Written Testimony

Committee on Environment and Public Works

U. S. Senate

November 5, 2013

Good Morning. I am Dan Hill and I am the Head of the Petroleum Engineering Department at Texas A&M University. I have been a faculty member for over 30 years after working in industry for about 5 years, and throughout my career I have conducted research on methods to improve oil and gas production. In recent years, one focus of my research has been various aspects of hydraulic fracturing of shale gas and oil reservoirs. Hydraulic fracturing is the key enabling well completion technique that has enabled the production of huge quantities of natural gas and oil from shale reservoirs to the enormous benefit to the U.S. economy and to U.S. consumers. In February, 2012, I was invited by Professor David Allen of the University of Texas at Austin to serve on the scientific advisory panel for the planned comprehensive study of methane emissions at natural gas production sites in the United States. I was happy to accept this invitation because this study was to be the first to my knowledge that would actually measure fugitive methane emissions from shale gas wells at many sites around the United States. Prior to this study, there was speculation in some publications that very large volumes of natural gas were being emitted during the flow back period immediately after hydraulic fracturing operations were completed. The assumptions made to derive such estimates did not seem reasonable, so I was anxious to see the results of actual emissions measurements made carefully and scientifically.

As a member of the Scientific Advisory Panel for this methane emissions study, I reviewed the planned measurement program, reviewed results part way through the study, reviewed the final results, and reviewed the publications describing the study and its results. Throughout the study, I was impressed with the careful and thorough approach of the study team. I would say that this was the unanimous opinion of the Scientific Advisory Panel.

Unconventional oil and gas production has changed the U. S. energy game.

In just a few years, applications of advanced technology have led to the most dramatic economic boost our country has seen in my lifetime. Production of natural gas and oil from unconventional reservoirs, primarily shale formations, is soaring, daily lessening this country's dependence on imported oil and natural gas. Slide 1 is a history and forecast of the U. S. natural gas supply – in less than 10 years, gas production from shale formations has grown to over 30% of the U. S. supply, and continues to grow. In fact, in a recent update to this 2011 forecast, the EIA is now predicting that the United States will be a net gas exporter before 2020.This is great news in every possible way – natural gas is the cleanest burning fossil fuel, it yields the least CO_2, and it is low cost, thanks to its newfound abundance in unconventional reservoirs.

The dramatic growth in U.S. natural gas production has come almost entirely from shale formations. As illustrated in Slide 2, there are large volumes of natural gas being produced from many different shale formations and the production from these reservoirs continues to increase despite the current low gas prices.

Thus, it is critical that development of natural gas production from shales continues in an environmentally responsible fashion. In my opinion, this study has alleviated the fear that large volumes of natural gas are emitted during the flowback period following hydraulic fracturing. However, this study did reveal significant sources of natural gas emissions occurring during other shale gas well operations. I feel confident that these important findings will cause operators to take measures to significantly reduce theses emissions.

Measurement protocols were sound and properly applied.

The validity of this study is founded on the measurement methods used and their correct application. The methods chosen were all proven from years of prior practice and were properly calibrated and applied in this study. To measure methane emissions during flowback or well unloading operations, gas from all possible vents from the tanks or separators receiving gas and liquids from the well was captured and forced through devices that measured the gas flow rate. The gas was sampled to measure the methane concentration. Slide 3 is a photograph of such a setup at one of the studied well sites and a schematic of the measurement apparatus.

Emissions from pneumatic controllers, pumps, and other leaking equipment were measured by first locating the leaks with an infrared camera, then measuring the emission rate with a device that essentially vacuums the leaking gas into itself, where flow rate and methane concentration are measured. This device has been in use for measuring leaks for decades.

Finally, on a few well sites, methane concentration was measured downwind of the well site to insure that no significant source of methane emissions had been missed. In all cases, this downwind measurement corroborated the point source measurements, confirming that no undetected major leaks or other emissions were occurring.

The study is comprehensive.

In this study, methane emissions were measured at 190 well sites, with 489 hydraulically fractured gas wells at these sites. The well sites were located in the Gulf Coast, Mid-Continent, Rocky Mountain, and Appalachian regions of the U.S. (Slide 4). Measurements were made on sufficient numbers of well sites to make the results statistically valid. Thus, within a reasonable statistical tolerance, the results of this study can be generalized to the more than 440,000 onshore gas wells in the United States.

Methane emissions during hydraulic fracturing flowback operations are 36 times less than that estimated in the EPA's 2011 greenhouse gas inventory.

The most important finding of this study is that methane emissions during the flowback period immediately following hydraulic fracturing are dramatically less than that estimated by the EPA in its 2011 greenhouse gas inventory – more than 36 times less. The EPA estimate was not based on actual measured methane emissions, as this study is, but simply assumed a certain percentage of all methane produced during flowback was emitted. Obviously, the assumed percentage emitted was too high, 36 times too high. Common industry practice during flowback operations is to separate the produced gas from the produced liquids, with the gas either being flared (the methane burned) or sent to a sales line. So, it is not surprising that emissions measured in this study during flowback operations were low.

Significant volumes of methane are being emitted from pneumatic controllers, from pumps, and from leaks.

This study found that emissions from pneumatic controllers, chemical pumps, and leaks exceed the 2011EPA estimates and are by far the largest sources of methane emissions at shale gas well sites. These emission sources are easily reducible. For example, pneumatic controllers, the largest source of methane emissions have high bleed and low bleed types, with the emissions being much larger from the high bleed type. It has been demonstrated that most high bleed controllers can be economically replaced with low bleed controllers.

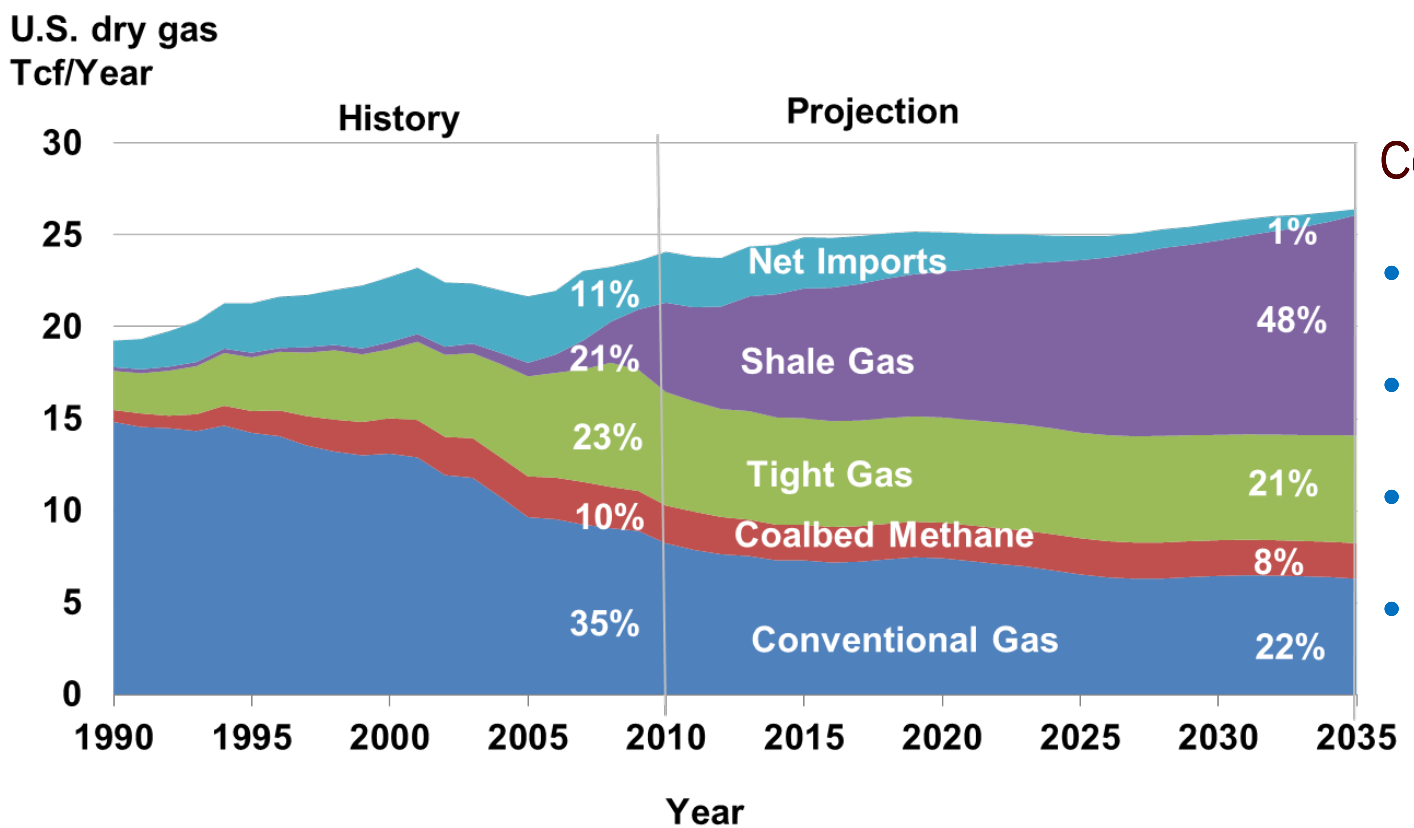
More study of methane emissions during gas well unloading is needed.

In this study, only nine gas well unloading events were monitored for methane emission, and in only three of these, all located in the Gulf Coast region, significant methane emissions occurred. The range of emissions measured during thes few tests was extremely variable, and not easily generalized. Unloading of gas wells by lowering the wellhead pressure is a common practice with shale gas wells, so it is important to understand the level of emissions from these operations. I recommend that a comprehensive study of methane emissions during unloading be conducted, following protocols like those used in this study.

Fugitive methane emissions are only 0.42% of the produced gas from shale wells.

This study has shown that only 0.42% of the methane produced from shale gas well sites is emitted as fugitive gas. It also showed that the large majority of emissions occur during normal production, and are not related to flow back after hydraulic fracturing. It is likely that this study will lead to improved industry practices that will significantly reduce methane emissions from shale gas well sites. It is instructive to realize that 0.42% of the current U. S. shale gas production is about 42 Bcf/year of gas, which even at current low prices, has a value of about $150 million. This is a significant economic target for the industry to capture by applying improved practices and developing new technologies.

UG Plays A Major Role In Future



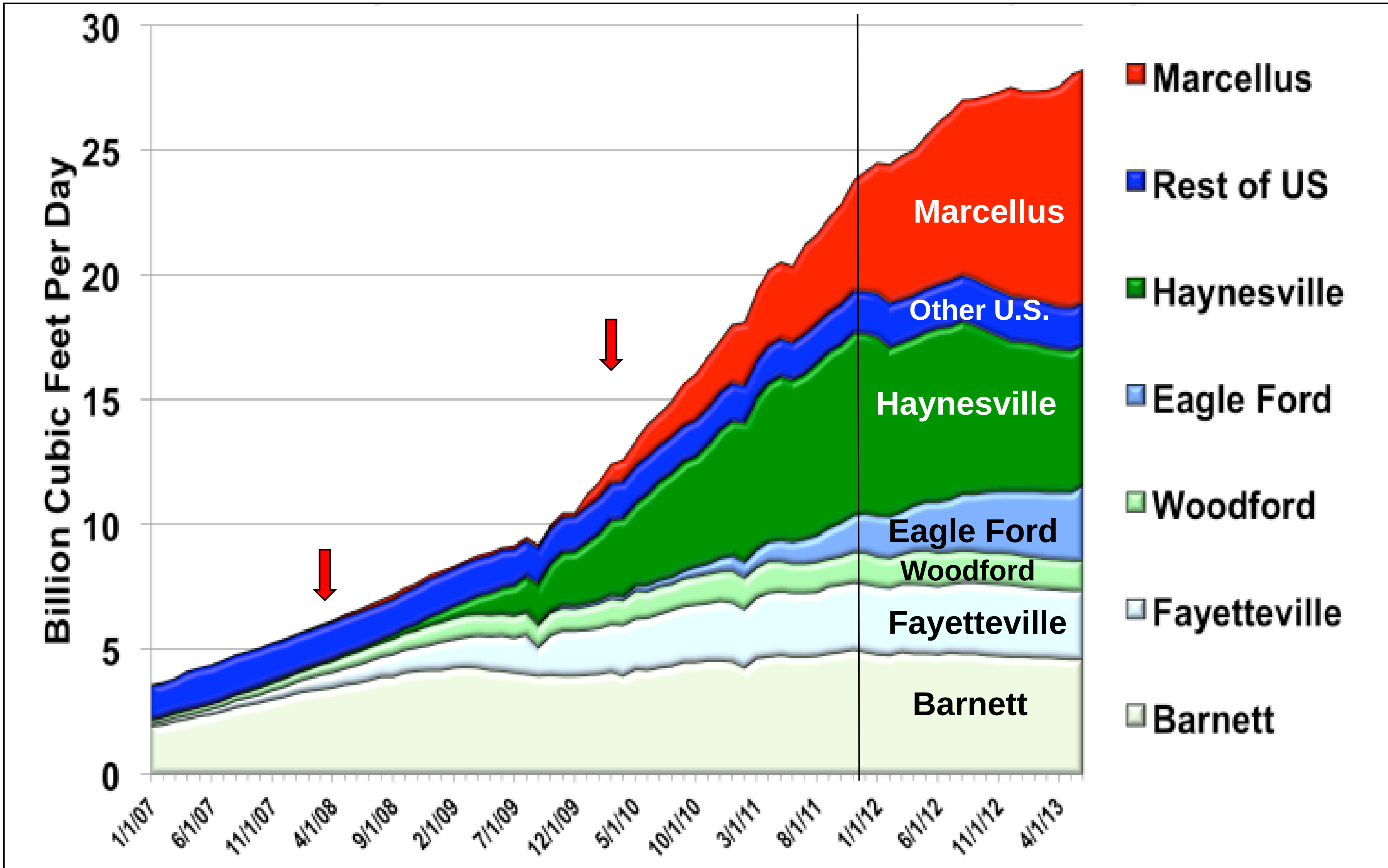
Consumption:

- 24.2 Tcf/year
- UG: 13.0 Tcf/year.
- Conventional: 8.6 Tcf
- Net imports: 2.6 Tcf

❑ **Natural gas production has increased over the last few years, largely due to increased unconventional gas production.**

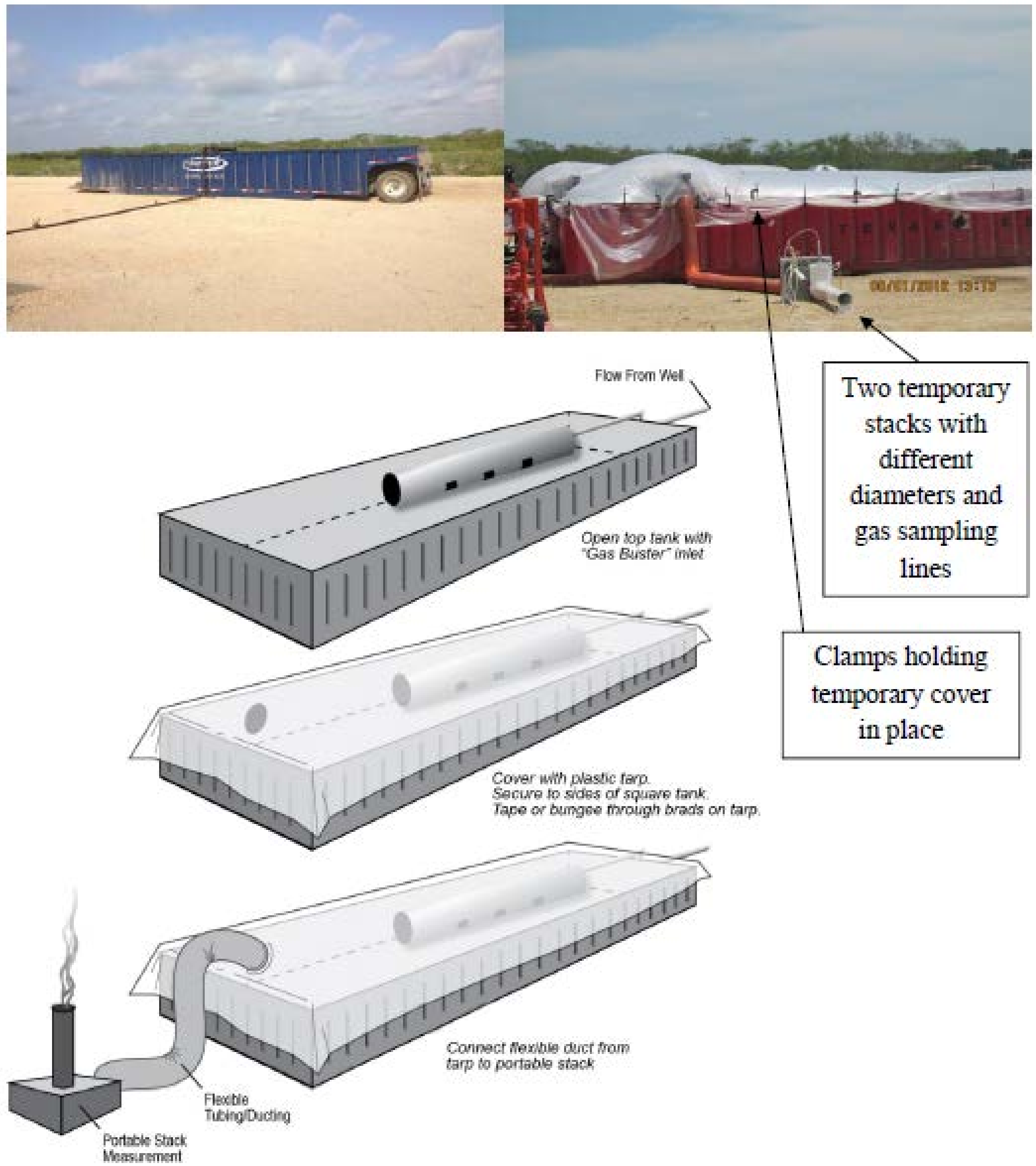
Source: EIA, *Annual Energy Outlook 2012*

U.S. Dry Shale Gas Production by Play

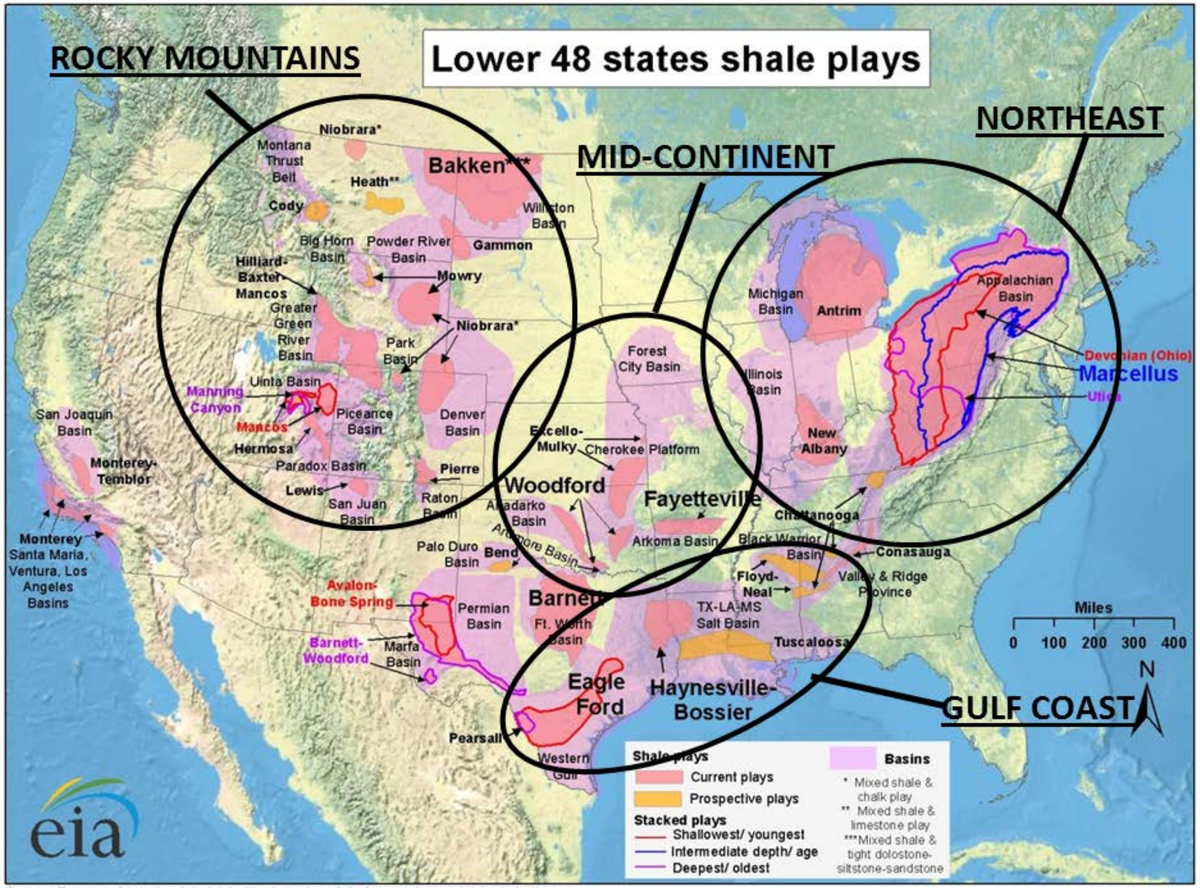


Data from *EIA 2013*

Open Top Tank Used in Flowback



Allen, et al., *PNAS*, 2013



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011