

# **An Assessment of Critical Mass for the Regional SO<sub>2</sub> Trading Program**

**Prepared for**

**Western Regional Air Partnership  
Market Trading Forum**

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## Executive Summary

### Overview

The Western Regional Air Partnership (WRAP) has developed a backstop trading program as an emissions reduction strategy to improve visibility in the 16 mandatory Class I areas of the Colorado Plateau. Under Section 51.309 of the regional haze regulations of July 1, 1999, the nine states and 211 tribal areas of the Grand Canyon Transport Visibility Region may develop State/Tribal Implementation Plans in accordance with WRAP plans. Alternatively, the states and tribal areas may elect to withdraw from the backstop trading program and instead fulfill regional haze requirements through Section 51.308.

This analysis was commissioned to help the WRAP Market Trading Forum (MTF) begin to understand the implications of one or more states choosing to opt-out of the regional trading program and instead fulfill regional haze requirements through Section 51.308. This analysis, which extends the economic study previously undertaken by WRAP/MTF<sup>1</sup> focuses on six state/tribal participation scenarios and was conducted using the analytical framework of ICF's Integrated Planning Model (IPM<sup>®</sup>) with assumptions and inputs developed by the MTF for the previous Economic Analysis.

This study has two objectives. First, the study seeks to assess the "critical mass" of states required for the trading program based on how regional compliance cost is affected by varying participation of states/tribes in the trading program. The study also seeks to examine the impact of allowance allocations by examining net allowance position of the participating states/tribes. Second, the analysis seeks to provide states/tribes with information that may be useful in making their opt-in or opt-out decisions for choosing 309. For the purposes of this analysis, the trading program affects stationary point sources and includes the electric generation, industrial steam boilers and process sources of SO<sub>2</sub>.

Key findings of the analysis suggest that:

- Under a regional backstop SO<sub>2</sub> trading program, the least-cost compliance (or greatest gains from trading) results when all states and tribes participate in the trading program.
- A state or tribe's decision not to participate in the trading program does not insulate it or its sources from the impacts of the trading program. This is particularly relevant for the states of California, Wyoming and Colorado, where the response to command-and-control requirements under an opt-out decision varies significantly depending on the decision of other states and tribes. This explains why the command-and-control compliance cost for states/tribes that opt-out varies under the different trading program participation scenarios.
- A full trading program with all states/tribes participating is likely to have regional compliance costs that in 2018 are approximately \$90 million lower than under a program where all states/tribes implement command-and-control.

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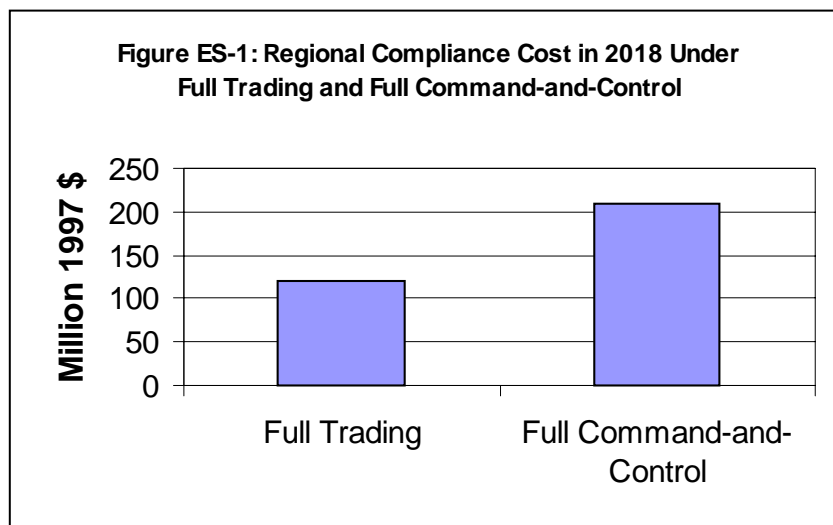
<sup>1</sup> "Regional Economic Impacts of Implementing a Regional SO<sub>2</sub> Emissions Cap in the Grand Canyon Visibility Transport Region," prepared by ICF Consulting for the WGA/WRAP, September 2000. (MTF 2000).

- The regional annual gains from trading range from \$15 million to \$90 million by 2018 across the different participation scenarios. Of the six scenarios analyzed, the highest regional gains from trading are realized when only California, Idaho and Nevada opt-out, while the least regional gains from trading are estimated to occur when Colorado, Wyoming and Wind River Reservation opt-out of the trading program. Under no scenario are the regional gains from trading fully eroded, because there may be gains even if only one state participates.
- Wyoming, Colorado and Arizona appear to be most important to the program in terms of the regional gains (cost savings) from trading. These states have the largest compliance cost under command-and-control and thus hold the greatest potential for regional gains (cost savings) from trading. Other states/tribes influence and are influenced by the trading program, but their impact on regional gains from trading remains limited because their share of the regional compliance cost is low.
- Wyoming and Arizona need out-of-state trading partners to realize the benefits of the trading, while Colorado is able to achieve some of the benefits through intra-state trading. Indian tribes will likely play a major role in the trading program as the key supplier of allowances.
- Tribes, New Mexico and Utah are likely to be net sellers of allowances while Oregon, Wyoming, Colorado and Arizona are likely to be net buyers of allowances.

The remainder of the executive summary discusses these results in more detail.

### *Compliance Cost With All States and Tribes Participating*

Based on previous economic analyses conducted by the MTF<sup>2</sup>, a full trading program (i.e., all nine states and tribal areas participating) would result in a compliance cost (cost of emissions reductions) of approximately \$120 million<sup>3</sup> in 2018. Achieving approximately the same level of emission reductions under command-and-control (i.e., all states/tribes



implementing command-and-control as required under Section 51.308) would result in a higher compliance cost of approximately \$210 million in 2018.

The \$90 million reduction in compliance cost under the full trading relative to the full command-and-control program is the result of the flexibility inherent in a trading program. Trading allows sources to seek out the least-cost compliance option through allowance transactions while command-and-control offers affected sources only limited compliance options. Critical mass becomes an issue for the regional trading program because if states/tribes elect to opt-out the loss of trading participants will make the trading program less flexible and more expensive. Additionally, the state or tribe opting-out may add to the regional compliance cost due to the fact that after opting out they need to implement command-and-control.

Recognizing that full participation may not be realized, the MTF constructed alternative scenarios of participation by the eligible state and tribes. Each scenario assumes that one or more states or tribes chooses not to participate in the trading program and that the state/tribe opting-out of the trading program would instead implement command-and-control measures through Section 51.308. Command-and-control under Section 51.308 requires states/tribes to implement the Best Available Retrofit Technology (BART) at affected sources.

### *Alternative Trading Scenarios*

A total of six alternative trading scenarios were analyzed. These scenarios differ in terms of participation of the states/tribes and also in terms of the milestones, and thus the level of emission reductions achieved. The scenarios selected were considered to be of greatest interest to the current analysis and therefore likely to yield the most pertinent information. Modeling analysis of each of the six scenarios was completed using ICF's Integrated Planning Model<sup>®</sup> and the data/assumptions of WRAP/MTF's previous study<sup>4</sup>.

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<sup>2</sup> Ibid., MTF 2000.

<sup>3</sup> Unless otherwise indicated, all dollars are quoted in real 1997 \$.

<sup>4</sup> Ibid., MTF 2000.

Table ES-1 below describes the six alternative trading scenarios analyzed.

Table ES-1: Alternative Trading Scenarios Evaluated in This Study

States/Tribes	Trading Scenario 1	Trading Scenario 2	Trading Scenario 3	Trading Scenario 4	Trading Scenario 5	Trading Scenario 6
AZ	T	T	T	T	T	T
NM	T	CC	T	T	T	T
UT	T	T	T	T	T	T
CO	T	CC	CC	CC	T	CC
OR	T	CC	T	T	T	T
WY	T	T	T	T	CC	CC
Navajo Nation	T	T	T	CC	T	T
Uintah and Ouray Reservation	T	T	T	T	T	T
Wind River Reservation	T	T	T	T	CC	CC
CA	CC	CC	CC	CC	CC	CC
NV	CC	CC	CC	CC	CC	CC
ID	CC	CC	CC	CC	CC	CC
Emissions Cap in Trading Program 2018 (Tons)	449,049	295,692	391,374	346,602	349,907	292,232

Note: T – Participating in the regional cap-and-trade program.  
 CC- Opting out of the trading program, engages command-and-control requirements.  
 The emissions cap reflects the SO<sub>2</sub> emissions only in the states/tribes that are assumed to participate in the regional trading program. States/tribes that are assumed to opt-out need to adopt command-and-control measures that will result in reductions in SO<sub>2</sub> emissions but are not reflected in the emissions cap.

The six scenarios presented above are only a fraction of all possible combinations. These were selected by the WRAP/MTF to represent known state positions on Section 309 of the regional haze rule and to offer a range of conditions that would provide insight on the potential impact of participation or nonparticipation in the program. Three states were treated as opting-out and excluded from participation in all scenarios: California and Nevada have announced that they were going to opt-out of the regional trading program; Idaho has the fewest SO<sub>2</sub> emissions of the remaining states, and, as such, was considered to have little potential to influence the viability of the trading program. The rest of the states and tribes were considered as potential participants in the trading program.

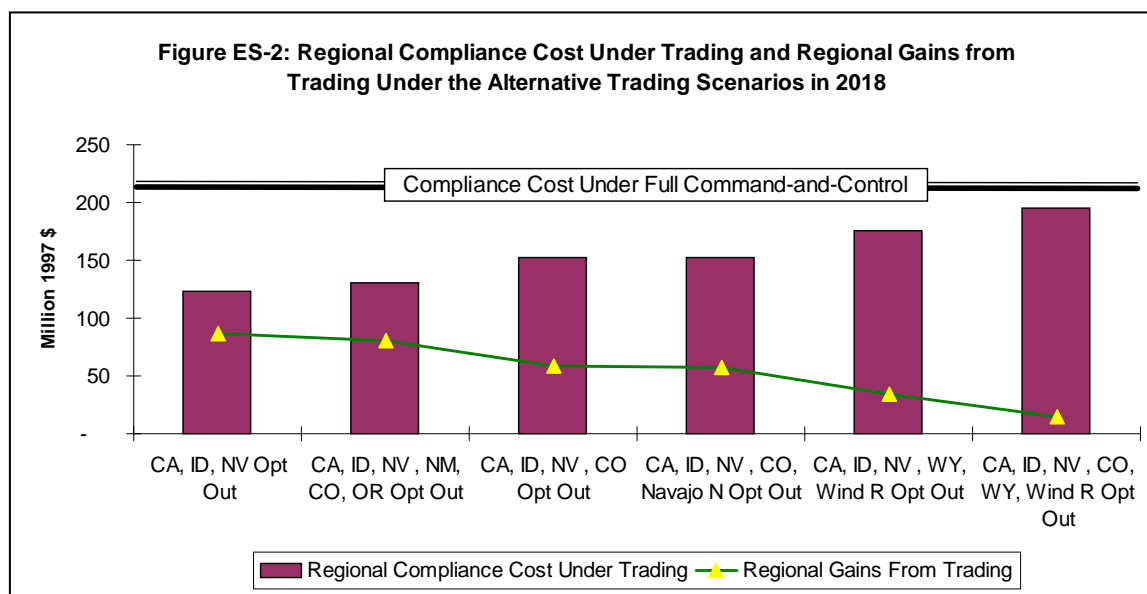
### Discussion of Results

This analysis estimates critical mass on the basis of compliance cost estimated from changes in the *production expenditures* that occur between a Business-As-Usual scenario and the scenario being analyzed. Production expenditures consist of fuel, annualized costs for new capital investments, operation and maintenance costs resulting from the production of electricity and thermal energy. In this case, the Business-As-Usual scenario does not include any regional haze requirements either through Section 51.308 or Section 51.309. Consequently, the compliance cost represents how much more sources will have to spend in order to meet the regulations being analyzed, in this case Section 51.308 or Section 51.309. Compliance cost as the metric for evaluating critical mass allows for comparability across other regulatory instruments, such as command-and-control and also across alternative trading scenarios.

The estimated compliance cost in this analysis reflects the regional compliance cost (i.e., the additional expenditures for emissions reductions incurred by sources in states/tribes participating in the trading program along with the additional expenditures incurred by sources in states/tribes that elect to opt-out and comply through a command-and-control approach). For the six scenarios analyzed, the total annual compliance cost for emissions reductions range from \$120 million to \$195 million. This cost represents a very small fraction, less than 1

percent, of the total modeled production expenditures for the production of electricity and industrial steam. Under the Business as Usual Scenario, total modeled production expenditures in 2018 were \$19 billion.<sup>5</sup>

A summary of the results of the alternative trading scenarios is presented in Figure ES-2 below. Based on analysis, the gains from trading over command-and-control in 2018 range from \$20 million to \$90 million. The gains from trading represent the reduced compliance costs of the alternative trading scenario relative to the full command-and-control. As noted earlier, the compliance cost reported in Figure ES-2 below includes both the compliance cost for the trading program and the compliance cost of meeting command-and-control requirements for states/tribes that elect to opt-out of the trading program.



Based on the scenarios analyzed, the lowest compliance cost (or the greatest gains from trading) occurs in the trading scenario where only California, Idaho, and Nevada opt-out of the trading program. Once states/tribes other than California, Idaho, and Nevada opt-out of the trading program, the compliance costs begins to increase reflecting the loss in flexibility of the trading program. The increase in compliance cost (or reductions in potential gains from trading) appears to be driven by states that have relatively high compliance cost under command-and-control (i.e., Wyoming, Colorado, Arizona).

As illustrated in Figure ES-2 above, the compliance costs is predominantly influenced by the participation status of Wyoming and Colorado. Compliance costs are highest (or potential gains from trading are the least) when Wyoming and Colorado both opt-out of the trading program. Wyoming and Colorado are likely to provide the largest gains from trading because these two states have the largest compliance costs under command-and-control. The two states appear to be critical to minimizing the compliance cost of the trading program and hence creating savings as compared to command-and-control. Consequently, the decision of Wyoming and Colorado to opt-out of the trading program most significantly reduces the gains from trading.

<sup>5</sup> "Modeled production costs" includes the variable costs of production, including fuel, variable operation & maintenance, fixed operation & maintenance; and incremental capital investment for capacity and environmental retrofits. Embedded costs associated with the capital cost of existing units' are not included in the modeling.

The analysis did not specially analyze any scenario that had Arizona opting out of the trading program. However, available modeling results suggests that if Arizona opts out it may lead to increased regional compliance cost of \$5 million to \$10 million since Arizona is a net buyer of allowances and may have to implement some higher cost investment under command-and-control. The opt-in, opt-out decision of Utah, New Mexico, Oregon and Tribal areas are unlikely to significantly affect regional compliance cost since compliance cost in these states under trading and command-and-control represent a relatively small share of the total regional compliance cost. As a result, the regional impact of Utah, New Mexico and Oregon opting out of the trading program will be relatively small.

### Net Allowance Position

While changes in compliance costs describe how the regional cost-efficiency of the trading program might change under the alternative trading scenarios, the net allowance position of a state or tribe describes how important a state or tribe might be to allowance transactions under a the trading program. The net allowance position describes the total emissions from affected sources in a state or tribe relative to the allowance budget of that state or tribe. It does not describe in-state allowance transaction but instead provides a summary of the allowance position of all sources in a state/tribe after all in-state transactions have been completed.<sup>6</sup> A state or tribe that has fewer total emissions than its budget will sell its excess allowances to out-of-state sources and will have a positive net allowance position. Sources in these states/tribes may be able to defray their compliance cost with revenues from allowances sales. A state or tribe that has more total emissions from affected sources than its budget will have a negative net allowance position and will have to purchase allowances from out-of-state sources to cover its emissions. Table ES-2 below describes the net allowance position in 2018 for the states/tribes and for each of the alternative trading scenarios. The table also describes the projected allowance prices. Projected allowance prices are based on the marginal compliance cost and are an estimate of the price at which allowances would be traded under each of the alternative trading scenarios.

Table ES-2: Net Allowance Position in 2018 (in Thousand Tons)

	States/Tribes Not Participating in the Trading Program					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	(11)	(7)	(8)	(8)	(17)	(18)
CA	-	-	-	-	-	-
CO	(2)	-	-	-	(8)	-
All Tribes	23	16	22	24	21	20
ID	-	-	-	-	-	-
NV	-	-	-	-	-	-
NM	8	-	8	7	8	7
OR	(3)	-	(4)	(4)	(6)	(9)
UT	5	1	4	4	3	2
WY	(19)	(9)	(21)	(20)	-	-
Allowance Price (\$/Ton)	1,328	1,570	1,190	1,190	2,125	1,070

Results of the net allowance position suggest that approximately 10% - 20% of the total allowances will be traded in net across the states/tribes in the trading program. In allowance transactions, Tribal Areas, New Mexico and Utah are likely to be net sellers of allowances, while

<sup>6</sup> It is implied that all in-state transactions will be completed prior to transactions across inter-states sources.

Arizona, Colorado, Oregon and Wyoming are likely to net buyers. Wyoming may be the largest net buyer of allowances because under the trading program sources in Wyoming will use allowances to avoid some of the high costs investments in pollution control. Unlike, Wyoming Colorado is not a larger buyer of allowances suggesting that for Colorado the flexibility of trading even just within state may offer most of the benefits from trading.

Though approximately only 10% - 20% of the total allowances are estimated to be traded in net across states/tribes, this result does not imply that there will not be greater volumes of allowance transactions in the overall allowance market. The state level net allowance position does not reflect many of the allowance transactions that may occur intra-state and is therefore not an indicator of the volume of transactions. Rather, the results of the analysis simply describe the role of inter-state/tribal allowance transactions in the trading program.

### *State/Tribal Level Impacts*

The preceding discussion on the regional gains from trading and net allowance position can be used to develop some broad characterization of the role that each state/tribe might play in the trading program. This characterization will be broader than earlier discussion of results because the alternative trading scenarios only represent a subset of possible configurations and do not contain enough data for a very precise and detailed presentation. Table ES-3 below provides a summary of impacts that states/tribes might have on the trading program if they elect to opt-in or opt-out.

Table ES-3: Summary of Role of Individual States/Tribes In Regional Trading Program

State	If State/Tribe Opts Out**		If State/Tribes Opt-in**	
	Potential Annual Impact on Regional Gains from Trading in 2018*	Compliance Response Under Command-and-Control (and others Trading)	Net Allowance Position	Compliance Response Under Trading
Arizona	<ul style="list-style-type: none"> <li>Approximately \$5 million - \$10 million</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios analyzed assumed Arizona opted out</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 10,000 to 20,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 10% to 15% of regional scrubber builds and approximately 7% of regional capacity changes</li> </ul>
California	<ul style="list-style-type: none"> <li>Could range from -\$2 to -\$54 million depending on what happens in the trading program</li> </ul>	<ul style="list-style-type: none"> <li>Response varies greatly with what happens in the trading program (or in regions outside of CA)</li> <li>What happens elsewhere significantly affects new capacity and generation choices in CA</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios assumed California would opt-in</li> </ul>	
Colorado	<ul style="list-style-type: none"> <li>Approximately \$30 million</li> </ul>	<ul style="list-style-type: none"> <li>Achieves approximately the same reductions as in the trading program but at a much higher cost</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 2,000 to 8,000 allowances</li> <li>Benefits of trading may be realized through intra-state trading</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 15% to 20% of regional scrubber builds and approximately 15% of regional capacity changes</li> </ul>
Idaho	<ul style="list-style-type: none"> <li>Negligible</li> </ul>	<ul style="list-style-type: none"> <li>Does not have sufficient sources or emissions to be a significant factor in regional compliance strategy</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios assumed Idaho would opt-in</li> </ul>	<ul style="list-style-type: none"> <li>Response, relative to region, is likely to be small</li> </ul>
Nevada	<ul style="list-style-type: none"> <li>Could range between -\$0 and -\$30 million depending on what happens in the trading program</li> </ul>	<ul style="list-style-type: none"> <li>Trading program significantly affects new capacity and generation choices in the state</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios assumed Nevada would opt-in</li> </ul>	

State	If State/Tribe Opt's Out**		If State/Tribes Opt-in**	
	Potential Annual Impact on Regional Gains from Trading in 2018*	Compliance Response Under Command-and-Control (and others Trading)	Net Allowance Position	Compliance Response Under Trading
New Mexico	<ul style="list-style-type: none"> <li>Approximately \$7 million</li> </ul>	<ul style="list-style-type: none"> <li>Compliance cost in state is lower under command-and-control than under trading</li> </ul>	<ul style="list-style-type: none"> <li>Net seller of approximately 10,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 10% of regional scrubber builds and approximately 2% to 4% of regional capacity changes</li> <li>Over-controls (relative to allocation for state) to sell allowances</li> </ul>
Oregon	<ul style="list-style-type: none"> <li>Approximately \$1 to \$2 million</li> </ul>	<ul style="list-style-type: none"> <li>Compliance strategy relatively unaffected under command-and-control by configuration of the trading program</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 3,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 5% to 10% of regional scrubber builds and approximately 2% to 4% of regional capacity changes</li> </ul>
Utah	<ul style="list-style-type: none"> <li>Unable to estimate regional cost impact if state opts out</li> <li>None of the alternative trading scenarios assumed Utah opting out</li> </ul>	<ul style="list-style-type: none"> <li>Compliance cost for state is lower under command-and-control than under trading in some</li> </ul>	<ul style="list-style-type: none"> <li>Net seller of approximately 1,000 to 3,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 5% of regional scrubber builds and 8% of regional capacity changes</li> <li>Over-controls (relative to allocation for state) to sell allowances</li> </ul>
Wyoming	<ul style="list-style-type: none"> <li>Approximately \$60 million</li> <li>Has the single largest impact on the regional compliance cost</li> </ul>	<ul style="list-style-type: none"> <li>Under command-and-control provides most of the capacity growth for the region</li> <li>Accounts for 45% to 50% of regional capacity changes</li> <li>Compliance cost higher by approximately \$50 million if state opts out when other are trading than under the full command-and-control</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 20,000 allowances</li> <li>Single largest buyer of allowances</li> </ul>	<ul style="list-style-type: none"> <li>Avoids many of the high cost investment under command-and-control through trading</li> <li>Accounts for approximately 10% to 15% of regional scrubber builds and 10% of regional capacity changes</li> </ul>
Indian Tribes	<ul style="list-style-type: none"> <li>Navajo opting out may</li> </ul>	<ul style="list-style-type: none"> <li>Not enough sources to</li> </ul>	<ul style="list-style-type: none"> <li>Net seller of approximately</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately</li> </ul>

State	If State/Tribe Opts Out**		If State/Tribes Opt-in**	
	Potential Annual Impact on Regional Gains from Trading in 2018*	Compliance Response Under Command-and-Control (and others Trading)	Net Allowance Position	Compliance Response Under Trading
(includes sources located in Indian Tribes and Tribal Set-Aside Allowances)	increase cost by approximately \$1 million <ul style="list-style-type: none"> <li>• Tribal Set-Asides will be an important part of the compliance strategy in the trading program</li> </ul>	significantly affect regional compliance cost	20,000 allowances <ul style="list-style-type: none"> <li>• Single largest seller of allowances</li> </ul>	10% to 30% of regional scrubber builds and approximately 8% of regional capacity changes

Notes:

- \* Potential Annual Impact on Regional Gains from Trading in 2018 signifies additional compliance costs that the region may incur as a result of the state/tribe electing to opt-out of the trading. Negative implies that the compliance costs may decline.
- \*\* Impacts by state/tribe are not additive across states/tribes; when two or more states/tribes opt-out the overall impact may be different than the sum of the individual state impacts.

### *Further Considerations*

This analysis examines critical mass strictly in the context of compliance cost and is focused on understanding how the compliance costs might change should one or more states/tribes elect to opt-out of the trading program. The study does not examine other non-compliance cost factors such as administrative costs of the program, market power and transaction costs that would be equally pertinent to an analysis of the efficiency of a trading program. The scope of the study did not allow for this extension in analysis, though readers should temper the suggested results of the analysis against other factors not explicitly covered in this report.

Readers should also be aware that the magnitude of the impacts of the alternative trading programs is extremely small and therefore likely to have a relatively larger error bound. The highest compliance cost recorded in this analysis occurs under the full command-and-control. There the compliance cost of \$210 million represents about 1 percent of total modeled production cost in the nine state and tribal areas of the GCVTC region. Given that the results represent such a small share of total costs, the overall direction, trends and broad insights about the impacts are more informative than the actual dollar cost estimate.

## I. Introduction

This analysis of critical mass was commissioned by the Market Trading Forum (MTF) of the Western Regional Air Partnership (WRAP) to help WRAP participants, western states and Indian tribes understand the implications of some states and/or tribes electing to opt-out of the SO<sub>2</sub> regional trading program for regional haze. The study focuses only on the components relating to SO<sub>2</sub> emission from stationary sources under Section 51.308 and Section 51.309 of the Regional Haze Rule.

This report is composed of five sections covering the analytical framework, data, assumptions and results.

- Section II provides some background to the motivation for the study, describes the key objectives of the analysis and highlights the main findings.
- Section III details the analytical framework used for the analysis. The section includes an overview of the modeling tool (the Integrated Planning Model<sup>®</sup>) along with a discussion of the modeling scenarios, analytical methods, data sources and assumptions used for the study.
- Section IV is devoted to the discussion on the findings of the study. A brief discussion of the underlying factors that are important to the analysis of critical mass provides a helpful context for interpreting the results. The discussion in this section is primarily focused around the regional gains from trading and the impact of allowance allocations. The section also includes a description of the role that individual states/tribes might play in the trading program.
- Section V describes the key changes in the electric system for each of the modeling scenarios. The changes provide details on compliance cost, changes in electric capacity, generation and scrubber installations.
- Section VI contains a discussion of the caveats and uncertainties underlying the results.
- Section VII describes the conclusions of the study.

## II. Overview

### II.1 Background

Section 169A and 169B of the Clean Air Act (CAA) established a national goal for protecting visibility in 156 Class I areas. The national visibility goal sought to remedy existing impairment and prevent future impairment in these Class I areas. Consistent with Sections 169A and 169B of the CAA, EPA promulgated the Regional Haze Rule (RHR) in 1999 requiring states to develop implementation plans designed to make reasonable progress towards the national visibility goal. Section 51.308 of the Regional Haze Rule describes the State Implementation Plan (SIP) requirements under the regional haze program. In developing the SIPs, states must demonstrate progress in achieving visibility goals for each Class I area, as well as emissions reductions strategies and other measures needed to meet these goals.

Based on the recommendation of the Grand Canyon Visibility Transport Council (GCVTC), EPA's regional haze rule also includes an optional approach in Section 51.309 that may be adopted by the nine Western states (Arizona, California, Colorado, Idaho, New Mexico, Nevada, Oregon, Utah and Wyoming) that comprise the transport region analyzed by the GCVTC. This optional approach is also available to Indian Tribes within the GCVTC geographic region. The objective of Section 51.309 is to provide a regional approach to air quality and allows states and participating Indian Tribes to address regional haze through reductions in SO<sub>2</sub> emissions at stationary sources. As intended by the GCVTC, the program allows for voluntary reductions in SO<sub>2</sub> emissions along with an enforceable market-based program that would serve as a "backstop" if the voluntary measures did not meet the goals. Because the GCTVC had not finalized the details of how the voluntary and enforceable phases of the program would be implemented when it submitted the recommendations in 1996, the option afforded by Section 51.309 were to be available under the regional haze rule only if an Annex to the GCVTC recommendations was submitted to EPA.

On September 2000, the Western Regional Air Partnership (WRAP) submitted to EPA the Annex outlining the detailed provisions requiring compliance with the milestones and backstop-trading program. In 2002 EPA proposed to amend Section 51.309 of the regional haze rule to incorporate the additional provisions proposed in the Annex. If the EPA amendment to Section 51.309 is adopted, the regional haze rule will be modified and will provide the complete regulatory framework to be used by western states and tribes in developing regional haze implementation plans.

The amended regional haze rule would provide states with considerable flexibility in addressing regional haze since they can elect to adopt Section 51.308 or Section 51.309. The latter section also allows Indian Tribes to participate in the regional program. Since each state/tribe must individually decide whether or not to opt into the regional SO<sub>2</sub> backstop-trading program through Section 51.309 in lieu of Section 51.308, the composition of participants in the regional trading program will not be known with certainty until 2003 when the first SIPs are due.<sup>7</sup>

WRAP/MTF had previously commissioned ICF to evaluate the regional economic implications of potential alternative milestones (or emissions caps) of the regional SO<sub>2</sub> backstop-trading program to support the Annex submission to EPA (henceforth referred to as "MTF economic analysis" in this report).<sup>8</sup> The purpose of the MTF economic analysis was to assess the regional economic impacts under the assumption that all western states and Indian tribes in the GCVTC region would opt into the trading program through section 51.309. Since then more information about the opt-in/ opt-out decision of the states and tribes have become available and there is a growing interest among WRAP, EPA, states and tribes in understanding the impact that opt-in/opt-out decision of states/tribes would have on the trading program. Furthermore, many of the states and Tribes have initiated the process of determining whether or not to opt into the program and are interested in learning how they and the region might be affected by their decision to adopt Section 51.308 or 51.309.

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<sup>7</sup> Indian Tribes are given flexibility under EPA regulations to submit implementation plans and opt into the program after the 2003 deadline.

<sup>8</sup> "Regional Economic Impacts of Implementing a Region SO<sub>2</sub> Emission cap in the Grand Canyon Visibility Transport Region," Prepared by ICF Consulting for WGA/WRAP, September 2000 (MTF 2000).

## II.2 Objective

Recognizing that states and Indian tribes of the GCVTC region have the option of electing to adopt Section 51.308 (opt-out of the regional backstop SO<sub>2</sub> trading program) or Section 51.309 (participate in the regional backstop SO<sub>2</sub> trading program) in response to the regional haze requirements, the primary objective of this analysis is to determine if a minimum number of participants (either States and/or Tribes) is necessary or if certain participants are critical to the regional backstop SO<sub>2</sub> trading program. This analysis is focused on SO<sub>2</sub> reduction from stationary sources from electricity, industrial steam and process sources in the nine states and tribal areas of the GCVTC region.

For the purposes of this analysis, “critical mass” is defined in terms of the potential compliance cost savings from a trading program (under Section 51.309) relative to a command-and-control approach (under Section 51.308) and does not include an assessment of visibility impacts, program administration costs and allowance trading market infrastructure costs. The use of *potential* compliance cost savings represents the fact that the analysis included the assumption of perfectly competitive markets and did not account for elements such as transactions cost or other market imperfections that may prevent participants from realizing the gains from trading.

In addition to the compliance cost based assessment of critical mass, ICF also examined the role that individual states and tribes might play in allowance transactions under the trading program. The analysis was designed to shed light on the collective net allowance position (emission minus budget) of each state and tribal area to estimate whether each state/tribe would be a net buyer or a net seller.

## II.3 Summary of Results

Key findings of the analysis suggest that:

- Under a regional backstop SO<sub>2</sub> trading program, the least-cost compliance (or greatest savings from trading) results when all states and tribes participate in the trading program.
- A state or tribe's decision not to participate in the trading program does not insulate it or its sources from the impacts of the trading program. This is particularly relevant for the states of California, Wyoming and Colorado, where the response to command-and-control requirements under an opt-out decision varies significantly depending on the decision of other states and tribes. This explains why the command-and-control compliance cost for states/tribes that opt-out varies under the different trading program participation scenarios.
- A full trading program with all states/tribes participating is likely to have regional compliance costs that in 2018 are approximately \$90 million lower than under a program where all states/tribes implement command-and-control.
- The regional annual gains from trading range from \$15 million to \$90 million by 2018 across the different participation scenarios. Of the six scenarios analyzed, the highest regional gains from trading are realized when only California, Idaho and Nevada opt-out, while the least regional gains from trading are estimated to occur when these three states plus Colorado, Wyoming and Wind River Reservation opt-out of the trading

program. Under no scenario are the gains from trading fully eroded, because there may be gains even if only one state participates.

- Wyoming, Colorado and Arizona appear to be most important to the program in terms of the regional gains (cost savings) from trading. These states have the largest compliance cost under command-and-control and thus hold the greatest potential for regional gains (cost savings) from trading. Other states/tribes influence and are influenced by the trading program, but their impact on regional gains from trading remains limited because their share of the regional compliance cost is low.
- Wyoming and Arizona need out-of-state trading partners to realize the benefits of the trading, while Colorado is able to achieve some of the benefits through intra-state trading. Indian tribes will likely play a major role in the trading program as the key supplier of allowances.
- Tribes, New Mexico and Utah are likely to be net sellers of allowances while Oregon, Wyoming, Colorado and Arizona are likely to be net buyers of allowances.

### III. Analytical Approach

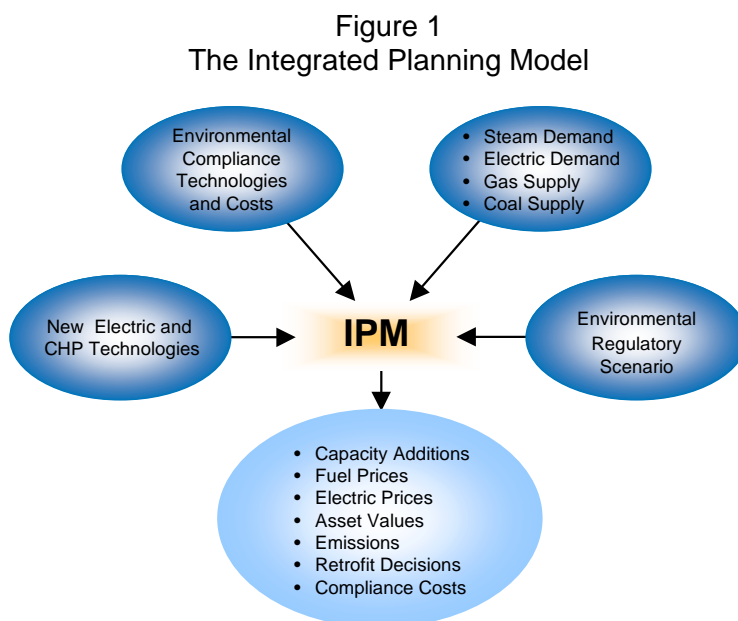
This section details the analytical approach and includes a discussion of the scenarios, analytical tools, data and assumptions used in the analysis.

#### III.1 Analytical Tool: Integrated Planning Model (IPM®)

This analysis was conducted using ICF's Integrated Planning Model (IPM®). IPM was used for the MTF economic analysis, upon which this study was based, and for the Air Pollution Prevention forum to analyze the regional economic impacts of renewable energy goals and energy efficiency.

IPM is a detailed engineering-economic capacity expansion and production-costing model of the power and industrial sectors supported by an extensive database of every boiler and generator in the nation. It is a multi-region model that provides least-cost capacity expansion plans, credible plant dispatch, electric prices forecasts, all based on power market fundamentals. IPM explicitly considers gas, oil, and coal markets, power plant costs and performance characteristics, environmental constraints, and other power market fundamentals.

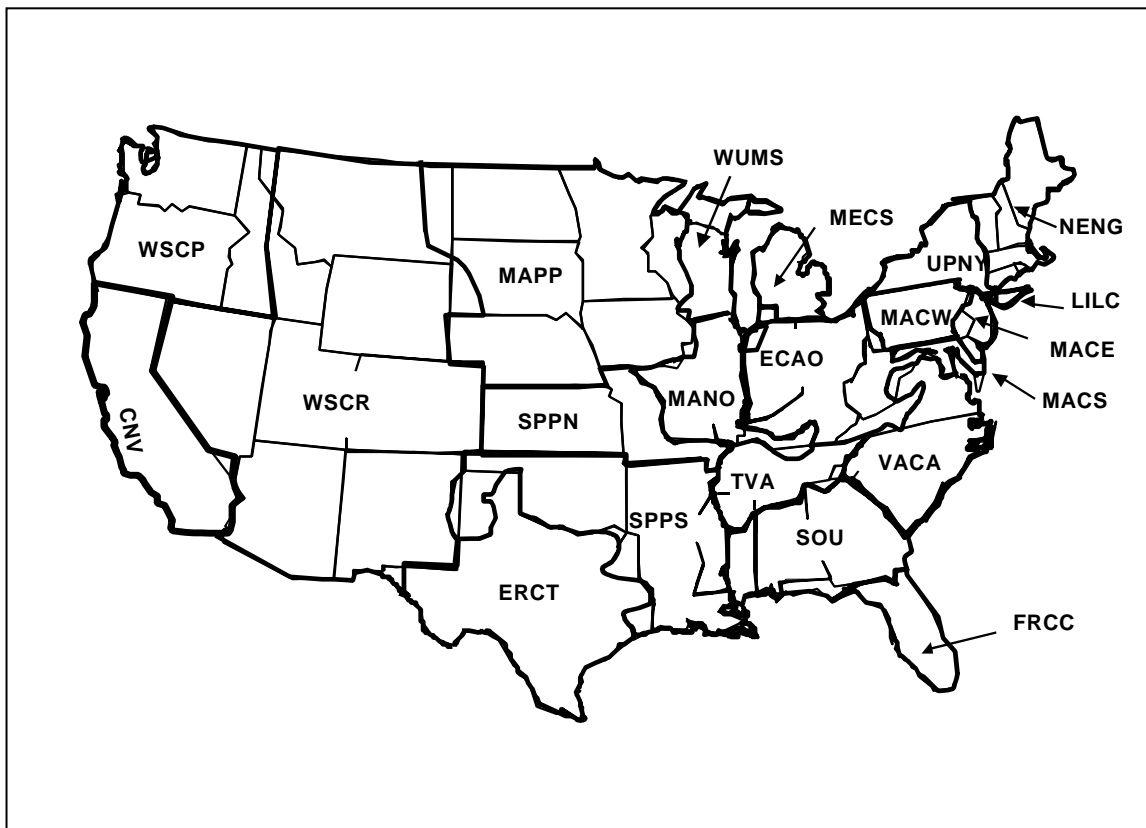
Unlike purely econometrically driven models, IPM captures the interactions of real world constraints and simulates electric and steam markets based on economic fundamentals rather than trends in historic data. The model utilizes a linear programming structure and can be used to examine air emissions and energy policies in conjunction with other complex phenomena, such as technological advances, unexpected regulatory announcements, changing risk patterns in capital investments, etc., that is almost impossible to capture with historical data. Figure 1 illustrates the key components of IPM.



IPM models the contiguous U.S. using distinct power markets represented as model regions. These regions correspond in most cases to the regions and sub-regions of the North American Electric Reliability Council (NERC). For this analysis, the nine western states and tribes of the

GCVTC region are contained within the model regions of CNV, WSCP and WSCR. The model regions used in this study are illustrated in Figure 2 below.

Figure 2.  
Regional Structure of IPM for Analysis of Critical Mass



The modeling for this analysis covered the electricity, industrial steam and process sources. The electricity sector includes all existing utility-owned boilers and generators, as well as independent power producers. IPM forecasts new capacity builds to meet the growth in electricity demand. The industrial steam sector includes sources that sell steam to industrial, commercial and institutional facilities. Expansion in steam demand is met through new boiler and/or combined heat and power (CHP) cogeneration facilities that the model projects. Process sources such as refineries and smelters are also included in the modeling to capture the interactions in the regional SO<sub>2</sub> allowance markets. The analysis does not model production activity of the process sources.

Air regulations, such as the regional backstop SO<sub>2</sub> trading program analyzed in this study, are modeled as environmental constraints that limit the emissions from affected sources. In determining the optimal compliance strategy, the model considers an array of options including fuel switching, repowering, pollution control retrofits, economic retirements and dispatch adjustments. The model determines the least cost compliance strategy for the emissions limits while also satisfying all other physical and operational constraints of the electric power system that have been assumed in the modeling.

### III.2 Alternative Trading Scenarios

There are nine states and 211 tribes in the GCVTC regions, each of whom may elect to participate or not participate in the trading program. Since an exhaustive analysis of all possible trading configurations would entail an inordinate number of modeling scenarios, MTF selected six scenarios that would be of most interest to policy makers. This analysis is primarily centered on these six scenarios, though the analysis used the results of these scenarios to draw inferences about other possible scenarios that were not explicitly evaluated. In addition, the study also drew from relevant results of previous MTF economic analyses to develop estimates of the regional gains from trading.

The six trading scenarios developed by the MTF for this analysis (alternative trading scenarios) describe the combination of states and tribes that participate in the regional trading program. A state or tribe not participating engages the stationary source SO<sub>2</sub> reduction requirements of Section 51.308. The Business-As-Usual, full trading and full command-and-control scenarios were modeled as part of the previous MTF economic analysis. Table 1 below describes the alternative trading scenarios along with other relevant scenarios used from the MTF economic analysis.

Table 1: Alternative Scenarios

States/Tribes	Business as Usual	Full Trading	Trading Scenario 1	Trading Scenario 2	Trading Scenario 3	Trading Scenario 4	Trading Scenario 5	Trading Scenario 6	Full Command-and-Control
AZ	No Regional SO <sub>2</sub> Program	T	T	T	T	T	T	T	CC
NM		T	T	CC	T	T	T	T	CC
UT		T	T	T	T	T	T	T	CC
CO		T	T	CC	CC	CC	T	CC	CC
OR		T	T	CC	T	T	T	T	CC
WY		T	T	T	T	T	CC	CC	CC
Shoshon		T	T	T	T	T	T	T	T
Navajo Nation		T	T	T	T	CC	T	T	CC
Uintah Ouray Reservation		T	T	T	T	T	T	T	CC
Wind River Reservation		T	T	T	T	T	CC	CC	CC
CA		T	CC	CC	CC	CC	CC	CC	CC
NV		T	CC	CC	CC	CC	CC	CC	CC
ID		T	CC	CC	CC	CC	CC	CC	CC

Note: T -Participating in the regional backstop SO<sub>2</sub> trading program through Section 51.309 track  
 CC – Opting out of the trading program, engaging command-and-control provisions to satisfy stationary source SO<sub>2</sub> reduction provisions of Section 51.308

The Business-as-Usual (BAU) scenario assumes that the stationary source SO<sub>2</sub> reduction provisions of the regional haze regulations are not in place and states/tribes do not need to undertake any further regulatory action. The only difference between the BAU and the alternative trading scenarios is the SO<sub>2</sub> reduction requirements for regional haze. Full trading assumes that all states and tribes are participating in the regional trading program, while the full command-and-control assumes that no state or tribe is participating in the trading program. The six alternative trading scenarios fall between the two extremes of full trading and full command-and-control and were explicitly evaluated as part of the study.

Based on the alternative trading scenarios developed by the MTF, three states were treated as opting out and excluded from participation in the six scenarios: California and Nevada have announced plans to opt-out of the trading program; Idaho has the lowest SO<sub>2</sub> emissions in the GCVTC region, and, as such, was considered to have little potential to influence the viability of the trading program. The rest of the states and tribes were considered as potential participants in the trading program.

For the full trading and each of the six trading scenarios, the emission milestones were developed using the state and tribal opt-in/opt-out adjustments developed by the WRAP/MTF<sup>9</sup>. The regional emission milestone reflects the budget only of those states and tribes participating in the trading program. In each of the scenarios, SO<sub>2</sub> emissions from affected sources in all participating states/tribes must collectively be below the milestones. Sources in those states/tribes may reduce their emissions or purchase allowances from other market participants to achieve the required reductions. Table 2 below describes the regional emission milestones for 2013 and 2018. State/tribal level details of the milestone can be found in Table A1 in the appendix.

Table 2: Regional Emissions Milestone for the Alternative Trading Scenarios

Year (Milestone in Tons of SO <sub>2</sub> )	Business as Usual	Full Trading	States/Tribes Not Participating in the Trading Program					
			CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
2013 Milestone	No Cap	655,000	588,973	382,839	500,678	449,413	445,564	357,270
2018 Milestone	No Cap	510,000	449,049	295,692	391,374	346,602	349,907	292,232

Note: The emissions cap reflects the SO<sub>2</sub> emissions only in the states/tribes that are assumed to participate in the regional trading program. States/tribes that are assumed to opt-out need to adopt command-and-control measures that will result in reductions in SO<sub>2</sub> emissions but are not reflected in the emissions cap.

The analysis includes the assumption that in all scenarios, sources in states/tribes not participating in the regional trading program are required to implement command-and-control measures to meet regional haze requirements. The command-and-control requirement, as modeled for this study, requires selected units (BART- eligible sources) to achieve targeted SO<sub>2</sub> reduction efficiency. The data for the selected units and targeted reduction efficiency were developed by WRAP/MTF and used previously in the MTF economic analysis.<sup>10</sup> Under the modeled command-and-control requirements:

- Utilities and industrial boilers currently achieving less than 70% SO<sub>2</sub> control efficiency were required to achieve at least an 85% control efficiency in SO<sub>2</sub>;
- Utilities and industrial boilers currently achieving between 70% and 80% SO<sub>2</sub> control efficiency were required to increase the SO<sub>2</sub> control efficiency to 85%; and
- Utilities and industrial boilers currently achieving greater than 80% SO<sub>2</sub> control efficiency required no further abatement activity.

Command-and-control estimates were also developed for other source categories such as refineries and copper smelters. The majority of the emission reductions were due to utilities and industrial boilers.

### III.3 Analytical Approach for Estimating Gains from Trading

The scenarios identified in Table 1 above were used to develop the gains from trading in order to evaluate how the opt-in/opt-out decision of various states and tribes might affect the regional trading program. Since the only difference between the BAU and the other scenarios is the regulatory requirement of SO<sub>2</sub> emissions reductions, the difference in modeled production cost<sup>11</sup>

<sup>9</sup> Budget for milestones were taken from "opt-in-opt-out adjustments.xls" www.wrapair.org/forums/MTF/group-reports/ANNEX/Supplement/opt-in-opt-out-adjustments.xls.

<sup>10</sup> Ibid., MTF 2000, Vol. I page 29.

<sup>11</sup> Modeled production cost describes the cost related to the production of electricity and industrial steam. Modeled production costs include the variable cost of production, including fuel, variable operation & maintenance; and incremental capital investment for capacity and environmental retrofits. Embedded cost associated with the capital

between the BAU and the other scenarios provides an estimate of the compliance cost of meeting the SO<sub>2</sub> reduction requirements.

The potential regional gains (or cost savings) from trading are defined as the difference between the regional compliance cost of the full command-and-control and the trading scenario. The largest potential gains from trading are likely to occur under the full trading program since all participants are involved in trading. As some states and/or tribes opt-out of the trading program, it is likely to reduce the gains from trading. The gains from trading under the different trading scenarios are measured against one another to evaluate critical mass and to examine which of the states or tribes might be important to the trading program.

### III.4 Analytical Approach for Estimating Net Allowance Position

While an estimate of the regional gains from trading provides some indication of how the regional compliance cost might change under the alternative trading scenarios, it does not fully characterize the role that an individual state/tribe might play in the trading program. As a corollary to the assessment of regional gains from trading, this analysis also includes an evaluation of the net allowance position of each state/tribe participating in the regions trading program. Net allowance position describes the total emissions from affected sources in a state or tribe relative to the allowance budget of that state or tribe. A state/tribe whose allowances exceed its emissions is a net seller and has a positive net allowance position, while a state/tribe whose emissions exceed its allowances is a net buyer and has a negative net allowance position. Projections of allowance prices at which the allowances would be traded are reported in IPM and reflect the marginal compliance cost.

WRAP/MTF provided the state and tribal level allocations for this analysis. These allowance allocations were prepared during the development of the Annex and may vary from final allocations included in state and tribal implementation plans. The analysis assumes that all tribal set-asides will be available to the allowance market. Tribes may choose to sell allowances in the tribal set-aside, use them to encourage economic development on tribal lands, or retire the allowances for environmental benefit. This study was not designed to evaluate the effects of different uses of the tribal set-aside. Since the allocation of tribal set-asides among the various tribes is not know, for purposes of this analysis all tribal allowances has been grouped under a broad Tribal category. This Tribal category also includes the allocations for Navajo Nation, Uintah Ouray and Wind River Reservation. If affected emissions in any of those three tribal areas exceed the allocations for the three tribes, the study assumes that they will be get the additional allowances from the pool of tribal set asides.

The analysis of net allowance position does not account for allowance transactions that might occur between sources *within* a state or tribal areas. Furthermore, any estimate of expenditures/revenues from purchase/sale of allowance does not imply that the state/tribe would receive those revenues or bear those expenditures. Those expenditures or revenues though borne by affected sources, may accrue to owners or electricity customers located outside the state or tribe.

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cost of existing units are not included in the modeling. Only the SO<sub>2</sub> reduction cost of process sources, such as smelters and refineries are also included in the modeling.

### III.5 Data and Assumptions Used in the Study

This analysis utilized the data, assumptions and analytical framework used in the MTF economic analysis completed in September 2000. The MTF economic analysis is suited to analyzing both command-and-control and alternative trading programs in the GCVTC region. The data and assumptions used in the study are fully documented in the report “Regional Economic Impacts of Implementing a Regional SO<sub>2</sub> Emissions Cap in the Grand Canyon Visibility Transport Region,” prepared by ICF Consulting for WGA/WRAP, September 2000; Volume I.

The starting point of the power system and environmental modeling for the MTF economic analysis was a dataset developed by EPA for its regulatory analysis process. These assumptions, documented in “*Analyzing Electric Power Generation Under the CAAA*”, developed by the U.S. EPA, can be found at <http://www.epa.gov/capi/ipm/epwr398.zip>. For the economic analysis, the MTF made selected adjustments to adapt the EPA data and assumptions for analysis of regional SO<sub>2</sub> trading program and command-and-control scenario. Such adjustments along with assumptions on electricity and steam demand, BART-eligible sources, pollution control options under command-and-control and trading, control cost, fuel prices, and technology cost and performance are described in the MTF economic analysis identified above.

## IV. Results

This section describes the findings of the study focused around the regional gains from trading, net allowance position and state/tribal level impacts. In an effort to provide readers a context for the results, the section also contains a brief discussion of the underlying factors that are important to the analysis of critical mass.

### IV.1 Understanding Critical Mass

Critical mass, as defined in this study, is based on estimates of the regional gains from trading over command-and-control. Gains from trading is said to occur if the regional compliance cost of reducing SO<sub>2</sub> emissions is lower under the trading program than in the command-and-control program. The regional gains from trading signify the cost savings possible under a trading program relative to a command-and-control approach. The objective in this analysis is to identify how the regional gains from trading are affected by the decision of a state/tribe to opt-out of the trading program. A ranking of the regional gains from trading across the alternative trading scenarios provides an analytical method for assessing which state or tribe may be important to the cost efficiency of the trading program.

The share of each state/tribe to the regional compliance cost under full command-and-control is an important determinant of the overall results on critical mass. States/tribes with relatively high compliance cost under full command-and-control are likely to experience the largest potential gains from trading, while states/tribes with a lower compliance cost under full command-and-control are likely to have smaller potential gains from trading. States/tribes with lower compliance costs are less likely to be as important to the regional trading program as those with higher costs.

States/tribes with relatively high compliance cost under command-and-control may be important to the program for two reasons. The first is that they command a large share of the regional compliance cost and the second reason is that sources in these states/tribes may have the greatest incentive in seeking cheaper alternatives to the reduction requirements under command-and-control. Table 3 below describes the state/tribal level compliance cost under the full command-and-control scenario. The table also lists the share of compliance cost borne by each state/tribe under the full command-and-control of required SO<sub>2</sub> reductions.<sup>12</sup>

Table 3: Compliance Cost in 2018 Under the Full Command-and-Control

	Full Command-and-Control (Million 1997\$)	Share of Regional Compliance cost (%)
AZ	40	19%
CA	(2)	-1%
CO	47	22%
All Tribes	2	1%
ID	0	0%
NV	(6)	-3%
NM	5	2%
OR	4	2%
UT	12	6%
WY	108	51%
Total	210	

<sup>12</sup> Ibid., MTF 2000, Vol. II page 11.

Table 3 above clearly identifies that Wyoming, Colorado and Arizona may be especially important to achieving cost-efficiency in the trading program since they collectively account for the most of the regional compliance cost under command-and-control. It must be recognized, though, that these state/tribal level compliance costs do not reflect only the regulatory requirements of the state/tribe. All of these states/tribes are located within a regional market where the response of sources in one state/tribe will affect what happens elsewhere. The \$108 million cost in Wyoming, for instance, does not imply that the cost results from the requirements in Wyoming alone. A portion of this cost may also have resulted from the collective response of regulations in other states/tribes.

Though states/tribes have the option of not participating in the regional backstop SO<sub>2</sub> trading program, they can never fully insulate their sources from some of the regional trading impacts. Production and compliance decisions of sources in states/tribes that elect to participate in the trading program are influenced by decisions of those that decide to opt-out. Just as importantly, decisions of participants in the regional trading program are influenced by what happens outside of the trading program.

This interdependent response to regulatory changes reflects the regional and integrated nature of electricity, fuel and emission markets in the western states. Wholesale power markets are regional with demand within any load center being met by generation in other parts of the region. Transmission lines connect load centers across state/tribal lines. In addition, plants in the region often share common fuel and other input markets. As a result, the impacts of regulatory programs, such as the regional SO<sub>2</sub> trading program, will certainly influence the decision of sources located outside of the trading region.

California serves as a good example to the effects of integrated electricity markets. Under the MTF economic analysis, the compliance cost in California was \$-22 million under the full trading scenario and -\$2 million under the full command-and-control scenario as compared to the BAU scenario. The negative compliance cost suggests that relative to the BAU scenario, the expenditures by sources in California would decline under the full trading, and to a lesser degree, under the command-and-control as well. Since California is able to import a large share of its electricity needs from other parts of the west, it is able to avoid investments in new capacity to the extent that the region is able to provide that power more cheaply than sources in California. In this case, the \$20 million savings in California reflects the avoided new capacity and generation in California that shifts to other states/tribes as a result of meeting regional haze requirements.

An immediate implication of the integrated electricity markets to the results for critical mass is that the impact of a particular trading scenario (or regulatory program) should not be evaluated based on the compliance cost of a single state/tribe. Rather, the *regional* compliance cost, including costs in states/tribes not participating in the trading program, provides a better estimate of the program impacts. State or tribal level compliance cost is useful in estimating how the alternative trading scenarios lead to different distribution of costs by state or tribe. In some instances, a change in the participation of the trading program leads to a redistribution of cost across states/tribes without changing the overall regional compliance cost. As a result, the importance of a state/tribe to the trading program should be evaluated in terms of how the decision of that state/tribe affects the regional compliance cost rather its own compliance cost.

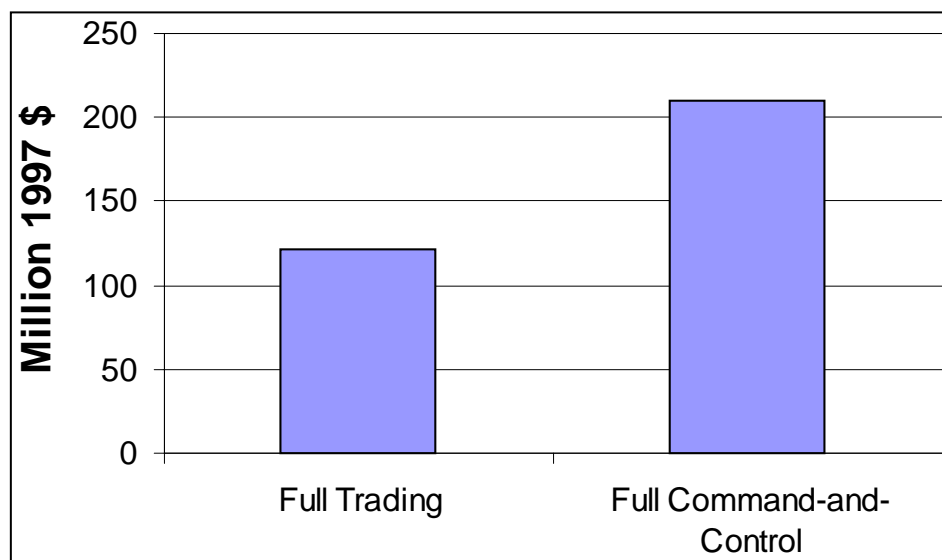
The fact that regional markets respond to the entire set of regulations, not just to the regulations of one state/tribe, implies that the state/tribal level impacts reflect the results of the scenarios upon which they are based. The compliance cost or other impacts estimated at the state/tribe

level is based on results of the alternative trading scenarios, which in turn reflects a specific configuration of the trading program. For instance, under the MTF economic analysis, Wyoming faces a compliance cost of approximately \$100 million in 2018 under the full command-and-control (i.e., all states/tribe opt-out). This result is dependent on the fact that all other states and tribes have elected to do command-and-control. As the results will indicate, the compliance cost in Wyoming for command-and-control is projected to increase beyond the \$100 million if other states/tribes elect to participate in the regional trading program. This is also true for other states and tribes where the compliance cost for opting in or out of the trading program often changes based on what everyone else is doing.

## IV.2 Regional Gains from Trading

The largest potential regional gains from trading occur when all states and tribes elect to participate in the regional trading. As illustrated in Figure 3, the annual regional gains from trading could be as high as \$90 million by 2018. The gains from trading represents the savings in compliance cost between the full trading and the full command-and-control. There is unlikely to be any significant gains from trading in years prior to 2018 as the SO<sub>2</sub> reduction requirements are far less stringent in these years.

Figure 3: Regional Compliance Cost Under Full Trading and Full Command-and-Control in 2018



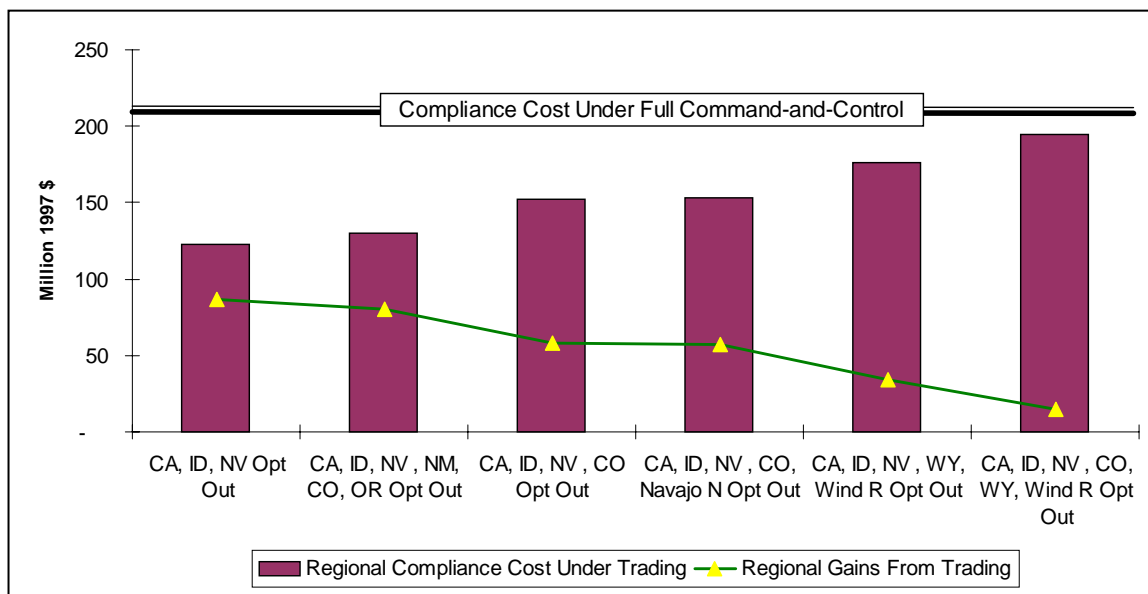
As different states/tribes elect to opt-out of the trading program, the gains from trading will diminish since a smaller pool of participants represents less flexibility in the trading options. Of the six alternative trading scenarios, however, there is no scenario that fully erodes the regional gains from trading. Therefore, in terms of gains from trading, the full trading program represents the most cost efficient configuration of the trading program.

### *Regional Gains from Trading Under the Alternative Trading Scenarios*

Based on the six alternative trading scenarios analyzed, the regional gains from trading range between \$20 million to \$90 million annually in 2018. The highest gains from trading occur when

only California, Idaho and Nevada opt-out of the trading program, while the lowest gains from trading occur when Wyoming, Colorado and Wind River Reservation opt-out in addition to California, Idaho and Nevada. In no scenario does the compliance cost of any alternative trading program exceed the compliance cost under full command-and-control (i.e., the gains from trading are never negative). Figure 4 below illustrates the regional compliance cost and regional gains from trading under the six alternative trading.

Figure 4: Regional Compliance Cost and Regional Gains from Trading Under Alternative Trading Scenarios in 2018



The estimated compliance cost and gains from trading reflects the regional compliance cost incurred by all sources in the nine states and tribal region of the GCVTC, i.e., sources in states/tribes that opt-in and opt-out. The range in compliance cost across all the scenarios represents a very small fraction, less than 1 percent, of the total production expenditures of all sources in the region. Under the BAU scenario, total annual modeled production expenditures in 2018 were \$19 billion, while the highest compliance cost is less than \$200 million. Details on the state level compliance cost for the six scenarios can be found in Table A2 located in the Appendix.

The results of the analysis suggest that in terms of the potential regional gains from trading (or the compliance cost) Wyoming and Colorado may be the most important states to the trading program. As illustrated in Figure 4 above, the regional compliance cost is highest in the scenario where Wyoming, Colorado and Wind River Reservation opt-out of the trading program along with California, Idaho and Nevada. The participation status of Wyoming, more than Colorado or Wind River Reservation, primarily influences the high regional compliance cost when Wyoming, Colorado, Wind River, California, Nevada and Idaho opt-out. When Wyoming incrementally opts out of the regional trading program in addition to California, Idaho and Nevada opting-out, the gains from trading drop to \$30 million (as compared to \$90 under the full participation scenario with the greatest savings). When Colorado and Wyoming both opt-out (in addition to California, Idaho, Nevada and Wind River), the annual gains from trading decline further to \$15 million by 2018. These results are primarily driven by what happens to the

compliance cost in Wyoming when the state elects to opt-out while most of the other states/tribes are participating in the trading program.

When Colorado is assumed to opt-out of the trading program along with California, Idaho and Nevada, the potential annual regional gains from trading fall to \$60 million from the \$90 million realized under full participation. The importance of Colorado and Wyoming to the gains from trading in the regional trading program reflects the fact that these two states collectively account for a large share of the regional compliance cost under full command-and-control. As a result, the flexibility of trading allows the sources in these two states to avoid the higher cost investments needed under command-and-control.

Similar to Colorado and Wyoming, Arizona is also likely to have a relatively large impact on the regional gains from trading if it opts out. Although, there were no scenarios that assumed Arizona individually opting out, the results of the analysis suggest that the regional gains from trading might decline if Arizona were to opt-out. Under some of the trading scenarios, in 2018 Arizona is able to avoid \$5 million - \$10 million of the investments required under command-and-control through trading. If Arizona were to opt-out, it is reasonable to expect that the gains from trading would decline by approximately \$5 million - \$10 million in 2018, relative to scenarios where Arizona opts in.

Although the compliance costs in the other remaining states and tribes are also affected by the configuration of the trading program, the overall regional impacts from the participation decision of these states are relatively small since their share of the regional compliance cost is small. Under the full command-and-control, these states account for 10% of the regional compliance cost. Their ability to significantly influence the regional gains from trading is, therefore, quite limited.

### **IV.3 Impact of Allowance Allocations**

While regional gains from trading describe how the compliance cost changes under the alternative trading programs, it does not fully describe the role that each state or tribe might play in the trading program. For instance, although Indian Tribes account for only a small component of the regional compliance cost, Tribal allowances are an important part of the overall compliance strategy under the trading program. The net allowance position, or total emissions net of allowances budgeted, of a state or tribe is a metric that describes the role a state or tribe might play in allowance transactions in the trading program.

A state/tribe that holds more allowances than emissions from its affected sources will have a positive net allowance position implying that it will have allowances to sell to sources outside the state/tribe. On the other hand, a state/tribe that does not have sufficient allowances to cover its affected emissions will have a negative net allowance position implying that it will need to purchase allowances from out-of-state/tribal sources in order to cover its emissions. A state or tribe not participating in the trading program is not allocated any allowances and the allowance position for that state/tribe is not described.

This analysis of net allowance position does not account for intra-state/tribal allowance transactions. The assumption contained in the analysis is that sources will first trade with other sources within the same state/tribe before trading with sources outside of the state/tribe. The net allowance position primarily describes whether sources in the state or tribe will purchase or sell allowances after all intra-state/tribal transactions have been completed, and at what level.

For the purposes of this analysis, Indian Tribes have been included under one category since the allocation of Tribal Set-Asides among the various tribes is not decided. The total allowance allocation to tribes includes the Tribal Set-Asides and allocation to specific tribes for sources located within their lands. The allowance position of the tribes, therefore, accounts for Tribal Set-Asides, Tribal allocations and emissions from affected sources located in Tribal lands. Table IV below describes the net allowance position by state/tribe in 2018.

Table 4 below also describes the allowance price at which the allowances might be expected to trade. Projections of allowance price are based on the marginal compliance cost and reflect the cost of controlling the last ton of SO<sub>2</sub> emissions.

Table 4: Net Allowance Position in 2018 (in Thousand Tons)

	States/Tribes Not Participating in the Trading Program					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	(11)	(7)	(8)	(8)	(17)	(18)
CA	-	-	-	-	-	-
CO	(2)	-	-	-	(8)	-
All Tribes	23	16	22	24	21	20
ID	-	-	-	-	-	-
NV	-	-	-	-	-	-
NM	8	-	8	7	8	7
OR	(3)	-	(4)	(4)	(6)	(9)
UT	5	1	4	4	3	2
WY	(19)	(9)	(21)	(20)	-	-
Allowance Price (\$/Ton)	1,328	1,570	1,190	1,190	2,125	1,070

Results of the net allowance position suggest that approximately 10%-20% of the total allowances may be traded in net across states/tribes. The results also suggest that Arizona, Indian Tribes, New Mexico and Wyoming will be the key participants in inter-state/tribal trading of allowances. The results in Table VI above describe the number of allowances sources in a state/tribe will purchase from or sell to sources outside of their state/tribe and the price at which those trades will be conducted. For instance, under the first scenario (i.e., CA, ID and NV opt-out) Wyoming is projected to purchase 19,000 allowances each at a forecasted price of \$1,328 per allowance. Similarly for the last scenario (i.e., CA, ID, NV, CO, WY and Wind River opt-out), Indian Tribes will sell a total of 20,000 allowances each at a price of \$1,070 per allowance.

Based on the results of the analysis, Wyoming, Arizona, Colorado and Oregon will be net buyers of allowances. The ability to purchase allowances is particularly important to Arizona and Wyoming since these states have high compliance cost under command-and-control. These states will seek to use allowance purchases to avoid some the high cost investments under command-and-control. When Wyoming opts out of the trading program, it loses the flexibility to purchase those allowances and therefore adds significantly to the regional compliance cost. When Wyoming opts-out of the trading program, Arizona becomes the largest buyer of allowances since it now able to tap into excess pool of allowances created by Wyoming opting out.

Though Oregon is a net buyer of allowances, suggesting that sources in the state prefer to avoid some of the investments required under command-and-control, the state is unlikely to have a major impact on the regional gains from trading because its share of regional command-and-control compliance cost is fairly small.

Although Colorado can reduce the regional gains from trading by as much as \$30 million when it opts out, Colorado is not as large a net buyer of allowances as Arizona or Wyoming. This result suggests that the flexibility of the trading program is important to Colorado though it may not be as dependent on external trading partners as Wyoming and Arizona. This is because Colorado may be able to achieve most of the benefits of trading simply through intra-state trading of allowances.

Analysis of the results suggests that Indian tribes will be the most dominant net seller of allowances in the trading program. The large positive net position of the tribe reflects the 20,000 tons of Tribal Set-Asides that are available to the tribes under the trading program. To the extent that some of those Tribal Set-Asides are not available to the program, it will reduce the gains from trading and affect the projected volume of trading. The results of the analysis also suggest that across all the alternative trading scenarios Utah will be a small net seller of allowances, implying that the sources in Utah face a reduction cost lower than allowance price in the trading program.

The allowance price under the alternative trading program is likely to range between \$1,100 per ton to \$2,100 per ton and reflects the cost of the marginal compliance option. The allowance price reflects both the pollution control installed on existing units and changes to new capacity and generation that are motivated by the trading program. The wide range in allowance prices across the alternative trading scenarios suggest that the allowance price is quite sensitive to small changes in participation and the allowance prices estimated for these scenarios cannot be easily applied to other scenarios not explicitly analyzed in this study.

The results presented in Table 4 above do not describe who will ultimately bear the cost of the allowance purchases or receive the benefits of allowance sales. For instance, sources in Wyoming will need to purchase between 10,000 – 20,000 allowances from out-of-state sources and with the allowance price, the cost for those sources could range from \$15 million to \$25 million. Since these costs will ultimately be reflected in the regional wholesale electricity price, these results cannot be interpreted to mean that electricity end user in Wyoming will bear the burden of those allowance purchases.

In perfectly competitive markets with no transaction costs, marginal abatement cost (which is reflected in the allowance price in Table 4 above) should be the price at which allowances are traded. However, the allowance price will be extremely sensitive to transaction costs, market power, market transparency, risk and other market factors that affect the flow of information between participants. To the extent that some or all of the above market imperfections are present, the price at which allowances may be traded might be significantly different.

#### **IV.4 Regional Impacts of Individual States/Tribes**

The regional gains from trading and the net allowance position discussed above describe the impacts only under the six alternative trading programs. While the six alternative trading scenarios do not fully encompass the wide range of possible scenarios, they provide some characterization of how each of the states/tribes might affect and be affected by the trading program.

Table 5 below provides a summary of the role that individual state/tribes might play in the trading program and is based on results of regional compliance cost and net allowance position. The section is less precise and only broadly characterizes the impacts because the six

alternative trading scenarios represent only a small fraction of all possible scenarios and cannot be used to precisely estimate the role of each state/tribe in the trading program.

Table 5: Summary of Role of Individual States/Tribes In Regional Trading Program

State	If State/Tribe Opts Out**		If State/Tribes Opt-In**	
	Potential Annual Impact on Regional Gains from Trading in 2018*	Compliance Response Under Command-and-Control (and others Trading)	Net Allowance Position	Compliance Response Under Trading
Arizona	<ul style="list-style-type: none"> <li>Approximately \$5 million - \$10 million</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios analyzed assumed Arizona opted out</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 10,000 to 20,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 10% to 15% of regional scrubber builds and approximately 7% of regional capacity changes</li> </ul>
California	<ul style="list-style-type: none"> <li>Could range from -\$2 to -\$54 million depending on what happens in the trading program</li> </ul>	<ul style="list-style-type: none"> <li>Response varies greatly with what happens in the trading program (or in regions outside of CA)</li> <li>What happens elsewhere significantly affects new capacity and generation choices in CA</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios assumed California would opt-in</li> </ul>	
Colorado	<ul style="list-style-type: none"> <li>Approximately \$30 million</li> </ul>	<ul style="list-style-type: none"> <li>Achieves approximately the same reductions as in the trading program but at a much higher cost</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 2,000 to 8,000 allowances</li> <li>Benefits of trading may be realized through intra-state trading</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 15% to 20% of regional scrubber builds and approximately 15% of regional capacity changes</li> </ul>
Idaho	<ul style="list-style-type: none"> <li>Negligible</li> </ul>	<ul style="list-style-type: none"> <li>Does not have sufficient sources or emissions to be a significant factor in regional compliance strategy</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios assumed Idaho would opt-in</li> </ul>	<ul style="list-style-type: none"> <li>Response, relative to region, is likely to be small</li> </ul>
Nevada	<ul style="list-style-type: none"> <li>Could range between -\$0 and -\$30 million depending on what happens in the trading program</li> </ul>	<ul style="list-style-type: none"> <li>Trading program significantly affects new capacity and generation choices in the state</li> </ul>	<ul style="list-style-type: none"> <li>None of the alternative trading scenarios assumed Nevada would opt-in</li> </ul>	

State	If State/Tribe Opts Out**		If State/Tribes Opt-In**	
	Potential Annual Impact on Regional Gains from Trading in 2018*	Compliance Response Under Command-and-Control (and others Trading)	Net Allowance Position	Compliance Response Under Trading
New Mexico	<ul style="list-style-type: none"> <li>Approximately \$7 million</li> </ul>	<ul style="list-style-type: none"> <li>Compliance cost in state is lower under command-and-control than under trading</li> </ul>	<ul style="list-style-type: none"> <li>Net seller of approximately 10,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 10% of regional scrubber builds and approximately 2% to 4% of regional capacity changes</li> <li>Over-controls (relative to allocation for state) to sell allowances</li> </ul>
Oregon	<ul style="list-style-type: none"> <li>Approximately \$1 to \$2 million</li> </ul>	<ul style="list-style-type: none"> <li>Compliance strategy relatively unaffected under command-and control by configuration of the trading program</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 3,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 5% to 10% of regional scrubber builds and approximately 2% to 4% of regional capacity changes</li> </ul>
Utah	<ul style="list-style-type: none"> <li>Unable to estimate regional cost impact if state opts out</li> <li>None of the alternative trading scenarios assumed Utah opting out</li> </ul>	<ul style="list-style-type: none"> <li>Compliance cost for state is lower under command-and-control than under trading in some cases</li> </ul>	<ul style="list-style-type: none"> <li>Net seller of approximately 1,000 to 3,000 allowances</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately 5% of regional scrubber builds and 8% of regional capacity changes</li> <li>Over-controls (relative to allocation for state) to sell allowances</li> </ul>
Wyoming	<ul style="list-style-type: none"> <li>Approximately \$60 million</li> <li>Has the single largest impact on the regional compliance cost</li> </ul>	<ul style="list-style-type: none"> <li>Under command-and-control provides most of the capacity growth for the region</li> <li>Accounts for 45% to 50% of regional capacity changes</li> <li>Compliance cost higher by approximately \$50 million if state opts out when other are trading than under the full command-and-control</li> </ul>	<ul style="list-style-type: none"> <li>Net buyer of approximately 20,000 allowances</li> <li>Single largest buyer of allowances</li> </ul>	<ul style="list-style-type: none"> <li>Avoids many of the high cost investment under command-and-control through trading</li> <li>Accounts for approximately 10% to 15% of regional scrubber builds and 10% of regional capacity changes</li> </ul>
Indian Tribes	<ul style="list-style-type: none"> <li>Navajo opting out may</li> </ul>	<ul style="list-style-type: none"> <li>Not enough sources to</li> </ul>	<ul style="list-style-type: none"> <li>Net seller of approximately</li> </ul>	<ul style="list-style-type: none"> <li>Accounts for approximately</li> </ul>

State	If State/Tribe Opt-Out**		If State/Tribes Opt-In**	
	Potential Annual Impact on Regional Gains from Trading in 2018*	Compliance Response Under Command-and-Control (and others Trading)	Net Allowance Position	Compliance Response Under Trading
(includes sources located in Indian Tribes and Tribal Set-Aside Allowances)	increase cost by approximately \$1 million <ul style="list-style-type: none"> <li>• Tribal Set-Asides will be an important part of the compliance strategy in the trading program</li> </ul>	significantly affect regional compliance cost	20,000 allowances <ul style="list-style-type: none"> <li>• Single largest seller of allowances</li> </ul>	10% to 30% of regional scrubber builds and approximately 8% of regional capacity changes

Notes:

- \* Potential Annual Impact on Regional Gains from Trading in 2018 signifies additional compliance costs that the region may incur as a result of the state/tribe electing to opt-out of the trading. Negative implies that the compliance costs may decline.
- \*\* Impacts by state/tribe are not additive across states/tribes; when two or more states/tribes opt-out the overall impact may be different than the sum of the individual state impacts.

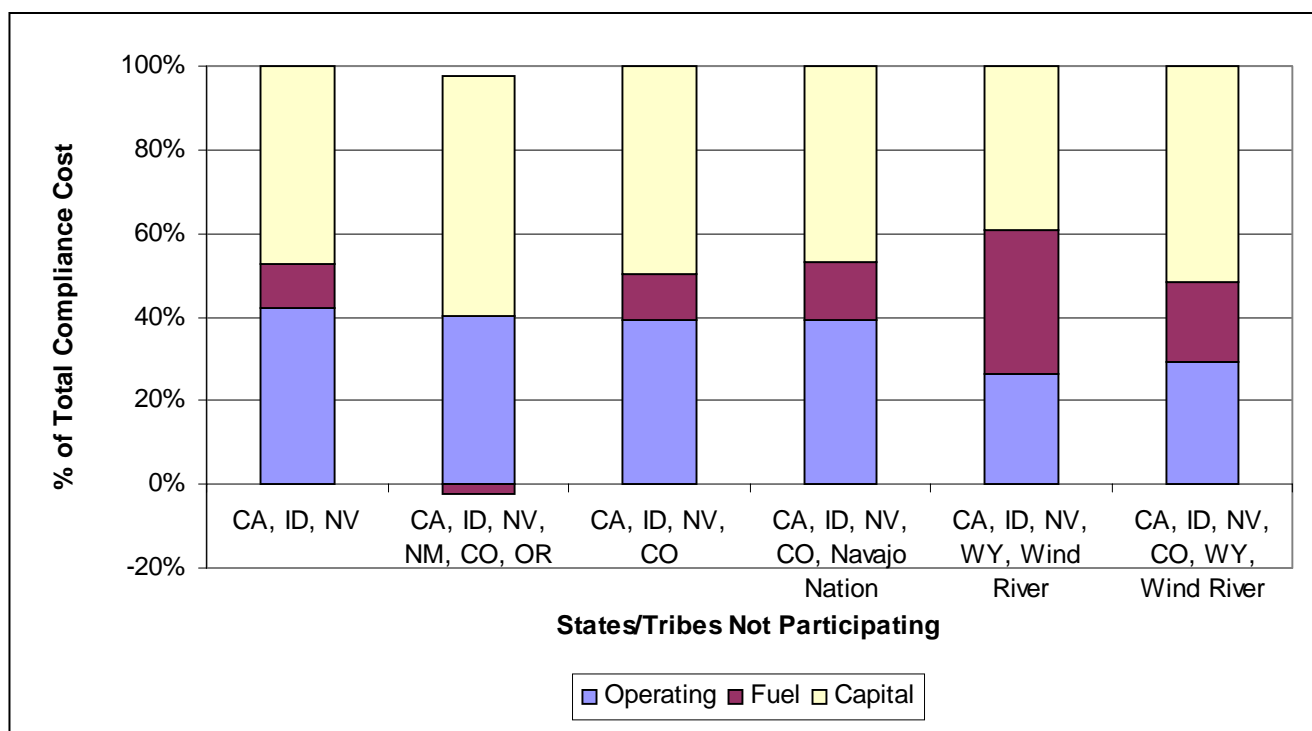
## V. Changes in the Regional Electric System Under the Alternative Trading Scenarios

The discussion in the remaining sections details underlying changes in compliance cost, electrical capacity/generation and scrubber installation that are projected to occur under the alternative trading scenarios. The purpose of this section is to provide additional details of the broader results that have already been discussed in the preceding sections.

### V.1 Compliance Cost

The composition of compliance costs helps to illustrate how compliance behavior differs under the six alternative trading scenarios. Under the command-and-control scenario, capital costs, which include investments in new generation capacity and pollution control equipment, are the most dominant compliance cost, whereas changes in fuel costs are the most significant component of the alternative trading scenarios. Under the alternative trading scenarios capital cost account for 40% to 60% of the regional compliance cost. Incremental expenditures for fuel account for 2% to 35% of the regional compliance cost, while 30% to 40% of the regional compliance cost is composed of incremental operating expenditures. Figure 5 below illustrates the relative share of capital, fuel and operating expenditures in compliance cost for each of the six alternative trading scenarios in 2018. State/tribal level details of the composition of compliance cost are described in Table A3 in the Appendix.

Figure 5: Composition of Compliance Cost Under Alternative Trading Scenarios in 2018



The results suggest that, in general, compliance actions taken under alternative trading scenarios are capital intensive. The capital intensity of the backstop trading program is largely the result of investments in pollution control and increases in new capacity, particularly coal,

which are more capital intensive than new gas capacity. As modeled in the analysis, new coal plants are relatively more attractive under command-and-control than under trading because new coal plants don't face as much emissions costs under command-and-control. Similarly, as modeled in the analysis, existing coal plants have no incentive for fuel adjustments under command-and-control because that regulation requires specific pollution control equipment independent of any fuel changes. The differences in composition of the compliance costs across the alternative scenarios, therefore, reflect how capital and fuel adjustments are valued by the affected sources in the program. In most cases, capital adjustments are the largest source of compliance in the regional trading program. When Wyoming opts-out, there is a significant increase in the fuel costs because of the increased use of gas generation through increased new cogeneration and reduced coal generation.

## V.2 Changes in Capacity and Generation

Although there are small changes to the mix of new capacity and generation under the alternative trading scenarios, the total electric capacity in the GCVTC region remains relatively unchanged. Small changes in total capacity and generation occur under different scenarios due to interactions with regions outside of the GCVTC region. The total changes in electric capacity represent less than half a percent of total capacity under the BAU scenario. Tables 6 and 7 below describe the regional net changes in electric capacity (MW) and generation (GWh) under the alternative trading scenarios relative to the BAU scenarios. State/tribal level details of the net changes in electric capacity and generation are described in Table A4 and Table A5 in the Appendix.

Table 6: Net Changes in Regional Electric Capacity (in MW) From Business-As-Usual by 2018 Under the Alternative Trading Scenarios

(in MW)	States/Tribes not Participating in the Trading Program					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
Coal	8	160	51	11	(205)	(12)
Gas	343	414	318	359	90	53
Cogeneration	(422)	(422)	(422)	(422)	292	292
Total	(71)	152	(53)	(52)	177	333

Table 7: Net Changes in Regional Electricity Generation (in GWh) From Business-As-Usual in 2018 Under the Alternative Trading Scenarios

(in GWh)	States/Tribes not Participating in the Trading Program					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
Coal	57	1,199	386	80	(1,532)	(91)
Gas	855	321	767	1,052	824	(475)
Cogeneration	(1,389)	(1,389)	(1,389)	(1,389)	1,106	1,106
Total	(477)	131	(236)	(257)	398	540

Net changes in electricity capacity and generation are mostly affected by the selection of new capacity. Across the alternative trading scenarios, there is a net increase in natural gas-fired capacity. The increase in natural gas capacity is a compliance strategy in response to the SO<sub>2</sub> reduction requirements of the trading program and substitutes for industrial boilers that would otherwise retrofit to cogeneration. Except for the scenario where Wyoming is assumed to opt-

out, the slight increase in regional coal capacity offsets the loss in coal capacity from scrubber installations. The increase in coal capacity reflects the fact that coal plants are more attractive under command-and-control than trading. To the extent that new plants can locate in states/tribes that opt-out, there may be a possibility for some expansion of coal capacity.

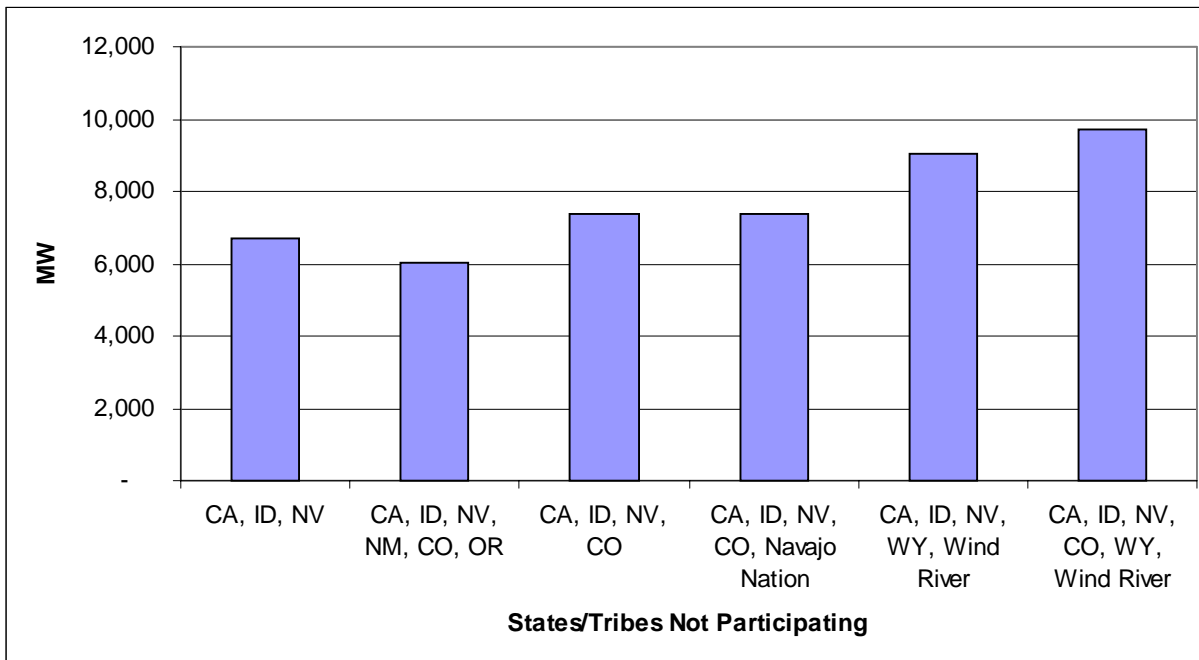
The increase in cogeneration capacity under the scenario where Wyoming is assumed to opt-out illustrates how regional markets affect the compliance behavior of sources in states/tribes that elect to opt-out. Under a trading program, affected industrial sources in Wyoming would prefer to install a scrubber, avoid the investment in cogeneration and offset part of the expenditures through the allowance markets. When Wyoming opts out, these sources cannot utilize the allowance markets and consequently re-power to cogeneration in order to utilize the energy markets to offset their compliance investments. The growth in cogeneration capacity in Wyoming reduces the need for capacity in other parts of the region since Wyoming supplies to meet some of the regional growth in power demand through the newly re-powered cogeneration facilities.

Although the changes in capacity and generation are indicative of what might have happened under the alternative trading scenarios, these impacts should be evaluated in the context of the magnitude of these changes. The changes in capacity and generation represent less than one half of one percent (0.5%) of total generating capacity in the 9 states and tribal region of the GCVTC. Consequently, an equally important implication of the results in capacity and generation is that the alternative trading programs will leave the mix of generation capacity relatively unchanged.

### **V.3 Changes in Scrubber Installations**

Scrubber installations represent an important component of the overall compliance strategy under each of the alternative trading programs. Affected sources under command-and-control are required to install new scrubbers or enhance existing ones, while under the trading program affected sources may install new scrubbers if it is economic to do so, but may otherwise comply through fuel switching, re-powering or dispatch changes. Figure 6 below illustrates the scrubbers added relative to the BAU scenario. In each scenario, additional scrubbers are installed than projected under the BAU scenario. Scrubber capacity also includes any enhancements/upgrades to scrubber efficiency at existing facilities. State/tribal level details of scrubber capacity are described in Table A6 in the Appendix.

Figure 6: Scrubber Installations Under the Alternative Trading Programs by 2018



The scrubber installations illustrated in Figure 6 above represents both the level of required scrubbing in states/tribes under command-and-control (if they elect to opt-out) and the capacity selected for scrubbing under the trading program. Changes to scrubber capacity also include the upgrades of existing pollution control to achieve higher SO<sub>2</sub> removal efficiency. Across the alternative trading scenarios, scrubbers are installed at 20% to 30% of coal capacity in GCVTC region.

In general across the alternative trading scenarios, the change in scrubber capacity correlates to the production costs and the resulting gains from trading – the higher costs (or lower gains from trading) relate to increased levels of scrubbing. Higher cost scenarios, such as the one where Wyoming and Colorado are assumed to opt-out, require a greater use of scrubbers in meeting the required SO<sub>2</sub> reductions, since less allowance trading options are available and the states/tribes opting out have to install scrubbers as part of the SO<sub>2</sub> reduction reductions under the command-and-control.

## VI. Caveats and Uncertainties

### *Caveats*

The objective of this analysis was to assist policy makers in understanding the implications of states/tribes opting out of the regional backstop SO<sub>2</sub> trading program and was conducted using sound analytical techniques and peer-reviewed data. As with any analytical assessment though, the findings presented in this report should be understood and applied in the context of its analytical framework and recognizing the caveats and uncertainties underlying the results.

This analysis of critical mass has been focused around the regional gains from trading, which were estimated using compliance cost. In general, gains from trading, particularly related to the cost-efficiency of a trading program relative to a command-and-control program will depend on a variety of factors that have not been entered into the analysis. One of the most important of these factors is program administration and/or enforcement costs. To the extent that the administrative and/or the enforcement costs differ between the command-and-control and alternative trading programs, the gains from trading may be different from those estimated in this analysis. Furthermore, it is unclear whether the administration and/or enforcement costs would change between the alternative trading programs. To the extent that these costs change significantly between the alternative trading scenarios, it may alter the ordering of which states/tribes are most important to the trading program.

Just as administrative and enforcements costs limit the extent to which these results can be applied to the overall efficiency of the trading program, transactions costs also significantly influence the success of a trading program. This analysis was constructed under the assumption of perfectly competitive markets, under which transaction costs are either zero or negligible. The projections of net allowance position, the allowance price and compliance cost in general, assume that participants in the trading program will be able to freely trade their allowances. Significant allowance transaction costs may influence the outcome of the trading program. Although a whole host of market infrastructure issues can lead to transaction costs, some of the more easily identified problems may include difficulty in locating trading partners, market barriers and access to information.

Though compliance cost has been used widely throughout this report, it should be applied cautiously particularly in evaluating who bears the burden of those costs. State/tribal level compliance costs presented in this report does not imply that the electricity end user or some other entity in that state/tribe will have to bear the burden of those costs. It is important to recognize that compliance cost reflects the location of the sources and not how they are recovered or who ultimately bears the burden of those costs.

For instance, under the scenario where Wyoming is assumed to opt-out along with Wind River Reservation, California, Idaho and Nevada, the compliance cost in Wyoming is \$165 million. Though this compliance cost is based on expenditures that occur in Wyoming, it is not necessary that an electricity end user in Wyoming will bear the burden of those costs. One of reasons for the high compliance cost in Wyoming when it is assumed to opt-out is the investment in combined-heat-and-power that occurs in that state, which consequently displaces the need for new capacity in the rest of the region. Although the investment occurs in Wyoming, the cost of recovery will be spread over the entire region since the actions in Wyoming are part of the overall compliance strategy of the region.

Although the modeling results provide detailed estimates of the gains from trading, compliance cost, new capacity additions, generation and other results, it is important to recognize that the magnitude of these impacts are extremely small and therefore likely to have a relatively larger error bound. The highest compliance cost recorded in the analysis occurs under the full command-and-control and even there the compliance cost of \$210 million represents about 1 percent of total modeled production cost in the GCVTC region. Given that the results represent such a small share of total costs, the overall direction, trends and broad insights are more informative than the actual dollar cost estimates.

This analysis was conducted using the data, assumptions and analytical framework developed by the WRAP/MTF in 2000 for the economic analysis of regional trading program in support of the Annex. Those assumptions describe the electric system operation, technology cost and performance including pollution control equipment, fuel prices and economic conditions.<sup>13</sup> No further changes were made to any of these assumptions prior to this study.

The WRAP/MTF economic analysis slightly differs from the Annex in terms of projected baseline SO<sub>2</sub> emissions. Under the Annex the projected baseline in 2018 was estimated to be 643 thousand tons, while the WRAP/MTF economic analysis baseline projected using the IPM was estimated at 648 thousand tons. The variations in emission baselines were the result of differing assumptions on availability (or potential utilization) of existing capacity and new capacity growth.

Recognizing the differences in baselines, the milestones used in modeling each of the alternative trading scenarios were constructed using the percent reduction implied by the milestone rather than the actual milestone tonnage. This ensured that the alternative trading scenarios would capture the intended stringency of the program. Similarly, the approach used in estimating the net allowance position by state and tribe used the reductions implied by the state/tribal budget rather than actual tonnage of the budgets. The net allowance position compares the implied reduction of the budget to the reductions achieved under each of the alternative trading programs. These adjustments to modeling were necessary in order to account for the differences in baselines between the Annex and the WRAP/MTF economic analysis. Greater variations between the baselines occur at the state level because the distribution of emissions is affected by the methodology used to calculate the baseline. Therefore, there is greater potential for error when looking at results at the state level than would be found at the regional level.

### *Uncertainties*

The results of the analysis reflect the data and assumptions used in the study and any change to those data and/or assumptions will affect the outcome of the analysis. Since the results reflect the entire array of assumptions, it is difficult to narrowly define a small set of parameters or assumptions to which the results might be most sensitive. In general, the results of compliance cost will be sensitive to assumptions in the cost and performance of pollution control (i.e., scrubbers), fuel prices and the cost and performance characteristics of new units. In this particular analysis, since pollution control on existing units is a major component of the compliance strategy, the results may be sensitive to the assumption on pollution control costs.

One of the important uncertainties relates to the possibility of future air regulations. This study assumed no other air regulatory changes outside of the SO<sub>2</sub> program in GCVTC region, though

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<sup>13</sup> Ibid., MTF 2000.

all states affected by regional haze would be required to submit a SIP. In addition, under 309 states and tribes need to address BART for NO<sub>x</sub> and PM in 2008 and have the option of developing a similar trading program for these pollutants. Changes to air regulations outside of those assumed in this analysis would significantly affect the outcome of the results. A trading program for NO<sub>x</sub> and PM in the GCVTC region, for instance, may lead to higher gains from trading if there are some co-benefit opportunities between the pollutants. Similarly, changes in air regulations in regions outside of the GCVTC region may affect compliance behavior and gains from trading in the GCVTC region through interactions in electricity, fuel and national emissions markets.

Though any changes to the assumptions will affect the outcome of the analysis, the overall impact of the uncertainty on the results will depend on how the uncertainty affects different participants. If the uncertainty is focused around a parameter that affects all sources in the state/tribe equally, then the overall compliance cost may change but the ordering of which states/tribe are important to the program will not change. For instance, if the assumption on the characteristics for scrubber control cost & performance is changed and all sources use similar scrubber types, then the regional compliance cost may change to reflect the new assumption. However, because the change in assumption affects all states/tribe more or less equally, it may not significantly affect the results in terms of the relative importance of each states/tribe to the trading program.

On the other hand, results of the relative importance of each state/tribe to the trading program may be significantly affected if the uncertainty is focused around a parameter or assumption that affects states/tribes differently. For instance, if assumptions on fuel prices are changed only for California, then the overall results on the relative importance of each state/tribe may be significantly affected since the sources in California have to make a decision under a climate that is very different from the sources in other parts of the region.

While the results of the analysis should always be evaluated recognizing the inherent uncertainty in the underlying data and assumptions, it should be noted that global uncertainties (parameters that are likely to affect all sources equally) might not significantly alter the results on the relative importance of each state/tribe. On the other hand, uncertainty on source specific parameters may have a larger impact on the relative importance of each state/tribe.

## **VII. Conclusions**

The purpose of this analysis was to develop insights on critical mass that would provide state and tribal decision makers with relevant information that might help guide their opt-in/opt-out decision. Modeling was conducted using six alternative trading scenarios. Outputs of the model included SO<sub>2</sub> emissions, compliance costs, allowance prices, net allowance position and electric system changes. Changes in compliance costs were used to quantify the gains from trading, while state/tribal level emission reductions relative to their respective budgets were used to estimate the net allowance position of each state and tribe.

A trading program with all states/tribes participating in the trading program would be the most efficient method of achieving the required SO<sub>2</sub> reductions. The regional gains from trading under the full trading scenario are expected to be around \$90 million in 2018. The potential regional gains trading of \$90 million would be eroded if different states/tribe opt-out of the trading. Wyoming appears to be most important state to the trading program in terms of its impact on the gains from trading. The results suggested that when Wyoming was assumed to

opt-out, the regional gains from trading could decline to \$20 million in 2018. Colorado may also be important to the trading program because when Colorado is assumed to opt-out, the regional gains from trading could decline to \$60 million in 2018. In general, states/tribes that have high compliance cost under command-and-control (i.e. Wyoming, Colorado, Arizona) may provide the greatest potential for regional gains from trading if they participate in the trading program. Other states/tribes that have relatively smaller compliance cost under command-and-control, may be less important to the trading program because their relative impact on regional compliance cost is likely to be small.

Approximately 10% to 20% of the allowances could be traded in net across states/tribes under the alternative trading scenarios. Tribes are projected to be the most important net seller of allowances. New Mexico and Utah will also be net sellers of allowances but will have far less allowances to sell than Indian tribes. Wyoming and Arizona are likely to be the largest net buyers of allowances, while Oregon and Colorado will be less dominant net buyers of allowances. The trading program will be important to Colorado but sources in Colorado will be less dependent on the external (out-of-state) partners for allowance trading.

## Appendix

Table A1. Emission Milestones for Alternative Trading Scenarios

Table A1.1 Emissions Milestones for Alternative Trading Scenarios in 2013 (Tons)

States/Tribes	Business as Usual	Full Trading	States/Tribes Not Participating in the Trading Program					
			CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ		122,599	122,599	122,599	122,599	122,599	122,599	122,599
NM		96,083	96,083	-	96,083	96,083	96,083	96,083
UT		39,436	39,436	39,436	39,436	39,436	39,436	39,436
CO		88,294	88,294	-	-	-	88,294	-
OR		21,757	21,757	-	21,757	21,757	21,757	21,757
WY		142,025	142,025	142,025	142,025	142,025	-	-
Shoshon	No Regional SO <sub>2</sub> Program	4,994	4,994	4,994	4,994	4,994	4,994	4,994
Navajo Nation		51,266	51,266	51,266	51,266	-	51,266	51,266
Uintah Ouray Reservation		1,135	1,135	1,135	1,135	1,135	1,135	1,135
Wind River Reservation		1,384	1,384	1,384	1,384	1,384	-	-
CA		25,959	-	-	-	-	-	-
NV		19,221	-	-	-	-	-	-
ID		12,506	-	-	-	-	-	-
Tribal Set Aside		20,000	20,000	20,000	20,000	20,000	20,000	20,000
Regional Trading Cap		646,660	588,973	382,839	500,678	449,413	445,564	357,270

Table A1.2 Emissions Milestones for Alternative Trading Scenarios in 2018 (Tons)

States/Tribes	Business as Usual	Full Trading	States/Tribes Not Participating in the Trading Program					
			CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ		94,903	94,903	94,903	94,903	94,903	94,903	94,903
NM		87,401	87,401	-	87,401	87,401	87,401	87,401
UT		30,746	30,746	30,746	30,746	30,746	30,746	30,746
CO		57,675	57,675	-	-	-	57,675	-
OR		8,281	8,281	-	8,281	8,281	8,281	8,281
WY		97,758	97,758	97,758	97,758	97,758	-	-
Shoshon	No Regional SO <sub>2</sub> Program	4,994	4,994	4,994	4,994	4,994	4,994	4,994
Navajo Nation		44,772	44,772	44,772	44,772	-	44,772	44,772
Uintah Ouray Reservation		1,135	1,135	1,135	1,135	1,135	1,135	1,135
Wind River Reservation		1,384	1,384	1,384	1,384	1,384	-	-
CA		25,959	-	-	-	-	-	-
NV		19,221	-	-	-	-	-	-
ID		12,506	-	-	-	-	-	-
Tribal Set Aside		20,000	20,000	20,000	20,000	20,000	20,000	20,000
Regional Trading Cap		506,736	449,049	295,692	391,374	346,602	349,907	292,232

Table A2. Annual Compliance cost by State Under the Alternative Trading Scenarios by 2018

Million 1997 \$	All Trading	All Command-and-Control	States/Tribes Not Participating in the Trading Program					
			CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	25	40	43	33	50	50	24	25
CA	(22)	(2)	(54)	(20)	(52)	(51)	(19)	(3)
CO	39	47	23	34	40	40	6	17
All Tribes	9	2	24	17	25	25	11	8
ID	1	0	(1)	(1)	(1)	(1)	(1)	(1)
NV	-	(6)	(23)	(24)	(22)	(22)	(27)	(29)
NM	10	5	16	11	15	15	8	7
OR	2	4	3	3	3	3	(1)	2
UT	16	12	20	10	21	21	10	8
WY	41	108	72	67	73	73	165	161
Total	121	210	123	130	152	153	176	195

Note: The distribution of compliance cost by state/tribe only reflects the location of sources and not how these costs are recovered or who ultimately bears the burden of those costs.

Table A3. Composition of Compliance Cost In 2018 Under the Alternative Trading Scenarios

Million 1997 \$	States/Tribes Not Participating in the Trading Program Changes in Capital Cost from Business-as-Usual					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	15	17	18	17	7	13
CA	(10)	(3)	(9)	(9)	(4)	-
CO	14	25	24	23	7	19
All Tribes	9	9	10	9	4	7
ID	(1)	(1)	(1)	(1)	(1)	(1)
NV	(4)	(2)	(3)	(3)	(5)	(4)
NM	8	6	8	8	5	6
OR	3	3	3	3	3	3
UT	6	5	7	6	2	4
WY	17	19	18	17	50	54
Total	57	78	75	70	68	101

Million 1997 \$	States/Tribes Not Participating in the Trading Program Changes in Fuel Cost from Business-as-Usual					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	17	7	20	21	9	3
CA	(40)	(16)	(39)	(38)	(13)	(3)
CO	(4)	(11)	(3)	(3)	(11)	(18)
All Tribes	12	7	12	12	7	1
ID	-	-	-	-	(1)	-
NV	(11)	(13)	(11)	(11)	(13)	(15)
NM	6	3	5	6	3	-
OR	(4)	(4)	(4)	(4)	(7)	(5)
UT	7	1	7	7	2	(2)
WY	30	23	30	31	84	76
Total	13	(3)	17	21	60	37

Million 1997 \$	States/Tribes Not Participating in the Trading Program Changes in Operating Cost from Business-as-Usual					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	11	10	12	12	8	9
CA	(4)	(1)	(4)	(4)	(1)	-
CO	12	18	19	19	9	16
All Tribes	4	3	4	4	1	2
ID	-	-	-	-	-	-
NV	(8)	(8)	(8)	(8)	(9)	(9)
NM	2	2	2	2	1	1
OR	4	4	4	4	3	4
UT	5	2	5	5	3	3
WY	25	25	25	25	31	31
Total	51	55	59	59	46	57

Note: The distribution of compliance cost by state/tribe only reflects the location of sources and not how these costs are recovered or who ultimately bears the burden of those costs.

Table A4. Net Changes in Electric Capacity by 2018 Under the Alternative Trading Scenarios

	States/Tribes not Participating in the Trading Program Changes in Coal Capacity (in MW) from Business as Usual by 2018					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	16	45	25	17	(19)	22
CA	-	-	-	-	-	-
CO	13	36	19	11	(20)	16
All Tribes	(36)	24	(29)	(35)	(60)	(31)
ID	-	-	-	-	-	-
NV	5	12	8	5	(4)	7
NM	(11)	(21)	(8)	(11)	(24)	(9)
OR	(3)	(3)	(3)	(3)	(3)	(3)
UT	9	25	14	10	(9)	12
WY	15	42	25	17	(66)	(26)
Total	8	160	51	11	(205)	(12)

	States/Tribes not Participating in the Trading Program Changes in Cogeneration Capacity (in MW) from Business as Usual by 2018					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	(25)	(25)	(25)	(25)	(25)	(25)
CA	-	-	-	-	-	-
CO	(194)	(194)	(194)	(194)	(194)	(194)
All Tribes	-	-	-	-	-	-
ID	-	-	-	-	-	-
NV	(148)	(148)	(148)	(148)	(147)	(147)
NM	-	-	-	-	-	-
OR	-	-	-	-	-	-
UT	(47)	(47)	(47)	(47)	(46)	(46)
WY	(8)	(8)	(8)	(8)	704	704
Total	(422)	(422)	(422)	(422)	292	292

	States/Tribes not Participating in the Trading Program Changes in Gas Capacity (in MW) from Business as Usual by 2018					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	155	123	146	155	64	23
CA	(353)	(129)	(333)	(334)	(156)	(15)
CO	148	117	139	147	61	22
All Tribes	107	85	100	106	44	16
ID	(4)	(4)	(4)	(4)	(5)	(4)
NV	41	33	39	41	18	7
NM	58	46	54	58	24	8
OR	(39)	(39)	(39)	(39)	(55)	(39)
UT	82	65	77	82	34	13
WY	148	117	139	147	61	22
Total	343	414	318	359	90	53

Table A5. Net Changes in Electricity Generation in 2018 Under the Alternative Trading Scenarios

	States/Tribes not Participating in the Trading Program Changes in Coal Generation (in GWh) from Business as Usual in 2018					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	119	335	191	125	(139)	166
CA	-	-	-	-	-	-
CO	92	270	141	80	(155)	117
All Tribes	(262)	177	(211)	(255)	(441)	(229)
ID	-	-	-	-	-	-
NV	39	95	59	42	(29)	52
NM	(87)	(156)	(60)	(83)	(183)	(69)
OR	(19)	(19)	(19)	(19)	(19)	(19)
UT	63	185	102	68	(75)	89
WY	112	312	183	122	(491)	(198)
Total	57	1,199	386	80	(1,532)	(91)

	States/Tribes not Participating in the Trading Program Changes in Cogeneration Generation (in GWh) from Business as Usual in 2018					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	(83)	(83)	(83)	(83)	(83)	(83)
CA	-	-	-	-	-	-
CO	(639)	(639)	(639)	(639)	(636)	(636)
All Tribes	-	-	-	-	-	-
ID	-	-	-	-	-	-
NV	(486)	(486)	(486)	(486)	(484)	(484)
NM	-	-	-	-	-	-
OR	-	-	-	-	-	-
UT	(153)	(153)	(153)	(153)	(152)	(152)
WY	(28)	(28)	(28)	(28)	2,461	2,461
Total	(1,389)	(1,389)	(1,389)	(1,389)	1,106	1,106

	States/Tribes not Participating in the Trading Program Changes in Gas Generation (in GWh) from Business as Usual in 2018					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	761	337	728	783	459	(1)
CA	(2,424)	(953)	(2,334)	(2,310)	(864)	(149)
CO	720	319	690	742	434	(1)
All Tribes	520	231	499	536	314	-
ID	(30)	(30)	(30)	(30)	(43)	(30)
NV	200	88	191	206	120	(1)
NM	280	125	242	262	142	-
OR	(292)	(292)	(292)	(292)	(413)	(292)
UT	400	177	383	413	241	-
WY	720	319	690	742	434	(1)
Total	855	321	767	1,052	824	(475)

Table A6. Scrubbed Capacity by 2018 Under the Alternative Trading Scenarios

	States/Tribes not Participating in the Trading Program Change in Scrubber Capacity (in MW) from Business as Usual					
	CA, ID, NV	CA, ID, NV, NM, CO, OR	CA, ID, NV, CO	CA, ID, NV, CO, Navajo Nation	CA, ID, NV, WY, Wind River	CA, ID, NV, CO, WY, Wind River
AZ	834	726	948	967	800	920
CA	-	-	-	-	-	-
CO	1,357	1,926	1,926	1,926	1,357	1,926
AllTribes	1,991	381	1,991	1,991	1,991	1,991
ID	-	-	-	-	-	-
NV	-	-	-	-	-	-
NM	781	1,575	781	781	781	781
OR	505	505	505	505	506	506
UT	423	129	423	423	423	423
WY	808	808	808	808	3,183	3,183
Total	6,699	6,050	7,382	7,401	9,041	9,730

Note: Changes in scrubber capacity also includes upgrades to any existing SO<sub>2</sub> removal efficiencies.