STATE OF NORTH CAROLINA
UTILITIES COMMISSION
RALEIGH

DOCKET NO. E-2, SUB 1095
DOCKET NO. E-7, SUB 1100
DOCKET NO. G-9, SUB 682

BEFORE THE NORTH CAROLINA UTILITIES COMMISSION

In the Matter of Application of Duke Energy Corporation and Piedmont Natural Gas Company, Inc. to Engage in a Business Combination Transaction and Address Regulatory Conditions and Code of Conduct	))))))	DIRECT TESTIMONY OF J. DAVID HUGHES FOR NC WARN, THE CLIMATE TIMES AND THE NC HOUSING COALITION

Q. PLEASE STATE YOUR FULL NAME, OCCUPATION, AND ADDRESS.

A. My name is J. David Hughes, and I am an earth scientist. My address is P.O. Box 237, Whaletown, British Columbia, Canada, V0P 1Z0.

Q. WHAT IS YOUR BACKGROUND?

A. I have studied energy resources for four decades, including 32 years with the Geological Survey of Canada as a scientist and research manager. I served as Team Leader for the Canadian Gas Potential Committee, and coordinated a publication assessing Canada's unconventional natural gas reserves. I developed Canada's National Coal Inventory to determine the availability and environmental constraints associated with coal resources. I have also studied U.S. shale gas extensively and published comprehensive reports on future shale gas production potential in the U.S.

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. Over the past decade, I have researched, published and lectured widely on global energy and sustainability issues in North America and internationally.

Q. IN WHAT CAPACITY ARE YOU APPEARING BEFORE THIS COMMISSION?

A. I am appearing as a witness on behalf of NC WARN, The Climate Times ("TCT") and The NC Housing Coalition. NC WARN and The NC Housing Coalition are interested in this proceeding because many of its members are customers of Duke Energy Carolinas, LLC ("DEC"), Duke Energy Progress ("DEP") and/or Piedmont Natural Gas ("PNG") who are concerned about the rising risks of generating electricity from natural gas. These risks are both economic – as

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[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?*, 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 *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*, 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/

natural gas prices have been notoriously volatile and unpredictable, and geological – as I believe the U.S. Department of Energy's Energy Information Administration ("EIA") natural gas production and price forecasts are too optimistic. NC WARN and its members are also concerned about climate change and pollution caused by the life-cycle emissions of natural gas power plants, including emissions from natural gas production and transportation.

Q. HAVE YOU APPEARED BEFORE THIS COMMISSION BEFORE?

A. I submitted an affidavit for NC WARN and TCT in Docket E-2, Sub 1089, for a Certificate of Public Convenience and Necessity (CPCN) for the Asheville natural gas plant, but since there were no evidentiary hearings, I did not submit formal testimony or appear before the Commission.

Q. WHAT IS THE PURPOSE OF YOUR DIRECT TESTIMONY IN THIS PROCEEDING?

A. My testimony addresses the following issues:

1) The risk of inadequate future supplies of natural gas given the optimistic nature of production forecasts for shale gas, which is the source of all production growth in EIA estimates, thus putting ratepayers at risk for potential major price increases and volatility;

2) Switching from coal to natural gas is not a climate-friendly solution, given full cycle emissions, including methane, from hydraulic fracturing to recover shale gas, which is projected to be the predominant future supply source.

Before the rise of hydraulic fracturing coupled with horizontal drilling, U.S. gas was produced mainly from "conventional" wells that were drilled vertically or

directionally. “Shale” gas is produced by hydraulic fracturing (“fracking”) of horizontal wells, a technique that fractures the source rock under high pressure to release hydrocarbons. The amount of U.S. natural gas that comes from hydraulic fracturing has increased rapidly over the past decade – from 7% in 2000 to 67% in 2016.[8] To ensure that the U.S. has adequate supplies of natural gas to meet increasing demand, prudency requires that estimates of future shale gas production be carefully reviewed.

1) THE RISK OF INADEQUATE FUTURE SUPPLIES OF NATURAL GAS GIVEN THE OPTIMISTIC NATURE OF PRODUCTION FORECASTS FOR SHALE GAS, WHICH IS THE SOURCE OF ALL PRODUCTION GROWTH IN EIA ESTIMATES, THUS PUTTING RATEPAYERS AT RISK FOR POTENTIAL MAJOR PRICE INCREASES AND VOLATILITY

Q. PLEASE DESCRIBE YOUR STUDIES OF NATURAL GAS SUPPLIES.

A. I have completed several detailed studies of both U.S. and Canadian oil and gas production and resources over the past decade. Starting in 2011,[9] I published a series of papers on the challenges of natural gas as a ‘bridge fuel’ from coal to renewables, including *Drill, Baby, Drill* (2013),[10] which took a far-ranging look at the prospects for various unconventional fuels in the United States; *Drilling California* (2013), which analyzed the EIA’s estimates of technically recoverable

[8] *Hydraulically fractured wells provide two-thirds of U.S. natural gas production*, Energy Information Administration, May 5, 2016: http://www.eia.gov/todayinenergy/detail.cfm?id=26112
[9] *Will Natural Gas Fuel America in the 21st Century?*, J. David Hughes, May 29, 2011: http://www.postcarbon.org/publications/will-natural-gas-fuel-america/
[10] *Drill, Baby, Drill: Can Unconventional Fuels Usher in a New Era of Energy Abundance?*, David Hughes, February 19, 2013: http://www.postcarbon.org/publications/drill-baby-drill/

tight oil in the Monterey Shale; *Drilling Deeper* (2014), which challenged the expectation of long-term domestic oil and natural gas abundance with an in depth assessment of drilling and production data from the major U.S. shale plays through mid-2014; and *Shale Gas Reality Check* (2015) and *Tight Oil Reality Check* (2015), which are updates to *Drilling Deeper*. I also authored *BC LNG: A Reality Check in 2014* and *A Clear View of BC LNG* in 2015,[11] which examined the issues surrounding a proposed massive scale-up of shale gas production in British Columbia for LNG export.

Q. WHAT WERE YOUR CONCLUSIONS IN *DRILLING CALIFORNIA* (2013)?

A. 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 overstated by at least 90%. In May 2014 the EIA downgraded its estimate from 13.7 billion to 600 million barrels. In late 2015 the U.S. Geological Survey (U.S.G.S.) released a report further downgrading resources, so that initial estimates were reduced by over 96%, thus agreeing with my conclusions.

Q. WHAT WERE YOUR CONCLUSIONS IN *DRILLING DEEPER (2014)*?

A. *Drilling Deeper* reviewed production data from major shale plays in the U.S., and found that production rates in the 2020-2040 timeframe are likely to be much

[11] *Report challenges B.C.'s claims of natural gas reserves for export,* Derrick Penner, May 25, 2015: http://www.vancouversun.com/technology/report+challenges+claims+natural+reserves+export/11082985/story.html

lower than the EIA's projections in its 2014 Annual Energy Outlook (AEO2014). The report reviewed U.S. shale plays that account for 88% of mid-2014 U.S. shale gas production, and analyzed available production data, historical production, well- and field-decline rates, drilling locations, and well-quality trends for each play, as well as counties within plays.[12] Forecasts of future production rates were then made based on projected well quality and drilling rates (and, by implication, capital expenditures).

I found that barring major new discoveries on the scale of the Marcellus, future shale gas production would be far below the EIA's forecast by 2040. Shale gas production from the top seven plays will underperform the EIA's reference case forecast by 39% from 2014 to 2040 in my "most-likely" case, and more of this production will be front-loaded than the EIA estimates. By 2040, production rates from these plays will be about one-third that of the EIA forecast. Production from shale gas plays other than the top seven will need to be four times that estimated by the EIA in order to meet its reference case forecast.

Q. SO ARE YOU SAYING THAT FUTURE SHALE GAS PRODUCTION ESTIMATES IN EIA'S ANNUAL ENERGY OUTLOOK 2014 (AEO2014) FOR MAJOR PLAYS ARE AT LEAST 50% TOO HIGH?

A. Yes. I believe the EIA's AEO2014 projections for shale gas production[13] from major plays through 2040 overestimate 2014-2040 production by at least 50%, and

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[12] *Drilling Deeper*, J. David Hughes, October 27, 2014, http://www.postcarbon.org/publications/drillingdeeper/

[13] *Annual Energy Outlook 2014*, Energy Information Administration, May 7, 2014: http://www.eia.gov/forecasts/archive/aeo14/

2040 production is likely to be at least 60% lower than the EIA reference case projection.

Q. WHAT WERE YOUR CONCLUSIONS IN YOUR MOST RECENT REPORT, *SHALE GAS REALITY CHECK* (2015)?

A. *Shale Gas Reality Check* updated *Drilling Deeper* with the EIA's AEO2015 projections of U.S. shale gas production (see Figure 1). My analysis found the EIA's numbers to be even *more* optimistic than its AEO2014 report by 9%.[14] The AEO2015 reference case projection of total shale gas production from 2014 through 2040 is an additional 9% (36 trillion cubic feet), 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. The AEO2015 relies much more on developing plays—like the Utica Shale—that aren't as yet producing very much shale gas.

[14] *Shale Gas Reality Check*, J. David Hughes, July 2015: http://www.postcarbon.org/wp-content/uploads/2015/07/Hughes_Shale-Gas-Reality-Check_Summer-2015.pdf

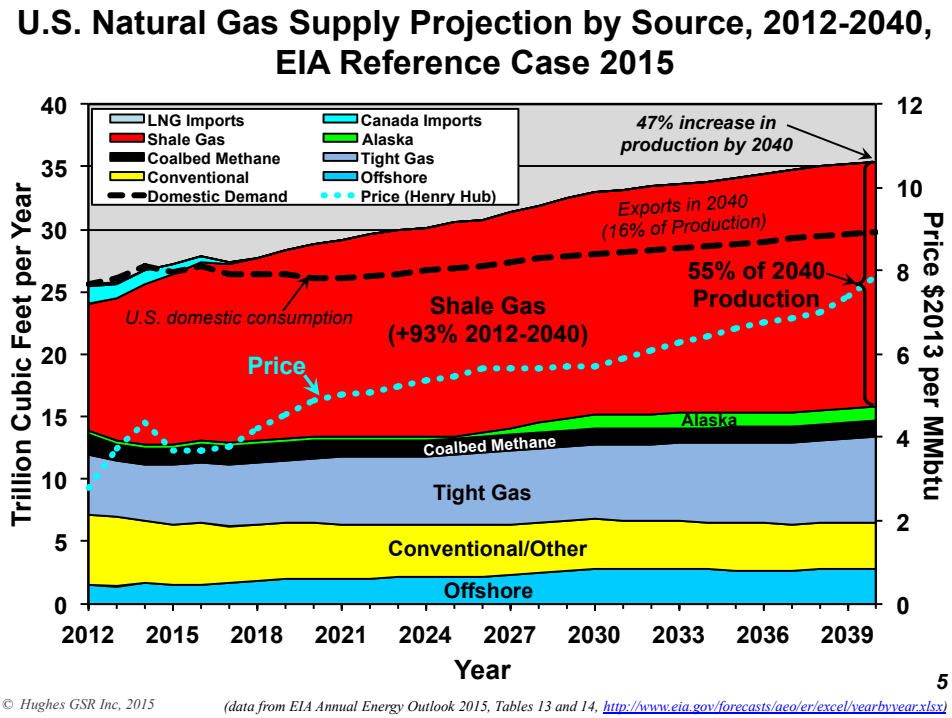

FIGURE 1: EIA 2015 ESTIMATE NATURAL GAS PRODUCTION

Q. WHAT PERCENTAGE OF U.S. SHALE GAS PRODUCTION DID YOUR STUDIES ANALYZE?

A. My analysis of shale plays looked at data for plays that accounted for 88% of mid-2014 U.S. shale gas production.

Q. WHAT OTHER FACTORS ACCOUNT FOR THE OVERESTIMATED SUPPLIES OF SHALE GAS?

A. Shale gas wells have very high decline rates, and the average well declines 75-85% over three years, so that 30-45% of a play's production must be replaced each year by more drilling.[15] High productivity "sweet spots" account for only 10-20%

[15] *Drilling Deeper*, J. David Hughes, October 2014: http://www.postcarbon.org/wp-content/uploads/2014/10/Drilling-Deeper_FULL.pdf

of the areal extent of most shale plays but account for the most productive wells. Drilling outside of sweet spots, as they are exhausted, will require more wells to maintain a given level of production, which will require higher prices. Sweet spots are being drilled first, and produce the cheapest gas. Prices will have to rise over time as drilling moves into less productive areas, as more and more lower productivity wells will be needed to maintain production or stem play production declines.

Q. PLEASE EXPLAIN WHERE U.S. SHALE GAS COMES FROM

A. Seventy-nine 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 U.S. shale gas play in 2012, and is now down 50% from its January 2012 peak. The largest U.S. shale play, the Marcellus, which produced 38.7% of U.S. shale gas in April 2016, has been on a production plateau since November 2015. Total U.S. shale gas production is down 2% from its February, 2016 peak.[16]

Q. PLEASE EXPLAIN WHY YOU DISAGREE WITH THE EIA AEO2015 CONCLUSION THAT U.S. SHALE GAS PRODUCTION WILL INCREASE FROM NOW THROUGH 2040.

A. I believe that total U.S. shale gas production from major plays constituting more than 80% of production will peak around 2017, with the largest shale play, the Marcellus, peaking a year or so later. The EIA, on the other hand, believes that shale gas production will grow strongly through 2040, with production coming from both

[16] *Natural Gas Weekly Update,* Energy Information Administration, June 2, 2016: http://www.eia.gov/naturalgas/weekly/

major existing plays and new plays. As Figure 2 shows, production from five significant legacy shale plays are collectively down 34% from their August 2012 peak, and all shale plays experienced a collective peak in February 2016, although this may be temporary.

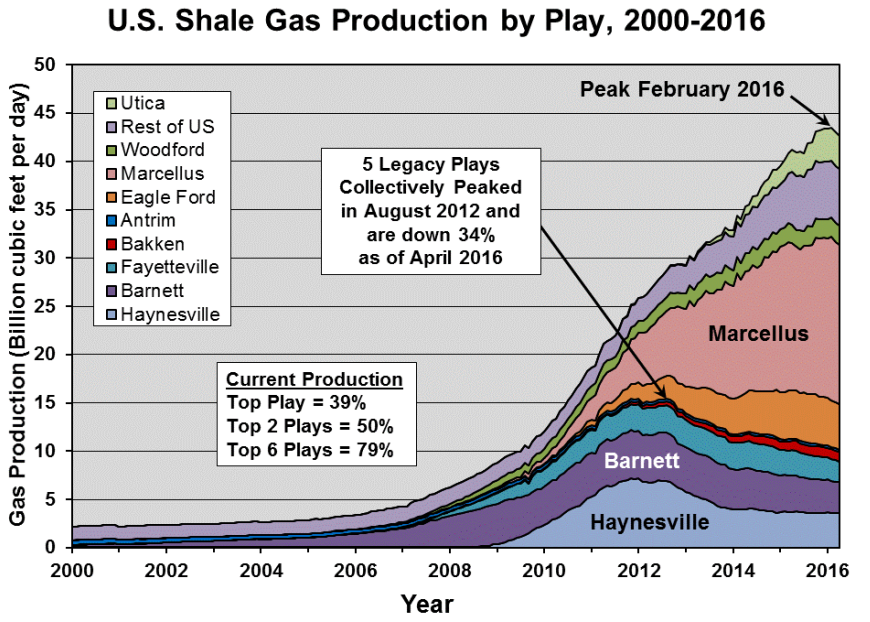

FIGURE 2: ACTUAL U.S. SHALE GAS PRODUCTION SHOWS FIVE LEGACY PLAYS ARE DOWN BY 32% SINCE AUGUST 2012 PEAK

Q. DO YOU HAVE ANY SPECIFIC EXAMPLES OF SHALE PLAYS THAT HAVE FOLLOWED THE DECLINE TRAJECTORY YOU DESCRIBE?

A. The decline of the Haynesville shale play provides an excellent example of what I term the shale play "life cycle" (See Figure 3). Production is down 50% from its peak, yet the EIA expects the Haynesville to start ramping up production around 2017, to exceed its 2011 peak around 2025, and continue to increase gas production through 2038. This is extremely unlikely, in my opinion, given geological constraints, the amount of drilling that would be needed and the gas price required

to justify it. The Haynesville's average three-year well decline rate is 89% over the first three years, which is comparable to decline rates I found in other shale plays.

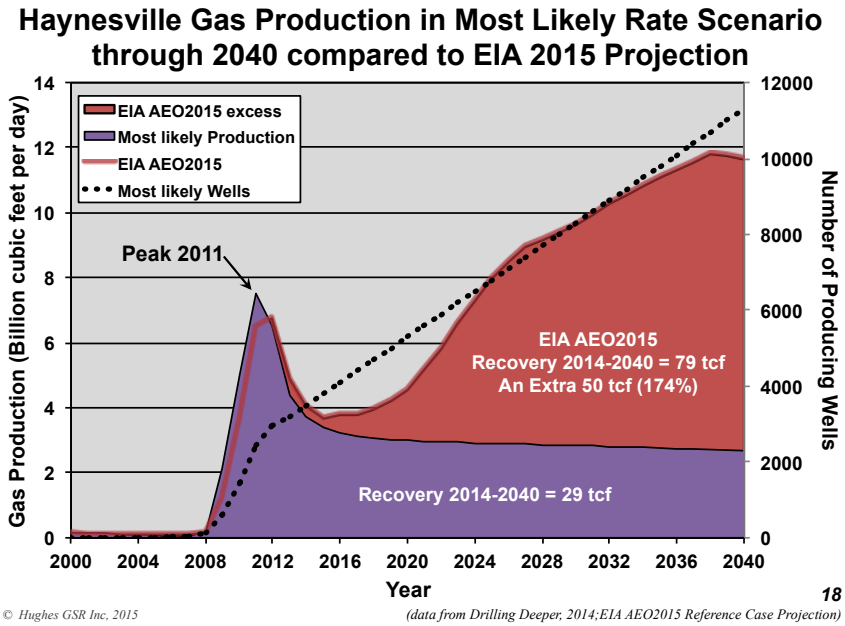

FIGURE 3: HAYNESVILLE PLAY PEAKED IN 2011, AND EIA PROJECTS HUGE PRODUCTION INCREASE STARTING 2017

Q. PLEASE EXPLAIN THE SHALE PLAY LIFE CYCLE

A. First, a play like the Haynesville is discovered, triggering a frenzy of land leasing as companies buy up leases to drill in locations they hope will pay off. Even if drilling is uneconomical because the price of gas is less than the cost of production, the drilling boom continues because the leases typically come with drilling commitments – so-called "held by production". Companies identify the "sweet spots" with the highest productivity wells, and those locations are drilled first. Production rises quickly and may be maintained for cash flow despite the fact that some wells may be losing money on a full-cycle basis. The sweet spots

eventually become saturated with wells, and production declines. Plays like the Haynesville become middle-aged after just five years.

Q. WHAT IS THE EIA'S TRACK RECORD ON ESTIMATING RESOURCES AND PROJECTING FUTURE PRODUCTION AND COSTS?

A. A review of past EIA projections shows that they typically err on the high side, although the EIA's initial estimates of future shale gas production back in 2010 were too low, and they have since been revised continually upward to the point which they are now over estimating future production. Admittedly, forecasting is very challenging, especially as it relates to shifting economic and technological realities. But the below ground fundamentals— the geology of these plays and how well they are understood—don't change wildly from year to year, as much more geological data is now available. And yet the AEO2015 and AEO2014 reference cases have major differences between them; production rates have been revised both down and up by amounts exceeding 40% in some plays.

Q. DO YOU SEE ANY SCENARIO WHERE THE EIA PROJECTIONS COULD BE CORRECT?

A. The only way to meet the reference case projections of the EIA would be for most of the existing plays to massively ramp up production years from now, as well as significant, some as yet undiscovered, new plays coming on line. But because the best wells are drilled first, and steep decline rates demand a "drilling treadmill" to maintain production (which consumes a finite number of drilling locations), massive ramp ups in production from existing plays that are more than a few years old are unlikely. And years of intense exploration has identified the most prospective plays

and limited prospects for new discoveries. The EIA is likely counting on new technologies that have not yet been developed, as well as significant new discoveries, to meet its forecasts. Although it is certainly true that better technology has increased average well productivity in the best counties of plays like the Marcellus in recent years, these developments have reached the law of diminishing returns, and average well quality has begun to decline. See Figure 4 for my estimate of the most likely gas production from the top shale plays given production data through mid-2014, as well as the number of producing wells needed to achieve it.

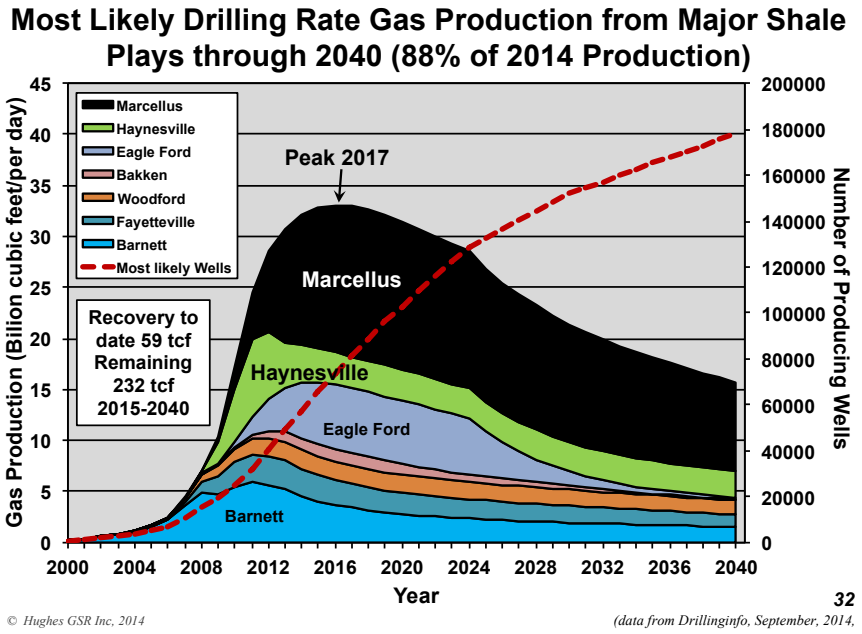

FIGURE 4: J. DAVID HUGHES MOST LIKELY PRODUCTION FOR MAJOR SHALE PLAYS

Q. WHY ARE HIGH DECLINE RATES FOR SHALE GAS WELLS AND OVERESTIMATED SUPPLIES RELEVANT TO THIS DOCKET?

A. The high decline rates for shale gas wells and overestimated supplies make the combination of Duke Energy and PNG, two companies that are heavily reliant on

the shale gas industry, vulnerable to supply shortfalls and price spikes. Duke Energy and PNG's gas supply is expected to come mainly from the Gulf coast and Appalachian regions, so production declines in either of those areas will affect the cost and availability of supplies over the lifetime of the two companies' investments in gas plants and other infrastructure. Higher costs resulting from supply restrictions will be passed on to ratepayers.

Q. ARE YOU THE ONLY EXPERT RAISING A RED FLAG ABOUT HIGH DECLINE RATES AND OVERESTIMATED FUTURE PRODUCTION RATES?

A. No. Mr. Art Berman has also sounded the alarm about overly optimistic production rates and resources for many years.[17] In a May 2016 article in Oilprice.com, Mr. Berman says the most recent EIA Annual Energy Outlook, AEO2016, "sparkles with pixie dust as it forecasts almost unlimited gas supply at low prices out to 2040 and beyond." Mr. Berman demonstrates, as I do, that U.S. shale gas production is declining due to low prices, and further that shale gas companies are in deep financial trouble because, "in the real world, price and cost matter."[18] Berman asserts that the current low gas price is well below the production cost for any operator in any play. Even in sweet spots of the Marcellus–

[17] *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, March 5, 2014: http://oilprice.com/Interviews/Shale-the-Last-Oil-and-Gas-Train-Interview-with-Arthur-Berman.html

[18] *Why Cheap Shale Gas Will End Soon,* Art Berman, May 24, 2016: http://oilprice.com/Energy/Energy-General/Why-Cheap-Shale-Gas-Will-End-Soon.html

the most commercially attractive shale gas play–break-even prices are more than $3.00.

Q. WHY IS THE FINANCIAL CONDITION OF THE U.S. SHALE INDUSTRY SO IMPORTANT?

A. The percentage of shale gas in U.S. total natural gas production has skyrocketed to over 50% and is the major prospect for future production growth – and with high decline rates, shale gas producers need to constantly drill new wells, which requires large amounts of capital. When credit is cheap, it's easier to maintain viable cash flows. However, the combination of higher interest rates plus low commodity prices is very damaging to the industry.

If natural gas production declines and drilling rates cannot be maintained due to poor economics, fuel prices could skyrocket, putting ratepayers at risk of shortages and price spikes.[19] 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.

2) SWITCHING FROM COAL TO GAS IS NOT A CLIMATE FRIENDLY SOLUTION

Q. PLEASE EXPLAIN YOUR RESEARCH ON THE VIABILITY OF NATURAL GAS AS A TRANSITION FUEL TO A LOW CARBON FUTURE.

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[19] 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
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/

A. In 2011, I published two studies: one looked at whether or not natural gas can serve as a "bridge fuel" from high-carbon sources of energy like coal and oil to a renewable energy future,[20] and another study that looked at conflicting reports on whether shale gas had lower life cycle greenhouse gas emissions than coal.[21]

I analyzed two studies with conflicting conclusions on the full life cycle greenhouse gas emissions from shale gas production: one from scientists at Cornell University [22] and another from a scientist at the National Energy Technology Laboratory (NETL). The Cornell study, published in a peer-reviewed journal, suggests that life cycle greenhouse gas (GHG) emissions from shale gas are 20%-100% higher than coal on a 20 year timeframe, especially considering that 70% of natural gas consumption is not used for electricity generation (although the amount of natural gas used for electricity production has increased since 2011). The NETL study, presented in a talk at Cornell University and later posted on the NETL website, suggests, on an electricity-generation comparison basis, that natural gas base load has 48% lower GHG emissions than coal on a 20 year timeframe. The NETL comparison, however, does not single out shale gas, which is projected by the U.S. Energy Information Administration (EIA) to be the major source of natural gas supply growth going forward, or the overall emissions from natural gas-fired

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[20] *Will Natural Gas Fuel America in the 21st Century?*, J. David Hughes, May 29, 2011: http://www.postcarbon.org/publications/will-natural-gas-fuel-america/

[21] *Life Cycle Greenhouse Gas Emissions from Shale Gas Compared to Coal: An Analysis of Two Conflicting Studies*, David Hughes, June 30, 2011: http://www.postcarbon.org/publications/life-cycle-ghg-shale-gas/

[22] *Methane and the greenhouse-gas footprint of natural gas from shale formations*, Robert W. Howarth, Renee Santoro and Anthony Ingraffea, 2011: http://www.acsf.cornell.edu/Assets/ACSF/docs/attachments/Howarth-EtAl-2011.pdf

electricity generation, focusing instead on the more efficient base load combined cycle component. When the assumptions of the NETL study are examined in detail, and compared to the U.S. Environmental Protection Agency (EPA) 2009 emissions inventory for natural gas, as well as the likely ultimate production from shale gas wells, the resulting conclusions are not significantly different than the Cornell study.

Thus, I found that shale gas full cycle greenhouse gas emissions are higher than coal when comparing both the existing electricity generating fleets and best-in-class electricity generation technologies for both fuels over a 20 year timeframe, and lower than coal on a 100 year timeframe basis. This has significant policy implications for utilizing natural gas as a "transition" fuel to a low carbon future in mitigating near term greenhouse gas emissions. More recent studies by Dr. Robert Howarth of Cornell[23] demonstrate that natural gas (methane) is not a climate solution, and that the use of methane must be reduced in the near term if we are to address climate change. In addition, methane leakage from natural gas production is a serious issue that must be addressed (note that the EPA is currently developing regulations to reduce methane emissions).

Q. HOW MUCH ELECTRICITY IS CURRENTLY PRODUCED FROM NATURAL GAS IN THE U.S. AND IN NORTH CAROLINA?

A. Total U.S. electricity produced from natural gas increased 19% from 2014 to 2015 due to low gas prices and coal plant retirements,[24] while in February 2016

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[23] *A bridge to nowhere: methane emissions and the greenhouse gas footprint of natural gas*, Dr. Robert W. Howarth, April 22, 2014: http://www.eeb.cornell.edu/howarth/publications/Howarth_2014_ESE_methane_emissions.pdf

[24] *Many natural gas-fired power plants under construction are near major shale plays*, Energy Information Administration, May 19, 2016: http://www.eia.gov/todayinenergy/detail.cfm?id=26312

nearly 32% of North Carolina's electricity came from natural gas, with coal-fired power down to 25.6%.[25] Between 2015 and 2030 the U.S. Department of Energy ("DOE") expects more new gas plants to be built in the Southeast than in any other region in the U.S. Since natural gas is not typically stored on-site, and is consumed as it is delivered, there is an increased risk of price spikes.[26]

Q. CAN YOU SUMMARIZE YOUR CONCLUSIONS PLEASE?

A. The large scale build out of natural gas-fired power generation to replace coal in the U.S. is based on overly optimistic supply projections and the assumption of low prices for the foreseeable future, and hence is risky, both from a security of supply and price point-of-view. Future natural gas supply growth in the EIA reference projections come almost entirely from shale gas, and are not supported by geological fundamentals in existing plays, particularly at the relatively low prices forecast. Barring windfall new discoveries, these forecasts are unlikely to be met. Development of extensive base load natural gas facilities creates an inelastic demand that must be met, regardless of price, and hence places ratepayers at risk of much higher prices in the future. Further, full-cycle greenhouse gas (GHG) emissions from shale gas may be worse than previously understood, and possibly worse than coal.

A shift to natural gas is not a silver bullet - there are other avenues that can yield lower greenhouse gas (GHG) emissions and fuel requirements and thus

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[25] *North Carolina*, Energy Information Administration: http://www.eia.gov/state/print.cfm?sid=NC (accessed 5/30/16)

[26] *Natural Gas Infrastructure Implications of Increased Demand from the Electric Power Sector*, U.S. Department of Energy, February 2015: http://energy.gov/epsa/downloads/report-natural-gas-infrastructure-implications-increased-demand-electric-power-sector

improve energy security. Strategies for energy sustainability must focus on reducing energy demand and optimizing the use of the fuels that must be burnt. See Figures 5 and 6 for a comparison of my estimates of U.S. shale gas production to the EIA's AEO2014 and AEO2015 projections, and note that EIA's AEO2015 projection includes significant amounts of gas from plays that are developing or have not yet been discovered.

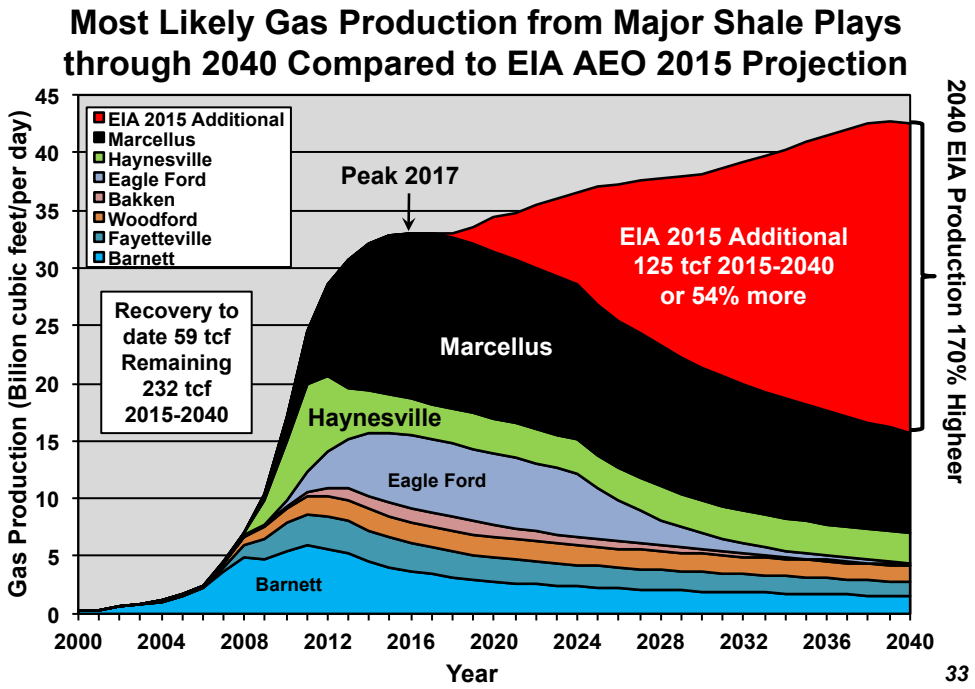

FIGURE 5

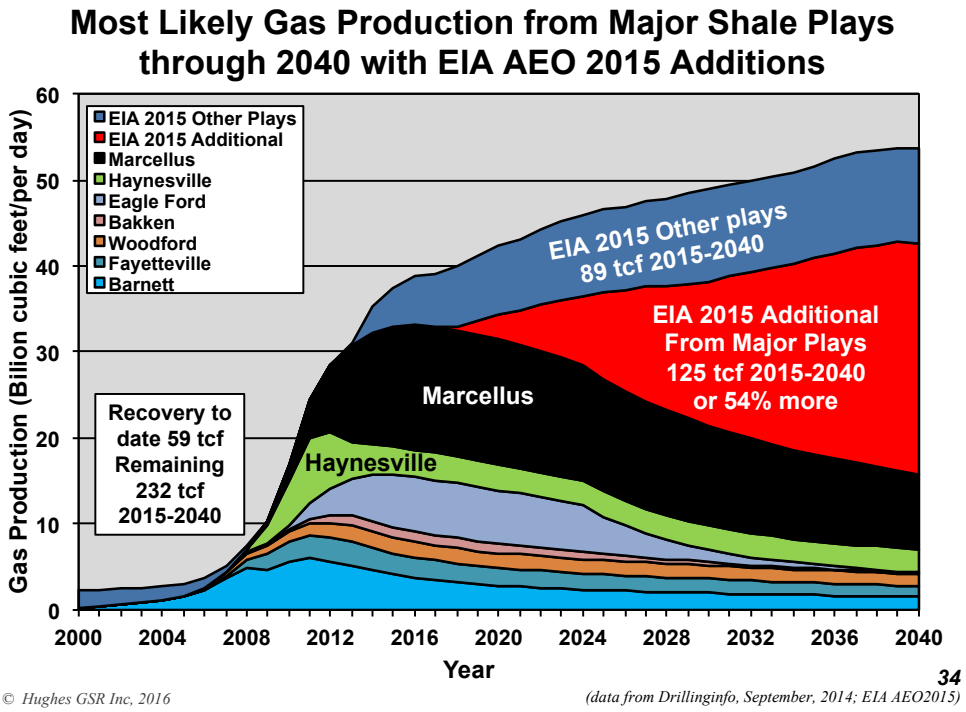

FIGURE 6

Q. ANY FINAL COMMENTS?

A. North Carolina's electricity future is largely determined by the assumptions and expectations we use today. As regulators of a monopoly utility, the North Carolina Utilities Commission is charged with making prudent decisions that are in the public interest. The findings of my analyses have clear implications for both the medium and longer term supply of shale gas and its resulting long term price. Electricity plays a critical role in the health of North Carolina's economy and environment, and the importance of getting it right can't be overstated. Future energy security depends on a holistic plan, including demand side management as well as alternative carbon-free energy sources which are being deployed at exponentially increasing rates elsewhere in the U.S. and the world. Reliance on natural gas to meet the majority of

incremental energy demand is likely to result in higher and more volatile costs in the future and a considerably larger carbon footprint than could otherwise be attained.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

CERTIFICATE OF SERVICE

I hereby certify that I have this day served a copy of the foregoing DIRECT TESTIMONY OF DAVID HUGHES upon each of the parties of record in this proceeding or their attorneys of record by deposit in the U.S. Mail, postage prepaid, or by email transmission.

This is the 10th day of June 2016.

/s/ *John D. Runkle*

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