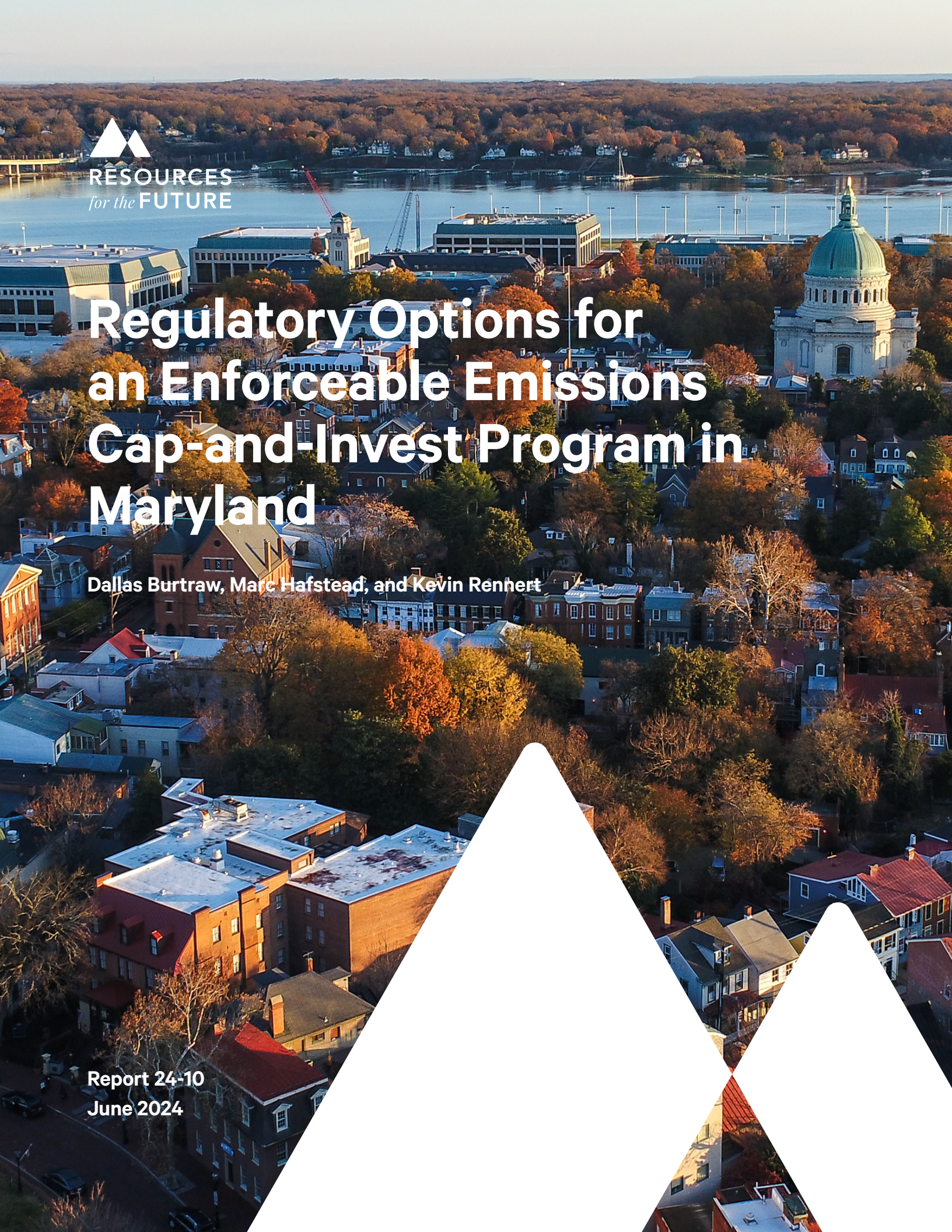

RESOURCES *for the* FUTURE

Regulatory Options for an Enforceable Emissions Cap-and-Invest Program in Maryland

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About the Authors

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1. Cap-and-Invest in the Context of Maryland's Emissions Reduction Goals

Climate change is the defining environmental problem of our time. Recent assessment reports from the **Intergovernmental Panel on Climate Change** and the **US government** have highlighted the urgency of reducing greenhouse gas (GHG) emissions to net zero (and beyond) in the next few decades to avoid the most catastrophic effects of climate change.

Eliminating GHG emissions throughout the global economy will entail comprehensive actions to reshape society's approach to producing and using energy. Shifting to complete reliance on low- and zero-emissions sources of energy will require substantial investments in technology and infrastructure. Such investments could simultaneously drive economic growth and deliver environmental benefits in disproportionately impacted communities.[1] Accomplishing a rapid energy transition—and doing so in a way that seizes the economic opportunity of that transition —will require a supportive policy framework.

The state of Maryland has already taken significant policy steps to guide its own transition. Reductions in emissions from the power sector are guided by Maryland's membership in the Regional Greenhouse Gas Initiative (RGGI) and further supported by the state's renewable portfolio standard (RPS). Efforts to address transportation emissions include the forthcoming Advanced Clean Cars II rule, under which the share of zero-emissions vehicles will reach 100 percent of new-vehicle sales by 2035, and the Advanced Clean Truck rule (effective in 2027). Building energy performance standards will require a 20 percent reduction in direct GHG emissions from existing large buildings by 2030, relative to 2025.

Maryland's efforts to reduce emissions also benefit from existing sector-specific federal mitigation policies: for the power sector, tax credits for solar, wind, and other low-carbon generation; for the transportation sector, electric vehicle and sustainable fuel credits, electric vehicle infrastructure investments, and GHG emissions standards for light-, medium-, and heavy-duty vehicles; for the residential sector, energy efficiency home tax credits and other consumer tax credits; and for the industrial sector, incentives for clean hydrogen and carbon capture and storage.

1 We use the term disproportionately impacted communities throughout this report to refer to both overburdened and underserved communities, as defined by Maryland's Climate Solutions Now Act (CSNA).

As required by the Climate Solutions Now Act (CSNA), the Maryland Department of the Environment (MDE) released its Climate Pollution Reduction Plan in December 2023, outlining policy actions to reach the state's ambitious climate goals: reducing GHG emissions by 60 percent from 2006 levels by 2031, achieving 100 percent clean energy by 2035, and reaching net-zero emissions by 2045. Highlights of the plan include the following:

- completing the transition away from coal-fired power plants;
- scaling up renewable infrastructure, including solar, wind, and battery power;
- providing more incentives for consumers to choose electric when they replace vehicles and expanding charging infrastructure;
- advancing energy-efficient retrofitting of 9,000 existing buildings and helping consumers electrify their homes by switching to heat pumps, electric water heaters, and electric appliances; and
- electrifying school buses, transit buses, and government fleet vehicles.

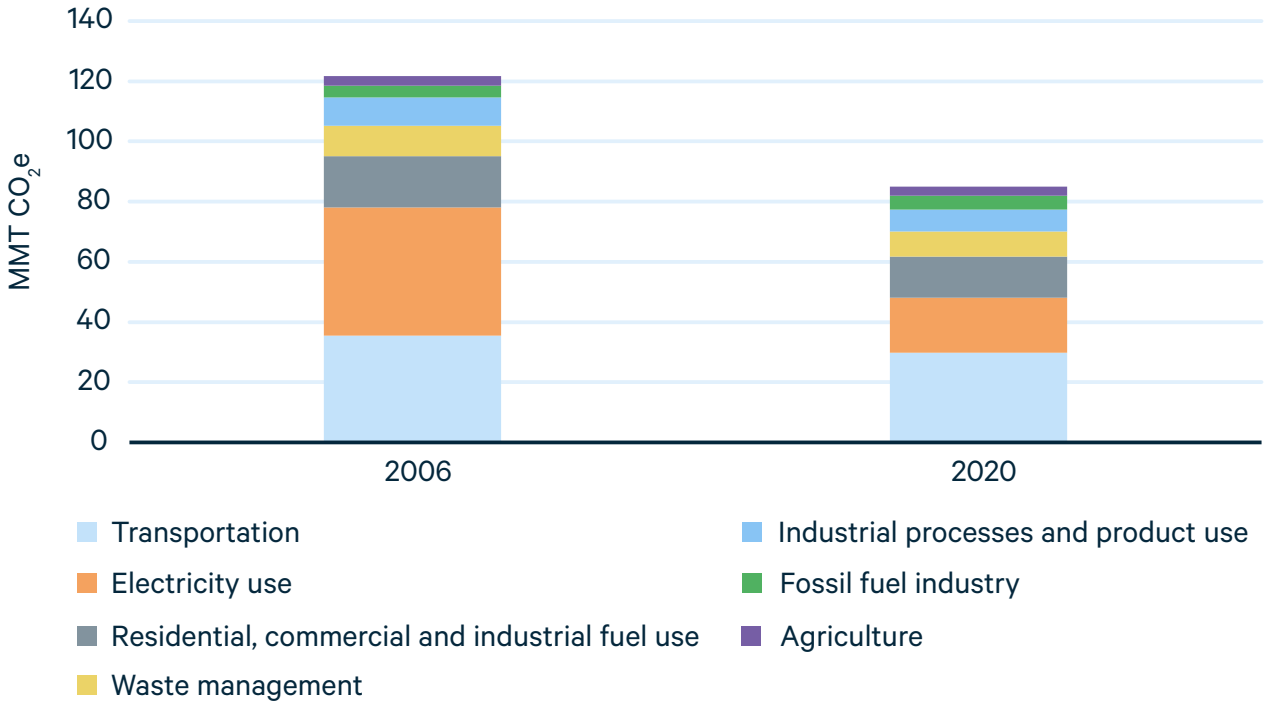
As part of the plan, MDE has committed to explore an economy-wide cap-and-invest program "to complement targeted investments and sectoral standards, while providing a sustainable revenue source for state-funded community investments." The program would aim to drive investments in energy infrastructure that enable reductions in climate pollution, to place a declining cap on such pollution, and to auction emissions allowances to raise proceeds to support program-related goals. The program could prioritize investments in disproportionately impacted communities. Further, it could provide resources to make the transition affordable for businesses and households.

This report outlines options for the design of such an economy-wide cap-and-invest program. We draw on both policy science literature and experience in existing emissions markets. Market-based mechanisms that place a price on emissions are an effective tool to incentivize cost-effective emissions reductions because they give private parties the flexibility to reduce emissions where it is least expensive to do so. An emissions cap boosts confidence that the climate plan goals, and the overall emissions reduction target, will be achieved. Adding the investment framework can provide incentives to leverage federal and private funds to achieve the goals and place equity for small businesses and low- and moderate-income households at the front of the energy transformation. However, in designing this emissions cap-and-invest program, policymakers face many decisions that will influence its fairness, effectiveness, and enforceability.

2. Emissions Sources and Policy Options

In 2006, Maryland's gross GHG emissions were 121.7 million metric tons of carbon dioxide equivalent ($mmtCO_2e$).[2] Between 2006 and 2020, gross GHG emissions in Maryland fell by 36.6 $mmtCO_2e$, to 85.1 $mmtCO_2e$ (Figure 1).[3]

Figure 1. Maryland Gross Emissions, by Source, 2006 and 2020



Between 2006 and 2020, emissions fell across all categories except the fossil fuel industry (the Cove Point LNG facility started exporting natural gas in 2018), with the largest reductions in electricity use emissions coming from in-state generators and imported electricity. More than 66 percent of reductions were associated with electricity, and a majority came from a switch from coal generation to natural gas generation throughout the PJM region.[4]

2 Source: Maryland DOE Greenhouse Gas Inventory. These numbers use AR5 20yr global warming potential as required by the CSNA.

3 Maryland has yet to release a postpandemic Greenhouse Gas Inventory; emissions were most likely higher in 2021 and 2022 than in 2020 as the economy recovered from the pandemic.

4 PJM is a regional transmission organization that coordinates the wholesale electricity market in 13 states and Washington DC, including Maryland.

In June 2023, MDE and the University of Maryland released "Maryland's Climate Pathway,"[5] a study that presented a "pathway to success" to close the emissions reduction shortfall with the CSNA target in 2031 through new policy actions across all sectors. Under this potential pathway, a majority of the additional reductions would come from transportation, electric power, and buildings, along with reductions in methane emissions in the agricultural, waste, and industrial sectors. Central to the proposed pathway was a cap-and-invest program, intended to deliver cost-effective mitigation across sectors.

The suggested sectoral policies include the following:

- expanding the state's RPS to 100 percent clean in-state electricity by 2035;
- strengthening RGGI to achieve zero GHG emissions at the regional level by 2040;
- reducing vehicle miles traveled;
- setting zero-emissions appliance and construction standards;
- strengthening energy efficiency standards;
- creating "Buy Clean" standards; and
- requiring cement plants to switch from coal to alternative fuels, such as natural gas or zero-carbon liquid fuels.

Those proposed sector-specific policies , like most current policies, use mandates or monetary incentives to motivate specific investments and emissions reductions. However, such approaches have multiple drawbacks: they are not designed to ensure emissions outcomes, the layering of policies can lead to policy redundancies, and the costs of reductions can vary widely within or across sectors.

Taking a different approach, the final proposed policy considered in "Maryland's Climate Pathway" is an economy-wide cap-and-invest program that would establish a single price on carbon emissions across sectors. Such a program offers multiple benefits relative to the other policy proposals: it helps ensure emissions outcomes, it provides flexibility in how reductions are achieved, it identifies low-cost emissions reduction opportunities that might be missed by direct regulations, it equalizes the marginal cost of mitigating additional tons of emissions beyond those mitigated through other policies, it encourages energy conservation, and it generates revenues that can be used to offset impacts on low-income and disadvantaged communities and invest in reducing emissions in those communities.[6] Further, a price on GHG emissions through an economy-wide cap-and-invest program can be justified through the "polluter pays" principle: polluters should pay for unabated emissions, and those payments can be used to address inequities from the policy and invest in emissions reduction technologies.

5 Maryland Department of the Environment and University of Maryland Center for Global Sustainability, "Maryland's Climate Pathway" (2023), available at **https://marylandclimatepathways.com/**

6 See RFF's Carbon Pricing Explainer Series, which describes the fundamentals of carbon-pricing policies, for more discussion.

Maryland's Final Climate Pollution Reduction Plan provides an illustrative example of a program in which certain GHG emitters would be required, through regulation, to buy allowances for the emissions they produce. Allowance prices would be determined by a market-based mechanism, and revenue from the sale of allowances would fund investments, as described in the plan.

3. Basic Architecture for a Cap-and-Invest Program

An emissions cap-and-invest program has several essential elements. In this section we consider how to design a strong foundation that can support ambitious emissions reductions.

3.1. Setting the Cap

The emissions cap is the total amount of annual emissions that will be allowed from covered sources collectively. A cap is typically divided into "allowed tons," or "allowances," with each allowance representing one ton. The cap for each year can be scheduled to decline over time to support achievement of the climate policy goal. Covered entities are obligated to surrender one allowance per ton of CO_2 emissions in each compliance period.[7]

Existing programs have used two approaches to determine an emissions cap. One approach might be considered "top-down": it uses information drawn from the statewide emissions inventory that describes the state's total GHG emissions. The emissions cap might be derived from the statewide inventory after subtracting sources that cannot be measured and monitored in real time, such as non-CO_2 emissions from animal feedlots, natural and working lands, and some industrial gases that cannot

7 Most of the state's GHG emissions are carbon dioxide (CO_2), but other gases can contribute importantly to the state's climate impacts, and all GHGs are included in Maryland's emissions inventory. Emissions reduction targets are measured in carbon dioxide equivalent (CO_2e). Measurement and enforcement of non-CO_2 gases, including methane, nitrous oxide, and fluorinated gases, are challenging because these gases may be emitted upstream outside of Maryland in fuel supply networks or on natural and working lands. California's carbon market includes these gases in the state's greenhouse inventory, but they are not covered by cap-and-trade. Methane emissions from sources like landfills, agriculture, and fuel supply operations and industrial gases such as nitrous oxide and fluorinated gases are often regulated through sector-specific programs or targeted regulations. New York State has yet to finalize its program, but it is aiming to account for upstream methane in the fuel supply under its emissions cap. If Maryland decides to account for life cycle and out-of-state emissions associated with fuel consumption in the state, emissions factors can be estimated and associated with the CO_2 emissions from in-state fuel combustion.

be practically covered by emissions pricing. Emissions from such sources must be addressed by other policies and incentives. This is the approach being implemented in New York.

However, a state inventory may not be adequate for cap-and-invest (or regulatory) purposes because some reported emissions may rely on coarse estimates. Often, the entities that report emissions are not the same as the entities that would be regulated. Yet emissions measurement, monitoring, and reporting are critical in a cap-and-invest program—for setting the cap, ensuring transparency and accountability, and underpinning enforceability.

Consequently, the RGGI, California, and the EU ETS take a "bottom-up" approach: they identify emissions sources that can be measured, monitored, and reported, such as energy use in buildings and most industries, power plants, and users of transportation fuels. They then use this set of sources to define the emissions cap. Either a top-down or a bottom-up approach could be feasible in Maryland.

3.2. Covered Entities

A threshold determination in the design of the program is which sources will be covered under the cap. Such determinations are typically based on the characteristics of each source type—for example, whether the number of sources is manageable and whether it is practical to measure, monitor, and report their emissions. Based on these and other characteristics, a large portion of Maryland's emissions could be covered under an enforceable emissions cap.

The largest share of emissions in the state comes from the transportation sector. On-road gasoline use (primarily light-duty vehicles) accounted for 21.6 percent of statewide gross GHG emissions in 2020, and other transportation categories, including on-road diesel, off-road gasoline and diesel, and rail, marine, and aviation fuels, were 13.4 percent. Including these categories under the emissions cap would place the point of regulation on the upstream fuel supply, and most of the cost of the program would be passed down to vehicle operators in fuel prices. Including all of these transportation categories as obligated sources would accelerate the decarbonization of transportation and be especially valuable for the frontline communities exposed to air pollution from Maryland's roads and highways.

Residential and commercial buildings accounted for 12.7 percent of statewide gross GHG emissions in 2020, primarily for heating and cooling of space and water. These emissions also have an environmental justice component because often, lower-income neighborhoods have less efficient buildings and appliances and thus face higher costs and greater exposure (often within buildings) to co-pollutants.

Power plant emissions are already regulated by the RGGI and influenced by state clean energy goals, including the RPS. These sources could be obligated in a state-level emissions cap to address community concerns about local air pollutants, or they might be excluded if the power plants are already firmly on a path to decarbonization. Whether to obligate the emissions embodied in imported power, and if so, how, are questions to consider.

Another potential category for inclusion under the emissions cap is industry. Maryland has a limited number of industrial facilities large enough to be realistically covered under a state-level emissions cap. These facilities were responsible for about 5.3 percent of gross GHG emissions in 2020. Most of those emissions came from two cement facilities, from burning coal for heat and from the chemical process that produces clinker. Except for these cement sources, the CSNA exempts manufacturing from regulations that require GHG emissions reductions or significantly increase costs for the sector. Nonetheless, manufacturing might be incentivized to reduce emissions through free output-based allocation of tradable emissions allowances, or through voluntary opt-in to the program.[8] Output-based allocation, used in California and the European Union, encourages production at in-state facilities by tying free allowances to levels of output (see "Free Allocation and Industrial Competitiveness" in Section 3, below).

3.3. Investment of Allowance Auction Proceeds

Capping emissions from sources covered by the program and requiring the surrender of an allowance for each ton of emissions creates scarcity value for allowances. That value can be distributed into the economy through either auctioning or free allocation of emissions allowances. Although some free allocation may be useful, as discussed elsewhere in this report, the cap-and-invest approach assumes that proceeds from an auction will be directed to accelerate and amplify emissions reductions and other environmental and economic benefits associated with pricing emissions. In addition, auction proceeds can help address distributional concerns if investments are prioritized for households and businesses in disproportionately impacted communities. These investments can also promote job creation and economic growth.

Various approaches have been used to channel auction proceeds to program-related investments. A global summary is produced annually by the International Climate Action Partnership (ICAP 2024).

RGGI was an innovator in the use of auctions when its program launched in 2009, and investment of proceeds is integral to its design. Revenues from its quarterly auctions are returned to the member states and have been invested in energy efficiency (51 percent), direct energy bill assistance (13 percent), beneficial electrification (13 percent), GHG abatement (11 percent), and clean and renewable energy (4 percent). A **RGGI report** finds that through 2021, program investments yielded $1.2 billion in lifetime energy bill savings.

8 Alternatively, the CSNA provision exempting manufacturing could be removed.

Washington State has also adopted an auction-based approach to distributing allowances into the market. That program, launched in 2023, is built on the cap-and-invest strategy.

New York's cap-and-invest program, which has yet to issue a regulatory proposal, currently plans to auction most allowances , with at least 30 percent of the auction proceeds to be directed to a "consumer climate action account" to mitigate any increased energy prices for households. A further amount of auction proceeds—at least 35 percent, with a goal of 40 percent—is planned to be directed to investments that benefit disproportionately impacted communities. State agencies (the New York Energy Research and Development Authority and the Department of Environmental Conservation) commissioned a "**Climate Affordability Study**" released in December 2023 to consider how best to distribute revenues from the Consumer Climate Action Account.

Under California's program, which launched in 2010, about half of the allowances are distributed for free to protect industry and utility ratepayers, and about half are auctioned, with revenues going to the Greenhouse Gas Reduction Fund. The funds are then distributed as California Climate Investments, which support projects that deliver significant environmental, economic, and public health benefits across the state. At least 35 percent of investments from the fund must benefit disadvantaged and low-income communities. As of May 2023, $27 billion in revenue had been raised and $9.8 billion had been invested. More than $7.2 billion had reached disadvantaged and low-income communities.

The European Union, which hosts the world's largest carbon market, has more than a decade of experience in using revenue proceeds from its existing Emissions Trading System, which covers industry and electricity (EU ETS 1), to fund innovation, infrastructure modernization, and additional mitigation efforts. A planned expansion will cover the transportation and building sectors (EU ETS 2) and include the Social Climate Fund, which will manage auction proceeds.

Canada and Austria have implemented redistribution mechanisms, directing almost all allowance revenue back to households for direct financial relief.

How to invest auction proceeds will be an important consideration for Maryland policymakers. Following the experience in other jurisdictions, the state may want to consider input from its agencies about opportunities for infrastructure investments that can unleash private capital for clean economic development. Agencies' information about disproportionately impacted communities can be factored into decisions about where to invest and where direct financial relief might be justified. A stakeholder process can be a valuable component of the ongoing monitoring and evaluation of spending priorities.

3.4. Key Elements in the Administration of the Cap-and-Invest Program

The emissions cap creates substantial economic value in the form of the transferable emissions allowances, elevating the importance of robust and transparent program administration. Policymakers have several issues to consider.

Allowance tracking system. The allowance tracking system is a database that records allowance holdings and compliance. Covered entities in Maryland's electricity sector already have accounts in the RGGI allowance tracking system. The US Environmental Protection Agency has also built tracking systems for other pollutants, such as for sulfur dioxide, that include Maryland entities.

Allowance auction. Allowances can enter the market through sale in an auction or be initially distributed for free. Auctions have multiple benefits. They are an open, transparent, and fair method of distribution. They eliminate the need for the government to make projections and provide multiple opportunities for price discovery each year. They offer a simple mechanism for adjusting the supply of emissions allowances when other regulatory programs and individual actions accelerate emissions reductions (see "Compliance Flexibility," below). They generate revenue that may (or may not be) used to address other objectives of the program. And finally, they avoid the potential for windfall profits to emitting entities (if the value of free allowances exceeds the costs of compliance).

A sealed-bid, uniform-price auction is the preferred design for multi-unit auctions (i.e., auctions for multiple identical items). In all existing programs, the quantity of allowances sold and the market-clearing (uniform) price are revealed after the auction. Programs have varied on whether to reveal the identity and bid price of each auction participant because revealing identity and bids might indirectly reveal proprietary information and possibly affect bidding behavior. Revealing the identity of winning bidders and the quantity each bidder received (at the uniform, market-clearing price) is standard practice.

Various features can help safeguard competition in an allowance auction (Holt et al. 2007). Imposing purchase limits is standard. Purchase limits help mitigate against the exercise of market power both in allowance auctions and in subsequent secondary markets where allowances can be bought and sold on a bilateral basis. Applying lower purchase limits to entities without a compliance obligation provides further protection against market manipulation. In addition, disclosure rules may require auction participants to report for whom they are bidding and disclose any legal associations

with other participants. Another measure to protect competition is a requirement for minimum holding periods for allowances, to limit short-term trades or electronic trading algorithms and associated price volatility.[9]

Distribution of allowances. This element has the largest consequence for the distribution of costs across households and businesses. For a representative household or business, how the emissions allowances are distributed may affect the costs of the program much more than the level of the carbon price (Williams III et al. 2015). Consumers generally see energy prices rise under emissions caps, but if allowances were distributed free to compliance entities, the program would not receive any revenue for compensation or investments and the covered entities would enjoy windfall profits. Existing programs have evolved toward auctioning allowances because the auction generates proceeds that can be directed to related program goals. In some cases, however, some free allocation of allowances has been justified to alleviate costs on businesses and/or prevent covered facilities from allocating production (and emissions) to facilities in states without emissions caps.

Points of obligation. An economy-wide cap-and-invest program should cover as many source types as practical while minimizing the number of obligated entities. Designing the program with relatively few points of compliance greatly reduces administrative complexity. The selection of the point of obligation for each sector is therefore critical.

To the extent practicable, points of regulation that are upstream of the emissions source and/or are already points of compliance for other regulations are preferred. For example, transportation fuels would be regulated not at the service station but upstream in the supply chain. Similarly, buildings could be covered by regulating fuel suppliers. The downstream behavioral response is expected to result from a change in energy prices, plus the influence of program-related investments. Stationary sources could include power plants and industrial facilities that combust fossil fuels if they exceed a minimum size.

Enforcement. Transparency and administrative ease in environmental markets have made enforcement a minor issue. To ensure enforcement, a program needs firm, clear, and unambiguous penalties for noncompliance. The penalty for noncompliance is usually remediation through surrender of allowances at greater than one allowance per ton (typically three to one). Some programs impose an additional financial penalty for delays in compliance.

Trading. Covered entities can procure the allowances needed for compliance directly through the auction process, but trading (buying and selling) emissions allowances

9 Stakeholders may suggest that participation in the auction be limited to obligated parties. That limits liquidity and reduces the number of agents in the market, which can drive noncompetitive behavior. However, accommodation can be made for small bidders and inexperienced parties. Permitting a limited number of allowances (e.g., less than 5 percent) to be auctioned to noncompetitive bidders provides an opportunity for smaller obligated entities to meet their compliance obligation with minimal administrative effort, especially if they initially lack knowledge about emissions reduction opportunities.

within the carbon market provides an additional, flexible way for entities to comply with the regulation. Moreover, it reduces overall costs by channeling mitigation activities to the least-cost opportunities and provides flexibility for individual entities. Trading is sometimes called "where flexibility" because the carbon market does not prescribe where emissions reductions should occur.

Banking. Emissions trading programs with "banking" permit an allowance holder to purchase an allowance in one compliance period and save it for use in a future compliance period. The opportunity to bank emissions allowances provides "when flexibility," enabling covered entities to schedule major investments and operational changes in a way that is least disruptive to business. Programs typically permit an emissions allowance to be used in any year after it was issued, but limits can be imposed to prevent banking over extended periods. Alternatively, programs could apply a discount rate on banked allowances so that the compliance value (tons per allowance) decreases by a certain percentage each year to reduce the incentive to bank allowances. Commensurately, if long-term emissions targets are viewed as credible, this discount provision would cause a steeper allowance price trajectory to achieve that goal.

Banking has important advantages. The bank provides an incentive to quickly identify and capture low-cost emissions reductions, thereby accelerating the pace of emissions reductions and air quality improvements. The bank also creates a constituency within the regulated industry: those who hold emissions allowances in the bank have an incentive to support continuation of the program rather than see their banked allowances become worthless. The bank also contributes to the performance of the market in achieving the emissions reduction goals. In programs without banking, covered entities practiced just-in-time emissions reductions and were not prepared to adjust to weather events, fuel supply disruptions, or regulatory changes.

Program review. A strong foundation for Maryland's program should include flexibility to revise the cap, adjust the supply of allowances, and review performance.

Most programs begin with an interim emissions target and conduct reviews before expanding to net-zero decarbonization. However, Washington and New York states described comprehensive pathways to net zero as part of their authorizing legislation. The European Union ETS recently adopted net-zero goals as well, and California and Quebec are updating their programs with net zero in their sights.

A declining emissions cap can help achieve the program's emissions reduction goals, but various factors can affect that trajectory and invite ongoing evaluation and review. A good program design features a price-responsive allowance supply: when allowance prices are unexpectedly low, an auction price floor and an emissions containment reserve, with price tiers, reduce the supply of allowances and accelerate emissions reductions. Prices might be low because of favorable technology trends, successful sector-specific regulations (state or federal), or investment subsidies (such as those provided by the Inflation Reduction Act). Conversely, if prices rise to unexpectedly high levels, a price-responsive allowance mechanism could inject additional allowances to ease the economic burden of the program while allowing technology to catch up.

The advantage of a price-responsive allowance supply is that it provides instantaneous, rule-based adjustments to the market, something likely to boost the program's efficiency. However, the opportunity for administrative review of the program always exists, and building in a schedule of program reviews or an ongoing review process is likely to enhance the sustainability of the program and engage the regulated community. A revision to the emissions cap may be an output of that process.

The RGGI program aims to conduct program reviews after each three-year compliance period. The process is not codified, and everything is on the table. The review is a stakeholder-oriented process. Adjustments to the emissions cap have always been a central topic, especially because of the large allowance banks that have occasionally accrued. Often, however, the process has taken longer than expected and drawn out the review schedule. This experience has contributed to RGGI's adoption of some automatic program adjustment mechanisms, such as the emissions containment reserve to automatically adjust the cap as an interim measure while the review proceeds.

The California program does not schedule regular reviews of its carbon market, but in practice, reviews have followed the issuance of its five-year scoping plan reports, which provide an overall blueprint of how the state plans to achieve its climate objectives. The last legislative review of the program, in 2017, explicitly authorized the program through 2030. The legislature also created oversight committees to provide annual reports, an independent emissions market advisory committee, and an environmental justice advisory committee. The leading state agency, the Air Resources Board, is currently conducting workshops that are expected to lead to an update of the program based on the most recent (2022) scoping plan.

Sweden's Climate Policy Council reviews progress in the government's overall policies for achieving the national climate goals. The council delivers to the Swedish parliament an annual report that reviews government objectives and how the country's participation in the EU ETS comports with those objectives. The United Kingdom has a similar committee on climate change that advises the government on emissions targets and reports to Parliament on progress.

3.5. Emissions Reductions in Disproportionately Impacted Communities

Some observers have expressed a concern that the flexibility that makes carbon markets more cost-effective than prescriptive regulation may disadvantage already disproportionately impacted communities (Sheats et al. 2023). The "where flexibility" of cap-and-invest means that firms and the market will identify where, and to some extent when, emissions reductions will occur. The least-cost pathway of emissions reductions is not necessarily aligned with emissions reductions in disproportionately impacted communities (Pastor et al. 2022).

Ultimately, all communities can expect to realize environmental improvements (Hernandez-Cortes and Meng 2023), but carbon markets can accommodate an instruction to prioritize emissions reductions in specific situations or communities. For example, a "meet or exceed" standard can require that facilities in disproportionately impacted communities achieve a pace of emissions reductions that is at least as fast as the average for the state (Burtraw and Roy 2023). In addition, auction proceeds from the carbon market can be directed to investments in those communities to accelerate local reductions in fossil fuel use and associated air pollution.

3.6. Interaction with Other Regulations

Cap-and-invest can amplify the effect of other regulatory policies, standards, and subsidies. Pricing carbon offers an advantage in identifying least-cost means of reducing emissions, but regulatory policies have their own advantages for reducing air pollution and promoting new technologies. The cap-and-invest program should take into account the potential for interactions with other policies.

If the program has an inflexible supply of allowances, the emissions cap can also become an emissions "floor," limiting the potential of regulations to reduce emissions beyond the specified level. That is, reductions from other regulations, policy initiatives, community leadership, or even individual actions may reduce emissions at one location, freeing up emissions allowances that can be used at other locations. This "waterbed effect" lowers the price of emissions in the carbon market without reducing emissions beyond those prescribed by the emissions cap.

A remedy to this policy interaction is to have the supply of emissions allowances respond to the market price via a market mechanism. This design can be built into the carbon market through a price-responsive allowance supply: when the auction price falls because of the contribution of other regulations or individual activities, signaling that emissions reductions are less expensive, the allowance supply contracts according to a schedule of quantities and prices. Thus the emissions cap can amplify and accelerate emissions reductions from other regulations. (See the next subsection.)

3.7. Compliance Flexibility

Cap-and-invest programs require caps to be set in advance. However, unexpected changes in economic activity, fuel prices, or other factors can lead to allowance prices that are higher or lower than projected. Prices that are viewed as too high or too low, whether by environmental advocates or covered entities, can threaten the long-term durability of the program. In response, multiple approaches have evolved to introduce compliance flexibility in an attempt to guard against unexpected prices, price volatility, and stability of auction revenue streams.

3.7.1. Price Floor and Emissions Containment Reserve

An adjustment to the allowance supply is naturally accomplished in the auction with a price floor that specifies a minimum acceptable bid. This is generally considered a good feature of auction design and is an element of the four operating North American carbon markets—RGGI, California, Quebec, and Washington. A price floor can be valuable when, for example, other regulatory programs reduce demand for allowances and cause the price to fall. The price floor in the auction ensures that prices will not fall below a specific level. If prices fall to the price floor level, not all allowances will be sold, and fewer emissions will result.

In addition to a price floor, adjustments to the allowance supply can be achieved through an emissions containment reserve (ECR), which is intended to reduce the number of allowances sold at low prices and preserve the incentive for additional emissions reductions when prices are low.[10] Generally, the supply of allowances can have several steps so that when allowance prices fall, the market will accelerate inexpensive emissions reductions. Additional price-responsive supply points, such as one or multiple ECRs, might make various quantities available at different price points to lock in changes in technology and behavior driven by companion efforts outside the carbon market (Burtraw et al. 2022).

Two questions frame the operation of a price floor and ECR:

1. What happens to the allowances that are not issued? Allowances could be held for potential sale in a future auction or added to the APCR. A disadvantage of this approach is that real emissions reductions will not be achieved if the allowances re-enter the market.[11]

2. How are freely distributed allowances affected by a price floor in the auction? In current programs, free allocation of allowances is not affected if a portion of allowances do not sell in the auction. However, freely distributed allowances could be adjusted proportionately during the annual true-up that usually accompanies freely distributed output-based allocation (see "Free Allocation and Industrial Competitiveness," below).

10 RGGI introduced an emissions containment reserve in 2021. The Washington State economy-wide carbon market has a similar mechanism, but it has been suspended while the state is pursuing links with the California and Quebec carbon markets.

11 In RGGI, allowances that do not sell at the price floor are held in reserve, and during previous program reviews these allowances have been canceled. Allowances that do not sell under the ECR are canceled automatically. In California, allowances that do not sell at the price floor are incrementally reintroduced in subsequent auctions after the auction price has cleared above the floor in successive auctions. During legislative reauthorization, remaining unsold allowances were deposited in the allowance price containment reserve, the state's version of a cost containment reserve.

3.7.2. Cost Containment Reserves and a Price Ceiling

To prevent allowance prices that are above a politically acceptable range the program can include a cost containment reserve and/or price ceiling. Economic theory suggests that allowance prices in a carbon market reflect marginal abatement costs, but in practice many other factors also affect prices. For example, energy supply disruptions, regulatory changes, and speculation may also push allowance prices away from the marginal cost of abatement in the short run and introduce price volatility into the market. A good market design would accommodate short-run disruptions while reinforcing long-run expectations of a gradually increasing carbon price that aligns with the marginal costs of reducing emissions across various sectors.

An analog to the emissions containment reserve, which reduces allowance supply when prices are unexpectedly low, is a cost containment reserve (CCR) that injects allowances into the market when prices are unexpectedly high. Market prices may rise if, for example, marginal abatement costs rise because of short-run phenomena, such as fuel supply disruptions. In this case, the CCR can provide resilience to the allowance market while fuel markets readjust and stabilize at long-run equilibrium levels.

As with the price floor and ECR, the operation of a CCR prompts questions.

1. Where do allowances in the CCR come from, and how do they affect the state's overall emissions goals? One approach is to pull forward a quantity of allowances from future years to populate the reserve.[12] This approach involves borrowing from future years but maintains the cumulative emissions reduction target. A second possibility is to supplement the allowance supply with additional allowances from outside the cap.[13] This approach has the disadvantage that it could add to cumulative emissions over time.
2. Which entities should be eligible to acquire CCR allowances? One approach is to limit their availability to compliance entities to ensure that these additional allowances do not fuel incentives for noncompliance entities to capitalize on price movements in the market. This restriction can be achieved naturally by preventing noncompliance entities from bidding higher than a level set just below the CCR trigger price. This would ensure that at high prices, all the allowances in the auction will be available to compliance entities. Further assurance would be provided if allowances sold that come from the reserve are deposited directly in the compliance accounts of compliance entities and thus not bankable or available for sale in the secondary market.[14]

12 This is the approach used in California and Washington State.

13 This approach has been used in the RGGI.

14 These provisions are in effect in California. In addition, compliance entities cannot purchase allowances from the state's price containment reserve if they hold an allowance bank.

3. How should the CCR allowances enter the market? In some programs they are available in a sale separate from the primary auction.[15] However, there are advantages to integrating them into the primary auction by treating the CCR trigger price for the supplemental allowances as a reserve price, analogous to the auction reserve price that sets the price floor.[16] This prevents strategic behavior or cycling of prices between the different allowance sale platforms that are implemented at different times.

Price ceilings are another option to mitigate higher-than-expected allowance prices. Investment of auction proceeds and sector-specific regulations are expected to help manage prices in the long run, but it may take time for these to affect emissions covered by the cap. The overall goal of a price ceiling, at which an unlimited supply of compliance instruments becomes available, is not to become a permanent price in place of the market but to provide buoyancy in the program when prices exceed expectations.

To ensure that the price ceiling does not undermine the functioning of the market in the long run, compliance instruments sold at the price ceiling can be nontransferable and nonbankable, similar to rules that might be applied to the CCR. In this situation, the instruments would be available only for direct compliance, and obligated parties would be eligible to purchase price ceiling compliance units only if their holding of transferable allowances is exhausted.

An important decision is how to use the proceeds from the sale of allowances at the price ceiling. These proceeds could be directed to support investments at obligated sources to accelerate emissions reductions, or they could be used to acquire out-of-market emissions reductions.[17]

3.8. Free Allocation and Industrial Competitiveness

In existing programs, allowances are distributed and enter the market primarily through a revenue-raising auction.[18] However, limited free allocation of allowances to covered entities may be important for program success. Specifically, strategic free allocation to energy-intensive, trade-exposed (EITE) industries may help prevent the

15 This is the California program design.

16 This approach has been used in the RGGI.

17 The California price ceiling enables an unlimited supply of additional compliance instruments, but equivalent emissions reductions must be obtained from outside the market.

18 In RGGI, virtually all allowances are distributed through a revenue-raising auction. In California, approximately half of allowances are distributed through the revenue-raising auction. The allowances distributed for free to electricity and natural gas utilities are consigned to the auction, as we discuss later in this subsection.

relocation of economic activity and emissions out of state ("leakage") and strengthen the environmental integrity of the state's efforts (if these entities are covered under the program).

Carbon markets primarily use "output-based" free allocation: free allowances are distributed based on production decisions in a recent period. If production levels decrease, the allocation is reduced. Hence, firms have an incentive to maintain production. They also have an incentive to take emissions-reducing measures because their eligible allocation is separate from their actual emissions. To achieve this outcome, free allocation is based on an emissions rate performance benchmark (e.g., tons per unit of product) times the level of economic activity (e.g., tons) and a cap reduction factor that describes the annual reduction in the market-wide emissions cap.

Output-based allocation has been mostly successful in the European Union and California in protecting EITE industries. Virtually no leakage for the EU industrial sector is attributable to carbon pricing, and there is some evidence that carbon pricing has spurred innovation and an increase in market share among regulated firms.

In California, **the allocation rate** is a function of facility output, an assistance factor, a benchmark emissions rate, and a cap adjustment factor. The assistance factor reflects GHG emissions leakage risk for individual industrial sectors. The benchmark is the representative GHG emissions per unit of specific product. The cap adjustment factor is the overall annual change in the emissions cap to keep the proportion of free allowances to the overall cap constant. With properly defined units, these factors can be multiplied to determine the annual number of allowances allocated to an industrial facility.

The design parameters for those programs are specific to each geographic context because they depend on the degree of energy intensity for affected industries and their trade exposure. Maryland policymakers will want to gather evidence informing these factors in determining the allocation for regulated industries.

If Maryland's CSNA allows for changes in the benchmark rate for free allocation to EITE compliance entities, the rate can be decided annually, in advance of the allowance auction, leading to a decline in free allocation over time. Alternatively, a cap reduction factor can phase down free allocation in proportion to other sources of allowance supply.

Output-based allocation can be an investment incentive to accelerate decarbonization of industrial facilities. However, free allocation conveys substantial value to the recipient, and to be perceived as fair, the allocation must be transparent. This can be achieved by requiring freely allocated allowances to be consigned to the auction before they can be used for compliance.

Consignment works by designating freely distributed allowances as invalid until the allowances are consigned and sold in the auction, with the proceeds from their sale returned to the original owners (Burtraw and McCormack 2017). Those entities can participate as buyers in the same auction, potentially buying fewer or more allowances than they were given initially.

It is useful for entities receiving free allocation to be brought into the auction because the auction has an important role in price discovery, especially in new and evolving markets. Expanding the supply in the auction by including consigned allowances supports liquidity, ensuring that allowances will be available for new and growing firms in Maryland, and reduces the likelihood of anticompetitive behavior. Also, including consigned allowances in the auction can be expected to strengthen the recognition of allowance value within firms that receive free allocation, leading to improved capital investment decisions.

Consigning freely allocated allowances to the auction also provides a way for rule-based adjustments to allowance supply to be implemented without administrative decisions. The supply of freely distributed allowances can adjust to auction prices in the same way the nominal cap adjusts if prices are at the price floor, resolving one of the questions posed previously (see "Compliance Flexibility," above) . For instance, if the allowance supply were adjusted at the price floor only through changes in the supply of state-owned allowances while the number of freely distributed, consigned allowances was static, then the adjustment would mean a transfer of value to the owners of free allowances and likely a decline in auction proceeds available for investments. To prevent unintended value transfers and to ensure revenues for investments, the price-responsive adjustment to the supply of allowances sold in the auction can be distributed proportionately across all sources of supply, including the freely allocated allowances. This would also reduce variability in auction proceeds, which otherwise would complicate investment planning by the state.

3.9. Emissions Offsets

Emissions offsets generally refer to reduced emissions or increased carbon storage that occurs outside the scope of the compliance market. Some existing programs permit covered entities to use emissions offsets as an alternative to emissions allowances for compliance with the cap to provide cost containment and flexibility. Despite the ample opportunities to reduce emissions from natural and working lands and other sources that cannot be covered by the carbon market because of monitoring and enforcement challenges, these efforts have attracted criticism because it is difficult to establish the validity and permanence of their emissions reductions. Moreover, allowing for out-of-market reductions results in fewer reductions at obligated facilities and fewer related environmental benefits, such as improvements in air quality. As a result, some programs have reduced the availability of offsets for compliance and/or required that offsets provide direct environmental benefits to the carbon market jurisdiction.

Nonetheless, to achieve its economy-wide goals, Maryland will need emissions reductions at sources outside the carbon market, and well-designed offset programs can create incentives for those reductions. The challenge is ensuring that the reductions are valid. California's Air Resources Board partners with Offset Project Registries to "help facilitate the listing, reporting, and verification" of offset projects.[19]

If Maryland decides to disallow offsets for compliance, it could nevertheless incentivize reductions from natural and working lands by designating a portion of auction proceeds for investment in, for example, Department of Natural Resources forestry programs, or for direct procurement of out-of-market reductions, as opposed to crediting those reductions under the emissions cap. The procurement of emissions reductions by the state might ensure greater accountability, and they might be prioritized by their environmental co-benefits. A characteristic of emissions reductions outside the carbon market is that in principle there exist many low-cost opportunities, which might make them a valuable investment. These emissions reductions reduce pressure on the emissions cap in achieving the state's comprehensive emissions reduction target.

3.10. Capitalizing on Federal Support

Federal climate policy has mobilized billions of dollars to accelerate the transition to a decarbonized economy. The Infrastructure Investment and Jobs Act (IIJA) provides $65 billion in transmission infrastructure. The Inflation Reduction Act (IRA) directs an estimated $369 billion toward clean energy investments using an array of incentives: clean energy tax credits, tax credits for carbon capture and storage, incentives for domestic clean tech manufacturing, credits and rebates primarily for low-income households, loan guarantees, and grants to states, communities, rural utilities, and nonprofit organizations.

The federal incentives by themselves are not expected to enable Maryland to achieve the CSNA targets. One reason is that the support for clean energy investments does not provide any incentive to differentiate among emitters that may have substantially different rates of pollution. Energy sector modeling has shown that a cap-and-invest approach, which differentiates among sources and sets an overall emissions limit, can be a powerful complement to tax credits and subsidy programs because it directly penalizes emissions (Domeshek et al. 2024). The combination of a state cap-and-invest program plus the federal initiatives can promote more efficient achievement of Maryland's goals while shifting some of the cost burden to the federal government.

Nonetheless, the billions of federal dollars for clean energy investments do not flow to the state until proactive leadership emerges in the private and public sector. The federal support creates opportunity to finance some of the costs of meeting the state's clean energy goals and to leverage private investment. Importantly, the IRA promises to distribute its own benefits and costs in a progressive way across the income

19 See **https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/about** for more information about California's offset program.

distribution. Thus, to the extent Maryland can promote the use of IRA tax credits to offset some of the costs of decarbonization, this shift will benefit the state's economy and help address concerns about affordability. Moreover, the lower electricity prices that are enabled by federal subsidies will help accelerate the electrification of buildings and transportation.

3.11. Program Launch

Initially, environmental markets often experience high prices as compliance entities adjust to new expectations and begin to develop their emissions abatement plans. Firms with new compliance obligations may have uncertainty about allowance availability, emissions market prices, and their own abatement opportunities. Some firms cannot respond immediately to the new reality of emissions prices, and efficient abatement efforts take time to develop. Short-term changes in economic conditions may have an immediate and sizable effect at the beginning, before firms have acquired an emissions bank. These effects may amplify prices because demand for emissions allowances is likely to be particularly inelastic early in the program. Risk aversion is likely to motivate firms to acquire a buffer of allowances at the launch of the program, which will cause greater demand for allowances that also drives up the allowance price.

Start-up behavior in previous markets has led to initial prices above expected levels, based on marginal costs, before falling to (or below) expected levels in the long run (Burtraw and Keyes 2018). MDE could anticipate a temporary spike and design around it to the extent possible. Cost containment measures (see "Compliance Flexibility," above) can help counter this phenomenon by injecting allowances into the market at specific trigger prices.

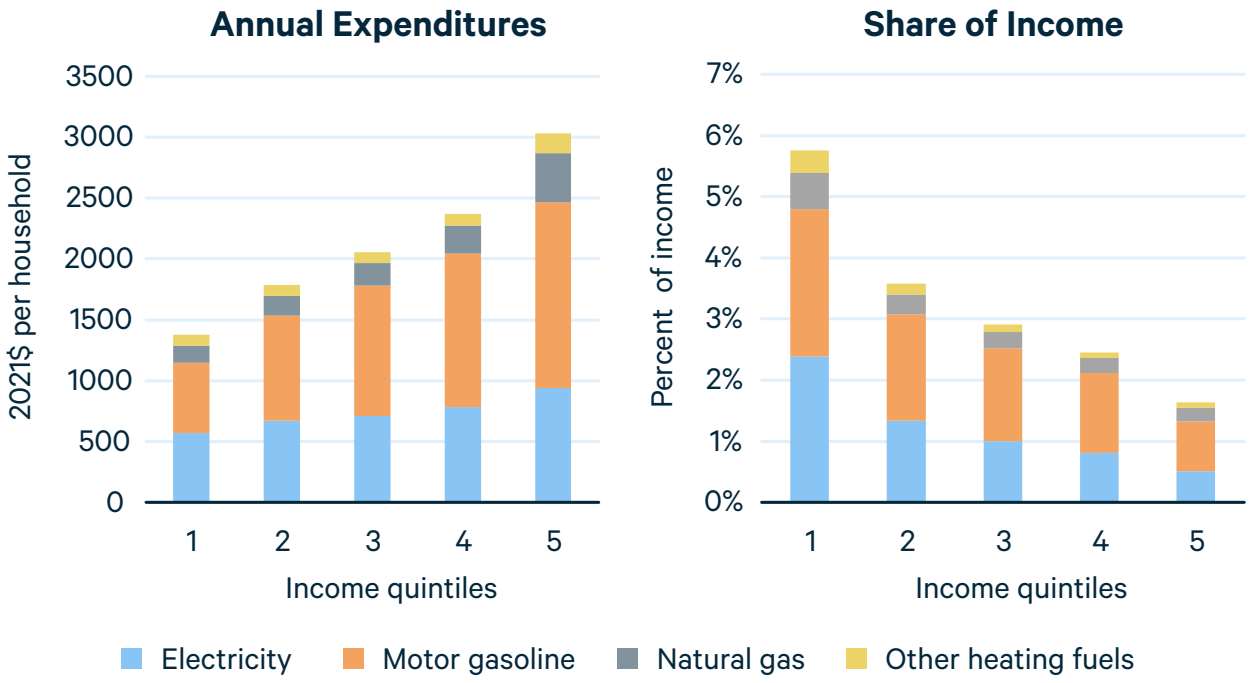
A more generous starting cap that ramps down slowly initially may help moderate prices at the outset of the program and enable entities to accumulate an allowance bank, accepting that a steeper annual reduction in the emissions cap may be necessary in later years to achieve the goals. Conducting an auction for a portion of future-year allowances—for example, a five-year-ahead auction—may help solidify long-run price expectations. These measures may help prevent an early-year price spike by reducing initial compliance costs while still sending the appropriate long-term signals to invest in abatement technologies.

The measures described above could provide important program safeguards; however, using them may undermine the initial credibility and political support for a new program. The allowance bank and the forward sale of future-year allowances may remedy the credibility problem because they vest compliance entities in the longevity of the emissions market. The prospect of linking the Maryland carbon market with other jurisdictions is another factor that could boost the credibility of the program (see Section 6, "Linking with Other Jurisdictions," below).

4. Affordability

The largest fraction of total spending on energy comes from higher-income households, with their larger homes, more vehicles, and more discretionary spending on things like travel (Williams III et al. 2015; Morris and Munnings 2013). In general, however, lower-income households spend a higher proportion of their total expenditures on energy. Figure 2 shows how energy expenditures vary in total dollars and as a fraction of household income across the income distribution in Maryland. All else equal, this distribution of energy expenditures implies that lower-income households will bear a greater financial burden from any increase in energy costs. Further, these households may be less responsive to changes in energy prices because of their limited discretionary resources to make investments to improve efficiency and reduce carbon footprints by, for example, purchasing electric vehicles or installing heat pumps.[20]

Figure 2. Household Energy Expenditures by Fuel across Maryland Income Deciles



Note: Panel A in dollars; Panel B in percentage of income.

20 Low-income households are also more likely to be renters, which introduces an incentive problem: it is the landlord who would invest in energy efficiency, but it is the renters who often pay the energy bills and would realize the savings from energy efficiency investments.

In addition to differences in burdens across income groups, burdens within income groups may also vary because of other household characteristics. For instance, 3 percent of households in Maryland live outside metropolitan areas, and low-income rural households that have long commutes would be more affected by higher gasoline prices than low-income urban households without personal vehicles. Because of data limitations on consumer spending patterns, it is especially difficult to quantify how burdens will vary within income groups. Below (see Section 5, "Sectoral Implementation"), we make rough estimates of the financial effect of carbon pricing on household expenditures for each income group, but the actual effect within each group will vary and depend on the use of auction proceeds and other features of state policy.

The revenues raised from auctioning allowances can be used to relieve low-income households from burdens created by the cap-and-invest program. One option would be to refund some or all revenues to every household in the state. Studies have shown that these "carbon dividends" can fully offset policy-induced increases in energy expenditures for most households.[21] Alternatively, a portion of auction revenues could be dedicated to dividends only to low- and middle-income households, which would preserve more revenues for targeted climate investments.[22] In Section 5, "Sectoral Implementation" (below), we show that only a fraction of expected auction proceeds, directed as dividends to low-income households, would be necessary to insulate them from financial effects.[23] Depending on which sectors are covered under the cap-and-invest program, rebating approximately 12–14 percent of carbon proceeds would keep the average household in the lowest income quintile harmless, and about 28–32 percent would keep average households in the bottom two quintiles harmless.

Concurrently or alternatively, other uses of the revenue could prioritize low-income through program-related investments. For example, proceeds could finance credits and incentives to help low-income households finance zero-emissions appliances and electric vehicles, and complementary investments in low-income communities could make renewable energy, electric vehicle infrastructure, and public transportation more available.

21 In 2017, the US Treasury's Office of Tax Analysis estimated that 70 percent of households would come out ahead from a federal carbon tax if all the revenues were returned in equal shares to each household.

22 For example, the New York Cap-and-Invest (NYCI) program will allocate 30 percent of auction revenues to a Consumer Climate Action Account (CCAA) that will distribute those revenues to primarily low- and middle-income households.

23 In a recent analysis, the New York Department of Environmental Conservation and the New York State Energy Research and Development Authority estimated that millions of state households would break even (at worst) under cap-and-invest with revenues distributed through the Consumer Climate Action Account (the exact distribution of Consumer Climate Action Account funds has yet to be determined and the expenditure methods were meant to be illustrative).

5. Sectoral Implementation

A cap-and-invest program provides equal incentives for cost-effective emissions reductions across sectors, harvesting the greatest emissions reductions where it is less expensive to do so, but it does not equalize actual reductions across sectors. How each sector responds to the market price for emissions allowances will vary, sometimes considerably, and greater levels of investment and technology development and deployment will be required in some sectors to achieve the state's goal for reductions across all sectors. In this section, we discuss the implementation of a cap-and-invest program by sectors and look at potential outcomes in emissions reductions and effects on household groups.

5.1. Transportation

Two decades ago, Maryland's transportation and electricity sectors each accounted for one-third of its total GHG emissions. Electricity sector emissions have since fallen to less than 20 percent of the state's declining emissions total, but the transportation sector still accounts for roughly 35 percent and is solidly the largest source. Most (82 percent) of transportation sector emissions come from on-road vehicles powered by gasoline or diesel.[24] Other transportation emissions sources include airplanes, trains, marine vessels, farm equipment, and construction equipment. Even in the absence of an emissions cap, transportation-related emissions are expected to decline as federal emissions standards for both light-duty and other transportation emissions sources become more stringent.[25]

A cap-and-invest program covering the transportation sector would ensure that regulatory standards that reduce emissions per vehicle mile traveled are translated into durable emissions reductions by instituting an emissions cap across the economy. The emissions cap would prevent backsliding if, for example, fuel prices decrease because of declining demand for fossil fuel. Likely, the program would be aimed primarily at personal transportation in light-duty vehicles and would amplify the emissions reductions expected from federal regulatory standards. Importantly, the cap-and-invest program can help achieve Maryland's climate goals by providing revenue for investments to remove barriers to low-carbon transportation and to ensure equity in the energy transition in the transportation sector.

Federal regulatory standards will affect personal transportation mostly through new-car purchases and the turnover of the vehicle fleet. Maryland has a portfolio of programs to address barriers to decarbonizing its transportation sector. New single-

24 Maryland Department of the Environment, Greenhouse Gas Inventory; available at **https://mde.maryland.gov/programs/air/climatechange/pages/greenhousegasinventory.aspx**.

25 **FACT SHEET: Biden-Harris Administration Proposes New Standards to Protect Public Health that Will Save Consumers Money, and Increase Energy Security | The White House**

family homes, duplexes, and townhouses are required to be ready for electric vehicles. Current access to vehicle chargers is especially limited in lower-income neighborhoods and multifamily units, making ownership of an electric vehicle less convenient in these communities. Dedicated funding from the cap-and-invest program can help the state target the build-out of charging infrastructure to provide equitable access, in line with (or potentially exceeding) the federal **Justice 40** goals. To complement vehicle ownership and help reduce vehicle miles traveled overall, Maryland currently has plans for a "Superuser Bonus" program for frequent users of public transportation. Other state-level investments to decarbonize, improve, and extend the state's public transit fleet can provide a clean alternative to vehicle ownership. Investment in electrified school buses can benefit the most vulnerable populations. The state is also on track to expand bicycle access and promote transit-oriented development.

According to Maryland's Climate Pollution Reduction Plan, many of these and other ambitious transportation initiatives are already launched or in planning. However, the programs depend on a sustained level of funding, which cap-and-invest can provide.

5.1.1. Options for Implementing Cap-and-Invest for Transportation

The entities responsible for surrendering allowances to cover the emissions embedded in transportation fuel is a central administrative feature of a cap-and-invest program. In existing programs, this point of compliance is upstream of the consumer with companies that own and distribute gasoline and diesel fuel at terminals where fuel delivered from oil refineries (via pipeline or oceangoing vessel) is stored, such as can be seen near the Port of Baltimore. These "position holders" tend to be large oil companies, like bp, Exxon, Shell, and Chevron. There can be multiple position holders at one terminal, and the fuel in a single terminal tank is often owned by multiple position holders.

Under an emissions cap program , a common approach is to require the position holder to report the embedded carbon emissions and surrender allowances for the emissions that will ultimately result from combustion of the fuel. For fuel dispensed from storage terminals in Maryland, the accounting would occur when that fuel is pumped from a tank into a tanker truck or rail car destined for sale in the state. The physical mechanism for dispensing fuel at a terminal to distribution trucks is called the "rack"; hence one can refer to the point of regulation as "the terminal rack." Because position holders already account for and report fuel removed from the terminal rack to comply with existing state and federal rules, this is a natural and convenient point to have them account for the emissions from the fuel under a cap-and-invest program.

Regulating position holders at the terminal rack would account for much of the fuel used in Maryland. However, a portion of the state's transportation fuel enters from elsewhere, via tanker truck or rail car, and does not pass through an in-state terminal. If fuel delivered by truck or rail could not be traced to the position holder that dispensed it at an out-of-state terminal, then the owner of the fuel in the truck or rail car could be required to purchase allowances to account for its carbon content. Companies that deliver fuel from out-of-state terminals are sometimes referred to as "enterers."

Another question in the regulation of transportation fuels (and other sources of energy in other sectors, including buildings and electricity) is whether and how emissions throughout the supply chain will be treated. Fuel extraction, transport of the fuel, and refining also generate emissions. However, since Maryland has no oil production or oil refineries, most upstream emissions are likely to occur outside of Maryland, and their magnitude can vary depending on the fuel source. The California carbon market does not account for out-of-state emissions that occur upstream in the supply chain, but the cap-and-invest program under development in New York is expected to account for these emissions.

Finally, the carbon intensity of transportation fuels varies. For gasoline, the carbon intensity depends on the ethanol content. Considerations about upstream emissions include how this variation affects the determination of the overall carbon budget (cap), whether these emissions are observable, and whether compliance is enforceable.

5.1.2. How Are Households Affected by Cap-and-Invest in the Transportation Sector?

All households can expect to see improvements in health resulting from air quality improvements and changes in personal transportation habits, such as walking and use of public transportation.[26] Households experience improved air quality on a regional basis from the introduction of cleaner new cars, and communities adjacent to transportation corridors, which are often low-income communities, will often experience local benefits as well.[27] Climate-friendly investments will amplify these benefits.

Retail gasoline prices depend on many factors, including refinery market power and geopolitics that affect crude oil prices. By requiring upstream fuel companies to submit allowances to cover the carbon emissions embodied in their fuel, the price associated with the carbon intensity of those fuels will be added to other costs of fuels for retail consumers. A rule of thumb is that a $10 per ton carbon price translates into 8 to 10 cents per gallon for retail gasoline at the pump if the full cost is passed through to consumers. It is noteworthy that this addition to the retail price of fuel would be moderate compared with the inter-annual fluctuations of gasoline prices over recent years.

26 TRECH Project Research Update on Health Benefits of TCI Policy Scenarios. **https://www.hsph.harvard.edu/c-change/news/trechstudy/**

27 **Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles - Regulatory Impact Analysis (EPA-420-R-24-004, March 2024)**

Table 1. Household Effects of a $25 Carbon Price on Transportation Fuels in Maryland

Income level	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)
Average annual financial effect (per household)					
	$54	$81	$101	$118	$143
Percent of associated revenue sufficient to offset financial effects					
	11%	16%	20%	24%	29%

The change in fuel prices would affect different households in different ways. To analyze the financial effects across households of a carbon price on transportation fuel use, we use the Resources for the Future Incidence Model which estimates changes in household spending patterns based on expected changes in the price of gasoline and the levels of fuel expenditures and income in 2021.[28] Using the model, we find that allocating 11 percent of the program's transportation-associated revenues through per household rebates would hold the average household in the bottom income quintile harmless from the higher gasoline and diesel fuel prices induced by a $25 allowance price (Table 1); protecting average households in the bottom two quintiles from financial harm would require 27 percent of transportation-associated revenues.

The overall expenditure effects would trend downward over time, reflecting improved fuel efficiency of vehicles, the transition to electric vehicles, and expanded use of alternative transportation. Rebates intended to hold households harmless from the financial effects of the program do not consider the health, safety, and environmental benefits that households may receive from the policy. Moreover, we do not account for fuel savings associated with adjustments to the change in energy prices. One can expect households and businesses to adjust, and therefore these costs may be an overestimate.

28 The model distributes financial effects according to households' original purchase share of those goods over 2010–2016. This means that in the absence of other information, the incidence model replicates existing social distributions of income and expenditures. Other non-transportation goods include non-direct energy goods such as food and services whose costs change due to changes in production costs stemming from changes in transportation fuel prices. The State Energy Demand System (SEDS) provides information for fuel expenditures and the National Income and Product Accounts (NIPA) provides information on income. These shares do not reflect changes in behavior that a carbon price would initiate or the benefits of investments that would accompany the price.

Variation in expenditure patterns across households within an income group means that equal per household rebates would overcompensate some households and undercompensate others in each income group. Low-income households are typically also in the bottom quintile for gasoline spending. Low-income, low-driving households would enjoy health benefits and feel almost no effect on their transportation expenditures, and possibly see a decline in expenditures on public transportation. Generally, in the Northeast and Mid-Atlantic, low-income, high-driving households constitute about 1 percent of all households; they would feel greater effects. These households might be good candidates for public investment incentives to promote clean transportation that would achieve both decarbonization and distributional goals.

New-car purchases are mostly affordable to upper- and middle-income households, positioning them to take advantage of federal and state tax credits for electric vehicles and realize fuel cost savings and substantial overall savings over the life of the vehicle. However, the lifetime financial savings of a new car—especially an electric vehicle—and its comfort and performance advantages are less available to modest-income households because of the high up-front cost.

The next car purchase for households with modest incomes is likely to be a used car. For many low-income households, financial support to purchase a new or used electric vehicle would be essential. Already, Maryland is providing income-graduated rebates for new and used electric vehicles; however, crucial to the success of this initiative is a reliable source of funds that cap-and-invest could provide. Support within the state will also leverage federal support for electric vehicles under the IRA.

5.2. Industry

Emissions from industry are considered hard to abate because current technology for mitigation is limited. In 2020, emissions from Maryland's industrial sector included about 2.7 mmtCO_2e from directly burning fossil fuels, and 1.8 mmtCO_2e from process emissions in the production of cement.[29] Maryland has relatively few large industrial emitters: two cement, one gypsum, one chemical, one LNG, one sugar refining, and one grain elevator facility.[30] These facilities may be subject to competition from producers in neighboring states or international trade partners. Stakeholders worry that the increased costs associated with a carbon price may drive down production at covered facilities (or lead to facility closures), and increased production and its corresponding emissions may increase in other locations, offsetting the emissions reductions achieved in Maryland.

29 Maryland also attributed 4.6 mmtCO_2e to the transportation and distribution of fossil fuels (primarily natural gas) and 5.2 mmtCO_2e of HFC, PFC, and SF6 emissions to the production of ozone-depleting substance substitutes in 2020.

30 Currently, most of the on-site emissions at the LNG facility are covered under RGGI, and Maryland retires allowances on its behalf. The Climate Pollution Reduction Plan suggests revising this provision.

5.2.1. Options for Implementing Cap-and-Invest for Industry

Maryland's industrial sector emissions might be considered for regulation under a cap-and-invest program in one of three ways:

1. Exempt industrial sector emissions from the program entirely (the CSNA specifically exempts manufacturing emissions from regulations requiring emissions reductions, with the exception of cement; see "Covered Entities" in Section 2, above).[31]
2. Designate industrial sector emissions as "nonobligated" sources. Emissions still count toward the overall economy-wide cap, but nonobligated sources are not required to submit emissions allowances. The cap on obligated sources is adjusted for emissions from nonobligated sectors. Under such a scenario, any additional reductions achieved from nonobligated facilities could help relieve the burden of a declining cap on obligated sources. Further, revenues from obligated sources could be used to develop incentives for nonobligated industries to reduce emissions (e.g., through adoption of carbon capture and storage at cement plants).
3. Obligate industrial facilities under the emissions cap with or without the strategic assignment of free allowances to each facility (see "Free Allocation and Industrial Competitiveness" in Section 3, above). Output-based allocation can prevent economic activity from leaving the state and help prevent the leakage of emissions to nearby jurisdictions. However, if these firms are producing other pollutants, the incentive to produce more output (and other pollutants) may not be consistent with efforts to reduce local air pollutants in nearby communities. In this case, output-based allocation could be combined with other regulations targeted to reduce local air pollutants from these facilities.

5.2.2. How Are Households Affected by Cap-and-Invest in the Industrial Sector?

Prices for products produced by the industrial sector are generally set in a national (or international) market and households would probably see little or no effect on the price of goods if industrial sector emissions were covered by a cap-and-invest program.

Households might be affected, however, if coverage of the industrial sector depressed economic activity within Maryland, which could reduce employment opportunities and tax revenues. Policymakers will want to assess the likelihood of industrial dislocation and design the policy to mitigate that. Ultimately, whether to include industrial emissions (with or without allocating free allowances to industrial facilities) may be a political rather than an economic question, since policymakers and other stakeholders need to balance multiple concerns—achieving cost-effective emissions reductions and generating revenues for investment versus potential changes in local economic activity, jobs, and community health.

31 MD HB990 altered the definition of "manufacturing" in the CSNA to allow MDE to regulate emissions associated with cement production. **https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb0990**.

5.3. Buildings

According to Maryland's Greenhouse Gas Inventory, direct fuel use in Maryland buildings accounted for 16 percent of total emissions in 2020. This source of emissions includes fuel used for space and water heating, cooking, and industrial heating processes. Several regulatory programs are already aimed at reducing emissions through energy efficiency improvements, including new building energy codes. Approximately 9,000 large buildings will soon be subject to building performance standards. According to Maryland's Climate Pollution Reduction Plan, current policies will achieve about half of the emissions reductions needed to reach the state's net-zero emissions goal.

Current standards for residential buildings primarily address new construction and typically do not affect existing structures (until time of sale, if ever). A carbon price may incentivize changes in household heating and cooling behavior, turnover of appliances, and adoption of heat pumps (perhaps the primary technology for decarbonizing buildings) in all buildings, not just new ones.

5.3.1. Options for Implementing Cap-and-Invest for Buildings

A carbon price for buildings would be implemented by obligating the upstream provider of fuel—either the natural gas distributor or the distributor of other heating fuels. The proceeds from cap-and-invest may be especially valuable in the building sector for closing the gap beyond what can be achieved by standards for new buildings (potentially applied at time of sale to existing buildings) by providing proceeds to support the transition to heat pumps for space and water heating in existing buildings, both residential and commercial.

5.3.2. How Are Households Affected by Cap-and-Invest for Buildings?

Households with high incomes tend to have larger homes and spend more on home heating than lower-income households. RFF's Incidence Model calculates that, with a $25 allowance price, the average household in the highest income quintile would increase their annual spending on natural gas and other heating fuels 2.5 times more than the average household in the lowest income quintile (Table 2). To compensate for the increase in the price of heating fuels, the average household in the lowest income quintile would require 14 percent of revenues associated with a carbon price on these fuels. To compensate households in the bottom two income quintiles would require 29 percent of the revenues from a carbon price in this sector. Spending on fuel oil is less common and more evenly distributed than spending on natural gas and is also likely to have a different geographic pattern. Households in the top quintile outspend other households on both types of fuel.

Table 2. Household Effects of a $25 Carbon Price on Natural Gas and Other Heating Fuels in Maryland

Income level	Quintile 1 (lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (highest)
Average annual financial effect (per household)					
	$19	$22	$24	$28	$49
Percent of associated revenue for targeted rebates sufficient to offset financial effects					
	14%	15%	17%	20%	34%

The IRA rebates already create opportunities for funding investments in buildings; however, those rebates may not be salient and may not be sufficient to overcome financial barriers for low-income households. The cap-and-invest program could provide additional targeted financial incentives and heighten awareness of the benefits of efficient capital purchase decisions for households and businesses, bringing forward decisions that cannot be reached with direct regulation. Revenues from the cap-and-invest program would enable Maryland to provide incentives for lower-income households, and because appliances cost less than vehicles (with the exception of heat pumps), gains in realizing equity in the energy transition may come quickly by accelerating investments in the building sector.

5.4. Electricity

According to Maryland's Greenhouse Gas Inventory, electricity consumption accounted for 21 percent of the state's GHG emissions in 2020. This share is 40 percent less than the sector's share of total emissions in 2006, reflecting the transition from coal to natural gas, the expanded availability of renewable energy, and energy efficiency improvements in buildings and appliances. Although energy efficiency measures, including building energy codes, are needed to help reduce wasteful energy use, further emissions reductions will hinge primarily on the producer side of the industry. Perhaps paradoxically, decarbonization of other sectors will lead to increased electricity use through the electrification of space and water heating and cooling, as well as the introduction of electric vehicles. Put simply, the clean energy transition will require clean electricity.

Maryland's Climate Pollution Reduction Plan estimates that current policies can reduce emissions in the power sector by almost half by 2030, but they fall short of meeting the state's net-zero goal. The state's RPS helps drive investments in renewable energy, and the state is currently developing a supplemental Clean Power Standard. Maryland participates in RGGI, the regional carbon market for the Mid-Atlantic and Northeast.

RGGI's carbon price creates a disincentive for polluting electricity generation and has helped cut power plant emissions and the emissions intensity of electricity imported to Maryland while delivering billions of dollars' worth of economic benefit through efficiency investments and renewable energy technologies. Nonetheless, the state still imports electricity generated in other states, and participation in the regional PJM power market makes it impractical to enforce limits on the emissions intensity of imported electricity.[32] Given the IRA's new incentives for investment in clean electricity generation, enhanced carbon pricing as part of a state cap-and-invest policy could be especially effective in disincentivizing the continued use of unabated fossil fuels. The IRA also offers incentives for carbon capture and storage, and federal regulations under the Clean Air Act are expected to further reduce the emissions intensity of electricity generation nationally. These policies support regional efforts to reduce the emissions intensity of electricity generation.

5.4.1. Options for Implementing Cap-and-Invest for Electricity

Because Maryland's electricity sector is already subject to a carbon price through RGGI, the inclusion of the electricity sector in a cap-and-invest program hinges on several important considerations. The emissions intensity of electricity generation has fallen regionally as well as in Maryland. Nonetheless, the state does not have the ability to constrain the flow of electricity on the regional power grid from outside the state based on emissions. Hence, actions taken in neighboring jurisdictions will affect the ability of the state to achieve its goals. This perspective argues for continued participation in RGGI to support and promote regional coordination, including with neighboring states that are not in RGGI, as Maryland moves forward with its ambitious goals.

There are several options regarding whether and how to incorporate the electricity sector in a state cap-and-invest program.

1. Exclude the electricity sector from the cap-and-invest program and rely on state clean energy standards and RGGI to regulate emissions. This option will likely not achieve the state's goals unless RGGI adopts more stringent standards and expands within the regional power market.
2. Leave RGGI and cover electricity exclusively under the cap-and-invest program. This approach would undermine the RGGI coalition even as the state needs stronger regional cooperation.
3. Continue to participate in RGGI and also oblige emitters in Maryland to simultaneously participate in the cap-and-invest program. To not disadvantage the electricity sector, a refund equivalent to the RGGI allowance price could be given to emitting electricity generators to align them with the economy-wide price under the state's cap-and-invest program.

32 California and New York are better positioned to regulate the emissions intensity of imported power because their power markets are largely congruent with jurisdictional borders.

5.4.2. How Are Households Affected by Cap-and-Invest for Electricity?

As in the transportation and building sectors, high-income households spend more on electricity than low-income households. However, for a given amount of energy services, such as space and water heating or cooling, electricity use in low-income households is likely to be relatively higher because of these households' older buildings and older appliances. The cap-and-invest program could be valuable in supporting energy efficiency in buildings and the turnover of appliances.

Accelerating electrification of the economy should not drive electricity prices higher relative to other fuels, however. The systematic inclusion of carbon pricing across the economy, including electricity, is expected to encourage electrification because carbon pricing is expected to increase electricity costs less than other fuels (the environmental costs of electricity generation are generally lower than other energy sources used for transportation and home heating; Borenstein and Bushnell 2022). Proceeds from cap-and-invest could be useful in maintaining and enhancing affordability, especially for low-income households.

5.5. Agriculture and Forestry

Roughly 4 percent of the state's emissions are associated with agriculture, with additional emissions associated with forestry and land-use changes. However, agriculture and forestry are generally considered the most challenging sectors to include in a cap-and-invest program because of the difficulty in attributing sources of emissions to specific entities. Instead, these sectors have often been included as providers of emissions offset credits, in which avoided emissions are sold as credits to firms in other sectors and are used to reduce those firms' compliance obligation. When this option is exercised, these offset credits represent cost savings for the program because earning offsets has cost less than reducing emissions in other sectors.

The use of emissions offsets is controversial because of the difficulty of establishing a baseline against which climate-friendly investments should be measured. Observers cannot readily distinguish an incremental beneficial investment from one that would have occurred anyway. Moreover, when practices at one location are adjusted to reduce GHG emissions, the related economic activity often shifts to another location. And the permanence of avoided emissions is often questioned, while actual emissions have long-lasting effects.

5.5.1. Options for Implementing Cap-and-Invest for Agriculture and Forestry

Involving agriculture and forestry in reducing emissions under a comprehensive emissions cap could take any of several approaches.

1. Allow offset credits. This traditional approach requires developing a protocol to ensure that measures are additional to what would have happened anyway and that they lead to permanent emissions reductions. Liability rules must be established for the case where commitments are not fulfilled. Currently, California and Quebec allow the use of offsets in their economy-wide programs. Washington requires that the aggregate emissions cap be reduced when offsets are used by entities for compliance. The European Union and RGGI have phased out a role for offsets.
2. Invest program revenue in the sector. Emissions reductions and carbon sequestration on natural and working lands can support climate goals even when these sectors are not included under the emissions cap. Most analysts see enormous low-cost opportunities for the sector to achieve emissions reductions; the challenge is measurement and enforcement. Hence, a different pathway is to channel a portion of cap-and-invest revenues to investments in out-of-market measures that can be overseen by state agencies and tailored to achieve broad environmental and economic development goals.
3. Include high-emissions subsectors. A focus could be placed on, for example, livestock production (specifically enteric fermentation) and manure management. A carbon price could be imposed on the use of inputs, such as feed or fertilizers. Inclusion of natural and working lands might be achievable in the long term by making dairy operators, farmers, and harvesters responsible for their emissions.

5.5.2. How Are Households Affected by Cap-and-Invest for Agriculture and Forestry?

As with the industrial sector, a carbon price applied to agriculture and forestry could affect the price of goods for households, but generally those prices are set in a national (or international) market. Households would probably see little or no effect on the price of goods stemming from inclusion of the agriculture or forestry sector as part of the cap-and-invest program.

6. Linking with Other Jurisdictions

In the absence of a comprehensive federal program, linking state and regional climate policies, and specifically carbon markets, can provide substantial economic advantages. Foremost is cost-effectiveness stemming from a larger carbon market, which is more likely than a narrow market to identify low-cost emissions reduction opportunities.

A second economic advantage is improved market stability. Fluctuations in renewable resources and fossil fuel supply imply fluctuations in the marginal cost of emissions reductions, which will be reflected in allowance prices. A market with more diverse energy resources covering a larger geographic area will be less susceptible to variations in resource availability, leading to less price volatility in the carbon market, thereby lowering the cost of compliance planning by regulated entities.

Especially at the outset of the program, and whenever fuel markets or economic conditions take a sharp turn, a small market with less liquidity will be less able to adjust. Greater short-term price swings are a likely result. Linking to existing markets and other jurisdictions can mitigate the price fluctuations associated with standing-up a new carbon market.

Linking also provides a mechanism to mitigate leakage of economic activity or emissions to outside the state by aligning the cost of carbon emissions in broader materials and product markets. Linking can create a stronger economic motivation for investments in clean energy and low carbon technology and products by the affected firms.

A related economic benefit is the contribution of a broader market to the formation of the allowance price in the market. Experience in other markets shows that price formation is primarily influenced by expectations among the regulated entities. When the market has credibility, entities are willing to make investments to reduce emissions. Linking with other jurisdictions will augment the state's ability to meet emissions reduction commitments because it will generate greater demand for allowances that are freed up and greater supply for necessary additional allowances, enhancing the credibility of those commitments. And credibility is essential to unleashing private sector capital to make the necessary investments.

Further, linking offers advantages in administrative and policy coordination within the region. Linked programs in the Western Climate Initiative and RGGI share enforcement authorities, auctions, market oversight, and other administrative features. Linking also provides a natural conduit for coordinating investments to reduce emissions on a regional basis. This coordination might be especially valuable for transportation-related investments—for example, for electric vehicle charging along the I-95 corridor. It is also valuable for multistate businesses looking to plan future investments.

Linking may nonetheless trigger concerns that should be addressed at the outset. One is that it may push private investments (and associated emissions reductions to meet Maryland's climate goals) outside the state, reducing new economic opportunities (and their associated environmental benefits) at home. Companion regulatory policies can

ensure that emissions reductions and environmental improvements occur in the state. Regular program review can follow where investments occur.

Another concern is the possibility of the dissolution of a linked carbon market. Policymakers should plan for disruption that might happen from delinking. If one jurisdiction is expected to withdraw from the market, for example, its associated allowances would likely lose value, with implications (and disincentives) for reduced auction proceeds to the jurisdiction. Various proposals to protect the jurisdiction in such a circumstance include retaining the origin of an emissions allowance in transactions, so that different allowances retain different market value depending on the market's assessment of future policy outcomes.

From a broader perspective, the greatest benefit of linking may be not economic but political. Linking Maryland's efforts with other states' programs sends a powerful message to outlier states and to the federal government about the severity of the climate crisis and the glaring need for federal leadership. If Maryland achieved its climate policy goals by itself and no comparable measures were taken in other jurisdictions, the state would indeed profit from economic opportunities and improved environmental outcomes, but progress in addressing the global climate challenge would be limited. Success in addressing climate change hinges in part on broadening the carbon market. Maryland can influence the design of climate policy in other states and nationally by linking its market with other jurisdictions. Such coordination magnifies the influence of state actions and elevates them to the national and international stage.

7. Conclusion

As Maryland considers implementation of an economy-wide cap-and-invest program, it has a wealth of information and experience to draw on, from both the academic literature and the real-world experiences of other states, and its own successful experience in RGGI. In this document we have highlighted best practices, design elements, and other considerations from RGGI and other programs.

The focus of this document has been on the design considerations for the structure of the program. However, the process by which Maryland considers these options and makes its design decisions will be critical to the success and durability of the program. Transparency, with robust public participation and comment, should be integral to the process as Maryland moves forward with the program.

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Abbreviations

CCR	Cost containment reserve
CSNA	Climate Solutions Now Act (Maryland)
ECR	Emissions containment reserve
EITE	Energy intensive and trade exposed
ETS	Emissions Trading System (European Union)
GHG	Greenhouse gas
IIJA	Infrastructure Investment and Jobs Act (federal)
IRA	Inflation Reduction Act (federal)
LNG	Liquefied natural gas
MDE	Maryland Department of the Environment
NIPA	National Income and Product Accounts
PJM	Pennsylvania, New Jersey, and Maryland energy market
RFF	Resources for the Future
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable portfolio standard
SEDS	State Energy Demand System (Maryland)