Northwest **Power** and **Conservation** Council

September 7, 2016

MEMORANDUM

TO: **Council members**

FROM: **Steven Simmons, Senior Economic Analyst**

SUBJECT: **Briefing on Natural Gas Extraction and Hydraulic Fracturing**

BACKGROUND:

Presenter: Steven Simmons

Summary: North America is now into the eighth year of the "shale boom". Technological advances in horizontal drilling, hydraulic fracturing, and seismic imaging has opened up vast new natural gas supplies in the United States and Canada. As a result, drilling efficiencies have greatly improved, production is at historic highs, and prices have remained relatively low and stable.

Staff will provide a high level overview of the natural gas extraction process which has led to the shale boom, including horizontal drilling, hydraulic fracturing, and waste disposal.

Though various methods of fracturing has been used to stimulate oil and gas well production since the 1940s, the birth of modern hydraulic fracturing traces to experiments run on the Barnett shale the late 1990s in Texas. Today, according to the E.P.A, upwards of 25,000 to 30,000 new oil and gas wells are hydraulically fractured annually in the U.S.

As a result of the increasing drilling activity, concerns have been raised about the potential risks of hydraulic fracturing for oil and natural gas,

including the potential for accidental migration of gas and fracking fluids into drinking water aquifers, increased methane leakage from natural gas production, and seismic events related to the underground waste disposal from production activities. Staff will provide a brief summary of recent studies which have looked into the potential for unwanted fluid migration and detection of methane leakage.

Relevance: Natural gas supply, demand and price play an important role for regional consumers of both natural gas and power. With looming coal power plant retirements, the region may have an increased reliance on natural gas as a fuel source. Assumptions around gas supply and price forecasts also factor into many of the Council's planning models and tools.

Workplan: A.3 Forecasting and Economic Analysis

Background: Staff is expected to reconvene the Natural Gas Advisory Committee later in 2016 to review the status of gas in the region. Staff will also be updating the natural gas price forecast by the end of 2016, roughly one year following the final forecast from the Seventh Plan.

Briefing on Natural Gas Extraction and Hydraulic Fracturing

September 13, 2016

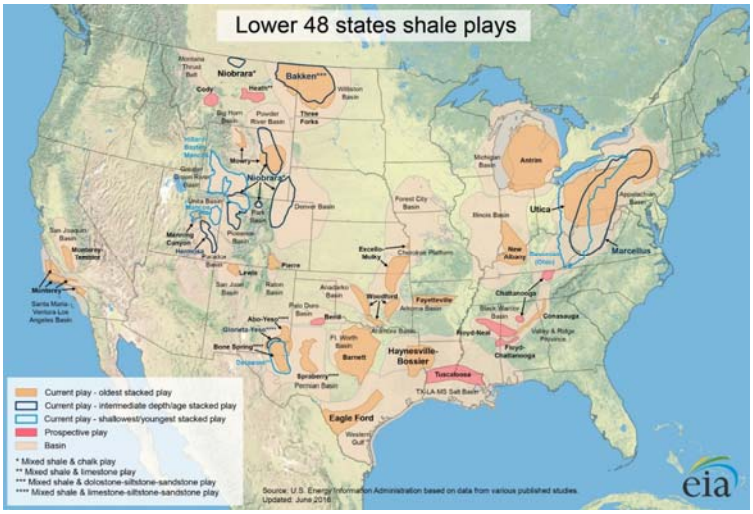
Spokane, Washington

Northwest Power and Conservation Council

Today's Presentation

1. Setting the context – the Shale Boom
2. Brief review of the history of hydraulic fracturing & environmental concerns
3. Natural gas extraction process and regulation
4. Summary of risks and findings from recent studies

Northwest Power and Conservation Council



1. SETTING THE CONTEXT

Simultaneous technological advancements

1. Digital Imaging
2. Horizontal Drilling
3. Hydraulic Fracturing

= SHALE BOOM

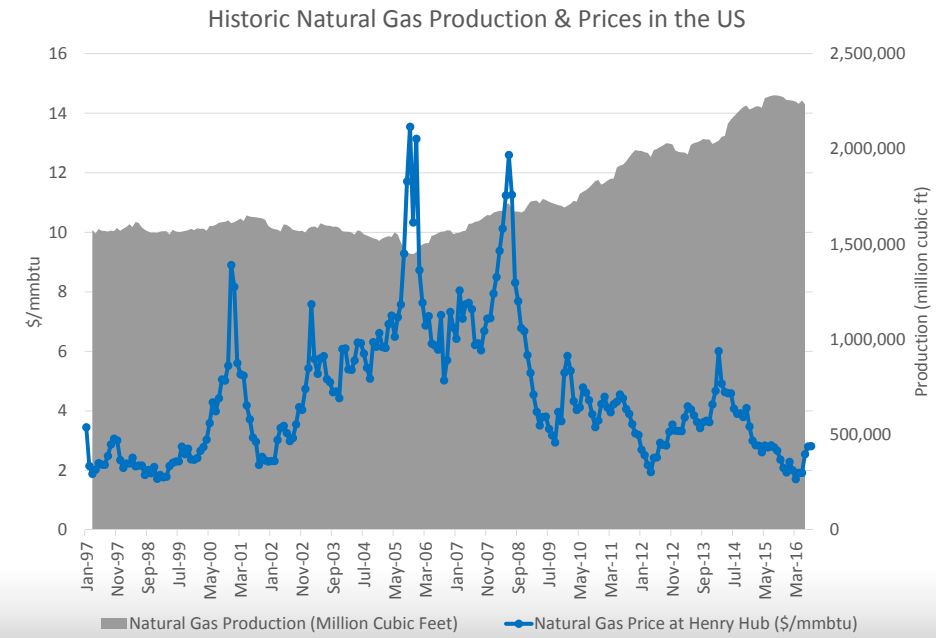
We are now eight years into the Shale Boom – what are the results ?

US moves from an expected constrained natural gas future – to one of abundance

1. Prices drop and become more stable
2. Gas flow dynamics across the US are altered
3. Imports decline, exports increase
4. Power production from gas increases and begins to surpass coal
5. Environmental and community concerns are raised

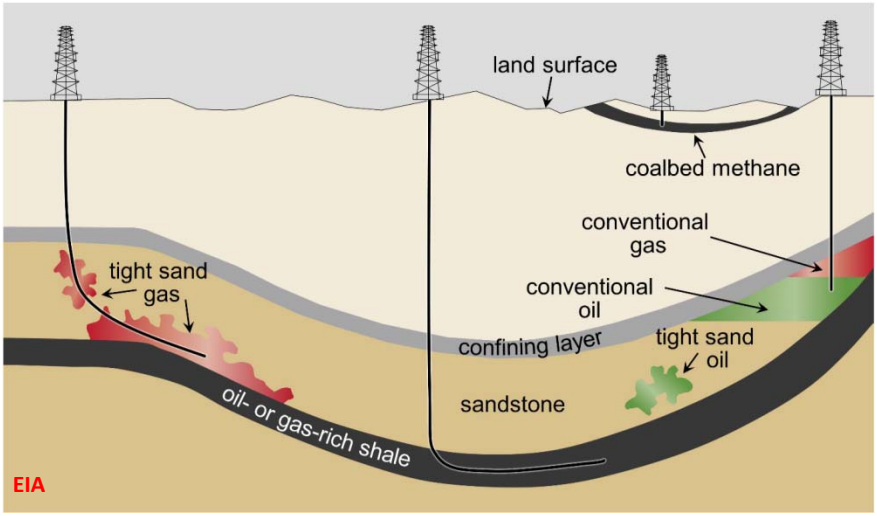
Northwest Power and Conservation Council

5



Northwest Power and Conservation Council

6



2. BRIEF HISTORY OF FRACKING

Brief Definition

Hydraulic Fracturing

Well stimulation technique – fluid (mostly water and sand) is pumped underground at high pressure to create tiny fractures in gas rich shale. Sand props open the fractures and the gas is released from the source rock.

Brief History Lesson

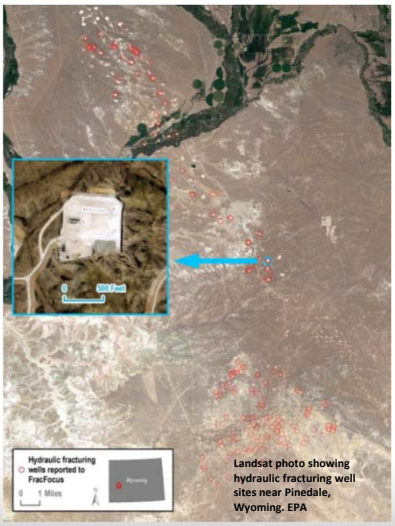
- Some form of fracking has been used to stimulate production since the 1940's
- Modern hydraulic fracking in shale was developed in the late 1990's by Mitchell Energy and in particular an engineer by the name of Nick Steinsberger
- S.H. Griffin #4 well near Ponder Texas – successful frack of shale using mostly water instead of fracking gel, in an effort to save $
- There were 25k to 30k wells drilled and fractured annually between 2011 and 2014

Concerns & Controversies

1. Community pushback due to increased noise, traffic, air pollution, and water use - results in communities passing moratoriums against fracking
2. Methane leaks from increased gas production potentially contributing to greenhouse gas build up
3. Gas and oil production from fracking impacting drinking water resources
4. Small earthquake activity picks up –tied to increased underground injection of oil & gas related wastewater

3. NATURAL GAS EXTRACTION PROCESS

Well Pad Development



1. Site assessment, securing mineral rights, permitting
2. Leveling of the site – around 3 acres
3. Construction of structures for erosion control
4. May excavate pits with liners to hold drilling fluids
5. Heavy traffic for a few weeks

Drilling the Well

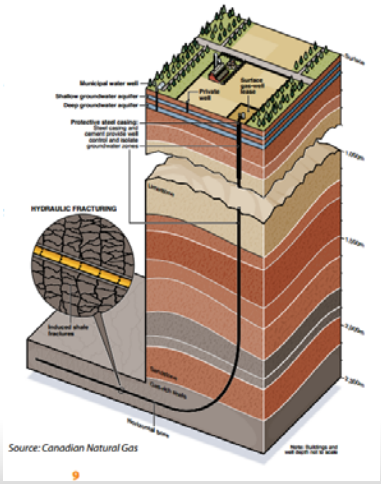
- Drilling rig is wheeled in and set up
- Vertical drilling as far as 10,000 feet down – taking 7 to 10 days
- Drilling halts for steel casing and cementing at stages
- Once at the "pay-zone" the "bend" is drilled – 1 to 2 days
- Horizontal drilling for another 4000 to 10000 feet, encased in cement with steel pipe running down middle, holes punched for fracking
- Drilling rig is packed up – to wait for the fracking crew

Hydraulic Fracturing & Completion

Fracfocus.org

- Trucks arrive with tanks, sand, water, chemicals, and blend the fluids for fracking
- The blend is pumped down the well at high pressure to fracture the shale –this is done in stages over 2 to 3 days
- Downward pressure is removed, some of the blend "flowback" and in a few days gas and/or oil flows begin
- Produced water may be trucked off site to be disposed of in deep injection wells, treated, or re-used for further fracking operations
- EPA regulates "green completions" for reduction in methane leakage

Casing & Cementing



- State regulated, API sets specs for construction and integrity
- Multiple steel casing strings are cemented into place
- Of special importance is the surface casing & cementing which isolates the ground water from inside of the well
- Proper sealing of the annular spaces with cement creates barriers to vertical and horizontal fluid or gas migration
- Typically the shale "pay zone" sits far below water aquifers
  - shale ~ 2200 m (7200 ft)
  - water ~ 100 m (330 ft)

Fracking Fluid Composition

Information from fracfocus.org

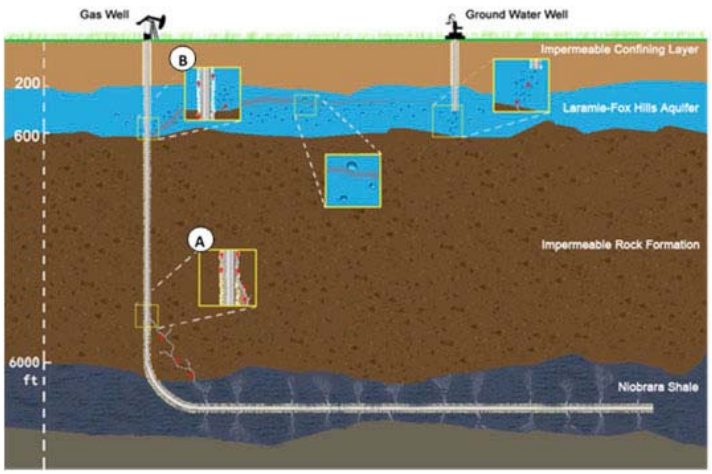
1. Primarily state regulated
2. Water and sand comprise 98 to 99.5% of the fracking mix, chemical additives make up the rest
3. Typically 3 to 12 different chemicals are used depending on the shale makeup – but can be selected from over 600 chemicals
4. Additives include
   1. Friction reducing chemicals (slick water)
   2. Biocides which prevent microorganism growth in the well

FracFocus.Org

- National hydraulic fracturing chemical registry – well operators can disclose the chemicals used during fracturing well by well
- Many states require operators to disclose the chemicals on this site (including Colorado and Utah), some states require disclosure to the state (Wyoming)

Waste Disposal

- Produced fluid is injected in deep underground wells, treated in wastewater treatment, or recycled for further use
- EPA regulates permitting, inspections, and enforcements for injection of wastewater related to oil and gas production – UIC program (underground injection control)



Source - Colorado State University

4. RISKS AND FINDINGS FROM RECENT STUDIES

Risks

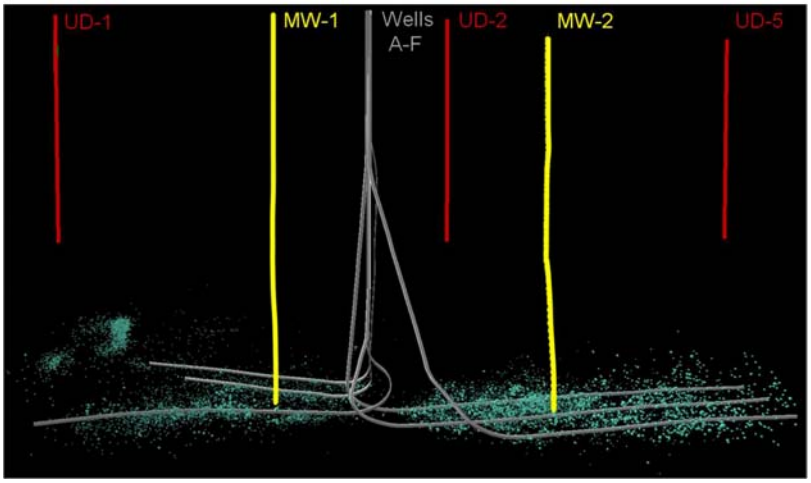
1. Migration of natural gas and/or fracking fluids to a drinking water aquifer
2. Communication with a older existing well that was not properly constructed
3. Fluid spills – on well pad site, or during transportation to and from the site
4. Small earthquakes resulting from underground injection of waste
5. Methane leakage

Three Related Studies

1. The National Technology Energy Lab (NETL-TRS-3-2014) did an extensive study on hydraulic fracturing in the Marcellus Shale in 2014 – looking to see if gas and/or fracking fluids migrate up to overlying gas fields or water aquifers
2. Scientists from Colorado State University have been performing a series of studies on the impact of oil and gas drilling on groundwater in the DJ Basin of Colorado
3. In 2015 there was a study of airborne measurements of methane in the Four Corners region – joint project with NASA, Cal Tech, NOAA and U of Michigan – to located point sources of methane leakage related to oil, gas and coal develoment

Summary of Conclusions

1. NETL - Stress from hydraulic fracturing in Marcellus Shale did not extend to the overlying gas field or water aquifers – and there was no detectable communication between the fracked horizontal wells and the gas field or water aquifers
2. CSU - They have not found evidence of water based contaminant from drilling leaking into water wells. However some wells (2 % of sampled) have shown some seepage of oil and gas related methane – the theory is that stray gas has moved alongside compromised well casings from much older wells
3. NASA - Airborne measurements directing ground team works as a mitigation effort. Log Normal distribution of methane point sources – has implications
   a) Heavy tail distribution – meaning a few emitters comprise the bulk of emissions (in this study, roughly 10% of the emitters were responsible for 60% of the emissions)



NETL STUDY: Fracked 6 horizontal wells in the Marcellus Shale from a single well pad - below an existing conventional gas field
Instruments lowered in 2 vertical wells were used to monitor the extent of the micro seismic events and PFC tracers were used to look for evidence of communication with the gas field

Monitoring Methane – From the Top Down

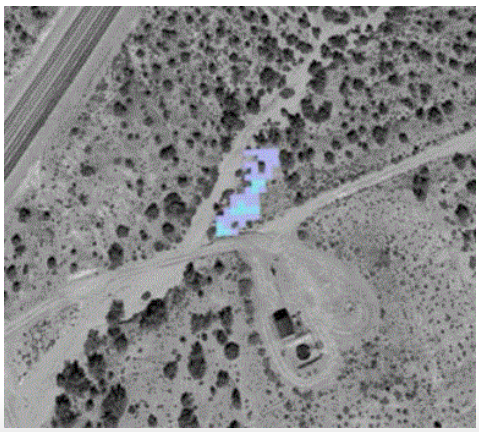
SATELLITE

↓

Airplane

↓

Ground Crew



http://www.pnas.org/content

Monitoring Methane – Top Down

http://www.pnas.org/content