

---

---

# Ohio Nuclear Power Plants' Contribution to the State Economy

---

PREPARED FOR

NUCLEAR MATTERS



PREPARED BY

Mark Berkman, Ph.D.  
Dean Murphy, Ph.D.

July 7, 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.

Copyright © 2015 The Brattle Group, Inc.

---

## **Table of Contents**

I.	Executive Summary.....	1
II.	Background .....	1
III.	Nuclear Plants Make a Considerable Contribution to the Ohio Economy .....	4
A.	Impact on Electric Generation Mix.....	6
B.	Impact on Electricity Prices .....	7
C.	Impact on Economic Output .....	8
D.	Impact on Employment .....	9
E.	Impact on Federal and State Tax Revenues .....	9
F.	Ohio Nuclear Plants Prevent Substantial Carbon Dioxide and Criteria Pollutant Emissions .....	10

## I. Executive Summary

At the request of Nuclear Matters, The Brattle Group has estimated the value of the nuclear plants in Ohio to the state's economy.

Our analysis has determined that the nuclear plants operating in Ohio:

- contribute approximately \$521 million to state gross domestic product (GDP) (\$786 million in gross output).
- account for 3,600 in-state full time jobs (direct and secondary).
- help keep electricity prices low.
- are responsible for almost \$17 million in net state tax revenues annually.

These values reflect the incremental contribution of these nuclear plants to the economy, measured by comparing the performance of Ohio's economy with and without its nuclear plants. 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 Ohio economy would rely more heavily on existing natural gas and coal fired generating plants, many of which are outside Ohio, 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 about 1.4% higher on average in Ohio. 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 Ohio, although the absence of in-state nuclear plants will have significant additional consequences beyond the state's borders.

The absence of Ohio's nuclear plants would also result in much higher carbon dioxide (CO<sub>2</sub>) emissions and greater emissions of criteria pollutants such as nitrogen oxides (NO<sub>x</sub>) and sulfur dioxide (SO<sub>2</sub>). These impacts are not limited to Ohio, first because much of the alternative fossil-fired generation would occur outside Ohio, 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 Ohio's nuclear plants, 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<sub>2</sub> and other pollutants.

## II. Background

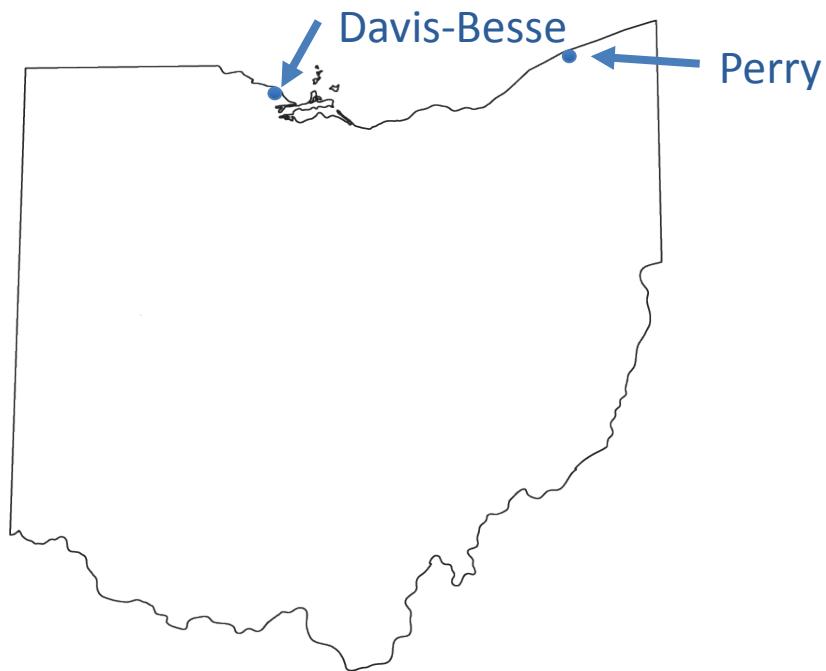
Two nuclear plants operate in Ohio, representing about 2,150 megawatts (MW) of capacity and nearly 17 million megawatt hours (MWh) of annual electricity generation, as shown in Table 1

and illustrated in Figure 1.<sup>1</sup> Ohio is within the electric region operated by the PJM independent system operator.<sup>2</sup> Ohio's nuclear generation makes up 1% of PJM's total capacity and 2% of its electricity generation, as shown in Table 2. It should be noted that PJM extends well beyond Ohio's borders, as illustrated in Figure 2. Within Ohio, nuclear power represents a larger share of capacity and generation at 7% and 11%, respectively, as shown in Table 3.

**Table 1: Summary of Nuclear Generation in Ohio**

Variable	Value
[1] Number of nuclear plants	2
[2] Number of nuclear reactors	2
[3] Total capacity (MW)	2,155
[4] Estimated generation (MWh)	16,768,059

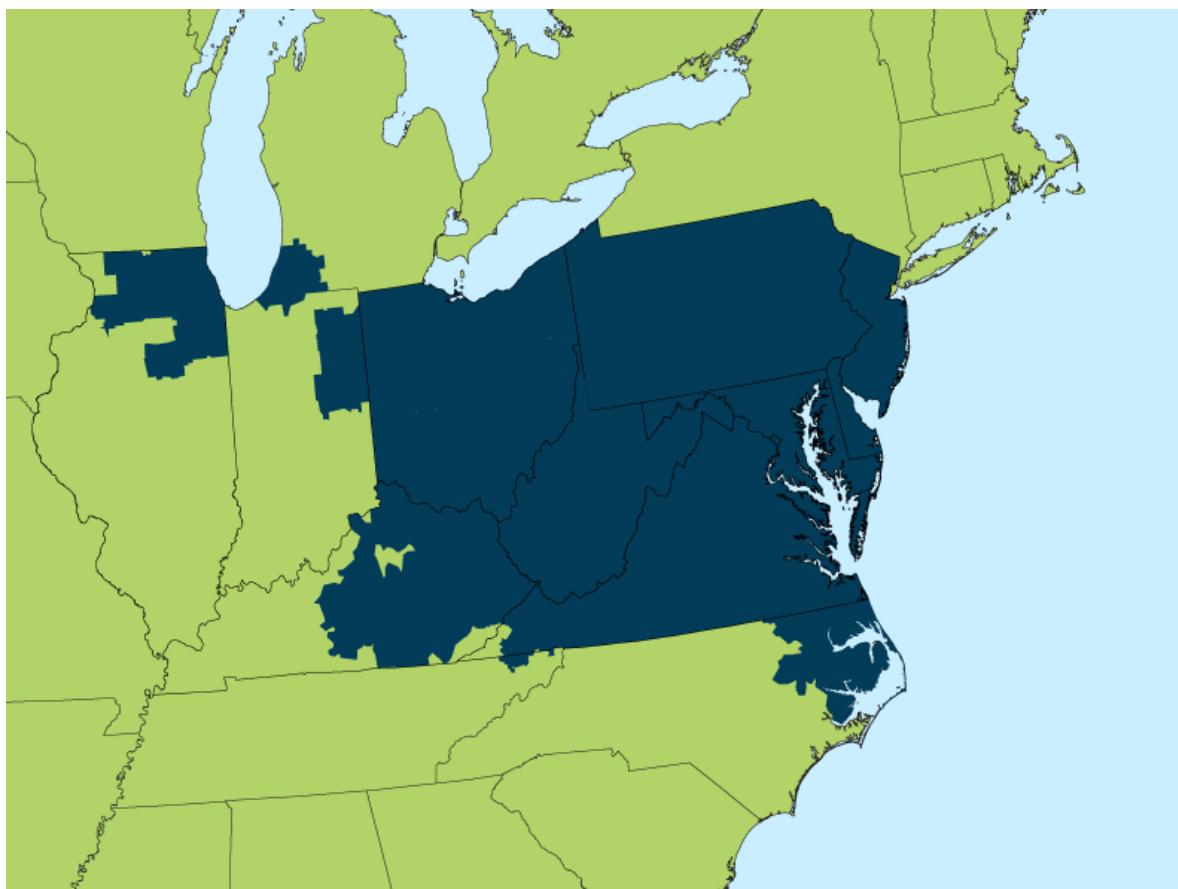
**Figure 1: Locations of Ohio Nuclear Plants**



<sup>1</sup> Data comes from Ventyx's Energy Velocity.

<sup>2</sup> Independent system operators (ISOs) establish and maintain electricity capacity and energy markets.

**Figure 2: PJM Region Map**



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

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

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

Category	Ohio nuclear share
[1] Ohio capacity	7%
[2] Ohio generation	11%

### **III. Nuclear Plants Make a Considerable Contribution to the Ohio Economy**

We have estimated the economic value of Ohio's nuclear plants to Ohio 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.<sup>3</sup> By linking these models, we are able to measure the economic output, employment, and tax revenue in Ohio with and without its nuclear plants, providing the most accurate picture of their incremental contribution to the economy. The economic impacts presented here are limited to Ohio, but the nuclear plants operating in Ohio have 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 the Ohio nuclear plants would require a regional model. Although we have not created such a regional model for Ohio, 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.<sup>4</sup>

This analysis indicates that Ohio's nuclear plants make a significant contribution to keeping regional electricity costs down, and this has a substantial effect on the Ohio economy. Netting out the value of the alternative electric generation that would substitute if they did not exist, Ohio's nuclear plants are responsible for substantial economic output and accompanying employment and tax revenues. Table 4 summarizes our findings for the impacts within Ohio (not including the impact outside the state).

---

<sup>3</sup> For more details on the REMI model, see [www.remi.com](http://www.remi.com).

<sup>4</sup> The Brattle Group, "The Nuclear Industry's Contribution to the U.S. Economy," July 7, 2015. Note that economic impacts presented for Ohio 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 Ohio Nuclear Plants to the Ohio Economy**

	Average Annual (2015-2024)
Direct and Secondary Employment (jobs)	3,600
Direct and Secondary Output (2015 dollars)	\$786 million
Direct and Secondary GDP (2015 dollars)	\$521 million
Direct and Secondary State Tax Revenues (2015 dollars)	\$16.9 million
Direct and Secondary Federal Tax Revenues (2015 dollars)	\$112.0 million

Ohio's nuclear plants contribute \$521 million to the state's GDP, and account for nearly 3,600 direct and secondary jobs.<sup>5</sup> Ohio's nuclear plants' owners also pay substantial federal and state taxes, as do businesses providing goods and services to the plants and their employees. In addition, the nuclear plants' incremental contributions to state output account for additional tax revenues. Ohio plants' effect on the economy leads to about \$17 million in additional state tax revenues and \$112 million in federal tax revenues, beyond what would be provided by the alternative electric supply that would be utilized in their absence.

Below, we provide further detail regarding the impact of Ohio nuclear plants on:

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

---

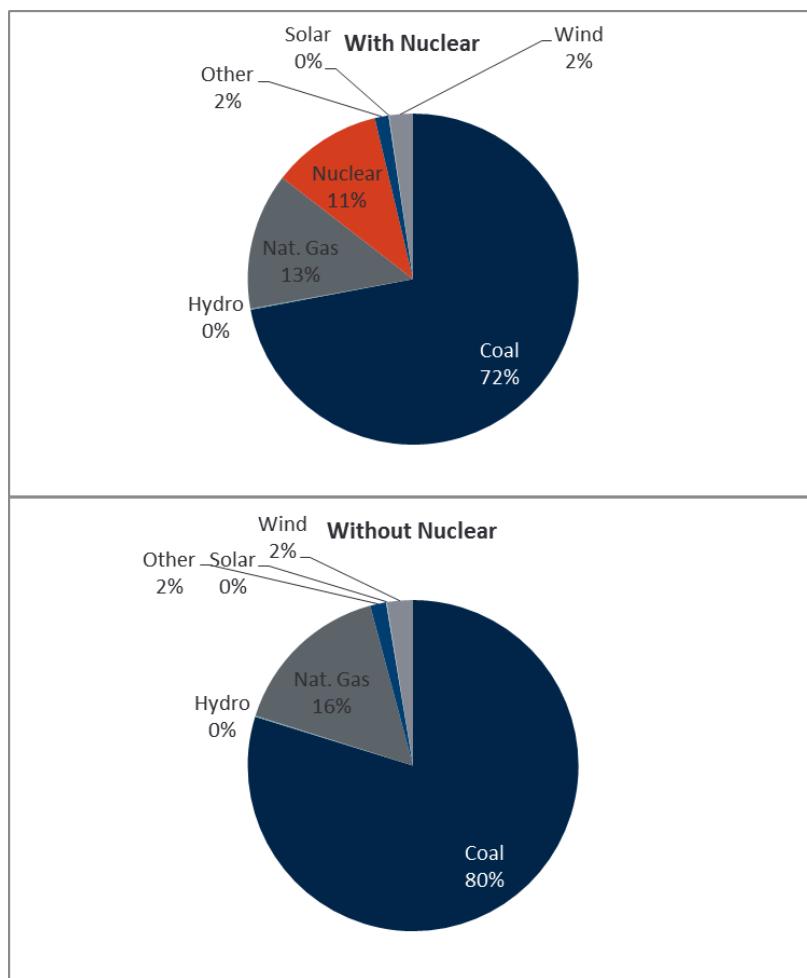
<sup>5</sup> We report both GDP and gross output since both are useful economic statistics in table 4. GDP is the most widely-used measure of national income. It reflects value added, which includes industry sales to other industries and to final users minus the value its purchases from other industries. 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 7, 2015.

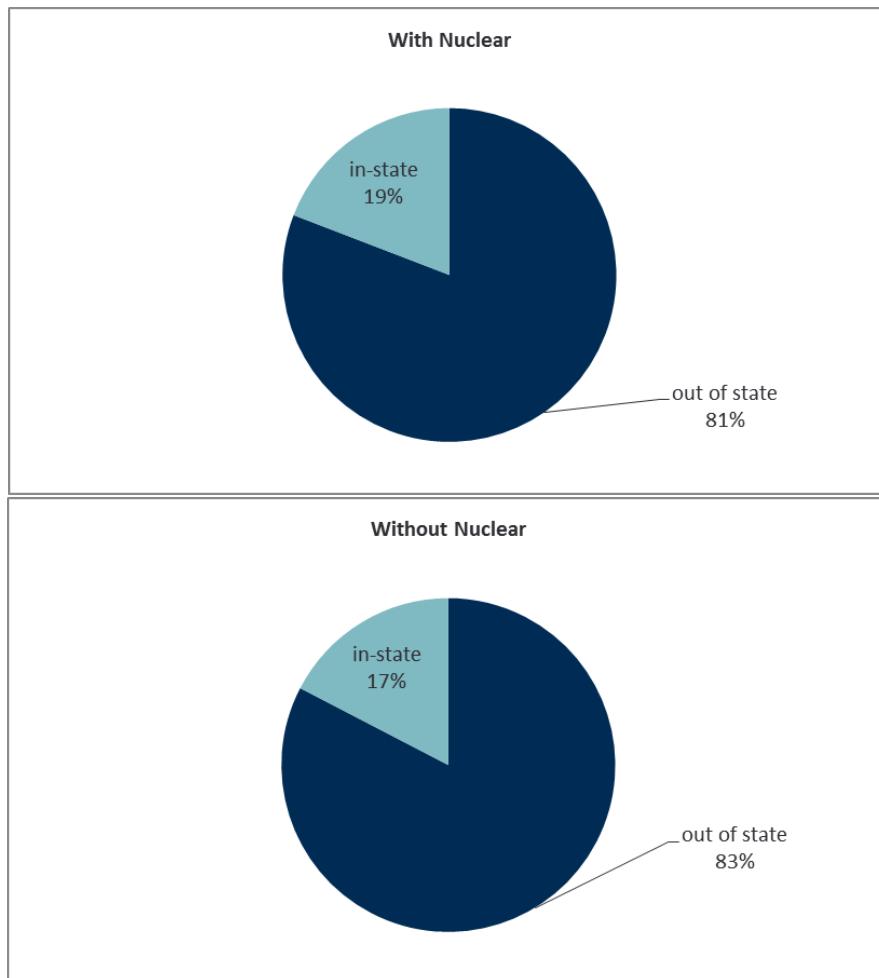
## A. IMPACT ON ELECTRIC GENERATION MIX

As shown in Figure 3, without Ohio’s nuclear power plants, electricity demand would be met mostly by increased reliance on existing natural gas and coal-fired generation. The share of Ohio generation from natural gas-fired plants would increase from 13% to 16%, and the share from coal-fired plants would increase from 72% to 80%. 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-Ohio power plants for 81% of its generation when the Ohio nuclear plants are included. This share would increase to 83% absent these plants, 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 Ohio in 2015**



**Figure 4: Ohio Share of PJM Generation in 2015**



## B. IMPACT ON ELECTRICITY PRICES

Ohio nuclear plants' impact on the Ohio economy is primarily the result of their influence on electricity prices. As noted above, absent Ohio's nuclear plants, electricity demand would be met by increased utilization of natural gas and coal-fired plants, some within Ohio but much outside it. This alternative generation mix would mean higher electricity prices across PJM. As shown in Table 5, on average electricity prices across the U.S. would be about 0.3% higher on a wholesale basis. In PJM, wholesale electricity prices would be more than 1.4% higher. Higher electricity prices hurt the economy primarily by reducing residential, commercial, and industrial spending on other goods and services.

**Table 5: Ohio Nuclear Plants Avoid 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	% change in wholesale price
[1] PJM	\$46.14	\$46.80	\$0.65	1.4%
[2] U.S. Weighted Average	\$39.72	\$39.84	\$0.13	0.3%

### C. IMPACT ON ECONOMIC OUTPUT

Ohio's nuclear plants contribute \$521 million to annual state GDP and \$786 million to gross output, largely through the electricity price effects shown above. These figures include both direct and secondary economic activity attributable to Ohio's nuclear plants, net of the economic activity associated with alternative generating capacity that would be necessary in their absence. The economic sectors most affected are shown in Table 6. The largest effects are found in the utilities, manufacturing, and construction sectors.

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

Sector	Direct and Secondary Output (millions of 2015 dollars)
Utilities	199.3
Manufacturing	147.2
Construction	113.7
Real Estate and Rental and Leasing	43.2
Retail Trade	43.1
Professional, Scientific, and Technical Services	35.3
Health Care and Social Assistance	35.1
Finance and Insurance	32.2
Wholesale Trade	22.6
Accommodation and Food Services	22.2
Other	91.9
Total	786

Note: Numbers may not sum due to rounding.

## D. IMPACT ON EMPLOYMENT

Ohio's nuclear plants account for about 3,600 direct and secondary jobs in the Ohio 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 Ohio  
(Average Direct and Secondary Impacts, 2015-2024)**

Sector	Direct and Secondary Employment (jobs)
Sales and related, office and administrative support occupations	910
Construction and extraction occupations	570
Management, business, and financial occupations	370
Food preparation and serving related occupations	250
Installation, maintenance, and repair occupations	240
Production occupations	220
Healthcare occupations	210
Transportation and material moving occupations	200
Building and grounds cleaning and maintenance, personal care and service occupations	180
Computer, mathematical, architecture, and engineering occupations	170
Other	280
Total	3,600

Note: Numbers may not sum due to rounding.

## E. IMPACT ON FEDERAL AND STATE TAX REVENUES

Ohio's nuclear plants and the businesses providing goods and services to these plants pay substantial federal and state taxes. In addition, since these plants avoid higher electricity prices, they create incremental economic output and associated tax revenues. Average incremental annual federal tax payments attributable to the plants total \$112 million, and average annual state tax payments total \$17 million.

**Table 8: Net Annual Federal and State Tax Payments Attributable to Economic Activity Related to the Ohio Nuclear Plants**

	Average Annual (2015-2024)
Direct and Secondary State Tax Revenues <i>(2015 dollars)</i>	\$16.9 million
Direct and Secondary Federal Tax Revenues <i>(2015 dollars)</i>	\$112.0 million
Total Federal and State Tax Revenues <i>(2015 dollars)</i>	\$128.9 million

## F. OHIO NUCLEAR PLANTS PREVENT SUBSTANTIAL CARBON DIOXIDE AND CRITERIA POLLUTANT EMISSIONS

Ohio's nuclear power plants prevent substantial emissions of CO<sub>2</sub>, SO<sub>2</sub>, and NO<sub>x</sub> compared to the alternative of natural gas and coal-fired generation. Average annual CO<sub>2</sub> emissions would be about 11 million tons greater absent the generation from Ohio nuclear plants. This represents a 2% increase over current power sector emissions in PJM. Similarly, power sector SO<sub>2</sub> emissions would be 18,000 tons higher, and NO<sub>x</sub> emissions would be 12,000 tons higher – about a 1% increase in PJM 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 Ohio. CO<sub>2</sub>, for example, is a global pollutant. The higher fossil generation and associated criteria pollutant emissions would originate in the larger PJM region outside Ohio as well as within it, and can be transported beyond the point of emissions into still other states.

**Table 9: Emissions Prevented by Ohio Nuclear Plants  
(Average Annual, 2015-2024)**

Pollutant	Avoided emissions (tons)
CO <sub>2</sub>	11,353,092
SO <sub>2</sub>	18,334
NO <sub>x</sub>	12,252
PM 2.5	1,232
PM 10	1,481

The social cost of these emissions can be estimated using the federal government's social cost of CO<sub>2</sub> emissions (\$43.31/ton) and the National Academy of Science's externality estimates for SO<sub>2</sub>, NO<sub>x</sub>, PM-2.5, and PM-10. Evaluated at these rates as shown in Table 10, the avoided social cost

of carbon dioxide is \$492 million, and the avoided costs of SO<sub>2</sub> and NO<sub>x</sub> are \$124 million and \$23 million, respectively. The avoided costs of particulate matter emissions are approximately \$14 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 Ohio Nuclear Power Plants  
(Average Annual, 2015-2024)**

Pollutant	Avoided emissions (thousands of tons)	Emissions cost per ton (\$/ton)	Avoided emissions value (millions of 2015 dollars)
CO <sub>2</sub>	11,353	\$43	\$492
SO <sub>2</sub>	18	\$6,789	\$124
NO <sub>x</sub>	12	\$1,873	\$23
PM 2.5	1	\$11,119	\$14
PM 10	1	\$538	\$1

Sources:

Carbon costs come from the Interagency Working Group on Social Cost of Carbon, United States Government.

SO<sub>2</sub>, NO<sub>x</sub>, 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

