The Greenhouse Impact of Natural Gas
Gas is best choice for transition fuel

Presentation to the
Basque Government
Shale Gas Conference

April 25, 2012
Vitoria, Spain

L. M. Cathles
L. Brown
Cornell University
Ithaca, New York
Is gas dirtier than coal?
Science vs advocacy at Cornell

Methane and the greenhouse-gas footprint of natural gas from shale formations
A letter
Robert W. Howarth • Renee Santoro • Anthony Ingraffea

A commentary on “The greenhouse-gas footprint of natural gas in shale formations” by R.W. Howarth, R. Santoro, and Anthony Ingraffea
Lawrence M. Cathles III • Larry Brown • Milton Taam • Andrew Hunter
Wrong basis for comparison with coal
- Comparison based on heat is irrelevant and deceptive
- Comparison on the appropriate basis of electricity is relegated to the electronic supplement
Unrealistically high estimates of fugitive emissions

- based on hidden assumptions, erroneous assumptions

Example: Assumes 100% of “pre-production” gas vented

- Never stated, much less justified
- Inconsistent with EPA assumptions
- Contradicted by their own sources
- Falsified by recent survey of actual gas industry practice
Fatal Flaws in Howarth et al., 2011

- Dismisses impact of existing “green” technology
  - contradicted by their own sources
  - falsified by recent survey of actual gas industry
  - assumes ineffective regulatory environment
Wrong basis of comparison
Compare on electricity not heat because:

- Coal used exclusively for electricity generation
- Gas can generate electricity 2x more efficiently than coal

Coal

~30% heat to electricity conversion efficiency

Natural Gas

60% heat to electricity conversion efficiency

85% if use turbine effluent to heat (CHP)

http://www.mpoweruk.com/gas_turbines.htm
Overestimates fugitive gas emissions
Where there is gas, there are gas leaks

Natural and human-assisted

Shale Creek Preserve at Chestnut Ridge Park, NY


Well after methane explosion in Dimock, Pa
Unconventional wells not worse

<table>
<thead>
<tr>
<th></th>
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<th>Shale Gas</th>
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<td>Emissions during well completion</td>
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\[\Rightarrow <0.01\%\]

Howarth et al.

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Flow-back is the return of hydraulic fracturing fluids to the surface immediately after fracturing and before well completion. For these wells, the flow-back period ranged from 5 to 12 days.


Avg 1.6% flowback + Venting during drill out = 0.33%
1.9% venting **not** supported

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All > 1.9%

Not physically reasonable

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$1$ million vented, fill $1$ sq mile to $176$ ft with explosive gas

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*aHaynesville: average from Eckhardt et al. (2009); Piceance: EPA (2007); Barnett: EPA (2004); Uinta: Samuels (2010); Denver-Julesburg: Bracken (2008)"

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Evidence of captured ≠ evidence of venting
Legal to vent ≠ venting
Gas release during drill out small
Unconventional losses during well completion is same as conventional- and negligible

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<th>EPA (2010)/Howarth et al.</th>
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<tr>
<td>% green completed</td>
<td>0</td>
<td>93.5</td>
</tr>
<tr>
<td>% vented</td>
<td>50</td>
<td>46</td>
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<tr>
<td>Avg. Mscf/completion</td>
<td>9175</td>
<td>765*</td>
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<td>Avg. vented per well</td>
<td>4587</td>
<td>23</td>
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<td>% lifetime production</td>
<td>1.9 (Howarth et al.)</td>
<td>&lt;0.01 ~ conventional**</td>
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* Assume venting at sonic rate allowed by choke for duration of well completion venting

** Venting during completion of a conventional gas well = 18.3 Mscf (EPA, 2010)
Leakage from established well to customer

Emissions that are common to both conventional and unconventional gas wells

GAO Gvmt Lease Study

= 1.5% x 4

“Her don’t think they’re really losing the gas, we just think they’re not paying for it.”

1.5%
Greenhouse Impact
Comparative life cycle analysis

Cathles, in review G³
At 1.5% leakage, substituting-gas takes 40% of way to low-carbon-fast.
Benefit of Gas Substitution

1 to 2% leakage

200 yr transition, $\psi=1.43$

100 yr

50 yr

50 yr, $\psi=1.94$

ocean mixing

Cathles, in review G³
The GWP metric is flawed
Summary

• Howarth et al (2011) analysis is not credible
  – **Wrong** basis for comparison with coal
  – **Wrong** assumptions used to estimates magnitude of fugitive gases associated with shale gas
  – **Wrong** to dismisses impact of best practices for shale gas
  – **Wrong** use of metric to estimate climate impact
Methane and the greenhouse-gas footprint of natural gas from shale formations
A letter

Robert W. Howarth · Renee Santoro · Anthony Ingraffea

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- Shale gas emits 1.9% of ultimate production during well completion (conventional well 0.01%)
- A further 1.7 to 6% of ultimate production leaks in delivery to customer
- Shale gas thus has a larger GHG footprint than coal and cannot be considered a cleaner fossil fuel
- Shale gas GHG footprint could be 2x that of coal
- Analysis “undercuts the logic of its use” [shale gas] as a bridging fuel over the coming decades”.

A commentary on “The greenhouse-gas footprint of natural gas from shale formations” by Robert W. Howarth, R. Santoro, and Anthony Ingraffea

Lawrence M. Cathles · Larry Brown · Milton Taam · Andrew Hunter

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- Shale gas emits ~0.01%
- Further emissions ~1.5%
- ... has smaller GHG footprint than coal unless leakage > ~18% of production
- ... GHG footprint is 1/2 to 1/3rd coal
- Shale gas remains an attractive bridging fuel
The Marcellus is a significant resource

*Spreading 363 TCF over 246 billion m² area of Marcellus and assuming $2.5 per thousand cubic feet value:*

- 1 ha contains $35,500 of producible gas

- 1 well tapping 32 ha produces 0.5 million kcf (equivalent to 3 million gallons of oil) with sales value of $2.4 million

- If *produced over 30 years* power surface density is 1.6 W m⁻² (~ wind at 2 W m⁻²)

- If “ and substituted for oil would save $200 billion per year in oil imports (@ $100/bbl)

- If “ output equivalent to **400 one GW nuclear power plants**

Europe has similar shale gas resources

Ugly?
Not for long

Reclaimed drill pad
Natural gas eases transitions

Growth Rate of Low Carbon Energy Sources

- A. Business as Usual
- B. Substitute Gas
- C. Low Carbon Fast

Cathles, in review G³
Conclusions

• Marcellus is a high value resource
• Managed properly it will be minimally intrusive
  – no permanent increase in population (schools, housed, roads,…)
  – value needed in poor rural areas
  – not new (Quarries)
  – opportunities: better roads, trails along pipelines
• Development risk: shallow drilling & water handling
• Shallow drilling risk (e.g., for water wells): remains whether develop Marcellus or not
• Good for climate (gas is better than coal)
  – 40% stabilization wedge
• Facilitates transition to low-C energy sources
  – Surge capacity and backup
• Societal benefits of low energy costs substantial
  – Jobs, taxes, stimulation of other industries
Recommendations

• Reduce leakage to ~1% of production

• Encourage the rapid substitution of natural gas for coal and oil

• Encourage as rapid a conversion to low carbon energy sources as possible
If not natural gas, then what?

Nuclear
Fukushima Daiichi

Coal
Mountaintop Mining

Oil
Deepwater Horizon
Renewables?

Wind

Solar

Biofuels

?Economics
?Environmental Impacts
Is discussion possible?
References


Seamus Mcgraw
The End of Country
(a balanced perspective)