

# Summary of Recent Science:

## Climate Impacts of Natural Gas Production and LNG Export

August 7, 2014

Concentrated scientific analysis over the last three years has evaluated the climate impacts of producing natural gas and exporting liquefied natural gas (LNG). These studies establish a clear bottom line: natural gas consumption – at home or abroad – exacerbates greenhouse gas pollution, and natural gas production and LNG exports offer no substantive reduction of carbon pollution over other fossil fuels.

This science summary highlights many of these studies. A review of the key literature on natural gas impacts was provided in two sets of comments submitted by the Sierra Club, Food & Water Watch, Cascadia Wildlands, Columbia Riverkeeper, and others to the United States Department of Energy (DOE) on July 21, 2014. The Comments referred to in this summary (Sierra Club *et al*)<sup>1</sup> respond directly to DOE’s life-cycle analyses of natural gas destined for export (DOE LNG Life-Cycle)<sup>2</sup> and form the basis of much of this summary.

During their reviews, scientists identified methane leakage as a key factor influencing the overall greenhouse gas impact of natural gas.

Natural gas is predominantly methane at the well, and essentially 100% methane post-refinery. Leakage occurs in drilling and production, transmission, processing and refining, and distribution (including liquefaction into LNG, its transport, and its regasification and redistribution). These fugitive methane emissions are critically important factors in the overall life-cycle pollution of natural gas.<sup>3</sup>

Natural gas has often been characterized as “the bridge to the future” or “the best of the worst” – the least-polluting fossil fuel. Industry works very hard to claim that natural gas is actually “clean.”<sup>4</sup>

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

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<sup>1</sup> 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, and are attached.

<sup>2</sup> 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>.

<sup>3</sup> For a note concerning other forms of environmental and economic damage not addressed in this summary, please see the final page of this summary.

<sup>4</sup> See, for example, the advertisements on any Sunday morning news or talk show.

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dioxide than burning other fossil fuels. However, unburned, 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 impact.<sup>5</sup>

But we do not have a century to make changes. The next two decades are the period that really matters, and methane emissions factor heavily into how we will address greenhouse gas pollution in this near term.

The IPCC projects that warming increases may reach 3.6° F (2° C) within decades.<sup>6</sup> It's possible that we will experience this additional average heat well before mid-century. The dramatic climate impacts we've seen to date come from an increase of only about 1.5° F.<sup>7</sup>

This 3.6° F heat 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.<sup>8</sup> So urgent near-term action against methane and other high-intensity greenhouse gases must parallel the necessary major reductions in direct carbon-dioxide output.<sup>9</sup>

Because methane is such a devastating greenhouse gas, even a tiny percentage of methane leakage at the well, in the pipeline distribution system, at the refineries, and in the consumer distribution system creates a dramatic impact. Variations that superficially appear small – say, from leakage rates of 1.5% to 3% – drastically increase overall pollution in the natural gas supply chain.

Most recently, on July 29, a panel of leading scientists called on the Obama administration to accurately account for the contribution of methane emissions to potential global warming, stating, “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....”<sup>10</sup>

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<sup>5</sup> Intergovernmental Panel on Climate Change (IPCC), *Climate Change 2013: Physical Science Basis, Anthropogenic and Natural Radiative Forcing*, p. 714

<sup>6</sup> IPCC, *Climate Change 2013: Physical Science Basis, Summary for Policymakers*, pp. 27-28.

<sup>7</sup> IPCC, *Climate Change 2013: Physical Science Basis, Summary for Policymakers*, p. 3.

<sup>8</sup> IPCC, *Climate Change 2013: Physical Science Basis, Summary for Policymakers*, pp. 27-29. Regarding the Oregon coast, see especially the analysis paragraphs on the melting of the Greenland ice sheet and on global sea-level rise, pp. 28-29.

<sup>9</sup> Sierra Club *et al*, pp. 10-12.

<sup>10</sup> 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>

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The scientists' letter directly urges the U.S. Environmental Protection Agency (EPA), DOE, and other agencies to use a 20-year timeframe to evaluate the greenhouse gas impact of methane because of the urgency of the current climate crisis.

In this vein, the Sierra Club *et al* comments address how DOE LNG Life-Cycle analysis consistently underestimates the methane leakage rate of domestic gas production in their attempt to evaluate the relative impacts of natural gas production and plans for LNG export.<sup>11</sup>

For example, a 2013 study by a team led by University of Texas professor David Allen<sup>12</sup> (Texas) directly measured methane leaks from wells chosen by the industry. These are likely to have some of the *best* controls and *lowest* emissions. 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 methane leakage rates.

Additionally, two other important studies – one at Argonne National Laboratory in 2011, led by Andrew Burnham,<sup>13</sup> and another at the federally-chartered Institute for Defense Analyses in 2012, by Christopher Weber and Christopher Clavin<sup>14</sup> – found markedly higher leakage estimates than DOE relies on.

Sierra Club *et al* also note that, in the last two years, peer-reviewed studies looking at methane levels in the atmosphere (“top-down” studies) have provided compelling evidence that the aggregate methane leakage estimates based on examinations of wells, pipelines, refineries, and other gas facilities (“bottom-up” reviews, like Texas) have dramatically underestimated gas-sector methane leaks.<sup>15</sup>

Two other recent studies addressed natural gas's life-cycle methane emissions nationwide and found that emissions levels are much higher than current EPA estimates.

The first, from a team led by Harvard University's Scot M. Miller<sup>16</sup> (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.”<sup>17</sup>

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<sup>11</sup> Sierra Club *et al*, pp 5-10.

<sup>12</sup> 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.

<sup>13</sup> 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.

<sup>14</sup> 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

<sup>15</sup> Sierra Club *et al*, p. 9.

<sup>16</sup> 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>

<sup>17</sup> Miller et al, p. 5.

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Specifically, Harvard concluded that atmospheric measurements show that methane emissions from all sources were 50% higher than the EPA 2013 Greenhouse Gas Inventory's bottom-up estimate of emissions. They show that gas emissions are a significant portion of the observed emissions that the EPA missed in their Inventory amendments, and suggest that the actual leak rate is likely to be 3% or more – a stunning figure that 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<sup>18</sup> (Stanford) similarly concluded that 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 below for a good summary of Stanford.)

Furthermore, Harvard and Stanford, as nationwide studies, stand in agreement with atmospheric studies examining individual regions, which have found even higher local methane emissions.

Two studies of Colorado's Front Range fracking region (the Denver-Julesburg Basin) by a team led by Gabrielle Petron of the National Oceanic & Atmospheric Administration (NOAA) have concluded that during gas production alone, the gas leak rate was about 4%.<sup>19</sup> This research did not include leaks from downstream segments of the industry, such as transmission and distribution pipelines and processing facilities.

Alarmingly, the same team of NOAA researchers, in a project led by Anna Karion, found even higher methane leak rates in Utah's Uinta Basin, estimating escaped methane at 9% ± 3% of total production.<sup>20</sup>

This evidence also makes it clear that, to assess the life-cycle impacts of natural gas production and export, we must look at the markets that would import LNG and consider their transportation leaks and other fugitive emissions. Unfortunately, DOE has so far ignored this key information.<sup>21</sup>

Moreover, DOE also 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 cause reductions in renewable energy development in

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<sup>18</sup> Brandt, A.R., et al., Methane Leaks from North American Natural Gas Systems, *Science*, Vol. 343, no. 6172, pp. 733-735 (Feb. 14, 2014)

<sup>19</sup> 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)

<sup>20</sup> 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>

<sup>21</sup> Sierra Club *et al.*, pp. 10-11.

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other countries – leading directly to increased greenhouse gas emissions. Similarly, U.S. LNG exports may also increase U.S. greenhouse gas emissions.<sup>22</sup>

Further, Sierra Club *et al* address reasons that DOE must do more than simply compare the life-cycle emissions of domestic LNG with other fossil fuels when assessing the impacts of natural gas production in and export from the U.S.

It's clear from these studies that the DOE LNG Life-Cycle estimates of natural gas life-cycle leak rates are far too low, and that EPA also currently underestimates the scope of the problem.

Lastly, because LNG export terminals and pipelines proposed for Oregon target Asian markets, decision-makers must consider the broader implications of approving West Coast projects for LNG exports to the Pacific Rim, and thereby opening up the most of the western half of North America to increased fracking.

One assessment by DOE LNG Life-Cycle shows the complexity and problematic nature of these impact analyses: DOE has concluded that U.S. LNG used for electricity generation in China would have higher life-cycle greenhouse gas emissions than coal on a 20-year timeframe.<sup>23</sup>

Taken as a whole, the current science provides a compelling case that Oregon should reject current proposals for the Pacific Northwest to become a throughway for fracked-gas exports. **In short, we will negate our local efforts to curb climate disruption if we permit LNG exports.**

### Other relevant information:

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

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

► *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, “[n]atural 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

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<sup>22</sup> Sierra Club *et al*, pp. 2-5.

<sup>23</sup> DOE's "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States", pp. 14-15.

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<http://www.scientificamerican.com/article/leaky-methane-makes-natural-gas-bad-for-global-warming/>.

► A factsheet by the Chesapeake Climate Action Network also raises good points about the DOE LNG Life-Cycle documents: *DOE: US LNG Exports to Asia are Likely Worse Than Coal for the Climate*. (June 9, 2014).

<http://chesapeakeclimate.org/press-releases/doe-u-s-lng-exports-to-asia-are-likely-worse-than-coal-for-the-climate/>.

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

- surface, ground water, and aquifer water pollution from toxic fracking fluids;
- massive consumptive water use (to extinction) for drilling and fracking;
- air pollution beyond fugitive methane emissions;
- gas pipeline and LNG terminal construction impacts;
- eminent domain use in pipeline routing for private-sector profit;
- residential, commercial, and manufacturer consumer cost increases from LNG export;
- health and safety risks of explosive facilities;
- fracking-induced earthquakes; and
- the siting of LNG facilities and pipelines in areas in Oregon guaranteed to suffer the most destructive seismic event and tsunami in U.S. history – and at very high risk of experiencing those during the lifetime of the LNG facilities.

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