

E-2 Sub 1089
on behalf of
NC WARN and
The Climate Times

AFFIDAVIT

City of Calgary
Province of Alberta
Canada

I, J.D. Hughes, appearing before the undersigned notary and being duly sworn, swears (or affirms) the contents of the foregoing statements are true to the best of my knowledge, except as to those matters stated on information and belief, and as to those matters, I believe them to be true.

J.D. Hughes
Signature

Sworn to (or affirmed) and subscribed before me this the 19 day of FEB, 2016

(Official Seal)
AMARINDER (ROB) VIRK
BARRISTER & SOLICITOR
NOTARY PUBLIC & COMMISSIONER FOR OATHS
in and for the Province of Alberta

AMARINDER VIRK
Official Signature of Notary

AMARINDER VIRK, Notary Public
Notary's printed or typed name

My commission expires: NO EXPIRY

AFFIDAVIT OF J. DAVID HUGHES
FOR NC WARN and The Climate Times

Docket E-2 Sub 1089

February 9, 2016

1. My name is J. David Hughes, and I am an earth scientist who has studied energy resources for four decades, including 32 years with the Geological Survey of Canada as a scientist and research manager. I coordinated a publication assessing Canada's unconventional natural gas potential as Team Leader for the Canadian Gas Potential Committee. I have also studied U.S. shale gas extensively and published comprehensive reports on future shale gas production potential. My work has been widely cited in the press, including *The Economist*, *Forbes*,¹ *Bloomberg*,² *The Los Angeles Times*,³ *The New York Times*⁴ and *The Atlantic*,⁵ and has been featured in *Canadian Business*,⁶ *Walrus*⁷ and elsewhere.
2. I am submitting this affidavit as a witness for interveners NC WARN and The Climate Times.
3. Future shale gas production estimates must be carefully reviewed, as more than 50% of U.S. natural gas production is now shale gas.⁸ "Shale" gas is produced by hydraulic fracturing

¹ *Does Anyone Really Know How Long the Shale Boom Will Last?* Tom Zeller, Jr., January 5, 2015:
<http://www.forbes.com/sites/tomzeller/2015/01/05/does-anyone-really-know-how-long-the-shale-gas-boom-will-last/>

² *Is the Shale Boom Going Bust?* Bloomberg View, Tom Zeller, April 22, 2014:
<http://www.bloombergview.com/articles/2014-04-22/is-the-u-s-shale-boom-going-bust>

³ *'Fracking' the Monterey Shale: boon or boondoggle?* Alex Prud'homme, December 29, 2013:
<http://www.latimes.com/opinion/op-ed/la-oe-prudhomme-fracking-california-20131222-story.html>, and *U.S. Officials cut estimate of recoverable Monterey Shale Oil by 96%*, Louis Sahagun, May 20, 2014:
<http://www.latimes.com/business/la-fi-oil-20140521-story.html>

⁴ *Studies Say Natural Gas Has Its Own Environmental Problems*, Tom Zeller, Jr., April 11, 2011:
<http://www.nytimes.com/2011/04/12/business/energy-environment/12gas.html>

⁵ *Yes, Unconventional Fuels Are That Big a Deal*, by Charles C. Mann, May 7, 2013:
<http://www.theatlantic.com/technology/archive/2013/05/yes-unconventional-fossil-fuels-are-that-big-of-a-deal/275616/>

⁶ *B.C. LNG industry will increase fracking-caused earthquakes: expert*, Laura Cane, August 30, 2015:
<http://www.canadianbusiness.com/business-news/b-c-lng-industry-will-increase-fracking-caused-earthquakes-expert/>

⁷ *An Inconvenient Talk: David Hughes Guide to the End of the Fossil Fuel Age*, Chris Turner, June 2009:
<http://thewalrus.ca/an-inconvenient-talk/>

⁸ *Natural Gas Weekly Update*, Energy Information Administration, February 11, 2016,
<http://www.eia.gov/naturalgas/weekly/>

("fracking"), in conjunction with horizontal drilling, a technique that cracks the source rock to release hydrocarbons.

4. My analysis of shale plays accounting for 88% of shale gas and 82% of shale oil shows that estimates of future production of natural gas from shale plays are likely overstated, given the high decline rates observed and the concentration of high quality wells in relatively small sweet spots within plays, putting ratepayers at risk of natural gas shortages and price spikes in the medium- and longer-term.⁹ The average shale gas well declines 75-85% over three years, and some 30-45% of a play's production must be replaced each year by more drilling. Drilling outside of sweet spots, as they are exhausted, will require more wells to maintain a given level of production and require higher prices.
5. Seventy-eight percent of U.S. shale gas comes from only six plays, with several currently in decline. The Haynesville in Louisiana and East Texas was the biggest shale gas play in 2012, and is now down 50% from its January 2012 peak.¹⁰ The largest U.S. shale play, the Marcellus, peaked in June 2015, and is now down 3.4% from peak. Since Duke Energy's gas supply is expected to be supplied by the Gulf coast and Appalachian regions, production declines should send up a red flag.
6. Per my analysis on shale gas well productivity in *Drilling Deeper* (2014) and *Shale Gas Reality Check* (2015), I believe the U.S. Department of Energy's Energy Information Administration's (EIA) 2014 projections for shale gas production¹¹ from major plays through 2040 overestimate 2014-2040 production by at least 50%, and 2040 production is likely to be at least 60% lower than the EIA reference case projection.
7. My estimates show that the EIA's 2015 projection of U.S. shale gas production is even more optimistic than the 2014 report by 9%.¹²

⁹ *Drilling Deeper: A reality check on U.S. Government forecasts for a lasting tight oil and shale gas boom*, October, 2014, http://www.postcarbon.org/wp-content/uploads/2014/10/Drilling-Deeper_FULL.pdf

¹⁰ *Natural Gas Weekly Update*, February 11, 2016, <http://www.eia.gov/naturalgas/weekly/>

¹¹ *Annual Energy Outlook 2014*, Energy Information Administration, <http://www.eia.gov/forecasts/archive/aeo14/>

¹² From *Shale Gas Reality Check*, 2015: http://www.postcarbon.org/wp-content/uploads/2015/07/Hughes_Shale-Gas-Reality-Check_Summer-2015.pdf

"The EIA's Annual Energy Outlook 2015 is even more optimistic than the AEO2014, which we showed in *Drilling Deeper* suffered from a great deal of questionable optimism. The AEO2015 reference case projection of total shale gas production from 2014 through 2040 is 9%, or 36 tcf, greater than AEO2014. Cumulative production from the major plays in AEO2015, which account for 80% of this production, is 50% higher than my "Most Likely" case in *Drilling Deeper*, and the projected production rate in 2040 is 170% greater. In AEO2015, the EIA is counting much more on unnamed plays or ones—like the Utica Shale—that aren't as yet producing very much shale gas."

8. Many companies are losing money on shale plays, and with interest rates increasing, the dollar value of shale assets being 'written down' is increasing.¹³ There is evidence that shale gas plays are cash flow negative for many companies, and maintaining the drilling treadmill necessary to offset steep declines requires ever-more investment capital.¹⁴ Many companies are facing bankruptcy.¹⁵
9. My 2013 analysis¹⁶ was recently proven correct in California's Monterey shale, where reserves were recently decreased by a stunning 96%. In 2011, the EIA estimated that the Monterey Shale in California contained two-thirds of the tight oil resources in the U.S. After reviewing the data, I concluded that the EIA's estimate was vastly overstated. In May, 2014, the EIA quietly downgraded its estimate from 13.7 billion to 600 million barrels.¹⁷ In October 2015 the U.S. Geological Survey (U.S.G.S.) released a report further downgrading resources, so that EIA's initial estimates were reduced by a startling 99%, thus agreeing with myself and others.
10. I am not the only expert disputing the EIA's numbers. Mr. Art Berman has also sounded the alarm about overly optimistic production rates and reserves for many years.¹⁸
11. In order to maintain the current level of shale gas production, the U.S. will need to drill many thousands of wells each year, and this number will need to escalate as the sweet spots become saturated with wells and drilling moves into lower productivity parts of plays. This will require higher prices.¹⁹ Drilling rates have already fallen below what is required to maintain production and U.S. shale gas production is declining from its peak in July 2015.²⁰

¹³ *BHP Billiton writes down \$7.2bn of shale assets*, January 15, 2016, BBC News: <http://www.bbc.com/news/business-35320918>

¹⁵ *Oil and gas drillers facing bankruptcy as prices crash*, January 14, 2016, Pennline.com, http://www.pennlive.com/news/2016/01/oil_and_gas_drillers_facing_ba.html

¹⁶ *Drilling California: A Reality Check on the Monterey Shale*, J. David Hughes, December 2, 2013: <http://www.postcarbon.org/publications/drilling-california/>

¹⁷ *U.S. Officials Cut Estimate of Recoverable Monterey Shale Oil by 96%*, Louis Sahagun, May 20, 2014: <http://www.latimes.com/business/la-fi-oil-20140521-story.html>

¹⁸ *Arthur Berman Interview: Why Today's Shale Era is the Retirement Party for Oil Production*, Chris Martenson, February 12, 2015: <http://www.resilience.org/stories/2015-02-12/arthur-berman-interview-why-today-s-shale-era-is-the-retirement-party-for-oil-production>

Shale, the Last Oil and Gas Train: Interview with Arthur Berman, James Stafford, www.oilprice.com, March 5, 2014: <http://oilprice.com/Interviews/Shale-the-Last-Oil-and-Gas-Train-Interview-with-Arthur-Berman.html>

¹⁹ *Shale Skeptics Take on Pickens as Gas Fuels Policies*, Edward Klump, Bloomberg, July 15, 2013: <http://www.bloomberg.com/news/articles/2013-07-14/shale-skeptics-take-on-pickens-as-gas-fuels-policies>

Energy: A Reality Check on the Shale Revolution, J. David Hughes, *Nature*, 494, pages 307-308, February 21, 2013: http://www.nature.com/nature/journal/v494/n7437/full/494307a.html?WT.ec_id=NATURE-20130221

²⁰ *EIA Natural Gas Weekly*, February 3, 2016, <http://www.eia.gov/naturalgas/weekly/>

12. If natural gas production declines, as is currently the case, and drilling rates cannot be maintained due to poor economics, fuel prices could skyrocket, putting ratepayers at risk of shortages and price spikes.²¹ Shale gas (and oil) industries are unsustainable in the longer term unless prices rise considerably, as the best parts of shale plays are exhausted and drilling moves into lower quality geology, requiring ever increasing drilling rates and capital inputs to stem production declines.
13. Long term price expectations are extremely important in estimating the overall lifetime cost of the proposed gas plants. Price versus production forecasts of the EIA are unrealistic in the long term, given the nature of shale gas plays and the fact that the best portions are being drilled now.
14. DEP refused to respond to NC WARN Data Request 1-8, which asked what DEP's price projections for natural gas would be over the plant's 30 year life. This information should be readily available, as it will significantly affect the plant's overall economics and hence the cost of electricity to ratepayers.
15. In my expert opinion, the cost of natural gas in the medium and long term will be much higher than today, and higher than the projections of the EIA, which will negatively impact the investments Duke Energy is making in natural gas power plants that are expected to run for 30 or more years, and will result in considerably higher costs for ratepayers than expected, if DEP is basing its economic analysis on EIA price projections.

²¹ During 2014, the Northeastern U.S. experienced price spikes for natural gas as the "polar vortex" – a long-lasting blast of Arctic air – drove heating demand off the charts, see *5 charts that explain U.S. electricity prices*, Gavin Bade, March 23, 2015: <http://www.utilitydive.com/news/5-charts-that-explain-us-electricity-prices/378054/>