# Clean Power Plan Impact Analysis Support

Southern Environmental Law Center

September 4, 2014

ICF was contracted by the Southern Environmental Law Foundation to compile and process data primarily published by the US EPA in conjunction with EPA's Proposed Clean Power Plan, formally published in the Federal Register as *Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units*. Specifically ICF compiled the data used in this *Clean Power Plan Impact Analysis Support* document from the following public sources:

- Power Sector Modeling of the Clean Power Plan proposed rule (http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html)
- Regulatory Impact Analysis: Clean Power Plan Proposed Rule (http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html)
- Other documents available in the Clean Power Plan Proposed Rule Technical Documents webpage (http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html)
- Other third party sources for the determination of changes in $CO_2$ reduction and other gases from power plants, which are noted explicitly in the report

The views, conclusions, and recommendations presented in this *Clean Power Plan Impact Analysis Support* document, however, are SELC's alone.

# Contents

## Introduction

ICF International (ICF) was contracted by Southern Environmental Law Center (SELC) to compile and process data primarily published by the US EPA in conjunction with EPA's proposed Clean Power Plan (CPP) to illustrate and quantify potential impacts the proposed rule that would control $CO_2$ emission rates from existing power plants. More specifically, ICF is assisting SELC in understanding the impacts of the CPP as it relates to the Commonwealth of Virginia. This report summarizes that data analysis. ICF has also separately provided SELC with a more detailed set of results associated with the scope of this analysis in spreadsheet format.

This analysis is wholly based on data collected from EPA's modeling results[1] and the Regulatory Impact Assessment (RIA)[2] of the CPP, as posted on EPA's website. Wherever applicable, we have noted any assumptions made.

This report discusses impacts due to the Option 1 standard, implemented both at the state level (Option 1—State Case) and regional level (Option 1—Regional Case). In both these cases, EPA modeled the CPP as a rate-based standard in which conventional generating resources, renewable resources and energy efficiency resources contribute to meeting the Best System of Emission Reductions (BSER) rate as proposed by EPA.

The next section of the report summarizes EPA's reported costs and benefits associated with the CPP. Following that, we briefly summarize the impacts of the CPP on power markets, both wholesale and retail, and also on employment. As mentioned earlier, the scope of this analysis is limited to impacts on Virginia only.

## Costs and Benefits

The RIA provides detailed discussion of the cost and benefit associated with the implementation of the CPP. However, the approaches of determining these cost and benefit components vary significantly from component to component. For instance, while EPA provided a detailed spreadsheet on the calculation of energy efficiency (EE) implementation costs, as they are an integral component of the proposed rule, it only provided a qualitative discussion of some of the benefits associated with reduced emissions of $SO_2$ and $NO_X$, which EPA describes as ancillary benefits to the rule. Therefore, while these costs and benefits provide a benchmark, they are not directly comparable, and not necessarily exhaustive. Limitations associated with each of these approaches are detailed in the RIA, and we have highlighted some of those limitations below.

### Compliance Cost

In EPA's analysis framework, compliance costs are defined as the difference between total system costs in a modeling run with the CPP (a policy case scenario) and a modeling run without it (a base case scenario). This difference therefore reflects the cost impacts attributable solely to the CPP. System costs

[1] EPA's modeling of the wholesale electric system was conducted using the Integrated Planning Model (IPM). Modeling results for the Clean Power Plan can be downloaded here: http://www.epa.gov/airmarkets/powersectormodeling/cleanpowerplan.html

[2] Regulatory Impact Assessment for the Clean Power Plan Proposed Rule can be downloaded here: http://www2.epa.gov/sites/production/files/2014-06/documents/20140602ria-clean-power-plan.pdf.

in this analysis were observed only for Virginia[3], and were taken as the sum of the following cost components for each run year[4]:

- Capital costs for the construction of new plants,
- Capital costs for the construction of new retrofits due to Heat Rate Improvements (HRI),
- Fixed operation and maintenance costs (FOM) and variable operations and maintenance (VOM) costs,
- Fuel costs for new and existing plants,
- Transportation and storage costs for fuel, and
- Costs associated with energy efficiency implementation.

Each of these cost components (except for energy efficiency costs) are reported separately for each generating unit in IPM (either new or existing). ICF aggregated these costs for generating units that were determined to be in Virginia. Energy efficiency (EE) was modeled exogenously in EPA's analysis, and costs associated with EE were reported separately by state. EE costs for Virginia were taken directly from EPA's GHG Abatement Measures TSD[5].

Tables 1 and 2 below show compliance costs, with wholesale market costs (system costs taken from IPM) separated from EE costs. We note that the implementation of the CPP leads to lower wholesale market costs, owing primarily to the fact that fewer new builds are required. However, accounting for EE costs shows that there is a net positive compliance costs associated with the implementation of CPP for the state of Virginia.

**Table 1: Virginia Compliance Costs Associated with CPP (Option 1--State Level)**

| (in Millions of 2011$) | 2016 | 2018 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Wholesale Market Costs | (31) | (266) | (81) | (175) | (64) |
| EE Total Annual Costs | - | 19 | 103 | 647 | 1,171 |
| ***Total Compliance Costs*** | ***(31)*** | ***(247)*** | ***22*** | ***472*** | ***1,107*** |

[3] Capacity additions of conventional generators in EPA's analysis are classified at the model region level. Region definitions within EPA's analysis do not necessarily align with state borders. In that regard, there are four regions that cover Virginia in EPA analysis: PJM Dominion, PJM AP, PJM West, and PJM_EMAAC. Moreover, some of these regions also overlap with other states. EPA does not directly provide what percent of each state corresponds to each modeling region. ICF has calculated this breakdown by observing what portion of a state's existing generation is classified under each modeling region. This breakdown was then used to translate other results that were provided by IPM modeling region to results by state.

[4] EPA's analysis does not model every year in the forecast horizon. Instead, it only models specific years of interest, called run years. In EPA's modeling runs, the run years chosen were 2016, 2018, 2020, 2025, 2030, 2040, and 2050.

[5] Report available in Excel spreadsheet format here: http://www2.epa.gov/sites/production/files/2014-06/20140602tsd-ghg-abatement-measures-scenario1.xlsx

**Table 2: Virginia Compliance Costs Associated with CPP (Option 1--Regional Level)**

| (in Millions of 2011$) | 2016 | 2018 | 2020 | 2025 | 2030 |
|---|---|---|---|---|---|
| Wholesale Market Costs | (15) | (269) | (161) | (219) | (166) |
| EE Total Annual Costs | - | 19 | 103 | 647 | 1,171 |
| ***Total System Costs*** | ***(15)*** | ***(251)*** | ***(58)*** | ***429*** | ***1,005*** |

## Carbon Reduction Benefits

Given the global nature of $CO_2$ impacts, it is inherently difficult to ascertain the benefits of $CO_2$ reductions only to Virginia. EPA's RIA uses the Social Cost of Carbon (SCC) to determine carbon reduction benefits, and notes in their RIA that "the SCC estimates represent global measures because of the distinctive nature of the climate change problem"[6]. Consequently, it is impossible to conceptualize and quantify $CO_2$ reduction benefits only to Virginia, and accordingly EPA measured these benefits on a global, rather than state-specific scale.

For this analysis, ICF has taken reductions in Virginia's $CO_2$ emissions and quantified its impact using the Social Cost of Carbon (SCC) values quoted in the study. The SCC value chosen here is the one that assumes an average discount rate of 3%[7]. Because $CO_2$ emissions have global impacts, the SCC represents assumed benefits worldwide, and not just to Virginia. Figure 1 shows the reduction in $CO_2$ emissions in Virginia's power sector as a result of the CPP, and Figure 2 shows the

[6] See page 4-8 of the RIA.

[7] Other SCC estimates provided in the RIA assumed an average discount rate of 2.5% and 5%. These SCC estimates are averages from three other models. In addition, a fourth SCC estimate assumed a discount rate of 3%, but the 95th percentile value from these models was used instead of the average. More details on this approach are provided in pages4-7 through 4-11 of the RIA.

**Figure 1: $CO_2$ Emission Changes in Virginia Due to the CPP**

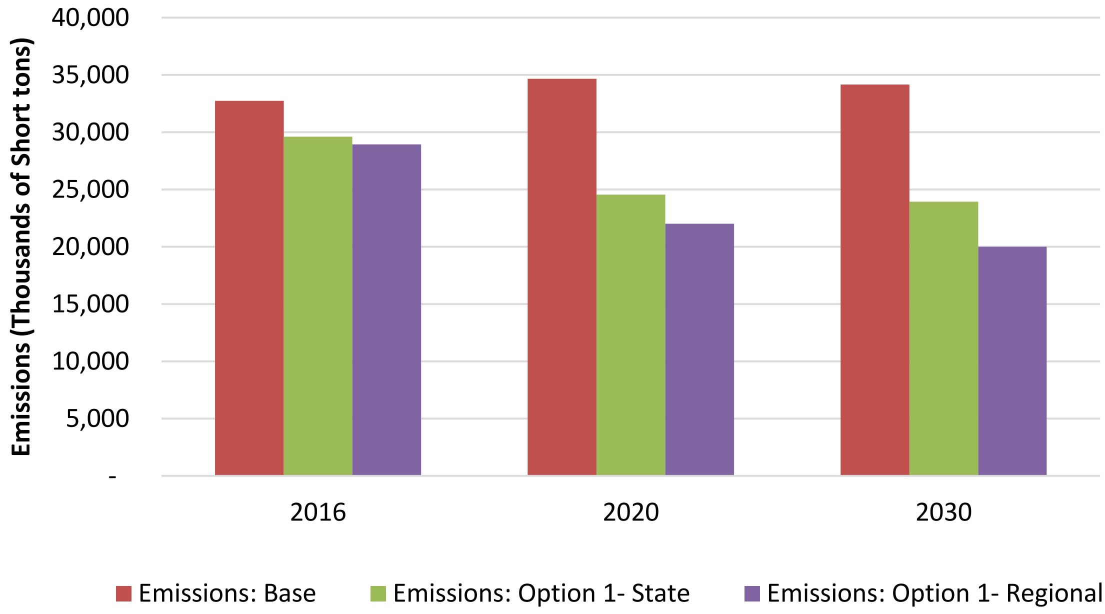
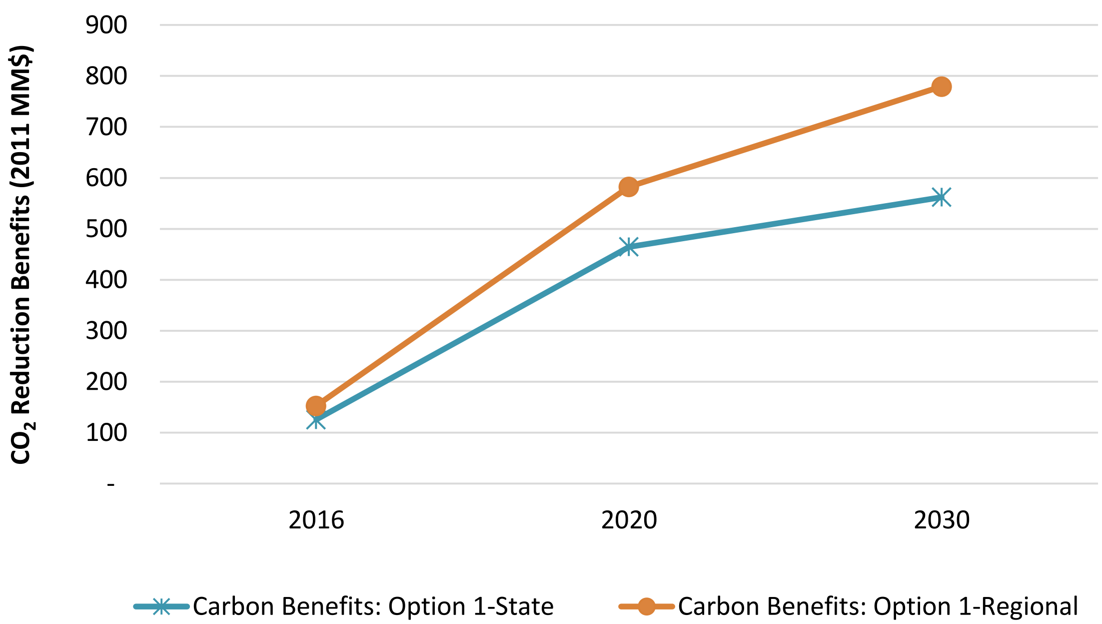



**Figure 2: Carbon Benefits (Global) as a result of Virginia's Lower CO2 emissions due to the CPP**



## Ancillary emission reduction benefits

As the CPP is aimed towards $CO_2$ emissions reductions, benefits associated with other pollutants are seen as “co-benefits”. In the RIA, EPA quantifies reduction benefits associated with $PM_{2.5}$ and ozone only (the RIA identified a number of benefits associated with these reductions, but did not quantify all of them). Reductions due to other pollutants such as HAPs (including mercury and hydrogen chloride), $SO_2$ and $NO_x$ are not quantified in the RIA.

EPA evaluated the health co-benefits associated with $PM_{2.5}$ by calculating total monetized human health co-benefits of reducing one ton of $PM_{2.5}$, or one of its precursors ($NO_x$ and $SO_2$). Similarly, EPA calculated health co-benefits of reducing one ton of $NO_x$ in order to estimate ozone co-benefits, as $NO_x$ is a precursor for ozone. In general, we did not find adequate data provided by the EPA in order for us to derive state-level impacts. Moreover, we also note that the RIA acknowledges that their own attempted analysis for a state-level impact was unreliable[8]. Therefore, this analysis only discusses the benefits associated with ancillary emission reductions in qualitative terms. ICF has also listed a few studies that show an indirect link between $CO_2$ emission reductions, and reductions of other gases in power plants.

Table 2 below shows non-$CO_2$ emission changes in Virginia due to the CPP. Even though Tables 3 through 5 show benefit-per-ton estimates and emissions for the East region, it would not be accurate to use the same relationship to monetize benefits to Virginia due to lower emissions shown in Table 2. In reality, as these pollutants can travel significant distances after being emitted, their effects (or reduction benefits) are not necessarily experienced in the same state as where they were emitted. Given the complexity in determining state-specific benefits of these reductions, EPA measured the benefits of such emission reductions on a regional scale.

[8] “When we evaluated the state-level estimates in the same manner as the national and regional estimates, we found that the state-level estimates performed similarly, in general, to the regional estimates for estimating total national benefits but were unreliable in estimating the benefits that would accrue to each state.” (Page 4A-25 of the RIA).

**Table 2: Non-$CO_2$ Emission Changes from Sources in Virginia Due to the CPP**

| | Emissions (thousands of tons) | | |
|---|---|---|---|
| | Option 1 - State | | |
| | 2020 | 2025 | 2030 |
| SO2 | -3 | -4 | -3 |
| Ozone Season NOx | -2 | -3 | -2 |
| Annual NOx | -6 | -9 | -6 |
| Hg | 0 | 0 | 0 |
| HCL | 0 | 0 | 0 |
| | Option 1 - Regional | | |
| | 2020 | 2025 | 2030 |
| SO2 | -3 | -4 | -4 |
| Ozone Season NOx | -2 | -5 | -5 |
| Annual NOx | -9 | -13 | -11 |
| Hg | 0 | 0 | 0 |
| HCL | 0 | 0 | 0 |

## *Benefits Associated with Lower $PM_{2.5}$ and Ozone*

There are numerous health effects associated with exposure to $PM_{2.5}$ and ozone. A reduction in these two pollutants will reduce the incidence of these health effects. Negative health effects of exposure to $PM_{2.5}$, include: adult premature mortality, acute bronchitis, asthma exacerbation, cerebrovascular disease, and reproductive and developmental effects. Negative health effects of exposure to ozone, include: premature mortality, premature aging of lungs, cardiovascular effects, and reproductive and developmental effects.

In addition to health risks associated with exposure to $PM_{2.5}$ and ozone; there are additional health risks associated with direct $NO_x$ and $SO_s$ exposure. The EPA's $NO_x$ *Integrated Science Assessment* found that there was a likely causal relationship between respiratory health effects and short-term $NO_2$ exposure.[9] There also exists a causal relationship between short-term $SO_2$ exposure and respiratory health effects.[10]

Benefit-per-ton estimates show the total monetized human health co-benefits of reducing one ton of the specified pollutant. Table 3 below shows the regional benefit-per-ton Estimate for the East[11]. Also, Table 4 and Table 5 show the corresponding emissions and monetized health co-benefits for the East.

[9] RIA 4-57
[10] RIA 4-58
[11] The "East" Region in this analysis is comprised of the following 37 states: Alabama, Arkansas, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New York, North Carolina,

**Table 3: Benefit-per-ton (2011$ per short ton) by Pollutant**

| | Benefit-per-ton (2011$ per short ton) | | | | | |
|---|---|---|---|---|---|---|
| | 2020 | | 2025 | | 2030 | |
| Pollutant | Min | Max | Min | Max | Min | Max |
| SO2 | $40,000 | $90,000 | $44,000 | $98,000 | $47,000 | $110,000 |
| Directly Emitted PM2.5 (EC+OC) | $140,000 | $320,000 | $150,000 | $340,000 | $160,000 | $370,000 |
| Direct emitted PM2.5 (Crustal) | $18,000 | $41,000 | $18,000 | $40,000 | $19,000 | $43,000 |
| NOx (as PM2.5) | $6,700 | $15,000 | $7,200 | $16,000 | $7,600 | $17,000 |
| NOx (as Ozone) | $4,600 | $19,000 | $5,900 | $25,000 | $6,300 | $27,000 |

**Table 4: National Non-$CO_2$ Emissions in the East Region Due to the CPP**

| | Emissions (thousands of tons) | | | | | |
|---|---|---|---|---|---|---|
| | Option 1 - State | | | Option 1 - Regional | | |
| | 2020 | 2025 | 2030 | 2020 | 2025 | 2030 |
| Pollutant | | | | | | |
| SO2 | 311 | 395 | 441 | 279 | 376 | 406 |
| Directly Emitted PM2.5 (EC+OC) | 5 | 6 | 5 | 5 | 5 | 5 |
| Direct emitted PM2.5 (Crustal) | 41 | 44 | 39 | 31 | 42 | 39 |
| NOx (as PM2.5) | 315 | 378 | 376 | 305 | 372 | 366 |
| NOx (as Ozone) | 135 | 164 | 163 | 130 | 160 | 158 |

North Dakota, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, and Wisconsin.

**Table 5: Monetized Health Co-benefits in the East Region Due to the CPP**

| | Estimated Monetized Health Co-benefits (millions of 2011$) | | | | | |
|---|---|---|---|---|---|---|
| | Option 1 - State | | | | | |
| | 2020 | | 2025 | | 2030 | |
| **Pollutant** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** |
| **SO2** | $13,000 | $29,000 | $18,000 | $40,000 | $21,000 | $47,000 |
| **Directly Emitted PM2.5 (EC+OC)** | $760 | $1,700 | $900 | $2,000 | $870 | $2,000 |
| **Direct emitted PM2.5 (Crustal)** | $790 | $1,800 | $830 | $1,900 | $800 | $1,800 |
| **NOx (as PM2.5)** | $2,200 | $4,900 | $2,900 | $6,500 | $2,900 | $6,600 |
| **NOx (as Ozone)** | $640 | $2,700 | $1,000 | $4,000 | $1,100 | $4,600 |
| ***Total*** | ***$17,390*** | ***$ 40,100*** | ***$23,630*** | ***$54,400*** | ***$26,670*** | ***$62,000*** |
| | Option 1 - Regional | | | | | |
| | 2020 | | 2025 | | 2030 | |
| **Pollutant** | **Min** | **Max** | **Min** | **Max** | **Min** | **Max** |
| **SO2** | $12,000 | $26,000 | $17,000 | $38,000 | $20,000 | $44,000 |
| **Directly Emitted PM2.5 (EC+OC)** | $750 | $1,700 | $850 | $1,900 | $840 | $1,900 |
| **Direct emitted PM2.5 (Crustal)** | $770 | $1,700 | $780 | $1,800 | $770 | $1,700 |
| **NOx (as PM2.5)** | $2,200 | $5,000 | $3,000 | $6,800 | $3,000 | $6,700 |
| **NOx (as Ozone)** | $630 | $2,700 | $1,000 | $4,300 | $1,100 | $4,500 |
| ***Total*** | ***$16,350*** | ***$37,100*** | ***$22,630*** | ***$52,800*** | ***$25,710*** | ***$58,800*** |

Since regional benefit-per-ton estimates assume a constant percentage of emission reductions across the region, they do not fully reflect the spatial differences in emission reductions and health impacts across the proposed compliance scenarios[12]. Furthermore, it is difficult to use the regional benefit-per-ton estimate to derive state-level estimates, since the regional benefit-per-ton estimates do not reflect the state level variability in emission reductions, population density, air quality response, interstate pollution transport, and base case heath incidence rates.[13] While the EPA tested different methods for creating state-level benefit-per-ton estimates, it could not find a reliable approach.[14]

### *Studies about changes in $CO_2$ and other pollutants*

Numerous studies show a link between emission reduction strategies and reduced emissions of $CO_2$, $SO_2$, and $NO_x$. We highlight some of these studies below. The 2001 study *Analysis of Strategies for Reducing Multiple Emissions from Electric Power Plants: Sulfur Dioxide, Nitrogen Oxides, Carbon Dioxide,*

[12] RIA 4A-24
[13] RIA 4A-24
[14] RIA 4A-24- 4A-25

*and Mercury and a Renewable Portfolio Standard* done by the EIA, modeled the impacts of imposing caps on power sector emissions of $NO_x$, $SO_2$, Hg, and $CO_2$. In the case of the $CO_2$ cap "the model chooses among investments in lower emitting technologies (mainly new natural gas and renewables), changes in operations and retirement decisions for existing and new electric power plants (using lower emitting resources more intensively than higher emitting resources and maintaining low emitting resources such as nuclear), and conservation activities by consumers (induced by higher prices)."[15] The modeled case had a $CO_2$ emissions cap at 7% below the 1990 level; the 1990 level had to be met by 2008, 7% below the 1990 level had to be maintained from 2008-2012, and the emission cap remained at the 1990-7% level from 2012 through 2020. The model projected that in 2020 the $CO_2$ emission cap would lead to (compared to the reference case) 18% lower $So_2$ emissions, 52% lower $NO_x$ emissions and 43% lower $CO_2$ emissions.

The article *Reduced emissions of CO2, NOx, and SO2 from U.S. power plants owing to switch from coal to natural gas with combined cycle technology* also shows a link between $CO_2$ and $SO_2$ and $NO_x$ reduction. This study used historical data to look at how the switch from coal to natural gas with combined cycle technology affected US emission rates. The study found that "as a result of the increased use of natural gas, $CO_2$ emissions from U.S. fossil-fuel power plants were 23% lower in 2012 than they would have been if coal had continued to provide the same fraction of electric power as in 1997".[16] Additionally (compared to if coal had continued to provide the same fraction of electric power as in 1997), the increased use of natural gas resulted in emission reductions of 40% for $NO_x$ and 44% for $SO_2$ in 2012.

A recent study, *A Systems Approach to Evaluating the Air Quality Co-benefits of U.S. Carbon Policies*, presents a systems approach to quantifying air quality co-benefits of U.S. policies to reduce GHG emissions. The study concluded that monetized human health benefits associated with air quality improvements could offset 26-1050% of the cost of U.S. carbon policies. It also found that flexible policies, such as cap-and-trade, had larger net co-benefits than policies that targeted specific sectors (such as electricity and transportation). Another key finding from the study suggested that net co-benefit is driven by costs, rather than benefits, for a number of carbon policy choices, including policies that offer subsidies influencing the cost of renewables. Finally, the study notes that potential co-benefits associated with carbon policies diminish rapidly as these policies became more stringent—the benefit-cost ratio decreases as lower cost controls are exhausted.

## Wholesale Electricity Market Impacts

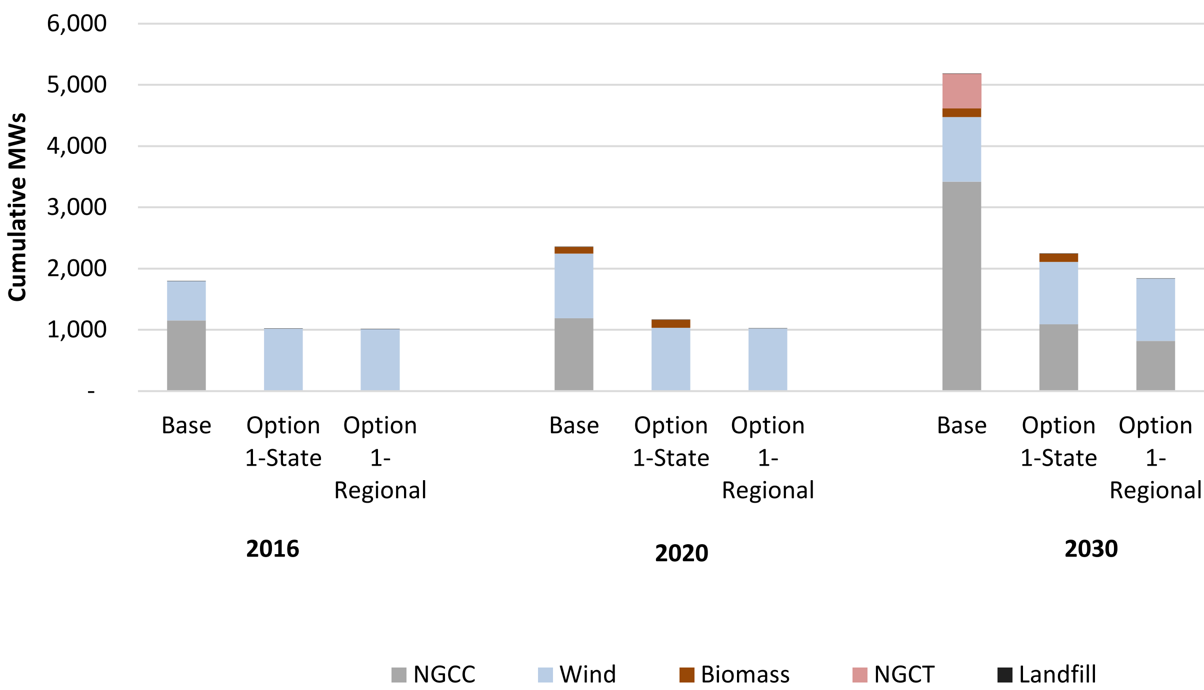
The implementation of the CPP will inevitably lead to changes in the power generation mix, as new capacity is added, and some existing capacity is retired or dispatched differently. Since, IPM directly reports new capacity builds, retirements, and the generation mix, ICF was able to parse these reports to determine impacts of the CPP on Virginia's power sector.

As shown in Figure 3, the amount of new capacity, particularly Natural Gas Combined Cycle (NGCC), required with the CPP is significantly lower in both the Option 1—State Case and the Option 1—Regional

[15] Pg. 14
[16] Pg. 75 of the study

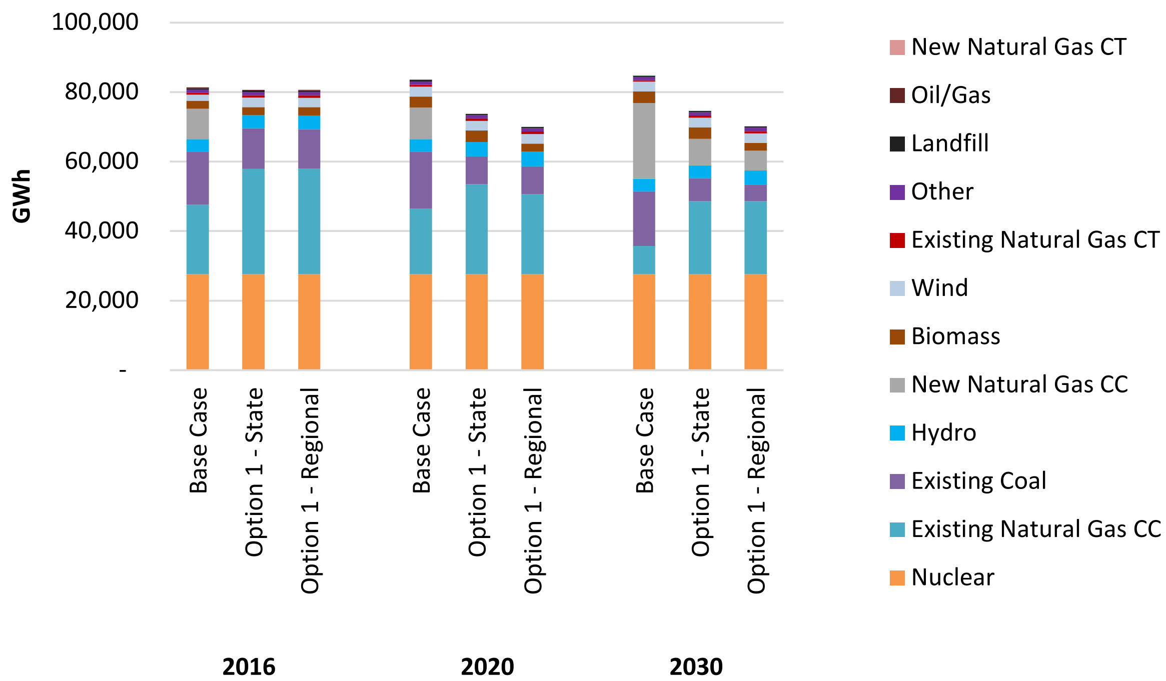
Case. These lower builds are primarily due to EE measures, which lower energy demand. Figure 4 illustrates this behavior even more clearly, where we notice that overall generation in Virginia is lower in the two CPP cases, than in the Base Case.

Figure 1: Virginia New Capacity Build Impacts Due to the CPP




The CPP results in new wind builds occurring earlier relative to the Base Case—wind builds in 2016 are over 60% higher in each of the CPP cases than in the Base case. However, in the long term, the difference in wind builds between the CPP cases and the Base case is negligible. There is also a small amount of landfill gas capacity that is built in each of the cases. No other renewable type is built in any scenario.

### Figure 2: Virginia Generation Mix Impacts Due to CPP




Changes in retrofits due to the CPP are relatively modest, as shown in Table 6—Heat Rate Improvement (HRI) technology is implemented in 401 MWs of existing coal in 2020 in the Option 1—State Case, and no such implementation occurs in the Option 1—Regional Case.

### Table 6: Impacts of the CPP on Retrofit Decisions in Virginia

| | Option 1--State Case | | | | | Option 1--Regional Case | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2018 | 2020 | 2025 | 2030 | 2016 | 2018 | 2020 | 2025 | 2030 |
| CCS | - | - | - | - | - | - | - | - | - | - |
| HRI | - | - | 401 | - | - | - | - | - | - | - |
| ACI | - | - | - | - | - | - | - | - | - | - |
| FGD | - | - | - | - | - | - | - | - | - | - |
| DSI | - | - | - | - | - | - | - | - | - | - |
| SCR | - | - | - | - | - | - | - | - | - | - |
| SNCR | - | - | - | - | - | (103) | - | - | - | - |
| C2G | - | - | - | - | - | - | - | - | - | - |
| CCG | - | - | - | - | - | - | - | - | - | - |

Retirements of existing coal units, however, increase by about 50% in the Option 1—State Case and 58% in the Option 1—Regional Case. Table 7 shows the changes in retirements due to the CPP.

**Table 7: Impacts of the CPP on Retirement Decisions in Virginia**

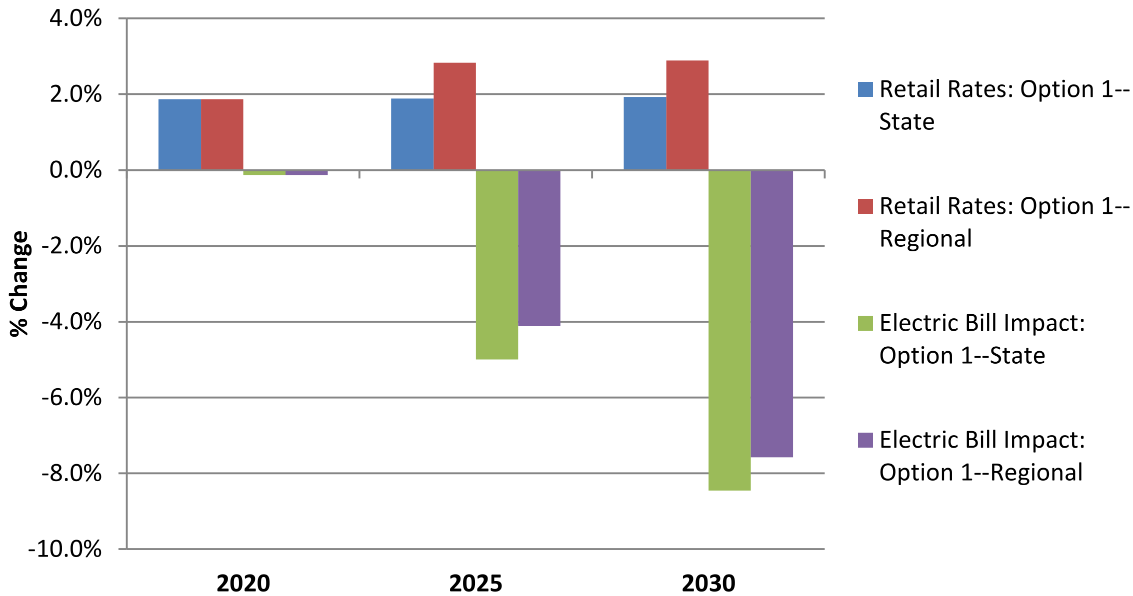
| | Option 1—State Case | | | | | Option 1—Regional Case | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2016 | 2018 | 2020 | 2025 | 2030 | 2016 | 2018 | 2020 | 2025 | 2030 |
| CC Retirement | - | - | - | - | - | - | - | - | - | - |
| CT Retirement | - | - | - | - | - | - | - | - | - | - |
| Non-Fossil Retirement | - | - | - | - | - | - | - | - | - | - |
| Coal Retirement | 884 | - | - | - | - | 1,055 | - | - | - | - |
| O/G Retirement | - | - | - | - | - | - | - | - | - | - |
| Nuke Retirement | - | - | - | - | - | - | - | - | - | - |
| IGCC Retirement | - | - | - | - | - | - | - | - | - | - |

## Retail Rate Impacts

Impacts on retail rates were provided by EPA at the regional level. Note that these are not the same broad regions used for reporting elsewhere (i.e. East, West, and California regions), but are more granular, so that they reflect impacts on Virginia more closely[17]. Based on this classification, Virginia is part of the SRVC region, along with North Carolina and South Carolina. Figure 5 shows the impact of the CPP on retail rates in this region.

[17] Retail rate impacts were provided by the EPA at sub-RTO region level, in which Virginia is part of the broader "Virginia-Carolina" region. ICF will assume that retail rate impacts experienced at the state-level will be the same as that at the regional-level.

Figure 3: Retail Rate and Electric Bill Impacts in Virginia due to the CPP




The implementation of the CPP will also result in lower household electric consumption, due to EE technologies. Therefore, while retail rates are higher as a result of the CPP, the lower household consumption counters that effect on the overall household bill. Figure 5 above shows the impact on bills, after accounting for both these effects[18].

[18] The percent change in electric bill is based on the decreases in Net Energy for Load, as modeled in IPM. We used the Net Energy for Load differences in the SERC-VACAR (which includes the Carolinas) and PJM-Dominion regions in this case, since the retail rate differences were reported by EPA collectively for these regions.

## Economic and employment impacts:

EPA's approach for determining employment impacts mostly looks at "first-order" jobs associated within the power sector, such as jobs for construction and maintenance of new units, jobs for heat-rate improvement upgrades, etc. The only "second-order" job impacts discussed are jobs in the coal mining and gas extraction sectors.

In order to derive these impacts for Virginia, ICF has followed the approach described by EPA in its RIA. In order to verify that our approach was consistent with that of EPA's, we first used the approach to derive job impacts at the national level, and compared that against what was reported by EPA (see Table 6-4 and Table 6-5 in the RIA). After determining that the values derived by our approach for national impacts were reasonably close to that reported by EPA, we adopted the same approach to calculate job impacts in Virginia.

Table 8 summarizes job impacts resulting from each of the two Option 1 cases. We also provide further detail below on each of the categories listed in the Table. The values shown in this table are in job-years, which represents the amount of work performed by one full time equivalent (FTE) employee in one year. For instance, 10 job-years in 2015 may represent 10 full-time jobs or 20 half-time jobs in the same year, or a combination of full- and part-time workers that would result in 10 FTEs.

However, jobs created in the energy efficiency sector represent both full-time and part-time jobs, and cannot be compared with other FTEs. Therefore jobs created in this sector are not shown in Table 8. Please refer to the section below on Jobs Gained due to Energy Efficiency for more details.

**Table 8: Job Impacts in Virginia due to the CPP**

| Construction-related (One-time) Changes | Option 1--State | | | Option 1--Regional | | |
|---|---|---|---|---|---|---|
| | 2017-2020 | 2021-2025 | 2026-2030 | 2017-2020 | 2021-2025 | 2026-2030 |
| **Heat Rate Improvement: Total** | **75** | **-** | **-** | **-** | **-** | **-** |
| Boilermakers and General Construction | 51 | - | - | - | - | - |
| Engineering and Management | 14 | - | - | - | - | - |
| Equipment-related | 7 | - | - | - | - | - |
| Material-related | 2 | - | - | - | - | - |
| **New Capacity Construction: Total** | **(743)** | **(1,133)** | **(64)** | **(985)** | **(1,114)** | **(310)** |
| Renewables | (743) | - | (132) | (985) | - | (126) |
| Natural Gas | - | (1,133) | 68 | - | (1,114) | (184) |
| **Recurring Changes** | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| **Operations and Maintenance: Total** | **(568)** | **(641)** | **(573)** | **(652)** | **(718)** | **(663)** |
| Changes in Gas | (134) | (246) | (224) | (135) | (247) | (247) |
| Retired Coal | (433) | (395) | (349) | (517) | (471) | (417) |
| Retired Oil and Gas | - | - | - | - | - | - |
| **Fuel Extraction: Total** | **(78)** | **(77)** | **(44)** | **(72)** | **(75)** | **(31)** |
| Coal | (78) | (77) | (44) | (72) | (75) | (31) |
| Natural Gas | - | - | - | - | - | - |
| **Supply-Side Employment Impacts** | **(571)** | **(717)** | **(617)** | **(725)** | **(793)** | **(694)** |

**Notes**:
1. The format for Table 4 above is the same as that for Table 6-4 and Table 6-5 of the RIA, which show job impact results at the national level
2. Job-year estimates shown above are Full-Time equivalent (FTE), and do not include impacts on energy efficiency jobs (which include both part-time and full-time jobs).
3. From the RIA: "Construction-related job-year changes are one-time impacts, occurring during each year of the 2 to 4 year period during which HRI installation activities occur."
4. From the RIA: "Recurring Changes are job-years associated with annual recurring jobs including operating and maintenance activities and fuel extraction jobs…In addition, there are recurring jobs prior to 2020 to fuel and operate new generating capacity brought online before 2020; the recurring jobs prior to 2020 are not estimated."
5. Job estimates for New Capacity Construction are estimated by extrapolating national job impacts shown in Table 6-5 and Table 6-4 of the RIA. This approach is different than what is described in the RIA. ICF was unable to reasonably reproduce EPA's estimates using the methodology described in the RIA, and thus implemented a simpler extrapolation to estimate job impacts in Virginia.

## Jobs due to Heat Rate Improvements

The EPA assumes that all construction jobs created owing to heat rate improvements (HRI) in coal plants will occur between 2017 and 2020. Construction jobs for HRI are further divided into the following four categories:

- Boilermakers and General Construction
- Engineering and Management
- Equipment-related
- Material-related

## Jobs Due to Construction of New Capacity

The implementation of the CPP results in accelerated deployment of new renewable capacity, and consequently results in more renewable construction jobs being created in the near term, relative to the Base case. The corollary to that is that there are fewer jobs in the long-term when compared to the Base case. Similarly, because there are fewer megawatts of new gas in the Option 1 cases, the implementation of the CPP results in fewer construction jobs in that sector.

Construction job impacts were calculated based on total capital costs spent in the construction of new capacity, as reported in the IPM results. These amounts were used in conjunction with labor productivity estimates. In that regard, EPA looked at the following labor categories:

- General power plant construction
- Engineering and management
- Material use (steel)
- Equipment Use (Machinery)

## Jobs Lost due to Retirement: Plant Operations

The retirement of fossil plants will lead to the elimination of operations and maintenance (O&M) jobs in such plants. EPA assumed an average fixed O&M cost for coal plants and for oil/gas plants, and also looked at labor productivity values for plant operators. These values were then taken in conjunction with total capacity retired, resulting in total jobs lost in power plants.

## Jobs Lost due to Retirement: Coal Extraction

The loss of coal plants will also lower demand for coal (both inside and outside Virginia), and will lead to job losses in the coal mining. EPA assumes labor productivities in the coal extraction sector for different coal supply regions. In that regard, in order to estimate job impacts in Virginia, we chose the labor productivity value provided for Appalachian coal.

As mentioned earlier, job impacts in the gas extraction sector are not examined here, as Virginia does not have any significant gas extraction activities.

## Jobs Gained due to Energy Efficiency

As energy efficiency (EE) is expected to play an important role in the implementation of the CPP, there is a significant potential for job creation in this sector. However, note that the CPP does not obligate states to pursue any EE activities, and consequently job creation in this sector is highly dependent on how states choose to develop their State Plans. EPA estimates jobs created in this sector by assuming a standard factor that translates dollars expended in EE implementation to jobs created in this field. EPA acknowledges that this approach has several limitations, which are noted in the RIA.

The RIA also notes that jobs estimated for other sectors (shown in Table 8 above) are all full-time equivalent jobs. However, EE jobs are either full-time or part-time jobs, and should not be lumped together with other jobs. Thus, in order to maintain consistency with EPA's recommendation, we list jobs created due to EE separately below.

**Table 9: Energy Efficiency Jobs Created in Virginia Due to the CPP**

| | Jobs Created in both Option 1--State and Option 1--Regional | | |
|---|---|---|---|
| | **2020** | **2025** | **2030** |
| **Additional jobs per additional million dollars spent on EE** | 265 | 1,657 | 2,998 |

Note: These figures are not comparable with other FTE jobs shown in the previous table, since EE jobs shown here represent number of employees (full-time or part-time).

## Other Job Impacts

The RIA does not detail job impacts associated with the CPP on an economy-wide basis. More specifically, the CPP only evaluates first-order jobs and some second-order jobs (which are discussed above). Some of these job impacts could be derived by using specialized modeling tools such as REMI and JEDI. For instance, the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impact (JEDI) Models[19] estimate jobs created due to the construction of new renewables such as wind and solar. These models calculate impacts on direct jobs, indirect jobs, and induced jobs. Although, these models are not able to calculate jobs lost in the power sector, and therefore the job impacts estimated are gross impacts, not net impacts. Even though the specific definition of direct, indirect, and induced impacts can vary, we provide potential examples of such impacts, as illustrated in a 2012 NREL study[20]:

1. Direct Impacts: These impacts are related to project development and onsite labor, and are included in the CPP RIA. For instance, direct impacts can include jobs, earnings, and outputs related to specialty contractors, construction workers, clean-up crews, truck drivers, management and support staff, and other specialists hired to permit, design, and install the system.
2. Indirect Impacts: These impacts account for jobs, earnings, and outputs associated with manufacturing of equipment and materials used in the facility, the supply chain that provides raw materials to these manufacturers, and the finance and banking sectors that provide services

[19] More information on JEDI available here: http://www.nrel.gov/analysis/jedi/

[20] Preliminary Analysis of the Jobs and Economic Impacts of Renewable Energy Projects Supported by the Section 1603 Treasury Grant Program (http://www.nrel.gov/docs/fy12osti/52739.pdf )

for the construction and operation of these facilities. For instance, these jobs could include jobs at a wind turbine manufacturing plant, jobs at other facilities that fabricate structural hardware, foundations, and electrical components for the wind facility's systems. These jobs would also include bankers who finance construction contractors, accountants who keep track of the contractors' books, and jobs at steel mills that provide raw materials to manufacturing facilities.

3. Induced Impacts: The impacts refer to jobs, earnings, and outputs that occur through spending of earnings by persons directly or indirectly employed by new projects (i.e. jobs described in the first two categories). For instance, jobs are induced when workers hired for construction spend their earnings to purchase food at grocery stores and restaurants, when they pay rent or mortgages in their homes, and purchase clothes or other goods to meet their needs.

In addition to indirect and induced jobs, other job impacts not captured in EPA's analysis include impacts due to price changes. For instance, the implementation of the CPP could lead to increased energy prices in some regions, which may increase the cost of doing business and hence have a negative impact on jobs, all else being equal. A potential countervailing impact on jobs may come from companies with sustainability goals that are looking to do business in states with lower-emissions intensive power and/or ready access to renewables. This level of analysis would require a more sophisticated platform such as The REMI model. Hence, the CPP RIA only analyzes a portion of the potential economy-wide job impacts due to the proposed rule.