Tina Graham

Subject:	CER12017(31) Draft Decision on HLD of PSF consultation - Response from Rahima Sayer
Attachments:	Howarth_Climatic_Change_Shale_Methane1.pdf; Steingraber.pdf; SGEIS_Comments.pdf; Steingraber.pdf

TO Eamonn Murtagh

CER

The Exchange

Belgard Square North

Tallaght

Dublin 24

Rahima Sayer

Owengallis

Bawnboy

Co. Cavan

29TH march 2012

Dear Sir

I write to you with the following observations for the Draft Framework Regulatory Document for the Oil and gas industry in Ireland.

I note with disappointment that absent from the document is any reference to hydraulic fracturing or 'fracing' which is the subject of my observation.

The draft statement deals exclusively with offshore oil and gas exploration and extraction and sets out goals for regulating the industry after the permissioning has taken effect.

I am disappointed that the process known as fracing has no more than a mention considering the number of observations received from members of the general public at the previous consultation stage. It goes without saying that the Commission for Energy Regulation has been entrusted with the task of providing a safety standard and code of practice intended to safeguard members of the public and the environment in which they live. It is a constitutional right for all our citizens to be entitled to live in a safe environment with clean air to breathe, and clean water to drink. The very essence of life.

The CER has therefore been entrusted with a duty of care to the general public to act in their best interests and provide for the highest standards in order to safeguard the environment in which we live.

The unconventional practice of shale gas extraction via a process generally referred to as fracing represents a dangerous and volatile practice which can irrevocably alter our environment and compromise our well being. The provisions set out in the consultation document do not even begin to address the known consequences of this industry and the high levels of risk, which have become apparent in its practice.

Of particular concern to me is the exclusion of any components aimed at addressing the very specific circumstances which present in association with the industry's impact on health. In order to support my contentions in this regard and related issues to do with the safety and suitability of the industry's practice I attach a number of papers compiled by experts as part of the *consultative hearings which are currently forming part of a review of the industry in New York, where fracing has been placed under moratorium pending its investigation as a result of very serious identified impacts on water quality and human and animal health.*

"Methane gas emissions from Shale Gas Formations" by

Professor Robert Howarth, and Professor Anthony Ingraffea:

"Epidemiologic and Public Health Considerations of Shale Gas Production: The Missing Link", by Dr. Sandra Steingraber.

These professors are all associates of Cornell University and have been researching these serious matters for some time. I ask you to have regard to these papers which should be reflected in the design and criteria applied to the development of the Regulatory Framework

Currently there is no legislation in place that covers the identified hazards of this industry. I therefore request the CER to honour its responsibility according to the Safety Act to ensure the health and well being of all the citizens of Ireland. I also request that the CER requires a Health Impact Assessment as a mandatory requirement of the regulatory process in common with the experts in New York whom have set out this requirement for their own state.

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The consultation paper does not propose any specific criteria under which proposals from the industry for licensing will be assessed. This is clearly remiss and currently what is being proposed is to allow licensee applications to bring forward their own set of proposals for the making of a safety case. Against a backdrop where no international best practice has been *established for a controversial process in its infancy requiring the use of large volumes of unspecified chemicals. This is hardly a responsible approach to take. If the State of New York with all its resources and its background experience of the oil and gas industry finds itself in a position where it must adopt a moratorium pending investigation then clearly the Irish situation must be reflective of this anomaly and great care must be exercised in proceeding further in the absence of data which will safeguard public health and safety.*

Existing industries which are the main stay of Ireland, namely agriculture and tourism are highly vulnerable to a non regulated industry such as hydraulic fracturing and measures must be in place to safeguard these industries. The issue of water quality is essential and the requirement for its' safeguarding cannot be overstated.

I also refer you to Dr Howarth's Statement to the Assembly Committee on Environmental Conservation regarding the draft sGEIS for shale gas development in New York State.

Also the document 'Public Health Considerations of the Draft Supplemental Generic Environmental Impact Statement" submitted to the new York State Department of Environmental Conservation by the Physicians, Scientists and Engineers for Healthy Energy Group.

I ask that you have regard to this document.

Here to the legislation failed to meet the requirements posed by hydraulic fracturing and the impact on water safety. So I will require the CER to provide regulations that will safeguard a high level safety standard of water quality consistent with the requirements of the Drinking Water Directive.

I also request that the CER keeps the consultation process opened so that the public are facilitated in making further submissions and allowing for expert analysis of the process by outside independent qualified persons.

I was also disappointed that there was no reference to the Seveso 2 Directive and this surely must be a requirement for any licensing to be issued. Given the nature of the process and the specialized type of treatments which will be required in the event of a major release of methane or any incident which might occur involving the release of radioactive or toxic waste as a result of the operation of this process.

How will a major release of methane be dealt with?

Where are the specialized hospital facilities in any of the regions proposed for hydraulic fracturing going to be provided?

It is with extreme concern that I note the CER proposes well casing inspection every five years when it a very well known fact that concrete is known to degrade after four. This does not give me very much reassurance that the CER has enough factual understanding of this unconventional and non -traditional industry and its implications.

Thank you for your attention and I look forward to a further consultation and evaluation.

Yours sincerely

Rahima Sayer

Climatic Change
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LETTER

Methane and the greenhouse-gas footprint of natural gas from shale formations

A letter

Robert W. Howarth · Renee Santoro · Anthony Ingraffea

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Abstract We evaluate the greenhouse gas footprint of natural gas obtained by high-volume hydraulic fracturing from shale formations, focusing on methane emissions. Natural gas is composed largely of methane, and 3.6% to 7.9% of the methane from shale-gas production escapes to the atmosphere in venting and leaks over the life-time of a well. These methane emissions are at least 30% more than and perhaps more than twice as great as those from conventional gas. The higher emissions from shale gas occur at the time wells are hydraulically fractured—as methane escapes from flow-back return fluids—and during drill out following the fracturing. Methane is a powerful greenhouse gas, with a global warming potential that is far greater than that of carbon dioxide, particularly over the time horizon of the first few decades following emission. Methane contributes substantially to the greenhouse gas footprint of shale gas on shorter time scales, dominating it on a 20-year time horizon. The footprint for shale gas is greater than that for conventional gas or oil when viewed on any time horizon, but particularly so over 20 years. Compared to coal, the footprint of shale gas is at least 20% greater and perhaps more than twice as great on the 20-year horizon and is comparable when compared over 100 years.

Keywords Methane · Greenhouse gases · Global warming · Natural gas · Shale gas · Unconventional gas · Fugitive emissions · Lifecycle analysis · LCA · Bridge fuel · Transitional fuel · Global warming potential · GWP

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Many view natural gas as a transitional fuel, allowing continued dependence on fossil fuels yet reducing greenhouse gas (GHG) emissions compared to oil or coal over coming decades (Pacala and Socolow 2004). Development of "unconventional" gas dispersed in shale is part of this vision, as the potential resource may be large, and in many regions conventional reserves are becoming depleted (Wood et al. 2011). Domestic production in the U.S. was predominantly from conventional reservoirs through the 1990s, but by 2009 U.S. unconventional production exceeded that of conventional gas. The Department of Energy predicts that by 2035 total domestic production will grow by 20%, with unconventional gas providing 75% of the total (EIA 2010a). The greatest growth is predicted for shale gas, increasing from 16% of total production in 2009 to an expected 45% in 2035.

Although natural gas is promoted as a bridge fuel over the coming few decades, in part because of its presumed benefit for global warming compared to other fossil fuels, very little is known about the GHG footprint of unconventional gas. Here, we define the GHG footprint as the total GHG emissions from developing and using the gas, expressed as equivalents of carbon dioxide, per unit of energy obtained during combustion. The GHG footprint of shale gas has received little study or scrutiny, although many have voiced concern. The National Research Council (2009) noted emissions from shale-gas extraction may be greater than from conventional gas. The Council of Scientific Society Presidents (2010) wrote to President Obama, warning that some potential energy bridges such as shale gas have received insufficient analysis and may aggravate rather than mitigate global warming. And in late 2010, the U.S. Environmental Protection Agency issued a report concluding that fugitive emissions of methane from unconventional gas may be far greater than for conventional gas (EPA 2010).

Fugitive emissions of methane are of particular concern. Methane is the major component of natural gas and a powerful greenhouse gas. As such, small leakages are important. Recent modeling indicates methane has an even greater global warming potential than previously believed, when the indirect effects of methane on atmospheric aerosols are considered (Shindell et al. 2009). The global methane budget is poorly constrained, with multiple sources and sinks all having large uncertainties. The radiocarbon content of atmospheric methane suggests fossil fuels may be a far larger source of atmospheric methane than generally thought (Lassey et al. 2007).

The GHG footprint of shale gas consists of the direct emissions of CO_2 from end-use consumption, indirect emissions of CO_2 from fossil fuels used to extract, develop, and transport the gas, and methane fugitive emissions and venting. Despite the high level of industrial activity involved in developing shale gas, the indirect emissions of CO_2 are relatively small compared to those from the direct combustion of the fuel: 1 to 1.5 g C MJ^{-1} (Santoro et al. 2011) vs 15 g C MJ^{-1} for direct emissions (Hayhoe et al. 2002). Indirect emissions from shale gas are estimated to be only 0.04 to 0.45 g C MJ^{-1} greater than those for conventional gas (Wood et al. 2011). Thus, for both conventional and shale gas, the GHG footprint is dominated by the direct CO_2 emissions and fugitive methane emissions. Here we present estimates for methane emissions as contributors to the GHG footprint of shale gas compared to conventional gas.

Our analysis uses the most recently available data, relying particularly on a technical background document on GHG emissions from the oil and gas industry (EPA 2010) and materials discussed in that report, and a report on natural gas losses on federal lands from the General Accountability Office (GAO 2010). The

EPA (2010) report is the first update on emission factors by the agency since 1996 (Harrison et al. 1996). The earlier report served as the basis for the national GHG inventory for the past decade. However, that study was not based on random sampling or a comprehensive assessment of actual industry practices, but rather only analyzed facilities of companies that voluntarily participated (Kirchgessner et al. 1997). The new EPA (2010) report notes that the 1996 "study was conducted at a time when methane emissions were not a significant concern in the discussion about GHG emissions" and that emission factors from the 1996 report "are outdated and potentially understated for some emissions sources." Indeed, emission factors presented in EPA (2010) are much higher, by orders of magnitude for some sources.

1 Fugitive methane emissions during well completion

Shale gas is extracted by high-volume hydraulic fracturing. Large volumes of water are forced under pressure into the shale to fracture and re-fracture the rock to boost gas flow. A significant amount of this water returns to the surface as flow-back within the first few days to weeks after injection and is accompanied by large quantities of methane (EPA 2010). The amount of methane is far more than could be dissolved in the flow-back fluids, reflecting a mixture of fracture-return fluids and methane gas. We have compiled data from 2 shale gas formations and 3 tight-sand gas formations in the U.S. Between 0.6% and 3.2% of the life-time production of gas from wells is emitted as methane during the flow-back period (Table 1). We include tight-sand formations since flow-back emissions and the patterns of gas production over time are similar to those for shale (EPA 2010). Note that the rate of methane emitted during flow-back (column B in Table 1) correlates well to the initial production rate for the well following completion (column C in Table 1). Although the data are limited, the variation across the basins seems reasonable: the highest methane emissions during flow-back were in the Haynesville, where initial pressures and initial production were very high, and the lowest emissions were in the Uinta, where the flow-back period was the shortest and initial production following well completion was low. However, we note that the data used in Table 1 are not well documented, with many values based on PowerPoint slides from EPA-sponsored workshops. For this paper, we therefore choose to represent gas losses from flow-back fluids as the mean value from Table 1: 1.6%.

More methane is emitted during "drill-out," the stage in developing unconventional gas in which the plugs set to separate fracturing stages are drilled out to release gas for production. EPA (2007) estimates drill-out emissions at 142×10^3 to 425×10^3 m^3 per well. Using the mean drill-out emissions estimate of 280×10^3 m^3 (EPA 2007) and the mean life-time gas production for the 5 formations in Table 1 (85×10^6 m^3), we estimate that 0.33% of the total life-time production of wells is emitted as methane during the drill-out stage. If we instead use the average life-time production for a larger set of data on 12 formations (Wood et al. 2011), 45×10^6 m^3, we estimate a percentage emission of 0.62%. More effort is needed to determine drill-out emissions on individual formation. Meanwhile, in this paper we use the conservative estimate of 0.33% for drill-out emissions.

Combining losses associated with flow-back fluids (1.6%) and drill out (0.33%), we estimate that 1.9% of the total production of gas from an unconventional shale-gas

Table 1 Methane emissions during the flow-back period following hydraulic fracturing, initial gas production rates following well completion, life-time gas production of wells, and the methane emitted during flow-back expressed as a percentage of the life-time production for five unconventional wells in the United States

	(A) Methane emitted during flow-back (10^3 m^3)[a]	(B) Methane emitted per day during flow-back (10^3 m^3 day^{-1})[b]	(C) Initial gas production at well completion (10^3 m^3 day^{-1})[c]	(D) Life-time production of well (10^6 m^3)[d]	(E) Methane emitted during flow-back as % of life-time production[e]
Haynesville (Louisiana, shale)	6,800	680	640	210	3.2
Barnett (Texas, shale)	370	41	37	35	1.1
Piceance (Colorado, tight sand)	710	79	57	55	1.3
Uinta (Utah, tight sand)	255	51	42	40	0.6
Den-Jules (Colorado, tight sand)	140	12	11	?	?

Flow-back is the return of hydraulic fracturing fluids to the surface immediately after fracturing and before well completion. For these wells, the flow-back period ranged from 5 to 12 days

[a] Haynesville: average from Eckhardt et al. (2009); Piceance: EPA (2007); Barnett: EPA (2004); Uinta: Samuels (2010); Denver-Julesburg: Bracken (2008)

[b] Calculated by dividing the total methane emitted during flow-back (column A) by the duration of flow-back. Flow-back durations were 9 days for Barnett (EPA 2004), 8 days for Piceance (EPA 2007), 5 days for Uinta (Samuels 2010), and 12 days for Denver-Julesburg (Bracken 2008); median value of 10 days for flow-back was assumed for Haynesville

[c] Haynesville: http://shale.typepad.com/haynesvilleshale/2009/07/chesapeake-energy-haynesville-shale-decline-curve.html1/7/2011 and http://oilshalegas.com/haynesvilleshalestocks.html; Barnett: http://oilshalegas.com/barnettshale.html; Piceance: Kruuskraa (2004) and Henke (2010); Uinta: http://www.epmag.com/archives/newsComments/6242.htm; Denver-Julesburg: http://www.businesswire.com/news/home/20100924005169/en/Synergy-Resources-Corporation-Reports-Initial-Production-Rates

[d] Based on averages for these basins. Haynesville: http://shale.typepad.com/haynesvilleshale/decline-curve/); Barnett: http://www.aapg.org/explorer/2002/07jul/barnett_shale.cfm and Wood et al. (2011); Piceance: Kruuskraa (2004); Uinta: http://www.epmag.com/archives/newsComments/6242.htm

[e] Calculated by dividing column (A) by column (D)

Table 2 Fugitive methane emissions associated with development of natural gas from conventional wells and from shale formations (expressed as the percentage of methane produced over the lifecycle of a well)

	Conventional gas	Shale gas
Emissions during well completion	0.01%	1.9%
Routine venting and equipment leaks at well site	0.3 to 1.9%	0.3 to 1.9%
Emissions during liquid unloading	0 to 0.26%	0 to 0.26%
Emissions during gas processing	0 to 0.19%	0 to 0.19%
Emissions during transport, storage, and distribution	1.4 to 3.6%	1.4 to 3.6%
Total emissions	1.7 to 6.0%	3.6 to 7.9%

See text for derivation of estimates and supporting information

well is emitted as methane during well completion (Table 2). Again, this estimate is uncertain but conservative.

Emissions are far lower for conventional natural gas wells during completion, since conventional wells have no flow-back and no drill out. An average of 1.04×10^3 m^3 of methane is released per well completed for conventional gas (EPA 2010), corresponding to 1.32×10^3 m^3 natural gas (assuming 78.8% methane content of the gas). In 2007, 19,819 conventional wells were completed in the US (EPA 2010), so we estimate a total national emission of 26×10^6 m^3 natural gas. The total national production of onshore conventional gas in 2007 was 384×10^9 m^3 (EIA 2010b). Therefore, we estimate the average fugitive emissions at well completion for conventional gas as 0.01% of the life-time production of a well (Table 2), three orders of magnitude less than for shale gas.

2 Routine venting and equipment leaks

After completion, some fugitive emissions continue at the well site over its lifetime. A typical well has 55 to 150 connections to equipment such as heaters, meters, dehydrators, compressors, and vapor-recovery apparatus. Many of these potentially leak, and many pressure relief valves are designed to purposefully vent gas. Emissions from pneumatic pumps and dehydrators are a major part of the leakage (GAO 2010). Once a well is completed and connected to a pipeline, the same technologies are used for both conventional and shale gas; we assume that these post-completion fugitive emissions are the same for shale and conventional gas. GAO (2010) concluded that 0.3% to 1.9% of the life-time production of a well is lost due to routine venting and equipment leaks (Table 2). Previous studies have estimated routine well-site fugitive emissions as approximately 0.5% or less (Hayhoe et al. 2002; Armendariz 2009) and 0.95% (Shires et al. 2009). Note that none of these estimates include accidents or emergency vents. Data on emissions during emergencies are not available and have never, as far as we can determine, been used in any estimate of emissions from natural gas production. Thus, our estimate of 0.3% to 1.9% leakage is conservative. As we discuss below, the 0.3% reflects use of best available technology.

Additional venting occurs during "liquid unloading." Conventional wells frequently require multiple liquid-unloading events as they mature to mitigate water intrusion as reservoir pressure drops. Though not as common, some unconventional wells may also require unloading. Empirical data from 4 gas basins indicate that 0.02

to 0.26% of total life-time production of a well is vented as methane during liquid unloading (GAO 2010). Since not all wells require unloading, we set the range at 0 to 0.26% (Table 2).

3 Processing losses

Some natural gas, whether conventional or from shale, is of sufficient quality to be "pipeline ready" without further processing. Other gas contains sufficient amounts of heavy hydrocarbons and impurities such as sulfur gases to require removal through processing before the gas is piped. Note that the quality of gas can vary even within a formation. For example, gas from the Marcellus shale in northeastern Pennsylvania needs little or no processing, while gas from southwestern Pennsylvania must be processed (NYDEC 2009). Some methane is emitted during this processing. The default EPA facility-level fugitive emission factor for gas processing indicates a loss of 0.19% of production (Shires et al. 2009). We therefore give a range of 0% (i.e. no processing, for wells that produce "pipeline ready" gas) to 0.19% of gas produced as our estimate of processing losses (Table 2). Actual measurements of processing plant emissions in Canada showed fourfold greater leakage than standard emission factors of the sort used by Shires et al. (2009) would indicate (Chambers 2004), so again, our estimates are very conservative.

4 Transport, storage, and distribution losses

Further fugitive emissions occur during transport, storage, and distribution of natural gas. Direct measurements of leakage from transmission are limited, but two studies give similar leakage rates in both the U.S. (as part of the 1996 EPA emission factor study; mean value of 0.53%; Harrison et al. 1996; Kirchgessner et al. 1997) and in Russia (0.7% mean estimate, with a range of 0.4% to 1.6%; Lelieveld et al. 2005). Direct estimates of distribution losses are even more limited, but the 1996 EPA study estimates losses at 0.35% of production (Harrison et al. 1996; Kirchgessner et al. 1997). Lelieveld et al. (2005) used the 1996 emission factors for natural gas storage and distribution together with their transmission estimates to suggest an overall average loss rate of 1.4% (range of 1.0% to 2.5%). We use this 1.4% leakage as the likely lower limit (Table 2). As noted above, the EPA 1996 emission estimates are based on limited data, and Revkin and Krauss (2009) reported "government scientists and industry officials caution that the real figure is almost certainly higher." Furthermore, the IPCC (2007) cautions that these "bottom-up" approaches for methane inventories often underestimate fluxes.

Another way to estimate pipeline leakage is to examine "lost and unaccounted for gas," e.g. the difference between the measured volume of gas at the wellhead and that actually purchased and used by consumers. At the global scale, this method has estimated pipeline leakage at 2.5% to 10% (Crutzen 1987; Cicerone and Oremland 1988; Hayhoe et al. 2002), although the higher value reflects poorly maintained pipelines in Russia during the Soviet collapse, and leakages in Russia are now far less (Lelieveld et al. 2005; Reshetnikov et al. 2000). Kirchgessner et al. (1997) argue against this approach, stating it is "subject to numerous errors including gas theft, variations in temperature and pressure, billing cycle differences, and meter inaccuracies." With the exception of theft, however, errors should be randomly distributed and should not bias the leakage estimate high or low. Few recent data on lost and unaccounted gas are publicly available, but statewide data for Texas averaged 2.3% in 2000 and 4.9% in 2007 (Percival 2010). In 2007, the State of Texas passed new legislation to regulate lost and unaccounted for gas; the legislation originally proposed a 5% hard cap which was dropped in the face of industry opposition (Liu 2008; Percival 2010). We take the mean of the 2000 and 2007 Texas data for missing and unaccounted gas (3.6%) as the upper limit of downstream losses (Table 2), assuming that the higher value for 2007 and lower value for 2000 may potentially reflect random variation in billing cycle differences. We believe this is a conservative upper limit, particularly given the industry resistance to a 5% hard cap.

Our conservative estimate of 1.4% to 3.6% leakage of gas during transmission, storage, and distribution is remarkably similar to the 2.5% "best estimate" used by Hayhoe et al. (2002). They considered the possible range as 0.2% and 10%.

5 Contribution of methane emissions to the GHG footprints of shale gas and conventional gas

Summing all estimated losses, we calculate that during the life cycle of an average shale-gas well, 3.6 to 7.9% of the total production of the well is emitted to the atmosphere as methane (Table 2). This is at least 30% more and perhaps more than twice as great as the life-cycle methane emissions we estimate for conventional gas, 1.7% to 6%. Methane is a far more potent GHG than is CO_2, but methane also has a tenfold shorter residence time in the atmosphere, so its effect on global warming attenuates more rapidly (IPCC 2007). Consequently, to compare the global warming potential of methane and CO_2 requires a specific time horizon. We follow Lelieveld et al. (2005) and present analyses for both 20-year and 100-year time horizons. Though the 100-year horizon is commonly used, we agree with Nisbet et al. (2000) that the 20-year horizon is critical, given the need to reduce global warming in coming decades (IPCC 2007). We use recently modeled values for the global warming potential of methane compared to CO_2: 105 and 33 on a mass-to-mass basis for 20 and 100 years, respectively, with an uncertainty of plus or minus 23% (Shindell et al. 2009). These are somewhat higher than those presented in the 4th assessment report of the IPCC (2007), but better account for the interaction of methane with aerosols. Note that carbon-trading markets use a lower global-warming potential yet of only 21 on the 100-year horizon, but this is based on the 2nd IPCC (1995) assessment, which is clearly out of date on this topic. See Electronic Supplemental Materials for the methodology for calculating the effect of methane on GHG in terms of CO_2 equivalents.

Methane dominates the GHG footprint for shale gas on the 20-year time horizon, contributing 1.4- to 3-times more than does direct CO_2 emission (Fig. 1a). At this time scale, the GHG footprint for shale gas is 22% to 43% greater than that for conventional gas. When viewed at a time 100 years after the emissions, methane emissions still contribute significantly to the GHG footprints, but the effect is diminished by the relatively short residence time of methane in the atmosphere. On this time frame, the GHG footprint for shale gas is 14% to 19% greater than that for conventional gas (Fig. 1b).

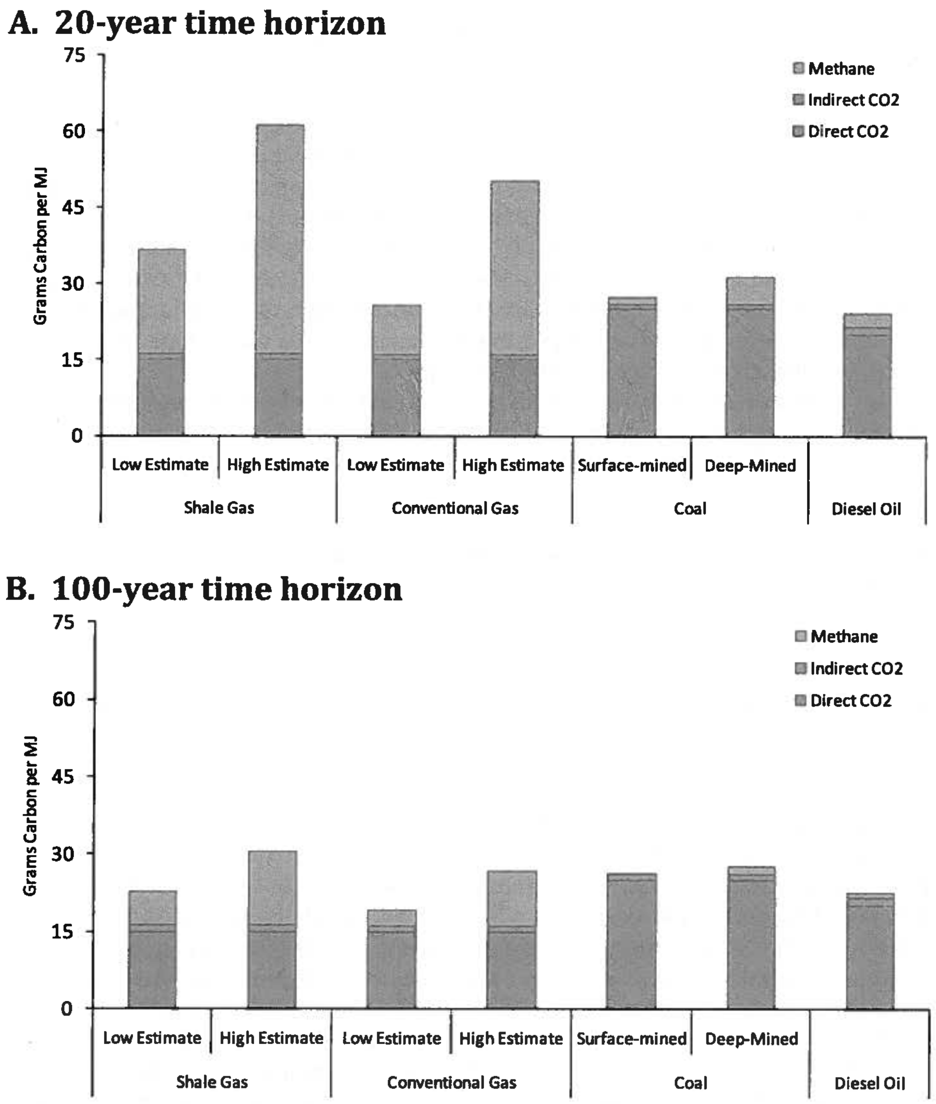

Fig. 1 Comparison of greenhouse gas emissions from shale gas with low and high estimates of fugitive methane emissions, conventional natural gas with low and high estimates of fugitive methane emissions, surface-mined coal, deep-mined coal, and diesel oil. **a** is for a 20-year time horizon, and **b** is for a 100-year time horizon. Estimates include direct emissions of CO_2 during combustion (*blue bars*), indirect emissions of CO_2 necessary to develop and use the energy source (*red bars*), and fugitive emissions of methane, converted to equivalent value of CO_2 as described in the text (*pink bars*). Emissions are normalized to the quantity of energy released at the time of combustion. The conversion of methane to CO_2 equivalents is based on global warming potentials from Shindell et al. (2009) that include both direct and indirect influences of methane on aerosols. Mean values from Shindell et al. (2009) are used here. Shindell et al. (2009) present an uncertainty in these mean values of plus or minus 23%, which is not included in this figure

6 Shale gas versus other fossil fuels

Considering the 20-year horizon, the GHG footprint for shale gas is at least 20% greater than and perhaps more than twice as great as that for coal when expressed per quantity of energy available during combustion (Fig. 1a; see Electronic Supplemental Materials for derivation of the estimates for diesel oil and coal). Over the 100-year frame, the GHG footprint is comparable to that for coal: the low-end shale-gas emissions are 18% lower than deep-mined coal, and the high-end shale-gas emissions are 15% greater than surface-mined coal emissions (Fig. 1b). For the 20 year horizon, the GHG footprint of shale gas is at least 50% greater than for oil, and perhaps 2.5-times greater. At the 100-year time scale, the footprint for shale gas is similar to or 35% greater than for oil.

We know of no other estimates for the GHG footprint of shale gas in the peer-reviewed literature. However, we can compare our estimates for conventional gas with three previous peer-reviewed studies on the GHG emissions of conventional natural gas and coal: Hayhoe et al. (2002), Lelieveld et al. (2005), and Jamarillo et al. (2007). All concluded that GHG emissions for conventional gas are less than for coal, when considering the contribution of methane over 100 years. In contrast, our analysis indicates that conventional gas has little or no advantage over coal even over the 100-year time period (Fig. 1b). Our estimates for conventional-gas methane emissions are in the range of those in Hayhoe et al. (2002) but are higher than those in Lelieveld et al. (2005) and Jamarillo et al. (2007) who used 1996 EPA emission factors now known to be too low (EPA 2010). To evaluate the effect of methane, all three of these studies also used global warming potentials now believed to be too low (Shindell et al. 2009). Still, Hayhoe et al. (2002) concluded that under many of the scenarios evaluated, a switch from coal to conventional natural gas could aggravate global warming on time scales of up to several decades. Even with the lower global warming potential value, Lelieveld et al. (2005) concluded that natural gas has a greater GHG footprint than oil if methane emissions exceeded 3.1% and worse than coal if the emissions exceeded 5.6% on the 20-year time scale. They used a methane global warming potential value for methane from IPCC (1995) that is only 57% of the new value from Shindell et al. (2009), suggesting that in fact methane emissions of only 2% to 3% make the GHG footprint of conventional gas worse than oil and coal. Our estimates for fugitive shale-gas emissions are 3.6 to 7.9%.

Our analysis does not consider the efficiency of final use. If fuels are used to generate electricity, natural gas gains some advantage over coal because of greater efficiencies of generation (see Electronic Supplemental Materials). However, this does not greatly affect our overall conclusion: the GHG footprint of shale gas approaches or exceeds coal even when used to generate electricity (Table in Electronic Supplemental Materials). Further, shale-gas is promoted for other uses, including as a heating and transportation fuel, where there is little evidence that efficiencies are superior to diesel oil.

7 Can methane emissions be reduced?

The EPA estimates that 'green' technologies can reduce gas-industry methane emissions by 40% (GAO 2010). For instance, liquid-unloading emissions can be greatly reduced with plunger lifts (EPA 2006; GAO 2010); industry reports a 99% venting reduction in the San Juan basin with the use of smart-automated plunger lifts (GAO 2010). Use of flash-tank separators or vapor recovery units can reduce dehydrator emissions by 90% (Fernandez et al. 2005). Note, however, that our lower range of estimates for 3 out of the 5 sources as shown in Table 2 already reflect the use of best technology: 0.3% lower-end estimate for routine venting and leaks at well sites (GAO 2010), 0% lower-end estimate for emissions during liquid unloading, and 0% during processing.

Methane emissions during the flow-back period in theory can be reduced by up to 90% through Reduced Emission Completions technologies, or REC (EPA 2010). However, REC technologies require that pipelines to the well are in place prior to completion, which is not always possible in emerging development areas. In any event, these technologies are currently not in wide use (EPA 2010).

If emissions during transmission, storage, and distribution are at the high end of our estimate (3.6%; Table 2), these could probably be reduced through use of better storage tanks and compressors and through improved monitoring for leaks. Industry has shown little interest in making the investments needed to reduce these emission sources, however (Percival 2010).

Better regulation can help push industry towards reduced emissions. In reconciling a wide range of emissions, the GAO (2010) noted that lower emissions in the Piceance basin in Colorado relative to the Uinta basin in Utah are largely due to a higher use of low-bleed pneumatics in the former due to stricter state regulations.

8 Conclusions and implications

The GHG footprint of shale gas is significantly larger than that from conventional gas, due to methane emissions with flow-back fluids and from drill out of wells during well completion. Routine production and downstream methane emissions are also large, but are the same for conventional and shale gas. Our estimates for these routine and downstream methane emission sources are within the range of those reported by most other peer-reviewed publications inventories (Hayhoe et al. 2002; Lelieveld et al. 2005). Despite this broad agreement, the uncertainty in the magnitude of fugitive emissions is large. Given the importance of methane in global warming, these emissions deserve far greater study than has occurred in the past. We urge both more direct measurements and refined accounting to better quantify lost and unaccounted for gas.

The large GHG footprint of shale gas undercuts the logic of its use as a bridging fuel over coming decades, if the goal is to reduce global warming. We do not intend that our study be used to justify the continued use of either oil or coal, but rather to demonstrate that substituting shale gas for these other fossil fuels may not have the desired effect of mitigating climate warming.

Finally, we note that carbon-trading markets at present under-value the greenhouse warming consequences of methane, by focusing on a 100-year time horizon and by using out-of-date global warming potentials for methane. This should be corrected, and the full GHG footprint of unconventional gas should be used in planning for alternative energy futures that adequately consider global climate change.

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Taking the Handle Off the Fracking Pump:

Human Rights and the Role of Public Health Inquiry

in an Age of Extreme Fossil Fuel Extraction

plenary presentation
"Epidemiologic and Public Health Considerations
of Shale Gas Production: The Missing Link"
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Summary

Horizontal hydrofracking is a form of fossil fuel extraction that turns the earth inside out. It buries a surface resource that is vital to life (fresh water) and brings to the surface subterranean substances (hydrocarbons, radioactive materials, heavy metals, brine) that were once locked away in deep geological strata and which now require permanent containment.

Before it is sent down the borehole, the fresh water used to fracture bedrock is mixed with inherently toxic materials. These include known and suspected carcinogens, neurological toxicants, and chemicals linked to pregnancy loss. At least one thousand truck trips are required to frack a single well. These trucks—along with earth-moving equipment, compressors, and condensers—release or create soot, volatile organic compounds, and ozone. Exposure to this kind of air pollution has demonstrable links to asthma, stroke, heart attack, cancers, and preterm birth.

As the shale gas boom sweeps eastward into densely populated areas already struggling with air pollution and whose rivers provide drinking water for millions, public health inquiry is desperately needed to explicate the cumulative health impacts of fracking and to quantify their economic costs.

This talk explores the human rights dimensions of fracking and the role of public health

research within that context. Of particular interest will be the ethical question of conducting such research in communities whose residents may be serving, in effect, as involuntary subjects in an ongoing, uncontrolled experiment. How does our moral obligation to prevent harm square with attempts to monitor the evidence for harm? What is the relationship between mitigation and prevention? When does research serve to sanction and legitimize polluting activities, and when does it challenge them?

* * *

[The below text is an expanded version of remarks delivered at the conference.]

Thank you for that kind introduction, Adam. It's an honor to be with you here today.

Behind every data point in epidemiology there is a human life. My intention today is to focus us on the human lives damaged by the technology known as horizontal hydrofracking and ask what role science can play in stopping that damage.

I have only two visual aids. The first is this portrait of Craig and Julie Sautner of Dimock, Pennsylvania. As you can see, they are holding up a bottle of water full of a brownish, murky fluid. This is water drawn from their own drinking water well.

Julie and Craig are, right now, in the center of a media maelstrom, and you may have heard some their story over the last week. Here is a summary: in 2008, the Sautners leased 3.5 acres of land to a gas drilling company. Shortly after the drilling started, their water turned cloudy, smelly, and bubbly. According to Pennsylvania state officials, the drilling company contaminated their water. The company contests this conclusion but nevertheless agreed to truck in water for three years to the Sautners' house until November 30 of this year when Pennsylvania regulators declared the water okay to drink.

The Sautners believe their water is not okay—citing the results of water testing which show the presence of lead, arsenic, methoxyethanol, and phthalates—and continued to receive a patchwork of water deliveries through December from a variety of sympathetic organizations, including Sierra Club, Water Defense, and the City of Binghamton, New York across the border.[1]

The Environmental Protection Agency (EPA) has had a puzzling involvement since early December. First, the agency declared that there was no evidence of water contamination from fracking operations. It then reversed course on January 5, declaring, according to the Sautners's account, that yes, there is a reason for concern and we will provide replacement water. Last Saturday, the EPA reversed course again, abruptly announcing that no water would be delivered after all.

Craig's reaction as reported in the press was to say, "You can't be playing with people's lives like this."[2]

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[1] N. Banerjee, "Landowners Left out of the Loop on 'Fracking' Risks," *Los Angeles Times*, 12 Dec. 2011; P. Bertrand, "EPA Revisiting, Announces Gaps in Dimock, PA Water Data," *International Business Times*, 6 Jan. 2012.
[2] M. Rubinkam, "Federal Agency Cancels Water Delivery to Pa. Town," Associated Press, 7 Jan. 2012.

This photo was not taken in Dimock, Pennsylvania but in my own village of Trumansburg, New York, which, in December 2010, sponsored a public teach-in on the environmental, economic and public health consequences of horizontal hydrofracking.

I was one of the presenters, too, but it was really the Sautners who stole the show that night with their plainspoken words, obvious love for the place they call home, and tangible grief for its ruination.

Trumansburg has since gone on to become one of more than 50 towns in upstate New York that passed a local ban on fracking even though the gas companies say we have no authority to do so, pointing out that only states can regulate energy extraction.[3] Our response has been, *Oh, maybe you didn't understand. We are not regulating you. We are banning you. We have zoned you out. You are not part of our comprehensive plan for ourselves.*

Such declarations have triggered lawsuits from the energy industry. One of them targets a nearby community on the other side of Cayuga Lake: the little town of Dryden is being sued by Denver-based Anschutz Exploration Corporation over its own local fracking ban.[4] In response, my town is filing an amicus brief in support of Dryden and its town attorney. To pay for the costs, we are hosting a fundraising party at the village bar at the end of this month.

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[3] Legal assistance for implementing local bans on fracking in upstate New York is provided by the non-profit organization Community Environmental Legal Defense Council, Inc. www.cedclaw.org. According to Keuka Citizens Against Hydrofracking, 54 upstate New York communities have enacted bans or moratoriums on fracking, as of January 2012. Binghamton, Albany, Syracuse, and Buffalo are the major upstate cities on the list. http://www.r-cause.net/bans--moratoria-local--global.html.

[4] A. Munzer, "Dryden Defends Gas Ban in State Supreme Court," http://www.pressconnects.com/article/20111104/NEWS01/111040380/Dryden-defends-gas-ban-State-Supreme-Court

The Anschutz Exploration Corporation is owned by Philip Anschutz, who, according to *Forbes*, is the 34th richest person in the United States.

Philip Anschutz has a net worth of $7 billion.

And so we stand, outlawyered and outbankrolled, before a line of tanks in Tiananmen Square.

But, right now, our local fracking ban still holds, and I truly believe it all began not because I, a Ph.D. biologist or Tony Ingraffea, a Ph.D. geological engineer, laid out the scientific evidence for harm but because of the testimony of these two brave people.

Here is one of my vivid memories from that night. On the way to the teach-in at our local public school auditorium, Craig looked out the window of the car in which we were both riding—at the shale creekbeds and farm fields and orchards and vineyards and the blue hills of Tompkins County—and remarked, "You have such a pretty country here. Don't let them frack it."

Forty percent of the land in Tompkins County, New York is leased to the gas companies. Fourteen percent of the acreage within my village is under lease.[5]

I made a promise to myself that night not just to study the problem and not just to work on mitigating the harm from the problem but to try to STOP the problem. As part of that effort, I took an exploratory research trip out west last summer and visited communities affected by fracking in New Mexico, Montana, North Dakota, and Utah. I spoke with mayors, ranchers, and scientists. And everywhere I went, I heard the same message: *You can't regulate away the dangers of fracking. This just has to stop.*

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5 The Marcellus Accountability Project for Tompkins County, http://www.tcgasmap.org/

I happened to be in Salt Lake City in July on the day that University of Utah graduate student Tim DeChristopher was sentenced to prison for disrupting, three years earlier, the auction of public lands for gas and oil drilling. Tim had participated in the auction as a bidder and indeed won many bids—but without the millions of dollars in his bank account needed to make the purchase. The publicity surrounding his actions served as a spotlight, ultimately revealing that the auctioning of these lands was actually illegal in the first place. The winning bids were declared null and void. So his actions really did stop fracking.

But that outcome did not prevent Tim from being charged with fraud. On July 26, 2011, he was sentenced to two years in federal prison. I was at the courthouse when it happened. In the most extraordinary moment, Tim said to the judge, "This is what love looks like."

Not long after, while still in Utah, I received a phone call from Teresa Heinz Kerry, letting me know that I was one of this year's lucky recipients of a Heinz Award for my research and writing on environmental health. Inspired by the words of Craig and Julie Sautner and by the actions of Tim DeChristopher, I decided to donate the award—which comes with a $100,000 cash prize—to the fight against fracking in upstate New York where a temporary moratorium on fracking is about to expire.

So, I'd like to thank Julie and Craig for bringing me here today. They are truly enacting Tim DeChristopher's words: *This is what love looks like.* Julie and Craig, too, exist in a kind of prison— the awful limbo of being unable to sell their house and move but also unable to live safely there. When a home is not safe, it is no longer a home. And so they travel from town to town, telling their cautionary tale so that other communities, maybe my own, does not end up with water that looks like that stuff.

This is what love looks like. I've brought with me today a letter that I've drafted to EPA chief Lisa Jackson that I hope you all will consider signing on to. It asks her to continue the investigation into the contamination of the Sautners' water supply—along with that of their neighbors—and in the meantime, to provision them with a reliable supply of clean water. Wes Gillingham of Catskill Mountainkeepers will be circulating around with clipboards.[6] [Letter is attached.]

* * *

I want to suggest a conceptual framework for thinking about the environmental crisis as a human rights crisis. I'll submit that the environmental crisis is actually two crises that, like a tree with two trunks, share a common root.

One trunk represents what is happening to our planet through the accumulation of heat-trapping gases in the atmosphere. If you follow this trunk along, you encounter endpoints such as droughts, floods, dissolving coral reefs, and the fact that 1 in every 4 mammal species is headed for extinction.

The other trunk represents what is happening to us through the accumulation of inherently toxic chemical pollutants in our bodies. If you follow this trunk along, you find asthma, pediatric cancers, early puberty, learning disabilities, and testicular dysgenesis syndrome.

The root of this tree is dependency on fossil fuels. When we light them on fire, their combustion byproducts—mainly carbon dioxide—or their uncombusted fugitive emissions—mainly methane—become greenhouse gases. When we use fossil fuels as feedstocks for petrochemicals, we create toxic substances that tinker with cell-signaling pathways and alter gene expression in ways that place cells on the pathway to tumor formation, otherwise contribute to chronic illness, or alter the course of development.

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6 This letter was signed by 26 physicians and health professionals attending the PSE conference. www.protectingourwaters.wordpress.com. At a January 13 press conference at the Academy of Nature Sciences in Philadelphia, Administrator Jackson said that the EPA needed more data on Dimock's water. http://stateimpact.npr.org/pennsylvania/2012/01/13/epa-chief-says-krancers-letter-wont-help-dimock-residents/

We tend to think of natural gas solely as a greenhouse gas, but, in fact, it is also the starting point for plastics, such as polyvinyl chloride (PVC), and farm chemicals, such as anhydrous ammonia. The credit cards in our wallets (PVC) began as bubbles of methane in deep geological strata.

So there are two connected crises, but they are populated by two somewhat disconnected groups of scientists and activists.

The climate change world is largely occupied by men. Its inspiring leaders include NASA climatologist James Hansen, journalist Bill McGibben, ecologist Carl Safina, and the aforementioned climate activist Tim DeChristopher. The time period of interest is the future and the human rights issue of concern is known as *generational inequity*. In the words of Carl Safina, we are eating the lunch of those who come after us and they will not likely forgive us for our reckless addiction to fossils.

Of course, the future keeps arriving, and now the World Health Organization has identified climate change as the biggest public health threat *to children alive today*: those "future generations" to which we are being so inequitable turn out to be the kids who sit across the dinner table from us every evening.

The world of toxic trespass and chemical reform activism is largely populated by women, with Rachel Carson and Lois Gibbs as guiding spirits. This movement looks to the past—at chemicals brought to market years ago without any advance testing or demonstration of safety that are now being implicated in human harm. The human rights issues of concern here are the right to bodily integrity and the right to free, prior, and informed consent.[7]

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[7] T. Kerns, *A Human Rights Assessment of Hydraulic Fracturing for Natural Gas*, Environment and Human Rights Advisory, Dec. 12, 2011.

In an age of extreme fossil fuel extraction, both crises are getting worse. With easy-to-get fossil fuels already gotten, the energy industry is pursuing a path of unconventional energy extraction, which is both more toxic and more carbon-intense. Extreme energy takes four forms: mountaintop removal (coal); tar sands (oil); deep sea drilling (oil); and fracking (natural gas).

Because there are two parallel crises, there are also two parallel scientific arguments about fracking. Both have public health consequences, but they exist in different spheres. The first concerns the greenhouse gas footprint of fracking. It's clear that natural gas, when burned, produces half the carbon dioxide of coal. But it's also clear that natural gas obtained by the fracturing of horizontal layers of shale is accompanied by much higher fugitive methane emissions than natural gas extracted through conventional (vertical) drilling. Methane is more than twenty times more powerful than carbon dioxide at trapping heat. But methane has a much shorter lifespan (two decades) than carbon dioxide, which can linger in the atmosphere for a century. So in a life-cycle analysis, how does the carbon footprint of gas compare to that of coal? Here's where arguments fly. Robert Howarth and Anthony Ingraffea—systems ecologist and geological engineer at Cornell—argue that, unit for unit, natural gas is just as bad, if not worse, than coal, when examined over a twenty-year time frame. Other Cornell scientists, led by geologist Lawrence Cathles, disagree, arguing that gas actually has one-half to one-third of the heat-trapping potential of coal if you assume lower leakage rates and change the time frame from twenty to one hundred years.[8]

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[8] R.W. Howarth, et al., "Methane and the Greenhouse-gas Footprint of Natural Gas from Shale Formations," letter, Climatic Change, 2011. http://www.sustainablefuture.cornell.edu/news/attachments/Howarth-EtAl-2011.pdf L. Cathles, III et al., "A Commentary on 'The Greenhouse-gas Footprint of Natural Gas from Shale Formations' by R.W. Howarth, R. Santoro, and Anthony Ingraffea," *Climatic Change*, 2012. http://www.springerlink.com/content/x001g12t2332462p/fulltext.pdf

I support Howarth and Ingraffea in this debate—they have the superior presumptions and methodology—but the whole dispute lacks grounding in the real world. We are fighting about how many carbon atoms can dance on the head of a pin.

In the real world, we have no energy plan. There is no deal to swap out coal for gas. It's possible, and likely, that we'll frack the whole Marcellus Shale and keep blowing up the mountains of Kentucky, too. We could, for example, keep the lights on with coal and sell the gas for export—to China or to Europe—where the prices are higher. The proposed plan to store liquefied petroleum gas in the old salt caverns under Seneca Lake—just down the road from where my son was born—indicates that such an outcome is not far-fetched. Or we could direct the excess gas into the chemical industry and make more PVC floor tiles or more synthetic fertilizer. Without a plan for carbon, the markets will have their own way with it.

The second real-world problem of the coal versus gas debate is that ignores the damage done in extracting the quarry. Fracking literally turns the earth inside out. It is a shock and awe operation. Fracking involves the massive movement of materials across state lines: millions of tons of sand, which are mined from open pits; billions of gallons of water, which exit the water cycle; millions of pounds of toxic chemicals; millions of tons of radioactive drill cuttings; billions of gallons of brine and wastewater; millions of diesel trucks; thousands of compressors and condensers; thousands of miles of pipeline. The amount of fracking wastewater from New York State alone, under the proposed build-out scenario, would exceed 62 billion gallons. It's radioactive and full of brine, heavy metals, and carcinogenic hydrocarbons. The technology does not exist to turn it back into drinkable water. Sixty-two billion gallons is the amount of water that flows over Niagara Falls in 35 hours. And it will all have to be safely contained. Forever.

Here's an interesting mental exercise: suppose that shale gas were completely carbon-free. Would we still want to blow up our bedrock. . . and pump it full of toxic chemicals. . . and fill the air with smog. . .and generate a Niagara Falls of toxic fluid in order to get it?

Fracking risks public health injury at every step. Open-pit mining of frack sand in the Midwest is flattening the sandhills of Wisconsin, Minnesota, and Illinois and sending silica dust—a lung carcinogen—into the air of rural communities. The siting of drill pads in forests fragments habitats, compresses soil, and contributes to sedimentation of surface waters. When chlorinated, water full of sediment will generate trihalomethanes (disinfection byproducts), which function as bladder and colon carcinogens. Trihalomethane exposures is also linked to pregnancy loss. Meanwhile, the deep-well injection of wastewater is linked to earthquakes in Ohio, Arkansas, and the United Kingdom. The drill cuttings contain radium-226, which has a half-life of 1,600 years. Fracking is invariably accompanied by increases in smog, soot, and criteria air pollutants. These are linked to asthma, cancer, stroke, heart attack, premature birth, and premature death.

So the debate about fracking goes way beyond coal versus gas.

On the other hand, those of us who focus on chemical threats and exposure pathways too often ignore the public health dimensions of climate change. The climate experts say that we need a very rapid phase-out of *all* fossil fuels to avert human calamity. Let me just mention one element of that calamity: loss of pollinators. As seasonal temperatures become decoupled from day length, pollination systems that rely on the synchronicity of bees and flowers start to falter.

Insect pollinators provide one-third of the United States' food supply and are responsible for all nuts, berries, and melons, and many tree fruits and vegetables.

For this reason and many others, climate scientists tell us we need to get on a war footing basis vis a vis carbon, and yet many of us are busy advocating for the *mitigation* of the chemical contamination risks posed by natural gas through *best practices* and *monitoring* of health impacts. As though shale gas extraction were simply inevitable, a foregone conclusion, a *fait accompli.*

If you see fracking as a resistance-is-futile, unstoppable force, then your goals are: chemical disclosure, health registries, before and after groundwater monitoring, and closed-loop systems. This is the kind of scientific involvement that can easily legitimize fracking. If, on the other hand, you see fracking as a human rights violation, then you are morally obligated as a scientist to speak out forcefully against it and to turn scientific inquiry into a force for public health protection.

My least favorite word from the world of fracking is *mitigate*. That word actually has two meanings. It's usually used in its first sense: "to make less bad." To mitigate the effects of fracking means to make them less harmful. Mitigated fracking may indeed kill fewer people than unmitigated fracking. But it still kills more people than no fracking. And killing people is still wrong.

The other meaning of mitigate is "to partly excuse a crime."

Think about that.

When scientists are studying the problem—setting up registries, and monitoring air and water—people relax. Not because they are actually being protected but because scientists and public health officials are on the job, actively monitoring the situation and collecting data. So, conflating detection with prevention, everybody feels safer. (I sometimes call this the "mammogram fallacy.")

Let's look at some of the tools of mitigation. What do they accomplish? If we disallow open pits for wastewater, less benzene evaporates into the air. But more benzene is contained in the wastewater that is buried, say, via deep well injection in Ohio. Sooner or later, that may find its way to the surface and poison people. We are just delaying its release.

What if we insist on recycling the fracking wastewater and reusing it to frack new wells? It's too briny and toxic to use as is, so it must be filtered or distilled. Filtration and distillation of millions of gallons of toxic fluid require massive amounts of energy—thus generating more air pollution and adding to the carbon footprint of gas—and the leftover sludge still has to be buried somewhere, but now the contaminants and radioactivity are even more concentrated.

Newton's laws still apply. Mitigation can't make toxic matter disappear. It just transfers it from one place to another.

The more we insist on setbacks, the more we push drill pads away from our populated areas into forested lands, the fragmentation and clearing of which sends sediment into surface waters. Chlorinating water full of sediment makes trihalomethanes. Sooner or later, people in downstream communities drink them and some of them go on to get bladder and colon cancers.

The more we insist on triple casings around well bores, the longer we delay their eventual corrosion and leakage. So instead of exposing our own kids to carcinogens, we expose our great-grandchildren. According to data gathered by biochemist Ron Bishop of SUNY Oneonta, half of all gas well casings leak within fifteen years. Repeatedly exposed to corrosive fluids on the inside and not bonded to the surrounding rock on the outside, wells can even continue to leak years after they are inactivated and plugged. In this way, wells can create portals of contamination between fracked shale and the overlying groundwater aquifers they penetrate.[9]

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[9] R.E. Bishop, *History of Oil and Gas Well Abandonment in New York*, Sustainable Otsego, 8 Jan. 2012. See also Paul A. Rubin's report for Delaware Riverkeeper Network: "Boreholes advanced for gas exploration breach key geologic confining beds that formed over millions of years and naturally separate deep saline waters from overlying freshwater aquifers. While the gas industry is actively researching and advancing concrete formulations to seal deep chemical-rich horizons from freshwater aquifers, the life of concrete subjected to harsh downhole conditions is probably less than 100 years—only about 0.01 percent of the life of a Basin aquifer." P.W. Rubin, "Report for the Delaware River Basin Commission on Natural Gas Development Regulations, December 9, 2010 Article 7 of Part III—Basin

Mitigation strategies make fracking seem less destructive than it really is.

Mitigation builds time bombs with longer fuses.

To advocate for mitigation is to sanction gas drilling.

* * *

I want to turn now to the title of this talk—taking the handle off the fracking pump. It's reference to John Snow, who is undoubtedly a figure known to all in this room. Snow is the English physician who stopped a cholera epidemic in 1854 in the Soho area of London by acting on correlative data. Based on maps of disease cases, he correctly guessed that a particular water well on Broad Street was the culprit. He convinced authorities to intervene, taking off the handle off the pump and disabling the well. The disease outbreak ebbed.

Interestingly, the chemical analysis and microscopic evidence was negative. The tools of science available at the time were too blunt to prove the connection, so Snow had to act on statistical evidence alone.

Only later did he learn that the Broad Street well was located a few feet from an old, forgotten sewage drain whose brick casing had crumbled.[10] In essence, the drinking water had been contaminated by an unmapped, leaking disposal well.

Here's another detail of the story that's interesting to me: government officials eventually replaced the pump handle and reactivated the well. They were unable to

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Regulations," (Stone Ridge, NY: Hydroquest, 9 April 2011). http://hydroquest.com/DRBCfigures/

[10] H. Brody et al., "Map-Making and Myth-Making in Broad Street: The London Cholera Epidemic, 1854," *Lancet* 356 (2000): 64-84.

accept the implications of Snow's underlying theory: namely, that cholera is transmitted by waterborne pathogens from human feces. Reviewers of his book were likewise unconvinced. In the language of the day: "There is, in our view, an entire failure of proof that the occurrence of any one case could be clearly and unambiguously assigned to water."[11]

How will future generations look back on us? People alive one hundred years from now might well might ask, *Why, in a time of environmental emergency, were they running around trying to blast methane out of the earth? Were they just unable accept the idea that the whole fossil fuel party needed to end?*

So how do we become the John Snows of fracking?

First, I'd like to underscore something Dr. Paulson said this morning. Namely, that we need to recognize that we are playing a part in an old, old script. The characters have changed—cholera, lead paint, tobacco, asbestos—but the lines are the same. We are going to be asked over and over again about proof. And about how we don't have it. And about how more research is needed.

Here we need to explain that science is slow and studies are often contradictory. We can say that the justifiable reluctance of scientists to reach conclusions in the absence of large sample sizes, corroborating evidence, and statistical significance and stability is why the Precautionary Principle was developed. In the words of David Gee of the European Environment Agency, the goal of precaution is to prevent the construction of "pipelines of unstoppable consequences," in situations of high uncertainty, high stakes, and high levels of ignorance.[12]

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[11] John Snow Society. www.johnsnowsociety.org/johnsnow/facts.html.

[12] D. Gee, *Late Lessons from Early Warnings: The Precautionary Principle 1896-2000*, European Environment Agency, Environmental Issue Report No. 22, 2001. http://www.eea.europa.eu/publications/environmental_issue_report_2001_22/issue-22-part-00.pdf. Here in the United States, the Science and Environmental Health

Fracking meets all of those criteria. While the wheels of scientific proofmaking grind slowly on, benefit of the doubt goes to public health, not to the things that threaten it. We can assert that the burden of proof is not ours to bear.

And then we need to bring the conversation directly back to the human rights issues: Fracking is a vast human experiment whose study subjects did not volunteer. As fracking moves east from sparcely populated western states to the shores of the Delaware River (whose watershed provides drinking water for 15 million people), we are enrolling ever more study subjects every week. We don't know what the results will be. This is unethical.

The veterinary scientist Michelle Bamberger takes this approach in her new study, "The Impact of Gas Drilling on Human and Animal Health." She writes, "Communities living near hydrocarbon gas drilling operations become de facto laboratories for the study of environmental toxicology." She calls the situation an "uncontrolled health experiment on an enormous scale."[13]

Third, we need science that gives immediate results and doesn't provide cover for continued damage. To cut through uncertainty and ignorance and quickly as possible, here are four suggestions:

- **Use EPA air pollution modeling programs and run them in reverse.** These models were recently employed, to good effect, to quantify the public health and economic benefits of lowering criteria air pollutant levels. The assessment demonstrated that a 73 percent reduction in sulfur

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Network carries the torch for the implementation of the Precautionary Principle. [full disclosure: I sit on SEHN's board.] www.sehn.org

13 M. Bamberger and R.E. Oswald, "Impacts of Gas Drilling on Human and Animal Health," *New Solutions* 22 (2012): 51-77. http://baywood.metapress.com/app/home/contribution.asp?referrer=parent&backto=issue,1,1;journal,1,56;linkingpublicationresults,1:300327,1.

dioxide and a 54 percent drop in nitrogen oxides would prevent, on a nationwide basis, 34,000 premature deaths, 15,000 heart attacks, 19,000 cases of bronchitis, 400,000 cases of asthma, 1.8 million sick days, and save $280 billion in health care costs. It turned out that these savings far exceeded the costs of the capital investments required to make the improvements.[14] In New York State, we could, for example, use the data in the draft environmental impact statement to project *increases* in, say, ground-level ozone, volatile organic compounds, and nitrogen oxides that are produced by fracking operations and attendant diesel truck traffic. Then we could run the numbers and report on the *increases* in deaths, heart attacks, bronchitis, asthma, and sick days that would result. We could put a price tag on the resulting health care costs. We could then—fairly quickly—answer the questions, "Would fracking kill more people than it employs? Does fracking cost more in Medicaid and Medicare expenses than the revenue stream it brings in?"

- **Look for health effects in livestock and companion animals.** Animals share their environments with humans but have shorter lifespans, shorter generation times, and avoid cigarettes and alcohol. Animals manifest symptoms sooner and have fewer confounding factors. Veterinary records are a good resource.

- **Biomonitor milk, both human and dairy.** Human milk and cows' milk are both four percent butterfat and serve as a quick, non-invasive medium for detecting exposures to fat-soluble contaminants, such as hydrocarbons. Populations of nursing mothers and dairy herds in areas of gas drilling activity can serve as sentinels of exposure.

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14 "U.S. EPA Curbs Air Pollution Blowing Across State Lines," *Environment News Service*, July 7, 2011. To be sure, the Cross-State Air Pollution Rule still met with overwhelming opposition in Congress.

- **Recast sociological impacts as public health threats.** Community cohesion can erode when towns are engulfed by fracking operations. Sharp increases in the price of rental housing that accompanies fracking booms can push low- and moderate-income families—often with young children—into desperate circumstances. Drilling booms have been variously accompanied by sharp upticks in crime, sexual assault, drug use, drunk driving, sexually transmitted diseases, teen pregnancy rates, and registered sex offenders. Motor vehicle accidents and emergency response calls also often increase.[15] Some of these changes are thought to result, directly or indirectly, from the dependency of the gas drilling industry on an influx of out-of-state workers, a large proportion of whom are young men living far from home and family, sometimes in "man camps." Popular media reports of these impacts often reference, with dismissive language, the "rough and tumble" culture of drill rig workers and their "rowdy," hard-drinking ways. The romance of the roughneck. We need to be clear: driving while intoxicated, teen pregnancy, assault, and STDs are public health problems.

I said at the opening of my remarks that I would be presenting two visual aids. The second one is myself.

I was diagnosed with bladder cancer at the age of 20. My own diagnosing physician asked me about my possible environmental exposures. I was a young biology major at the time. Prompted in part by his questions, I decided not to go

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[15] See, for example, Staci Covey, President, Troy Community Hospital, "Local Experiences Related to the Marcellus Shale Industry," Guthrie, May 10, 2011; M. Levi, "Drilling Boom Brings Surge in Crime to Small Towns," Associated Press, 26 Oct. 2011. Also, J. Berger and J.P. Beckmann, "Sexual Predators, Energy Development, and Conservation in Greater Yellowstone," *Conservation Biology* 24 (2010): 891-96; M. Reilly, "Sex Offenders Thrive in Oil and Gas Boom Towns," *Discovery*, 23 Feb. 2010.

on to medical school but pursued work in environmental science instead. Years later, with the help of a post-doc at Harvard, I learned I was just one data point in an area with excess rates of cancer. I also learned that my hometown drinking water wells contained perchloroethylene, a solvent with suspected links to bladder cancer. That was an interesting discovery because the underlying geology should not have allowed that to happen. But there it was.

Years ago, it was standard practice for industries using degreasing solvents like perc to simply dump them out the back door. They don't do that any more. It's possible I grew up drinking bladder carcinogens as a child because of actions taken by someone years before I was even born.

I don't want my own two children to become data points in New York's cancer registry because of actions that will be proven, many years from now, to be reckless. It's my job as their parent to make sure that doesn't happen. And because their bodies are rearranged molecules of air, food, and water, it's my job to protect the environment they inhabit. That's what love looks like.

Thank you.

January 9, 2012

Lisa Jackson, Administrator
United States Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Dear Administrator Jackson,

We, the undersigned health professionals and scientists, are writing to ask you to take urgent action to protect the victims of hydraulic fracturing in Dimock, Pennsylvania. Following the contamination of their water wells, these families are living without a safe source of drinking water and face possible health consequences if they are forced to use their contaminated well water. Specifically, we request that you investigate the contamination and, in the meantime, provide clean, potable drinking water as an emergency response action for these citizens. We believe that the US Environmental Protection Agency should step in to protect local residents if a driller jeopardizes drinking water supplies and the state government does not act. Your testimony before Congress in May 2011 on this very issue assures us that you also believe that the provision of safe drinking water in such circumstances is the duty of the EPA.

As you are aware, twelve Dimock families living in the Carter Road area suffered contamination of their wells shortly after the initiation of natural gas development using hydraulic fracturing. The contaminated condition of these families' drinking water was confirmed by the Pennsylvania Department of Environmental Protection (DEP) in 2010, at which time the drilling company arranged for daily water deliveries. But these water deliveries ended on November 30, 2011 even though questions about the safety of the well water remain.

On December 1, 2011, hundreds of concerned citizens, environmental groups, and Mayor Matt Ryan of Binghamton, New York, took on the task of paying for and delivering water. Commendably, EPA Region 3 began further investigation into the affected well water in Dimock in mid-December, and then, in the first week of January, residents were informed that the EPA would continue to investigate the drinking water. On January 6th, EPA Region 3 officials told the affected Dimock families that EPA would provide safe drinking water. And then, in an unexplained reversal on January 7th, EPA backed away from that pledge, leaving the families in Dimock, once again, without the assurance of a safe and reliable supply of drinking water.

We understand that EPA is continuing its investigation into the nature and extent of the contamination in Dimock. However, as long as there are reasonable doubts to the safety of the drinking water and the potential of it's consumption posing a significant health threat, the families should not be placed in harms way. In the face of the complete abdication of responsibility by the polluter and the state of Pennsylvania, it is incumbent upon EPA to ensure that these families have access to safe, potable water.

We are each 65 percent water by weight. Drinking water becomes our blood plasma, our cerebral spinal fluid, our sweat, and our tears. It is the steam of our exhaled breath on a cold winter's day. There is no other human right as fundamental as the right to clean water, which is the right to life itself.

We call on EPA to ensure that the families of Dimock do not endure another day without access to safe drinking water.

Sincerely,

Sandra Steingraber, Ph.D.
Distinguished Scholar in Residence, Ithaca College
Science Advisor, Breast Cancer Action
Former working group member, National Action Plan on Breast Cancer
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Public Health Considerations of the Draft Supplemental Generic Environmental Impact Statement

Statement submitted to the New York State Department of Environmental Conservation

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Introduction:

The verdict is still out on the public health impacts of unconventional natural gas drilling (HVHF). There have been multiple, consistent reports of adverse health effects from around the country from different shale gas plays and preliminary survey data (1,2). Yet, there have been no epidemiologic studies nor any systematic registry put in place to track such complaints. Efforts have been made to stimulate public health research, although the studies themselves have yet to conclude anything since this specific form of extraction is still so novel. While the technology was developed in Texas about decade ago it is far from perfected. In other parts of the country there has only been significant experience with shale gas development in the past three to four years. Unconventional natural gas development has gone largely unnoticed until this past year, and public health experts around the country are scrambling to catch up. In short, the scientific information for the public health impacts of high-volume hydraulic fracturing has yet to be gathered. Since Governor Cuomo has stressed the importance of science in determining the future of shale gas development in our state, areas in which there is a paucity of scientific information must be addressed in the SGEIS. One such area is the natural gas industry's potential impact on public health.

According to the SGEIS, the DEC is required by Article 23 of ECL to protect the "environment, public health, and safety" (SGEIS 1.2 67). Further, the New York State SEQRA law includes the mandate to include human health in the DEC's environmental impact statement process given how the environment is defined. "Environment means the physical conditions that will be affected by a proposed action, including land, air, water, minerals, flora, fauna, noise, resources of agricultural, archeological, historic or aesthetic significance, existing patterns of population concentration, distribution or growth, existing community or neighborhood character, and human health." (617.2.l) However, the SGEIS's analysis of public health is far from adequate. The word "health" only makes it into 3 subheadings (5.4.3.1 Chemical Categories and Health Information 5-63 and 8.1.1.6 County Health Departments 8-5 and 8.1.3.2 Occupational Safety and Health Administration – Material Safety Data Sheets 8-21), none of which address the human health effects of shale gas extraction in the comprehensive and systematic fashion it merits.

Many important considerations that one would expect in a comprehensive report including public health or human health impacts are missing. For instance, there is minimal mention of human disease and no discussion of pathways of exposure or the pathogenesis of disease caused by exposure to single toxins or the possibility of the interaction of several toxins. Endocrine and metabolic disruption are not mentioned in this report, despite their emerging importance as mechanisms in the causation of environmentally mediated disease. The NYS DOH had a piecemeal approach in their contributions and demonstrated a lack of vision with respect to an overall consideration of all the elements that should make up a thorough-going analysis of health impacts. Independent health care providers, hospitals, local departments of health, public health schools, and other healthcare stakeholders within NYS should have played a significant role in the SGEIS. The comment period does not substitute for this, as there remains an absence of critical thinking within the DEC and NYDOH on health issues that could readily have been supplemented by having included these groups in the process.

As we've approached the new deadline for comments, more and more experts from around the country have begun to wake up to this significant public health concern. There was a significant effort to promote research on January 9th at a national academic conference in Washington, DC on the epidemiologic and public health considerations of natural gas production. This conference grew out of a suggestion by the National Institute of Environmental Health Sciences (NIEHS) to investigate the methodological aspects of creating pertinent epidemiologic studies. This conference brought together public health experts from around the country to address this issue and the following agencies and institutions will be represented: CDC, ATSDR, EPA, NIEHS, OSHA, APHA, Cornell University, University of Pittsburgh, Columbia University, George Washington University, Johns Hopkins University, Harvard University, University of Pennsylvania, Colorado School of Public Health, Drexel University, and University of North Carolina, among others. Conference information, including a program, list of attendees, and video footage can be found at www.psehealthyenergy.org. There have been similar efforts around the country to bring attention to this issue, perhaps most notably two annual conferences hosted by the University of Pittsburgh Graduate School of Public Health on the health effects of shale gas extraction. The ball has begun rolling, and one can easily excuse the lag time given that the natural gas industry has made our citizenry responsible for conducting the research. The science, however, is far from complete.

We believe it would be prudent to wait for the findings of the conferences, conversations, and research among health care professionals and public health experts that is now beginning to take place. This should be done before gas drilling commences in NYS. New York is in a unique position to benefit from awaiting the determinations of public health studies in other states such as PA, TX, and WY, where drilling has been underway for years. The natural gas in the Marcellus Shale is not going anywhere and it will hold the same potential after these studies are conducted and their findings weighed.

We recommend that before the the draft SGEIS is accepted that it be supplemented to include a full assessment of the public health impacts of gas exploration and production. Specifically, we would like to make the following recommendations and point to various papers and reports we find critically important which are not included in the SGEIS. Until the following recommendations are carried out we urge that the current moratorium be continued. Since neither this nor any other measure mentioned here has been addressed in the rdSGEIS, we believe that the rdSGEIS is not protective of human health and should be withdrawn.

(1) http://www.earthworksaction.org/voices/detail/pavillion_wyoming_health_survey
(2) http://www.earthworksaction.org/voices/detail/dish_texas_health_survey

Recommendation: Conduct cumulative health impact assessment (HIA) for HVHF

A health impact assessment (HIA) is conducted in land use decisions to determine how human health will be impacted before a project or policy is enacted. It enables communities to proactively address any risks associated with the health hazards of unconventional natural gas development before bringing these considerations into the decision-making process. HIAs typically consist of a screening process to determine their utility, followed by a scoping stage which determines the health effects to be considered. The nature of these potential impacts are then assessed before recommendations are made. This is followed by an evaluation period where health impacts are monitored and managed and the results are presented to policy-makers (1). This type of health assessment process is widespread and HIAs have already been used for natural gas development (e.g. Garfield County, CO) (2) and other types of natural resource extraction (e.g. Alaska's Northeast Petroleum Reserve) (3). This practical assessment tool will address the potential root causes of health problems and help to ensure the health and safety of our communities. It will also provide an essential component for an appropriate risk analysis that will weigh potential benefits of shale gas development with potential health risks. Given that the New York Department of Health has been unwilling to evaluate and assess health impacts, an HIA should be conducted by an independent entity such as a school of public health. Until an HIA is conducted, we recommend the current moratorium be continued.

(1) http://www.cdc.gov/healthyplaces/hia.htm
(2) http://www.garfield-county.com/public-health/battlement-mesa-health-impact-assessment-ehms.aspx
(3) http://www.hiaguide.org/hia/national-petroleum-reserve-alaska-oil-development-plan
Other Resources:
http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/health-impact-assessment
http://www.hiaconnect.edu.au/files/HIA_International_Best_Practice_Principles.pdf

Recommendation: Create a health registry for tracking symptoms and conditions associated with high-volume hydraulic fracturing (HVHF)

Given that unconventional natural gas production has the potential to affect human health, there must be a system in place to track health issues. There have been a number of anecdotal health complaints reported across the United States in areas where fracking has been or continues to be in effect. Without any kind of registry it is impossible to scientifically track and evaluate such complaints. Without a central repository, health complaints would remain undocumented and unsubstantiated. In order to be effective, information on diseases and conditions associated with natural gas production needs to be submitted in a uniform way. A health registry would allow for such documentation. Such registry systems have been developed for cancers as well as communicable and chronic diseases. Of note, the Surveillance Epidemiology and End Results (SEER) registry collects statistical information on cancer from specific geographic locations around the US. We recommend that a system analogous to SEER be implemented prior to any natural gas development in the state of New York (1). We recommend that local health Departments submit information to the State Health Department, which would make the data available to researchers. Such a registry system would be invaluable for monitoring and tracking the impact natural gas extraction on human health. Until such a registry is created, we recommend the current moratorium be continued.

(1) http://seer.cancer.gov/

Recommendation: Conduct a detailed cancer risk analysis

The SGEIS contains no sections devoted to carcinogenesis and the word "cancer" itself appears only ten times within the 1,537-page SGEIS document. This is despite the fact that cancer-causing chemicals are associated with all stages of the HVHF process. Known carcinogens such as benzene and naphthalene have been identified in fracking fluids (1). In fact, more than 25% of the chemicals used in the process have been shown to cause cancer or mutations (2). Thirty-seven percent of fracking fluid chemicals have been identified as endocrine-disruptors, which can alter hormonal signaling pathways within the body (and form tumors), even at very low concentrations. These types of endocrine-disrupting chemicals have been shown to cause breast, prostate, pituitary, testicular, and ovarian cancers (3). Additionally, radioactive and other volatile organic compounds are released from the shale during the fracturing process. Drill cuttings and flowback wastewater are contaminated by these naturally radioactive substances and carcinogenic metals such as arsenic, chromium, benzene, uranium, radon, and radium (4).

There is a significant chance of human exposure to chemical carcinogens during the storage, treatment, and disposal of contaminated wastewater (5). Furthermore, carcinogens can also pollute drinking water and affect air quality. Researchers in Colorado, using US EPA risk assessment tools to look at carcinogenic effects of air quality at oil and gas sites, found excess cancer risks from air pollution alone (from 5 to 58 additional cancers per million) (6). A recent EPA study in Pavillion, WY confirmed the presence of the carcinogen 2-butoxyethanol, a widely used fracking chemical, in the aquifer under the intensively drilled community (7). Additionally, preliminary evidence in Texas points to high cancer rates in intensively drilled areas (8). While this evidence is not conclusive, it does support the need for a cancer risk analysis. Until a detailed cancer risk analysis is conducted, we recommend the current moratorium be continued.

(1) Committee Staff for Waxman, H. A., Markey, E.J., and DeGette, D. (2011). Chemicals Used in Hydraulic Fracturing: United States House of Representatives Committee on Energy and Commerce.

(2) Colborn, T., Kwiatkowski, C., Schultz, K., & Bachran, M. (2011). Natural gas operations from a public health perspective. *Human and Ecological Risk Assessment, 17*(5).

(3) Birnbaum, L. S., & Fenton, S. E. (2003). Cancer and developmental exposure to endocrine disruptors. *Environmental Health Perspectives, 111*(4), 389-394.

(4) Bishop, R. E. (2011). Chemical and Biological Risk Assessment for Natural Gas Extraction in New York. Retrieved November 11, 2011, from http://sustainableotsego.org/Risk%20Assessment%20Natural%20Gas%20Extraction-1.htm.

(5) Volz, C. D. (2011). Testimony to the U.S. Senate Committee on Environment and Public Works and the Subcommittee on Water and Wildlife, Joint Hearing on "Natural Gas Drilling, Public Health and Environmental Impacts." April 12, 2011.

(6) Witter, R., Stinson, K., Sackett, H., Putter, S., Kinney, G., Teitelbaum, D., & Newman, L. (2008). Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper: Colorado School of Public Health.

(7) U.S. Environmental Protection Agency. (2011). *Groundwater Investigation: Pavilion, Wyoming.* Retrieved from http://www.epa.gov/region8/superfund/wy/pavillion/.

(8) Heinkel-Wolfe, P. (2011). Breast cancer rate climbs up: Six counties including Denton have state's highest incidence rates, August 31, 2011. *Denton Record Chronicle.* Retrieved from http://www.dentonrc.com/sharedcontent/dws/drc/localnews/stories/DRC_Breast_Cancer_0831.11947df68.html

Recommendation: Analyze impact of industry on healthcare services and resources

There needs to be a thorough and comprehensive analysis of the likely impacts of the unconventional shale gas industry on the provision of healthcare and its required resources. Hospitals are not mentioned in the SGEIS, but hold a central role in the mitigation of health impacts. This includes the provision of emergency services for gas field exposures and injuries, hazmat training, and occupational health. In addition, the healthcare providers require education in the recognition, work-up, and management of individuals in affected communities presenting with sub-acute or chronic exposures to air or water pollution from nearby natural gas operations. Primary care providers also have special needs in terms of education, creation of referral pathways to specialists in occupational and environmental health, and tools they can use for documentation, tracking and management of suspected cases. Healthcare workers should be trained to report exposures and suspected shale gas industry related disease to the Department of Health for inclusion in registries. There should be plans to coordinate and integrate responses to health impacts between primary care providers, hospitals, health departments and local government. The costs of increased acute and chronic ill-health caused by this industry requires modeling, tracking, and reporting so that currently stretched resources are not drawn down. Until the impact of industry on healthcare services and resources is analyzed, we recommend the current moratorium be continued.

Recommendation: Establish well monitoring surveillance prior to drilling to allow for the gathering of baseline data

Inadvertent water contamination of unfiltered private wells in the vicinity of unconventional natural gas drilling is a significant public health concern. Just as municipal water supplies are monitored so as to maintain a healthy and safe water source, residential private wells must be monitored as well. To properly test and analyze the contents of wells and ground/surface waters for contamination there must be baseline data. We cannot wait for the occurrence of illness clusters before we start to monitor for obvious reasons. Without baseline data, post exposure analysis may provide little information, and physicians may not be able to connect the clinical manifestations of exposure to gas development. We believe quarterly monitoring for 2 years prior to the start of drilling is appropriate for gathering the required data. This monitoring would then continue throughout the well's operation and then after the cessation of drilling. This is consistent with what others have proposed as a suitable prototype: Title 6 NYCRR Part 360 of DEC regulations governing municipal solid waste landfills (1). Monitoring wells should surround not only the perimeter of well pads and flow-back impoundment pits, but all areas of operation that could potentially impact local water quality. The monitoring locations should then be analyzed by independent DEC-approved environmental laboratories. Based on known drilling constituents, we submit the following should be added to the current SGEIS monitoring parameters: TICs to identify volatile organic compounds (e.g. arsenic), petroleum hydrocarbons should include gasoline and diesel range hydrocarbons, and anions to determine inorganic compounds. Until an appropriate system for well monitoring analysis is established, we recommend the current moratorium be continued.

(1) http://www.dec.ny.gov/regs/4415.html

Recommendation: Include endocrine disrupting and metabolic disrupting chemicals in SGEIS health effect analysis

The EPA defines an endocrine disruptor as "an exogenous agent that interferes with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body which are responsible for the maintenance or homeostasis, reproduction, development and or behavior."(1) MDCs are an important subset of EDCs that disrupt metabolic pathways causing abnormalities in energy homeostasis and contributing to the pathogenesis of metabolic diseases including type 2 diabetes mellitus, obesity and the metabolic syndrome. (2) (3) Neither EDCs nor MDCs are mentioned in the SGEIS. Yet there are many candidate EDCs and MDCs in the chemicals added to hydraulic fracturing fluids and also in the flow-back/produced waters and volatile emissions. The SGEIS discloses the unique chemical identities of 322 chemicals used in hydraulic fracturing fluid (Revised Draft SGEIS 2011, Page 5-55 - 62). However The DEC excludes an unknown number of chemicals that do not meet "the confidential business information exception to the Department's records access program"(Revised Draft SGEIS 2011, Executive Summary, Page 22). An unknown proportion of these chemicals may be EDCs or MDCs. Potent EDCs and MDCs should be identified and eliminated from hydraulic fracturing fluids and drilling muds. They should be identified, assayed and mitigated from flow-back/produced waters and volatile emissions from venting and flaring or leaks in transmission.

An important, peer-reviewed paper not cited nor addressed in the SGEIS is "Natural Gas Operations from a Public Health Perspective" in the current edition of *Human and Ecological Risk Assessment: An International Journal* (4). This is an important contribution to the literature as it is the first peer-reviewed paper attempting to classify the chemicals used in shale gas extraction by their possible health effects. In the absence of disclosure of unique chemical identities by industry, they reviewed 944 products from Material Safety Data Sheets, from which they identified 632 chemicals, for which they could identify 353 CAS registry numbers defining them as unique individual chemicals. They searched each unique chemical in the biomedical databases including TOXNET and The Hazardous Substances Databank, alongside other literature searches. They used 12 classes to categorize diseases including 7 which are designated as priority health conditions by the ATSDR based upon CERCLA Data. This analysis estimates that 37% of these chemicals may affect the endocrine system. Until endocrine disrupting and metabolic disrupting chemicals are included in the SGEIS health impact analysis, we recommend the current moratorium be continued.

(1) EDSP Archive | Endocrine Disruptor Screening Program | US EPA [Internet]. [cited 2011 Dec 11]; Available from: http://www.epa.gov/endo/pubs/edsparchive/2-3attac.htm

(2) Casals-Casas C, Desvergne B. Endocrine disruptors: from endocrine to metabolic disruption. Annu. Rev. Physiol. 2011 Mar 17;73:135–62.

(3)Neel BA, Sargis RM. The paradox of progress: environmental disruption of metabolism and the diabetes epidemic. Diabetes. 2011 Jul;60(7):1838–48.

(4) Theo Colborn, Carol Kwiatkowski, Kim Schultz & Mary Bachran. Natural Gas Operations from a Public Health Perspective. Human and Ecological Risk Assessment: An International Journal. 17(5):1039–56.