Memorandum

To: Maryland Department of Natural Resources, PPRP
Maryland Department of Environment
Exeter Associates

From: Resources for the Future

Re: Additional Model Analysis of Maryland Joining RGGI

Date: September 18, 2007

The work for this memo was performed under task III-A, RGGI Support for MDE, under contract #KOOB-5200175 by Dallas Burtraw, Karen Palmer and Anthony Paul with assistance from Richard Sweeney. This work builds on research that was performed under contract between the University of Maryland and RFF (among others) and the Maryland Department of the Environment, which resulted in the report from the Center for Integrated Economic Research at the University of Maryland entitled “Economic and Energy Impacts from Maryland’s Potential Participation in the Regional Greenhouse Gas Initiative: A Study Commissioned by the Maryland Department of the Environment” in January 2007. The purpose of this memo is to describe the results of model simulations that vary two of the underlying assumptions in the initial report: the share of Regional Greenhouse Gas Initiative (RGGI) CO_2 emission allowances that are sold at auction and the amount of allowance auction revenue in Maryland that is used to fund energy efficiency. The initial study assumed that 25% of the allowances were sold in an auction and all the revenue was used to fund energy efficiency.

The RFF Haiku Electricity Market model was used for this project. Documentation for the model can be found in Appendix D.1 of the aforementioned January 2007 report. In preparation for that research, Haiku was outfit with a set of “efficiency supply curves” describing the potential for emerging more-efficient technologies to replace less-efficient, older technologies in end-use electricity markets for the residential, commercial and industrial sectors of our economy. These are termed supply curves because they provide a schedule of potential investments and other measures that could improve efficiency in end-use energy consumption. These supply curves were derived from research performed by ACEEE and they are identical to the supply curves supplied by ACEEE to the RGGI Staff Working Group for use in their development of the RGGI MOU. The ACEEE supply curves represent the technical potential and engineering cost of efficiency investments. Our research team is currently engaged in re-estimating these supply curves, but as this effort is not yet complete the analysis in this memo relies on the ACEEE estimates. In addition, the Haiku model incorporates a 2.5 cents per kWh administrative fee for each unit of end-use efficiency in the supply curve. This fee is added to the technical costs provided by ACEEE on a per kWh basis.

The remainder of this memorandum will present the scenarios under consideration, a brief discussion of the alternative methods for allowance allocation, and finally the results and conclusions of the study.

Scenarios

This analysis considers five different scenarios. The salient characteristics of each scenario are presented in Table 1. In all five scenarios, the Maryland Healthy Air Act (HAA) is assumed in effect. The baseline scenario treats Maryland as a non-participant in RGGI. In all other scenarios, the policy scenarios, Maryland is treated as a participant in RGGI with the RGGI allowance cap adjusted to reflect the inclusion of Maryland. This adjustment and the allocation of RGGI allowances in states other than Maryland are constant across scenarios. Consistent with the assumptions in the earlier report, these states are assumed to auction 25% of their RGGI allowances and to distribute the remainder to emitting generators based on historic generation levels, a practice also referred to as grandfathering. The exception is Vermont, which is assumed to auction all of their RGGI allowances.[1]

Title	Description		
Baseline	MD is NOT a participant in RGGI.		
25 %	MD participates in RGGI and auctions…	25%	…of its RGGI allowances. Auction revenues fund energy efficiency initiatives in Maryland.
50 %		50%	
75 %		75%	
100 %		100%	

Table 1. Scenario definitions

The four policy scenarios differ by level of funding for energy efficiency initiatives in Maryland. In particular, the four scenarios represent auctions of 25%, 50%, 75% or 100% of Maryland's allotment of RGGI allowances, with the remaining allowances grandfathered. In all four scenarios any revenue generated by a RGGI allowance auction are used to fund energy efficiency initiatives.

Auction Alternatives

The modeling effort for this analysis depends on the assumption that any RGGI allowances that are not auctioned are grandfathered in the same way that Title IV SO_2 allowances are grandfathered, i.e. a utility owning a generator that is earmarked to receive a grandfathered endowment of allowances retains its right to that endowment even if the generator is retired from service. There are alternatives to auctioning or grandfathering allowances in this manner, like updating or grandfathering specified in other ways, but these alternatives will receive no attention in this report.

The assumption that grandfathering is the alternative to an allowance auction implies that in Maryland the choice about the fraction of allowances auctioned will have no market impacts, neither in electricity markets nor in allowance markets. In general, the method of allowance allocation can create incentives that influence a facility manager's decision about capacity utilization on the margin. This can cause second-order decisions about investment and retirement of electricity generation capital. For this analysis, the tradeoff between auctioning RGGI allowances or grandfathering them in this way has no direct effect on operating decisions. There is no effect because

1 . In fact several states, including New York, Massachusetts, Maine and Rhode Island have declared their intention to auction 100% of the RGGI CO_2 emission allowances apportioned to their states.

generators will optimally take account of the opportunity cost of allowances in their operating decisions regardless of whether they were acquired for free or purchased at auction. Moreover, the method of allowance allocation will have no effect on decisions about investment and retirement. The difference between an auction and grandfathering as approaches to the initial distribution of emission allowances is simply an asset transfer in which economic efficiency and the prices of electricity and allowances are unaffected. It is important to note that this holds because electricity generation prices in Maryland are set in a competitive market, not by a regulator who employs cost of service regulation.

To better understand why an allowance auction and a grandfathering scheme in a region with competitive markets for electricity yield identical market outcomes consider the following example. Suppose that a generator is in a grandfathering environment in which capacity retirement does not affect any grandfathered allowance endowment. The allowance price is $5/allowance. Suppose further that the generator uses 100 allowances in a year, all of which were acquired for free, and there are no excess allowances. Then the value of the allowances used is $500. The generator's annual profit (revenues in excess of variable costs) must be at least $500. If it were not, the generator would have retired since it would keep the $500 in allowance value anyway and sell unused allowances into the market. So the minimum profit for the generator to continue to operate is the value of allowances received through the grandfathering process, in this case $500. Now suppose that the generator does not acquire allowances for free and must instead purchase them at auction. Profits for our generator will decline by $500, the cost of purchasing the allowances in an auction, but since profits had previously been at least $500, they are now at least positive. So the generator still will not retire. In general, any capacity decision that is optimal in a grandfathering environment will also be optimal in an auction environment. Switching between grandfathering and auction changes nothing about the market equilibrium. However, it obviously can have significant effects on the profitability of the firm and the welfare of consumers.

There may be other issues affecting firms that result from the initiation of an auction that are not addressed by the simulation model. The cash flow requirements of participating in an auction may impose additional costs on a firm. Firms may face challenges in budgeting and financing, especially at the beginning of the program. In the long run the cost of participation in an auction for allowances should appear no different than the cost of purchases of other factors such as fuel, but in the short run firms may have to incur costs associated with changes in their debt and capital structure since the allowance cost is a new cost of operation. It also is possible that large expenditures in the auction may slow down investment because firms may face capital-market constraints. However, absent specific evidence it seems unlikely that highly profitable investments would be foregone because of difficulty raising funds for them.

In addition to the cost of acquiring allowances in an auction, the program design that we model where allowance value from the auction is used to fund investments in end-use efficiency will impose a second type of cost (loss) on firms. The reduction in demand can be expected to lead to a reduction in sales and a reduction in electricity price, resulting in an overall reduction in revenues. The magnitude of this effect is examined in the results presented below.

Results

This memo is focused on the effects of funding end-use efficiency initiatives in Maryland using revenues generated by a RGGI allowance auction. The analysis of the baseline scenario in which Maryland is not a participant in RGGI and does not fund any additional end-use efficiency initiatives was presented in the January 2007 report. The analysis of the first policy scenario, in which Maryland auctions 25% of its RGGI allowances and uses all of the revenues to fund demand efficiency initiatives, was also in the January 2007 report. Table 2 shows the relevant results of that study[2]. The comparable table showing the results of the policy scenarios simulated for this memo is Table 4 in Appendix A. The remainder of this analysis will focus on the four policy scenarios with selected results from Table 4 highlighted. All prices in this document are expressed in 2004 $.

Year	2010		2015		2020		2025	
Scenario	BL	25%	BL	25%	BL	25%	BL	25%
Electricity Price ($/MWh)	86.9	86.5	93.4	93.1	97.2	97.5	102.1	102.7
Demand (BkWh)	72.1	71.0	78.3	76.8	85.1	83.0	91.9	89.3
Efficiency Savings (BkWh)	0.0	1.1	0.0	1.6	0.0	2.0	0.0	2.5
RGGI Allowance Price ($/ton CO2)	4.5	4.1	6.6	6.0	9.6	8.9	11.5	11.2
Gen by Fuel (BkWh)								
Coal	35.0	32.2	33.3	32.0	35.8	32.2	36.9	33.2
Natural Gas	4.0	2.9	4.0	2.4	4.3	2.1	5.8	1.8
Non-Hydro Renewables	2.2	2.2	2.3	2.3	2.3	2.4	3.3	3.6
Other Fuels	15.2	15.2	15.3	15.3	15.4	15.4	15.5	15.5
Net Imports	20.2	22.7	28.0	29.2	32.3	35.5	35.7	40.2
Total	76.5	75.2	82.8	81.2	90.1	87.7	97.2	94.3
Capacity (GW)								
Coal	5.1	5.1	5.1	5.1	5.5	5.1	5.6	5.1
Natural Gas	3.4	3.4	3.4	3.4	3.4	3.4	3.8	3.5
Non-Hydro Renewables	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.8
Other Fuels	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Total	13.3	13.3	13.3	13.3	13.6	13.3	14.4	13.5
Emissions								
NOx (k tons)	30.5	22.8	26.4	22.3	27.9	22.4	28.3	25.3
SO2 (k tons)	57.4	49.3	39.2	42.0	41.6	41.0	42.2	38.9
CO2 (M tons)	39.3	35.6	37.3	35.1	39.7	35.2	41.2	36.0
Hg (tons)	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

Table 2. Summary of baseline and 25% auction scenarios

2. The 25% auction scenario was simulated for this memo using a model identical to that used for the January 2007 report. The convergence parameters of the models are not identical and therefore the results in this memo differ slightly from those published in January 2007.

End-Use Efficiency

Spending on end-use energy efficiency will yield declining marginal benefits because each additional kWh of efficiency savings will be more expensive than the last. Figure 1 illustrates this as the marginal cost of efficiency improvements. The points in the figure are upward sloping because the cost to reduce a unit of electricity demand increases as more reductions are pursued. It is noteworthy that even if Maryland auctions all of its endowment of RGGI allowances in 2025, when their value is greatest, it would still be cost effective to invest in even more efficiency initiatives since the marginal cost of end-use efficiency will still be less than the retail price of electricity. This result follows directly from the efficiency supply curves developed for the RGGI modeling effort and our assumptions about administrative cost.

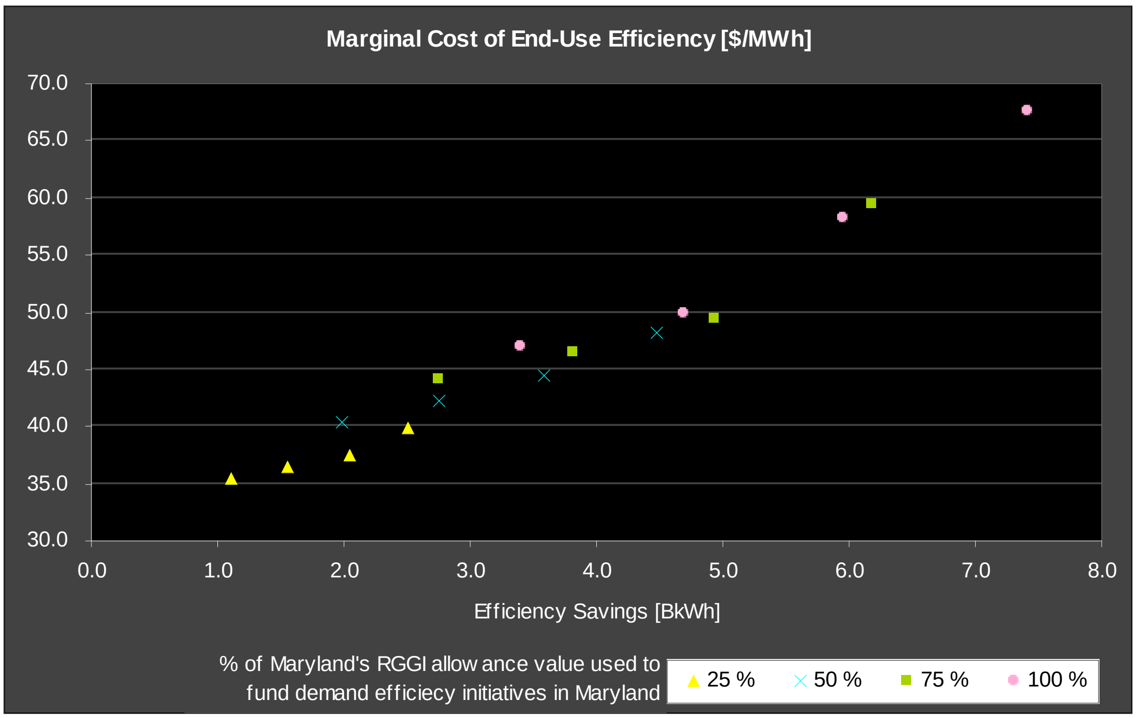


Figure 1. Marginal cost of end-use efficiency in Maryland under different levels of efficiency funding

Figure 2 and Figure 3 show the amount of spending on efficiency measures and the amount of electricity conserved by those measures in the four policy scenarios. The reductions in electricity demand apparent in Figure 3 are the drivers of all further results in this report.

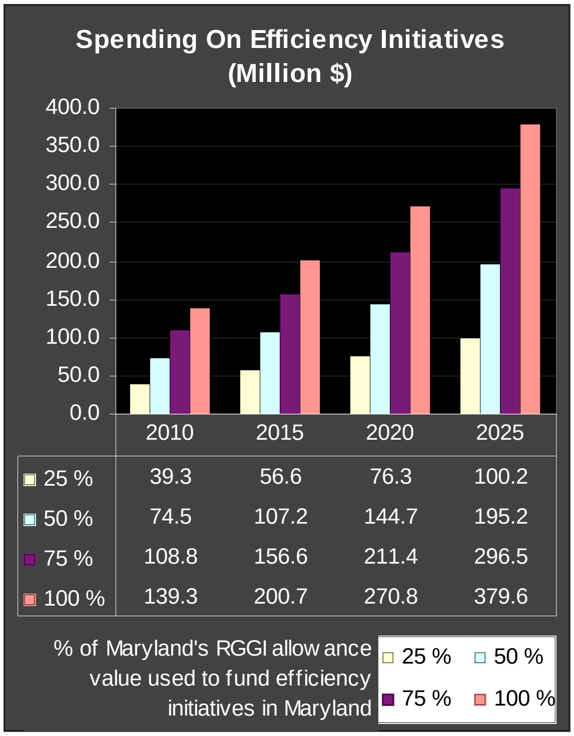


Figure 2. End-use efficiency spending in Maryland under different levels of funding

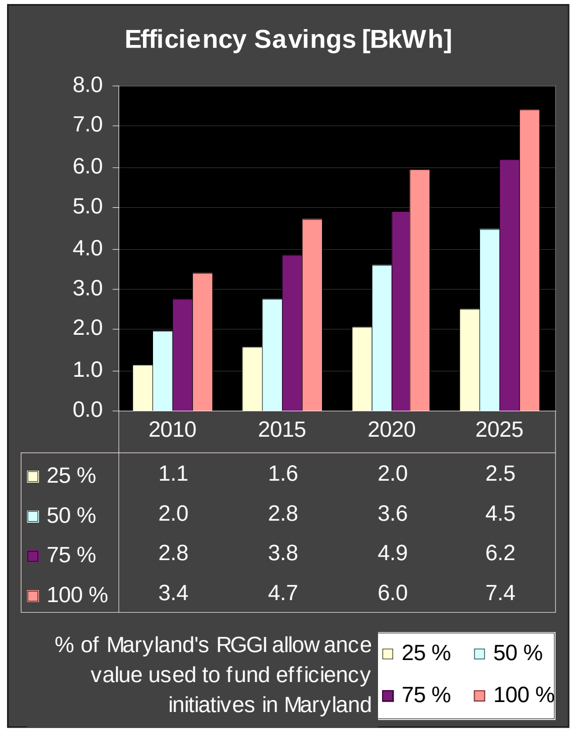
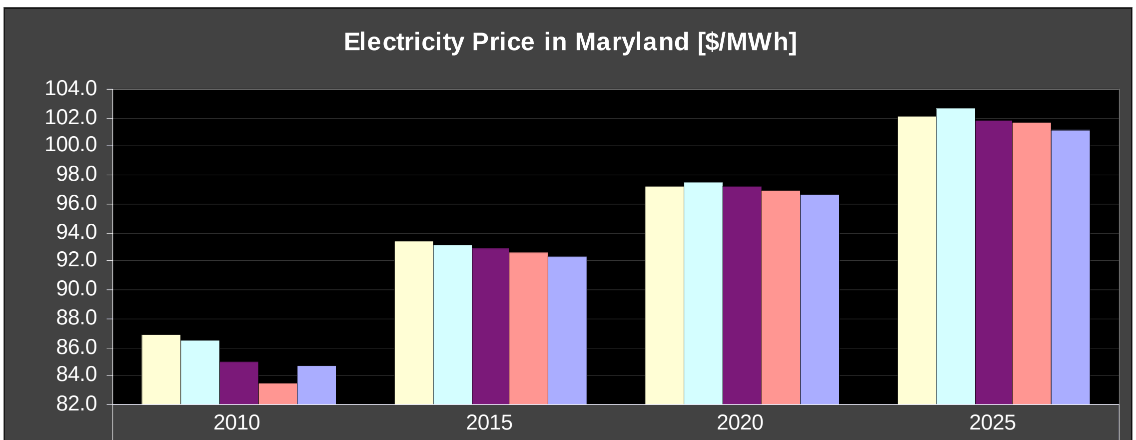


Figure 3. End-use efficiency savings in Maryland under different levels of funding

Maryland Electricity Price

As more funding is provided for demand efficiency initiatives, demand for electricity in Maryland will fall and the marginal cost of electricity generation in Maryland will be driven down as well. A variety of effects will follow from this decrease in marginal generation cost including reduced power importation and usually a decrease in the price of electricity. Because the price of electricity depends not just on the marginal cost of power generation, but also on the cost of ancillary services such as spinning and capacity reserve, it is possible for electricity prices to climb slightly in one year in response to reduced native demand for power generation in other years. This may occur because of the extra cost of reserve services if generation capital otherwise might retire or not be built because of decreased electricity demand. Figure 4 shows the effects of funding end-use efficiency initiatives on the price of electricity in Maryland. Given that Maryland will participate in RGGI, electricity prices will fall uniformly with greater funding for end-use efficiency, except in 2010 when funding is increased from 75% to 100% of RGGI allowance value in Maryland. Starting from a funding level of 25%, the allocation of each additional 25% of Maryland's RGGI allowance value to efficiency initiatives can be expected to yield a decline in electricity prices in Maryland of about 0.25% after the year 2010.



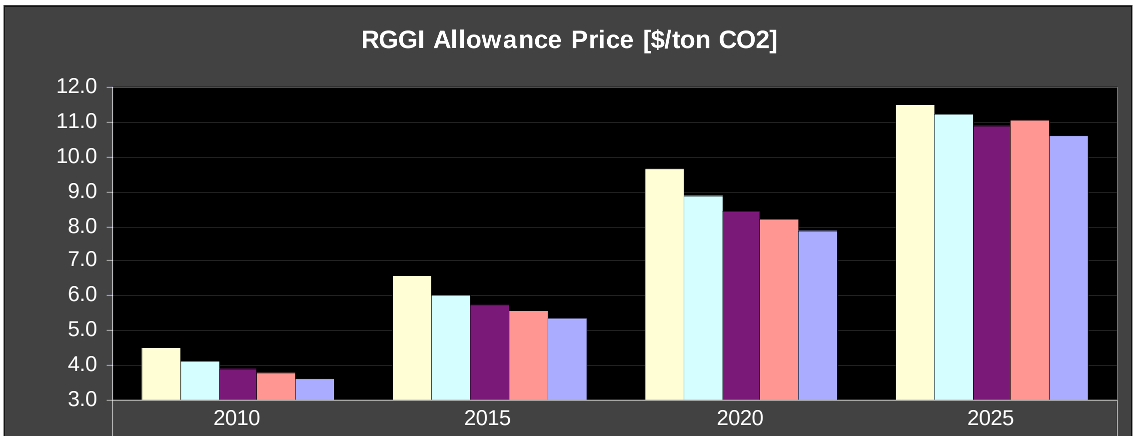
	2010	2015	2020	2025
0 %	86.9	93.4	97.2	102.1
25 %	86.5	93.1	97.5	102.7
50 %	85.0	92.9	97.2	101.8
75 %	83.5	92.6	96.9	101.7
100 %	84.7	92.3	96.6	101.2

Figure 4. Electricity prices in Maryland under different levels of end-use efficiency funding

RGGI Allowance Price

As funding for end-use efficiency lowers demand for electricity and tends to lower the retail price of electricity, so too will such funding tend to lower the price of RGGI allowances. Figure 5 shows these effects. Starting from a funding level of 25%, the allocation of each additional 25% of Maryland's RGGI allowance value to end-use efficiency yields a decline in the price of RGGI allowances of 2.5% - 5.5%. An exception occurs in 2025 for a funding level of 75%. This anomalous result is perpetuated through markets for ancillary services and Maryland's transmission inter-connections with its neighbors.

Note that as the funding for end-use efficiency is increased, the RGGI allowance price will fall. As the RGGI allowance price falls, the revenues generated at auction to fund end-use efficiency will also fall, which is accounted for in the model. The allowance prices in Figure 5 and the spending on efficiency in Figure 2 are internally consistent.



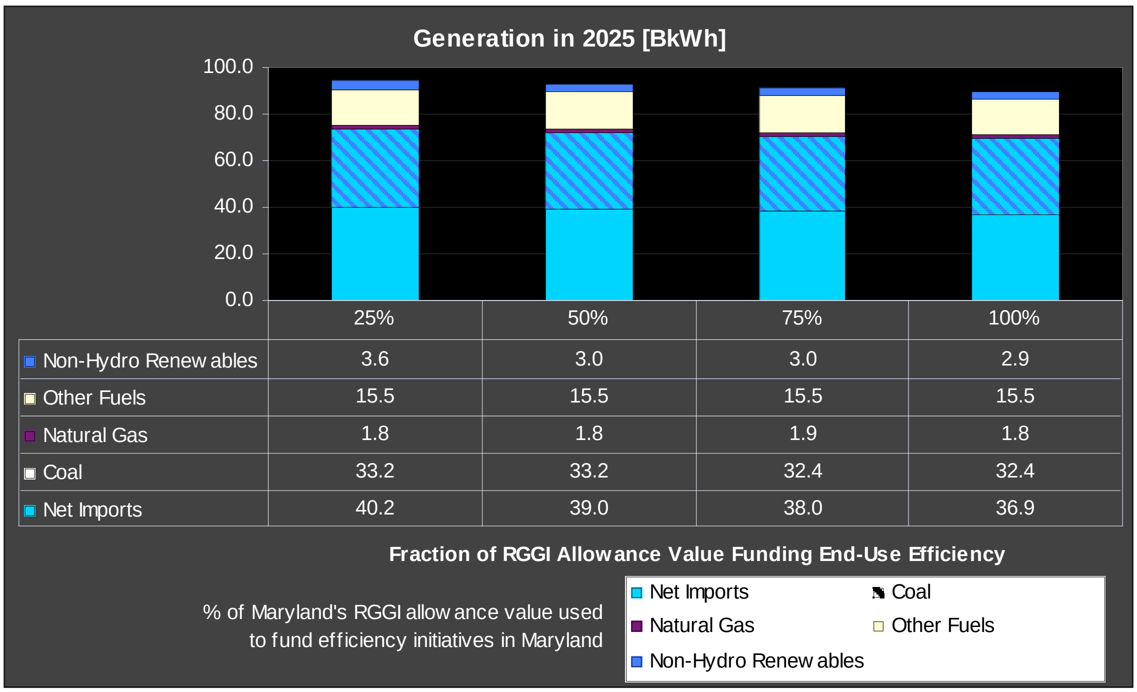
	2010	2015	2020	2025
0 %	4.5	6.6	9.6	11.5
25 %	4.1	6.0	8.9	11.2
50 %	3.9	5.7	8.4	10.9
75 %	3.8	5.6	8.2	11.0
100 %	3.6	5.3	7.9	10.6

Figure 5. RGGI allowance price under different funding levels for end-use efficiency

Maryland Generation Capacity, Fuel Mix

The choice over how much funding should be provided to end-use efficiency initiatives in Maryland will result in no major shifts in Maryland's generation capital stock or future investments in new capacity. Compared to the scenario in which 25% of Maryland's RGGI allowances are auctioned, the largest expected change in generation capacity will occur if 100% of Maryland's RGGI allowances are auctioned and used to fund end-use efficiency. This change will amount to no more than 350 MW and will be accounted for almost entirely by the retirement of oil-fired steam generators.

The mixture of fuels used to generate electricity in Maryland will also be largely unaffected by end-use efficiency investments. Figure 6 shows the fuel mix projected in MD in 2025 in each policy scenario. The only energy source that is projected to change significantly at different levels of efficiency investment is net imports. Apparently demand reductions in Maryland will be largely offset on the supply side not by generation reductions in Maryland, but by reduced imports from neighboring states.



	25%	50%	75%	100%
Non-Hydro Renewables	3.6	3.0	3.0	2.9
Other Fuels	15.5	15.5	15.5	15.5
Natural Gas	1.8	1.8	1.9	1.8
Coal	33.2	33.2	32.4	32.4
Net Imports	40.2	39.0	38.0	36.9

Figure 6. Fuel mix in Maryland in 2025

Economic Surplus in Maryland

The funding for end-use efficiency in Maryland will affect the electricity sector, both the producers and consumers of power, in numerous ways. These effects can be aggregated for producers and consumers and expressed in terms of economic surplus. In general, lower electricity prices lead to greater consumer surplus and lesser producer surplus. In this analysis, we have found that greater investment in end-use efficiency will tend to depress electricity prices. It is therefore no surprise that consumer surplus is increasing and producer surplus is decreasing in funding for end-use efficiency initiatives. On net, the losses by producers will usually be more than offset by the gains to consumers. Table 3 shows the surplus projections under each policy scenario relative to the 25% scenario. In each year, more funding for efficiency initiatives will lead to improved total economic surplus in Maryland[3]. As mentioned previously, these results depend on the characterization of the cost and availability of end-use efficiency measures. The current analysis uses the supply curves for end-use efficiency that were developed by ACEEE and used by the RGGI Staff Working Group in their analysis of the RGGI program, combined with our assumption about administrative cost. Our research team is currently engaged in re-estimating these supply curves. Any further analysis will be based on these forthcoming end-use efficiency supply curves.

	2010			2015			2020			2025		
(million $)	50%	75%	100%	50%	75%	100%	50%	75%	100%	50%	75%	100%
Consumer Surplus	186	356	325	130	250	348	170	320	450	280	470	630
Producer Surplus	-126	-237	-192	-24	-104	-172	-77	-129	-247	-164	-267	-355
Government Surplus	-5	-5	6	-1	-5	10	0	-2	10	-2	-4	8
Total Surplus	64	123	127	107	141	166	95	195	189	120	200	270

Table 3. Economic surplus improvement relative to 25% scenario

3. The single exception could occur in 2020 when the decline in producer surplus under a 100% auction relative to a 75% auction would exceed the commensurate increase in consumer surplus.

Conclusions

Given that the alternative to a RGGI allowance auction in Maryland is a grandfathering scheme in which the owners of retired generators retain their right to allowance endowment, then the fraction of allowances that are sold at auction will, by itself, have no effects in Maryland or elsewhere. However, any auction revenues that are used to fund end-use efficiency initiatives will affect changes in MD that will have small spillover effects in other regions. Maryland can expect its electricity price to fall by about 0.25% for each additional 25% of RGGI allowance value that is used to fund demand efficiency measures in Maryland. Each additional increment of spending on efficiency will slightly reduce Maryland's importation of power by about 3% and lower the price for RGGI allowances by about 2.5% - 5.5%. No large shifts in Maryland's generation capacity are expected no matter the funding level for demand efficiency. There will also be no large shifts in the mix of fuels used by Maryland to produce power, though power imports will decline with greater efficiency investment. Power generators in Maryland can expect to see lower profits as the result of two effects – the auctioning of allowances which raises their variable costs, and the reduction in demand as a result of investments in end-use efficiency. These lost profits will not be large enough to affect significant change in the generation capital stock. Furthermore, the losses borne by power producers will be more than offset by the gains of electricity consumers. Even without counting the benefits of reduced emissions, Maryland will see greater economic surplus in increased funding for end-use efficiency initiatives.