Maryland Nuclear Power Plant's Contribution to the State Economy

PREPARED FOR

NUCLEAR MATTERS

PREPARED BY

Mark Berkman, Ph.D.

Dean Murphy, Ph.D.

September 2015

THE Brattle GROUP

This report was prepared for Nuclear Matters. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group, Inc. or its clients.

The authors would like to acknowledge the invaluable assistance of Stephen Lagos, Wade Davis, and Paul Organ in preparing this analysis.

Table of Contents

I. Executive Summary

At the request of Nuclear Matters, The Brattle Group has estimated the value of Calvert Cliffs, the only nuclear plant in Maryland, to the state's economy.

Our analysis has determined that the nuclear plant operating in Maryland:

- **contributes approximately $397 million to state gross domestic product** (GDP) ($536 million in gross output).
- **accounts for about 2,300 in-state full time jobs** (direct and secondary).
- **helps keep electricity prices low.** Maryland consumers would pay about $40 million more annually (2015$) and over $340 million over the next ten years (on a present value basis) without Calvert Cliffs.
- **is responsible for nearly $15 million in net state tax revenues** annually.

These values reflect the incremental contribution of Calvert Cliffs to the economy, measured by comparing the performance of the Maryland economy with and without the plant. This approach nets off the contribution of the alternative generation that would be necessary if the nuclear industry did not exist, to determine its incremental contribution. Absent nuclear energy, the Maryland economy would rely more heavily on existing natural gas and coal-fired generating plants, many of which are outside Maryland, leading to greater reliance overall on out-of-state generation. The greater use of fossil generation would mean higher electricity prices – wholesale prices would be higher on average in Maryland. It is this effect on electricity prices that accounts for the majority of nuclear's overall incremental economic impact. Note that these measures do not reflect the impacts outside Maryland, although the absence of the in-state nuclear plant will have significant additional consequences beyond the state's borders.

The absence of Calvert Cliffs would also result in much higher carbon dioxide emissions and greater emissions of criteria pollutants, such as nitrogen oxides (NO_X) and sulfur dioxide (SO_2). These impacts are not limited to Maryland, first because much of the alternative fossil-fired generation would occur outside Maryland, and second because air pollution impacts can cross state borders – they are often regional in the case of criteria pollutants and global in the case of carbon. Large-scale renewable energy probably would not substitute significantly for nuclear; intermittent renewable generation is not a direct substitute for the baseload profile of nuclear.

Absent Maryland's nuclear plant, consumers would pay more for electricity, the economy would suffer both in terms of GDP and jobs, and we would face substantially higher emissions of CO_2 and other pollutants.

II. Background

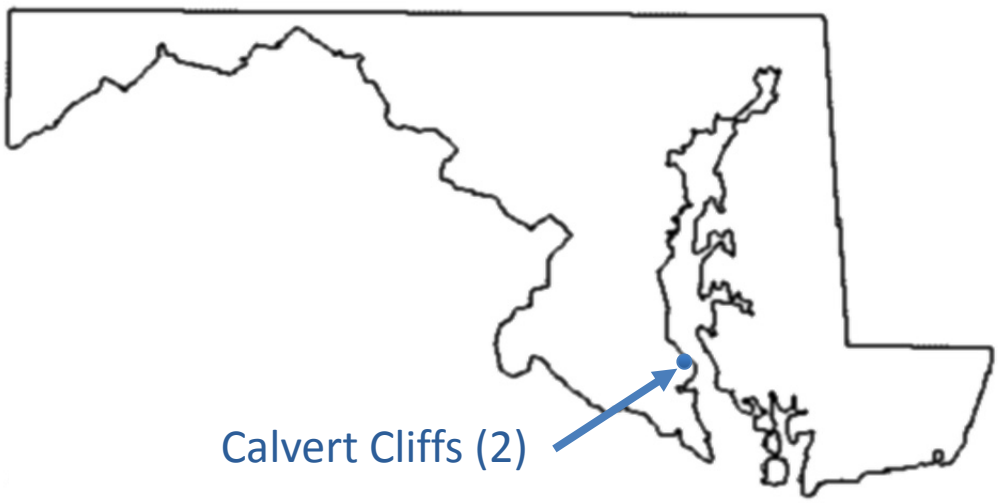
One nuclear plant with two reactors operates in Maryland, representing 1,725 megawatts (MW) of capacity and over 13 million megawatt hours (MWh) of annual electricity generation, as

shown in Table 1 and illustrated in Figure 1.[1] Maryland is within the electric region operated by the PJM independent system operator.[2] Maryland's nuclear generation makes up 1% of PJM's total capacity and almost 2% of its electricity generation, as shown in Table 2. It should be noted that PJM extends well beyond Maryland's borders, as illustrated in Figure 2. Within Maryland, nuclear power represents a considerably larger share of capacity and generation at 13% and 32%, respectively, as shown in Table 3.

Table 1: Summary of Nuclear Generation in Maryland

	Variable	Value
[1]	Number of nuclear plants	1
[2]	Number of nuclear reactors	2
[3]	Total capacity (MW)	1,725
[4]	Estimated generation (MWh)	13,351,919

Figure 1: Location of Maryland Nuclear Plant



[1] Data comes from Ventyx's Energy Velocity.

[2] Independent system operators (ISOs) establish and maintain electricity capacity and energy markets.

Figure 2: PJM Region Map

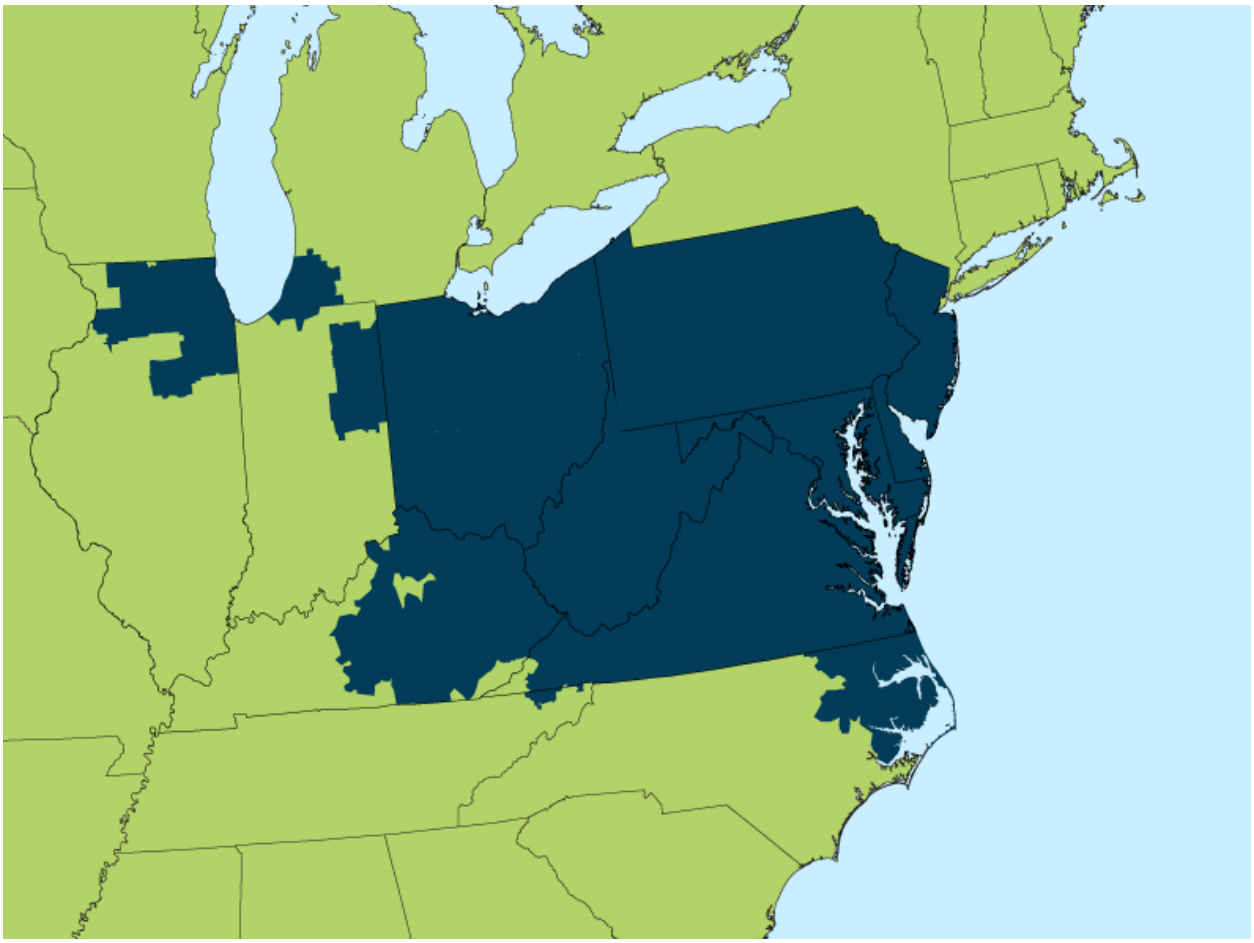


Table 2: Maryland Nuclear Power Share of Capacity and Generation by Reliability Region

	Region	Maryland nuclear share of region's capacity	Maryland nuclear share of region's generation
[1]	PJM	1%	2%

Table 3: Nuclear Power Provides a Large Share of Maryland Capacity and Generation

	Category	Maryland nuclear share
[1]	Maryland capacity	13%
[2]	Maryland generation	32%

III. Nuclear Plants Make a Considerable Contribution to the Maryland Economy

We have estimated Calvert Cliffs' economic value to Maryland using REMI, a widely-used dynamic input output model of the U.S. economy, linked with a simplified Brattle model of the electricity sector to better capture the dynamics of power markets and prices.[3] By linking these models, we are able to measure the economic output, employment, and tax revenue in Maryland with and without its nuclear plant, providing the most accurate picture of its incremental contribution to the economy. The economic impacts presented here are limited to Maryland, but Calvert Cliffs has significant economic impacts well beyond the state's borders. Economic markets, including electricity markets, do not generally coincide with state borders. As a result, estimating the overall economic impacts of Calvert Cliffs would require a regional model. Although we have not created such a regional model for Maryland, we have developed a national model that looks at the entire U.S. nuclear fleet, accounting for electricity and other market activities both within and across states.[4]

This analysis indicates that Calvert Cliffs helps keep regional electricity costs down, which has a substantial effect on the Maryland economy. Netting out the value of the alternative electric generation mix that would substitute if it did not exist, Maryland's nuclear plant is responsible for substantial economic output and accompanying employment and tax revenues. Table 4 summarizes our findings for the impacts within Maryland (not including the impact outside the state).

---

[3] For more details on the REMI model, see www.remi.com.

[4] The Brattle Group, "The Nuclear Industry's Contribution to the U.S. Economy," July 7, 2015. Note that economic impacts presented for Maryland in the national study will differ substantially from those reported in this study. In the national report, we measure the contribution of all nuclear plants. Consequently, state impacts are influenced not only by plants located within a given state, but also by plants located in other states. The economic impacts presented in this report are limited to only the contributions of in-state nuclear plants.

Table 4: Net Contribution of Maryland's Nuclear Plant to the Maryland Economy

	Average Annual (2015-2024)
Direct and Secondary Employment *(jobs)*	2,300
Direct and Secondary Output *(2015 dollars)*	$536 million
Direct and Secondary GDP *(2015 dollars)*	$397 million
Direct and Secondary State Tax Revenues *(2015 dollars)*	$14.9 million
Direct and Secondary Federal Tax Revenues *(2015 dollars)*	$64.8 million

Maryland's nuclear plant contributes $397 million to the state's GDP, and accounts for about 2,300 direct and secondary jobs.[5] Calvert Cliffs' owners also pay substantial federal and state taxes, as do businesses providing good and services to the plant and their employees. In addition, the plant's incremental contributions to state output account for additional tax revenues. Calvert Cliffs' effect on the economy leads to about $15 million in additional state tax revenues and $65 million in federal tax revenues, beyond what would be provided by the alternative electric supply that would be utilized in its absence.

Below, we provide further detail regarding the impact of Maryland's nuclear plant on:

- The electricity generation mix
- The cost of electricity
- Economic output and GDP
- Employment (direct and secondary)
- Federal and state tax revenues

[5] We report both GDP and gross output since both are useful economic statistics in table 4. GDP is the most widely-used measure of national income. It reflects value added, which includes industry sales to other industries and to final users minus the value its purchases from other industries. Gross output is a measure of industry sales, which includes sales to final users and intermediate sales to other industries. This leads to a form of double counting, but does not prevent the measure from being a meaningful indicator of how individual industries perform relative to one another.

Further details regarding our data, assumptions, and modeling results can be found in "The Nuclear Industry's Contribution to the U.S. Economy," prepared for Nuclear Matters by the Brattle Group, July 2015.

A. Impact on Electric Generation Mix

As shown in Figure 3, without Maryland's nuclear power plant, electricity demand would be met mostly by increased reliance on existing natural gas and coal-fired generation. The share of Maryland generation from natural gas-fired plants would increase from 5% to 8%, and the share from coal-fired plants would increase from 57% to 83%. Large-scale renewable energy probably would not be significantly different; intermittent renewable generation alone is not a direct substitute for the baseload profile of nuclear, and at current capital and fuel prices (absent other policy changes), natural gas generation is generally more cost-effective. PJM relies on non-Maryland power plants for 95% of its generation when the Maryland nuclear plant is included. This share would increase to 96% absent this plant, as shown in Figure 4. Higher electricity prices, however, might somewhat reduce demand for grid-based electricity, by inducing efficiency, conservation, and switching to alternative fuels or electricity sources.

Figure 3: Electric Generation Mix in Maryland in 2015

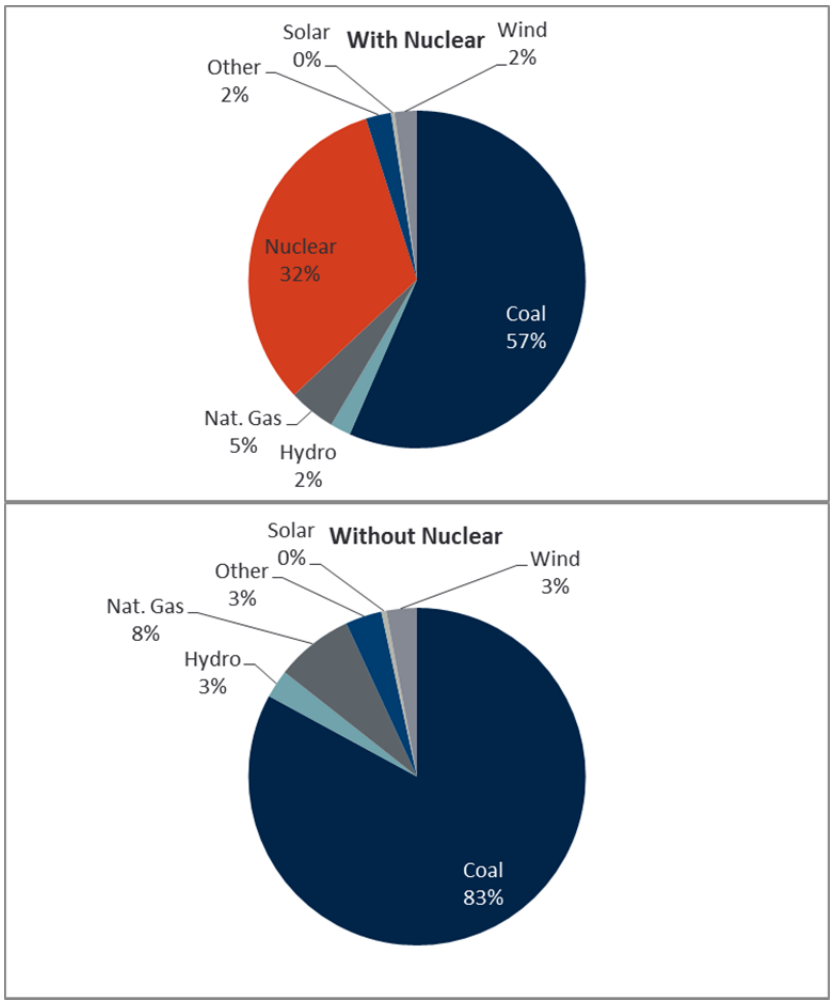
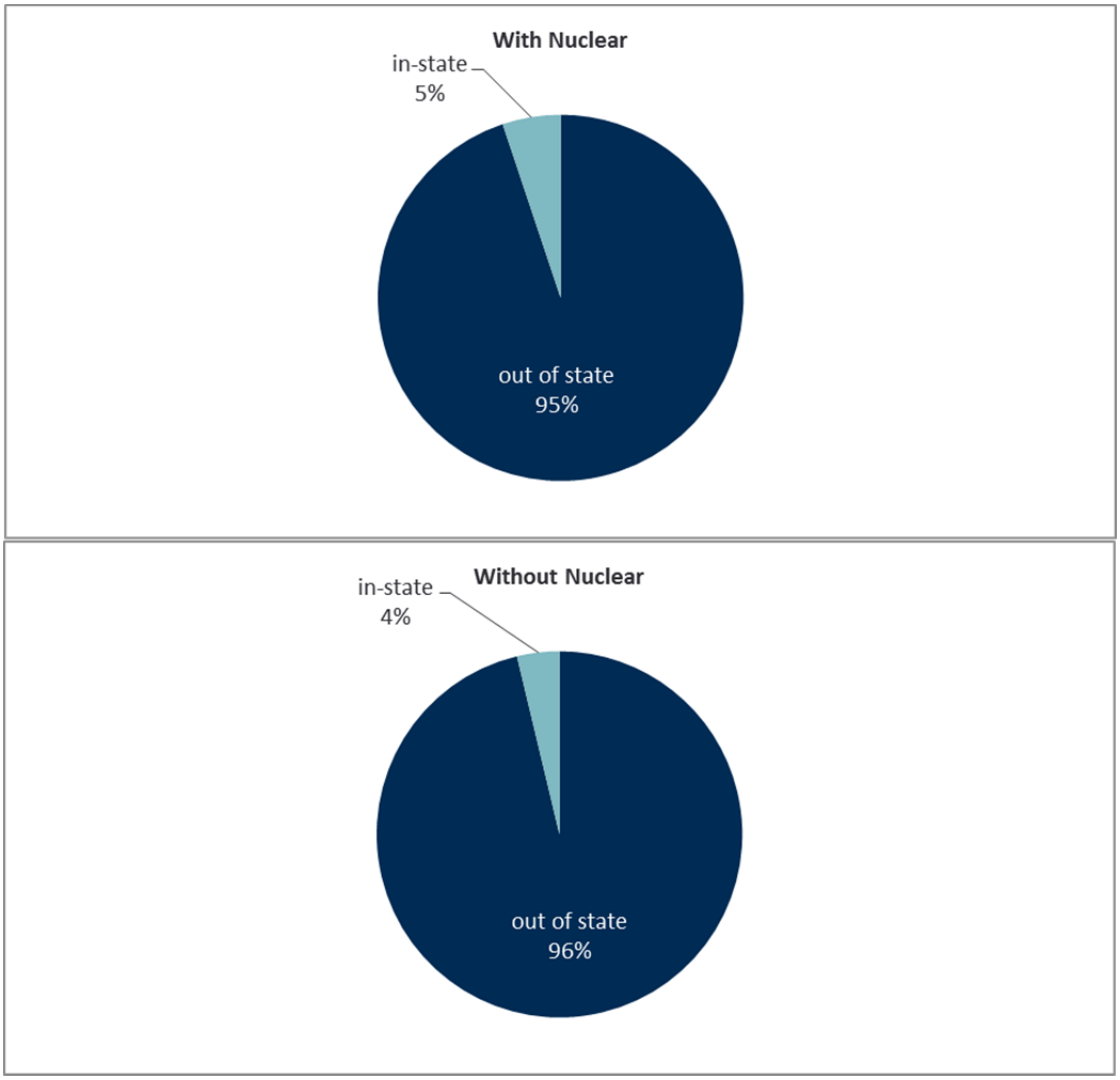


Figure 4: Maryland Share of PJM Generation in 2015



B. IMPACT ON ELECTRICITY PRICES

Calvert Cliffs' impact on the Maryland economy is primarily the result of the plant's influence on electricity prices. As noted above, absent Calvert Cliffs, electricity demand would be met by increased utilization of natural gas and coal-fired plants, some within Maryland but much outside it. This alternative generation mix would mean higher electricity prices across PJM. As shown in Table 5, on average wholesale electricity prices would be higher in Maryland and PJM. These increases represent higher costs to consumers. Maryland customers would spend $40 million more per year on electricity absent Calvert Cliffs. Between 2015 and 2024 this increase totals about $341 million on a present value basis. Throughout all PJM states, that would translate into over $3.6 billion between 2015 and 2024. Higher electricity prices hurt the economy primarily by reducing residential, commercial, and industrial spending on other goods and services. The magnitude of power price effects, and ultimately the economic and job effects,

cold depend on movements in the price of natural gas, since it plays a primary role in setting power prices in most U.S. regions.[6] In addition, although local and possibly regional transmission needs might differ, perhaps significantly in the absence of nuclear plants, we do not consider changes in transmission investment levels as costs in this report.[7]

Table 5: Maryland Nuclear Plant Avoids Higher Electricity Prices
(All-in Wholesale Electricity Prices with and without Nuclear, Average Annual $/MWh, 2015-2024)

	Region	Wholesale price with nuclear	Wholesale price without nuclear	Wholesale price change	Electricity consumption *(millions of MWh)*	Total annual electricity cost change *(millions of 2015 dollars)*	Total electricity cost increase 2015-2024 *(millions of dollars)* [1]
[1]	PJM	$46.14	$46.65	$0.51	843	$428	$3,647
[2]	Maryland	$46.14	$46.65	$0.51	79	$40	$341

[1] Present value for the periods 2015-2024 at a 3% discount rate.

C. Impact on Economic Output

Calvert Cliffs contributes $397 million to annual state GDP and $536 million to gross output, largely through the electricity price effects shown above. These figures include both direct and secondary economic activity attributable to Maryland's nuclear plant, net of the economic activity associated with alternative generating capacity that would be necessary in its absence. The economic sectors most affected are shown in Table 6. The largest effects are found in the utilities, construction, and manufacturing sectors.

6 For, example, the economic and jobs effects could be up to twice the values shown here if gas prices were to return to levels seen just a few years ago.

7 These transmission costs are not captured here because the contribution of nuclear plants to the economy is measured by comparing scenarios with and without nuclear plants – the cost of transition to other generation sources don't enter this comparison. Transmission costs could, however be substantial if a premature transition to natural gas occurred.

Table 6: Net Economic Output Impacts by Sector in Maryland (Average Annual Direct and Secondary Impacts, 2015-2024)

Sector	Direct and Secondary Output *(millions of 2015 dollars)*
Utilities	208.3
Construction	105.6
Manufacturing	34.4
Real Estate and Rental and Leasing	33.8
Professional, Scientific, and Technical Services	29.4
Retail Trade	26.0
Health Care and Social Assistance	19.0
Finance and Insurance	17.6
Accommodation and Food Services	11.0
Wholesale Trade	10.7
Other	40.7
Total	536

Note: Numbers may not sum due to rounding.

D. IMPACT ON EMPLOYMENT

Maryland's nuclear plant accounts for about 2,300 direct and secondary jobs in the Maryland economy, as shown in Table 4. The employment sectors most influenced are sales, construction, and business and financial occupations, as shown in Table 7. As with the economic impact, the jobs impact occurs mostly indirectly; not as employment within the nuclear sector itself, but as enhanced employment in other sectors primarily caused by the economic effect of lower power prices.

Table 7: Net Employment Impacts by Sector in Maryland
(Average Direct and Secondary Impacts, (2015-2024)

Sector	Direct and Secondary Employment *(jobs)*
Sales and related, office and administrative support occupations	570
Construction and extraction occupations	460
Management, business, and financial occupations	230
Installation, maintenance, and repair occupations	180
Food preparation and serving related occupations	130
Healthcare occupations	120
Building and grounds cleaning and maintenance, personal care and service occupations	110
Computer, mathematical, architecture, and engineering occupations	110
Transportation and material moving occupations	110
Production occupations	100
Other	160
Total	2,300

Note: Numbers may not sum due to rounding.

E. IMPACT ON FEDERAL AND STATE TAX REVENUES

Calvert Cliffs and businesses providing goods and services to it pay substantial federal and state taxes. In addition, since the plant avoids higher electricity prices, it creates incremental economic output and associated tax revenues. Average incremental annual federal tax payments attributable to the plant total $65 million, and average annual state tax payments total $15 million.

Table 8: Net Annual Federal and State Tax Payments Attributable to Economic Activity Related to Maryland's Nuclear Plant

	Average Annual (2015-2024)
Direct and Secondary State Tax Revenues *(2015 dollars)*	$14.9 million
Direct and Secondary Federal Tax Revenues *(2015 dollars)*	$64.8 million
Total Federal and State Tax Revenues *(2015 dollars)*	$79.7 million

Note: Numbers may not sum due to rounding.

F. MARYLAND NUCLEAR PLANT PREVENTS SUBSTANTIAL CARBON DIOXIDE AND CRITERIA POLLUTANT EMISSIONS

Calvert Cliffs prevents substantial emissions of CO_2, SO_2, and NO_X compared to the alternative of natural gas and coal-fired generation. Average annual CO_2 emissions would be about 9 million tons higher absent the generation from Maryland's nuclear plant. This represents a 2% increase over current power sector emissions in PJM. Similarly, power sector SO_2 emissions would be 15,000 tons higher, and NO_X emissions would be 10,000 tons higher in PJM – about a 1% increase each. Particulate matter emissions (such as PM 2.5 and PM 10) would be approximately 1% higher in PJM. These reductions are summarized in Table 9. Note that the beneficiaries of these reductions are not necessarily located in Maryland. CO_2, for example, is a global pollutant. The higher fossil generation and associated criteria pollutant emissions would originate in the larger PJM region outside Maryland as well as within it, and can be transported beyond the point of emissions into still other states.

Table 9: Emissions Prevented by Maryland's Nuclear Plant (Average Annual, 2015-2024)

Pollutant	Avoided emissions *(tons)*
CO_2	9,051,026
SO_2	14,798
NO_x	9,804
PM 2.5	989
PM 10	1,190

The social cost of these emissions can be estimated using the federal government's social cost of CO_2 emissions ($43.31/ton) and the National Academy of Science's externality estimates for SO_2,

NOx, PM 2.5, and PM 10. Evaluated at these rates as shown in Table 10, the avoided social cost of carbon dioxide is $392 million, and the avoided costs of SO_2 and NO_X are $100 million and $18 million, respectively. The avoided costs of particulate matter emissions are approximately $11 million. These costs reflect environmental and human health damages and are independent of and in addition to the direct and secondary economic impacts addressed elsewhere in this report. They reflect costs incurred by society, not directly by the economy; the subsequent economic implications of these social costs are not reflected in the economic results above.

Table 10: Value of Emissions Prevented by Maryland's Nuclear Power Plant (Average Annual, 2015-2024)

Pollutant	Avoided emissions *(thousands of tons)*	Emissions social cost per ton *($/ton)*	Avoided emissions value *(millions of 2015 dollars)*
CO_2	9,051	$43	$392
SO_2	15	$6,789	$100
NO_x	10	$1,873	$18
PM 2.5	1	$11,119	$11
PM 10	1	$538	$1

Sources:
Carbon costs come from the Interagency Working Group on Social Cost of Carbon, United States Government.
SO2, NOx, PM-2.5, and PM-10 costs come from "Hidden Cost of Energy: Unpriced Consequences of Energy Production and Use" by the National Research Council.

CAMBRIDGE
NEW YORK
SAN FRANCISCO
WASHINGTON
LONDON
MADRID
ROME

THE Brattle GROUP