Historic and Future SO_2 Emissions Analysis - 9 State Western Region

James H. Wilson Jr., Manish Salhotra, Erica J. Laich
E.H. Pechan & Associates, Inc., 5528-B Hempstead Way, Springfield, VA 22151
jwilson@pechan.com

ABSTRACT

The Western Regional Air Partnership (WRAP) Market Trading Forum has worked diligently to advance discussions and reach consensus on the regional sulfur dioxide (SO_2) emission milestones and basic elements of backstop cap-and-trade program designed to assure that regional milestones are achieved. These components of the regional haze program need to be submitted to the U.S. Environmental Protection Agency in October 2000 by the WRAP, and will form the basis of regional haze and State and tribal implementation plan submittals by States and tribes wishing to comply with the requirements of the regional haze rule. This paper examines the historic (1990 to 1998) SO_2 emissions from non-utility point sources in the western region. The study area is comprised of the following States: Oregon, Idaho, Wyoming, California, Nevada, Utah, Colorado, Arizona, and New Mexico. The historic emissions analysis focuses on the sources with an SO_2 emissions change of 250 tons per year or more, between 1990 and 1998, which were investigated to determine the primary reasons for this emissions change. The second part of the analysis performed for this study is an SO_2 emissions projection. Using 1998 as a baseline, SO_2 emission projections were made to 2003, 2008, 2013, and 2018. These emission projections were made using growth factors, retirement rates, and new source control factors from the Grand Canyon Visibility Transport Commission Integrated Assessment System.

This paper provides examples of the types of regional cooperation on emission inventory development and application in a policy analysis framework that is a forerunner of the types of planning and execution that will need to take place in future years for regional haze planning and modeling.

INTRODUCTION

The Market Trading Forum (MTF) has been working diligently to advance discussions and reach consensus on the regional sulfur dioxide (SO_2) emission milestones and basic elements of backstop cap-and-trade program designed to assure that regional milestones are achieved. These components of the regional haze program need to be submitted to the U.S. Environmental Protection Agency (EPA) in October 2000 by the Western Regional Air Partnership (WRAP) in the form of an Annex to the Grand Canyon Visibility Transport Commission (GCVTC) report, and will form the basis of regional haze and State and tribal implementation plan (SIP and TIP) submittals by States and tribes wishing to comply with the requirements of the regional haze rule.

A majority of the MTF, in October 1999, agreed to a provisional 2018 milestone of 540,000 tons of SO_2 across the region based on the best information available at that time, and the understanding that the data and the emissions projections would be reviewed and trued-up. However, the latest estimates of year 2000 actual emissions have raised concerns among some stakeholders because the 2000 emissions appear to be well below previous expectations. Thus, some stakeholders now believe that the original milestone agreement no longer represents adequate further reductions to meet the requirements of the regional haze regulations. Other stakeholders maintain that the original agreement is sufficient in light of early reductions achieved in the region, as well as the forecasts and intentions of the GCVTC. In addition, EPA has raised concerns about the Best Available Retrofit Technology (BART) emission reduction estimate that was used by the MTF in the provisional 2018 milestone agreement. EPA recently provided an alternative BART range.

The analysis provided in this report examines the historic (1990 to 1998) SO_2 emissions from non-utility point sources in the western region. The study area is comprised of the following States:

Oregon, Idaho, Wyoming, California, Nevada, Utah, Colorado, Arizona, and New Mexico. The historic emissions analysis focuses on three years: 1990, 1996, and 1998. As part of this historic data analysis, all non-utility point sources with an SO_2 emissions change of 250 tons per year (tpy), or more, between 1990 and 1998 were investigated to determine the primary reasons for this emissions change.

The second part of the analysis performed for this study is an SO_2 emissions projection. Using 1998 as a baseline, SO_2 emission projections were made to 2003, 2008, 2013, and 2018. These emission projections were made using growth factors, retirement rates, and new source control factors from the GCVTC Integrated Assessment System (IAS).

HISTORIC SO_2 EMISSIONS ANALYSIS

This section provides an analysis of the non-utility point source emissions in the nine western States during the period 1990 to 1998. The three primary years of focus are 1990, 1996, and 1998. The western States whose emissions were evaluated in this study include Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming.

The starting point for the analyses performed for this project was a Microsoft Excel file received from Pat Ryan on June 18, 2000 with the filename EMISSION.XLS. The information in the following columns was used directly:

1) State
2) State ID
3) County ID
4) Facility ID (Radian)
5) IAS Region
6) SIC
7) MTF Sector
8) Sector Description
9) Mike George Facility Name
10) Source Type
11) WRAP 1990 (SO_2 Emissions)
12) 1996 (SO_2 Emissions)

The 1998 SO_2 emission estimates were taken from one of two columns labeled *Mike George's WRAP-1099 file* or *Latimer*.

The decision rules used to select the appropriate 1998 SO_2 emission estimate were as follows:

1) If the *Source: Mike George's WRAP-1099 file* column had a numeric entry, it was used.
2) Otherwise, the emission estimate in the *Latimer* column was used.
3) The exception to the above was that the *Latimer* column was used in total for all Oregon, Utah, and Wyoming point sources.

Once this composite emissions data file was compiled, two columns were added to record information about the primary reasons for emissions changes that were observed from 1990 to 1998. Then, State air pollution control agencies were contacted for information about why SO_2 emission changes occurred from 1990 to 1998. This analysis focused on facilities whose SO_2 emissions changed by more than 250 tpy (up or down) over this period.

RACT/BACT/LAER Clearinghouse

The EPA RACT/BACT/LAER Clearinghouse (RBLC) was used to query for situations where SO_2 emissions were affected in the western States. RACT, BACT, and LAER are acronyms for different program requirements under the Clean Air Act.

1) RACT, or Reasonably Available Control Technology, is required on existing sources in areas that are not meeting national ambient air quality standards (i.e., nonattainment areas).

2) BACT, or Best Available Control Technology, is required on major new or modified sources in clean areas (i.e., attainment areas).
3) LAER, or Lowest Achievable Emission Rate, is required on major new or modified sources in nonattainment areas.

However, data in the Clearinghouse is not limited to just sources subject to these requirements. Noteworthy prevention and control technology decisions are included in the RBLC even if they are not related to RACT, BACT, or LAER decisions.

This data base did not identify situations where SO_2 emissions in the western States were influenced by emission limits. Queries were run for SO_2 for each of the three EPA regions with States in the study area (Regions VIII, IX, and X). Searches were limited to RBLC determinations added during or after January 1990. No facilities matched the search criteria for Region X. Only one facility matched the criteria for Region VIII. This was a cogeneration plant with NO_x controls specified in the RBLC, but no SO_x control. The Region IX query generated a list of about 30 facilities in California (one in Arizona), but all were minor sources of SO_2 that did not appear in the 9-State emissions data set.

Smelters

Table 1 lists the 9-State smelter emissions for 1990, 1996, and 1998. This information is unchanged from that received from the WRAP Data Working Group. Note that this table includes both smelters and mines. The largest plant level emissions change results from the plant modernization that occurred at the Kennecott smelter in Utah during the mid-1990s. The Asarco Hayden smelter in Arizona had a 31 day major shutdown in March/April 1998. During this shutdown, the flash furnace was rebuilt and the existing gas handling system was replaced. During the third quarter of 1999, Phelps Dodge temporarily closed its Hidalgo smelter in New Mexico and the smaller of its two concentrators at its Morenci, Arizona mining complex. The production curtailment will result in an average reduction of approximately 150 million pounds of total annual copper production, but allows the company to retain its ability to smelt substantially all of its copper concentrates internally at its Chino smelter in New Mexico, and continue to produce most of the acid consumed by its mining operations.

Non-Smelters

Table 2 summaries the 1990 to 1998 SO_2 emissions for the non-smelters. This table shows that 1996 non-smelter SO_2 emissions declined by 11 percent from 1990 levels. Non-smelter SO_2 emissions remained stable from 1996 to 1998. The major factors in the SO_2 emission changes by State are described below:

1) Arizona – reductions in SO_2 from 1990 to 1998 in this State are primarily attributable to the process changes at Stone Container, now Abitibi.
2) California – Observed changes in SO_2 emissions in this State during the 1990s are a combination of factors, including fuel switching, oil and gas industry production changes, and refinery crude quality.
3) Colorado – sulfur emissions are relatively constant over the time period 1990 to 1998.
4) Idaho – Emission changes are produced by production variations during the 1990s. Note that the 1990 emission estimates for this State are from the 1985 National Acid Precipitation Assessment Program (NAPAP) inventory, so they are not 1990 emissions estimates.
5) New Mexico – Emissions during 1990 are dominated by gas plants. Changes to previous SO_2 emission estimates that were provided by the New Mexico Bureau of Air Quality were mostly changing potential to emit values to actual emissions.
6) Nevada – There are a small number of non-utility facilities in Nevada. Note that not all 1996 emission estimates were corroborated by the State, or the Clark County Health District, so 1996 emission estimates shown may not be actual values.

7) Oregon – Emissions in this State are dominated by the pulp and paper industry. In addition, Reynolds Metals has some significant production variations during the 1990s that affect Statewide emission trends, as well.

8) Utah – Most of the SO_2 emission reductions in Utah resulted from controls required by the PM_{10} SIP for the Salt Lake City nonattainment area.

9) Wyoming – Emission changes in this State were affected mostly by new well field drilling programs during 1996 and 1998.

Changes in emissions that have occurred over this period were classified into six categories: (1) market-driven production changes, (2) plant closures, (3) process changes, (4) fuel switching, (5) controls in response to air pollution control regulations, and (6) emission estimation method changes.

Table 3 summarizes the emission changes that have been estimated to occur over this period according to the primary reason for the emission change. This analysis was based primarily on information provided by State and local air pollution control agency staff about facility SO_2 emissions that changed by more than 250 tons per year over this period. Smelter emissions changes are not included in this table. Table 3 shows that the more than one-half of the observed emission change from 1990 to 1998 from this sector was in response to air pollution control emission regulations. However, most of the 22 thousand ton emission reduction occurred at sources in Utah, so the reduction was not evenly spread over the western State region. The reductions observed in Utah were in PM_{10} nonattainment areas.

Other significant factors affecting SO_2 emissions from non-smelter point sources in the region included market-drive production changes (these increased regional SO_2 emissions), process changes, and emission estimation method changes. Note that emission estimation method changes are artificial, rather than real reductions in SO_2. In addition, there are instances where more than one of these factors influenced facility-level emission changes. Only the primary factor is represented in Table 3 (one was selected for each facility).

SO_2 EMISSION PROJECTIONS

This section presents the smelter and other non-utility sector source SO_2 emission projections to 2018. For non-utilities, IAS methods were used to estimate potential emissions in 2003, 2008, 2013, and 2018. In short, this analysis takes the best estimates of 1998 SO_2 emissions at the facility-level, and applies IAS growth and retirement rates, and new source emission rates to establish a baseline future year forecast.

Projection Methods

Figure 1 summarizes the emission projection techniques used in this study for the non-smelters. The starting point for the emission projections is the facility-level SO_2 emission estimates described in Chapter II. Because the IAS Model is organized so that emissions are projected by IAS cell (a combination of IAS Region and source category (scc_id)), more detail about the individual source types within a plant is needed than is provided by a facility-level emission estimate. To solve this problem, the 1998 facility-level emissions were allocated to Source Classification Codes (SCC) using the SO_2 emission proportions from the 1990 GCVTC inventory[1]. Then, these SO_2 emissions by SCC were linked with IAS cells (region and scc_id). The IAS cells determine the growth factors, retirement rates, and new versus existing source control factors.

The growth factors, retirement rates, and new source control factors are too voluminous to display in this report. Readers interested in more detail about the projection methods are referred to the two reports prepared by Pechan during 1999 to document[2] and augment[3] the IAS model for the Western Governors' Association (WGA). There are also reports by Argonne and Decision Focus, Inc. from 1995 that provide the most detailed reporting of the IAS model development. These reports are all cited on the reference page of this report.

Note that all of the IAS model data bases that were used in this analysis were those received from Pat Ryan in June 2000. This version of the model should include all of the non-utility augmentations that were made in the Spring of 1999[3]. While modifications were being made to the utility sector modeling portion of IAS during 2000, those updates would not affect the non-utility modeling data bases.

The following equation illustrates the emission projection calculation that was performed for each of the projection y ears in this analysis.

Equation (1) $EM_{py} = EM_{by} \times (1 - RT_{py}) + NWCT \times EM_{by} \times (GF_{py} - (1 - RT_{py}))$

where

EM_{py}	=	Projection year emissions
EM_{by}	=	Base year emissions
RT_{py}	=	Percent retired in projection year
NWCT	=	Emission level for new sources (relative to existing)
GF_{py}	=	Growth factor for projection year

Essentially, the equation is simply: $EM_{py} = EM_{ex,py} + EM_{nw,py}$

where

$EM_{ex,py}$	=	Residual emissions from existing sources (base year minus retirements)
$EM_{nw,py}$	=	New source emissions due to growth and retirement, at the new source emission level

Projection Results

Table 4 presents the SO_2 emission projections for copper smelters for 2003 to 2018 that have been agreed upon by the Emissions Forum and the MTF. This projection assumes that copper smelter operations and emissions remain constant over the 20 year projection time horizon at near 1998 emission levels. Note that Kennecott Utah Copper Corporation SO_2 emissions listed in Table 4 only include the smelter emissions from that facility. Boiler emissions from this facility are included in the utility sector analysis.

Non-smelter SO_2 emission projection results for 2003, 2008, 2013, and 2018 are shown in Table 5 for each of the nine western States. For the nine State region, the IAS-based emission projections show that non-smelter emissions are expected to decrease from 162,100 tpy in 1998 to 140,760 tpy in 2018 – a 13 percent decline. Expected changes in any individual State are directly related to the industry types in that State, and IAS region-based growth factors for those industries. States with expected SO_2 emissions over the 20 year forecast period include Arizona, Colorado, and Nevada. Idaho's SO_2 emissions are expected to remain constant over the forecast period. States with expected SO_2 emission declines by 2018 include California, New Mexico, Oregon, Utah, and Wyoming.

Regional SO_2 emission projection results by MTF Sector are in Table 6, and provide some insight about how industry differences affect the results. Because the Oil and Gas Industry (MTF Sector 6) dominates the SO_2 emissions in this region, the SO_2 emissions for this sector are further broken down among Oil/Gas Production, Petroleum Refining, and Other. Table 6 shows that the expected declines in SO_2 emissions over the 20 year forecast horizon are largely attributable to the expected reductions from oil/gas production and refineries.

Table 7 shows the regional breakdown between existing source and new source emissions in the future year SO_2 emission projections. This information is provided to assist the MTF in making SO_2 emission allocations for new versus existing sources.

Table 8 presents an example SO_2 emissions projection to 2018 for a petroleum refinery using IAS-based methods. This example shows how the various SO_2 sources within the facility are treated in the 20 year projection. The IAS model uses source categories, listed as scc_id's in Table 8 to link emission sources with growth factors, retirement rates, and new source control levels. The scc_id *inpere* represents process sources at refineries. In this example, the refinery process sources are a blowdown system with vapor recovery and flaring, a fluid coking unit, and a fluid catalytic cracking unit. SO_2 emissions from these units are expected to decline substantially over the 20 year forecast period because the growth factor is 1.0 (no growth in activity/production), 42 percent of the existing production capacity is replaced with units that emit at new source emission rates, and this new source emission rate is 10 percent of the existing source rate. As a result, the *inpere* scc_id emissions in 2018 are about 40 percent lower in 2018 than they were in 1998.

This example facility also has an oil-fired industrial boiler, which is scc_id *inoibo* in Table 8. There is much less of an expected reduction in SO_2 emissions from oil-fired boilers in this IAS Region because the growth factor (1.25) indicates a 25 percent expected increase in activity, only 12 percent of the existing capacity is expected to retire over the 20 year period, and existing and new source SO_2 emission rates are the same.

The final two scc_ids in the Table 8 example represent a sulfur plant, and a sulfuric acid plant, respectively. These sources have a higher growth factor than the other sources at this refinery, retirement rates equal to those for refinery process sources, and new source control levels that represent 97.8 percent, and 70 percent control from existing source rates, respectively. The result is a slight downward SO_2 emission trend for these sulfur and acid plants.

RECOMMENDATIONS

If the IAS model is to continue to be used as a planning tool by the MTF, then it is recommended that a 2000 base year data base similar to the GCVTC emission inventory for 1990 be developed to establish a new baseline year. The most important component of this 2000 data base is having a regionally consistent point source emissions data base. Once a 2000 base year data set is available, then it is appropriate to update growth factors and retirement rates being used for the every ten year emission projections. This is important both to reflect the new base year, and to account for more recent information about regional growth expectations.

With the establishment of an SO2 emissions allowance market and a tracking system, it is recommended that steps be taken to eliminate the potential differences in SO_2 emissions associated with changing emission estimation methods. In the historic data analysis performed for this study, changes in emission estimation methods were responsible for over 6 thousand tons of the emissions difference between 1990 and 1998. While this amount is a small fraction of the total observed emissions difference in this period, it is still important. A standard stack test, or other confirming emissions measurement is needed. An EPA AP-42 emission factor application to estimate emissions should be insufficient for establishing base year SO_2 levels. On the other hand, requiring continuous emission monitoring is probably too much of an expense for facilities that have 100 to 1,000 tpy of SO_2 emissions.

REFERENCES

1. "An Emission Inventory for Assessing Regional Haze on the Colorado Plateau"; Prepared for the Grand Canyon Visibility Transport Commission by Radian Corporation. January 23, 1995.
2. "Grand Canyon Visibility Transport Commission Integrated Assessment System Documentation Summary"; Prepared for Western Governors Association by E.H. Pechan & Associates, Inc., Springfield, VA. 1999.
3. "Emissions Information Acquisition and Verification Task 2.2 - Other Point Source Costing"; Prepared for Western Governors Association by E.H. Pechan & Associates, Inc., Springfield, VA. 1999.

Table 1. Smelter SO_2 emissions summary.

State	Facility Name (1990)	SO_2 tpy 1990	SO_2 tpy 1996	SO_2 tpy 1998
Arizona	ASARCO SMELTER - HAYDEN	29,814	33,124	22,077
Arizona	BHP(Magma Metals)	15,900	16,678	10,409
Arizona	CYPRUS MIAMI MINE	5,676	5,737	6,097
Arizona	Cyprus Sierrita	800	548	<100
New Mexico	PHELPS DODGE/CHINO MINES	28,058	14,784	15,685
New Mexico	PHELPS DODGE/HIDALGO SMELTER	41,433	32,121	29,188
Utah	Kennecott Utah Copper Corp.	26,829	1,556	762
	Totals	**148,510**	**104,549**	**84,218**

Table 2. State-level non-smelter SO_2 emissions summary.

State	SO_2 tpy 1990	SO_2 tpy 1996	SO_2 tpy 1998
Arizona	8,989	3,138	4,150
California	35,973	37,366	36,640
Colorado	8,273	8,440	7,461
Idaho	24,350	22,806	22,299
Nevada	1,143	340	521
New Mexico	37,145	36,395	32,756
Oregon	8,360	4,202	6,716
Utah	26,592	7,646	6,418
Wyoming	32,326	42,292	45,134
Totals	**183,151**	**162,625**	**162,095**

Table 3. Reasons for 1990 to 1998 SO_2 emissions changes.

Primary Reason for Emission Change	1990 to 1998 SO_2 Emissions Change (tpy)
Market driven production changes	(8,114)
Plant shutdowns	4,336
Process changes	12,755
Fuel switch	1,923
Controls in response to air regulations	22,544
Emission estimation method change	4,773
Total	**38,217**

Table 4. Copper smelter SO_2 emission projections (tpy).

State	Facility Name	2003	2008	2013	2018
Arizona	ASARCO Smelter-Hayden	23,000	23,000	23,000	23,000
Arizona	BHP-San Manuel	16,000	16,000	16,000	16,000
Arizona	CYPRUS MIAMI MINE	8,000	8,000	8,000	8,000
New Mexico	PHELPS DODGE-CHINO MINES	16,000	16,000	16,000	16,000
New Mexico	PHELPS DODGE-HIDALGO SMELTER	22,000	22,000	22,000	22,000
Utah	Kennecott Utah Copper Corp.	1,000	1,000	1,000	1,000
Total Copper Smelter		**86,000**	**86,000**	**86,000**	**86,000**

Table 5. Non-smelter SO_2 emission projections by State (tpy).

State	**1998**	**2003**	**2008**	**2013**	**2018**
Arizona	4,150	4,508	4,977	5,266	5,695
California	36,641	34,926	33,037	31,131	29,237
Colorado	7,461	7,492	7,586	7,555	7,621
Idaho	22,300	22,346	22,441	22,298	22,342
Nevada	521	591	656	723	789
New Mexico	32,755	30,319	27,882	25,443	23,006
Oregon	6,716	6,690	6,630	6,512	6,439
Utah	6,418	6,278	6,145	5,989	5,851
Wyoming	45,135	43,808	42,484	41,118	39,784
Totals	**162,100**	**156,960**	**151,840**	**146,030**	**140,760**

Table 6. Non-smelter SO_2 emission projections (tpy) - MTF sector.

	1998	**2003**	**2008**	**2013**	**2018**
1 Electricity	553	550	547	544	541
3 Wood/Paper/Pulp	9,321	9,443	9,603	9,598	9,722
4 Cement/Concrete	7,699	8,423	9,152	9,747	10,447
5 Chemicals/Plastic	20,185	20,211	20,287	20,147	20,176
6 Oil/Gas					
SIC 13 Oil/Gas Production	52,356	49,267	46,171	43,088	39,995
SIC 29 Refining	47,901	44,810	41,684	38,484	35,340
Other	376	362	347	333	318
7 Food	4,564	4,484	4,399	4,309	4,223
8 Glass	2,035	2,279	2,487	2,690	2,897
9 Miscellaneous	2,679	2,644	2,610	2,567	2,531
10 Metals/Mining/Minerals	14,428	14,485	14,551	14,526	14,573
Totals	**162,100**	**156,960**	**151,840**	**146,030**	**140,760**

Table 7. Non-smelter regional SO_2 emission projections - existing versus new source components.

	2003	**2008**	**2013**	**2018**
Sources Existing in 1998	150,216	138,333	126,448	114,564
New Sources	6,744	13,504	19,587	26,200
Totals	**156,960**	**151,840**	**146,030**	**140,760**

Table 8. Example calculation - refinery source.

SCC	**scc_id**	**1998 SO_2 tons**	**20 Year Growth Factor**	**20 Year Retirement Fraction**	**New Source Control Level**	**2018 SO_2 tons**
30600401	inpere	1,781	1.00	0.42	0.1	1,108
30601201	inpere	2,703	1.00	0.42	0.1	1,682
30600201	inpere	582	1.00	0.42	0.1	362
10200501	inoibo	190	1.25	0.12	1.0	134
30103202	ptesc2uc	44	1.45	0.42	0.022	27
30102306	ptsap2uc	116	1.45	0.42	0.3	94
Totals		**5,416**				**3,407**

Figure 1. Emission projection methods diagram.