



2002 Emissions Inventory of Oil and Gas Sources

ENVIRON Presentation to the
WRAP Stationary Sources Joint Forum
Oil & Gas Work Group
May 5, 2005

Outline for Today's Presentation

- ⇒ Present the draft area source emissions estimate.
- ⇒ Describe methodology used to estimate area source emissions.
- ⇒ Steps necessary to complete the inventory of oil and gas sources.
- ⇒ Status of the inventory of oil and gas sources on Tribal lands.
- ⇒ Projections

2002 Oil & Gas Area Source Emissions

⇒ Sources covered

- Oil/Gas well drilling (NO_x) – drill rig prime movers
- Natural gas compressor engines (NO_x)
- Wellhead activities – (NO_x, VOC) dehydration, heaters, tanks, etc...
- Coal bed methane generators

2002 Draft Uncontrolled Area Source NOx Emissions

| State | Compressors | Drill Rigs | Wellhead | CBM Generators |
|-----------------------|-------------|------------|----------|----------------|
| | (tons) | | | |
| Alaska ¹ | - | 877 | 91 | - |
| Arizona | 7 | - | 9 | - |
| Colorado ² | - | 5,736 | 17,493 | 202 |
| Idaho | - | - | - | - |
| Montana | 2,015 | 1,044 | 4,337 | - |
| New Mexico | 40,382 | 6,653 | 13,845 | 36 |
| North Dakota | 1,393 | 1,536 | 101 | - |
| Nevada | 0 | 24 | 4 | - |
| Oregon | 19 | - | 12 | - |
| South Dakota | 254 | 36 | 44 | - |
| Utah | 6,675 | 676 | 2,127 | - |
| Washington | - | - | - | - |
| Wyoming | 40,345 | 4,991 | 6,409 | 814 |

¹State agencies indicate compressors and wellhead equipment will be found in point source inventory. Only drill rig and completion emissions are reported here as area sources.

²Compressors are included in point source inventory, i.e. there are no area source emissions.

Methodology

- ⇒ Drilling of oil and gas wells (draft complete)
- ⇒ Natural gas compressor engines (draft complete)
- ⇒ Wellhead activities (draft complete)
- ⇒ Coal bed methane generators (draft complete)

Drilling

- ⇒ Contacted drilling companies to request additional data (6 total)
- ⇒ Obtained drill permit data from Oil and Gas Commissions
- ⇒ Obtained emissions data for drill rigs from WYDEQ survey



Summary of Data Collected

- ⇒ Contacted drilling companies chose not to contribute data at this time
- ⇒ Pertinent oil and gas commissions' permit data
 - Well depth
 - Spud date – date drilling begins
 - Completion date – date well preparation is finalized; occurring with some delay after drilling ceases
- ⇒ WYDEQ survey of drilling emissions in Jonah-Pinedale

Revised Drilling Methodology

- ⇒ Have base activity data from permits
- ⇒ Lack a more sophisticated level of activity data
 - Equipment types
 - Load factor
 - Operational schedule
- ⇒ WYDEQ survey has this additional data

Utilizing Jonah-Pinedale Survey Data

⇒ Jonah-Pinedale survey emission factors

- 13.5 tons NO_x / well
- 3.3 tons SO₂ / well

⇒ Well drilling emissions dependent upon

- Depth of well
- Composition of substrate
- Drilling equipment

⇒ Need to scale emission factor to other areas using available data

- Well depth
- Approximation of drilling duration

Procedure Used to Scale J-P EFs

⇒ Assumptions

- Though the completion date does not equal the date drilling ceases, the difference between the two is on average constant relative to total duration of preparation activities
- The capacity of the equipment used to drill a well is dependent upon the depth of the well

⇒ Interpretation: Scaling the emission factor based on well depth and “duration” corrects for variations due to well depth, composition of substrate and engine capacity

Calculation for Scaling J-P EFs

- ⇒ Data shows that drilling activities within a single formation vary within a small range
- ⇒ A formation specific emission factor permits use of local data without suggesting accuracy for an individual well

$$EF_A = EF_J \times (D_A / D_J) \times (T_A / T_J)$$

where:

EF_A = The emission factor for another formation

EF_J = The Jonah-Pinedale emission factor

D_A = The average depth of wells drilled in another area

D_J = The average depth of wells drilled in Jonah-Pinedale

T_A = The duration of drilling in another area

T_J = The duration of drilling in Jonah-Pinedale

Calculation of Drilling Emissions

$$E = EF \times W$$

where:

E = The 2002 emission for a given formation

EF = The formation specific emission factor

W = The number of wells drilled in the formation in 2002.

- ⇒ Emissions calculated by formation as the product of the number of wells spudded in the formation in 2002 and the formation-specific emission factor
- ⇒ Formation emissions then allocated to counties

2002 Draft Drilling Emissions Estimates

| State | Wells Drilled | NOx (tons) | SO2 (tons) ¹ |
|--------------|---------------|------------|-------------------------|
| Alaska | 205 | 877 | 214 |
| Arizona | - | | |
| Colorado | 1,245 | 5,736 | 1,402 |
| Idaho | - | | |
| Montana | 463 | 1,044 | 255 |
| New Mexico | 935 | 6,653 | 1,626 |
| North Dakota | 157 | 1,536 | 375 |
| Nevada | 6 | 24 | 6 |
| Oregon | - | | |
| South Dakota | 7 | 36 | 9 |
| Utah | 126 | 676 | 165 |
| Washington | - | | |
| Wyoming | 2,959 | 4,991 | 1,220 |

¹SO2 emissions will be adjusted for varying fuel sulfur levels

Natural Gas Compressor Engines

- ⇒ Contacted compressor operators to request activity data
- ⇒ Obtained production data from oil and gas commissions
- ⇒ Reviewed existing inventories of compressor engines



Initial Data Gathering

- ⇒ Contacted compressor renters/owners but none was willing to provide data at this point
- ⇒ Reviewed other sources of data
 - Colorado's 2002 point source emission inventory (2004)
 - New Mexico Oil and Gas Association's (NMOGA) 2002 Inventory of Unpermitted Sources in the San Juan Basin (2003)
 - BLM Environmental Impact Statements
 - 2002 Inventory of East Texas Emissions (2005)

Revised Compressor Engine Methodology

- ⇒ Analyze existing inventory data to develop production based emission factor
- ⇒ Use 2002 gas production reported by oil and gas conservation commissions as activity

Colorado 2002 Emissions Inventory

- ⇒ Coverage: Inventoried sources down to 2 tpy of emissions.
- ⇒ Analysis: Extract small compressor engines from inventory and compare to county level gas production
- ⇒ Results inconclusive
 - Insufficient information to extract only compressor engines
 - Difficult to determine the fraction of emissions that would represent area source emissions in other states
 - Limited results suggest good correlation between engine emissions and gas production

NMOGA 2002 Emissions Inventory

- ⇒ Coverage: Obtained data representing activity at 10,582 of 17,108 wells in the San Juan Basin – New Mexico
- ⇒ Analysis: Extract emissions from compressors and compare to gas production for the same region
 - Total emissions for compressor engines = 23,934 tons
 - Total 2002 gas production for San Juan, Rio Arriba and Sandoval Counties = 1,030,453 MMCF
 - Obtained emission factor of 2.3×10^{-5} tons NO_x / MCF

BLM Environmental Impact Statements

- ⇒ Coverage: Powder River Basin EIS (2002) includes most detailed air quality impact analysis
 - Estimated production
 - Estimated equipment requirements as quantity of 380 hp compressors to be installed and assumption of their activity
- ⇒ Analysis: Combine equipment activity estimates with EPA emission factor to estimate emissions and relate projected emissions to projected production
- ⇒ Obtained emission factor of 4.4×10^{-4} tons NO_x/MCF
- ⇒ Difficulty: Projected equipment and production, not actual

East Texas 2002 Emission Inventory

- ⇒ Coverage: The Tyler/Longview/Marshall Flexible Attainment Region
- ⇒ Method of East Texas EI: Used survey of operators to develop production based emission factor
- ⇒ Emission factor: 5.6×10^{-5} tons NO_x / MCF
- ⇒ Survey data have been requested for verification and possible additional analysis

Summary of Available Compressor Emission Factors

| Source | Emission Factor (tons NO _x / MCF) | Advantages | Disadvantages |
|------------------|--|---|--|
| CO Inventory | Inconclusive | | |
| NMOGA Inventory | 2.3×10^{-5} | <ul style="list-style-type: none"> •Very good coverage/response •Important WRAP production area | |
| Powder River EIS | 4.4×10^{-4} | <ul style="list-style-type: none"> •Important area of growth | Projected, not actual equipment and production |
| East Texas EI | 5.6×10^{-5} | <ul style="list-style-type: none"> •Existing and locally accepted EF | |

Summary of Available Compressor Emission Factors

| Source | Emission Factor (tons NO _x / MCF) | Advantages | Disadvantages |
|--------------------|---|--|---------------|
| NMOGA Inventory | 2.3×10^{-5} | <ul style="list-style-type: none">•Very good coverage/response•Important WRAP production area | |
| East Texas EI | 5.6×10^{-5} | <ul style="list-style-type: none">•Existing and locally accepted EF | |

Method for Estimating Compressor Engine Emissions

- ⇒ Emission factor: 2.3×10^{-5} tons NO_x / MCF, derived from NMOGA inventory
- ⇒ Activity data: Gas production obtained from oil and gas commissions

Emission Calculation

$$E = P \times EF$$

Where:

E = 2002 NO_x emission

P = 2002 gas production (MCF)

EF = Emission factor, 2.3×10^{-5} tons NO_x / MCF

Exceptions to the Compressor Engine Methodology

- ⇒ Colorado – compressor engines are included in the State's point source emission inventory
- ⇒ Alaska – discussion with personnel of the Alaska OGCC and DEC determined that compressors of this kind would fall within permitted facilities

2002 Draft Uncontrolled Compressor Engine Emissions Estimates

| State | Gas Produced (MMCF) | NOx Emission (tons) |
|-----------------------|---------------------|---------------------|
| Alaska ¹ | 3,496,429 | |
| Arizona | 304 | 7 |
| Colorado ² | 1,242,775 | |
| Idaho | - | |
| Montana | 86,762 | 2,015 |
| New Mexico | 1,738,604 | 40,382 |
| North Dakota | 59,980 | 1,393 |
| Nevada | 6 | 0 |
| Oregon | 837 | 19 |
| South Dakota | 10,955 | 254 |
| Utah | 287,400 | 6,675 |
| Washington | - | |
| Wyoming | 1,736,994 | 40,345 |

¹State agencies indicate compressors will be found in point source inventory, i.e. there are no area source emissions

²Compressors are included in point source inventory, i.e. there are no area source emissions

CBM Generators

- ⇒ Contacted State DEQs to request permitted generator databases
- ⇒ Obtained information on CBM field electrical supply from OGCs
- ⇒ Obtained water production data for CBM wells from OGCs



Progressing cavity pump with generator (behind) used for dewatering a CBM well

Summary of Data Collected

⇒ Generator databases

- Wyoming database of diesel generators
 - Generator make, model, emission factor
 - Generator activity (hours per year)
- Wyoming list of permitted natural gas generators

⇒ Field power supply

- Fields electrified: Montana and Utah
- Generators used: Wyoming, Colorado and New Mexico

⇒ Pertinent OGC data

- Well depth
- Water produced

CBM Generator Methodology

- ⇒ Wyoming, Colorado and New Mexico wells use generators to power pumps
- ⇒ Only Wyoming DEQ was able to provide database of CBM generators
- ⇒ Derive relationship between water production and generator activity from WY data and apply to water production at CBM wells in CO and NM

Wyoming CBM Generators

- ⇒ Activity of diesels used to estimate activity of natural gas generators (ratio of “operated capacity”, see formula below)
- ⇒ State total diesel generator activity = 26.4 M hp-hrs
- ⇒ Estimated state total natural gas generator activity = 42.4 M hp-hrs

$$A_{g,c} = A_{d,c} \times \left(\frac{F_g \times \sum_i C_{g,i}}{F_d \times \sum_j C_{d,i}} \right)$$

Where:

$A_{g,c}$ = County activity (hp - hrs) of gas generators

$A_{d,c}$ = County activity (hp - hrs) of diesel generators

F_g = Load factor for gas generators (NONROAD)

F_d = Load factor for diesel generators (NONROAD)

$C_{g,i}$ = Capacity of gas generator i

$C_{d,j}$ = Capacity of diesel generator j

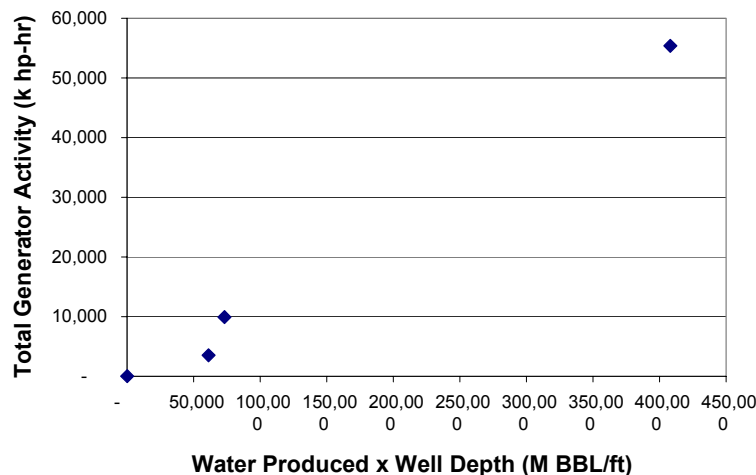
CBM Generator Activity

➔ Work performed by generators is related to:

- mass of water moved
- depth of well
- efficiency of pump

➔ Assumption: Reservoir pressure effect negligible

CBM Generator Activity & Water Production



$$A_p = \frac{\varepsilon_p}{\varepsilon_w} \times A_w \times \frac{\sum_i W_{p,i} \times D_{p,i}}{\sum_j W_{w,j} \times D_{w,j}}$$

Where :

A_p = Generator activity in area p

A_w = Generator activity in Wyoming

ε_p = Efficiency of pumps in area p

ε_w = Efficiency of pumps in Wyoming

$W_{w,j}$ = Water produced at well j in Wyoming

$D_{w,j}$ = Depth of well j in Wyoming

$W_{p,i}$ = Water produced at well i in area p

$D_{p,i}$ = Depth of well i in area p

2002 Draft CBM Generator Emissions Estimates

| State | Water Produced x Depth (M BBL-ft) | NOx Emission (tons) |
|--------------|--|--------------------------------|
| CO | 232,941 | 202 |
| NM | 38,703 | 36 |
| WY | 548,868 | 814 |

Wellhead Activities

- ⇒ Used emission factors developed by WYDEQ
- ⇒ Adjusted controls assumed in WYDEQ tanks emission factor for local conditions
- ⇒ Replaced WYDEQ factors when local factors provided
- ⇒ Obtained oil and gas production data from oil and gas commissions



WYDEQ Emission Factors

| Oil Wells | | Gas Wells | |
|-------------------|--|-------------------|------------------------------|
| Source | Emission Factor | Source | Emission Factor |
| Condensate Tanks | 3,271 lbs VOC per year / BPD | Heater | 0.005 lbs NOx per year / BPD |
| Dehydrator | 27,485 lbs per year / MMCFD | Pneumatic Devices | 0.1 tons VOC / well |
| Heater | 1,752.0 lbs NOx per year / well | Tanks | 160.0 lbs VOC per year / BPD |
| Completion | 86.0 tons VOC / well completion 1.75 tons NOx / well completion | | |
| Pneumatic Devices | 0.2 tons VOC per year / well | | |

Exceptions for Wellhead Emissions Calculations

- ⇒ Colorado Department of Health and Environment provided an emission factor for completion emissions, 16.664 ton VOC per completion
- ⇒ From discussion with the Alaska OGCC and DEC we determined that wellhead equipment of these types would not exist outside permitted facilities

Calculation of Wellhead Emissions

- ⇒ Divided production into that occurring at oil wells and that occurring at gas wells based on OGC data
- ⇒ Estimated emissions for oil wells based on production at oil wells and emissions at gas wells based on production at gas wells and WYDEQ emission factors for each well type

Calculation of Wellhead Emissions for Individual Wells

Gas Well

$$E = \text{SUM}_i(P_g \times EF_{g,i}) + \text{SUM}_j(P_c \times EF_{c,j}) + \text{SUM}(EF_w)$$

Where:

E = The 2002 emission

P_g = 2002 gas production

$EF_{g,i}$ = Emission factor for gas process i

P_c = 2002 condensate production

$EF_{c,j}$ = Emission factor for condensate process j

EF_w = Per well emission factor

Oil Well

$$E = \text{SUM}_i(P_o \times EF_{o,i}) + \text{SUM}(EF_w)$$

Where:

E = The 2002 emission

P_o = 2002 oil production

$EF_{o,i}$ = Emission factor for oil process i

EF_w = Per well emission factor

2002 Draft Uncontrolled Wellhead Emissions Estimates

| State | VOC (tons) | NOx (tons) | CO (tons) |
|---------------------|------------|------------|-----------|
| Alaska ¹ | 430 | 9 | 2 |
| Arizona | 47 | 9 | 2 |
| Colorado | 145,030 | 17,493 | 3,756 |
| Idaho | | | |
| Montana | 24,419 | 4,337 | 925 |
| New Mexico | 168,091 | 13,845 | 2,936 |
| North Dakota | 9,843 | 101 | 21 |
| Nevada | 130 | 4 | 1 |
| Oregon | 34 | 12 | 2 |
| South Dakota | 288 | 44 | 9 |
| Utah | 35,896 | 2,127 | 465 |
| Washington | | | |
| Wyoming | 118,833 | 6,409 | 1,379 |

¹State agencies indicate wellhead equipment will be found in point source inventory, thus only emissions from completion activities have been included.

Steps to Complete the Inventories

- ⇒ Revise draft emissions estimates if any new factors and/or activity data are provided
- ⇒ Incorporate additional data from stakeholders, if provided
- ⇒ Complete thorough review of States' inventory methods to ensure that no overlap exists between point and area sources
- ⇒ Finalize adjustment for controls
- ⇒ Eliminate sources on Tribal lands from States' inventories and provide separate tribal inventories

Point vs. Area Reconciliation

| State | Point Source Inventory Threshold | Reconciliation still to be done |
|--------------|----------------------------------|--|
| Alaska | PTE 100 TPY ¹ | |
| Arizona | Yet to be determined | Yet to be determined |
| Colorado | 2 TPY actual emissions | Determine if wellhead emissions were included in point inventory and extract from area source inventory if appropriate |
| Montana | PTE 25 TPY | |
| New Mexico | PTE 25 TPY | |
| North Dakota | PTE 100 TPY | Currently reviewing State's internal inventory for smaller (down to 500 hp) compressors. |

¹Smaller equipment is reportedly grouped in large facilities. This will be verified by determining if a reasonable equipment count is found within the inventory of these large facilities.

Point vs. Area Reconciliation (cont.)

| State | Point Source Inventory Threshold | Reconciliation still to be done |
|--------------|----------------------------------|--|
| Nevada | PTE 5 TPY | Eliminate compressor engine emissions from area source emissions |
| Oregon | PTE 40 TPY | Determine if “medium” compressor engines have been omitted from both point and area inventories and incorporate if necessary |
| South Dakota | Yet to be determined | Yet to be determined |
| Utah | PTE 100 TPY | Obtain from Utah DEQ data on sources with a PTE between 25 and 100 TPY. Incorporate additional sources. |
| Wyoming | PTE 25 TPY | |

Controls Reported by DEQs

| State | Compressors | Drill Rigs | Condensate Tanks | Glycol Dehydrators | Completion: Flaring & Venting |
|-------------------|---|------------|-----------------------------------|-----------------------------------|-----------------------------------|
| Colorado | Included in point source EI | None | None | Yet to be determined | Included in EF provided |
| Montana | None | None | *Flare or vapor recovery required | *No dehydrators installed to date | *Flare or vapor recovery required |
| New Mexico | None | None | None | None | *None |
| Utah | *If uncontrolled emissions > 5 TPY, catalyst required | None | None | None | *None |
| Wyoming | *Catalyst required | None | Included in EF provided | None | Included in EF provided |

*Indicates that controls will most likely result in a change in the emissions estimate

Tribal Emission Inventories

- ⇒ Reviewed existing inventories
- ⇒ Data collection in progress
 - Data constraints
 - Permitting
 - Production data
 - Possibility of applying some of the data from the State oil and gas commissions

Projections

- ⇒ Data available from State agencies limited
- ⇒ BLM Resource Management Plans seem to be the best source of data
- ⇒ Backup will be to use EIA forecasts
- ⇒ Incorporate information on upcoming controls gathered from State agencies