



# SPP Clean Power Plan Compliance Assessment - State-by-State

July 27, 2015

SPP Engineering

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## Executive Summary

Following the Environmental Protection Agency's (EPA) June 2014 issuance of its draft Clean Power Plan (CPP) – which would cut by 30 percent existing power-plant carbon dioxide emissions from 2005 levels by 2030 – Southwest Power Pool (SPP) performed a reliability impact assessment evaluating the impacts of the plan's projected generation unit retirements on the reliability of the SPP region's bulk power system. SPP published its assessment and submitted comments based on that assessment to the EPA on October 9, 2014<sup>1</sup>.

In January 2015, SPP's Strategic Planning Committee (SPC) directed staff to proceed with a second CPP assessment to identify impacts on existing and planned resources, identify at-risk generation in SPP's region, evaluate resource planning measures to facilitate compliance with the proposed carbon emission goals, and estimate compliance costs. The SPC instructed staff to first assess compliance with the CPP under a regional approach, then to assess compliance under individual state-by-state approaches. SPP published a report of its regional compliance assessment March 30, 2015<sup>2</sup>. This report includes information and results from the state-by-state compliance analysis along with a comparison of the previously published regional compliance assessment, which was slightly revised based on information discovered through preparation of the state compliance analysis.

An estimate of SPP's regional and state-by-state share of the EPA's proposed state carbon emissions goals was used to evaluate a range of carbon reduction measures for the SPP region and member states<sup>3</sup>. A vital part of the analysis was identifying and implementing an effective carbon-cost adder<sup>4</sup> as a mechanism to effectuate dispatch of lower carbon-emitting resources, which, coupled with modifications to current resource plans, would indicate the

implications of meeting SPP's regional and states' emissions goals by 2030. To determine an effective carbon-cost adder, SPP evaluated the relationship between emission rate reductions and carbon cost increases. As seen in Figure 1, a nominal \$45/ton<sup>5</sup> carbon-cost adder

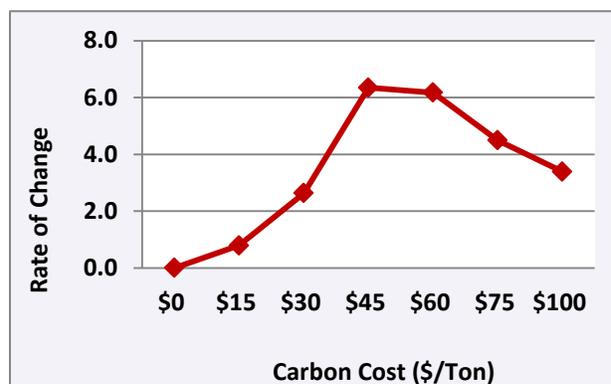


Figure 1: Rate of Change of SPP Emissions Rate per Carbon Cost

<sup>1</sup> SPP's comments and reliability assessment report can be found at [http://www.spp.org/publications/2014-10-09\\_SPP\\_Comments\\_EPA-HQ-OAR-2013-0602.pdf](http://www.spp.org/publications/2014-10-09_SPP_Comments_EPA-HQ-OAR-2013-0602.pdf)

and [http://www.spp.org/publications/CPP\\_Reliability\\_Analysis\\_Results\\_Final\\_Version.pdf](http://www.spp.org/publications/CPP_Reliability_Analysis_Results_Final_Version.pdf)

<sup>2</sup> SPP's CPP regional compliance assessment can be found at:

[http://www.spp.org/publications/SPP\\_Regional\\_Compliance\\_Assessment\\_Report.pdf](http://www.spp.org/publications/SPP_Regional_Compliance_Assessment_Report.pdf)

<sup>3</sup> The state-by-state analysis assumes no inter-state credit for abatements or debits for emissions. For example, State A is given credit for a renewable resource located in State A even if the renewable resource in State A is contracted to serve load in State B. Also, State A is assigned the emissions from existing generator units located in State A even if the existing generator unit in State A is contracted to serve load in State B.

<sup>4</sup> It is possible that a carbon-cost adder higher than \$30/ton and less than \$45/ton would have been found to be more effective but for purposes of this analysis SPP only evaluated carbon-cost adders in increments of \$15/ton, except for the final increment of \$25/ton.

<sup>5</sup> The carbon cost adder as reflected throughout this report is shown in 2030 dollars.

was determined to be most effective for the regional compliance assessment after evaluating the carbon emission rate reduction achieved per increase in carbon-cost adder applied. The nominal \$45/ton carbon-cost adder was also determined to be reasonable for the state-by-state assessment mainly for the purposes of providing a consistent comparison of regional and state-by-state compliance approaches. The common nominal \$45/ton carbon-cost adder optimistically assumes that the SPP Integrated Marketplace will provide the same level of benefits by minimizing production costs as a function of the emissions rate for each carbon-emitting resource in the simulation of SPP's market footprint. An initial analysis indicated the Integrated Marketplace would yield its more than 115 participants an additional \$131 million in annual net savings during its first year of operation in addition to the \$170 million in annual net savings of the previous market, the EIS. SPP expects there will be a reduction in the savings that the SPP Integrated Marketplace provides in order to comply with the CPP under any implementation strategy, while a state-by-state approach would have a much more negative impact.<sup>6</sup>

SPP's assessments show that the SPP regional goal can be met under a 2030 regional compliance scenario and more so under a 2030 state-by-state compliance scenario. Unlike the state-by-state compliance scenario, the regional compliance scenario did not require all states to be compliant with their individual goals. This result can be attributed to different emission reductions for each state and the implicit nature of a regional scenario including more inter-state exchange of economic resources, emissions, and abatements.

Under the 2030 regional compliance scenario, carbon emissions in six of the 11 SPP states evaluated exceeded the individual SPP-calculated state emissions goals. For the 2030 state-by-state compliance scenario, additional resource changes were required at an incremental cost in order for each state to be compliant. These resource changes included additional coal retirements, conventional generation additions, and renewable wind generation additions in the SPP states with emissions in excess of their goals after application of the \$45/ton carbon cost adder. SPP chose to use wind as a reasonable abatement measure in both the regional and state-by-state compliance assessments given the high wind potential for the majority of SPP states and to maintain a consistent approach for comparison purposes.

In the 2030 state-by-state compliance scenario, SPP's analysis assumed approximately 4,700 megawatts (MW) of coal retirements incremental to those retirements already planned. Even with the incremental 2,500 MW of retirements above the 2,200 MW assumed in the regional analysis, this assumption may be conservative considering SPP's analysis indicates nearly all existing coal-fired generation in the region would operate above an 80 percent capacity factor in the Business-As-Usual (BAU) model but approximately 13,400 MW of coal-fired generation would operate below an 80 percent capacity factor after application of a nominal \$45/ton carbon-cost adder and other resource mix modifications needed to facilitate compliance with SPP state goals.

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<sup>6</sup> The SPP Integrated Marketplace would require additional enhancements to harmonize with 14 individual state plans versus regional or sub-regional plans to maintain even a similar level of efficiency, reliability, and compliance. SPP has not fully assessed the enhancements and corresponding implementation cost that would be required in order to facilitate CPP compliance.

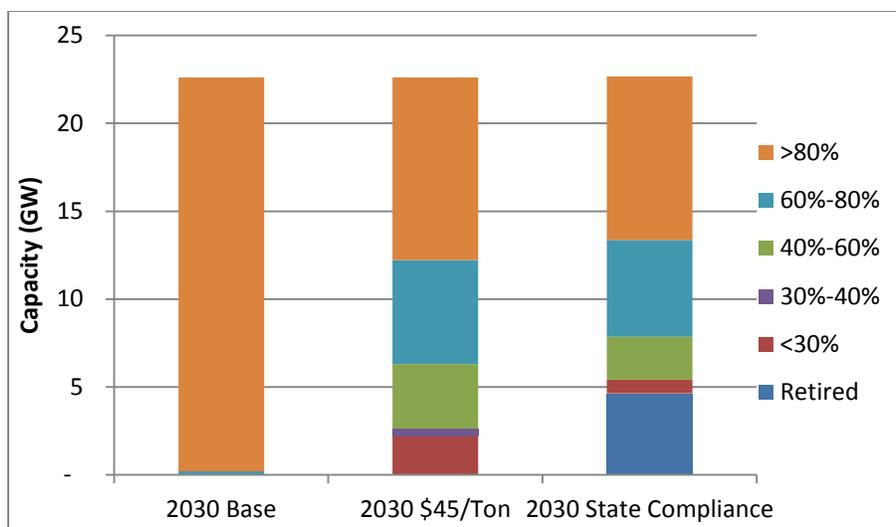


Figure 2: Coal Capacity by Capacity Factor

Based on the resulting coal fleet operations in the state-by-state compliance scenario and identification of an additional 1,700 MW of generation retirements contained in updated resource planning information, SPP concludes that up to 15,100 MW of generation retirements beyond that assumed in its most recent transmission planning models are at risk under a state-by-state compliance approach<sup>7</sup>.

The table below details the incremental costs of meeting state-by-state compliance beyond the resources necessary to meet future demand absent the CPP. This includes the cost of additional resources necessary to reduce the each state’s emissions rate, offset potential retirements, and effectuate changes in the compliance scenario’s mix of future resources. The increase in the system’s total fuel and operations and maintenance production costs is also shown. This analysis assumed an additional 9.5 GW of capacity would be needed by 2030 at a total of \$16.9 billion in capital costs incremental to a BAU resource plan. Including production cost, this equates to \$3.3 billion per year in additional costs to comply with the CPP on a state-by-state basis.

| Type                   | Capacity (GW) | 2015 \$B (Total Cost) | 2015 \$B (1-Year Cost) |
|------------------------|---------------|-----------------------|------------------------|
| Wind                   | 5.5           | \$14.0                | \$2.4                  |
| CC                     | 0.0           | \$0.0                 | \$0.0                  |
| CT                     | 4.0           | \$2.9                 | \$0.5                  |
| CC to CT Conversions   | 0             | \$0.0                 | \$0.0                  |
| <b>Production Cost</b> |               |                       | <b>\$0.4</b>           |
| <b>Total</b>           | <b>9.5</b>    | <b>\$16.9</b>         | <b>\$3.3</b>           |

Table 1: Incremental State-by-State Compliance Scenario Costs

The production cost referenced in the table does not include the costs directly resulting from the CO<sub>2</sub> emissions cost adder. The analysis’ carbon-cost adder was used as a modeling tool to

<sup>7</sup> In comparison, SPP’s regional compliance assessment concluded that up to 13,900 MW of generation retirements beyond that assumed in most recent transmission planning assumptions were at risk in a regional compliance scenario.

achieve a desired result; it was not meant to be reflective of SPP's compliance expectations for the CPP.

The costs reported above are only reflective of one potential change in production costs and the SPP regional resource fleet's capital costs to facilitate CPP compliance. The emissions targets can be met many ways. SPP is not suggesting this is the only path to compliance. Furthermore, this assessment did not consider the additional cost of transmission expansion, gas infrastructure expansion, and market enhancements that would be necessary to facilitate CPP compliance or the transmission congestion and losses that could result from CPP compliance.

Individual state-by-state plans will be difficult to manage and coexist. Each state has many options to choose from in order to meet their EPA mandated goals, and inter-operability challenges and impacts resulting from implementation of plans developed by states operating within the SPP Integrated Marketplace will be difficult to anticipate. Some states may choose rate-based approaches while others may choose mass-based approaches. Some states may choose to implement physical limitations while others may impose economic drivers. Coordinating individual state plans in a regional market where energy flows without respect to state boundaries and benefits are shared regionally will be extremely challenging and increasingly risky for the states. In addition to the increased cost shown by this analysis, a state-by-state compliance approach would also have a greater detrimental impact on the benefit realized from the SPP Integrated Marketplace, compared to a regional compliance approach.

A regional approach to compliance would be more cost effective and less disruptive than a state-by-state approach and may provide mutually beneficial opportunities for more efficient inter-state exchange of economic resources, emissions, and abatements that are not available within state boundaries. Individual states working on their own to develop unique compliance plans that can be implemented efficiently will be complex; it will be difficult for states to anticipate how other individual state plans might impact their own through the SPP Integrated Marketplace.

## State-by-State Analysis

Consistent with the regional compliance assessment, SPP assumed that its Integrated Marketplace structure would remain largely intact in this analysis and modeled the commitment and dispatch of all available resources within the Integrated Marketplace on a least-cost basis to meet regional hourly system demand obligations.<sup>8</sup> SPP did not model and simulate individual state-wide dispatch and commitment markets<sup>9</sup>. While market design enhancements may be necessary to facilitate a regional compliance approach, it is expected that market design changes needed to support a state-by-state compliance approach would be more extensive and complex in order to accommodate the potential diversity of choices states might make with regard to their own compliance plans.

Consistent with the regional analysis, SPP's goal was not to analyze each of the EPA building blocks, but to implement reasonable carbon-abatement measures capable of meeting each state's emissions-rate target.

### **Developing the SPP State-by-State Carbon Emissions Goal**

Consistent with how SPP's regional carbon emissions goal was derived in the regional compliance assessment, the SPP state-by-state carbon emissions goals (lbs/MWh) were derived by first determining the emission rates of fossil-fueled generation operating in SPP for each state using the EPA's baseline data. The EPA-specified goals were then adjusted for each state with generating resources operating in SPP. SPP's state share of a building block contributing to a particular state's goal was derived based on the ratio of SPP member-owned generation by state to total state generation, for the type of generation applicable to that building block. The Renewable Energy and Energy Efficiency building blocks allocated to each state were derived based on the ratio of all SPP member-owned generation by state to the state's total generating capacity, excluding wind capacity.

Table 2 shows the comparison of the EPA-developed state targets to the SPP-derived state targets as well as the SPP derived regional target.<sup>10</sup>

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<sup>8</sup> SPP does not anticipate a change in the fundamental structure of the SPP Integrated Marketplace in order to facilitate CPP compliance.

<sup>9</sup> Within the SPP region, a state-by-state approach to compliance with the CPP that uses individual state dispatch and commitment markets is not expected because it would void the immense reliability and economic benefits provided by the Integrated Marketplace. Further, this approach is difficult to simulate given that eight SPP utilities span two or more states.

<sup>10</sup> The SPP-derived regional target changed from 1309 to 1324 when developing SPP's North Dakota and South Dakota state target goals. For North Dakota, the Renewable Energy and Energy Efficiency allocation to SPP was corrected by lowering SPP's allocation. For South Dakota, SPP Assumed a 35% capacity factor for an existing CC unit versus the 1% capacity assumed by EPA. These modifications were made to limit the additional measures that would be needed for complying with SPP derived state targets.

| State        | EPA 2030 Target Rate<br>(lbs/MWh) | SPP 2030 Target Rate<br>(lbs/MWh) |
|--------------|-----------------------------------|-----------------------------------|
| Arkansas     | 910                               | 1,577                             |
| Iowa         | 1,301                             | 1,548                             |
| Kansas       | 1,499                             | 1,499                             |
| Louisiana    | 883                               | 1,656                             |
| Missouri     | 1,544                             | 1,432                             |
| Nebraska     | 1,479                             | 1,479                             |
| New Mexico   | 1,048                             | 744                               |
| North Dakota | 1,783                             | 1,761                             |
| Oklahoma     | 895                               | 969                               |
| South Dakota | 741                               | 368                               |
| Texas        | 791                               | 1,302                             |
| SPP          | N/A                               | 1,324                             |

Table 2: SPP State Emission Rate Goals

## **State-by-State Compliance Case Development**

Using the BAU reference case developed for the regional compliance assessment, SPP first analyzed a series of carbon-cost adders. A carbon-cost adder was applied on the CO<sub>2</sub> emissions output of each fossil unit. This affected the dispatch of each fossil resource by increasing the cost of CO<sub>2</sub> output per MWh produced. Unlike the regional assessment, the initial intent of the state-by-state carbon-cost adder assessment was to develop a range of reasonable carbon-cost adders by state that would contribute to each state's carbon abatement measures.

In order to gain a reasonable starting point, SPP analyzed each state under the single carbon-cost adder methodology utilized for the regional assessment. The single carbon-cost adder at which each state met its individual goal was identified and utilized as an input for a variable carbon-cost adder methodology. A multitude of simulations were analyzed in an attempt to determine a reasonable adder for each state. For each carbon-cost adder, the operation of units by unit type, regional energy costs, and emission rates were monitored for reasonableness.

The beginning simulations resulted in some states requiring carbon-cost adders much greater than the nominal \$45/ton utilized in the regional assessment to comply with state targets. Recognizing additional measures would need to be taken to reduce emissions, carbon-cost adders were adjusted to determine a more reasonable range for each of the states analyzed. Each adjustment made to a state's carbon-cost adder had an impact on the regional simulation. Adjusting the carbon-cost adder in order for one state to meet compliance affected the ability of other states to stay in compliance. The interdependence of each state's operation within the regional footprint proved the variable carbon-cost adder approach extremely difficult. Many of the variable carbon-cost adder simulations involved much higher carbon-cost adders or resulted in very high unit operation of older gas-steam units in certain areas of the footprint and higher than 80 percent capacity factors of combined cycle units. Using a reasonable (nominal \$0-\$45/ton) variable carbon-cost adder to compare emissions and energy costs for the region to the nominal \$45/ton regional carbon-cost adder simulation, the analysis showed that both emissions

and energy costs for the region are higher in the variable carbon-cost adder results as seen in Figure 3.

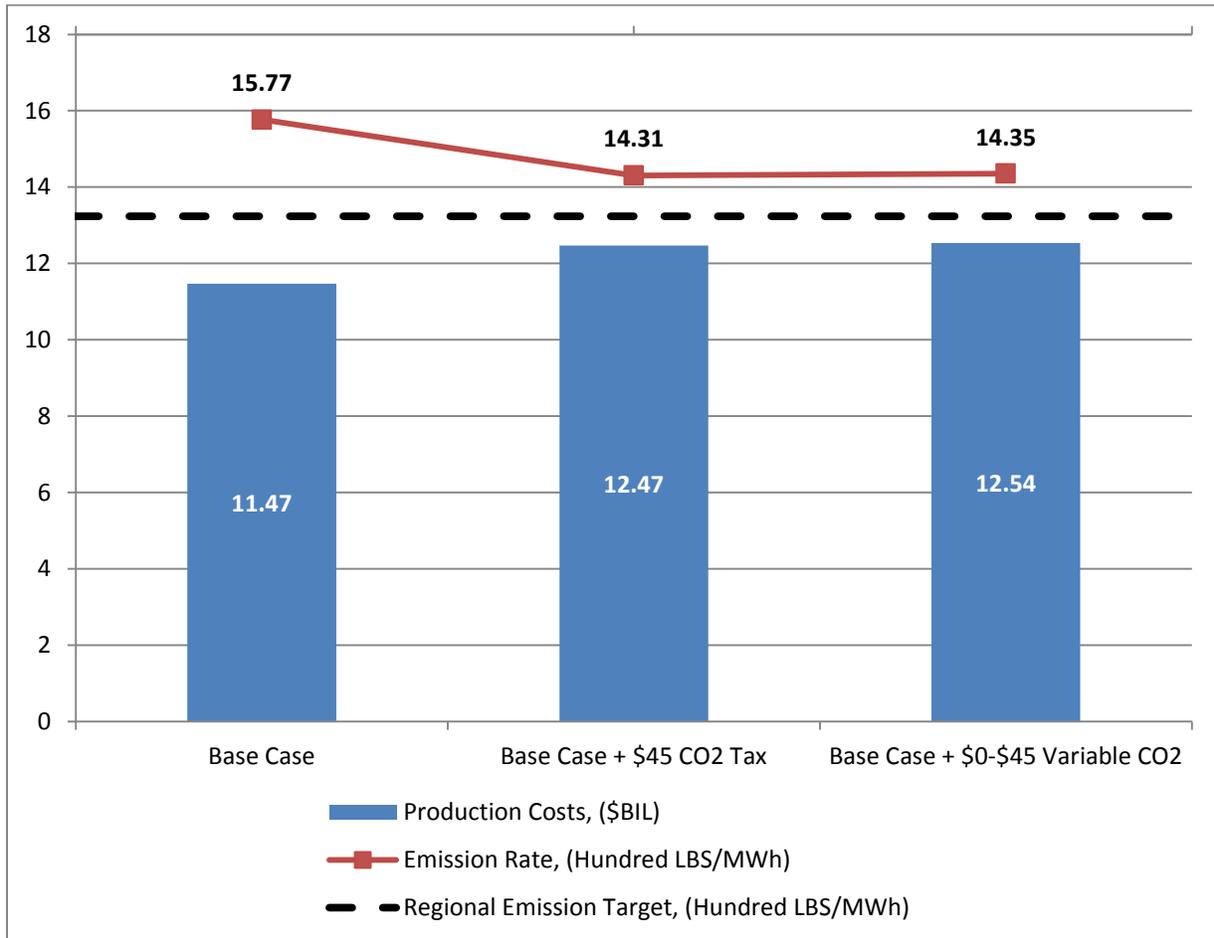


Figure 3: Comparison of Emission Rates and Energy Costs

Based on this analysis, the carbon adder analysis performed for the regional compliance assessment was leveraged as a starting point for the state-by-state analysis. This analysis produced a more expected regional dispatch as a result of assuming that the same level of benefits and harmonization would be maintained by varying SPP Integrated Marketplace enhancements.<sup>11</sup>

One might conclude from the analysis that utilizing a single carbon-cost adder for both the regional approach and the state-by-state approach assumes market enhancements would achieve the same level of benefits from the SPP Integrated Marketplace. For the purposes of this analysis, it was assumed that SPP would continue to work through the SPP stakeholder process to maximize the savings, benefits and efficiencies provided by the SPP Integrated Marketplace at an equivalent level under either approach. A variable state-by-state carbon-cost adder proved difficult to control both production cost and emissions, and the increase in production cost and

<sup>11</sup> SPP did not assess the cost difference in market enhancements that would be needed to achieve the same level of SPP Integrated Marketplace benefits in either compliance approach.

emissions is an indication of how individual state plans might significantly reduce the benefits of the SPP Integrated Marketplace.

With a cost to carbon and the resulting reduced operation of coal units in the SPP region, a certain amount of coal capacity will be considered “at risk.” Figure 4 shows the coal capacity by capacity factor percentage for the SPP region, assuming a nominal \$45/ton carbon-cost adder. The figure shows nearly 6,300 MW of coal capacity operating below a 60 percent capacity factor.

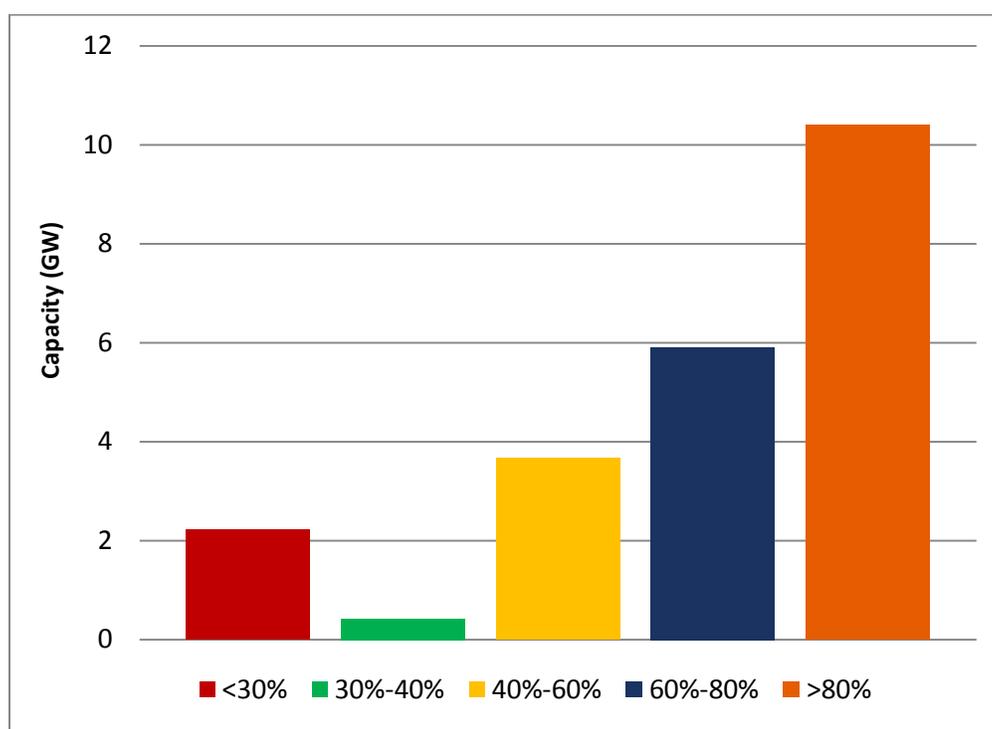


Figure 4: Coal Capacity by Capacity Factor at Nominal \$45/ton Carbon-Cost Adder

Similar to the regional analysis, SPP chose to retire a group of units operating at less than 30 percent capacity factor. Only states not meeting their emission rate goal under the nominal \$45/ton regional carbon-cost adder were targeted, resulting in 1,500 MW of coal retirements incremental to the reference case, as compared to the 2,200 MW in incremental retirements assumed for the regional compliance scenario.

The next step taken in order to ensure each state met its emission rate goal was to leverage renewable additions, following the expectation of wind expansion in the SPP footprint. Consistent with the regional analysis, wind capacity was included in the compliance resource plan to meet 25 percent of non-coincident, peak-load obligations within the SPP region. Contrary to the regional analysis, but consistent with the retirement approach in the state-by-state analysis, this assessment targeted only states not meeting their emission rate goals under the nominal \$45/ton carbon-cost adder with additional retirement of coal units operating at a low capacity factor. The wind additions for SPP member utilities operating in both a compliant and non-compliant state were sited in the non-compliant state. An additional 5.4GW of wind was included in the state-by-state compliance resource plan.

The retirement of potential “at risk” coal capacity and the addition of 5.4 GW of wind capacity required an adjustment to the compliance scenario’s resource plan to maintain a 12 percent capacity margin or greater. Taking technology advancements of new wind into account and its possible acceleration through CPP compliance, a 10 percent accreditation toward capacity margin requirements was used for new wind generation; this was an increase to the 2015 ITP10’s existing 5 percent accreditation assumption. Each load zone’s shortfall was reevaluated and conventional generation was considered to meet capacity margin requirements.

Consistent with the regional analysis, a portion of the future combined cycle (CC) units were converted to combustion turbines (CT) to account for the energy gained by wind additions and the cheaper capital cost of CTs. To determine the appropriate amount of capacity to convert, the energy gained by the wind additions was compared to the energy produced by the CCs. This calculation assumed a capacity factor of 70 percent for CCs and an average capacity factor of 44 percent for the new wind machines added based on assumed siting in the state-by-state analysis. This resulted in converting 3,600 MW of CC capacity contained in existing resource plans to CT capacity for the state-by-state compliance scenario.

Following the implementation of the modified regional compliance assessment methodology, additional measures were needed in order for all states to be within compliance. Recognizing the renewable additions in the regional and state-by-state assessments were nearly equal and the coal retirements in the state-by-state assessment was nearly half, the next step was to consider additional coal retirements and other resource plan adjustments capable of reducing emissions.

First, additional incremental coal retirements were assumed using a tiered approach. The first tier of retirements came from additional information gathered through preparation for SPP’s 2017 ITP10 assessment. This included an additional 300 MW of coal units expected to be retired by 2030 based on updated projections. The next three tiers took an age-based approach, targeting units over 60 years of age by 2030, 55-60 years of age by 2030, and 50-55 years of age by 2030. Utilizing this criteria and targeting states not meeting compliance, an additional 3,200 MW of retirements were assumed for the state-by-state compliance case. This methodology did not consider the capacity factor operation under the nominal \$45/ton carbon-cost adder scenario and resulted in retirement of units operating above the 30 percent capacity factor threshold assumed for the initial capacity retirements. Figure 5 shows the capacity factor of the coal retirements assumed in this state-by-state compliance assessment after application of the nominal \$45/ton carbon-cost adder. This includes a comparison to the assumed retirements in the regional compliance assessment.

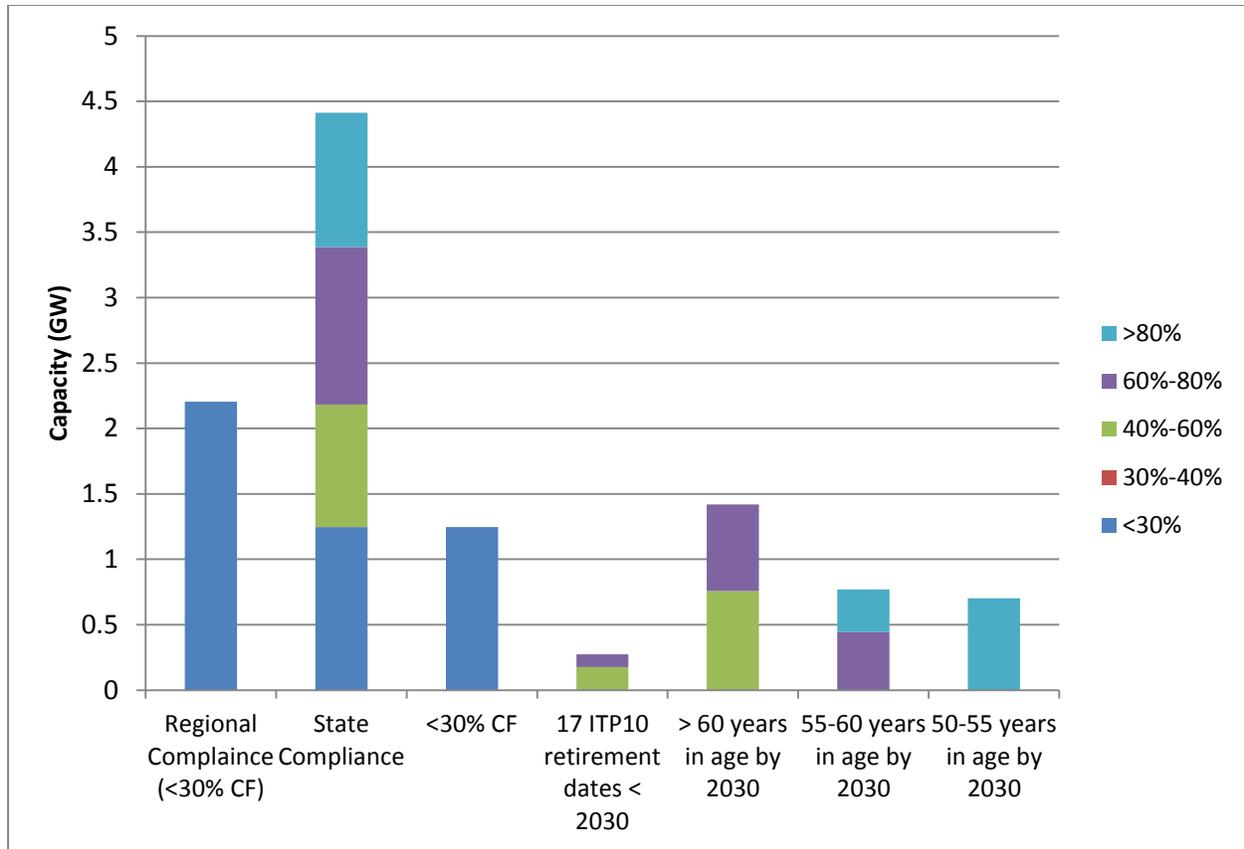


Figure 5: Capacity by Capacity Factor at Nominal \$45/ton Carbon-Cost Adder of Assumed Coal Retirements

The above figure shows the retirement of over 1 GW of coal operating above 80 percent capacity factor and an additional 2.1 GW operating above 30 percent in the state-by-state compliance scenario. Similar to the adjustment of the assumed CC-to-CT capacity ratio due to added wind capacity, it was necessary to revisit this ratio due to the amount of lost energy from additional coal retirements operating at higher capacity factors. Assuming an average operation for a new CC unit of 70 percent capacity factor, 1,800 MW of additional CC units would be required in order to make up the lost energy from this additional retired coal-fired generation. While it was already assumed 3,600 MW of CC units would be converted to CT based on the wind additions, the additional coal retirements would require 1,800 MW of that to remain as CC units. Unlike the regional analysis, this ultimately resulted in keeping the entirety of the BAU resource plan CC units intact and installing an additional 3,990MW of CT units along with the wind to meet capacity margin requirements in the state-by-state compliance scenario. Figure 6 shows the state-by-state compliance resource plan.

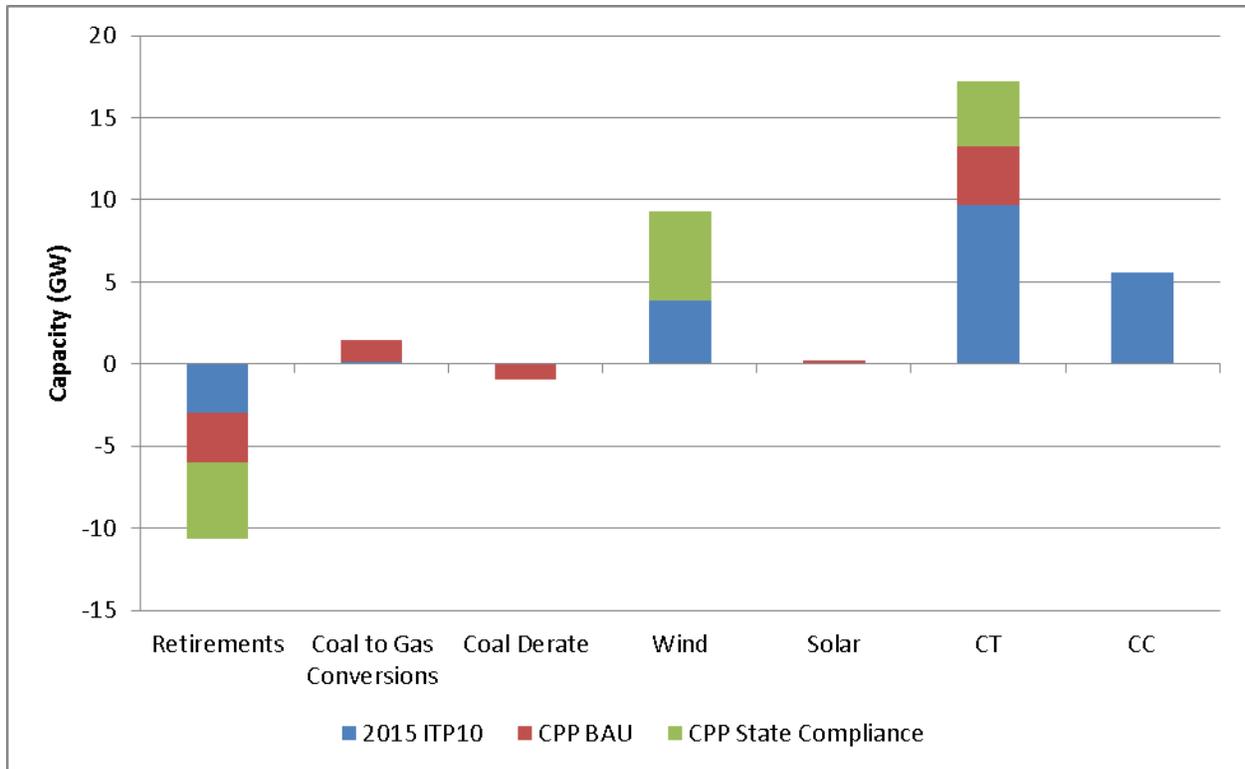


Figure 6: CPP State-by-State Compliance Resource Plan

Many options could be considered when establishing plans to meet the EPA’s emission-rate goals. SPP chose an approach in both the regional and state-by-state assessments that focused on an increase in gas usage, conservative-to-moderate coal generation retirements and utilization of the region’s wind potential. The purpose of evaluating consistent approaches in the regional and state-by-state compliance assessments was to get a more indicative and “apples-to-apples” cost comparison. The solutions developed by SPP in these assessments are not the only solutions and may not be the best solutions for compliance but are reasonable and useful for purposes of showing relative differences in implications between the two approaches. Other measures are available for compliance and should be considered in the ultimate development of either a regional or individual state-by-state compliance plans.

## State-by-State Compliance Scenario Results

The final state-by-state compliance scenario achieved a regional emissions rate of 1,226 lbs/MWh, 98 lbs/MWh below the SPP regional emission rate target of 1,324 lbs/MWh. This is compared to the resulting 1,285 lbs/MWh of the regional compliance scenario. Figure 7 shows the emission rates for the BAU reference case, the nominal \$45/ton carbon-cost adder analysis, and the final state-by-state compliance scenario. With the additional measures taken in order for each state to meet its emissions goal, the region experienced a 59 lbs/MWh further reduction in emissions rate.

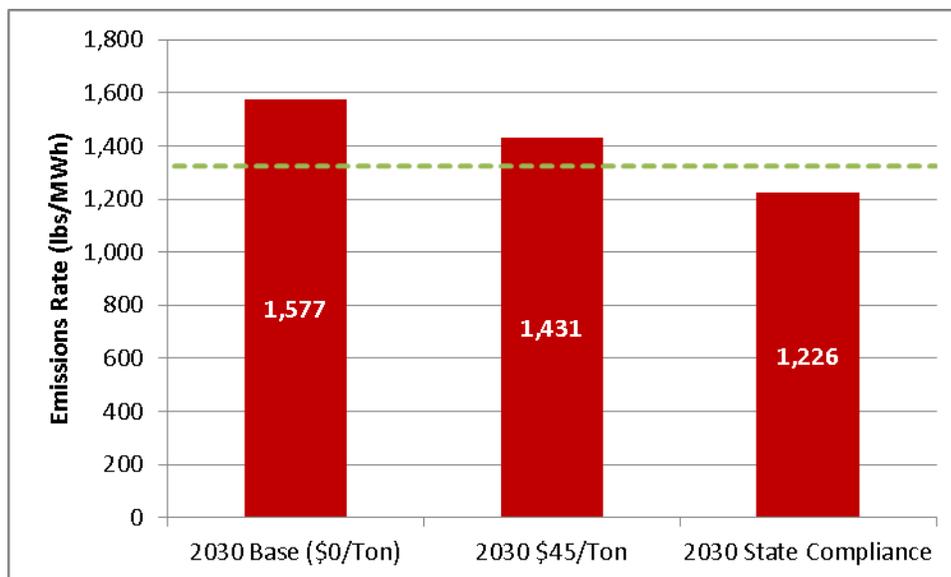


Figure 7: Comparison of SPP Regional Emission Rates

Some states in the state-by-state compliance scenario are below their target rate. Some of this is due to slight over compliance, while the more drastic differences are due to how close each state was to reaching its emissions-rate goal in the reference case. Figure 8 shows the emission rate of each analyzed state for the reference and state-by-state compliance scenarios as compared to each state's emission-rate goal. Each leg of the chart represents the starting rate, target rate and compliance scenario rate for the analyzed states.

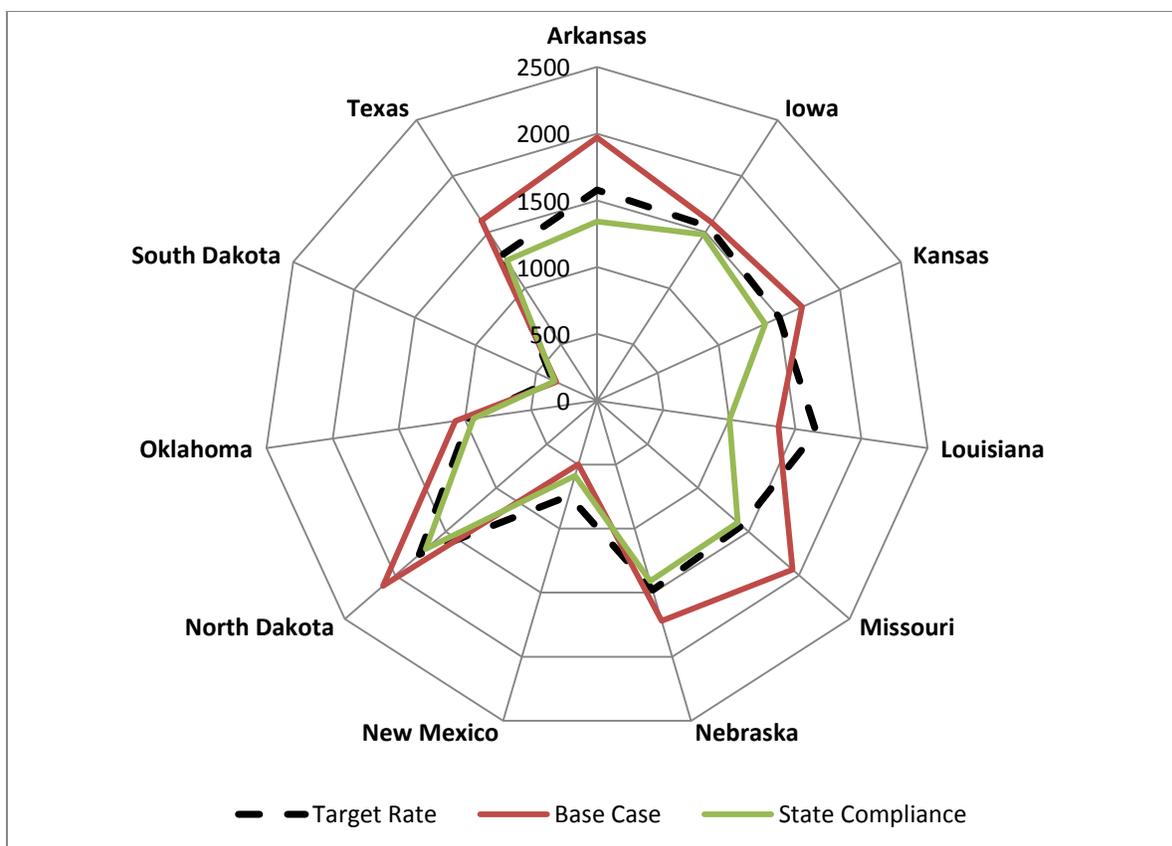


Figure 8: State-by-State Emission Rates

Comparisons of total emissions output, system production costs, and change in capital costs for each of the scenarios is summarized in Table 3. The change in production cost for the SPP region increases significantly when only including a carbon-cost adder. With the additional wind energy, the compliance case helps bring down the overall system production cost, but with an increase in required capital costs.

| Scenario                                     | CO2 Emissions (BIL LBS) | System Production Cost Benefit (\$MIL) | Carbon-Cost Adder (\$/ton) | Change in Capital Cost of Resource Plan (\$BIL) | Incremental Capacity (GW) |
|--|-------------------------|--|----------------------------|---|---------------------------|
| Base Case - Current Resource Plan            | 407                     | -                                      | \$0                        | -   | -                         |
| Carbon Price Case - Current Resource Plan    | 344                     | \$688                                  | \$31.07                    | -   | -                         |
| State-by-State Compliance Resource Plan Case | 298                     | \$409                                  | \$31.07                    | \$17  | 9.5                       |

*All in 2015 Dollars*

Table 3: Summary of State-by-State Compliance Scenario Results

Just fewer than 15 GW of coal capacity is operating above a 60 percent average capacity factor in the compliance scenario. With the addition of wind energy and keeping the BAU combined

cycle units installed, approximately 800 MW of coal generation is shown to be operating below the 30 percent average capacity factor criteria used to determine that scenario's initial incremental coal retirements. Including the assumed retirements incremental to the reference case resource plan, the compliance scenario resulted in 13,400 MW operating below an 80 percent capacity factor. Figure 9 shows a comparison of each scenario's average coal generation capacity factor.

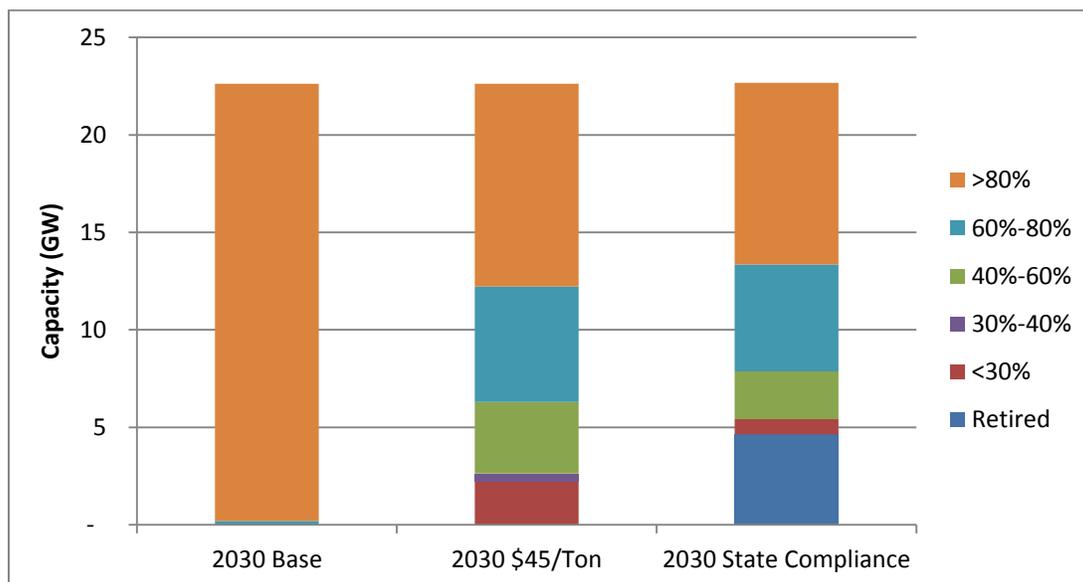


Figure 9: Coal Capacity by Capacity Factor

The state-by-state compliance scenario's overall average capacity factor for coal units dropped to 75 percent from the reference scenario's nearly 90 percent capacity factor.<sup>12</sup> At the same time, the CC units' average capacity factor increased from approximately 20 percent to nearly 70 percent. Figure 10 shows the compliance scenario's average capacity factor of selected unit types.

<sup>12</sup> The operation of coal units in the reference case is much higher than would be expected due to removal of unit forced outages and the copper sheet approach. This is intended only to be a comparative analysis between compliance implementations.

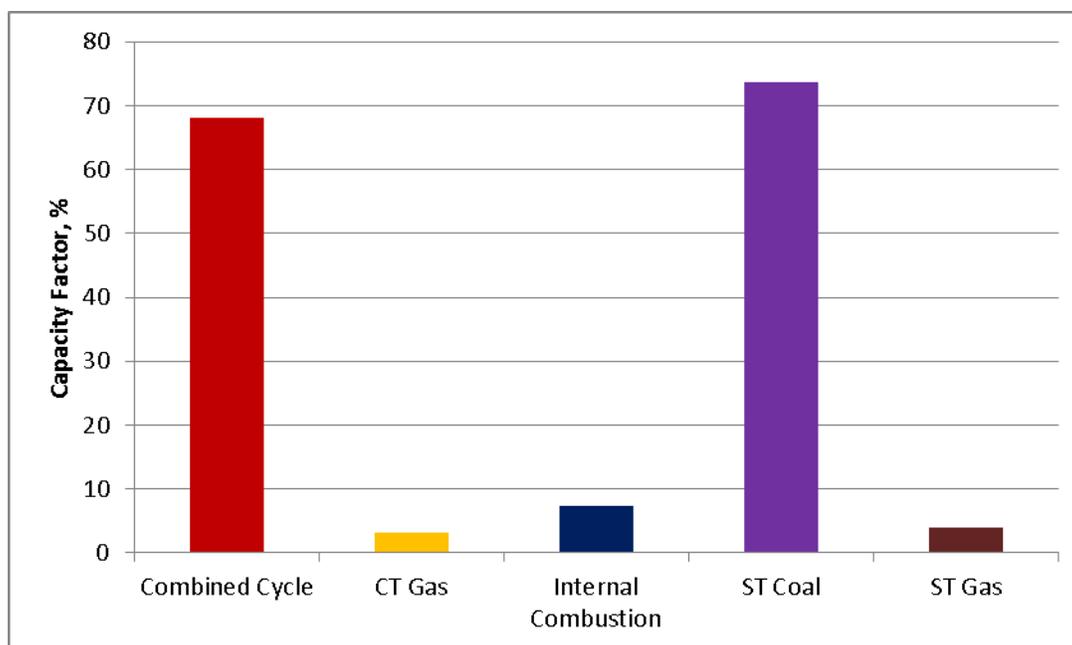


Figure 10: State-by-State Compliance Scenario Capacity Factors by Unit Type

Table 4 details the incremental costs of meeting state-by-state compliance beyond the resources necessary to meet future demand absent the CPP. This includes the cost of additional resources necessary to reduce each state's emissions rate, offset potential retirements and effectuate changes in the compliance scenario's mix of future resources. The increase in the system's total fuel and operations and maintenance production costs is also shown. This analysis assumed an additional 9.5 GW of capacity would be needed by 2030 at a total of \$16.0 billion in capital costs incremental to a BAU resource plan. Including production cost, this equates to \$3.3 billion per year in additional costs to comply with the CPP on a state-by-state basis.

| Type                   | Capacity (GW) | 2015 \$B (Total Cost) | 2015 \$B (1-Year Cost) |
|------------------------|---------------|-----------------------|------------------------|
| Wind                   | 5.5           | \$14.0                | \$2.4                  |
| CC                     | 0.0           | \$0.0                 | \$0.0                  |
| CT                     | 4.0           | \$2.9                 | \$0.5                  |
| CC to CT Conversions   | 0             | \$0.0                 | \$0.0                  |
| <b>Production Cost</b> |               |                       | <b>\$0.4</b>           |
| <b>Total</b>           | <b>9.5</b>    | <b>\$16.9</b>         | <b>\$3.3</b>           |

Table 4: Incremental State-by-State Compliance Scenario Costs

The production cost referenced in Table 4 does not include the costs directly resulting from the CO<sub>2</sub> emissions cost adder. The analysis' carbon-cost adder was used as a modeling tool to achieve a desired result; it was not meant to be reflective of SPP's compliance expectations for the CPP.

The costs reported above are only reflective of one potential change in production costs and the SPP regional resource fleet's capital costs due to CPP compliance. The emissions targets can be met many ways. SPP is not suggesting this is the only path to compliance. Furthermore, the compliance scenario costs do not consider the additional cost of transmission expansion,

transmission congestion and losses, gas infrastructure expansion and market enhancements that would be necessary to facilitate CPP compliance implementation.

## Regional vs State-by-State Compliance

The consistent approach taken to meet regional and state-by-state compliance with the Clean Power Plan Section 111(d) led to a result of over-complying with emission rate goals both in the regional and state-by-state compliance scenarios. The decision to start with a carbon-cost adder and then apply additional carbon abatement measures based on a blanket criteria approach led to a final regional emissions rate of 1,285 lbs/MWh in the regional compliance scenario and following the same approach in the state-by-state led to an additional 59 lbs/MWh on a regional basis for a final regional emissions rate of 1,226 lbs/MWh in the state-by-state compliance scenario. Figure 11 shows the comparison of the final regional and state-by-state compliance scenarios as well as the 2030 reference and nominal \$45/ton carbon-cost adder scenarios.

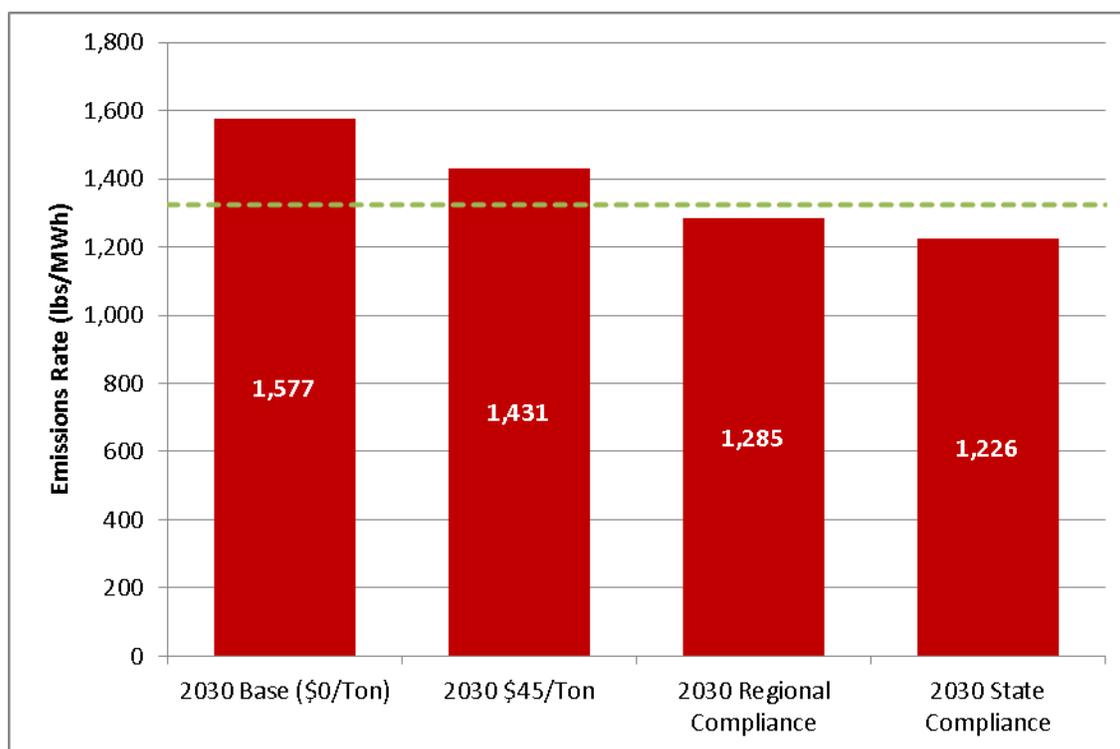


Figure 11: Comparison of SPP Regional Emission Rates

In order to validate the comparison of compliance costs on a regional and state-by-state basis, the issue of over-compliance was investigated and summarized in Figure 12.

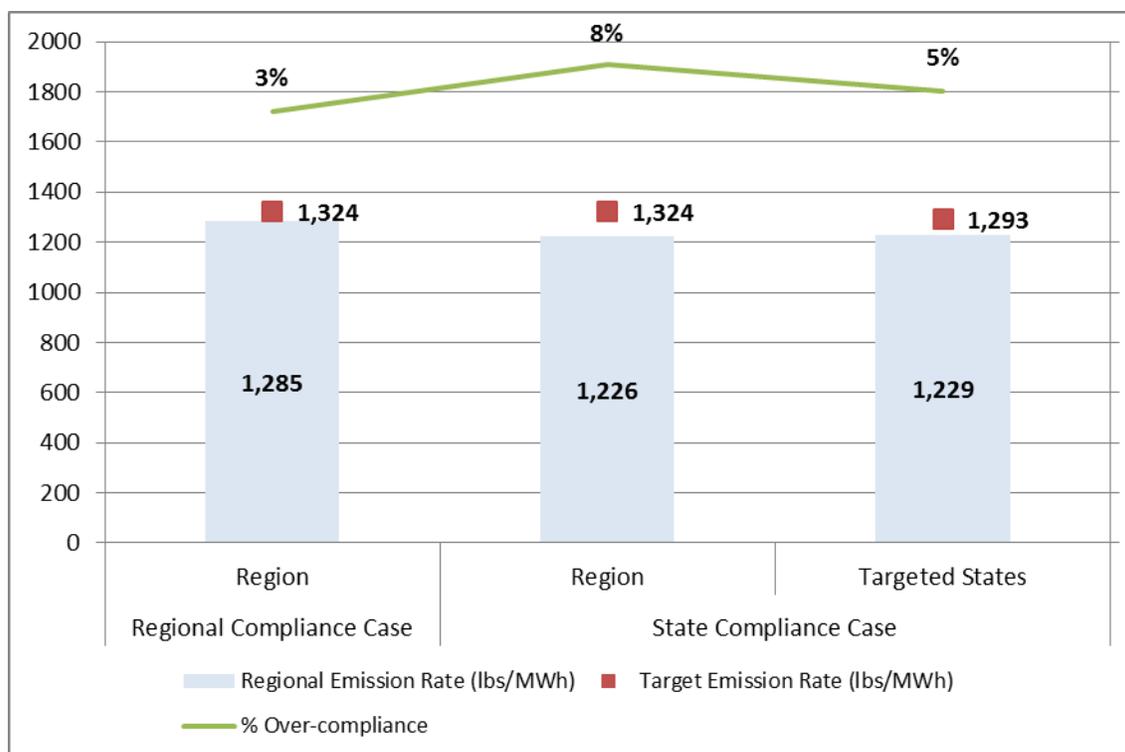


Figure 12: State-by-State and Regional Comparison of Over-Compliance

The regional compliance scenario resulted in three percent over-compliance with the regional emissions goal. In comparing that percentage to the state-by-state compliance scenario, the summary of results on a regional basis could not be used due to the states already meeting compliance without additional measures. In order to compare the data equally, the analysis had to be looked at from a targeted states perspective, which are the states driving the cost of compliance. In the regional analysis, all states operating fully or partially in the SPP footprint were targeted. In the state-by-state analysis, only those states not meeting compliance after the application of the carbon-cost adder were targeted. An alternate emissions goal<sup>13</sup> was calculated and shown in the targeted states data of the state-by-state compliance case. Comparing the results of the targeted states to their goal, the state-by-state compliance scenario resulted in a five percent over-compliance, a two percent margin when compared to the regional compliance case. SPP concludes that the comparison of cost between the regional and state-by-state compliance scenarios is reasonable. These comparisons are detailed in Table 5.

<sup>13</sup> Similar to the weighted average goal for the SPP region, this emissions goal was calculated as a weighted average of the states which were targeted for additional carbon reduction measures.

| Compliance Case               | Wind   | CC    | CT    | Solar | CC to CT Conversion | Production Cost <sup>14</sup> | Total  |
|-------------------------------|--------|-------|-------|-------|---------------------|-------------------------------|--------|
| <b>Capacity (GW)</b>          |        |       |       |       |                     |                               |        |
| Regional                      | 5.6    | 0.0   | 4.6   | 0.0   | 3.2                 | -                             | 7.0    |
| State                         | 5.5    | 0.0   | 4.0   | 0.0   | 0.0                 | -                             | 9.5    |
| <b>2015 \$B (Total Cost)</b>  |        |       |       |       |                     |                               |        |
| Regional                      | \$13.5 | \$0.0 | \$3.4 | \$0.0 | -\$3.6              | -                             | \$13.3 |
| State                         | \$14.0 | \$0.0 | \$2.9 | \$0.0 | \$0.0               | -                             | \$16.9 |
| <b>2015 \$B (1-Year Cost)</b> |        |       |       |       |                     |                               |        |
| Regional                      | \$2.3  | \$0.0 | \$0.6 | \$0.0 | -\$0.6              | \$0.2                         | \$2.4  |
| State                         | \$2.4  | \$0.0 | \$0.5 | \$0.0 | \$0.0               | \$0.4                         | \$3.3  |

**Table 5: Comparison of Incremental State-by-State and Regional Compliance Scenario Costs**

A comparison of resource modifications and production cost shows that the cost of state-by-state compliance increases by approximately \$0.9 billion annually over the cost of regional compliance, or nearly 40 percent more.<sup>15</sup> This comparison in costs is optimistic when considering that the 2030 state-by-state compliance includes a common nominal \$45/ton carbon adder assuming the same level of market efficiencies and equilibrium in market offers and bidding strategies, creating a best case scenario for state-by-state compliance.

SPP did attempt to quantify potential differences in capital cost, environmental cost, public opposition, congestion, generation interconnection availability<sup>16</sup> and capacity accreditation of the wind additions adjusted to sites in the states with less potential versus the top-tier SPP states used in the regional analysis. SPP expects that there would be capacity accreditation differences, interconnection, delivery and installation challenges given the 1.3 GW of Arkansas wind additions assumed in the state-by-state analysis. These additions amount to approximately 70 percent penetration of Arkansas wind potential in SPP, assuming SPP would interconnect 1.8 GW of the 9.2 GW total potential<sup>17</sup> assumed by a summary from the Department of Energy<sup>18</sup>. North and South Dakota were also utilized for new wind additions in the state-by-state analysis, but the Dakotas rank in the mid-range of SPP states for wind potential. In quantifying the cost of realizing the potential modeled in the lower potential states utilized in the state-by-state analysis, SPP determined a reasonable cost adder to the capital cost of wind which was re-sited to new

<sup>14</sup> The production cost calculation was corrected in the state-by-state analysis and resulted in an adjustment of the regional compliance scenario cost.

<sup>15</sup> The analysis does not quantify the differences in cost of transmission additions, transmission congestion and losses, gas infrastructure, and market enhancements.

<sup>16</sup> These assertions are from a high level review of the NREL's Potential Wind Capacity maps with respect to the SPP transmission footprint and given there is less than 100 miles of 345 kV in Arkansas of SPP's 8500 miles of 345 kV.

<sup>17</sup> SPP covers roughly 20% of the state of Arkansas.

<sup>18</sup> [http://apps2.eere.energy.gov/wind/windexchange/filter\\_detail.asp?itemid=2542](http://apps2.eere.energy.gov/wind/windexchange/filter_detail.asp?itemid=2542). Using NREL Estimates of Land Area1 and Wind Energy Potential, by State, for areas >= 35 percent capacity factor at 80, 110, and 140 meters, Arkansas ranks 18th using 110m hub height, current 2014 turbine technology with less than half the potential than that of Oklahoma which ranks last among seven other SPP states in the top 10.

[http://apps2.eere.energy.gov/wind/windexchange/windmaps/resource\\_potential.asp](http://apps2.eere.energy.gov/wind/windexchange/windmaps/resource_potential.asp)

locations. As an approximation, the Dakotas were excluded based on their rank for wind potential and a 28.6 percent increase in the capital cost was applied to wind sited in Arkansas.<sup>19</sup>

SPP also quantified the potential capacity accreditation differences between wind additions in the regional versus state-by-state compliance scenarios that was not included in the analysis. Focusing on wind sited in Kansas versus Arkansas and using SPP's resource accreditation methodology, it was determined the capacity accreditation difference that a SPP Load Serving Entity could receive is approximately 30 percent higher in Kansas than Arkansas. This equates to two additional CTs that would be needed for the state-by-state scenario for wind sited in Arkansas that would not be needed in the regional scenario if the same wind was sited in Kansas. SPP has not included this in the cost of compliance as additional capital expenditures that would be required for state-by-state compliance.

The resulting 2030 compliance plans developed and evaluated by SPP shows that approximately 1.2 GW less coal is operating above an 80 percent capacity factor in the state-by-state compliance scenario as compared to regional compliance. This results in the conclusion that an additional 1.2 GW of coal is considered to be at risk of retirement in the state-by-state compliance scenario. This is illustrated in Figure 13.

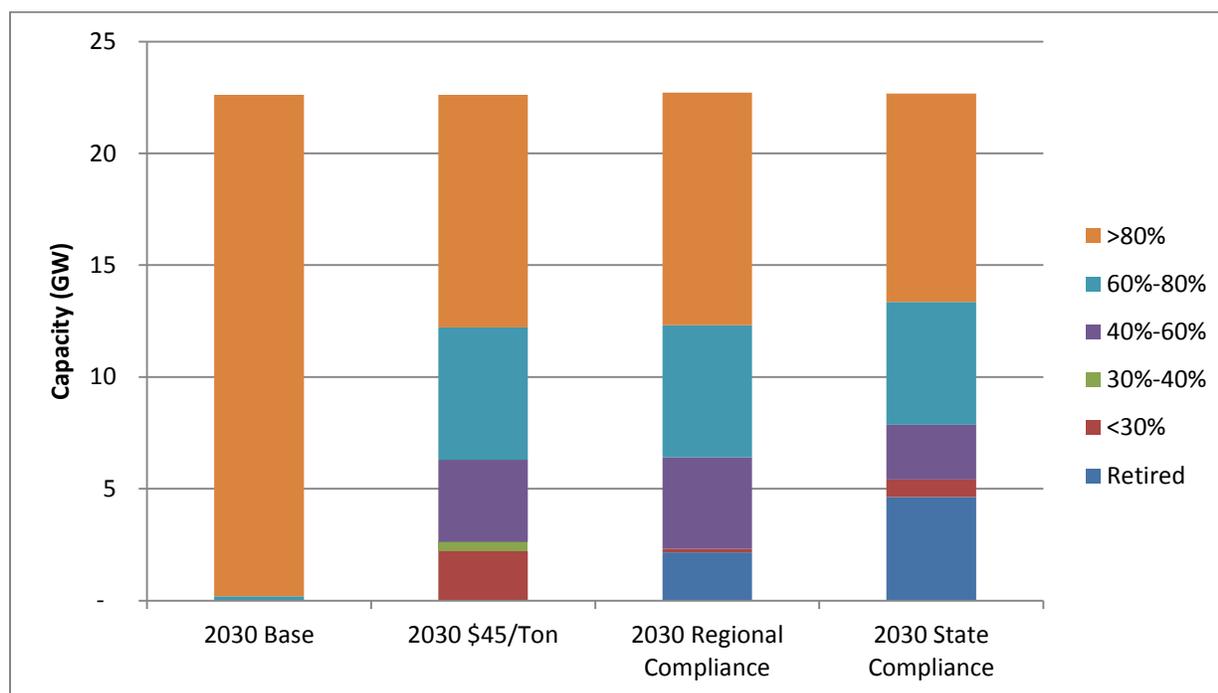


Figure 13: Coal Capacity by Capacity Factor

SPP is not suggesting this is the only path to compliance for a regional or state-by-state approach. Furthermore, the costs of the compliance scenarios do not consider the additional cost of transmission expansion, transmission congestion and losses, gas infrastructure expansion, and

<sup>19</sup> This increase is based on a low end vs. high end assumption of capital costs for wind from Lazard's 2014 Levelized Cost of Energy Analysis—Version 8.0: [http://www.lazard.com/media/1777/levelized\\_cost\\_of\\_energy\\_-\\_version\\_80.pdf](http://www.lazard.com/media/1777/levelized_cost_of_energy_-_version_80.pdf). Following completion of the regional compliance analysis, SPP Stakeholders approved use of the Lazard generation prototypes for the 2017 ITP10 resource plan analysis as opposed to the EIA Annual Energy Outlook dataset utilized in the 2015 ITP10.

market enhancements that could be necessary to facilitate CPP compliance implementation. The state-by-state compliance scenario also assumed a best case utilization of the SPP Integrated Marketplace in order to facilitate compliance. SPP has not evaluated the incremental cost of market efficiency losses but expect that a reduction in the market savings seen since launch of the SPP Integrated Marketplace in 2014 as well as the market design enhancements necessary to facilitate compliance would increase in a state-by-state implementation over regional or sub-regional implementation.

## Conclusion

Development of a stable, secure, efficient and effective bulk electric power system takes time and requires collaboration to continuously improve efficiency. Disruptive changes such as retirements, retrofits and/or changes in the operating characteristics of base load resources must be considered carefully and communicated clearly in a transparent, open process. Given some of the assumptions and difficulties performing the analysis, SPP expects that state-by state compliance plans will be more costly and will present more uncertainty and complexities for SPP stakeholders.

Both the regional and state-by-state assessments indicate varying levels of new generation will be necessary to meet the compliance requirements by 2030. A comparison of the regional and state-by-state assessments indicates additional generation will be needed for a state-by-state compliance. This assessment took a “copper sheet” approach that did not consider transmission constraints or interchange with adjacent pools and represents an optimistic scenario for state-by-state compliance in quantifying the costs for comparison. Although these assessments did not evaluate transmission expansion needs, SPP’s 2014 reliability impact assessment showed that additional infrastructure would be needed to facilitate compliance with the CPP. SPP also believes that a state-by-state compliance approach will require more transmission expansion than a regional compliance approach because the regional transmission planning process and assumptions that have been utilized to develop SPP’s current transmission system better align with a regional compliance approach. SPP will require more comprehensive planning efforts with stakeholders and new tools and metrics to fully identify the transmission, generation infrastructure and SPP Integrated Marketplace enhancements required. In addition, broader system assessments of the bulk power system and natural gas pipeline and storage systems based on environmental constraints will be required.

Individual state-by-state plans will be difficult to manage and coexist. Each state has many options to choose from in order to meet their own compliance and feedback between respective plans operating within the SPP Integrated Marketplace will provide challenges that will be difficult to anticipate. Coordinating different plans will be extremely challenging and not without risk for the states. In addition to the increased cost shown by this analysis, a state-by-state compliance approach would also have a greater detrimental impact on the benefit realized from the SPP Integrated Marketplace, compared to a regional compliance approach.

A regional approach to compliance would be more cost effective and less disruptive than a state-by-state approach and may provide mutually beneficial opportunities that are not available within state boundaries.