Methane Leakages from Completion of Unconventional Wells
CH₄ as a Mass Fraction of GHG Emissions in the U.S.

GWP (20 years) vs. GWP (100 years)

- CH₄ 22%
- CO₂ 72%
- HFC 2%
- PFC, SF₆ trace
- N₂O 4%

(- GHG emissions, EPA 2010)
CH$_4$ Emissions from Unconventional Well Completions: Perspectives

- **Emissions from:**
  - **Unconventional well completions**
    - 48 Bcf / yr or 0.9 Mtonnes/yr
  - **Natural gas systems**
    - 550 Bcf / yr or 10.3 Mtonnes/yr
  - **All CH$_4$ sources in the U.S.**
    - 1,700 Bcf / yr or 31.8 Mtonnes/yr

- **In CO$_2$ equivalent terms:**
  - 19 Tg or 0.3% of GWP (100 yrs)
  - 50 Tg or 0.6% of GWP (20 yrs)

- **Revenue loss** (1 MCF~1 mmBTU, $4/mmBTU):
  - ~$200 M / yr

- **Fraction of annual nat gas demand:**
  - Annual ~21 Tcf/yr
  - 48 Bcf / 21 Tcf ~ 0.2%

---

(- GHG emissions, EPA 2010
- Technical note on the 1990 – 2009 inventory estimates for natural gas systems)
Projected U.S. CH₄ Emissions from Unconventional Well Completions

Use values from the previous slide and apply the same percentage growth of 0.9% yoy production growth and attribute all growth to unconventional gas production:

- 1.1 Mtonnes/yr of CH₄
- 24 Tg CO₂ equivalent (100 yr) or 63 Tg CO₂ equivalent (20 yr)
- 60 Bcf/yr or ~$240 M/yr (1 MCF ~ 1 mmBTU, $4/mmBTU)
Lowest hanging fruit is regulation of well completion practices.

Pipeline leakage = hard to detect and survey, costly to excavate and fix.

Equipment leakage = small locations from many locations, accounting problems.

Impact may be low, but if it is easy to fix, why not?
Outline

- When do emissions occur?
- What is a green completion?
- What technology is available?
  - BP, Williams
  - Questor
- Why is it sometimes difficult to implement green completions?
  - High pressure
  - Low pressure
  - Lack of infrastructure
  - High impurity concentrations
- Academic opportunities
  - Enhanced recovery through well stimulation
  - Reservoir characterization and modeling
CH₄ Emission Source: Fluid Flow-Back During Fracking

- Well is drilled, fracked using water, proppant (sand), chemicals.
- The frack fluid is allowed flow-back under reservoir pressures, along with CH₄ (both free and dissolved), typically into an open pit.
- Sometimes additional fluids are injected to clean out the well bore after each fracking stage.
- Well is shut in, and a plug is set to isolate stage 1.
- After stage 1 is isolated, stage 2 (closer to well head) is fracked.
- This is repeated for 5 to 6 stages (approx. 1,000 ft per stage).
After all stages are fracked, isolation plugs are drilled out.
Different isolation techniques exist in the industry, but concept is the same, and all techniques require drill out.
Gases migrate up the well bore as plugs are drilled out.
CH$_4$ Emission Source: Well Clean Up

- Fluid is cleaned out of well-bores using additional gas.
- Pump-jacks can be used to remove fluid, but relatively high in cost and fluid removal may be incomplete.
- Well bore must become liquid-free as quickly as possible.
- Well blow down is also used in mature conventional wells with low reservoir pressures to remove water columns.

(· Reduced emission (green) completion in low energy reservoirs, BP America Production Company, 2008)
Green completions are mandatory starting January 1, 2015. Until then, all production gases must be flared.

CO, WY already require green completions.

Operators in CO can override standards for safety reasons. In case CH₄ cannot be captured, produced gases must be flared.

(– EPA's Air Rules for the Oil&Natural Gas Industry: Summary of key changes to the new source performance standards
- COGCC)
Green Completions: CH$_4$ Capture

“Green completion techniques are methods that minimize the amount of natural gas and oil vapors that are released to the environment when a well is being flowed during the completion phase of a well.” (COGCC)
Under suitable reservoir conditions, technology exists to capture CH₄ for sales:

- BP
- Weatherford
- Devon

Questor (for flaring)

Appropriate tech and properly sized surface units must be deployed for given reservoir conditions.
Green Completion Challenges: High Pressures

- Flow back unit leading to high back pressure build up, impeding flow-back.
- If fluid is not discharged as quickly as possible, well “damage” can occur.
- Surface equipment requires additional pipe and equipment with various fittings and bends:
  - High pressure may lead to wash outs (compare to simple venting to open pits)
  - Workers are exposed to additional risks

(- Reducing methane emissions during completion operations, 2007 Natural Gas STAR Production Technology Transfer Workshop)
Green Completion Challenges: Low Energy Reservoirs

- Low pressure reservoirs may not allow frack water flow-backs against back pressures.
- Air clean out preferred over liquid clean out due to low reservoir pressure – separation of gases are costly, especially at lower pressures.
- EPA has identified and exempted roughly 10% of unconventional natural gas wells from green completion standards.

(- EPA ruling changes 2012)
Green Completion Challenges: Wildcat wells (No Sales Line)

- Wildcat wells do not have pipelines near by into which gases can be unloaded.
- Many unconventional plays (shale, tight sand, tight coal) are wildcats that turn into production wells.
- Attributes of a wildcat well must be carefully defined.
Green Completion Challenges: Impurities

- Impurities (CO₂, N₂, moisture, and other VOCs) in production gases must be separated prior to CH₄ capture.
- Separation units and dehydration units can be costly.
- There may be flow-back gases from which CH₄ cannot be separated and are also hard to flare.
- Companies like Questor, who specialize in combusting impure gases could play an important role.

(- Questor Inc.)
In the absence of CH₄ capture and flaring, the next best solution is drilling less wells.

Academic opportunities:

- Develop understanding of flow physics and subsurface to better estimate decline curves
- Improve reservoir characterization / simulation techniques in order for optimal well placement and orientation through target
- Engineer enhanced oil / gas recovery methods
Conclusions

- CH$_4$ impact from unconventional natural gas well completions are relatively small in comparison to other GHG emission sources in the U.S.
- CH$_4$ emitted annually during unconventional well completion accounts for 3% of all yearly CH$_4$ emissions in the U.S.
- CH$_4$ emissions during an unconventional well completion occur during:
  - Frack fluid flow-back
  - Drill out of plugs
  - Clean out, blow down of well bore
- Cost effective industry solution is readily available under appropriate reservoir conditions.
- Implementation challenges of green completions remain:
  - High pressure = surface risks, pressure build up
  - Low pressure = slow fluid flow back + costly capture
  - Wildcat wells = lack of pipeline for capture
  - High impurities = costly to capture and maybe hard to flare
- Next best after CH$_4$ capture is flaring (e.g. Questor) or minimizing number of wells drilled in the first place (academic).