OIL AND GAS GREENHOUSE GAS EMISSIONS REDUCTIONS

STAFF DRAFT REPORT
December 10, 2007

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EXECUTIVE SUMMARY [to be added]

BACKGROUND

1. Executive Order Directive

This report has been prepared pursuant to a directive in Governor Richardson's Executive Order 2006-069, "New Mexico Climate Change Action":

> *III.1.d. NMED [New Mexico Environment Department] shall conduct a study of voluntary and mandatory mechanisms for reducing greenhouse gas emissions from oil and gas processes by January 1, 2008 and shall submit such study to the [Climate Change Action Implementation] Team, the Clean Energy Development Council, and the Governor by said date. Proposed mechanisms shall reduce methane emissions in oil and gas operations by 20% by 2020 and carbon dioxide emission from fuel combustion.*

This directive is intended to implement two of the policy recommendations (ES-12 and ES-13) of the New Mexico Climate Change Advisory Group (CCAG). The CCAG was a stakeholder advisory group established by Governor Richardson's Executive Order 05-33 in June 2005. The Governor directed the CCAG to prepare a report including a projection of New Mexico's future greenhouse gas emissions and a list of policy recommendations for reducing New Mexico's greenhouse gas emissions to 2000 levels by 2012, 10% below 2000 levels by 2020 and 75% by 2050. The CCAG recommended 69 policy measures addressing greenhouse gas emissions from all sectors of the economy.

The Executive Order does not explicitly specify the base year or base emissions for the methane emissions goal of 20% reduction by 2020. However, examination of the methods used in the CCAG Final Report to evaluate policy recommendations shows that the percentage reduction goal for methane is relative to projected (business-as-usual, BAU), emissions for the year 2020. In the CCAG Final Report, goals were translated into absolute emissions reductions and then subtracted from "reference case emissions" (i.e., projected BAU emissions) for 2012 and 2020 to yield the annual emissions that would result if CCAG recommendations are implemented. This is evident from Figure EX-1 and Table EX-1 of the CCAG Final Report (Appendix A of this report).

2. CCAG Recommendations ES-12 and ES-13

Details of the CCAG Recommendations implemented by Executive Order directive cited above may be found in the CCAG Final Report. Recommendations ES-12 and ES-13 are summarized as follows, and the full text of the Recommendations is given in Appendices B-1 and D-1 respectively.

ES-12 Methane Reduction in Oil and Gas Operations (BMPs & PROs)

There are a number of ways in which methane emissions in the oil and gas industry can be reduced. Natural gas consists primarily of methane, so any leaks during production, processing, and transportation/distribution should be addressed. In addition to reducing potent GHG emissions,[9] eliminating leaks and venting is economically beneficial because it prevents the waste of valuable product. The EPA Natural Gas STAR program offers numerous methods of preventing leaks. These methods, called Best Management Practices (BMPs) and Partnership Reduction Opportunities (PROs) include opportunities to reduce leaks in venting in the production, processing, and transportation/distribution of natural gas.[10]

The CCAG recommends that – subject to verification of technical and economic feasibility and reduction potential: (a) New Mexico implement, on a voluntary basis, all BMPs, PROs, and available technologies starting in 2007 to reduce overall CO2e emissions due to methane emissions from the oil and gas sector by ~20% by 2020; (b) New Mexico actively promote participation by oil and gas operators in EPA's Natural Gas Star program and New Mexico's San Juan VISTAS program; and (c) as voluntary measures are implemented, if the State determines that oil and gas operators are not on track to achieve the above goal, the State should implement mandatory approaches where appropriate. Mandatory measures would be implemented only after following formal rule making or statutory change procedures with the appropriate "due process" requirements.

[9] Methane has 21 times the global warming potential of CO2.
[10] For a complete list, see http://www.epa.gov/gasstar/techprac.htm#tabnav.

[CCAG Final Report, pp. 5-13 & 5-14]

ES-13 CO2 Reduction from Fuel Combustion in Oil and Gas Operations

There are a number of ways in which CO2 emissions in the oil and gas industry can be reduced, including (1) installing new efficient compressors, (2) replacing compressor driver engines, (3) optimizing gas flow to improve compressor efficiency, (4) improving performance of compressor cylinder ends, (5) capturing compressor waste heat, and (6) utilizing waste heat recovery boilers. Policies to encourage these practices can include education and information exchange, financial incentives, and mandates or standards that require certain practices.

The CCAG recommends that New Mexico focus attention on reducing GHG emissions from fuel combustion in the oil and gas industry through education, financial incentives, mandates and/or standards – coupled with cost and investment recovery mechanisms, if appropriate – to: (1) improve the efficiency of compressors; (2) boost waste heat recovery for compressors and boilers including

the deployment of CHP systems that could sell excess power back to the grid; and to a lesser extent, (3) replace gas-driven compressors with electrical compressors when doing so reduces CO2 emissions (the average carbon intensity of New Mexico electricity would need to be reduced by approximately 30% to make this option carbon-neutral).[11]

The CO2 reduction goals for this policy option reflect – subject to verification of technical and economic feasibility and reduction potential – a reduction in CO2 emissions from fuel combustion by 75% by 2020. This CO2 reduction goal is provided for the sole purpose of partially meeting the targets set by Governor Richardson's directive and are not necessarily confirmed or validated by any current study or analysis regarding economic or technical feasibility. It is the intent of the CCAG to require further study and analysis of the approaches recommended above by the NMED and other appropriate agencies, and that from this study and analysis, changes in goals and determinations regarding the economic and technical feasibility of these approaches may result.

[11] *See Attachment H-9 of Appendix H, Energy Supply Policy Recommendations.*

[CCAG Final Report, p. 5-14]

3. Oil and Gas Industry Emissions of Greenhouse Gases in New Mexico

The CCAG Final Report includes an inventory of New Mexico greenhouse gas emissions and projected reference-case (BAU) emissions for future years. Details of the CCAG inventory for Fossil Fuel Industry Emissions are included in the present report as Appendix E.

Ton for ton, methane is a more potent greenhouse gas than carbon dioxide. In the CCAG emissions inventory, the different global warming potentials of greenhouse gases other than CO2 are accounted for by converting emissions amounts from absolute mass to the equivalent amount of carbon dioxide (CO2e). The inventory used global warming potential values from the Second Assessment Report of the Intergovernmental Panel on Climate Change, which assigned methane a global warming potential of 21, meaning that a ton of methane would result in the same radiative forcing as 21 tons of carbon dioxide.

According to the CCAG emissions inventory, fossil fuel industry emissions accounted for 24% of New Mexico's emissions in the year 2000, and were the second largest sector after electricity production (Fig. 1).

Details of the fossil fuel industry emissions are given in Table D-13 of Appendix E (of this report). For Year 2000, emissions from the natural gas industry contribute 87% of fossil fuel industry emissions, oil production and processing contributes 12%, and 1% was from methane emissions from coal mines.

A breakout of oil and gas industry emissions by gas (CO2 vs. methane) is shown in Fig. 2. Carbon dioxide accounts for two-thirds of industry emissions, and methane accounts for one-third.

Figure 1. New Mexico greenhouse gas emissions by sector, Year 2000 (from CCAG Final Report Appendix D, Figure D-2).

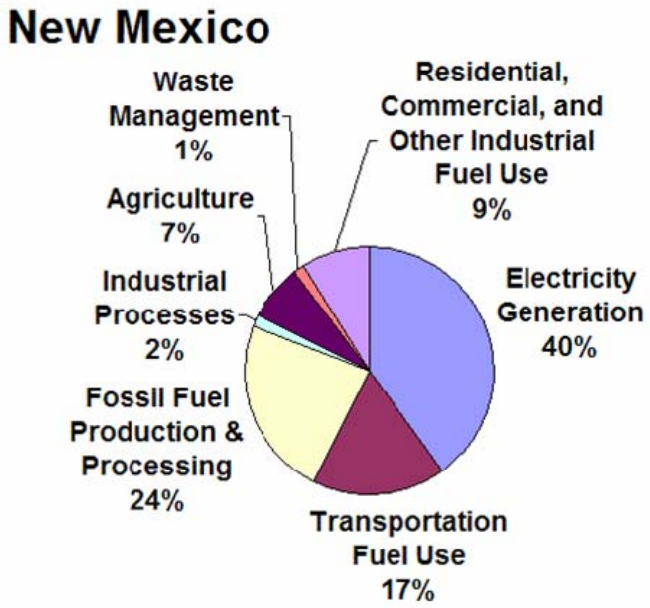
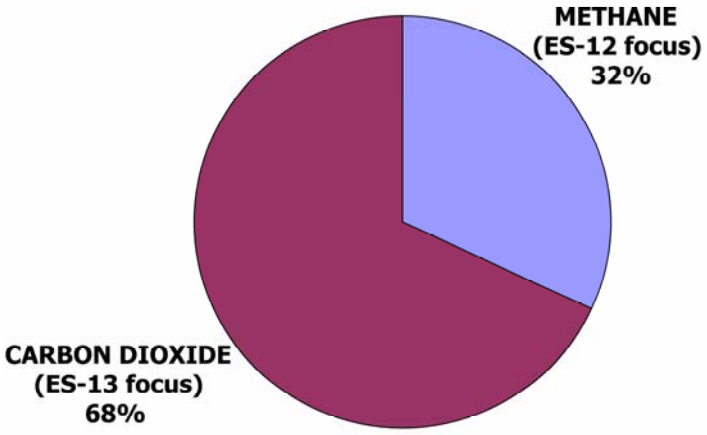


Figure 2. Greenhouse gas emissions by gas within the oil and gas industry, Year 2000. Data from Appendix D, Table D-13 (CCAG Final Report Appendix D, Attachment D-2). Only a portion of the carbon dioxide emissions are within the scope of ES-13.



Oil and gas industry emissions can be further broken down by industry sector and source type (combustion vs. venting), as shown in Fig. 3 for methane and Fig. 4 for carbon dioxide. The industry sectors identified in Figs. 3 and 4 may be briefly described as follows:

For purposes of this inventory, Gas Production includes everything upstream from natural gas processing plants, including drilling, wellhead equipment, and gathering lines. Gas Processing refers to sources within natural gas processing plants. Gas Transmission refers to the high-pressure, large diameter pipeline system and associated compressors and other equipment that transport pipeline-quality natural gas from the processing plant to the distribution system. Gas Distribution includes "city gates" which take gas from the transmission system and reduce the pressure, and the system for distributing gas from the city gate to end-use consumers. Oil Production includes all petroleum production equipment upstream of the refinery, and Oil Refining includes petroleum refineries. In the CCAG emissions inventory, oil transport emissions were included in oil production and refining.

Figure 3. Methane emissions by oil and gas industry sector, Year 2000. Methane emissions are predominantly from venting and leaks, as described in App. D, p. D-42. Data from Appendix D, Table D-13 (CCAG Final Report Appendix D, Attachment D-2).

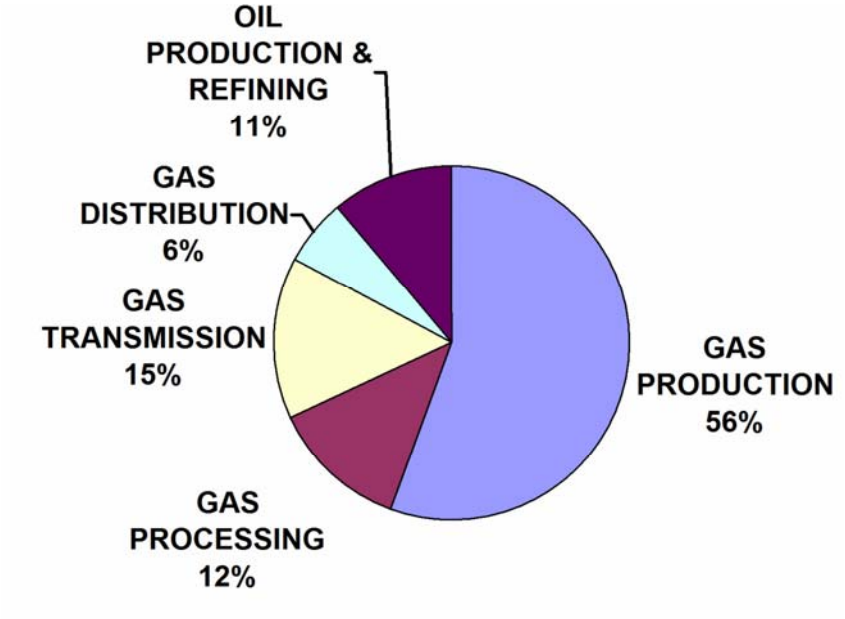
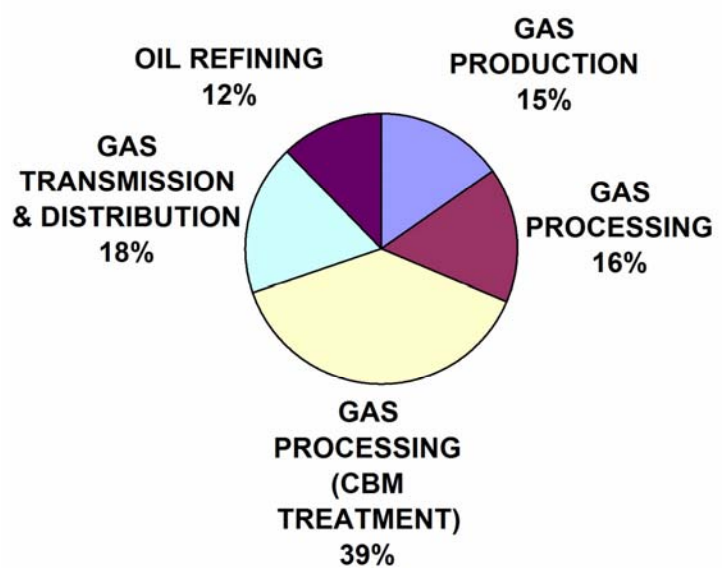


Figure 4. Carbon dioxide emissions by oil and gas industry sector, Year 2000. Data from Appendix D, Table D-13 (CCAG Final Report Appendix D, Attachment D-2). Emissions are predominantly from combustion, except for coal bed methane (CBM) treatment, in which CO2 is stripped from raw CBM gas and vented.



In actuality, sector divisions are not always clear-cut. For example gathering line systems are sometimes owned and operated by gas processing companies, who in this case would take custody of the gas at the wellhead. Some gas treatment may occur at the wellhead or at some point in the gathering system upstream of the gas treatment plant. Compressor stations, including some which are large enough to be Title V sources, are sometimes located upstream of the gas processing plant as part of the gathering activities. There are also some pump stations for transport of natural gas liquids, and it is not always clear to what sector these should be assigned.

The CCAG report noted the uncertainty of future oil and gas production levels in New Mexico, and concluded that the most likely scenario was that production would remain at about current levels through 2020. Consequently, projected 2020 reference case (BAU) emissions from the oil and gas industry in New Mexico would increase very little from current levels (App. E of this report, Table D-13). As explained in the report:

> *The future of New Mexico natural gas and oil production is highly uncertain, dependent on global price trends, discovery of new reserves, and other factors. For projection purposes, we assume that new reserves will be found and exploited such that recent production levels of oil and gas will be maintained.*
> (CCAG Final Report, p. 2-8)

4. Relevant Aspects of Oil and Gas Industry Structure in New Mexico

Attachment D-2 of the CCAG Emissions Inventory (App. E of this report) provides a concise description of the oil and gas industry in New Mexico in relation to greenhouse gas emissions. Following is some additional information that may be useful in policy design.

Although New Mexico has a large number of oil and gas producers, this sector is dominated by a relatively small number of companies accounting for most of the production. In natural gas production, the top 20 producers account for about 80% of total production (Figure 5). Concentrated is less in oil production, where the top 20 companies account for about 64% of production (Figure 6).

Figure 5. Cumulative Percentage of New Mexico Natural Gas Production by Company

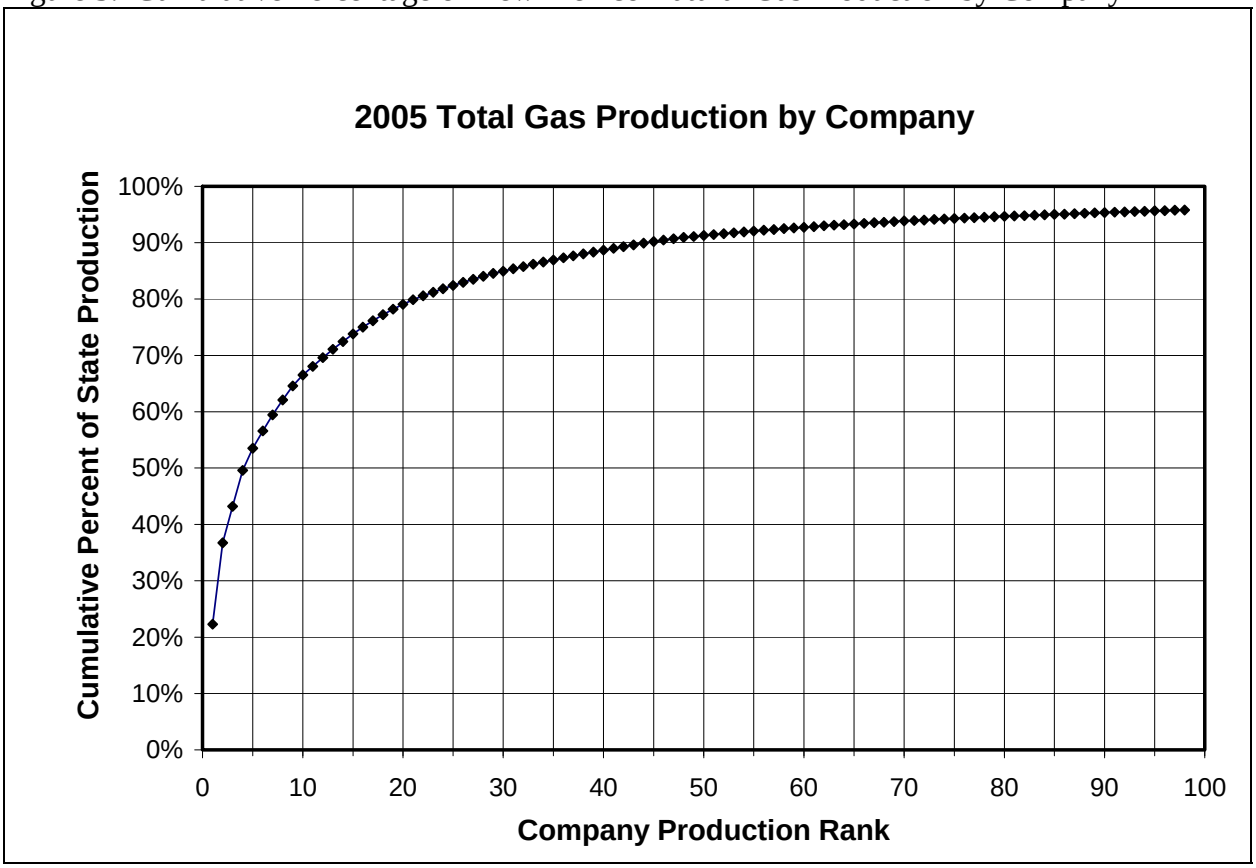
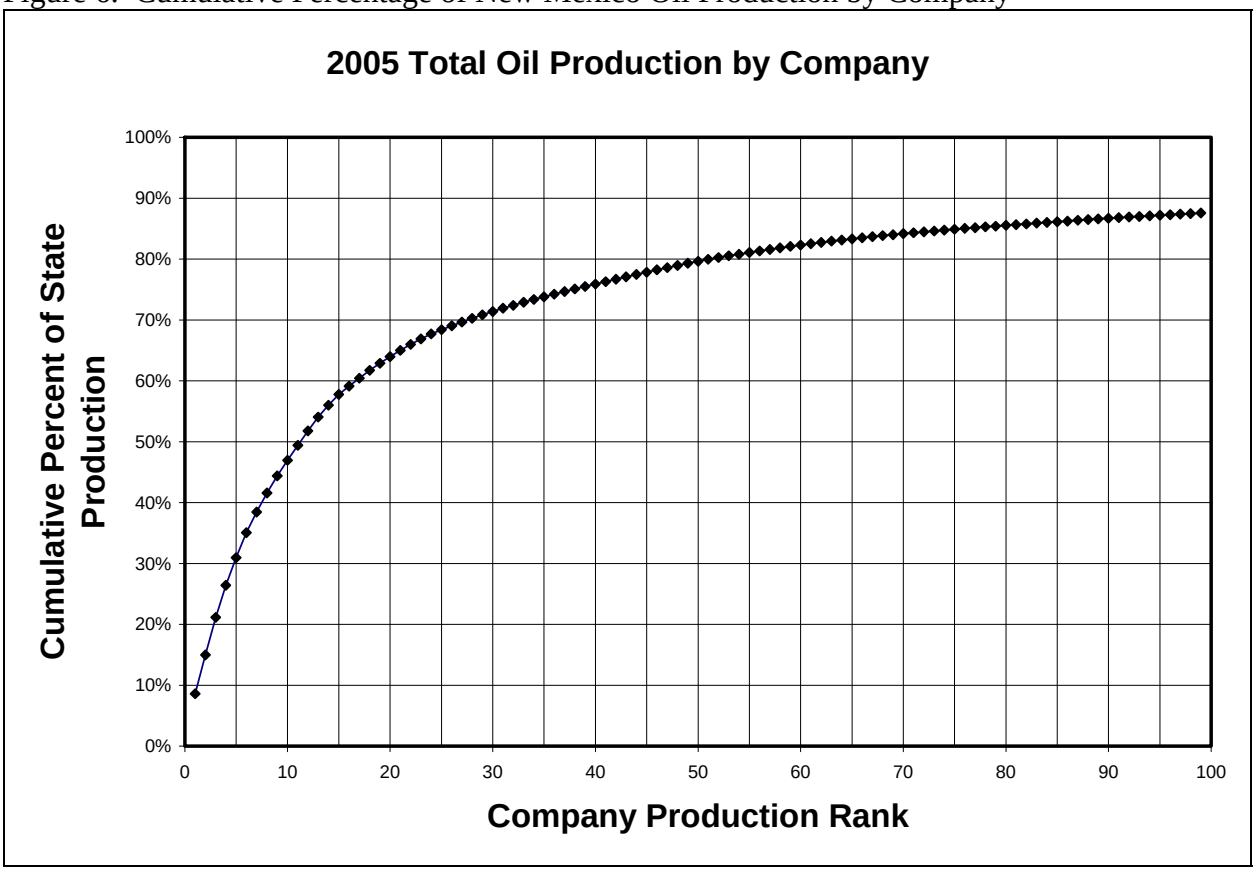


Figure 6. Cumulative Percentage of New Mexico Oil Production by Company



Further indications of diversity within the production sector are evident in Figure 7. Slightly over half (53%) of the 578 operators have 10 or fewer producing wells. Average production per well varies about two orders of magnitude (mostly in the range of 100 to 10,000 BOE/yr) among operators, except for the larger operators, who tend to have mostly high-producing wells.

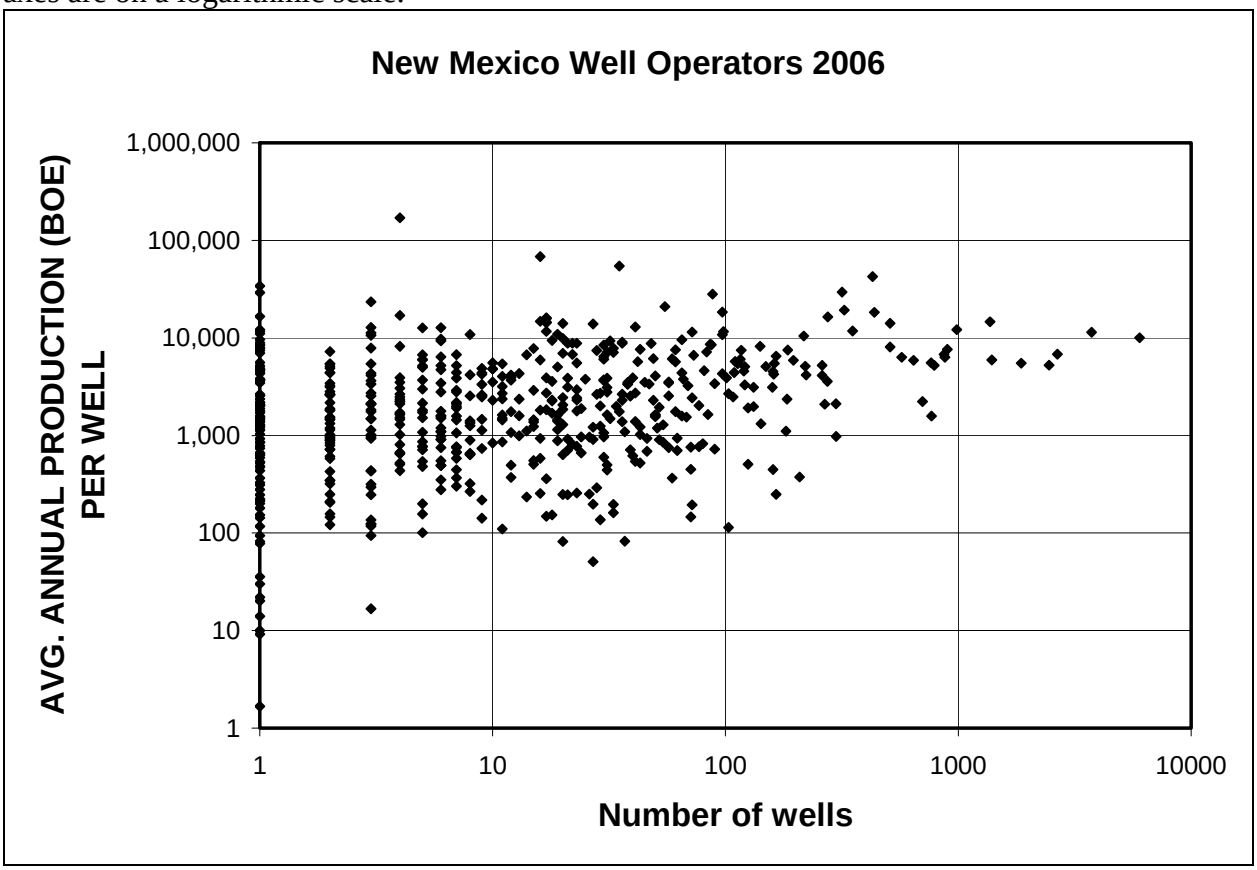
Although some processes that might be called gas treatment take place in field gathering systems, most gas processing plants are major sources of criteria air pollutants and have Title V air quality permits. Within NMED jurisdiction, there are 25 gas processing plants with Title V permits, operated by 13 companies.

Within NMED jurisdiction, there are 81 compressor and pumping stations in the oil and gas sector, operated by 15 companies. These are predominantly compressor stations for natural gas pipelines, and which use natural gas as fuel. Most of the natural gas compressor stations are operated by transmission sector companies, but some are located in field gathering systems upstream from gas processing plants. A few of these sources transport natural gas liquids or other petroleum products and use diesel as fuel.

New Mexico has three petroleum refineries and a refinery-related facility which produces asphalt. All are Title V sources.

In the natural gas distribution sector in New Mexico, there are about 16 companies. This sector is dominated by one company (Public Service Company of New Mexico), which accounts for about 82% of distribution.

Figure 7. Average Annual Production per Well for Oil and Gas Well Operators in 2006. Gas Production is expressed as Barrels of Oil Equivalent (BOE), where BOE = mcf/6. Note that both axes are on a logarithmic scale.



ES-12 ANALYSIS: METHANE EMISSIONS REDUCTION

1. Translating the 20% Reduction Goal into Tons of Emissions Avoided

In the CCAG report, ES-12 was reported to have, for the period 2007-2020, the highest cumulative emissions reductions of all the quantifiable policy recommendations (Fig. EX-2 in CCAG Final Report). However, the expected emissions reduction given by the report does not correspond to the stated goal of 20% reduction, but to a much higher percentage reduction in methane emissions.

The sum of reference case methane emissions in 2020 from the natural gas industry and the oil industry can be obtained as the sum of appropriate values in Table D-13 (App. E of this report):

Table D-13. Emissions Estimates for the Oil and Gas Sector, by Source and Gas, 1990-2020 (Scenario A)

(Million Metric Tons CO2e)	1990	2000	2010	2020	Explanatory Notes for Projections
Fossil Fuel Industry	**15.2**	**19.5**	**20.3**	**20.7**	
Natural Gas Industry	**12.7**	**17.0**	**17.3**	**17.7**	
Production					
Fuel Use (CO2)	1.8	2.0	1.9	1.9	grows with gas production
Methane Emissions (CH4)	1.9	3.4	3.7	3.7	grows with gas production
Processing					
Fuel Use (CO2)	1.9	2.1	2.0	2.0	grows with gas production
Methane Emissions (CH4)	0.8	0.8	0.9	0.9	grows with gas production
Entrained Gas (CO2)	0.8	5.0	5.2	5.6	grows with CBM prod & CO2 concentration
Transmission					
Fuel Use (CO2)	4.2	2.3	2.3	2.3	no change assumed from 2003 on
Methane Emissions (CH4)	1.0	0.9	0.9	0.9	no change assumed from 2003 on
Distribution					
Fuel Use (CO2)					included in transmission (above)
Methane Emissions (CH4)	0.4	0.4	0.3	0.4	grows with gas consumption
Oil Industry	**2.3**	**2.3**	**2.3**	**2.3**	
Production					
Fuel Use (CO2)					included in industrial oil use (above)
Methane Emissions (CH4)	0.7	0.7	0.7	0.7	grows with oil production
Refineries					
Fuel Use (CO2)	1.6	1.6	1.6	1.6	assumes no major changes
Methane Emissions (CH4)					included in oil production (above)
Coal Mining (Methane)	**0.2**	**0.2**	**0.7**	**0.7**	no change assumed from 2003 on

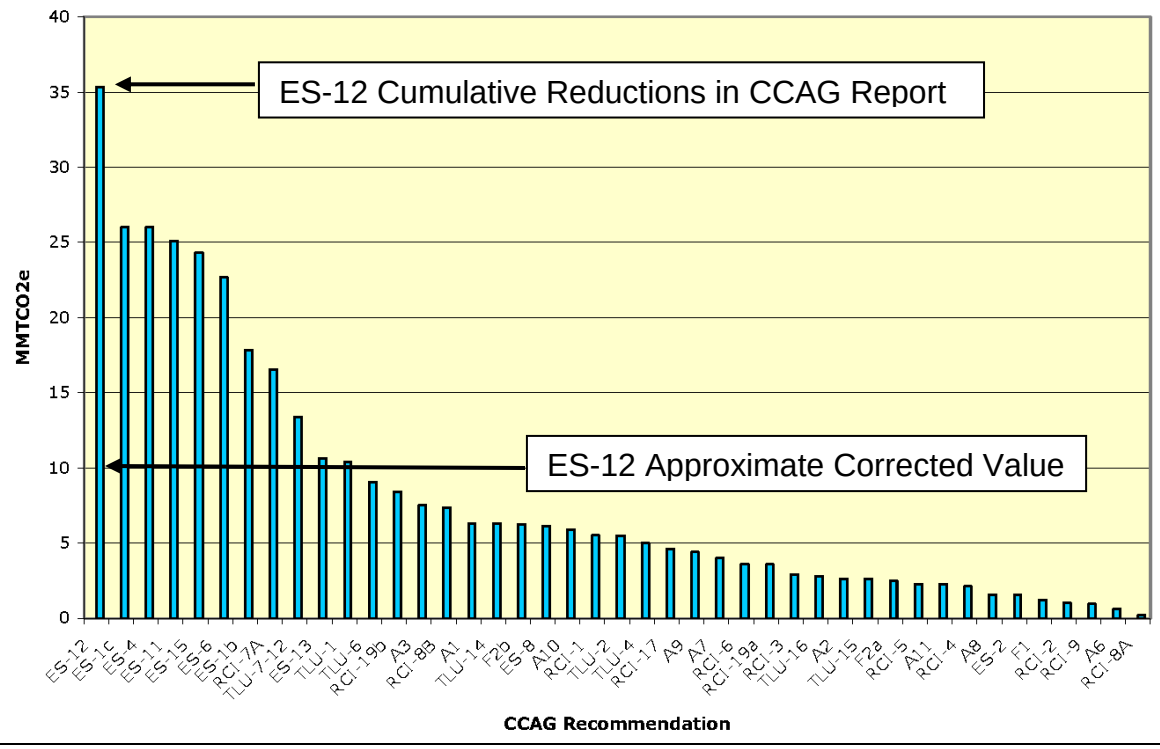
The sum of the circled values (in the original spreadsheet, before rounding) in Table D-13 above, which would be the 2020 reference case methane emissions for oil and gas operations, is 6.50 MMTCO2e. The ES-12 goal of 20% reduction would amount a reduction of 0.2 x 6.50 = 1.30 MMTCO2e. However, the CCAG report gives a value for year 2020 reductions of 3.43 MMTCO2e (App. B-1 of this report, p. H-49), which is a 53% reduction from the reference case value. Examination of the spreadsheet used to estimate greenhouse gas reductions and costs per ton (App. B-2 of this report) indicates that these calculations cited in the CCAG report were

made on the basis of more ambitious goals than the stated target for this policy, which is achievement of 20% reductions by 2020.

Cumulative 2007-2020 reductions depend not only on the target emissions level in 2020, but also on assumptions about the rate of increase in reductions during this period. Assuming a linear reduction in emissions from 2006 levels to the 20% reduction target in 2020 yields a cumulative reduction of 9.78 MMTCO2e. A theoretical maximum cumulative reduction could be based on the highly improbable assumption that a 20% reduction is achieved immediately in 2007 and then maintained through 2020, which yields a value of 18.12 MMTCO2e, approximately half the value of 35.34 MMTCO2e given in the CCAG report. That is, even with an unrealistically ambitious scenario of reduction leading to the target value, cumulative reductions could be no higher than about half the reductions given in the CCAG Final Report. Figure EX-2 in the CCAG report should be revised to indicate that ES-12 could yield cumulative reductions of about 10 MMTCOe:

Figure EX-2

CCAG Policy Recommendations Ranked by Cumulative GHG Reductions, 2007-2020



Using this corrected value for cumulative reductions, ES-12 would be the eleventh highest policy measure rather than the highest. Correcting the total emissions reductions from CCAG Recommendations gives a value of 36.2 MMTCO2e for 2020 emissions, which is still below the Executive Order target level of 43.7 MMTCO2e (CCAG Report, Table EX-1.

2. Absolute versus Relative Target

The goal is stated as a 20% reduction of 2020 reference case emissions. Given that 2020 reference case emissions are 6.50 MMTCO2e, and 20% of this value is 1.30 MMTCO2e, then the target emissions level for methane emissions from oil and gas would be 6.50 - 1.30 = 5.20 MMTCO2e.

It might be asked whether the value for 2020 reference case emissions should be adjusted in future years to account for deviations from the CCAG assumptions used to project future emissions, principally the assumption that production would remain nearly unchanged. Changes in production greater than ±20% are within the realm of possibility. The question is whether the absolute emissions target of 5.20 MMTCO2e should potentially be recalculated (as 80% of a revised reference case emissions value) if there is a foreseeable or actual significant change in New Mexico's oil and gas production.

The purpose of the CCAG recommended policies is to achieve the goals of the Governor's Executive Order, and those goals were stated as reductions from emissions in the base year of 2000 (e.g., "10% below 2000 levels by 2020"). Since the Executive Order does not include any indication of adjustment of goals for changes in population or production, we conclude that the intent was to reduce absolute emissions levels by the stated percentages, and goals should not be adjusted for changes in production. We therefore interpret the goal for policy ES-12 to be reduction of methane emissions from oil and gas to a level of 5.20 MMTCO2e by 2020, regardless of changes in production.

3. CCAG Recommended Policy Design

The CCAG recommends what is essentially a three-step approach to implementation:

1) promote voluntary use of Gas STAR methane reduction measures;
2) track progress towards achievement of goal (20% below reference case level by 2020); and
3) implement mandatory adoption of Gas STAR measures if progress is not on track to achieve goal. (App. B-1 of this report, p. H-48).

In addition, the Policy Design calls for this approach to be subject to verification of technical and economic feasibility and reduction potential.

4. Key Features of US EPA Gas STAR Program

Complete information on the Gas STAR program is given in US EPA's web site for this program (http://epa.gov/gasstar/index.htm). Some key features are relevant to the possible design of any programs to implement ES-12 recommendations in New Mexico.

- Participation in the program is voluntary.

- Program outreach is provided through the web site, annual national two-day implementation workshops, and sector- or activity-specific technology transfer workshops or webcasts, often with a regional focus (approximately six to nine per year).
- Companies agreeing to join ("Partners") commit to evaluating Best Management Practices (BMPs) and implementing them when they are cost-effective for the company. In addition, "...partners are encouraged to identify, implement, and report on other technologies and practices to reduce methane emissions (referred to as Partner Reported Opportunities or PROs)".
- Best Management Practices are a limited set of reduction measures identified at the initiation of the program as widely applicable. PROs subsequently reported by partners have increased the number of reduction measures to a current total of 83 measures across all sectors (see App. C-1 of this report).
- The program provides calculation tools for estimating emissions reductions for BMPs and PROs, based on the relevant features of the equipment and application.
- Projected emissions reductions can be estimated accurately and simply; for example, reductions from replacing high-bleed pneumatic devices with low-bleed devices are a simple function of the known bleed rates of the respective devices, and the methane content of the gas. For others, such as those involving inspection and maintenance to detect and repair leaks, emissions reductions are difficult to anticipate because the number and magnitude of leaks is initially unknown or poorly estimated.
- Tools are also provided for estimating the economics of emission reduction measures, as a function of factors such as gas value, capital costs, and operation and maintenance costs.
- Technical feasibility is variable between measures and is often site- or application-specific. For example, in the Gas STAR Lessons Learned for replacing high-bleed with low-bleed pneumatic devices, it is estimated that "nearly all" high-bleed devices can feasibly be replaced with low-bleed devices. Some specific exceptions are listed, including very large valves requiring fast and/or precise response, commonly on large compressor discharge and bypass controllers (App. C-2 of this report).
- Partners report emissions reductions annually, but the individual partner reports are confidential. Publicly reported data are aggregated nationally, but include total reductions by sector and by emissions reduction measure.

The only currently available measure of Gas STAR program participation in New Mexico is by company, although the degree of implementation by each company is unknown. Furthermore, complex and changing ownership and corporate organization in some sectors make it somewhat difficult to accurately match Gas STAR partner names with operator names in New Mexico databases, so the following data should be considered approximate. In the gas production sector, Gas STAR partners are predominantly the larger companies, mostly publicly traded shareholder-owned corporations. In the aggregate, Gas STAR partners accounted for 72% of New Mexico gas production in 2006, and 8 of the top 10 and 14 of the top 20 gas producers are Gas STAR partners. Of the 25 gas processing plants in NMED jurisdiction, 18 are operated by Gas STAR partners. Of the 81 large Title V compressor and pumping stations in NMED jurisdiction, 64 are operated by Gas STAR partners. In the gas distribution sector, only one company (PNM) out of 16 distributors is a Gas STAR partner, but this company accounts for 82% of the sector activity.

5. Tracking Progress: Updating the CCAG Inventory

Tracking progress in reducing methane emissions from oil and gas operations would seem to be a simple matter of periodically updating the original emissions inventory for the appropriate source categories as indicated in Table D-13 above. However, a closer examination of the methods used to calculate emissions for the inventory indicates that updating the inventory calculations with current-year data will not be likely to detect the results of any state-specific program to reduce emissions from these sources. Inventory methods are given in Table D-12 of of the CCAG Report (see Appendix E of this report).

As shown in Table D-13 above, methane emissions from oil and gas operations were calculated for five subsectors:

1) natural gas production;
2) natural gas processing;
3) natural gas transmission;
4) natural gas distribution; and
5) oil production and refining

For each of these subsectors, emissions were calculated using either the formula:

$$NM\ emissions = US\ emissions \times \left(\frac{NM\ activity}{US\ activity} \right) \qquad \text{EQ. 1}$$

or the following, which is the same formula with rearrangement of the right-hand terms:

$$NM\ emissions = NM\ activity \times \left(\frac{US\ emissions}{US\ activity} \right) \qquad \text{EQ. 2}$$

The activity measures for each subsector are given in Table 1.

Table 1. Activity measures used in calculation of oil & gas subsector emissions.

Oil & Gas Subsector	Activity Measure (NM and US)
Natural Gas Production	Marketed Production Volume
Natural Gas Production	Volume of Natural Gas Processed
Natural Gas Transmission	Transmission Pipeline Mileage
Natural Gas Distribution	Natural Gas Consumption
Oil Production & Refining	Barrels of Crude Oil Produced, Refined, Transported

US emissions for each subsector were obtained from the US greenhouse gas emissions inventory published annually by the US EPA (e.g., US EPA, 2005). Methane emissions reductions reported by Gas STAR program partners are accounted for in the US emissions inventory. US emissions are estimated by first calculating a business-as-usual estimate, by adjusting the emissions from 1990 to account for changes in activity factors, and then subtracting the reported Gas STAR emissions reductions (ignoring the sunsetting provisions of the Gas STAR program.

The second term on the right-hand side of Equation 2 is emissions divided by activity, so this is essentially an emissions factor. Therefore, the calculation of NM emissions is equivalent to multiplying the NM activity measure by a US emissions factor, which in essence assumes that the NM emissions factor is the same as the US emissions factor. If NM emissions are estimated using Equation 2, the only way NM emissions thus estimated can decrease is if the NM activity level goes down or if the US emissions factor goes down.

If a New Mexico program actually resulted in greatly accelerated adoption of Gas STAR emissions reduction measures, NM emissions as estimated by Equations 1 or 2 would not fully reflect the actual decrease in NM emissions. If all else was unchanged, then a decrease in the NM emissions factor would cause some decrease in the US emissions factor, proportional to New Mexico's share of US emissions and activity, but the decrease would be far less than actually occurred in New Mexico. We therefore conclude that the measures of oil and gas methane emissions used in the CCAG emissions inventory are not sufficiently sensitive to actual changes in New Mexico emissions to monitor progress of a state-specific emissions reduction program.

Partners in the Gas STAR program currently report methane emissions reductions from adoption of BMPs and PROs on a national basis, so the program does not provide any data which is specific to individual states. Individual partner reports are confidential, and the publicly reported data are aggregated nationally, so emissions reductions from those partners who operate in a single state cannot be distinguished. Therefore the current Gas STAR program cannot provide data that would help in tracking emissions reductions occurring specifically in New Mexico.

6. Tracking Progress: Alternative Methods

A) Voluntary reporting of Gas STAR reductions at the state level

One possible way to better track emissions reductions in New Mexico would be for the state to request Gas STAR partners operating in the state to separately calculate the New Mexico portion of their Gas STAR emissions reductions and report those values publicly and/or to a state agency.

However, quantifying emissions reductions would not be sufficient to determine emissions. It would not be appropriate to subtract the New Mexico Gas STAR emissions reductions from the emissions calculated using the CCAG inventory methods, because the CCAG emissions calculation method already accounts for the impact of Gas STAR reductions at the national scale.

An appropriate method would be to first calculate New Mexico emissions assuming no Gas STAR reductions were implemented, on the basis of US emissions calculated on the same business-as-usual (BAU) assumption, and then subtract the NM-specific Gas STAR reductions if these were reported publicly or to a state agency:

$$NM\ emissions = NM\ BAU\ emissions - NM\ Gas\ STAR\ reductions \qquad \text{EQ. 3}$$
$$= US\ BAU\ emissions \times \left(\frac{NM\ activity}{US\ activity} \right) - NM\ Gas\ STAR\ reductions$$
$$= (US\ emissions + US\ Gas\ STAR\ reductions) \times \left(\frac{NM\ activity}{US\ activity} \right) - NM\ Gas\ STAR\ reductions$$

Several factors may affect the accuracy and completeness of voluntarily reported Gas STAR reductions in New Mexico. Gas STAR partners may find it burdensome to separate out the New Mexico portion of their emissions reductions, and may therefore choose not to report New Mexico reductions. Furthermore, not all operators in New Mexico are Gas STAR partners, although they may nevertheless implement some of the emissions reductions measures. Company-specific data are confidential in the federal Gas STAR program, and some Gas STAR partners may not wish to give up confidentiality for state- and company-specific data. These factors would all tend to make the reported reductions incomplete. On the other hand, there is no independent verification of company-reported Gas STAR reductions, so there is also the possibility that reported reductions could be inflated.

More accurate data on New Mexico Gas STAR reductions could be obtained by making such reporting mandatory and requiring reporters to certify accuracy. However, we do believe it would be unfair to require reporting from only those companies which are partners in the federal Gas STAR program, because it would penalize them for participation in a voluntary emissions reduction program.

Equation 3 uses US EPA reported data on US methane emissions from oil and gas in calculating New Mexico emissions. Accuracy of the New Mexico emissions value would therefore be in part dependent on the accuracy the US emissions estimate. The US EPA emissions inventory relies heavily on emissions factors and equipment population profiles obtained in a study jointly funded by the Gas Research Institute and US EPA and conducted in 1991-1996 (GRI/EPA, 1996). A recent study notes that some GRI/EPA methane emissions factors need to be improved, and that some methane sources were not included in the 1996 report. New Mexico oil and gas industry representatives have stated that the GRI/EPA study needs to be updated to account for changes in equipment and technology over the last 10-15 years.

Currently, one of the greatest readily identifiable shortcomings of the US EPA inventory is its assumption that gas well completion emissions are all flared and that methane emissions from this source are therefore insignificant. For 2006, Gas STAR partners reported that "green completions", in which methane that would otherwise be vented is largely captured and treated for marketable production, achieved reductions of 30 Bcf of methane emissions. This one measure accounted for 56% of the production sector emissions reductions, and for 35% of the total Gas STAR emissions reductions. The US BAU emissions estimate fails to include 30 Bcf of avoided well completion emissions reported by Gas STAR partners, plus an unknown amount avoided by non-partners using green completions, plus an unknown amount of emissions occurring where green completions were not used. Actual emissions are therefore underestimated, because total Gas STAR emissions reductions (including those from green completions) are subtracted from BAU emissions (which do not include completion emissions).

B) Mandatory emissions reporting (NMED Air Quality Bureau and Albuquerque/Bernalillo County Air Quality Division)

Recently adopted regulations of the NM Environmental Improvement Board and the Albuquerque/Bernalillo County Air Quality Control Board include a requirement for reporting of methane emissions by oil and gas facilities. Annual methane reporting will begin with reporting of 2009 emissions by refineries and by facilities required to have Title V Operating Permits. Under the Clean Air Act, Title V Operating Permits are required for facilities with emissions exceeding 100 tons per year of any criteria air pollutant. In the oil and gas industry, Title V facilities are mostly, if not all, large combustion sources that trigger this requirement because of emissions of carbon monoxide and/or oxides of nitrogen, which are products of combustion. Reporting of methane emissions by smaller registered or permitted oil and gas sources will begin with 2010 emissions.

The total methane emissions from oil and gas facilities reported under these regulations will have certain shortcomings as a measure for tracking ES-12 progress:

1) Emissions from facilities on tribal land will not be included, because these facilities are outside the jurisdiction of either the Environmental Improvement Board or the Albuquerque/Bernalillo County Air Quality Control Board's authority to regulate air quality. Air quality on tribal land is regulated by the tribes or by US EPA.

2) Emissions from the gas distribution sector will not be included, because this sector does not have large combustion sources.

3) Emissions from many sources in the production sector will not be included because these sources are not in a facility required to obtain an air quality permit. Examples include well completions, wellhead venting, and most emissions sources in field gathering pipelines.

These regulations should result in fairly complete reporting from the processing sector (petroleum refineries and natural gas processing plants) and the transmission sector because most of these sectors' emissions occur at facilities which are large combustion sources and therefore required to have air quality permits. However, methane emissions data will not be available until mid-2010.

C) Voluntary emissions reporting (climate registries)

Voluntary emissions reporting to The Climate Registry by oil and gas companies in New Mexico could provide information useful in tracking progress towards the ES-12 target, if certain conditions are met.

There are a number of voluntary systems for companies to report their greenhouse gas emissions. The more rigorous of these, such as the California Climate Action Registry, require entity-wide reporting and verification of data by independent third-party consultants. Currently under development is a multi-state registry, The Climate Registry, which will also require rigorous reporting similar to that of the California Climate Action Registry (CCAR). New Mexico is one of the consortium of states developing The Climate Registry, which is scheduled to complete their General Reporting Protocol in January 2008. The General Reporting Protocol will set

standards for such general issues as gases reported, determining entity boundaries, and so forth. It will also include emissions quantification methods for common greenhouse gas sources such as fuel combustion.

Sector-specific reporting protocols are needed for some industry sectors where specialized emissions quantification methods are required, or where there are other industry-specific issues not addressed by general reporting protocols. The New Mexico Environment Department, California Air Resources Board, and CCAR, in cooperation with the Western Regional Air Partnership, has begun a joint initiative to develop a registry reporting protocol specific to the upstream oil and gas industry sector (i.e., production) and natural gas processing. This protocol, in combination with protocols already developed or soon to be completed for petroleum refining and natural gas transmission and distribution, will provide a basis for accelerated adoption of a complete oil and gas sector protocol by The Climate Registry.

As noted elsewhere in this report (p. 7 ff.), a relatively small number of companies account for a large percentage of New Mexico's oil and gas production, processing, transmission, and distribution.

If many of the larger oil and gas companies voluntarily report their emissions to The Climate Registry, and if the reports available to the Department separately account for methane emissions in New Mexico, then high quality data on a large portion of the emissions addressed by ES-12 would be available. It is likely that not all companies will voluntarily report (a virtual certainty for the production sector), so there must be some means of estimating the emissions of non-reporters. One possibility would be to estimate non-reporter emissions by the methods used in the CCAG inventory (Equations 1 and 2 above), based on their portion of the New Mexico activity factors. Total methane emissions would be obtained by summing the registry-reported emissions and the estimated emissions from non-reporters, and the accuracy of the value would be largely dependent on what proportion of the total was derived from non-reporters.

This approach might need to be used for only the production and distribution sectors, given that the mandatory reporting regulations described above will yield good estimates of the processing and transmission sector emissions but incomplete estimates of production and distribution sector emissions.

7. New Mexico State Agencies Regulating the Oil and Gas Industry

No single state agency regulates all sectors of the oil and gas industry. More or less sector-specific regulatory authority and technical expertise is divided among different rule-making bodies and administrative agencies. Three agencies administer regulations pertaining to the sources of oil and gas emissions of methane into the atmosphere. However, their statutory mandates and regulatory concerns with these sources and with methane emissions have not been related to methane's role as a greenhouse gas.

The Public Regulation Commission regulates the natural gas distribution sector, which is composed of gas utilities serving residential, commercial and industrial consumers. Regulation

is primarily for the purposes of ensuring customer service and public safety. For example, leak tests of customer meters are required (17.10.650 NMAC), but for the purposes of ensuring accurate billing and customer safety rather than to estimate aggregate methane emissions to the atmosphere.

The Air Quality Bureau of the Environment Department regulates air pollution, under the statutory authority of the New Mexico Air Quality Control Act, and enforces those provisions of the federal Clean Air Act for which it has been delegated authority by US EPA. The agency has not regulated methane emissions until recently, when regulations requiring methane emissions reporting were adopted by the Environmental Improvement Board. Most of the sources in the oil and gas sector required to have air quality permits, or subject to federal emissions standards, are combustion sources such as compressor engines, equipment for gas treatment, or refinery process equipment. These sources are mostly in the processing and transmission sectors, but there are some in the production sector. Many methane sources in the production sector are not subject to current air quality regulation because they are too small, temporary, or do not emit criteria or toxic air pollutants regulated under the Clean Air Act.

Air quality permitting and regulation have historically been at the facility level, although there were later added requirements that apply at the unit or equipment level. The definition of "facility", and the application of this definition, have been the subject of much legal and regulatory disputation. The definition of "facility" applies well to many of the common smokestack industries, where there is a factory with a fence around it defining the boundaries. But application of this term to the oil and gas production sector is often problematic, given that the equipment may be interconnected over long distances. Common business arrangements in the production sector, such as use of contractors for specific functions and use of leased equipment, also present problems in applying traditional air quality regulatory concepts.

The Oil Conservation Division (OCD) of the Energy, Minerals and Natural Resources Department enforces rules of the Oil Conservation Commission, adopted under the authority of the New Mexico Oil and Gas Act. This Act, and the regulations administered by OCD, pertains primarily to the oil and gas production sectors. OCD issues permits for drilling, development and production of oil and natural gas. The purpose of the OCD-administered regulations and permits is to prevent waste, protect correlative rights, and to protect oil, gas, potash, geothermal water, or other fresh waters.

8. Recommendations

[To be determined]

ES-13 ANALYSIS: CO2 EMISSIONS REDUCTION

1. CCAG Recommended Policy Design for ES-13

The CCAG recommended that New Mexico "focus attention on reducing GHG emissions from fuel combustion in the oil and gas industry through education, financial incentives, mandates and/or standards – coupled with cost and investment recovery mechanisms, if appropriate – to: (1) improve the efficiency of compressors; (2) boost waste heat recovery for compressors and boilers including the deployment of CHP systems that could sell excess power back to the grid; and to a lesser extent, (3) replace gas-driven compressors with electrical compressors when doing so reduces CO2 emissions (the average carbon intensity of New Mexico electricity would need to be reduced by approximately 30% to make this option carbon-neutral)." Each of these recommended strategies are described below.

2. Emissions Reduction Strategies

A) Improving the Efficiency of Compressors

CO2 emissions from combustion are directly related to the amount of fuel combusted. As a result, emissions of CO2 from combustion can be reduced by using less fuel to accomplish the same amount of work. This applies to compressors powered by engines or turbines. While replacing older, less efficient, engines with newer, more energy efficient models would be effective, capital costs would be significant. The scenario used in Attachment H-8 of the CCAG Final Report for estimating potential emissions reductions from improving the efficiency of compressors was to retrofit with automated air/fuel ration controllers existing 600 horsepower or greater natural gas compressor engines. Attachment H-8 states:

Based on field studies of the use of automated air/fuel ratio controllers in the Gulf of Mexico and EPA data, CO2 reductions from the use of such controllers were estimated to average 230.9 tons/year/engine. Automated air/fuel ratio controllers have been suggested as a best management practice in the San Juan Basin.

Natural gas use savings from the use of an automated air/fuel ratio controller come from more efficient startups, decreased fuel use, and increased production. Average natural gas savings of 78 Mcf/day have reported [in US EPA PRO Fact Sheet No. 111], as well as increased production rates of between 1% and 6.8%. Fuel savings could yield a payback of as much as $14,235/year per engine at $5 Mcf. Additional costs of operating an automated air/fuel controller, which include electricity costs, are reportedly offset by the reduction in engine maintenance costs, according to suppliers. The cost of an automated air/fuel ratio controller was estimated to be $120,000, based on data provided by the EPA and suppliers.

Under 'Key Uncertainties', Attachment H-8 also notes:

For automated air/fuel ratio controllers, it is uncertain exactly how many compressor stations could be equipped with this technology and how many controllers would be required. Data

regarding the horsepower, type, location, and grouping of internal combustion engines in New Mexico was not available in time for this analysis.

These uncertainties have not been resolved. NMED does not have access to industry data that would be necessary to estimate the number of compressors that already have or could potentially have air/fuel ratio controllers. No new information has been received by NMED regarding technical feasibility during the course of this study.

B) Boosting waste heat recovery for compressors and boilers

CO2 from combustion can be reduced by using waste heat to perform work, such as heating materials that would otherwise be heated by burning fuel, or generating electrical power to replace a small portion of existing grid power. The scenario used in Attachment H-8 of the CCAG Final Report for estimating potential emissions reductions from waste heat recovery was to deploy organic Rankine cycle combined heat and power (CHP) systems on compressors and boilers and sell the produced power to the grid.

Attachment H-8 states:

Organic Rankine cycle ("ORC") CHP systems have been used at compressor stations in Canada, and are being developed for compressor stations along the North Border pipeline in North and South Dakota, according to industry reports [46]. They are also in use at landfills in Texas and Illinois, where waste heat from flares and reciprocating internal combustion engines is used to fuel ORC systems, according to the EPA.47 These systems range from 1-10 MW. The cost of installing an ORC system to generate power was estimated at $1,000/kW ($1,000,000/MW), and operation and maintenance costs estimated at $1/MWh, based on supplier and industry data.48 Overall cost is estimated at $40/MWh of output according to suppliers and field studies.49

Estimated annual CO2 reductions using ORC can reach 6,600 tons of CO2 reduced per MW installed according to suppliers and industry 50. This could lead to a 6,600 to 66,000 tons/year reduction in CO2, depending on the size of the ORC system. Using the midpoint of 36,300 ton/year reduction, this would amount to a $9.17 cost per ton reduction in CO2 emissions, assuming a total operating time of 8322 hours, which is based on the reported 95% availability of ORC systems.51

Under 'Key Uncertainties', Attachment H-8 also notes:

For ORC CHP systems, it is uncertain how many systems would be required and where such systems would be most feasible and effective. Although baseline research and development appears well-developed, additional research and development costs to specifically apply ORC to facilities in New Mexico may arise. It is also uncertain what degree of payback may be expected through the sale of electricity from ORC CHP systems.

These uncertainties regarding technical feasibility still exist. NMED has not received any additional data that would help in determining how many ORC CHP systems could potentially be installed, nor the costs and benefits of this measure.

C) Replacing gas-driven compressors with electrical compressors

Another strategy in the CCAG Report for reducing CO2 emissions from combustion was to replace gas-driven compressors with electrical compressors. However, CO2 emissions would only be reduced if the CO2 emissions created when the electricity is produced are less than the CO2 emissions emitted by the gas-driven compressors that the electric compressors would replace. The analysis in Attachment H-8 assumed availability of zero-carbon electricity. However, the electricity currently available on the grid is not zero-carbon. In fact, the average carbon intensity of New Mexico electricity would need to be reduced by approximately 30% to make this option carbon-neutral (see Attachment H-9 to the CCAG Final Report). At such time that the carbon-intensity of grid electricity is reduced, this option may be revisited.

3. What are the Reduction Goals?

A) Executive Order 2006-069

Executive Order 2006-069 stated that, "Proposed mechanisms shall reduce methane emissions in oil and gas operations by 20% by 2020 and carbon dioxide emission from fuel combustion." It is not clear from the construction of the sentence whether the 20% reduction goal applies to CO2 emissions from fuel combustion or whether the goal is more generally to reduce emissions. However, in the context of the CCAG Report's description of ES-13, it seems reasonable to interpret the EO as not setting a quantitative goal for reducing CO2 emissions from fuel combustion in oil and gas operations.

B) CCAG Proposal

While the CCAG Final Report includes estimates quantifying potential reductions, the CCAG did not adopt a specific goal for the reduction of CO2 emissions from oil and gas sector fuel combustion.

An "initial cursory estimate" of potential reductions that could result from implementation of the recommendations for ES-13 (Attachment H-8 to the CCAG report) reflects a reduction in CO2 emissions from fuel combustion of 75% by 2020. The analysis that includes this estimate was introduced to the Energy Supply Technical Work Group (ES TWG) near the end of the process and was not approved by the ES TWG or the CCAG. The analysis addressed 3 potential policies described above and estimated the following emissions reductions for the following implementation of each: automated air/fuel ratio controllers, 20% emissions reduction; organic Rankine cycle combined heat to power (CHP) systems, 25% emissions reduction; and replacing natural gas fired compressor engines with electric compressor motors, 30% emissions reduction. The sum of estimated reductions from these policies would equal 75%.

The initial response by ES TWG members (Attachment H-9 to the CCAG report) addressed only the policy of replacing natural gas fired compressor engines with electric compressor motors, and showed that such a policy would not result in any emissions reduction, due to the carbon

intensity of the electricity that would be used to power the replacement motors. In response, the emissions reductions reflected in Table 5-1 (CCAG Recommended Policy Options and Results for the Energy Supply Sector) do not include emissions reductions from this policy; thus the CCAG recommendations assume an emissions reduction of 45% from fuel combustion, rather than the 75% included in the initial estimate.

However, neither the 45% nor the 75% reduction levels were adopted as goals by the CCAG. Significant uncertainties for these estimates were noted in the attachments, resulting from a lack of data regarding the numbers of equipment for which the strategies would be feasible or effective. The CCAG Final Report (page 5-14) states that reduction goals would be "subject to verification of technical and economic feasibility and reduction potential."

4. Implementation Strategies

A) Education

An increasing amount of information from a variety of sources is becoming available regarding ways to increase energy efficiency. Industry publications have carried articles addressing energy efficiency options, and manufacturer's information lists the anticipated energy use by their equipment. The Department of Energy provides general information regarding energy efficiency practices for combustion, process heating and steam generation at http://www.eere.energy.gov/consumer/industry/20ways.html and at http://www1.eere.energy.gov/industry/bestpractices/resources.html.

The Four Corners Air Quality Task Force has also drafted mitigation options that would improve energy efficiency in the oil and gas industry (http://www.nmenv.state.nm.us/aqb/4C/DraftTaskForceReport.html).

B) Financial incentives

An existing financial incentive to reducing fuel use, and as a result the CO2 emissions from combustion of fuel, is the rising prices of oil, gas and electricity. Individual companies are more likely to evaluate the cost effectiveness of measures to increase energy efficiency as this incentive increases. Information supporting such evaluations is referenced in the paragraph above.

Another potential financial incentive for reducing CO2 emissions from fuel combustion could be a market based emissions reduction program, which would result in placing a price on greenhouse gas (including CO2) emissions. The possibility of such a program being implemented in the future may be a disincentive to emissions reductions in the present, if current reductions are uncertain to receive credit in the future program.

Publicly funded financial incentives (tax breaks, reduced-interest loan funds, etc.) may be difficult to justify for measures that are expected to increase profits.

c. Mandates and/or standards – coupled with cost and investment recovery mechanisms, if appropriate

Current statutory authority may preclude NMED from establishing mandates or standards for the energy efficiency of equipment in the oil and gas sector. Likewise, statutory authority for NMED to provide or facilitate "cost and investment recovery mechanisms" does not currently exist.

5. Tracking Progress

A) Updating the CCAG Inventory

The CCAG Emissions Inventory relied primarily on state-level data from the U.S Department of Energy's Energy Information Administration (EIA) to estimate combustion CO2 emissions from the oil and gas industry sector.

Natural gas combustion data were taken from EIA's summary of gas consumption by end use. Natural gas use listed therein as "lease use" was attributed to the natural gas production sector. Natural gas use listed by EIA as "plant fuel use" was attributed to the natural gas processing sector. "Pipeline and distribution use" were attributed to the transmission and distribution sectors collectively, although there is very little, if any, fuel consumption in the distribution sector and this amount should perhaps be considered entirely attributed to the transmissions sector.

The EIA data on "lease use" of natural gas appear to derive from a summary report to EIA from New Mexico's Oil Conservation Division (OCD), which in turn receives the data from individual producer reports on their OCD Form C-115.

In oil production, marketed fuels such as diesel are used to power wellhead and transport equipment. The EIA data on liquid fuel consumption by end use do not provide sufficient detail to distinguish liquid fuel in oil production, so the CCAG Inventory included these combustion emissions in the general category of industrial fuel use. Therefore the CCAG Inventory includes no data specifically on CO2 emissions in the oil production sector.

In the CCAG Inventory, combustion CO2 emissions from oil refining were estimated from permit data on allowable fuel consumption, combined with EIA data on utilization of refinery capacity statewide.

Although the CCAG Inventory of this sector used best available methods and data, and the inventory as a whole is valuable for comparison of sector emissions in New Mexico, simply updating the CCAG Inventory data for combustion emissions by the oil and gas sector may not provide an accurate and reliable measure of progress in implementing the ES-13 emissions reduction measures over the 2000-2020 time frame. One issue is the accuracy of the EIA data on which the inventory methods heavily rely. These data may be of questionable accuracy, because there do not appear to be any strictly enforced recordkeeping requirements to support the

reporting by source facilities, and NMED is unaware of any EIA or OCD audits to verify the accuracy of the reported fuel use amounts. Another issue is that the ES-13 recommendations apply only to compressor engines and compressor stations, but the CCAG Inventory methods do not distinguish emissions from these sources separately from other combustion CO2 emissions.

B) Emissions reporting regulations

Greenhouse gas emissions reporting regulations newly adopted by NM Environmental Improvement Board (described above in regard to ES-12) will begin providing data on combustion CO2 emissions from refineries and large compressor stations beginning with 2009 emissions. New Mexico's three refineries are all in the EIB's jurisdiction, so the resulting data will provide statewide coverage of this category. Further research is needed to determine how many large natural gas compressors are on tribal land and thus outside EIB jurisdiction, and to develop a method for estimating emissions from these to give a statewide total for this category. Data from minor permitted sources will be available for the 2009 emissions year in mid-2010.

6. Recommendations

[to be added]