An Analysis of Impacts on Households at Different Income Levels from Carbon Pollution Pricing in Maryland

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I. Executive Summary

A carbon pricing system in Maryland that includes all fossil fuels and electricity consumption would be intended to substantially reduce the state's emissions of the air pollution that is the primary cause of climate change. At the same time, it would yield about $1.2 billion annually in revenues if the initial price is set at $15 per ton of CO_2 emitted, and $3.5 billion annually at an eventual price of $45 per ton. About half these funds would come from households and half from employers.

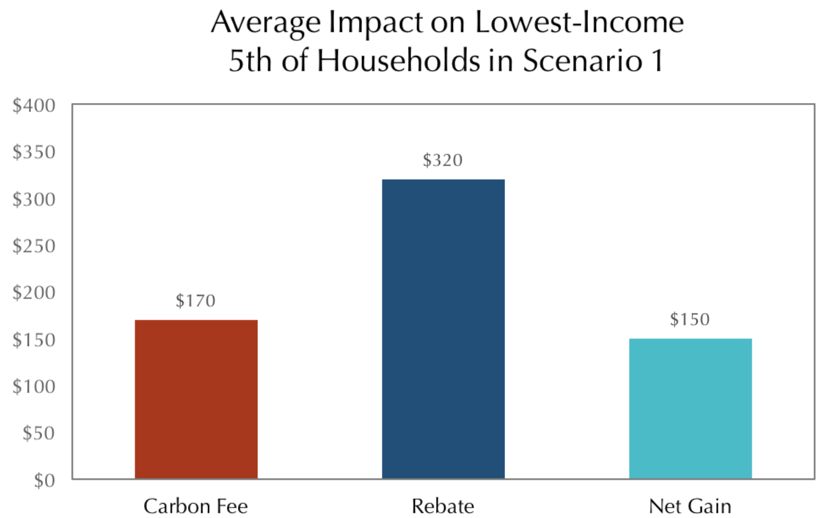
This study examines the impacts on households at different income levels, with an emphasis on low and moderate income people, from carbon fees and rebates in Maryland. Households are divided into fifths of the total, based on income, with the lower 3/5ths regarded as low and moderate income. The study looks at a variety of options for how the revenues could be divided among households, employers, and GHG-reduction programs; and how funds going to households could be divided among those at different income levels and in different circumstances.

There are 12 scenarios in total. In all scenarios larger rebates per person are provided to households with low and moderate incomes than to those with higher incomes. We find that judicious use of the revenues can provide sufficient protection to most households. Vulnerable households can best be protected by providing direct rebates based primarily on number of household members and on income.[1]

Scenario 1, Revenue Distribution: households receive 67.5%, employers receive 22.5%, climate-related investments and transition benefits for workers and communities receive 10%

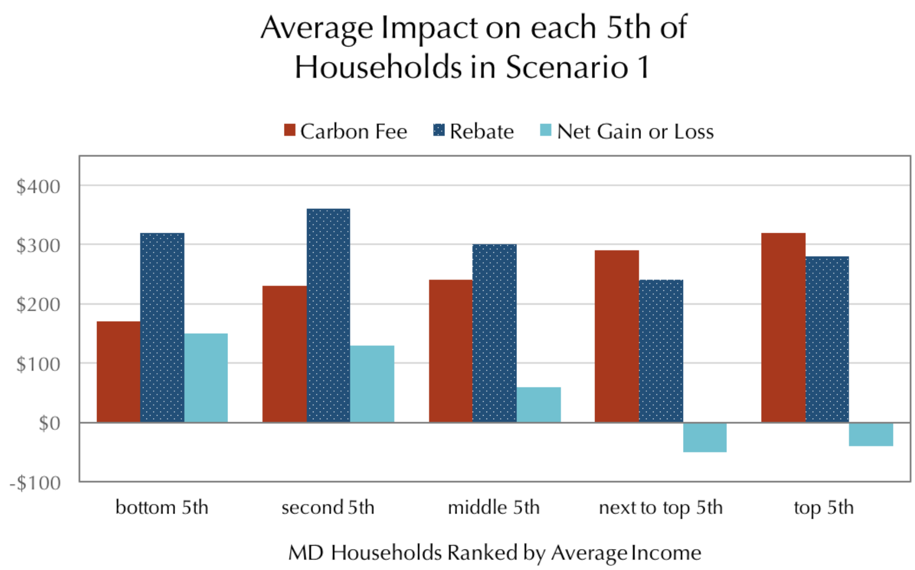
Graphs 1 and 2 below show the impacts from Scenario 1, which devotes these fractions of the total revenues to major spending categories: households (67.5%), employers (22.5%), and climate-related investments along with transition benefits for workers and communities (10%). Graph 1 show the average fees, rebates, and net gains for the lowest-income fifth of households. Because low-income people typically use less energy than higher-income people, and because the policy design provides them with higher rebates per person, **on average these households would have a net gain of about $150 in the first year**, when carbon pollution fees are $15/ton. In year 7, when fees reach their maximum of $45/ton, the fees, rebates, and net gains would each be three times as much.

[1] There are different options for the specific mechanism by which rebates are provided. For example, for those households who pay state income taxes the mechanism could be an income tax credit.



Graph 1 –The average impact of a carbon price on the lowest income families by quintile in Scenario 1

Graph 2 shows the average fees, rebates, and net impacts on each fifth of households. The lower three-fifths, or 60%, of households would on average have net gains, while the top two-fifths would have small net losses of about $50 in year one. The gains exceed the losses because households as a whole receive 67.5% of the overall rebates, larger than their share of the total fees. [2]



Graph 2 – The average impact of a carbon price on all income brackets by quintile in Scenario 1

[2] As is shown in Tables 2 and 3, about half of the revenues would derive from sales to households and half from sales to employers. Returning 60 to 70 percent of the overall total to households means that all households, on average, have a net gain; and makes it possible to ensure that a high fraction of low income households have a net gain.

Variation in energy use among households within the same income category

Energy use varies greatly from one household to another, even when they have similar incomes, due to differences in size and efficiency of homes and amount of driving. As a result, even when the bottom fifth of households (who we term low income in this study) come out ahead on average, a significant fraction of them could have a negative impact. To prevent this result, we distribute the revenues so that there is a substantial gain, on average, for low income households, which leads to only a small fraction having net losses.

To protect a high fraction of low/moderate income households from increases in their living costs, 60% to 70% of the funds need to be returned to households. The higher percentage is needed if the system provides equal rebates to every adult (and half-shares per child), while a lower percentage may be sufficient if smaller rebates are provided to higher-income people and greater rebates to lower-income people, as is done in all the scenarios in this study. Table 10A from full study, below, shows that in Scenario 1 about 85% of low-income households have net gains or come out even), with high fractions of the second and middle fifths also coming out ahead.

Scenario 1 (Table 10A in full study):
Year 1, $15 fee/ton, showing percentages of households with net gains and losses

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$300	$50	60%	40%
bottom 5th	$170	$320	$150	85%	15%
second 5th	$230	$360	$130	80%	20%
middle 5th	$240	$300	$60	70%	30%
next to top 5th	$290	$240	-$50	40%	60%
top 5th	$320	$280	-$40	40%	60%

Additional scenarios

We construct six primary policy scenarios, each at an initial carbon pollution fee rate of $15 per metric ton and with electricity generation being part of the fee system. Scenarios 1, 3, and 5 each place primary emphasis on a different objective, and so one or the other may be preferable to policymakers and the public for that reason. The differences between the chosen scenarios are relatively small, because all attempt to balance protection for low/moderate income households, protection for possibly vulnerable employers, investment in clean energy and resilience to climate change impacts, and transition benefits. Scenarios 3 and 5, that provide greater emphasis on different goals, have the characteristics described below. Detailed numeric results are shown in this summary only for Scenario 1; for the other scenarios see Section VII.

Scenario 3, 20% investment/transition benefits: Raises the percentage of revenues that are used to fund investment programs and transition benefits for workers and communities to 20%; while still balancing the degree of protection provided to low/moderate income households and to employers.

Scenario 5, 15% investment/transition benefits: Maximizes benefits to households while providing a moderate level of investments in programs (15%), which then leaves a moderate level of rebates available for "vulnerable" employers.

Scenarios 1 through 6 all devote 60% to 70% of the funds to households, give higher rebates to lower-income than to higher-income households, give 16% to 22.5% of the total funds to employers, and give 10% to 20% to climate-related investments and transition benefits.

Protection for vulnerable employers

We find that about 20% of the total revenues would be sufficient to protect "vulnerable" employers from the impacts of carbon pollution fees. These include manufacturers who are both energy-intensive and face strict interstate competition; agriculture; relatively small non-profit organizations; and state and local government agencies. Scenario 1 devotes 22.5% of the funds to this purpose. However, this study does not include a detailed examination of each business sector in Maryland, and such a study would be needed to provide more precise results.

Funds for investment in programs that reduce greenhouse gas emissions

The percentages of the funds necessary for households and employers leave 10% to 20% of the revenues available for other purposes. These include programs that reduce greenhouse gas emissions (renewable energy, energy efficiency, clean transportation), increase resilience to climate change, and provide transitional assistance to workers and communities who may face losses due to shrinkage of fossil-fuel related industries.

In Section IX we provide the results for six other scenarios that all parallel Scenarios 1 through 3. Scenarios 7 through 9 exclude electricity generation from the system, while scenarios 10 through 12 include electricity generation and set the carbon fee at $45 per ton, the rate it would reach during year seven, assuming an initial fee of $15 per ton and an annual ramp-up of $5 per ton.

II. Introduction

Climate change, or global warming, is a worldwide crisis. There is widespread recognition that emissions of greenhouse gases must be reduced by at least 80% by 2050 if the climate is to be stabilized. Many U.S. states have adopted goals, targets, or legally-binding requirements to reduce their own emissions. Maryland itself has set a target of reducing emissions 40% below the 2006 level by 2030.[3]

Emissions in some states have already been reduced significantly from their peak levels. But to some degree, these reductions have been achieved through policies and independent circumstances that have utilized "low hanging fruit" – changes in our energy sources and systems that are easiest to achieve. These include, for example, large-scale shifts from coal-fired to natural

[3] "Status Report: What Do We Know About 40 by 30?", Maryland Department of the Environment, June 21, 2017, available at: http:/bit.ly/2FMKjGL; "Maryland sets bolder target for cutting greenhouse gas emissions," Ovetta Wiggins, *Washington Post*, 2/24/16.

gas-fired electric generation; improvements in the fuel efficiency of new automobiles and trucks; more efficient electric appliances; and stricter building codes.

Bringing emissions down by 80% will require much greater efforts. We know how to do so in terms of the necessary technologies – renewable electricity from solar power, wind power and other sources; renewable thermal power; converting most of our transportation and heating energy use to high-efficiency electric systems or other renewable sources; and much more efficient use of energy.

In an age where the cost of fossil fuels remains low, and the cost of natural gas has dropped greatly, it is difficult to identify what mechanism will trigger a societal shift from fossil fuels to carbon neutral alternatives. Carbon pollution pricing – putting fees or taxes (we will use the two words interchangeably in this study) on the burning of fossil fuels in proportion to their emissions – is increasingly seen as the most powerful policy that can yield the necessary shifts throughout all energy-consuming sectors.

Such pricing can be expected, however, to raise the prices of fossil fuels and electricity; in fact that is the primary purpose of the policy. At the same time, it will yield large revenues to those governments which adopt such pricing policies. In order to protect the living standards of households, particularly those with low and moderate incomes, most of the revenue must be returned to them. How to do so, in what amounts to households at different income levels, and in what living circumstances, is the subject of this study.

It is vital to recognize that returning revenues to households does **not** mean that each individual household will receive back exactly what it pays in higher costs for fossil fuels. Such a system would eliminate the incentive to pursue energy efficiency and convert to clean energy technologies. Rather, revenues must be returned on some basis that is unconnected to the exact amount of energy consumed, so that the incentives are retained. We consider allocating revenues on simply a per-person basis, on a basis that distinguishes between adults and minors, with variation according to income levels, and with additional rebates for those in circumstances that cause a need for higher energy use, such as living in a rural area.

Of course, since the goal of carbon pricing is to cut use of fossil fuels, over time the total fees/revenues, rebates, and money available for programs will shrink. Since fees and rebates will change at the same rates this should not cause a problem for households and employers. However, for planning GHG-reduction programs, especially those that require capital investment and long-term planning, such as public transit, it will be important to project how much revenue will be available over time.

III. Fossil fuel energy use, greenhouse gas emissions, and prospective carbon pollution fee revenues in Maryland

Maryland's greenhouse gas emissions (GHG) were about 87 million metric tons (mmtons) in 2014.[4] Of this, about 77 mmtons came from the burning of fossil fuels in the residential, com-

[4] "2014 Greenhouse Gas Emissions Inventory," Maryland Department of the Environment. Downloaded from: http://mde.maryland.gov/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx

mercial, industrial, and transportation sectors, which are most likely to be included, at least initially, in a carbon pricing system. Another 9.7 mmtons came from other sources: GHG gases other than CO_2 used in industrial processes and systems, such as refrigerants and methane leakage; agriculture; and waste combustion. Whether or not to include any or all of these other sources is a topic that the current report will not address.

Within the emissions from fossil fuel combustion, about 41%came from electricity consumption (both in-state generation and electricity imports), 30% from gasoline, 8% from diesel motor fuel, and 20% from heating of buildings and industrial production. Emissions were split about equally between the residential sector and the commercial/industrial sectors, in both cases including use of motor fuels.

Electricity-sector emissions from the commercial and industrial sectors significantly exceeded those from the residential sector. On the other hand, emissions from motor fuels (gasoline and diesel fuel combined) were almost 1/3 greater in the household sector than from commercial/industrial sources. One result of these comparisons is that if carbon fees are **not** imposed on electricity generation, the total emissions from, and fees paid by, households are about 54%t of the total, with employers paying 46%. As will be seen in the detailed impact results shown below, this will shift somewhat the impacts on households at different income levels.

Table 1: 2014 Maryland greenhouse gas emissions by source, million metric tons CO_2 equivalent

	Energy/fuel type					
Economic Sector	**total**	**total not including electricity**	**electricity**	**heating fuels**	**gasoline**	**diesel motor fuel**
Principal GHG sources (fossil fuels)						
Total (residential, commercial, industrial, transportation)	77.1	45.1	32.3	15.6	23.2	6.3
Commercial, industrial	38.4	20.8	17.6	8.7	5.8	6.3
Residential	38.7	24.3	14.4	6.9	17.4	0.0
Transportation			0.3			
% total CO_2 emissions	100.0%	58.5%	41.5%	20.3%	30.1%	8.2%
Other GHG sources						
Total other sources	9.7					
Industrial processes (non-CO_2 gases)	4.8					
Agriculture	1.9					
Waste combustion	3.0					

Based on an initial price of $15/mmton in the first year of operation, a carbon fee system would yield approximately $1.2 billion ($1,160 million) in fees (which become revenues for the state to allocate), assuming that it only covered fossil fuel combustion.

Table 2: Maryland overall carbon fees (revenues) based on 2014 GHG emissions at $15/ton (1st year in policy design used for this study)

Carbon fees principal GHG sources						
Carbon fees $millions at $15/ton	**total**	**total not including electricity**	**elec-tricity**	**building heating, indus-trial**	**gas-oline**	**diesel motor fuel**
Total (residential, commercial, industrial)	$1,157	$677	$479	$235	$348	$95
Commercial, industrial	$576	$312	$264	$131	$87	$95
Residential	$580	$365	$216	$104	$261	$ -
Carbon fees other GHG sources						
total other sources	$145					
Industrial processes	$72					
Agriculture	$28					
Waste combustion	$45					

Once it reached $45 per ton, the initially anticipated maximum price under the legislation, the system would bring in about $3.5 billion. Since the goal of the system is to reduce fossil fuel use, over time this revenue would fall in proportion to how successful the policy is.

Table 3: Maryland overall carbon fees based on 2014 GHG emissions at $45/ton (year 7 after implementation in policy design used in this study)

Carbon fees principal GHG sources						
Carbon fees $mil-lions at $45/ton	**total**	**total not including electric-ity**	**elec-tricity**	**building heating, industrial use (natural gas, heating oil, etc)**	**gaso-line**	**diesel motor fuel**
Total (residen-tial, commercial, industrial)	$3,470	$2,031	$1,438	$704	$1,043	$284
Commercial, indus-trial	$1,729	$937	$792	$392	$261	$284
Residential	$1,741	$1,094	$647	$312	$782	$ -
Carbon fees other GHG sources						
Total other sources	$436					
Industrial pro-cesses	$215					
Agriculture	$85					
Waste combustion	$135					

IV. Should revenues be returned to households via tax cuts or rebates?

Fees on CO_2 emissions will raise costs for fuel importers, whether they are wholesalers, distributors, power generators, or electric and gas utilities. To change the behavior energy suppliers and consumers, the fees must be a substantial percentage of the price of fuels and electricity. Correspondingly, they will also be high enough to impact the living costs of households and the operating costs of businesses, non-profit organizations, and government agencies (collectively termed "employers" here).

Because of these impacts it will be important to offset at least part of the costs to households. Among economists and many public officials, reducing taxes is an often-favored method of returning funds. Economists generally consider tax rates on both workers and owners of capital to be a disincentive to work or to invest in productive businesses. Thus, many economists view using carbon fees to reduce other taxes as providing a "double dividend" to society – both by reducing the impacts of pollution and increasing incentives to expand economic output.

However, if fees are increased on fossil fuels (including those used in electricity generation), this has differential impacts on people at different income levels. For most taxes, people at lower incomes pay a higher fraction of their incomes in the tax than do people at higher incomes, and this is true for most forms of energy.

Examine, for example, Table 4, which divides Maryland households into fifths of the total according to their pre-tax income levels.[5] The poorest fifth of Maryland households pay only 0.5% of total state income taxes and the next-to-lowest fifth pay only 4.4% of the total. These same two income groups pay 6% and 13.5 percent of the state's total personal sales taxes. In contrast, the present study estimates that the bottom fifth (quintile) of households would pay approximately 12% of the total carbon fees collected from fuel sales for household use, and the second quintile would pay 18.6% of the total (see the last line of Table 4). As a result, if a "tax swap" were instituted, by which higher carbon fees were used to reduce the state income tax rate, the bottom 40% of households would come out substantially behind. The same is true, although to a lesser degree, if sales taxes were reduced to compensate for fees on carbon emissions. Thus, we conclude that reducing either of the state's two major taxes on households as a way of returning carbon fees would yield inequitable results.

Another option would be to reduce property taxes. But these are typically levied by local government, so administratively it would be difficult to have a tax swap that reduced such taxes. Further, even if it were feasible, the same inequity applies, since property taxes on the bottom fifth of households constitute 3.6% of the total taxes and those on the second fifth are 6.1% – in both cases much smaller percentages than their shares of carbon fee revenues.

[5] Institute for Taxation and Economic Policy, data for 2013 or 2014, provided by Matthew Gardner via e-mail to Marc Breslow, August 2017.

Table 4: State and local taxes in Maryland

For each tax, the figure given is the % of total tax revenues that come from each 5th (quintile) of households ranked by income					
	lowest 20%	next-to-lowest 20%	middle 20%	next-to-highest 20%	top 20%
Sales & excise taxes	7.6%	14.8%	18.4%	23.8%	35.4%
general sales – individuals	6.0%	13.5%	17.7%	24.9%	37.8%
other sales & excise - individuals	9.6%	16.8%	18.8%	23.3%	31.5%
sales & excise on business	8.1%	15.3%	19.4%	22.5%	34.8%
Property taxes	3.2%	6.1%	14.0%	24.0%	52.7%
property taxes on families	3.6%	6.7%	14.9%	25.6%	49.3%
other property taxes	0.0%	3.5%	0.0%	8.9%	87.6%
Income taxes	0.5%	4.3%	10.7%	19.0%	65.5%
personal income tax (state & local)	0.5%	4.4%	10.9%	19.0%	65.2%
corporate income tax	0.0%	0.0%	0.0%	0.0%	100.0%
Total taxes	2.8%	7.2%	13.2%	21.0%	55.8%
Federal deduction offset	0.0%	1.1%	7.2%	18.6%	73.2%
Overall total	0.8%	1.9%	3.4%	5.1%	88.8%
Prospective carbon fees[6]	12.0%	18.6%	18.2%	24.6%	26.6%

Note: each row sums to approximately 100%, meaning that between them the five income quintiles pay all of that tax. The figure in each cell is the fraction of total revenues from that tax which come from that income quintile. For example, in the second row, the lowest income fifth of households pay 6% of the total sales tax on individuals that the state collects.

Due to these results, we and other analysts have concluded that providing rebates to households that are not tied to their tax payments, but rather are based on some other criterion such as the number of people in a household, or the number of adults with possibly a smaller share per child, or an equal rebate per household, results in more equitable impacts.

V. How should revenues be divided among households, employers, and programs to reduce GHG emissions, increase resilience to climate change, and provide transition benefits?

A. Evidence from other states and nations

According to the state's GHG inventory, about half of the revenues would each come from sales of fuel intended for final consumption by households and by employers. At the national level, and in some geographic areas, proposed legislation would return all of the funds to households. In Massachusetts, the proposed bills would return to households and to employers the shares of the revenues that derive from sales to their sectors.

[6] "Maryland Study 09_27_17cp, mb," Excel workbook, CES data tab, Marc Breslow and Chynna Pickins, based on Consumer Expenditure Study data for 2014, U.S. Bureau of Labor Statistics.

The largest carbon pricing systems in the world are cap-and-trade systems: in the European Union, California (now in combination with several Canadian provinces), and the northeast U.S. through the Regional Greenhouse Gas Initiative. The EU has been transitioning from allocating most of its allowances for free to industry, with a projection that 57% of the allowances will be auctioned during the years 2013-2020.[7] Manufacturing was given 80% of its emissions allowances at no cost in 2013, but for most industries this will fall to 30% in 2020. Of the allowances that are auctioned, more than 80% are used for GHG reduction or other "green" programs.[8] At the same time, the EU intends to continue protecting industries that it deems at risk of moving to countries outside the EU, termed "leakage." The EU's primary definition of such industries are those whose energy costs are at least 5% of total production costs and who sell at least 10% of their output outside the EU.[9]

Similar to the EU, California reserves a portion of its allowances for what are considered to be "vulnerable" employers. The state has complex formulas for classifying industries according to their degree of vulnerability and for giving them free allowances on that basis and on their degree of energy intensity. The number of allowances declines over time in accordance with the declining cap level for the state.[10]

Under RGGI, emissions prices have been much lower than in Europe and California, which has meant that cost impacts on consumers have been small. Each state makes its own decisions on how to use its revenue. From 2009 through 2014, across the region 58% of the money was used for energy efficiency, 13% went to renewable energy, 8% to other GHG abatement measures, and 15% to direct assistance for residential electric ratepayers.[11]

The Canadian province of British Columbia is the one substantial territorial unit where the carbon tax system is "revenue neutral," with all revenues being returned to the public. Initially, 64% of the revenues were returned to individuals and 34% to business. But this has gradually changed since the system was instituted in 2008. The provincial government reports that in fiscal 2016-2017, 35% of the funds will be returned to individuals and 65% to businesses. The return mechanism has been primarily through cuts in personal and business taxes, rather than through rebates. Additional assistance has been given to low income and rural residents. In addition, local governments and school boards that commit to being carbon neutral are given grants covering 100% of their carbon tax costs.[12]

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[7] "Climate Action: Free Allocation," European Commission, https://ec.europa.eu/clima/policies/ets/allowances_en , accessed 11/1/2017.

[8] "Climate Action: Auctioning," European Commission," https://ec.europa.eu/clima/policies/ets/auctioning_en , accessed 11/1/2017.

[9] "Climate Action: Carbon Leakage, European Commission, https://ec.europa.eu/clima/policies/ets/allowances/leakage_en , accessed 11/1/2017.

[10] Subarticle 9: Direct allocations of California GHG allowances," from "Summary of California's Cap and Trade Program," as adopted by CARB 10/20/2011, summarized by C2ES.

[11] "The Investment of RGGI Proceeds through 2014," Regional Greenhouse Gas Initiative, Inc., September 2016, www.rggi.org .

[12] "British Columbia Carbon Tax: Presentation to the State of Connecticut" British Columbia Ministry of Finance, April 2016.

Jeremy Carl and David Fedor conducted a thorough study of the use of revenues in cap-and-trade and carbon tax systems throughout the world, published in 2016.[13] and found that revenues tend to be used differently between the two predominant carbon pricing systems. In cap-and-trade systems, about 70% of the funds go to "green" spending, while in carbon tax systems about 72% of the funds go consumer refunds (either via taxes or rebates) and to general government funds.

Because it collects more funds than any other system in the U.S., we will examine California in some depth. California began collecting funds in 2012, and Carl and Fedor report that about 55% of the money allocated through 2014 was used for "revenue recycling," meaning returned to consumers. This has been done primarily through giving emissions allowances to electric and gas utilities, with the benefits then provided to consumers. The Public Utilities Commission has required that 85% of the funds go to residential customers and 10% to small business customers. The funds are delivered as flat rebates per customer, regardless of electricity usage or income level. The authors say, however, that the percentage recycled to consumers is expected to drop after 2015 as more revenues are used for GHG reduction programs.[14]

The Union of Concerned Scientists reports that at present (2017 and 2018) about half of the total emissions allowances are given to particular industries at zero cost. A large majority of these go to electric and gas utilities, which are then required to pass along the savings to their customers. The remainder of the free allowances go to energy-intensive, trade-exposed industries and to the petroleum industry (principally refiners).[15] The most recent reports from the state's Legislative Analysis Office appear to confirm these estimates.[16]

Using reports from the California Air Resources Board (CARB), we derived somewhat different results for fiscal 2016-2017, that may differ from those above in that emissions from motor vehicles are not fully incorporated in those below. Table 5 provides approximate figures for fiscal 2016-2017 on how California divided the value of its emissions allowances and auction revenues among energy producers, industrial consumers, household and small business consumers of electricity and natural gas, and programs to reduce GHG emissions.[17] The data appear to show that between about 25% and 40% of the value of the allowances and auction revenues are being used for GHG reduction programs; a substantial fraction is going to customers of electric and gas utilities (with 85% to residential customers and 10% to small businesses), and significant percentages go to specific industrial sectors that are considered vulnerable and to the suppliers/refiners of petroleum.

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[13] "Tracking global carbon revenues: A survey of carbon taxes versus cap-and-trade in the real world," Jeremy Carl and David Fedor, Hoover Institution of Stanford University, *Energy Policy* 96 (2016) 50-77.

[14] Carl and Fedor, page 63.

[15] Jason Barbose, Union of Concerned Scientists to Daniel Gatti of UCS, via email 1/25/18; Daniel Gatti and Marc Breslow, via phone, 1/24/18.

[16] "The 2017-18 Budget: Cap-and-Trade," Mac Taylor, California Legislative Analyst's Office, February 2017, page 9; https://www.arb.ca.gov/cc/capandtrade/allowanceallocation/v2018allocation.pdf; "California Allowances 2018," Excel workbook, Jonah Kuran-Faber, Climate XChange, February 2018.

[17] California Cap-and-Trade Program, February 2017 Joint Auction #10, California Post Joint Auction Public Proceeds Report, Update Issued on March 22, 2017, https://www.arb.ca.gov/cc/capandtrade/auction/may-2017/ca_proceeds_report.pdf

Table 5: Use of greenhouse gas emissions allowances by State of California, fiscal 2016-2017[18] (one allowance covers one metric ton of CO_2 equivalent emissions)

Category	Total allowances (1,000s)	% of to-tal allo-cated	% of total allocated and auctioned for GHG fund
Allocated and auctioned by California Air Resources Board (CARB)	247,379		100%
Allocated at zero cost			
overall total allocated (provided at no charge)	184,278	100%	74%
industrial total	15,580	8%	6%
petroleum industry	36,486	20%	15%
electric, gas utilities to be used for consumer benefit (85% to households, 10% to small businesses)	132,212	72%	53%
Auctioned by CARB for GHG reduction fund (data for auctions 8/16-5/17) (25% of the GHG reduction fund is re-served for disadvantaged communities)	63,101		26%

B. Need for assistance among "vulnerable" employer sectors in Mary-land

The examples above of the largest existing carbon pricing systems provide some guidance on how to use revenues in a Maryland carbon pricing system – with most revenues going to residential consumers, a portion to particular industries that would face burdens due to the fees, and a significant fraction to climate-related programs. Since, unlike California, Maryland does not have a large fossil fuel industry of its own, the portion that California is devoting to the petroleum industry is likely not relevant. In our analysis, we also look at employers who may not face competitive pressures, but who are in situations where they cannot, without great difficulty, raise their prices in order to cover increased costs.

Many industries will have carbon fee costs that are small percentages of their total operational expenses. The study conducted for the Massachusetts Department of Energy Resources found this for most of the state's largest industries, including those which are office-based and so do not have high expenses for either transportation or industrial processes.[19] In addition, for advanced economies such as Maryland's that consist primarily of service and knowledge industries, companies compete to a large degree with other in-state firms, not with those in other states and nations. Only when an industry has both high energy costs and is competing with industries from geographic areas that do not have carbon fees will it face a significant competitive

[18] https://www.arb.ca.gov/cc/capandtrade/auction/may-2017/ca_proceeds_report.pdf.

[19] "Analysis of a Carbon Fee or Tax as a Mechanism to Reduce GHG Emissions in Massachusetts," Marc Breslow, Sonia Hamel, Patrick Luckow, and Scott Nystom, for the Massachusetts Department of Energy Resources, December 2014, see pages 63-72.

problem. Both California and the European Union's cap-and-trade systems recognize this fact, and as a result provide free emissions permits ("allowances") almost exclusively to energy-intensive manufacturers.

Table 6 provides one analysis of employer industries which could be significantly impacted by carbon pricing in Maryland. "Trade-sensitive industries," including manufacturing and agriculture, make up only about 6% of Maryland's economy, and contribute about 5% of its CO_2 emissions (9.5% if electricity is not included in the system). Not all manufacturing industries are likely to be vulnerable, rather only those with high energy costs relative to their total expenses.

State and local government account for about 11% of emissions (10% without electricity). While not trade-sensitive, these government agencies are severely constrained in their ability to obtain more revenues to cover increased costs – they cannot raise taxes without great difficulty, nor can, for example, public transit agencies raise their fares. However, for some agencies energy costs are likely to be a small fraction of their total expenses.

Among non-profit organizations, which by themselves are a significant portion of many state economies, they range from quite large enterprises, such as hospitals and universities, which may be able to increase prices in order to cover their costs, to small social service agencies and other organizations whose budgets are highly constrained. A size criterion might be appropriate here, with non-profits below a certain revenue base being eligible for rebates. We have not conducted a detailed analysis of non-profits within Maryland. However, the hospitals/health care, education, and social assistance sectors, most of which are non-profit entities, constitute about 8% of the state's economy.

In the present study we have not conducted a detailed analysis of the impacts of carbon pricing on particular types of businesses, non-profit organizations, and government agencies. We recommend that such an analysis be done, in order to provide more evidence concerning the portion of carbon fee revenues that should be used for this purpose. **However, the evidence shown here does indicate that about 20% of the revenues should be sufficient to protect trade-sensitive industries, state and local government, and relatively small non-profit organizations.**

Table 6: Maryland employers that could be vulnerable to impacts of carbon pricing[20]

Industry	2015 GDP $millions	% of total Gross State Product	% of total MD carbon fees on employers, no fees on electricity	% of total MD carbon fees on employers (electricity included)
Trade-sensitive industries	$21,890	6.0%	4.5%	5.8%
Agriculture, forestry, fishing, and hunting	$861	0.2%	0.8%	0.7%
Manufacturing (whether energy-intensive or not)	$21,029	5.7%	3.7%	5.1%
Other possibly vulnerable industries				
Non-profits below a certain size	not estimated	n/a	n/a	n/a
State & local government	$30,741	8.4%	9.8%	10.6%
Maximum emissions from possibly vulnerable industries (not including non-profits)	$52,631	14.3%	14.3%	16.4%

VI. Policy scenarios for Maryland

A. Criteria for choosing between scenarios

A carbon pollution pricing system for Maryland should be designed to achieve the following objectives:

- Institute fee levels high enough to create an incentive that makes a major contribution to achieving the GHG reduction goals set by state policy
- Raise the fee levels gradually in order to give society time to adjust to higher fossil fuel prices and to begin making investments in clean energy, energy efficiency, and low-emission forms of transportation

The present report focuses on policy choices related to the impacts on households at different income levels, and secondarily to the impacts on employers. For these purposes, the objectives include providing:

- a high degree of protection for low and moderate income households, which we define as the lower 3/5ths of households ranked by income; for whom higher fossil fuel prices could be a substantial burden on their living standards
- sufficient funds to protect vulnerable employers
- losses for the upper 2/5ths of households that are within acceptable levels
- a fraction of the revenues for clean energy, energy efficiency, and clean transportation, which can also make a substantial contribution to reducing GHG emissions; for resilience to climate change impacts; and for transition benefits to workers and communities

[20] Author's own calculations, derived from BEA Regional data and Input-Output Tables.

who could face losses due to shrinkage of fossil fuel industries. The present study does not address how these funds could be used or the levels of funding needed.

B. The difficulty in protecting low and moderate income households

On average, use of energy rises with the income of households. At first glance, it might appear that providing equal rebates per household or per person would provide adequate protection to low and moderate income households because their lower use of energy means that they will pay lower carbon pollution fees. Unfortunately, this turns out to be only partially correct for two reasons: (1) on average, the number of people in a household rises along with income,[21] and (2) average energy use varies greatly from one household to another, even for those with similar incomes. This occurs because homes vary greatly in size, energy efficiency, and what fuel is used for home heating; and the need for driving differs greatly based on distances from home to work, whether public transit is available, etc.

In this study we address these issues by how rebates are distributed to households in terms of their number of adults and children, their income levels, and their source of heating fuel.[22] First, previous analysis has shown that providing equal rebates per household or by person are both beneficial for lower-income people, compared, for example, to cutting particular tax rates (see Section IV). However, neither yields fully equitable results, primarily because energy use rises with household size, but at a slower rate than number of household members.[23] A compromise, used by the organization Citizens Climate Lobby in its analyses and legislative design, is to provide equal rebates per adult with half a rebate per child (minor).[24] We have adopted this design in the present study. Our analysis finds that equal rebates per adult result in the **average net impact** (rebates minus fees) being positive for the lower two quintiles (40%) of households and about even for the middle quintile.

These positive average impacts provide a high degree of equity to the system. But due to the great variability in energy use among individual households, a significant fraction of low and moderate income households still appear to experience net losses. Due to limitations in the data at the state level we cannot show with precision the percentages of households in each quintile in Maryland that will come out ahead or behind. But it appears that, with equal rebates per adult, a significant fraction of low and moderate income households, maybe as much as 1/4th to 1/3rd, may come out behind.

One sophisticated analysis at the national level, where the data is better, looked at carbon pricing where all the revenue was returned to households, but via three different formulas – two different types of tax cuts, and equal per person rebates. The authors found that low and moderate

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[21] Most households with only one or two members are single adults, two adults without children, or an adult with one child. A large fraction of these are young adults or senior citizens. Higher-income households commonly have two adults who are both employed, and one or more children. These factors are much of the explanation for why, on average, income and family size rise together.

[22] As will be discussed below, the data shows that carbon fee costs in Maryland will vary significantly between households that use natural gas versus heating oil for home heating.

[23] See "Analysis of a Carbon Fee or Tax as a Mechanism to Reduce GHG Emissions in Massachusetts, Marc Breslow et al, Massachusetts Department of Energy Resources, December 2014, Section III.B, pages 44 to 54.

[24] "Impact of CCL's proposed carbon fee and dividend policy: A high-resolution analysis of the financial effect on U.S. households," Kevin Ummel, International Institute for Applied Systems Analysis, prepared for Citizens Climate Lobby," April 2016, Working Paper v 1.4.

households ranked by “equivalent expenditures” were only well-protected with the equal rebates. Their published study assumed that all the revenues were returned to households, with none allocated to employers and to climate-related investments.[25]

However, this national study is not directly comparable to Maryland. First, energy use by both households and employers, household income distribution, and the structure of the economy are substantially different between Maryland and the entire United States. Second, there are several methodological differences between the national study and the present one. Nevertheless, due to the better dataset available nationally, it is useful to examine that study’s results.

The national study assumed that all revenues are returned to households. For Maryland, the scenarios discussed in Sections VI.C and VII below return to households between 60% and 72% of the revenues (including those that derive from energy sales to employers), with the remainder going to employers and to climate-related investments. To address this difference, at our request the authors of the national study conducted modeling runs in which 50%, 60%, 70%, 80%, 90%, or 100% of the revenue went to households. They then calculated for each modeling run what percentage of people in each decile (tenths of the population, ranked by average expenditures) came out ahead due to the combination of carbon fees and rebates. The results are shown in Table 7.

It is a matter of ethical and political judgement which of the scenarios below is considered acceptable. Given the current distribution of income in Maryland and throughout the United States, where there is an increasing divide between low/middle income households and those with higher incomes; we judge that it is reasonable to look at the impacts on the lower 60% of households/people as the criterion for what is a “fair” outcome to the system. During the decade from 2006 through 2016, mean incomes (adjusted for inflation) for the bottom fifth of households fell by 4.2%, while rising by increasing percentages for the higher fifths: 0.7% for the second fifth, 3.0% for the middle fifth, 4.75 for the next to highest fifth, and 6.9% for the top fifth. During the longer period from 1996 through 2016, the same pattern held true: incomes for the bottom fifth fell by 1.2% while rising by 21.5% for the top fifth.[26] Only if a high percentage of people in the lower end of the income distribution come out ahead, and a majority of people in the middle do as well, can the system be considered equitable.

Such an outcome can be seen in the column titled “70% dividend,” where 93% of the bottom tenth of households come out ahead, with this fraction decreasing as income rises, so that 53% of those in the 4th decile (people between the 30th and 40th percentiles of income in the state) come out ahead. Even in this case, only 31% of those in the middle 5th of people (the 5th and 6th deciles, averaging 40% and 22%) come out ahead. Importantly, **67% of the lower half of the population come out ahead**.

[25] "A Short-Run Distributional Analysis of a Carbon Tax in the United States," Anders Fremstad and Mark Paul, August 2017, Political Economy Research Institute, University of Massachusetts Amherst.

[26] https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-income-households.html, “Historical Income Tables: Households,” U.S Bureau of the Census, downloaded 2/9/18.

Table 7: Effect on Households in United States by Size of Dividend Program (from Fren-sted and Paul analysis)[27]

			Fraction of Individuals Better Off					
Decile by Equivalent Household Expendi-tures	**Equiva-lent Household Expendi-tures[28]**	**Mean household CO2 foot-print**	**Full Divi-dend (100% of fees go to house-holds)**	**90% Divi-dend**	**80% Divi-dend**	**70% Divi-dend**	**60% Divi-dend**	**50% Divi-dend**
1	$ 9,980	11.7	0.99	0.98	0.96	0.93	0.88	0.78
2	$ 14,670	16.3	0.95	0.92	0.87	0.79	0.68	0.54
3	$ 18,123	18.8	0.91	0.86	0.79	0.69	0.54	0.37
4	$ 21,564	21.9	0.84	0.76	0.66	0.53	0.33	0.18
5	$ 25,326	23.6	0.74	0.65	0.54	0.40	0.24	0.11
6	$ 29,411	28.0	0.61	0.49	0.37	0.22	0.12	0.04
7	$ 34,301	32.9	0.51	0.39	0.28	0.15	0.08	0.05
8	$ 40,610	34.1	0.33	0.24	0.14	0.07	0.02	0.01
9	$ 50,784	39.9	0.17	0.12	0.05	0.01	0.01	0.00
10	$ 79,719	52.6	0.05	0.01	0.01	0.00	0.00	0.00
Mean Total Population	**$ 32,449**	**28.0**	**0.61**	**0.54**	**0.47**	**0.38**	**0.29**	**0.21**
Mean Bot-tom Half of Population	**$ 17,933**	**18.5**	**0.88**	**0.83**	**0.77**	**0.67**	**0.54**	**0.40**

Note: "equivalent household expenditures" is the square root of actual household expenditures. See explanatory foot-note.

Table 7, however, assumes that rebates are distributed on an equal per person basis. **The diffi-culties in achieving equity demonstrated in Table 7 can be mitigated by shifting some of the rebate funds away from higher income people and toward lower income people.** This is the strategy that we have adopted in the modeling runs described in detail below.

C. Description of policy scenarios tested with electricity generation in-cluded

To achieve the objectives given in section (A) above, a variety of policy levers can be used in designing the system. These include first, basic choices that will determine the amount of money collected in fees – the price per metric ton of carbon dioxide emissions, and whether or not emissions from electricity generation are included in the fee system.

[27] Received by email from Anders.Fremsted@gmail.com, 9/22/17. Based on study cited above.
[28] Fremstad and Paul, page 16. The authors sort individuals into deciles by what they term "equivalent household expenditures," which is the square root of actual expenditures by the household. Their purpose in doing so is to account for energy spending not rising as fast as the number of household members, and so this calculation is in-tended to provide a better picture of the relationship between income and carbon emissions. The average actual expenditures by decile would be much higher than shown here.

Second, the fee revenues can be used in various ways. A portion, ranging from zero on up, can be devoted to programs that will themselves reduce emissions, such as programs to promote renewable energy, energy efficiency, more efficient vehicles, low-carbon fuels, and mass transit and other low-emission forms of transportation (bicycling, walking, etc.). Another portion can also be used for programs to increase the state's resilience to the impacts of climate change. For equity reasons a portion should also be used to provide benefits that ease the transition of workers and communities that currently depend on fossil-fuel industries.

After a portion of the fees are devoted to such programs, the remaining funds – which could be all the funds except for a small percentage needed to administer the program – can be divided between different types of consumers, including commercial businesses, industrial enterprises, non-profit organizations, government agencies, and households.

Third, the funds going to households can be divided in many ways depending on relevant criteria, such as household income levels, number of household members, and factors that influence energy consumption needs such as location in a rural area and source of heating fuel.

In the scenarios tested for this study we have used the following policy variables to illustrate their impacts on households:

1) Fee level per metric ton of carbon dioxide emissions
2) Inclusion or not of electricity in the system
3) Portion of total revenues appropriated to households, employers and programs to reduce GHG emissions and to provide transitional benefits for workers and communities. The scenarios vary the household share from 60% to 72%, with employers receiving between 16% and 22.5%, and programs from 10% to 20%.[29] One pending policy proposal specifies that 10% goes to programs, with the remaining 90% split 75% to households and 25% to employers. This results in 67.5% of the overall revenues going to households and 22.5% to employers.
4) Division of revenues among households. All of the primary scenarios analyzed here have the following characteristics:
    (a) Of the funds reserved for households, initially 10% goes to each of the bottom and second-lowest income quintiles, and 5% goes to the middle quintile. This shift substantially increases the percentage of low and moderate income households who obtain a net benefit
    (b) Minors (those below 18 years of age) receive half the rebate of an adult;
    (c) 10% of the revenues that derive from sales of direct heating fuels (fuel oil and propane, but not electricity) are transferred to the state's low-income fuel assistance program
    (d) Households that heat with fuel oil are given an extra rebate, based on the difference between the average carbon fees that we project would be paid by households with heating oil and those that heat with natural gas[30]

[29] The particular percentages, including the numbers after the decimal point, are in part due to the design of the policy. The design first sets aside a percentage of the funds for clean energy and transition programs. Then the remaining funds are divided between households and employers. Numerically this sometimes results in non-round percentages of the total going to households and employers.

[30] For the provision concerning fuel oil users, the additional rebate is the same regardless of household size.

(e) The funds remaining after (a) through (d) are divided among all residents of Maryland on the basis of equal shares per adult and half-shares per minor.

Section IX provides details on additional scenarios: (1), the results when electricity is excluded from the system of carbon fees. (2) the results when electricity is include and the carbon fees reach $45 per metric ton, which is in year seven if the fee level begins at $15 and rises by $5 per year.

Table 8 restates the descriptions and values used for each of the policy variables.

Table 8: Scenario characteristics (after other $'s are allocated, remainder goes to equal rebates per adult state resident and 1/2 rebate per child)

Scenario characteristic	Description
Basics	
(1) CO2 price/metric ton	Price paid by fuel distributors when bringing products into the state or extracting and refining them within the state - at first point of sale or transfer
(2) Electricity included ?	Whether or not fossil fuels used for electricity generation, whether at plants inside Maryland or from imported power, have the carbon pollution fees applied to them
Division of revenues among households, employers, programs	
(3) % all revenues to clean energy/transport/other programs	Percent of all carbon fees collected that are used for government programs to reduce GHG emissions through incentives for renewable energy, energy efficiency, and public transportation; for climate change resilience; and for assistance to displaced workers and vulnerable communities
(4) % of all revenues to employers	The percent of total revenues that go to employers (including for-profit businesses, not-for-profit organizations, and government agencies
(5) % of all revenues to households	The percent of total revenues that go to households, further subdivided by the formulas below
Division of household share of total revenues among different groups of households	
(6) Half rebate share/child	In all scenarios, children (people under 18) receive half the rebate of an adult
(7) % household rebates initially devoted to bottom three quintiles (60%) of households	In all the primary scenarios, 10% of the revenues for households are initially provided to the bottom quintile, 10% to the second quintile, and 5% to the third (middle) quintile
(8) Heating fuel revenues used for low-income fuel assistance	10% of the carbon fees that derive from sales of heating fuels (not including electricity) are allocated to the state's fuel assistance program; with the funds assumed to go to the bottom 5th of households
(9) Extra rebate for households using fuel oil	Data shows that heating bills for homes using fuel oil are on average much higher than those using natural gas. This provision would provide an extra rebate based on the average difference in carbon fees between homes with the two different fuels
(10) Remaining rebates	The remaining funds available for households would be divided equally among all adults in the state, with half-shares for each child

VII. Specific characteristics and results of policy scenarios – all described here include electricity generation and are at the initial value of $15 per metric ton of CO_2[31]

For perspective on how the impacts by household income quintile relate to the average incomes for each quintile in Maryland, see Table 9. Note that according to the U.S. Census Bureau, Maryland has the highest median income of any U.S. state.

Table 9: Mean incomes for each income quintile in Maryland, 2016[32]

	Median	Average (mean)
All Maryland households	$75,847	$97,801
MD income quintiles 2017	**Quintile**	**Mean**
Less than $31,300	1	$16,700
$31,300 - $58,600	2	$44,900
$58,600 - $91,000	3	$73,900
$91,000 - $140,500	4	$113,500
Above $140,500	5	$231,600

A. Scenarios 1 to 3: revenue to programs ranging from 10% to 20%, remaining revenue split 75% to households and 25% to employers

Scenario 1, revenue distribution: households 67.5%, employers 22.5%, climate-related investments and transition benefits for workers and communities 10%

In Table 10A and Graphs 1 and 2 below, 10% of the revenues go to clean energy, resilience, and transition benefit programs, with the other 90% going to households and employers. Scenarios 2 and 3 raise programs to 15% and 20% respectively. All scenarios provide sufficient revenues to protect low and moderate income households and potentially vulnerable employers, while providing a relatively small share of the revenues for GHG programs, resilience, and transition benefits. In Scenario 1, the highest percentage of low-income households have a net benefit, 85%, with that percentage dropping slightly in Scenarios 2 and 3, to 80% and 75%, respectively.[33]

Scenario 3 (high investment in programs) maximizes revenues for programs/transition benefits, while yielding lower benefits for households and employers.

While the available data at the state level is insufficient to cite precise numerical results, it appears that increasing the fraction of revenues that goes to programs/transition benefits by 5%

[31] Carbon fees, rebates, and net impacts are rounded to the nearest $10. Net gain and net loss are rounded to the nearest 5%.
[32] https://statisticalatlas.com/state/Maryland/Household-Income
[33] Note, however, that the Consumer Expenditure Survey sample of households is not large at the state level, nor is it fully randomized. As result, we cannot be confident that the 5% difference in low income households showing a net benefit is a significant result.

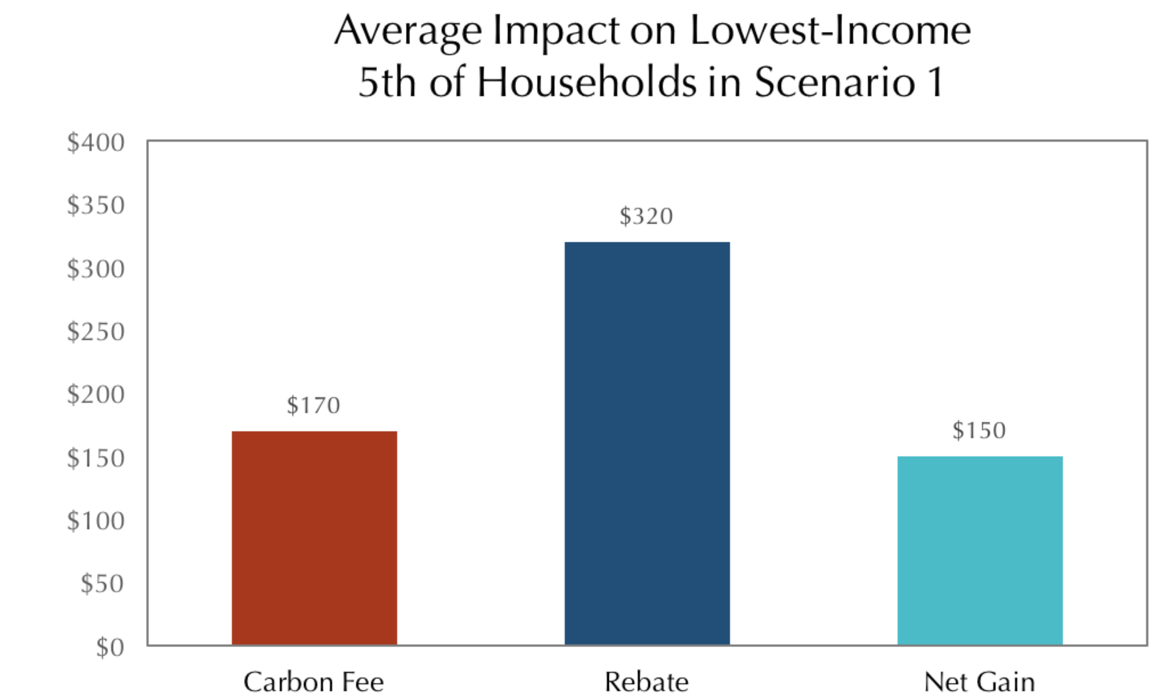
causes the fraction of households in the lowest quintile with a net benefit to fall by about 5%. However, even with 20% of revenues going to programs, on average low income households come out about $90 ahead, and about 3/4th of such households have net gains.

Table 10A, Scenario 1
Percentage allocation of revenues:
Climate-related investments and transition benefits: 10%
Households: 67.5%
Employers: 22.5%

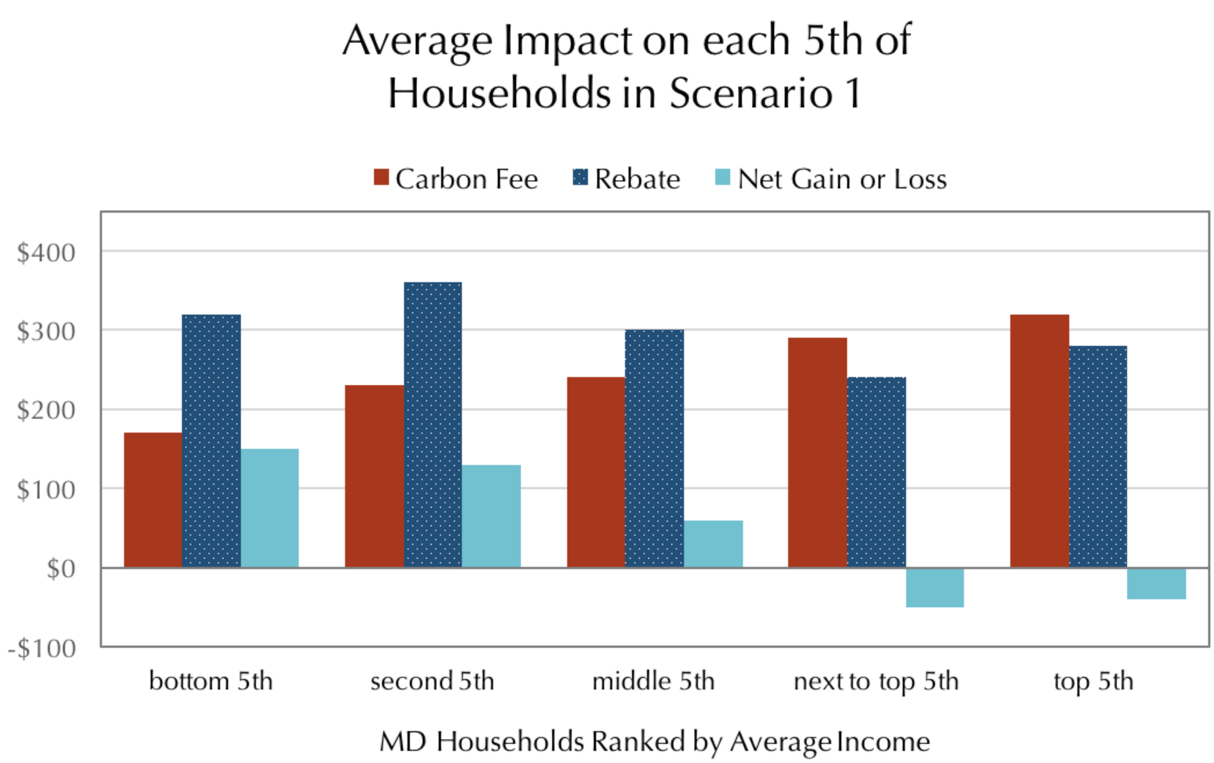
Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$300	$50	60%	40%
bottom 5th	$170	$320	$150	85%	15%
second 5th	$230	$360	$130	80%	20%
middle 5th	$240	$300	$60	70%	30%
next to top 5th	$290	$240	-$50	40%	60%
top 5th	$320	$280	-$40	40%	60%

As shown by Table 10A above and Graphs 1 and 2, the distribution of revenues produces the desired result, with low and moderate income households (the lower 60% of households) having net gains on average. Our greatest concern is with the bottom 20%, who we consider low income, and approximately 85% of such households have net gains (with the caveat that the survey data available is insufficient to be precise about these numbers). High percentages of both the second and middle fifths also have net gains.[34]

[34] The average rebate is higher for the second quintile than the first, and for the top versus the next-to-top. The reason is that most of the rebates are distributed on the basis of number of adults and children in a household, and on average household size rises with income. On the other hand, 25% of the rebates are reserved initially for the lower three quintiles, which results in their receiving higher average rebates than the top two quintiles.



Graph 1 –The average impact of a carbon price on the lowest income families by quintile in Scenario 1



Graph 2 – The average impact of a carbon price on all income brackets by quintile in Scenario 1

Table 10B, Scenario 2
Percentage allocation of revenues:
Climate-related investments and transition benefits: 15%
Households: 63.8%
Employers: 21.3%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$270	$20	50%	50%
bottom 5th	$170	$290	$120	80%	20%
second 5th	$230	$320	$90	70%	30%
middle 5th	$240	$260	$20	55%	45%
next to top 5th	$290	$220	-$70	30%	70%
top 5th	$320	$250	-$70	30%	70%

Table 10C, Scenario 3
Percentage allocation of revenues:
Climate-related investments and transition benefits: 20%
Households: 60.0%
Employers: 20.0%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$240	-$10	45%	55%
bottom 5th	$170	$260	$90	75%	25%
second 5th	$230	$290	$60	65%	35%
middle 5th	$240	$230	-$10	45%	55%
next to top 5th	$290	$190	-$100	25%	75%
top 5th	$320	$220	-$100	25%	75%

B. Scenarios 4 to 6: revenue to programs ranging from 10% to 20%, remaining revenue split 80% to households and 20% to employers

In these three scenarios, after an allocation to investment programs of 10% to 20%, the remaining revenue is shifted more toward households than in Scenarios 1 through 3, with households receiving 80% and employers 20%. As a result, the fraction of low and moderate income households who experience net benefits remains at somewhat higher levels than in the first three scenarios as the percentage of funds devoted to investment rises, as shown in Tables 10D through 10F. Scenario 6 would provide the greatest funding for programs while still providing a high level of funding for households. Even in this scenario, with 20% of the funds going to investment programs, 80% of the bottom fifth of households have net gains, as do 65% of the second (next to lowest) fifth of households.

Table 10D, Scenario 4
Climate-related investments and transition benefits: 10%
Households: 72%
Employers: 18%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$330	$80	65%	35%
bottom 5th	$170	$350	$180	90%	10%
second 5th	$230	$390	$160	80%	20%
middle 5th	$240	$310	$70	70%	30%
next to top 5th	$290	$260	-$30	45%	55%
top 5th	$320	$300	-$20	50%	50%

Table 10E, Scenario 5
Climate-related investments and transition benefits: 15%
Households: 68%
Employers: 17%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$290	$40	60%	40%
bottom 5th	$170	$310	$140	85%	15%
second 5th	$230	$340	$110	75%	25%
middle 5th	$240	$280	$40	60%	40%
next to top 5th	$290	$230	-$60	35%	65%
top 5th	$320	$270	-$50	35%	65%

Table 10F, Scenario 6
Climate-related investments and transition benefits: 20%
Households: 64%
Employers: 16%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$250	$260	$10	50%	50%
bottom 5th	$170	$280	$110	80%	20%
second 5th	$230	$300	$70	65%	35%
middle 5th	$240	$250	$10	50%	50%
next to top 5th	$290	$200	-$90	25%	75%
top 5th	$320	$230	-$90	25%	75%

VIII. Additional Scenarios

The scenarios below cover (A) a policy where electricity generation is not included in the carbon pollution fees. While the proposed legislation does include electricity, excluding it has been considered due to Maryland's participation in the Regional Greenhouse Gas Initiative (RGGI). Second, scenarios (B) provide numerical results when the fee per metric ton has reached $45, which would be in the year seven if fees begin at $15 per metric ton and rise at $5 per year.

A. Scenarios with electricity generation not included, at $15 per metric ton

The three scenarios below have identical policy choices to those in Scenarios 1 through 3 above, except that emissions from electricity are not covered by the carbon fees.

Table 11A, Scenario 7, electricity not included
Percentage allocation of revenues:
Climate-related investments and transition benefits: 10%
Households: 67.5%
Employers: 22.5%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$140	$190	$50	70%	30%
bottom 5th	$80	$200	$120	90%	10%
second 5th	$130	$210	$80	80%	20%
middle 5th	$130	$170	$40	75%	25%
next to top 5th	$170	$140	-$30	55%	45%
top 5th	$190	$160	-$30	50%	50%

Table 11B, Scenario 8, electricity not included
Percentage allocation of revenues:
Climate-related investments and transition benefits: 15%
Households: 63.8%
Employers: 21.3%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$140	$160	$20	65%	35%
bottom 5th	$80	$170	$90	90%	10%
second 5th	$130	$180	$50	75%	25%
middle 5th	$130	$140	$10	65%	35%
next to top 5th	$170	$120	-$50	45%	55%
top 5th	$190	$130	-$60	40%	60%

Table 11C, Scenario 9: electricity not included
Percentage allocation of revenues:
Climate-related investments and transition benefits: 20%
Households: 60.0%
Employers: 20.0%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$140	$150	$0	60%	40%
bottom 5th	$80	$150	$70	85%	15%
second 5th	$130	$160	$30	70%	30%
middle 5th	$130	$120	-$10	60%	40%
next to top 5th	$170	$100	-$70	40%	60%
top 5th	$190	$120	-$70	35%	65%

B. Scenarios at $45 per metric ton of CO2 emissions, electricity generation included

Table 12A, Scenario 10: $45/ton, electricity included
Percentage allocation of revenues:
Climate-related investments and transition benefits: 10%
Households: 67.5%
Employers: 22.5%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$750	$910	$160	60%	40%
bottom 5th average	$500	$970	$470	85%	15%
second 5th average	$690	$1,090	$400	80%	20%
middle 5th average	$710	$890	$180	65%	35%
next to top 5th average	$880	$730	-$150	40%	60%
top 5th total or average	$950	$840	-$110	40%	60%

Table 12B, Scenario 11, $45/ton, electricity included
Percentage allocation of revenues:
Climate-related investments and transition benefits: 15%
Households: 63.8%
Employers: 21.3%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$750	$820	$70	55%	45%
bottom 5th average	$500	$870	$370	80%	20%
second 5th average	$690	$970	$280	75%	25%
middle 5th average	$710	$790	$80	60%	40%
next to top 5th average	$880	$650	-$230	30%	70%
top 5th total or average	$950	$750	-$200	30%	70%

Table 12C, Scenario 12: $45/ton, electricity included
Percentage allocation of revenues:
Climate-related investments and transition benefits: 20%
Households: 60.0%
Employers: 20.0%

Average impact per household	Carbon fee	Rebate	Net gain or loss	% net gain or even	% net loss
All households	$750	$720	-$30	45%	55%
bottom 5th average	$500	$780	$280	75%	25%
second 5th average	$690	$860	$170	65%	35%
middle 5th average	$710	$700	-$10	45%	55%
next to top 5th average	$880	$570	-$310	25%	75%
top 5th total or average	$950	$660	-$290	25%	75%

IX. Limitations of the analysis

There are significant, but not dramatic, differences between each of the six scenarios shown in the tables above for Maryland and in Table 7 for the United States. However, our ability to evaluate the relative impacts of the scenarios is limited by several factors, including:

1. We do not have precise percentages for those who come out ahead and behind in the six scenarios of Table 10, making it more difficult to judge what are the most equitable choices.
2. The data in the Consumer Expenditure Survey (CES) from the U.S Bureau of Labor Statistics is of limited accuracy at the state level, especially for a small state. Thus, the data above in Tables 10A through 10F must be regarded as only presenting an estimate of the true results.

3. The data here are ranked by household pre-tax income.[35] There are arguments that a “fairer” examination of the relative welfare of people would be to rank by expenditures rather than income, and on an individual rather than a household basis. We will not explore this topic further here.
4. Tables 9 and 10 do not take into account benefits from spending on clean energy, transportation, and transitional assistance for workers and communities, particularly to lower income households, from the 10% to 20% of funds devoted to such programs in the scenarios. Estimating these benefits is a complex analysis, which requires specifying the exact nature of such programs. We have not attempted this analysis here.
5. We have not, as of now, conducted an industry-by-industry analysis of the net impacts of carbon fees and rebates on employers; nor have we specified the formula on which such rebates would be based. In pending Massachusetts, Rhode Island, and Connecticut bills, the formula is distribution according to full-time equivalent employees of each employer, but other formulas are possible.

X. Methodology for analyzing impacts on households

To examine the impacts on households at different income levels, a source of data is needed on the fossil fuel and electricity expenditures for such households. Every two years the U.S. Bureau of the Census conducts a random survey of households across the United States, on behalf of the U.S. Bureau of Labor Statistics (BLS) in the Department of Labor, called the Consumer Expenditure Survey (CES).[36] The survey is conducted in two ways – by oral interviews and by having consumers keep diaries of their spending. A larger sample of households is included in the oral interviews, which provides for greater statistical reliability, so we have used that portion of the survey. For each year’s worth of spending the BLS interviews households five times – once during each quarter of the current year and then a final time during the first quarter of the following year, asking for information on the last three months of the prior year.[37]

For Maryland, each quarter had 105 interviews, or a total of 525 interviews over five quarters, for the most recent years available. We combined the data for 2013 through 2015 in order to provide a larger sample size. This yielded 1,575 separate interviews. Ideally, the same households would be interviewed five times, providing a consistent set of data on the annual expenditures of each one. However, because of difficulties in obtaining participation by the same households for all five quarters, only a fraction of the data covers an entire year for particular households. This limits the degree to which conclusions can be formed for individual households, but

[35] The Bureau of Labor Statistics believes that respondents to their random survey often under-report their incomes, so the BLS has a procedure to “impute” higher incomes to households who the BLS’s algorithm predicts are under-reported. So the households here are actually ranked according to the BLS’s “imputed incomes.”

[36] “Consumer Expenditure Survey,” Bureau of Labor Statistics, U.S. Department of Labor, home page and linked pages, https://www.bls.gov/cex/

[37] “Public-Use Microdata (PUMD),” Consumer Expenditure Study, https://www.bls.gov/cex/pumd.htm ; “FMLD Data Dictionary 2015,” Bureau of Labor Statistics; “2015 Documentation, Diary Survey, Consumer Expenditure Public Use Microdata, August 30, 2016, Bureau of Labor Statistics; phone conversation with Jeffrey Paulin of CES section of the BLS, 6/26/17; phone conversation with Arsenis Roja of BLS, 8/8/17; phone conversation with Aaron (last name not obtained) of BLS, 9/8/17

does provide sufficient data to report on the average impacts for each fifth of the households interviewed, with 315 interviews being included in each quintile.

The BLS interviews provide data on the dollar value of spending by households on gasoline, natural gas, heating oil, "other heating fuel" (which is predominantly propane, also referred to as liquefied petroleum gas), and electricity. We sum the quarterly data to calculate a year's worth of spending. Spending is converted into physical units of energy using the average residential retail prices for each energy form in Maryland during 2014. Energy units are then converted into metric tons of CO_2 using standard conversion factors for each fuel.

As a check on the accuracy of the BLS survey data we compare it to data on overall energy use and CO_2 emissions for the state of Maryland.[38] We divide the number of people in the CES sample by the entire state population, which gives us the sample as a percentage of the population. When the emissions of each fuel source are divided by this percentage it produces an estimate of total state emissions derived from the CES spending figures. Through this method we determined that there was reasonable consistency between the CES household data and the overall state data, giving us confidence in our results.

Electricity is somewhat of a special case. For natural gas, gasoline, and other fuels, a gallon or other physical unit of each fuel contains the same number of pounds of CO_2 throughout the United States. But for electricity the CO_2 emitted to produce a kilowatt of power is different for every power plant, depending on the fuel burned to generate electricity and the efficiency of the plant. The CO_2 output of each plant is tracked by the U.S Environmental Protection Agency (EPA) and by state environmental agencies, and total emissions for electricity generated within each state can be obtained from these agencies. However, each state that has implemented a cap-and-trade system and that is considering direct carbon pricing wishes to place the fee on all electricity **consumed** by people and institutions within the state, not just those produced by power plants in the state. Some states are net exporters of electricity and some are net importers. Maryland imports a large fraction of its power and we also need to know the emissions from these imports. Fortunately, the periodic emissions inventory published by the Maryland Department of the Environment does provide an estimate of the emissions from imports.

The BLS's "imputed" annual pre-tax income is used for households in the sample, the households are ordered by quintile, and totals calculated for each quintile. Total emissions fees are calculated for each quintile. An initial calculation of rebates was done, assuming that each state resident receives an equal rebate. These figures are then modified for each scenario, based on the adjustments shown in Tables 7 and 8.

XI. Further research to be considered

This study has examined impacts on households in detail, particularly with reference to their income levels. Impacts on employers that might be particularly vulnerable to the impacts of carbon pollution fees, including for-profit businesses, non-profit organizations, and government agencies, have been considered only briefly. A second study for Maryland could look at each of

[38] 2014 Greenhouse Gas Emissions Inventory, Maryland Department of the Environment, http://www.mde.state.md.us/programs/Air/ClimateChange/Pages/GreenhouseGasInventory.aspx; State of Maryland 2014 Greenhouse Gas Emission Inventory Documentation, June 14, 2016, Maryland Department of the Environment, www.mde.state.md.us/programs/.../2014Inventory/MD2014PeriodicGHGInventory.pdf

the individual business sectors as a separate entity, estimating the fees, rebates, and net impacts on each sector as a percentage of their overall operating costs. Such a study would provide a better base of knowledge for policymakers to understand which sectors could face significant impacts from the fees. Whether these impacts then affect their competitiveness with businesses in other states and nations would also require an analysis of their energy-intensity and the degree to which they face sufficient competition to make it difficult for them to raise their prices to cover increased costs. Such an analysis was conducted for the Massachusetts study, in two different forms[39]:

- The direct impacts of fees and rebates
- The impacts including macro-economic changes to the state's economy due to the fee-and-rebate system

It would also be valuable to conduct additional research on the practical aspects of implementing such a system in Maryland, including such items as how the fees would be collected, how rebates would be returned to tax-paying households, how they would be provided to low-income households who may not pay state income taxes and therefore not be in the computer records of the state's revenue agency, and how they would be provided to employers.

XII. Conclusions

Climate change is one of the principal challenges facing the world community, perhaps the most serious environmental crisis that we must address. Various policies to reduce the greenhouse gas emissions that cause climate change are in use today by national, state, and local governments. Putting a price, fee, or charge on the burning of fossil fuels that accounts for the damage they cause is widely recognized as one of the most important measures that could be instituted, perhaps the most important. It is also recognized as the most-cost effective method, meaning that it would yield emissions reductions at the lowest cost.

Carbon pricing would also yield substantial revenues to a state government that adopts it. How to use these revenues is a critical element in designing such a policy. This study has examined the options for using this revenue in the particular conditions that exist in Maryland, The funds can be split among households, employers, programs to further reduce GHG emissions, and transition benefits for workers and communities that currently depend on fossil fuel industries; and funds going to households can be distributed among them in various ways.

We have presented a number of scenarios for using the revenues, all of which meet the principal criteria of protecting low and moderate income households, protecting vulnerable employers, and devoting some funds to programs. The scenarios devote different percentages of the funds to each of these purposes. Policymakers and the public can choose among the scenarios based on their values and judgements on what are the most important criteria to emphasize.

However, regardless of which scenario is preferred, in all cases Maryland's critical interest in implementing a cost-effective policy to substantially reduce its GHG emissions can be accomplished while still allowing its households and employers to prosper.

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[39] "Analysis of a Carbon Fee or Tax as a Mechanism to Reduce GHG Emissions in Massachusetts," Marc Breslow, Sonia Hamel, Patrick Luckow, and Scott Nystrom, for the Massachusetts Department of Energy Resources, December 2014, see sections III.D and IV.

XIII. Principal author biographical information

Marc Breslow is the Policy and Research Director at Climate XChange, based in Boston, Massachusetts, where he focuses on analysis of carbon pricing policies and their economic and environmental impacts. In December 2014, he co-authored *Analysis of a Carbon Fee or Tax as a Mechanism to Reduce GHG Emissions in Massachusetts*, as part of a consulting team for the Massachusetts Department of Energy Resources. Also in 2014 Breslow co-authored the *Massachusetts Clean Energy and Climate Scorecard*, published by the Global Warming Solutions Project of the Environmental League of Massachusetts. He has participated in the design of carbon pricing legislation in Massachusetts and several other states.

Breslow formerly held two positions in Massachusetts state government: Director of Transportation & Buildings Policy with the Executive Office of Energy & Environmental Affairs, and Director of the Electric Power Division of the Department of Public Utilities. In 2010, Breslow was lead author of the state's Clean Energy and Climate Plan for 2020. He was principal author of the Massachusetts *Clean Energy Biofuels Act of 2008*, and lead author of the state's *Advanced Biofuels Task Force Report*, also issued in 2008. Before joining state government, Breslow was the founding Executive Director of the Massachusetts Climate Action Network, and earlier was a Senior Associate with the Tellus Institute for Energy and Environmental Research. He has a Ph.D. in Economics from the University of Massachusetts-Amherst, and a B.A. Summa Cum Laude in Public Policy Studies from Duke University.

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