

Review of WRAP Oil & Gas Phase II Emissions Inventory and Controls Analysis



WRAP Lessons Learned
Workshop

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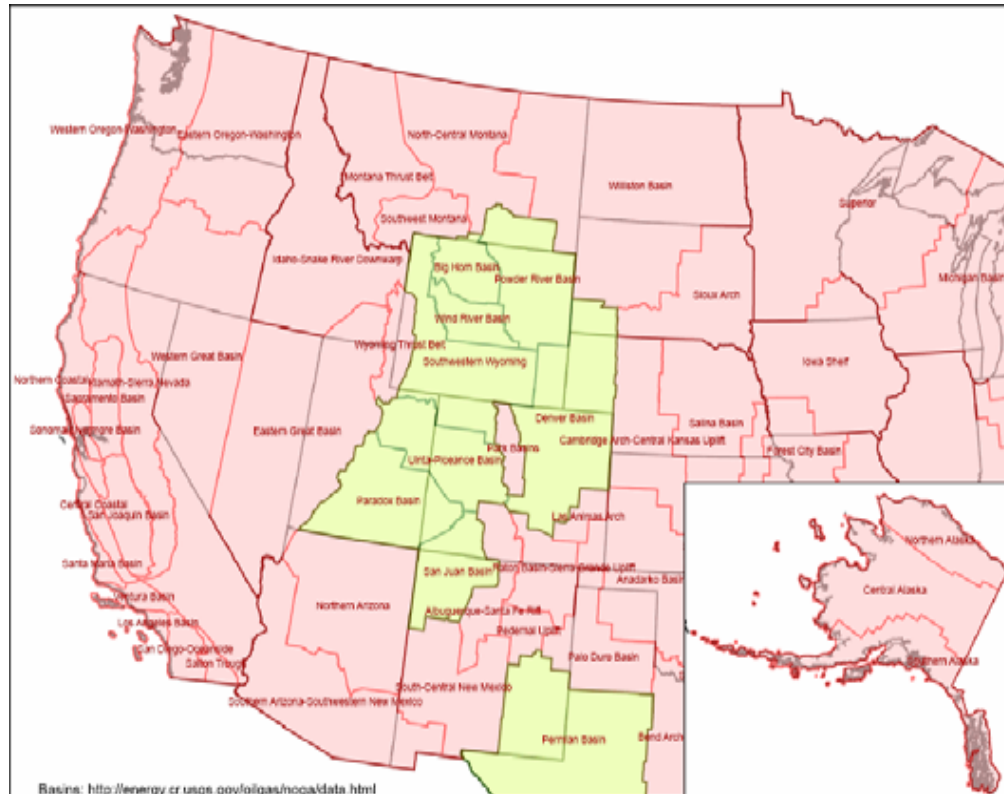
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WRAP Oil & Gas Phase II Project Overview

- Project was focused on developing an improved emissions inventory of oil and gas exploration and production area sources in the WRAP region
- Area source categories included compressor engines, drilling rigs, heaters and other wellhead equipment
- Previous emission inventory (EI) efforts:
 - WRAP Phase I analysis, 2002 and 2018 (completed 2005)
 - NMED EI for San Juan and Rio Arriba counties (completed 2006)
- Specific objectives of the Phase II project:
 - Emissions inventory improvements for 2002
 - Current base year updates for 2005
 - 2018 growth factor projections improvements
 - Control technology evaluations and control strategies scenarios
 - 2018 point source SO₂ emissions improvements

Western States Oil & Gas Regions of Interest



Major basins of O&G activity in Phase II analysis:

Permian Basin (NM)

San Juan Basin North (CO)

Denver-Julesburg Basin (CO)

Green River Basin (WY)

Big Horn Basin (WY and MT)

San Juan Basin South (NM)

Uinta-Piceance Basin (CO and UT)

Paradox Basin (UT)

Wind River Basin (WY)

Powder River Basin (WY and MT)

2002 and 2005 Emissions Inventory Improvements

- New methodology estimated 2002 emissions on a basin-wide average basis for all basins in the WRAP region, focusing on those basins where major O&G activities are occurring and detailed producer information is available
 - In basins where significant activity was not occurring, or producer information was unavailable, used Phase I estimates
- Data were collected from most major and some medium-sized and independent oil and gas companies operating in the WRAP region, in the form of a questionnaire
- Better region-specific data and assumptions were derived to improve geographic resolution of inventory, and several assumptions were revised to improve estimates of specific source categories
- 2005 emissions estimated by scaling 2002 county-level emissions on the basis of total well count in the county, or total production in the county (gas, oil and water) depending on the source category

2002 Emissions Inventory

Drilling Rig Emissions

- Improved estimate of actual drilling time by formation and basin from producer information on drilling times (rather than spud date and well completion date)
- Improved estimate of average drilling rig engine load by formation and basin
- Determined average horsepower requirements by formation and basin and identified most often used or representative makes/models of drilling rig engines
- Incorporated manufacturer's rated emissions factors for makes/models identified, or producers' emissions tests where available
- Incorporated SO₂ emissions factors (based on sulfur content of fuel)

2002 Emissions Inventory

Compressor Engine Emissions

- Determined for each basin either (a) the average percentage of wells with wellhead, lateral and central compression, or (b) percentage of total HP with wellhead, lateral or central compression
- Did not include central and lateral compressors that have been counted in a point source inventory for each state
- Determined for each basin a representative or most often used make/model of compressor, including HP and rated or tested emissions factors
- Determined for each basin an average load factor for wellhead/lateral compressors
- Basin-wide emissions estimate on the basis of total well count

Updated 2002 and 2005 Emissions

Drill Rig Emissions - TPY

	NOx		SOx	
	2002	2005	2002	2005
Alaska	877	835	66	62
Arizona	0	0	0	0
Colorado	2,803	8,000	118	350
Montana	1,046	3,007	225	640
Nevada	24	37	1	1
New Mexico	5,476	8,640	244	362
North Dakota	1,536	3,055	358	688
Oregon	0	0	0	0
South Dakota	29	203	6	43
Utah	334	2,888	17	149
Wyoming	4,997	15,783	150	541
WRAP Total	17,123	42,448	1,185	2,835

Updated 2002 and 2005 Emissions Compressor Engine Emissions - TPY

	NOx		SOx	
	2002	2005	2002	2005
Alaska	0	0	0	0
Arizona	8	6	0	0
Colorado	3,271	3,302	0	0
Montana	1,791	2,267	0	0
Nevada	33	33	0	0
New Mexico	35,140	35,345	1	1
North Dakota	2,920	2,799	0	0
Oregon	73	51	0	0
South Dakota	284	305	0	0
Utah	843	996	0	0
Wyoming	1,791	3,288	0	0
WRAP Total	46,154	48,393	1	1

Note: Emissions estimates include data from previous work for the NMED in the San Juan Basin and the Southern Ute inventory in Colorado. Other Colorado compressor emissions are assumed to be part of Colorado's point source inventory and are not included here.

2018 Emissions

- Emissions estimated for county-level emissions in WRAP region for:
NO_x, SO₂, VOC, CO
- Emissions included updated growth projections from Resource Management Plans, Alaska Oil & Gas Report, and National Energy Forecast released by the Energy Information Administration (EIA)
- Projected emissions to 2018 using 2005 base case and growth factors
- State controls evaluated:
 - Wyoming BACT requirements for permitted sources
 - Colorado controls requirements for point sources (ERG)
 - Utah BACT requirements for compressors
- Federal controls evaluated:
 - Federal nonroad engine standards
 - EPA nonroad diesel fuel sulfur content standards

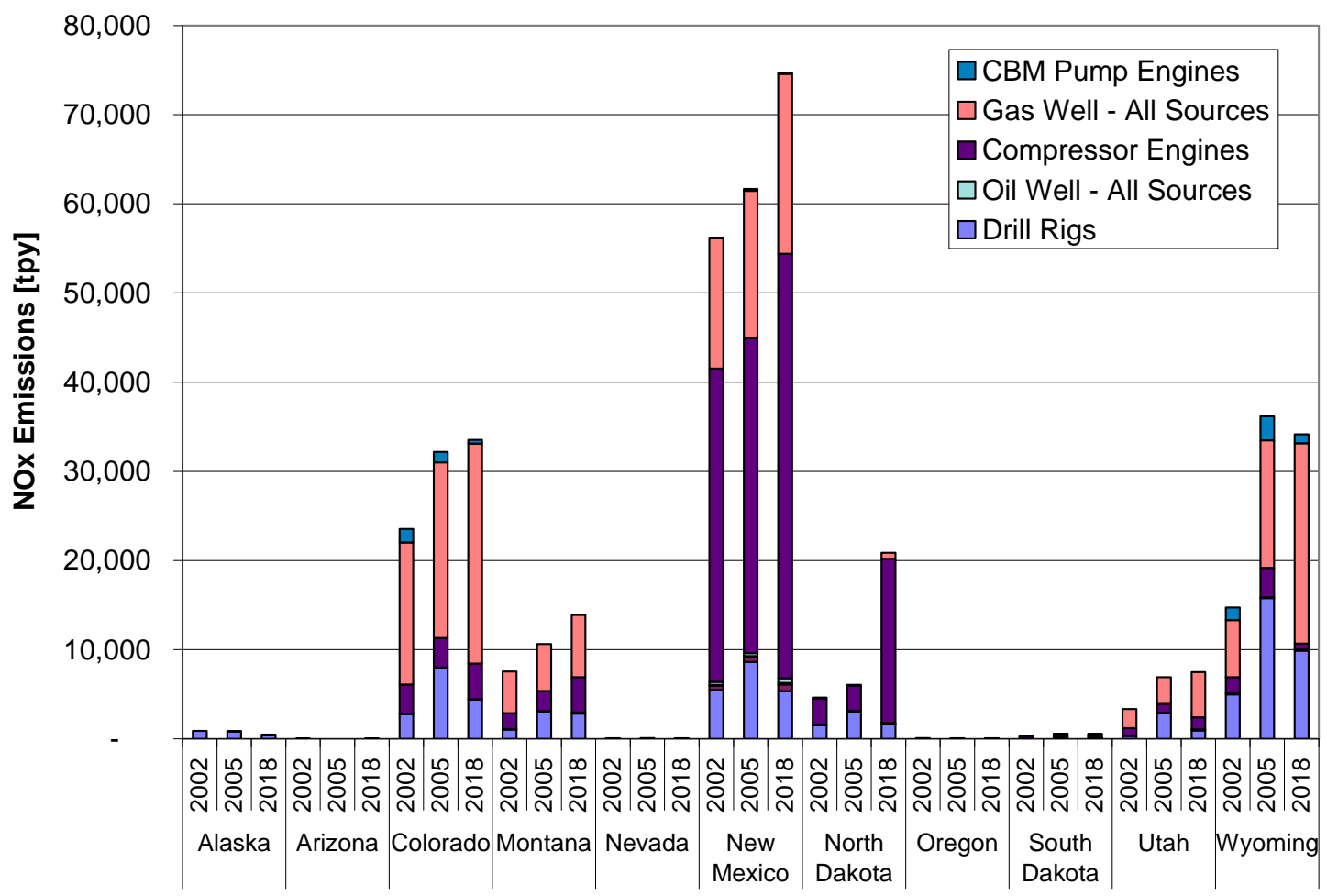
2018 NOx Emissions Projections

All O&G Sources

States	Drill Rigs	Oil Well –All Sources	Compressor Engines	Gas Well – All Sources	CBM Pump Engines	All Area Sources	All Point Sources	TOTAL
Alaska	452	0		0		453	36,382	36,835
Arizona		0	8	7		15	382	397
California							10109	10,109
Colorado*	4,413	12	4,006	24,687	400	33,517	14,825	48,342
Idaho							1,734	1,734
Montana	2,821	126	3,946	6,987		13,880	2,533	16,413
Nevada	21	2	40	0		63	47	110
New Mexico	5,343	522	47,599	20,183	67	73,714	36,320	110,034
North Dakota	1,655	126	18,399	689		20,869	3,928	24,797
Oregon		0	37	7		44	753	797
South Dakota	118	6	368	66		557	311	868
Utah	944	122	164	5,066		6,297	1,930	8,227
Washington							247	247
Wyoming	9,883	147	655	22,449	1,008	34,142	9,075	43,217
WRAP Total	25,652	1,063	75,222	80,140	1,475	183,551	118,576	302,127

*Note: Colorado 2018 emissions projections for compressor engines are applied only to the Southern Ute inventory. All other compressor emissions are assumed to be part of Colorado's point source inventory and are not included here.

NOx area source emissions estimates 2002, 2005, and 2018



2018 Point Source SO₂ Emissions

- Revised Pechan report on 2018 SO₂ emissions projections to incorporate ENVIRON projection methodology and producers' information on growth forecasts and emissions controls
- Identified major SO₂ point source emissions sources in each state of interest
- Obtained producer information on control strategy effectiveness, implementation rate, timetable and growth trends from 2002 – 2005 as well as for 2018 based on production forecasts
- Conducted review of Title V Permits to determine emissions with and without control technologies
- Revised estimates of 2018 emissions

State	Number of Plants	Previous 2018 SO₂ Emissions Estimate (tpy)	Revised 2018 SO₂ Emissions Estimate (tpy)
Wyoming	9	18,961	5,105
New Mexico	11	12,936	8,027

Controls Evaluated

- Developed a series of white papers on control technologies for drill rigs and compressors and some VOC sources
- White papers include only those technologies deemed technically feasible now
- List of control technologies includes:
 - Engine modifications (e.g., lean-burn engines, ignition timing)
 - Aftertreatment control devices (e.g., catalysts, exhaust gas recirculation)
 - Engine replacement/repowering
 - VOC controls (e.g., dehydrators, pneumatics)

White Papers

- Control effectiveness
- Capital and Operating Cost
- Potential emissions reduction
 - Based on applying control effectiveness to specific engine types and activity identified in the emissions inventory tasks
- Cost-effectiveness (\$/ton)
 - Evaluated using potential emissions reduction and costs and provided as a range over the WRAP region

Summary of Emissions Reductions and Cost-Effectiveness: Drill Rigs

Measure No.	Control Measure Name	Control Efficiency %	NOx Reduction [tpy]	Cost-Effectiveness [\$ /ton]
DRE-1	ITR	15 to 30	6.6 to 17.2	1,000 to 2,200
DRE-2	SCR	80 to 95	25.8 to 66.8	3,000 to 7,700
DRE-3	EGR	40	11.8 to 30.6	800 to 2,000
DRE-7	LNC	10 to 20	4.4 to 11.5	1,400 to 3,400
DRE-8	Low S Diesel	14	TBD	TBD
DRE-8	NG	85 to 91	TBD	TBD
DRE-8	Emulsified Diesel	20	5.9 to 15.3	4,500 to 11,600
DRE-9	Tier 2 to Tier 4 Replacement	43 to 93	7.8 to 33.6	900 to 2,400
DRE-9	Tier 3 to Tier 4 Replacement	43 to 89	4.7 to 20.1	900 to 2,000

NSCR - Non-selective catalytic reduction AFR - Air Fuel Ratio Control, ITR - Ignition Timing Retard, PSC - Prestratified Charge, L-E - Low Emission Engine, SCR - Selective Catalytic Reduction, EGR - Exhaust Gas Recirculation, CEC - Crankcase Emission Control, DPF - Diesel Particulate Filter, DOC - Diesel

Oxidation Catalyst, LNC - Lean NOx Catalyst, NG - Natural Gas, VRU – Vapor Recovery Unit

Summary of Emissions Reductions and Cost-Effectiveness: Compressor Engines

Measure No.	Control Measure Name	Control Efficiency %	NOx Reduction [tpy]	Cost-Effectiveness [\$ /ton]
CE-1	NSCR	90 to 98	1.0 to 45.3	200 to 7,900
CE-2	AFR	10 to 40	0.3 to 12.1	100 to 2,500
CE-3	ITR	15 to 30	0.3 to 10.8	100 to 1,200
CE-4	AFR + ITR	10 to 40	0.3 to 12.1	100 to 3,600
CE-5	PSC	80	0.9 to 38.5	100 to 3,000
CE-6	L-E	80	0.9 to 38.5	100 to 2,600
CE-7	SCR	80	0.9 to 38.5	900 to 31,000
CE-8	Replace Engine	60 to 100	0.9 to 38.5	100 to 4,700

NSCR - Non-selective catalytic reduction AFR - Air Fuel Ratio Control, ITR - Ignition Timing Retard, PSC - Prestratified Charge, L-E - Low Emission Engine, SCR - Selective Catalytic Reduction, EGR - Exhaust Gas Recirculation, CEC - Crankcase Emission Control, DPF - Diesel Particulate Filter, DOC -

Diesel Oxidation Catalyst, LNC - Lean NOx Catalyst, NG - Natural Gas, VRU – Vapor Recovery Unit

Future Work on Oil and Gas Emissions Inventory

- Independent Petroleum Association of the Mountain States (IPAMS) is considering funding a Phase III oil and gas inventory
- Phase III would be a collaboration between IPAMS, major oil and gas companies, WRAP and/or other state agencies to develop most comprehensive oil and gas emissions inventory to date
- Phase III inventory would improve estimates of all source categories from oil and gas operations and include all major criteria pollutants (NO_x, SO_x, VOC)
 - Engines (e.g. drilling rigs, compressors, CBM pumps)
 - VOC sources (e.g. pneumatic devices, flares, tank condensates)
- Phase III to proceed in three steps:
 1. Focus on Denver-Julesburg Basin in support of Colorado ozone SIP modeling as a pilot study
 2. Expand to include other major basins covered by IPAMS members
 3. Develop an annual reporting tool to facilitate future reporting