

EXHIBIT A

AFFIDAVIT OF ROBERT W. HOWARTH

For NC WARN and The Climate Times

Docket E-2 Sub 1089

February 9, 2016

1. My name is Robert W. Howarth, and I am an Earth system scientist and ecologist who has been a tenured faculty member at Cornell University in Ithaca, New York for the past 30 years. I earned a Ph.D. jointly from MIT and the Woods Hole Oceanographic Institution in 1979. I have studied global change since the 1970s and have published over 200 research papers and have edited or written 7 books. I have served on 12 committees and panels of the US National Academy of Sciences, the U.S. Environmental Protection Agency, and the International Council of Science, including several that addressed global change. I have chaired 4 of these committees and panels. I am an expert on the role of methane emissions as a driver of global warming.

2. I am submitting this affidavit as a witness for interveners NC WARN and The Climate Times.

3. When burned, natural gas emits 60% of the CO₂ that coal emits to produce the same amount of energy. Thus, natural gas has been seen by some, including utilities, as a so-called “bridge fuel” from other fossil fuels to the future when renewable energy dominates our country’s electrical energy generation.

4. This concept of natural gas as a bridge fuel was based solely on CO₂ emissions, and ignored emissions of methane, a very potent greenhouse gas that also is contributing significantly to global warming. The latest synthesis report from the Intergovernmental Panel on Climate Change (IPCC, 5th Synthesis) from 2013¹ concluded that current emissions of methane equal the current emissions of CO₂ as a driver of global warming.

5. In 2011, I was the lead author on the very first analysis of the role of methane in the greenhouse gas footprint of natural gas produced from shale formations (“shale gas”), published in the peer-reviewed journal *Climatic Change*²

¹ Intergovernmental Panel on Climate Change (IPCC) 5th Assessment:
<https://www.ipcc.ch/report/ar5/>

² Methane and the greenhouse-gas footprint of natural gas from shale formations, Robert W. Howarth, Renee Santoro, Anthony Ingraffea, March 13, 2011, *Climatic Change*, DOI 10.1007/s10584-011-0061-5:
<http://www.acsf.cornell.edu/Assets/ACSF/docs/attachments/Howarth-EtAl-2011.pdf>

with a follow-up in the prestigious journal *Nature*.³ We concluded that even small emissions of methane could make the global warming consequences of using natural gas worse than coal. Natural gas is composed overwhelmingly of methane, and some leakage is inevitable.

6. Our 2011 analysis⁴ indicated that methane emissions from using natural gas were high enough to make the use of natural gas a poor choice as a “bridge fuel.” Rather than mitigating global warming, the use of natural gas might actually aggravate global warming. Our analysis also suggested that shale gas was likely to be worse than conventional natural gas. We called for more study, though, since the publicly available data to support our conclusion were limited.

7. Our study received global attention, and was reported in 1,200 newspapers including the *New York Times*.⁵ The scientific community took on our challenge for more study, and many new research projects were launched to better measure methane emissions from both conventional natural gas and shale gas development.

8. Several new studies published in 2013 and 2014, such as those led by Miller et al. from Harvard⁶ and Brandt et al. from Stanford,⁷ supported our analysis that methane emissions from conventional natural gas are large enough as to make this fuel highly undesirable from the standpoint of global warming.

9. A 2012 study by Shindell (then at NASA and now at Duke University) in the journal *Science*⁸ concluded that methane emissions were even more important to control than our 2011 papers had concluded. This new study, now endorsed by the United Nations, showed that the temperature of the Earth would warm to dangerous levels of 1.5° C within 15 years and 2° C within 35 years unless global

³ *Natural gas: should fracking stop?* Robert W. Howarth, Anthony Ingraffea and Terry Engelder, September 15, 2011, *Nature* 477, 271–275, doi:10.1038/477271a: http://www.nature.com/nature/journal/v477/n7364/full/477271a.html?WT.ec_id=NATURE-20110915

⁴ See footnote 2.

⁵ *Methane Losses Stir Debate on Natural Gas*, Tom Zeller Jr., *New York Times*, April 12, 2011: <http://green.blogs.nytimes.com/2011/04/12/fugitive-methane-stirs-debate-on-natural-gas/>. *Studies Say Natural Gas Has Its Own Environmental Problems*, Tom Zeller, *New York Times*, April 11, 2012: <http://www.nytimes.com/2011/04/12/business/energy-environment/12gas.html>

⁶ *U.S. methane emissions exceed government estimates* Collaborative study indicates fossil fuel extraction, animal husbandry major contributors, Caroline Perry, SEAS Communications, November 25, 2013: <http://news.harvard.edu/gazette/story/2013/11/u-s-methane-emissions-far-exceed-government-estimates/>

⁷ *America's natural gas system is leaky and in need of a fix, new study finds*, Stanford Report, February 13, 2014, <http://news.stanford.edu/news/2014/february/methane-leaky-gas-021314.html>

⁸ *Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security*, Drew Shindell et al, *Science*, January 13, 2012: <http://science.sciencemag.org/content/335/6065/183.abstract?sid=397ac687-9144-4bec-9e96-6a3de6e25dd3>

emissions of methane were curtailed. Simply reducing CO₂ emissions would have no effect on this time scale.

10. In 2014, Schneising and colleagues published a peer-reviewed paper based on satellite imagery across the surface of the Earth between 2002 and 2012.⁹ They concluded that methane emissions had risen globally over this time period, aggravating global warming. They further concluded that shale gas and oil development in the United States since 2008 had greatly increased global fluxes of methane to the atmosphere and may well be the major driver of the increased concentrations observed by satellite.

11. By early 2015, many studies by academic scientists and US government scientists in the National Oceanic and Atmospheric Administration published in peer-reviewed publications had concluded that methane emissions from the natural gas industry were high.¹⁰

12. In 2015, the engineer who holds the patent on the instrument approved by the US Environmental Protection Agency to measure methane emissions (Touche Howard) published two peer-reviewed papers concluding that his instrument had been systematically mis-used in a way that had led to under-estimation of methane emissions from the natural gas industry in some highly publicized studies, and quite likely by many studies previously relied upon by the US EPA.¹¹

13. The current status of our understanding of how methane emissions affect the greenhouse gas footprint of natural gas is summarized in a peer-reviewed article I published in October 2015 in the journal *Energy & Emissions Control Technologies*,¹² based on over a dozen new peer-reviewed studies published since 2012. Considering the complete lifecycle assessment from production at the well through to delivery and use by the final consumer, conventional natural gas emits approximately 3.8% of the natural gas produced to the atmosphere as methane, and shale gas emits substantially more, probably 10% plus or minus 5%.

14. To compare methane emissions and CO₂ emissions requires a specified time frame. Historically, most analyses used a 100-year time frame, but the

⁹ Schneising, O., Burrows, J. P., Dickerson, R. R., Buchwitz, M., Reuter, M. and Bovensmann, H. (2014), *Remote sensing of fugitive methane emissions from oil and gas production in North American tight geologic formations*. *Earth's Future*, 2: 548–558. doi:10.1002/2014EF000265: <http://onlinelibrary.wiley.com/doi/10.1002/2014EF000265/abstract>

¹⁰ National Oceanic & Atmospheric Administration, *Trends in Atmospheric Methane*, accessed 2/9/2016: http://www.esrl.noaa.gov/gmd/ccgg/trends_ch4/

¹¹ *Methane Leaks May Greatly Exceed Estimates, Report Says*, John Schwartz, August 4, 2015: <http://www.nytimes.com/2015/08/05/science/methane-leaks-may-greatly-exceed-estimates-report-says.html>

¹² *Methane emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy*, R.W. Howarth, July 1, 2015: <https://www.dovepress.com/methane-emissions-and-climatic-warming-risk-from-hydraulic-fracturing--peer-reviewed-article-EECT>

Intergovernmental Panel on Climate Change in their 2013 5th assessment report called this arbitrary, and stated that the comparison should be based on time frames more appropriate for the concern being considered. Since the Earth will warm to 1.5 degrees above the pre-industrial baseline within the next 15 years and to 2 degrees within 35 years unless methane emissions are reduced, a 20-year time frame for comparing methane and CO₂ emissions is far more appropriate than a 100-year time frame.

15. At a 20-year time frame for comparison, the Intergovernmental Panel on Climate Change concluded that methane is 86 times more potent than CO₂ as a greenhouse gas.

16. Using the best available data for estimates on methane emissions and the 20-year time frame for comparing methane and CO₂ as greenhouse gases, my recent peer-reviewed paper concluded that both conventional natural gas and shale gas have larger greenhouse gas footprints than coal, even though the CO₂ emissions from burning coal are greater. The total greenhouse gas footprint for conventional natural gas is approximately 1.2 times greater than that for coal. For shale gas, the greenhouse gas footprint is approximately 2.7 times greater than that for coal.

17. Shale gas production now contributes approximately 40% of the total production of natural gas in the United States. Therefore, the average natural gas used in the country (40% from shale gas and 60% from conventional sources) has a greenhouse gas footprint that is 1.8 times greater than that for coal. The U.S. Department of Energy predicts that the percentage of gas production coming from shale gas will increase in coming years, which will increase the greenhouse gas footprint for average natural gas compared to coal.¹³

18. When natural gas is used to generate electricity, the efficiency with which the electricity is generated from the heat released as a fuel is burned must also be considered. Most coal burning plants have efficiencies of 30% to 37%, although higher efficiencies are possible, according to several published studies. Natural gas plants have efficiencies that range from 28% to 58%.¹⁴

19. Using the information from point #17 and the average efficiencies of 33.5% for coal plants and 43% for natural gas plants, the greenhouse gas footprint for producing electricity per MWh from natural gas (including 40-50% of it coming from shale gas) is 1.4-fold greater than that produced from coal. That is, for every 100 g CO₂ equivalents of emission from using coal, the natural gas plant would produce 140 g CO₂ equivalents.

¹³ See *The Growth of U.S. Natural Gas: An Uncertain Outlook for U.S. and World Supply*, For 2015 EIA Energy Conference, June 15, 2015, Washington, D.C., by John Staub, Team Lead, Exploration and Production Analysis

<http://www.eia.gov/conference/2015/pdf/presentations/staub.pdf>

¹⁴ See EIA webpage on power plant efficiency: <https://www.eia.gov/tools/faqs/faq.cfm?id=107&t=3>

20. Based on the above numbers, the Duke Energy proposal to generate 560 MW of electricity from natural gas will produce twice as much in greenhouse gas emissions as the Asheville 376MW coal plant that is proposed to be replaced. That is, each of the planned two, 280 MW natural gas plants individually will produce greenhouse gases equal to the single, old 376 MW coal plant.

21. One clear conclusion is that natural gas – particularly as it comes increasingly from shale gas – is not a bridge fuel. When emissions of methane and CO₂ are compared over appropriate time scales, natural gas is an even worse fuel choice than is coal from the standpoint of global warming.

22. It is also critical to re-state and emphasize the point made in #9 above. It is far more important to reduce methane emissions than carbon dioxide emissions over the coming decade or two, if we are to avert extremely dangerous levels of global warming within the next 15 to 35 years. This means that building new plants to produce electricity from natural gas is a disastrous strategy.

23. Several recent studies, including two peer-reviewed papers co-authored by me, show that it is entirely feasible to replace electricity generation from fossil fuels with renewable electricity on the time scale of the next 20 years. It is essential that society do so if we are to reduce the chances of catastrophic damage from global warming.

AFFIDAVIT

Town of Ulysses, Tompkins County, State of New York

I, Robert Howarth, appearing before the undersigned notary affirm the contents of the following statement are true to the best of my knowledge, based on my professional judgement and experience with such matters.

Rob Howarth

Signature

Sworn to (or affirmed) and subscribed before me this the 10th day of February, 2016.

CARISSA M. PARLATO
Notary Public, State of New York
No. 01PA6303992
Qualified in Tompkins County, 18
Commission Expires May 19, 2018

Carissa M Parlato

Official Signature of Notary

Carissa Parlato, Notary Public
Notary's printed or typed name

My commission expires: 5/19/18