Proposed Rule 1148.2
Notification and Reporting Requirements for Oil and Gas Wells and Chemical Suppliers

Working Group Meeting
February 14, 2013

Definitions - Subdivision (c)

- Revised definition for “well production stimulation activity”
  - Well Production Stimulation or Enhancement Activity means acidizing, gravel packing, hydraulic fracturing, or any combination thereof.
  - Includes a definitive list of activities
  - Added definition for “acidizing” and “gravel packing”
- Clarified following definitions to refer to “well production stimulation or enhancement activity”
  - “flowback fluid”
  - “well completion”
  - “well completion fluid”
  - “rework”

Definitions - Subdivision (c) *(Continued)*

- Modified definition of “rework” to include “plugging”
- Added definition for “air toxic”
  - Definition of “air toxic” references AB2588 chemicals
  - Generally includes all chemicals that are in definition for “toxic air contaminant” and “hazardous air pollutant”
  - Removed definitions for “toxic air contaminant” and “hazardous air pollutant”
- Added definitions for:
  - Owner or Operator (c)(10)
  - Trade Secret (c)(15)

Notification and Reporting Requirements - Subdivisions (d) and (e)

- Clarified notification and reporting to require:
  - Name and contact information of oil or gas well owner or operator (d)(1)(A) and (e)(1)(A)
  - Well name and if the API well number (if available) (d)(1)(B) and (e)(1)(B)
- Adding a provision to post notification within 24 hours of receipt on AQMD website*
- Corrected reference to air toxics definition and reformatted reporting requirement for suppliers (e)(2)

* This provision will be added. Not in draft distributed 2/13/13.

Notification and Reporting Requirements - Subdivision (e)

- Changed references to new definitions and to specific provisions to clarify requirements for suppliers (e)(3)
- Specified 30 day time period for submittal of information for suppliers (e)(4)
- Reworded for clarity and required identification of the affected well in report to the Executive Officer (e)(5)

Air Quality Studies

- Industry representatives recommended that AQMD staff review studies
  - EPA NSPS TSD Supporting Studies
  - TSD – Specifically Sections 4.2, 5.2, 6.2, and 7.2
  - Environmental Defense Fund Study
- AQMD staff reviewed studies looking for
  - PM emissions from mixing operations
  - VOC and toxic emissions from well completions, focusing on flowback or drilling fluids
  - Other air quality data related to drilling, well completions, or reworks

EPA NSPS TSD Supporting Studies

- TSD included fifteen studies reviewed for emissions and activity data
- AQMD staff reviewed studies

Table 4-1. Major Studies Reviewed for Consideration of Emissions and Activity Data

Report Name	Affiliation	Year of Report	Activity Factor(s)	Emission Information	Control Information
Greenhouse Gas Mandatory Reporting Rule and Technical Supporting Documents [3]	EPA	2010	Nationwide	X	
Inventory of Greenhouse Gas Emissions and Sinks: 1990-2008 [4,5]	EPA	2010	Nationwide	X	
Methane Emissions from the Natural Gas Industry [6, 7, 8, 9]	Gas Research Institute /US Environmental Protection Agency	1996	Nationwide	X	X
Methane Emissions from the US Petroleum Industry (Draft) [10]	EPA	1996	Nationwide	X	
Methane Emissions from the US Petroleum Industry [11]	EPA	1999	Nationwide	X	
Oil and Gas Emission Inventories for Western States [12]	Western Regional Air Partnership	2005	Regional	X	X
Recommendations for Improvements to the Central States Regional Air Partnership's Oil and Gas Emission Inventories [13]	Central States Regional Air Partnership	2008	Regional	X	X
Oil and Gas Producing Industry in Your State [14]	Independent Petroleum Association of America	2009	Nationwide		
Emissions from Natural Gas Production in the Barnett Shale and Opportunities for Cost-effective Improvements [15]	Environmental Defense Fund	2009	Regional	X	X
Emissions from Oil and Natural Gas Production Facilities [16]	Texas Commission for Environmental Quality	2007	Regional	X	X
Availability, Economics and Production of North American Unconventional Natural Gas Supplies 1	Interstate Natural Gas Association of America	2008	Nationwide		
Petroleum and Natural Gas Statistical Data [17]	U.S. Energy Information Administration	2007-2009	Nationwide		
Preferred and Alternative Methods for Estimating Air Emissions from Oil and Gas Field Production and Processing Operations [18]	EPA	1999		X	
Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program [19]	New York State Department of Environmental Conservation	2009	Regional	X	X
Natural Gas STAR Program [20, 21, 22, 23, 24, 25]	EPA	2000-2010	Nationwide/ Regional	X	X

EPA NSPS TSD Supporting Studies *(Continued)*

- Six studies focused on GHGs from natural gas development and production processes
- Four studies evaluated production or post production activities/data and some GHG emission information
- One study had no emissions information
- Five studies estimated emissions from non-GHG emissions, however, information and data showed gaps:
  - No emission estimates for mixing operations and flowback fluids for non-hydraulically fractured wells
  - Two studies included emissions estimates for flowback fluids from hydraulically fractured wells
    - Inadequate information on basis for emissions (sampling, monitoring, empirical data)
    - Emission estimate methodologies not sufficiently detailed
  - Combustion equipment lacked information to quantify emissions (no activity data, equipment size, and emission factors)

TSD Section 4.2

- Estimates of methane, VOC, and HAPs during oil and gas well completions and recompletions
- Emissions based on using natural gas releases (from a previous GHG inventory) as a surrogate and percent composition of methane, VOC, and HAPs from data referenced in other sources

Table 4-4. Nationwide Baseline Emissions from Uncontrolled Oil and Gas Well Completions and Recompletions

Well Completion Category	Uncontrolled Methane Emissions per event (tpy)	Number of Uncontrolled Wells[a]	Baseline Nationwide Emissions (tons/year)[a]		
			Methane[b]	VOC[c]	HAP[d]
Natural Gas Well Completions without Hydraulic Fracturing	0.8038	7,694	6,185	902	66
Exploratory Natural Gas Well Completions with Hydraulic Fracturing	158.55	446	70,714	10,317	750
Developmental Natural Gas Well Completions with Hydraulic Fracturing	158.55	9,313	1,476,664	215,445	15,653
Oil Well Completions	0.0076	12,193	93	87	.008
Natural Gas Well Recompletions without Hydraulic Fracturing	0.0538	42,342	2,279	332	24
Natural Gas Well Recompletions with Hydraulic Fracturing	158.55	12,050	1,910,549	278,749	20,252
Oil Well Recompletions	0.00126	39,375	50	47	.004

TSD Section 4.2 *(Continued)*

- Specific emission sources not identified
- No PM or NOx emissions estimated
- No combustion equipment emissions estimated
- No direct measurement/sampling
- Did not include oil wells undergoing hydraulic fracturing
- EPA concluded that they lacked sufficient data on the emissions to set NSPS standards for hydraulically fractured oil wells

TSD Sections 5.2, 6.2, and 7.2

- Description of Sections 5.2, 6.2, and 7.2
  - Section 5.2: Emission estimates from pneumatic devices used in production, transmission, and storage of natural gas
  - Section 6.2: Emission estimates from compressors used in production, transmission, and storage of natural gas
  - Section 7.2: Emission estimates from storage tanks for oil and natural gas production
- Findings
  - No well drilling, completion or recompletion information
  - Not the focus of PR 1148.2

Environmental Defense Fund Study

- Focus on natural gas production and distribution network
- No information on drilling, completions, or reworks
- Estimated emissions from GHG emissions

Greater focus needed on methane leakage from natural gas infrastructure

Ramón A. Alvarez[a,1], Stephen W. Pacala[b,1], James J. Winebrake[c], William L. Chameides[d], and Steven P. Hamburg[e]

[a]Environmental Defense Fund, 301 Congress Ave Suite 1300, Austin, TX 78701; [b]Department of Ecology and Evolutionary Biology, 106A Guyot Hall, Princeton University, Princeton, NJ 08544; [c]College of Liberal Arts, Rochester Institute of Technology, Rochester, NY 14623; [d]School of the Environment, Duke University, Durham, NC 27708; and [e]Environmental Defense Fund, 18 Tremont Street, Boston, MA 02108

Contributed by Stephen W. Pacala, February 13, 2012 (sent for review December 21, 2011)

Natural gas is seen by many as the future of American energy: a fuel that can provide energy independence and reduce greenhouse gas emissions in the process. However, there has also been confusion about the climate implications of increased use of natural gas for electric power and transportation. We propose and illustrate the use of technology warming potentials as a robust and transparent way to compare the cumulative radiative forcing created by alternative technologies fueled by natural gas and oil or coal by using the best available estimates of greenhouse gas emissions from each fuel cycle (i.e., production, transportation and use). We find that a shift to compressed natural gas vehicles from gasoline or diesel vehicles leads to greater radiative forcing of the climate for 80 or 280 yr, respectively, before beginning to produce benefits. Compressed natural gas vehicles could produce climate benefits on all time frames if the well-to-wheels CH_4 leakage were capped at a level 45–70% below current estimates. By contrast, using natural gas instead of coal for electric power plants can reduce radiative forcing immediately, and reducing CH_4 losses from the production and transportation of natural gas would produce even greater benefits. There is a need for the natural gas industry and science community to help obtain better emissions data and for increased efforts to reduce methane leakage in order to minimize the climate footprint of natural gas.

With growing pressure to produce more domestic energy and to reduce greenhouse gas (GHG) emissions, natural gas is increasingly seen as the fossil fuel of choice for the United States as it transitions to renewable sources. Recent reports in the scientific literature and popular press have produced confusion about the climate implications of natural gas (1–5). On the one hand, a shift to natural gas is promoted as climate mitigation because it has lower carbon per unit energy than coal or oil (6). On the other hand, methane (CH_4), the prime constituent of natural gas, is itself a more potent GHG than carbon dioxide (CO_2); CH_4 leakage from the production, transportation and use of natural gas can offset benefits from fuel-switching.

The climatic effect of replacing other fossil fuels with natural gas varies widely by sector (e.g., electricity generation or transportation) and by the fuel being replaced (e.g., coal, gasoline, or diesel fuel), distinctions that have been largely lacking in the policy debate. Estimates of the net climate implications of fuel-switching strategies should be based on complete fuel cycles (e.g., "well-to-wheels") and account for changes in emissions of relevant radiative forcing agents. Unfortunately, such analyses are weakened by the paucity of empirical data addressing CH_4 emissions through the natural gas supply network, hereafter referred to as CH_4 leakage.* The U.S. Environmental Protection Agency (EPA) recently doubled its previous estimate of CH_4 leakage from natural gas systems (6).

In this paper, we illustrate the importance of accounting for fuel-cycle CH_4 leakage when considering the climate impacts of fuel-technology combinations. Using EPA's estimated CH_4 emissions from the natural gas supply, we evaluated the radiative forcing implications of three U.S.-specific fuel-switching scenarios: from gasoline, diesel fuel, and coal to natural gas.

A shift to natural gas and away from other fossil fuels is increasingly plausible because advances in horizontal drilling and hydraulic fracturing technologies have greatly expanded the country's extractable natural gas resources particularly by accessing gas stored in shale deep underground (7). Contrary to previous estimates of CH_4 losses from the "upstream" portions of the natural gas fuel cycle (8, 9), a recent paper by Howarth et al. calculated upstream leakage rates for shale gas to be so large as to imply higher lifecycle GHG emissions from natural gas than from coal (1). (*SI Text*, discusses differences between our paper and Howarth et al.) Howarth et al. estimated CH_4 emissions as a percentage of CH_4 produced over the lifecycle of a well to be 3.6–7.9% for shale gas and 1.7–6.0% for conventional gas. The EPA's latest estimate of the amount of CH_4 released because of leaks and venting in the natural gas network between production wells and the local distribution network is about 570 billion cubic feet for 2009, which corresponds to 2.4% of gross U.S. natural gas production (1.9–3.1% at a 95% confidence level) (6).† EPA's reported uncertainty appears small considering that its current value is double the prior estimate, which was itself twice as high as the previously accepted amount (9).

Comparing the climate implications of CH_4 and CO_2 emissions is complicated because of the much shorter atmospheric lifetime of CH_4 relative to CO_2. On a molar basis, CH_4 produces 37 times more radiative forcing than CO_2.‡ However, because CH_4 is oxidized to CO_2 with an effective lifetime of 12 yr, the integrated, or cumulative, radiative forcings from equi-molar releases of CO_2 and CH_4 eventually converge toward the same value. Determining whether a unit emission of CH_4 is worse for the climate than a unit of CO_2 depends on the time frame considered. Because accelerated rates of warming mean ecosystems and humans have less time to adapt, increased CH_4 emissions due to substitution of natural gas for coal and oil may produce undesirable climate outcomes in the near-term.

The concept of global warming potential (GWP) is commonly used to compare the radiative forcing of different gases relative

Author contributions: R.A.A., S.W.P., and S.P.H. designed research; R.A.A. performed research; R.A.A., S.W.P., and S.P.H. analyzed data; and R.A.A., S.W.P., J.J.W., W.L.C., and S.P.H. wrote the paper.

The authors declare no conflict of interest.

Freely available online through the PNAS open access option.

*Analogous uncertainties exist in the quantification of CH_4 emissions from the extraction of coal. We use the term "leakage" for simplicity and define it broadly to include all CH_4 emissions in the natural gas supply, both fugitive leaks as well as vented emissions.

†This represents an uncertainty range between ~19% and ~81% of natural gas system emissions. For CH_4 from petroleum systems (6% of which we assign to the natural gas supply) the uncertainty is ~24% to ~96%; however, this is only a minor effect because the portion of natural gas supply that comes from oil wells is less than 20%.

‡One-hundred-times on a mass basis. This value accounts for methane's direct radiative forcing and a 40% enhancement because of the indirect forcing by increased stratospheric water vapor (10).

§To whom correspondence may be addressed. E-mail: pacala@princeton.edu or ralvarez@edf.org.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1202407109/-/DCSupplemental.

Additional Comments Received

- Comment: Delay March Public Hearing for PR1148.2
  - Public Hearing moved from March 1 to April 5, 2013
- Comment: Public meetings needed in the communities affected by oil and gas operations
  - Two Public Consultation Meetings added on February 20, 2013 in Baldwin Hills and Wilmington
- Comment: PR1148.2 should include VOC and GHG emissions from storage/process tanks and H2S emissions from well operations
  - AQMD staff will investigate storage and collection operations through a sampling and monitoring program

Additional Comments Received *(Continued)*

- Comment: Include a 2 year sunset provision for PR 1148.2 for the entire rule
  - PR1148.2 includes a sunset provision for the reporting requirements
  - Governing Board can decide if they want to expand the sunset provision
- Comment: PR1148.2 is unnecessary and overly burdensome to industry – AQMD and industry can data share
  - Rulemaking provides greater accuracy, consistency, clarity, and timeliness of data gathering

Additional Comments Received *(Continued)*

- Comment: Sampling and monitoring plan is needed
  - AQMD staff developing initial concepts for sampling and monitoring plan
    - PM sampling
    - VOC and toxics sampling
    - H2S sampling
  - Use of portable analyzers to identify magnitude
  - More intensive monitoring if needed

Schedule

• Baldwin Hills Public Consultation Meeting	February 20, 2013, 2:00 PM West Church of God in Christ Multipurpose Building 3045 Crenshaw Blvd.
• Wilmington Public Consultation Meeting	February 20, 2013, 6:00 PM Wilmington Senior Citizen Center 1371 Eubank Ave. Wilmington, CA
• Working Group Meeting	March 6, 2013, 2:00 PM AQMD Headquarters, GB
• Stationary Source Committee	March 15, 2013
• Public Hearing	April 5, 2013