), and included carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). Emissions factors for each GHG gas were taken from the Environmental Protection Agency (EPA).[21] Per guidance from MDE,[22] emissions were calculated using a 20-year global warming potential (GWP). Additionally, the analysis focused solely on combustion emissions and did not consider full lifecycle emissions.

As previously noted, our analysis did not address any increases in emissions on the grid that may result from electrification measures. This is because we are expecting that emissions from the electric sector will be achieved through policies and actions taken to address that sector specifically and will happen independently of a clean heat standard for buildings. The implications of this are that electrification measures achieve full emissions reductions of a fossil fuel use in a building, making electrification measures very effective at reducing emissions. If the emissions reduction credit assigned to clean heat measures netted out increases in grid, the

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[20] We assume weatherization occurs randomly across the population of buildings. For example, if 50% of homes were assumed to have electrified space heating in a given year and the equivalent of an additional 10% were assumed to have completely switched to biofuels, then we assumed that only 40% of the weatherization measures were producing emission reductions in that year (another 50% were reducing the cost of electrification and another 10% were reducing the cost of the biofuels conversion).

[21] https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Annex-6-Additional-Information.pdf

[22] Personal communication with Mark Stewart, June 2023.

percentages of buildings that must implement clean heat standard measures to meet the CNSA goals – at least the 2031 target – would be higher.

Developing Clean Heat Measure Packages to Meet 2031 and 2045 Goals

The next step in developing the analysis was to establish the emissions reductions necessary to hit the CSNA goals. As mentioned previously, because we focused the analysis on a subset of fossil fuels and end uses, the analysis accounts for only about 96% of total emissions from the state. We focused on achieving the CNSA goals based on this subset of emissions. Using the 96% of emissions total, the emissions reductions necessary is about 5.9 MMTCO2e in 2031 and 9.9 MMTCO2e in 2045.

After establishing the emissions reductions targets, we determined the percentages of buildings that must implement each clean heat standard measure to meet the goals. These percentages were based on professional judgement and were grounded in the maximum number of possible units, based on the number of households per fuel type for residential and the total statewide energy consumption (MMBtu) for commercial.[23]

Resulting Illustrative Pathways

After incorporating the fossil fuel baseline emissions and the resulting emissions reduction potential from each clean heat standard measure, we were able to determine the level of adoption for the mix of measures for both pathways that achieve the CNSA goals for 2031 and 2045. Table 4 displays the results of the analysis as the percentage of buildings that would need each measure to be installed to reach the CNSA goals.

[23] Number of households by fuel type was taken from the American Community Survey (ACS 1-Year Estimates Public Use Microdata Sample 2021). Total statewide energy consumption for the commercial sector was taken from https://www.eia.gov/consumption/commercial/data/2018/.

Table 4: Percentage of Buildings Currently Using Fossil Fuels that Need to Install Clean Heat Measures to Achieve 2031 and 2045 Emission Reduction Goals

Sector and Measure	% of Buildings with Measure			
	2031 Electrification Pathway	2031 Electrification + Biofuels Pathway	2045 Electrification Pathway	2045 Electrification + Biofuels Pathway
Residential				
Air Source Heat Pump	50%	40%	90%	75%
Ground Source Heat Pump	5%	4%	10%	8%
Heat Pump Water Heater	60%	50%	100%	90%
Electric Stove	40%	30%	100%	90%
Electric Dryer	40%	30%	100%	100%
Weatherization (lite)	15%	15%	40%	40%
Weatherization (comprehensive)	20%	20%	40%	40%
Commercial				
Air Source Heat Pump	50%	40%	80%	50%
Ground Source Heat Pump	12%	10%	20%	12%
Heat Pump Water Heater	60%	40%	100%	75%
Electric Cooking	50%	25%	100%	75%
Weatherization (lite)	15%	15%	35%	30%
Weatherization (comprehensive)	15%	15%	35%	30%
Biofuels				
Renewable Gas (RNG) % of Fossil Gas	0%	7%	0%	16%
Biodiesel % of Fuel Oil	0%	30%	0%	50%
% of CO2e Reductions	0%	18%	0%	21%
Results				
CO2e Reductions	5,927,010	5,934,241	9,891,195	9,909,632
CO2e Goals	5,934,717	5,934,717	9,891,195	9,891,195
Reduction % of Goals	99.9%	100.0%	100.0%	100.2%

A major takeaway from the results presented in Table 4 is the scale at which the clean heat measures would need to be deployed to reach the CNSA goals. To reach the 2031 goal, a significant percentage of buildings would need to adopt the measures in just eight years. And to reach the 2045 goal, close to 100% of buildings would need to electrify water heating, cooking, and drying, and 75% of buildings would need to install an air source heat pump. Substantial deployment of electrification and weatherization measures is required in both pathways, particularly in the 100% electrification pathway.

It's important to note that these measure penetrations are not analytically optimized, but rather are informed by experience with more detailed modeling work in other states as well as the reality of the end uses dominating fossil fuel use in and emissions from Maryland buildings. For example, while one could shift emphasis from space heating electrification to other measures, one cannot do much of that because of how dominant space heating is. Alternatively, because cooking consumption is relatively low, you could accommodate zero electrification of that end use by increasing space heating electrification only a few percentage points. However, the customer economics would likely lead to relatively similar percentages of end use electrification because of the value to customers of getting off gas fixed charges (which is only possible with full electrification).

Conclusions

Achieving Maryland's CSNA emission reduction goals from residential and commercial buildings will require significant deployment of a range of clean heat measures. Our analysis shows that there will need to be a significant shift to electrification of end uses in either pathway. Even in the electrification + biofuels pathway, which maximizes biofuel use, about 80% of emissions reductions come from electrification. The amount of electrification required in either pathway will result in changes to the electric grid that we have not addressed in this report. However, other studies have suggested that, though there will be some challenges associated with those changes, they can be manageable.

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Getting to a 60% reduction in emissions from buildings by 2031 will be particularly challenging given the short time period the state will have to achieve this near-term goal. The challenge is so great that Maryland may need to consider the use of biofuels in the near-term, even if 100% electrification is preferred in the long-term.

Energy efficiency can play a role in reducing emissions in the near term, but that role declines quickly over time. There are several reasons for this. First, we assume that weatherization will only achieve an average of 25% heating load reductions. Second, there are practical limits to how quickly weatherization can be accelerated. Third, and probably most importantly, as electrification proceeds, weatherization will affect emissions from electricity consumption rather than from buildings. The same is true if buildings rely on biofuels. This is not to say that building envelope improvements are not important. Indeed, decarbonization studies typically suggest that they are extremely important. However, their importance in the long-run is primarily in reducing the cost of the transition to electrification and/or biofuels – potentially quite substantially – rather than in direct emission reductions. Those cost reductions may be vital to ensuring that energy bills are affordable, particularly for lower income households.

Energy efficiency can play a role in reducing emissions in the near term. In the longer term, as the building stock electrifies and/or switches to biofuels, efficiency investments provide less direct emission reductions, but are critical to keeping the cost of the energy transition affordable, particularly for lower income households.