Climate Impacts of Natural Gas Production and LNG Export

A Synopsis of Current Science

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Edition 1.3

The climate impacts of producing natural gas and exporting liquefied natural gas (LNG) have been analyzed in major peer-reviewed studies over the last three years.

We now have a clear outcome:

- Natural gas consumption – here or abroad – exacerbates greenhouse gas pollution, and
- Natural gas production and LNG exports offer no substantive reduction of carbon pollution over other fossil fuels. They are not "climate solutions."

Therefore, natural gas cannot be a "bridge to the future."

This synopsis explains why.

The LNG Export Tanker "Arctic Lady"

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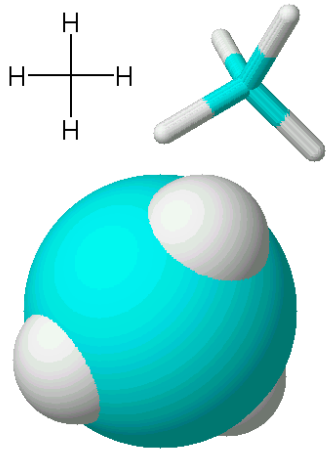
Methane Leakage is Pervasive in the Supply Chain

Natural gas is predominantly methane at the well, and essentially 100% methane post-refinery. The studies detailed here identified methane leakage as a key factor determining the overall greenhouse gas impact and life-cycle pollution of natural gas. [1]



Methane – CH_4 – the fundamental, simplest, and most versatile hydrocarbon.

Illustration: Effeietsanders, Netherlands–Methaan. License: Creative Commons Attribution-Share Alike 2.5, Wikimedia Commons.

Leakage creates fugitive methane emissions throughout the gas supply chain: in drilling and production, transmission, processing and refining, and distribution (including liquefaction into LNG and its transport, regasification, and redistribution).

Methane is More Dangerous Than Carbon Dioxide

The characterization of natural gas as the ideal long-term transition fuel to a distant renewable-energy economy ("the bridge to the future") comes from the perception that it is the least-polluting fossil fuel. (It also embodies the false claim that renewable energy is not ready for prime time.[2]) Industry constantly claims that natural gas is actually "clean."[3]

It is true that direct methane combustion, viewed in isolation from the rest of the natural gas supply chain and the methane atmospheric life cycle, releases significantly less carbon dioxide than burning other fossil fuels. Unburned, however, methane is a much more potent heat-trapping greenhouse gas than carbon dioxide.

Specifically, the Intergovernmental Panel on Climate Change (IPCC) assesses methane impact over a twenty-year period as having a global warming potential **86 times greater than carbon dioxide**. Over a 100-year period, methane presents a global-warming effect 34 times that of carbon dioxide – still a massive imbalance, with dangerous ramifications.[4]

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[1] For a list of other forms of environmental, economic, and personal damage not specifically addressed in this synopsis, please see *Note: Other Damages from LNG Exports and Natural Gas Production and Consumption* on page 8.
[2] See, for example, Al Gore, *The Turning Point: New Hope for the Climate*, Rolling Stone, June 18, 2014.
[3] See, for example, Energy Tomorrow, www.energytomorrow.com; America's Natural Gas Alliance, anga.us.
[4] Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2013: Physical Science Basis*, Anthropogenic and Natural Radiative Forcing, p. 714.

Superstorm Sandy, October 30, 2012, one day after landfall.
It extended from the Florida Panhandle to Lake Superior and across Eastern Canada.
Photo: NASA, Norman Kuring, Ocean Color Web. Public domain: Wikimedia Commons.

Time is of the Essence

Tragically, we do not have a century to make changes. The next ten to twenty years are critical, and methane emissions factor heavily into addressing greenhouse gas pollution in this near term. The IPCC projects that warming increases may reach 3.6° F (2° C) within decades. The dramatic climate impacts witnessed to date come from a heat increase of only a bit more than 1.5° F.[5]

This 3.6° F increase is the level that scientists agree is about the maximum that the Earth can stand without suffering the most devastating consequences of climate change. Furthermore, the growth in heat-trapping gases will continue for decades, regardless, and the impacts will build for centuries.

Because methane is such a devastating greenhouse gas, even a tiny percentage of leakage at the well, in the pipeline distribution system, at refineries, and in the consumer distribution system creates an enormous impact. Variations that superficially may appear small – say, from a rate of 1.5% to 3% – drastically increase overall fugitive-methane pollution.

Scientists Sound the Alarm on Methane Leakage

On July 29, 2014, a panel of leading scientists called on the Obama administration to account accurately for the contribution of methane emissions to potential global warming. They urged the Department of Energy (DOE), the Environmental Protection Agency (EPA), and other agencies to use a 20-year timeframe to evaluate methane's greenhouse gas impact because of the urgency of the climate crisis:

"As evidence continues to mount that serious climate change impacts are already upon us, research indicates that mitigation of short-lived pollutants such as methane can play a significant role in slowing the rate of climate change…."[6]

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[5] IPCC, *Climate Change 2013: Physical Science Basis*, Summary for Policymakers, p. 3. See pp. 27-29 for discussion of time frames and long-term impacts, including coastal losses from the melting of the Greenland ice sheet and global sea-level rise. See also the November 2014 *Synthesis Report* for a comprehensive climate overview: www.ipcc.ch.

[6] Chapin, Davidson, Hong, Howarth, et al., Letter to the U.S. EPA, U.S. DOE, CEQ, and White House Domestic Policy Council, July 29, 2014. "Recommendation to accurately account for warming effects of methane." See: http://tinyurl.com/mjg79hg.

Governmental Analyses are Deficient

An important review of key literature on natural gas impacts was provided in two sets of comments submitted by Sierra Club, Food & Water Watch, Cascadia Wildlands, Columbia Riverkeeper, and others (*Sierra Club et al.*)[7] to DOE on July 21, 2014. *Sierra Club et al.* makes it clear that DOE's life-cycle analyses of natural gas destined for export (*DOE LNG Life-Cycle*)[8] contain significant gaps and flaws, highlighted throughout this synopsis.

The Industry Has Failed to Monitor and Stop Methane Leakage

Sierra Club et al. addresses how *DOE LNG Life-Cycle*, attempting to evaluate relative impacts of natural gas production and LNG export plans, consistently underestimates the methane leakage rate.[9]

For example, a 2013 study by a team led by University of Texas professor David Allen[10] (*Texas*) directly measured methane leaks from wells chosen by the industry. These specimens are likely to have some of the best controls and lowest emissions. The EPA and DOE estimate the industry average leak rates to be about the same as the *Texas* best-case examples – a severe underestimate of realistic leakage rates.

Significantly, two other seminal studies – one at Argonne National Laboratory in 2011, led by Andrew Burnham,[11] and another at the federally-chartered Institute for Defense Analyses in 2012, by Christopher Weber and Christopher Clavin[12] – found markedly higher leakage estimates than those cited by DOE.

Halliburton preparing a fracking site in North Dakota's Bakken field.

Photo: Joshua Doubek. License: Creative Commons Attribution - Share Alike 3.0, Wikimedia Commons.

Top-Down versus Bottom-Up Makes a Difference

In the last two years, peer-reviewed studies looking at methane levels in the atmosphere ("top-down" studies) provide compelling evidence that the aggregate methane leakage estimates based on measurements at wells, pipelines, refineries, and other gas facilities ("bottom-up" reviews, like *Texas*) have dramatically underestimated gas-sector methane leaks.[13] Two recent nationwide life-cycle methane emissions studies found emissions levels much higher than current EPA estimates.

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[7] Sierra Club et al., Comments re DOE, "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States," addressed "Attn: LCA GHG Report Comments," July 21, 2014. See: http://tinyurl.com/lh9phuj. In addition to this comment set on LNG and methane, please see the related comment set focused on fracking: Comments re DOE, "Environmental Impacts of Unconventional Natural Gas Development and Production" and other DOE documents, addressed, "Attn: Addendum Comments," July 21, 2014. See: http://tinyurl.com/qc94dph. These comment sets interact.

[8] U.S. Department of Energy, *Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States*, May 29, 2014. See http://tinyurl.com/orc3ytz.

[9] Sierra Club et al., pp 5-10.

[10] Allen, D. T., Torres, V. M., Thomas, J., Sullivan, D. W., Harrison, M., Hendler, A., Herndon, S.C., Kolb, C.E., Fraser, M.P., Hill, A.D., Lamb, B.K., Miskimins, J., Sawyer, R.F., Seinfeld, J. H. (2013). *Measurements of methane emissions at natural gas production sites in the United States*. Proceedings of the National Academy of Sciences.

[11] Burnham, A., Han, J., Clark, C.E., Wang, M., Dunn, J.B., and Palou-Rivera, I. (2011). *Lifecycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum*. Environmental Science & Technology.

[12] Weber, C. L., and Clavin, C. (2012). *Life Cycle Carbon Footprint of Shale Gas: Review of Evidence and Implications*. Environmental Science & Technology, DOI: 10.1021/es300375n.

[13] Sierra Club et al., p. 9.

Natural gas production on public land, leased out by the US Bureau of Land Management, west of the Wind River Range, Wyoming.

Photo: Pinedale BLM Field Office. Public domain via Wikimedia Commons.

The first, from a team led by Harvard University's Scot M. Miller[14] (*Harvard*), reviewed atmospheric measurements of methane and concluded that the "EPA recently [in the 2013 Greenhouse Gas Inventory] decreased its [methane] emission factors for fossil fuel extraction and processing by 25–30% (for 1990–2011), but we find that [methane] data from across North America instead indicate the need for a larger adjustment of the opposite sign."[15]

Harvard concluded that atmospheric measurements of methane emissions from all sources were 50% higher than the EPA 2013 Greenhouse Gas Inventory's bottom-up estimate. *Harvard* emphasizes that gas emissions are a significant part of the observed emissions that the EPA missed in their Inventory amendments, and suggests that the actual leak rate is likely to be 3% or more.

This stunning figure establishes natural gas production and LNG exports as significant contributors to climate-changing pollution, even as destructive as coal or oil.

The second study, by a team led by Stanford University's Adam Brandt[16] (*Stanford*) also concluded that the EPA's Inventory and other bottom-up estimates, which generally use values similar to those assumed by DOE, significantly underestimate methane emissions from oil and gas production. (See *The Stanford Report* article referenced below for a good summary of *Stanford*.)

Harvard and *Stanford*, as nationwide studies, parallel with atmospheric studies examining individual regions, which have found even higher local fugitive methane emissions. In Colorado's Front Range fracking region (the Denver-Julesberg Basin), two studies by a National Oceanic & Atmospheric Administration (NOAA) team led by Gabrielle Petron concluded that during gas production alone, the gas leak rate was about 4%.[17]

Alarmingly, the same NOAA research team, led by Anna Karion, found dramatically higher leak rates from wells in Utah's Uinta Basin, estimating escaped methane at 9% ± 3% of total production.[18] Notably, these valuable research projects did not include additional leaks from downstream segments of the industry, such as transmission and distribution pipelines and processing facilities.

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[14] Miller, S., et al., *Anthropogenic emissions of methane in the United States*. Proceedings of the National Academy of Sciences (Dec. 10, 2013) ("PNAS Study"), available at http://calgem.lbl.gov/Miller-2013-PNAS-US-CH4-Emissions-9J5D3GH72.pdf

[15] Miller et al., p. 5.

[16] Brandt, A.R., et al., *Methane Leaks from North American Natural Gas Systems*. Science, Vol. 343, no. 6172, pp.733-735 (Feb. 14, 2014).

[17] Petron, et al., *A new look at methane and non-methane hydrocarbon emissions from oil and natural gas operations in the Colorado Denver-Julesburg Basin*. 119:9 J. Geophys. Res. Atmospheres (June 3, 2014), abstract available at http://onlinelibrary.wiley.com/doi/10.1002/2013JD021272/abstract. The second Colorado study is Petron, et al., *Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study*. 117:D4 J. Geophys. Res. Atmospheres 4304 (Feb. 21, 2012).

[18] Karion, et al., *Methane emissions estimate from airborne measurements over a western United States natural gas field*. 40:16 Geophysical Research Letters 4393 (Aug. 27, 2013), abstract available at: http://onlinelibrary.wiley.com/doi/10.1002/grl.50811/abstract.

Federal Perspectives Must Change

This evidence makes it clear that, to fully assess the life-cycle impacts of natural gas production, consumption, and export, we must examine markets that would purchase and import LNG, and consider their local transportation leaks and other fugitive emissions. Unfortunately, DOE has ignored this.[19]

Sierra Club et al. also addresses why DOE must do more than simply compare the life-cycle emissions of domestic LNG with other fossil fuels to fully analyze production and export impacts. DOE cannot assume that U.S. LNG exports will offer one-for-one displacement of other fossil fuel use overseas. The International Energy Agency (IEA) predicts that U.S. LNG exports would reduce renewable energy development in other countries – leading directly to increased greenhouse gas emissions. Similarly, U.S. LNG exports may also increase U.S. greenhouse gas emissions.[20]

One assessment in *DOE LNG Life-Cycle* shows the complexity and problematic nature of these impact analyses: DOE concluded that using U.S. LNG for electricity in China would have higher life-cycle greenhouse gas emissions than Chinese coal-based electrical generation during a 20-year timeframe![21]

Market Economics Alone Cannot Reduce Climate Impacts

Methane, like coal and oil, is a market commodity, with economic benefits and costs. But its economic impacts also are core to energy choices and climate evolution; these three spheres connect. A study of energy-economic-climate interactions led by Haewon McJeon[22] of DOE's own Pacific Northwest National Laboratory (*PNNL*) found that natural gas is not a global climate solution on that basis.

PNNL assembled international cross-disciplinary teams to evaluate the affects of dramatic increases in global gas consumption through 2050. The teams evaluated natural gas through five independent assessment models, each integrating this three-part energy-economic-climate analysis. This market-model study showed that long-term gas expansion escalates the climate crisis because gas would replace not only other fossil fuels, but also low-carbon energy sources, including renewable energy. *PNNL* also notes the key role of fugitive methane emissions. Most critically, *PNNL* points out that public policies expanding and protecting renewables are vital to prevent the market push for gas superiority.

It's clear from these studies that:

- *DOE LNG Life-Cycle* estimates of the natural gas supply chain leak rates are far too low;
- the EPA also currently underestimates the scope of that problem; and
- depending on a larger gas sector through the market for fossil fuels cannot protect the climate.

An off-grid solar photovoltaic array outside Denver. Our technical and economic capabilities are fully adequate for complete conversion of our energy supply systems through sustainable renewable energy, efficiency, and conservation. See note 2 above.

Photo: Ted Gleichman.

[19] Sierra Club et al., pp. 10-11.
[20] Sierra Club et al., pp. 2-5.
[21] DOE Life Cycle, pp. 14-15. See footnote 10.
[22] McJeon, H., et al., *Limited impact on decadal-scale climate change from increased use of natural gas*. Nature (October 15, 2014), DOI:10.1038/nature13837, abstract available at: http://www.nature.com/nature/journal/vaop/ncurrent/pdf/nature13837.pdf.

LNG Exports Require More Fracking

LNG export terminals and pipelines proposed for Oregon target markets in Asia, working to lock in 20-year export contracts.[23] One agonizing result of West Coast LNG exports to the Pacific Rim would be opening up most of Western North America to much more fracking, long term.

In fact, the Jordan Cove Energy Project proposed in Oregon even highlights that as a major plus, to "balance supply and demand…in the current market environment of oversupply and low prices." A Jordan Cove consultant states, "LNG exports… should be seen as instrumental in providing the increased demand to spur exploration and development of gas shale assets in North America."[24] Projects on U.S. Gulf and Atlantic Coasts will similarly induce much more regional fracking.

Climate-Change Mitigation Efforts Would be Undone by LNG Exports

Taken as a whole, the current science makes a compelling case:
Natural gas production and consumption and LNG exports are not climate solutions. Oregon should reject proposals to make the Pacific Northwest a throughway for fracked-gas exports. Pipeline and terminal proposals on the Gulf and Atlantic Coasts claiming climate benefits are equally misguided.

The bottom line: Urgent near-term action against methane and other high-intensity greenhouse gases **must** parallel the necessary major reductions in direct carbon dioxide output.[25]

We will negate efforts to curb climate disruption if we permit LNG exports and unrestricted natural gas production and consumption.

Other relevant information:

► *The Stanford Report* published a briefing paper summarizing the Brandt/Stanford study: *America's natural gas system is leaky and in need of a fix, new study finds*. (February 13, 2014). news.stanford.edu/news/2014/february/methane-leaky-gas-021314.html.

► *The Washington Post* analyzed *DOE LNG Life-Cycle*: *Exporting U.S. Natural Gas isn't as "Clean" as You Think.* (June 9, 2014). washingtonpost.com/blogs/wonkblog/wp/2014/06/09/exporting-u-s-natural-gas-isnt-as-clean-as-you-think/.

►A *Chesapeake Climate Action Network* factsheet raises good points about *DOE LNG Life-Cycle*: *DOE: US LNG Exports to Asia are Likely Worse Than Coal for the Climate.* (June 9, 2014). chesapeakeclimate.org/press-releases/doe-u-s-lng-exports-to-asia-are-likely-worse-than-coal-for-the-climate/.

►*Scientific American* discusses a new NOAA study, from a team led by Stefan Schweitzke of Carnegie Mellon University, showing leakage rates double or triple the DOE estimates and *Texas* findings. The article notes, "natural gas fields globally may be leaking enough methane, a potent greenhouse gas, to make the fuel as polluting as coal for the climate over the next few decades…" *Leaky Methane Makes Natural Gas Bad for Global Warming.* (June 26, 2014). scientificamerican.com/article/leaky-methane-makes-natural-gas-bad-for-global-warming/.

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[23] Snow, N., *DOE approves LNG exports to non-FTA countries from Oregon project*. Oil & Gas Journal, March 24, 2014. This details the 20-year export approval granted conditionally to Veresen, Inc., the Canadian corporation that owns the Jordan Cove Energy Project, proposed for Coos Bay, Oregon, and the affiliated Pacific Connector Pipeline proposal, which would extend 234 miles from the terminus of the Ruby Pipeline in Malin, Oregon, to Coos Bay.
[24] Jordan Cove Resource Report 1, March 2012, p. 1-4.
[25] Sierra Club et al., pp. 10-12.

Note: Other Damages from LNG Exports and Natural Gas Production and Consumption

The natural gas supply chain and LNG export development cause many other forms of environmental, economic, and personal damage not addressed in this synopsis. These include but are not limited to:

- Surface water, ground water, and aquifer pollution from toxic fracking fluids;
- Massive consumptive water use for drilling and fracking, with the water permanently removed from the natural hydrologic cycle (used to extinction);
- Toxic air pollution beyond fugitive methane emissions;
- Gas pipeline and LNG terminal construction impacts to forests, rivers, and farms and the people and species that depend on them;
- Corporate use of eminent domain authority against landowners in pipeline routing, eliminating other land-use options and causing permanent deprivation for private-sector profit;
- Increased costs for residential, commercial, and manufacturing gas use from LNG export, partially spurred by corporate trade treaties reducing governmental oversight and sovereignty;
- Massive loss of manufacturing jobs in the United States;
- Fracking-induced earthquakes;
- Health and safety risks of explosive facilities; and
- In Oregon, the planned siting of LNG facilities and pipelines in areas guaranteed to suffer the most destructive seismic event and tsunami in U.S. history – and at very high risk of experiencing that earthquake and flood during the lifetime of the proposed LNG pipelines and terminals.

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This project has been developed by these contributors; for more information, please contact any of us. **Please notify us of use; thank you.**

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Errata a