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July 21, 2014

U.S. Department of Energy (FE–34)
Attn: LCA GHG Report Comments
Office of Oil & Gas Global Security & Supply
Office of Fossil Energy
Forrestal Building, Room 3E–042,
1000 Independence Avenue SW., Washington, DC 20585.

Dear Secretary Moniz:

Thank you and the Department of Energy's Office of Fossil Energy ("DOE/FE") for accepting these comments on the "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States" ("Export LCA") and "Life Cycle Analysis of Natural Gas Extraction and Power Generation" ("Gas LCA") reports, as well as the related "Addendum to Environmental Review Documents Concerning Exports of Natural Gas from the United States" and the "Environmental Impacts of Unconventional Natural Gas Development and Production" report. We submit these comments on behalf of the Sierra Club, our millions of members and supporters, and Cascadia Wildlands, Otsego 2000, Inc., Columbia Riverkeeper, Stewards of the Lower Susquehanna, Inc., Friends of the Earth, Chesapeake Climate Action Network, Food and Water Watch, and Earthjustice.

I. Introduction

This comment supplements the comment concurrently submitted by the above groups regarding the "Addendum to Environmental Review Documents Concerning Exports of Natural Gas from the United States" and related materials. We incorporate that comment here by reference, including in particular sections I and II, which summarize DOE's National Environmental Policy Act ("NEPA") and Natural Gas Act obligations regarding the review of export authorization applications, explain the errors in DOE's interpretation of those obligations, and present addition concerns regarding the packaging of and procedures surrounding the four environmental documents released on May 29, 2014.

II. DOE Must Do More than Compare The Lifecycle Emissions of U.S. LNG with Other Fossil Fuels

As explained in the comment incorporated above, NEPA and the Natural Gas Act require DOE to consider the environmental impacts of the proposed LNG exports. DOE's "Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States" provides some useful information regarding the climate impacts of proposed LNG exports. Full consideration of the climate impacts of LNG exports, however, requires much more than mere comparison of the lifecycle emissions of LNG with those of other fossil fuels.

In DOE's words,

> The primary questions addressed by the [Export LCA] are:
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> - How does exported liquefied natural gas (LNG) from the U.S. compare with regional coal (or other LNG sources) for electric power generation in Europe and Asia, from a life cycle greenhouse gas (GHG) perspective?
> - How do those results compare with natural gas sourced from Russia and delivered to the same European and Asian markets via pipeline?[1]

This comparison of the greenhouse gas intensity of U.S.-sourced LNG with other fossil fuels for purposes of electricity generation does not reflect the climate impacts of proposed exports, because U.S. LNG exports will not simply and exclusively displace other fossil fuels. End use markets in Europe and Asia are rapidly investing in clean energy infrastructure like wind, solar, and efficiency. U.S. LNG exports would likely displace these energy investments in addition to, or instead of, displacing use of other fossil fuels. In addition, U.S. LNG exports will affect U.S. greenhouse gas emissions in ways not captured by this lifecycle analysis. As modeled by the EIA over two years ago, LNG exports will raise U.S. natural gas prices, which will likely shift some electricity generation from gas to coal, with EIA predicting a net increase in carbon dioxide emissions from U.S. electricity generation. We discuss both of these issues below.

A. DOE Cannot Assume that The Only Effect of U.S. LNG Exports in End Use Markets Will Be One-for-One Displacement of Other Fossil Fuel Use

[1] 79 Fed. Reg. 32260, 32261 (June 4, 2014). *See also* Export LCA at 2 n.1 ("The goal of this analysis is to model plausible (medium and long distance) export scenarios while also considering regional fuel alternatives. The purpose of the medium and long distance scenarios is to establish low and high bounds for likely results.").

As reported by the International Energy Agency's ("IEA"), renewables are projected to become the world's second-largest source of power generation by 2015, and are expected to close in on coal as the primary source by 2035.

Other sources of information similarly predict an increasing role for renewables in likely import markets. For example, a June 2013 report by Bernstein Research predicts that in China, "wind and solar will expand from roughly 61GW and 8.3GW of installed capacity currently to 250GW and 200GW, respectively, by the end of the decade. In combination, wind and solar will account for roughly half of incremental power generation over the rest of the decade." [2] Forecasts for India are similar, with HSBC concluding that wind power is already at "parity," or cost-competitiveness, with new coal fired generation[3] and HSBC and KPMG predicting that photovoltaic power will reach parity between 2016 and 2018.[4] In Europe, renewables constitute 55% of new electric generating capacity installed since 2000, and 72% of new capacity installed in 2013, with wind power the single most installed power source in 2013.[5] European environmental interest groups agree that U.S. LNG exports to Europe would likely frustrate Europe's transition to clean renewable energy.[6] Thus, energy infrastructure in the regions DOE identifies as likely markets for U.S. LNG exports is strongly trending toward renewables.

In light of this trend toward clean energy, there is no reason to assume that countries importing U.S. LNG would use that fuel exclusively in lieu of other fossil fuels. On the contrary, the IEA predicts that international trade in LNG and other measures to increase global availability of natural gas will cause natural gas to displace use of wind, solar, or other renewables that would otherwise occur in many countries, and that these countries may also increase their overall energy consumption beyond the level that would otherwise occur.[7]

Even within DOE's frame of looking at the lifecycle impacts of energy used in end use countries, if even a small fraction of LNG imported from the U.S. is used without displacing other sources of fossil fuels, this profoundly affects the net climate impact of U.S. LNG exports. Even using

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[2] Bernstein Research, *Asian Coal & Power: Less, Less, Less... The Beginning of the End of Coal*, 37 (June 2013), attached as Exhibit 1.

[3] Sophie Vorrath, *Wind at parity with new coal in India, solar to join by 2018: HSBC*, RenewEconomy (Jul. 11, 2013), available at http://reneweconomy.com.au/2013/wind-at-parity-with-new-coal-in-india-solar-to-join-by-2018-hsbc-14836 and attached as Exhibit 2.

[4] *Id.*, KPMG, *The Rising Sun: Grid parity gets closer*, (Sept. 2012), available at http://indiasmartgrid.org/en/resource-center/Reports/Rising-Sun-2%20%20KPMG%20Report%202012.pdf and attached as Exhibit 3.

[5] EWEA, *Wind in power: 2013 European statistics* (Feb. 2014), available at http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_Annual_Statistics_2013.pdf and attached as Exhibit 4

[6] *See, e.g.*, Friends of the Earth Europe, PowerShift (Germany), Sierra Club, and Oil Change International, *Leaked Trade Document Exposes Dangerous European Union Energy Proposal* (July 8, 2014), attached as Exhibit 5and *available at* http://content.sierraclub.org/press-releases/2014/07/leaked-trade-document-exposes-dangerous-european-union-energy-proposal; Sierra Club, et al., *Energy Trade in the Transatlantic Trade and Investment Partnership: Endangering Action on Climate Change* (June 17, 2014), http://youtu.be/I353xn8Guwg, (remarks of Susanna Williams, Policy Officer – Climate and Energy, European Environmental Bureau, at 22:00 to 30:00.

[7] International Energy Agency, *Golden Rules for a Golden Age of Gas*, Ch. 2 p. 91 (2012).

the most skewed of DOE's emission estimates (*i.e.*, the estimates DOE provides that are most favorable to LNG),[8] U.S. LNG would need to displace at least twice as much coal as renewable energy to show any climate benefit. As we explain below, however, DOE significantly underestimates U.S. LNG's lifecycle emissions. Based on methane leakage rates indicated by atmospheric studies (*e.g.*, 3% or more), U.S. LNG's lifecycle emissions approach will likely exceed coal's, applying 100-year and 20-year methane global warming potentials, respectively.[9] Adding in the fact that U.S. LNG will also compete with regional LNG, which DOE estimates to have lower lifecycle emissions than U.S. LNG, makes it even less likely that U.S. LNG exports would decrease importing countries' aggregate lifecycle energy emissions. Thus, using realistic estimates of the lifecycle greenhouse gas emissions of U.S.-sourced LNG, if even a small fraction of U.S. LNG exports are used in lieu of renewables and efficiency, this will significantly impact the overall effect on end use markets' lifecycle energy emissions.

B. U.S. LNG Exports May Also Affect Other Sources of Greenhouse Gas Emissions in the U.S.

U.S. LNG exports will also have greenhouse gas emission impacts not reflected in an analysis that only looks at lifecycle greenhouse gas emissions of electricity generation in end-use markets. More than two years ago, the EIA, in response to a request from DOE, modeled how U.S. energy production and consumption would respond to several levels of U.S. LNG exports.[10] Using the National Energy Modeling System, EIA predicted that U.S. LNG exports would increase domestic gas prices, which would lead to a reduction in domestic gas consumption. EIA predicted that this effect would be particularly pronounced in the electricity generation sector, and that electricity producers would "primarily" respond by replacing gas fired generation with coal.[11] Specifically, EIA predicted that 72 percent of the decrease in gas-fired electricity production will be replaced by coal-fired production, with increased liquid fuel consumption, increased renewable generation, and decreases in total consumption (8, 9, and 11 percent, respectively) making up the remainder of the gap.[12] EIA then modeled the effect this shift in electricity generation would have on total electricity sector greenhouse gas emissions, and

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[8] Export LCA at 13.
[9] Export LCA at 15.
[10] EIA, *Effect of Increased Natural Gas Exports on Domestic Energy Markets* (Jan. 2012).
[11] *Id.* at 6; *see also id.* at 17 ("[H]igher natural gas prices lead electric generators to burn more coal and less natural gas.").
[12] *Id.* at 18. We note that the relationship between gas, coal, and renewables is different in the U.S. than in likely import markets, because gas prices in the U.S. do not include the economic cost of liquefying, transporting, and regassifying LNG. This may mean that gas in the U.S. is priced so low that, even if prices increase in response to exports, prices will remain below renewables in many areas, limiting the extent to which U.S. generation displaced from gas as a result of exports transitions to renewables (EIA's 9% forecast). In likely import markets, on the other hand, gas prices are more often higher than renewables, such that providing cheaper gas in the form of U.S. LNG may cause greater displacement of renewables.

concluded that U.S. LNG exports would increase U.S. electric sector carbon dioxide emissions by hundreds of millions of metric tons annually.[13]

DOE's Export LCA does not address this impact of LNG exports. DOE's Addendum to Environmental Review Documents tersely acknowledges, in a single footnote, EIA's prediction of gas-to-coal switching in response to exports, but does not address the environmental impacts of this shift. This change, however, would plainly be the type of indirect effect of federal action that must be considered under NEPA. Accordingly, DOE cannot approve proposed LNG export projects without evaluating the potential for shifts in *domestic* electricity generation in response to LNG exports, and the environmental effects of any such shift.

Since the EIA's January 2012 analysis was completed, EPA has proposed greenhouse gas emission standards for gas and coal fired power plants. These standards could limit gas-to-coal switching to levels below those forecast by EIA in 2012. These standards are still at the proposal stage, however, and may not take effect as currently proposed. Moreover, DOE must consider whether, even if the standards are adopted as proposed, gas price increases could still cause gas to coal switching. For example, there may be states that, in a no-LNG-exports scenario, would reduce their emissions even below the ceiling set by the proposed standards, but that, if exports occur and cause a marginal increase in gas prices, would experience some gas-to-coal switching and increase their emissions without exceeding the proposed ceiling. Thus, while the particular predictions made by EIA in January 2012 should be revisited, the EIA report demonstrates that DOE must consider the extent to which LNG exports, by increasing gas prices, cause changes in domestic fuel and energy use that will have climate and other environmental consequences.

In summary, while comparing the lifecycle emissions of U.S. LNG with other fossil fuels can provide a useful perspective on the climate impacts of potential LNG exports, it does not answer a key question before DOE: how will greenhouse gas emissions change if DOE approves or disapproves LNG exports. If LNG is exported from the U.S., a small portion of the exported gas will come from production that would have occurred anyway, importing countries will not fully offset their use of U.S. LNG by decreasing consumption of other fossil fuels, and the U.S. will increase consumption of other, also harmful, fossil fuels in response to increased domestic gas prices. In reviewing applications for LNG exports, DOE must consider these broader effects.

III. DOE Underestimates the Lifecycle Greenhouse Gas Emissions of U.S. LNG

In discussing the lifecycle impacts of U.S. LNG, DOE understates the amount of methane that is emitted during the gas lifecycle (the "leak rate"), DOE improperly omits consideration of emissions from pipeline transportation in LNG's end-use markets, and DOE understates the impact of the methane that is emitted. These errors cause DOE to understate the lifecycle impacts of US LNG, and similarly apply to the broader analyses DOE must undertake, such as evaluation of the net impact on U.S. greenhouse gas emissions.

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[13] *Id.* at 19. EIA looked only at end use combustion emissions, rather than the full lifecycle greenhouse gas impacts of this shift.

A. DOE Underestimates the Methane Leak Rate of Domestic Gas Production

DOE's lifecycle analysis assumes that 1.3 and 1.4 percent of extracted conventional and unconventional gas, respectively, is released as methane between the well and liquefaction facility.[14] DOE's maximum emission rate for both forms of production is 1.6 percent.[15] This estimate is almost certainly too low, as demonstrated by, *inter alia*, recent studies measuring methane in the atmosphere, which indicate that the methane leak rate for domestic onshore gas is 3 percent or higher.

As a threshold matter, DOE has failed to adequately explain the basis for its leak rate estimates. The Export LCA states that these estimates are derived from the Gas LCA. The Gas LCA discussion of emissions from gas production, in turn, relies almost exclusively on documents simply cited as EPA 2011a, EPA 2011b, EPA 2011c, and EPA 2012c.[16] The Gas LCA's references section, however, contains errors that prevent commenters from identifying or retrieving these documents. The references section identifies EPA 2011a as "Background Technical Support Document – Petroleum and Natural Gas Industry."[17] The URL provided,[18] however, points to a different document, "Greenhouse Gas Emissions Reporting from the Petroleum and Natural Gas Industry: Background Technical Support Document." This document describes EPA's Subpart W Greenhouse Gas Reporting Program. The title of this particular document, retrieved from the EPA 2011a URL, is the title the Gas LCA ascribes to *both* EPA 2011b and EPA 2011c (but not EPA 2011a). Neither the URL for EPA 2011b nor the URL for 2011c, however, leads to a document with this title. Nor does NETL appear to have simply transposed the titles or URLs for 2011b or 2011c with 2011a, because neither of the URLs for 2011b or 2011c leads to the document named in EPA 2011a.[19] Thus, the supporting materials only actually identify one of the three EPA 2011 documents they rely upon, and they do not indicate which of EPA 2011a, 2011b, or 2011c this is. This confusion limits the public's ability to evaluate or comment upon the inputs DOE uses. Different EPA documents provide different estimates of gas production emissions (for example, in documents related to Clean Air Act rules for oil and gas production, the subpart W reporting program, and the annual greenhouse gas inventories), and these different EPA documents often rely on different estimates for individual source emissions. While Sierra Club and other environmental commenters criticized these EPA's estimates in their associated EPA dockets, here, because DOE has not revealed which particular source of estimates it is using, we cannot offer commentary on the validity of the particular

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[14] Export LCA, 6-8.
[15] *Id.*
[16] Gas LCA at 13-15, 17.
[17] Gas LCA at 79.
[18] http://epa.gov/ghgreporting/documents/pdf/2010/Subpart-W_TSD.pdf.
[19] The URL for EPA 2011b, http://www.epa.gov/climatechange/emissions/downloads10/Subpart-W_TSD.pdf, is invalid, returning a "File Not Found" message. The URL for EPA 2011c, http://www.epa.gov/climatechange/emissions/subpart/w.html, leads to a short summary page with a title different than the one included in the references.

estimates used by DOE. Even for the "Greenhouse Gas Emissions Reporting" document we were able to retrieve, because we cannot determine which of 2011a, 2011b, and 2011c this is supposed to be, we cannot determine which sources are ones for which DOE drew estimates from this document.

Despite this confusion as to the inputs for NETL's leak rate estimates, it's clear that NETL's ultimate answer is too low. One line of evidence indicating that actual emissions are higher comes from recent direct measurements of gas production emissions. The Gas LCA, like the EPA estimates summarized above, uses a "bottom-up" method of estimating emissions. That is, it uses an estimate of the average emissions for each type of individual piece of equipment or individual event, such as a high-bleed pneumatic device or a well completion, and multiplies that per-component value by an estimate of the total number of components or events of that type. DOE acknowledges that this method of analysis has significant limits, explaining that "Emissions estimates are generally uncertain because direct measurements are lacking, industry practices are evolving for unconventional resources, and practices are not standard across the industry."[20] Yet a recent study by David Allen *et al*. directly measured emissions from wells that likely to have some of the *lowest* emission controls found and emissions similar to what EPA and NETL estimate to represent the industry *average*.[21] Allen worked in partnership with several major oil and gas producers to directly measure emissions from hydraulically fractured oil and gas production at sites and times controlled by the industry partners. The sites included in this study were therefore unlikely to be representative of the industry at large: larger gas producers typically employ more stringent emission controls, these producers had opted in to the study, the producers knew that their emissions were being monitored for publication, and they had control over the wells actually studied.[22] Unsurprisingly, the observed sites had a high usage of pollution control techniques that EPA's industry-wide estimates assume to be uncommon, such as reduced emission completions.[23] These sites, however, had emissions largely equivalent to estimate indicated by EPA's 2013 GHG Inventory.[24] Although the sampled sites had lower emissions from well completion than the EPA estimate of the industry average, these low well completion emissions were offset by high emissions from leaks, controllers, and pumps. [25] For these other categories, emissions at the sites included in the study were much higher than EPA's estimate of the industry average.[26] Because surveys and other data indicate that the industry as a whole uses

[20] Addendum at 36-37.

[21] 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.

[22] Allen *et al* at 2 of 6 (acknowledging that the study may not represent the industry as whole).

[23] *E.g.*, *id.* at 2-3 (only 23% of wells in study did not use reduced emission completions or equivalent); *compare* DOE Addendum at 24 (describing completion-related emissions as one of the major sources of methane emissions).

[24] Allen *et al.* at 4, Table 2. For the fraction of the lifecycle covered by Allen, the rates were 0.42% and 0.47% for Allen *et al.* and EPA's 2013 Greenhouse Gas Inventory, respectively. *Id.* As explained by DOE, the EPA 2013 Greenhouse Gas Inventory indicated that the leak rate for the entire lifecycle is 1.54%. DOE Addendum at 40.

[25] Allen *et al.* at 4, Table 2.

[26] *Id.*

less stringent pollution control than did the wells observed in this study, the industry's average emissions are almost certainly higher than the rates measured by Allen, and thus higher than EPA's 2013 GHG Inventory indicates. The NETL lifecycle leak rate estimates, 1.3 and 1.4%, are lower even the 1.54% lifecycle leak rate DOE derives from EPA's 2013 GHG Inventory.[27] Allen therefore indicates that the NETL estimates of natural gas lifecycle leak rates are too low.

Another indication that NETL's leak rate estimates are too low is that NETL's estimate is lower than *all* of the other life-cycle leak rate estimates NETL cited. NETL states that, including NETL's own work, "[t]here are five major studies that account for the GHG emissions from upstream natural gas. . . . While a number of studies have been conducted on this topic, these five studies represent the breadth of all natural gas lifecycle work . . . ."[28] Three of the non-NETL studies provide estimates of methane leak rates.[29] NETL provides an extensive discussion of one of these studies, explaining why NETL's leak rate estimates differ from those provided by Robert Howarth of Cornell.[30] For a second study, work led by Burnham, while NETL identifies several differences between NETL and Burnham in the inputs used to estimate leak rates, it appears that differences in inputs alone should lead to Burnham to estimate a *lower* leak rate, but Burnham's estimated leak rate is higher than NETL's, including an estimate of 2.01% for unconventional production.[31] For the third "major study" to provide a leak rate, led by Weber, NETL offers no explanation whatsoever for the discrepancy between NETL's estimates and Weber's estimate of 2.8 and 2.42 percent leak rates for conventional onshore and unconventional production, respectively.[32] Thus, the DOE package of materials provides no basis for concluding that the NETL estimate of the leak rate is more accurate than the estimates provided by Burnham and Weber.[33]

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[27] DOE Addendum at 40.

[28] Unconventional Production Report at 39; *see also id.* at 2.

[29] DOE Addendum at 40, Unconventional Production Report at 52; *see also* Gas LCA at 70 (briefly discussing two of these studies, Burnham 2011 and Jiang 2011).

[30] Unconventional Production Report at 52-54 (discussing Howarth, R.W., Santoro, R., and Ingraffea, A. (2011). Methane and the Greenhouse-gas Footprint of Natural Gas from Shale Formations. *Climatic Change*, DOI 10.1007/s10584-011-0061-5).

[31] *Id.* at 55 (discussing Burnham, A., Han, J., Clark, C.E., Wang, M., Dunn, J.B., and Palou-Rivera, I. (2011). Life-cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum. *Environmental Science & Technology*). The Unconventional Production Report states that Burnham assumed a 2% higher volume of natural gas in flowback water from well completions (9,175 as opposed to 9,000 Mcf/well). It appears that this difference should be more than offset by Burnham's much higher assumption about the proportion of this gas that is flared rather than vented (41% instead of 15%) and Burnham's higher estimated ultimate recovery (3.5 instead of 3-3.25 bcf).

[32] *Id.* at 52 (discussing 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).

[33] Separate from this discussion, the DOE Addendum concludes that EPA's 2014 greenhouse gas inventory implies a leak rate of 0.8%. DOE Addendum at 33-34. DOE derives this estimate by omitting emissions from the "distribution" segment of the natural gas lifecycle. DOE provides no basis for excluding distribution. Although natural gas delivered to large users like an LNG export terminal might suffer lower distribution losses than the national average, it is inappropriate to assume that no distribution loss occurs. *See, e.g.*, Gas LCA at 36 (providing one estimate of lifecycle methane leakage for gas distributed to power plants or other large scale users). We further

Still further evidence that DOE and NETL's estimates of the leak rate are too low comes from a growing body of recent, peer-reviewed atmospheric studies. As noted above, NETL, like EPA and the other "major studies" NETL discusses, uses a "bottom-up" method of estimating lifecycle emissions. A different method of estimating natural gas sector methane emissions is a "top-down" approach, where researchers measure the methane accumulation in the atmosphere in an area where gas production is occurring and then estimate the fraction of this atmospheric methane attributable to gas production. For example, a researcher might measure methane concentrations upwind and downwind of gas activity to find the methane emitted in the area between the two measurements, and then subtract out the estimated methane emissions from non-gas-production sources in that area. Certainty in source attribution has increased in recent years as scientists are better able to distinguish methane sources based on detected levels of co-occurring compounds such as ethane or isotopic composition of atmospheric methane. While, as DOE acknowledges, bottom-up estimates are limited by uncertainty regarding the prevalence of specific industry practices, this uncertainty does not affect top-down estimates, because that prevalence is not an input in the analysis. Thus, there are reasons to believe that the top-down estimates are more accurate than the bottom-up approaches.

In the last two years, peer-reviewed publications utilizing top-down techniques to estimate methane emissions from gas have proliferated, and these studies provide compelling evidence that the aggregate methane emission estimates based on bottom-up studies conducted to date have underestimated gas sector methane emissions by a significant margin. Two recent studies addressed natural gas's lifecycle methane emissions nationwide. The first, published by Scot M. Miller, *et al.*, reviewed atmospheric measurements of methane and concluded that "[t]he U.S. 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."[34] Specifically, Miller, *et al.* conclude that atmospheric measurements show that methane emissions from all sources were 50% higher than the 2013 Inventory's bottom-up estimate of emissions. They show that gas emissions are a significant portion of the observed emissions not accounted for in EPA's Inventory, and suggest that the actual leak rate is likely to be 3% or more.[35] The second, published by Adam Brandt, *et al*., similarly concluded that EPA's Inventory

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note that the DOE Addendum relies on the DRAFT 2014 inventory; the final inventory, released in April of 2014, estimates higher emissions for the gas sector.

[34] *See, e.g.*, Miller, S., *et al.*, *Anthropogenic emissions of methane in the United States*, Proceedings of the National Academy of Sciences (Dec. 10, 2013) ("PNAS Study"), at 20,022, *available at* http://calgem.lbl.gov/Miller-2013-PNAS-US-CH4-Emissions-9J5D3GH72.pdf, attached as Exhibit 6.

[35] Specifically, the paper states that in moving from the 2012 Inventory to the 2013 Inventory, EPA "decreased its CH4 emission factors for fossil fuel extraction and processing by 25–30% (for 1990–2011), but we find that CH4 data from across North America instead indicate the need for a larger adjustment of the opposite sign." *Id.* The 2012 Inventory implied a leak rate of approximately 2.4%; a 25% increase brings the leak rate to 3%.

and other bottom-up estimates, which generally use values similar to those assumed by DOE here, significantly underestimate methane emissions from oil and gas production.[36]

These nationwide studies stand in agreement with atmospheric studies examining individual regions, which have found even higher methane emissions in the regions studied. Two studies of Colorado's Denver-Julesberg Basin have concluded that during gas production alone (not including emissions from downstream segments of the industry - transmission and distribution), the gas leak rate was about 4%.[37] The same team of researchers found even higher methane leak rates in Utah's Uinta Basin, estimating escaped methane at 9 ± 3% of total production.[38]

The Export LCA does not acknowledge any of this recent science. The Gas LCA and Unconventional Production Report briefly acknowledge the Brandt[39] and earlier Colorado study (Petron 2012),[40] but it does not discuss the other studies, and it offers no argument as to why the estimates adopted by the Gas LCA are superior to those provided by atmospheric studies. NETL's Unconventional Production Report argues that the Colorado Study is not applicable to shale gas, because it concerned production in tight sandstone.[41] Yet this report does not identify any difference between shale and tight sandstone that would limit the study's applicability to shale. Moreover, EIA predicts that some production induced by LNG exports will come from tight sandstone.

Because methane is an extremely potent greenhouse gas, increases in the methane leak rate drastically increase the lifecycle greenhouse gas emissions of LNG. The Export LCA acknowledges this sensitivity,[42] and thus the importance of this issue, but numerous lines of evidence indicate that DOE gets this important issue wrong.

B. DOE Fails to Account for Transportation Emissions in Importing Markets

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

[37] The 4% estimate is provided by the more recent of these studies, 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, attached as Exhibit 7. This is consistent with an earlier study, by the same lead author, which estimated using top-down techniques that 2.3 to 7.7% of production was vented in the study and concluded more generally that "the methane source from natural gas systems in Colorado is most likely underestimated by at least a factor of two." Petron, *et al.*, *Hydrocarbon emissions characterization in the Colorado Front Range: A pilot study*, 117:D4 J. Geophys. Res. Atmospheres 4304 (Feb. 21, 2012).

[38] 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, attached as Exhibit 8.

[39] Gas LCA at 72, Unconventional Production Report at 56.

[40] Gas LCA at 72

[41] Unconventional Production Report at 65.

[42] Export LCA at15.

Once LNG is delivered to an import terminal and regasified, it must be transported by pipeline to the end user. As DOE acknowledges in discussing U.S. pipeline transportation elsewhere, pipeline transportation of gas emits methane as a result of fugitive emissions and carbon dioxide as a result of combustion in compressors and other equipment along the pipeline route.[43] DOE, however, explicitly omits emissions from this stage of the LNG lifecycle from DOE's analysis. DOE bases this omission on the "assum[ption] that the natural gas power plant in each of the import destinations is existing and located close to the LNG port."[44] DOE does not, however, provide any basis for this assumption.

Pipeline emissions in end-use markets are potentially significant. DOE's Export LCA identifies U.S. pipeline transportation emissions as a significant source of emissions. Although the journey from regasification to end use may be shorter than the journey from the well to the liquefaction terminal, the emissions per pipeline mile may be higher in some end use markets. The Intergovernmental Panel on Climate Change's ("IPCC") most recent "Guidelines for National Greenhouse Gas Inventories" explains that, measured against emissions in North America and Western Europe, "in developing countries and countries with economies in transition . . . there are [generally] much greater amounts of fugitive emissions per unit of activity."[45]

C. DOE Understates The Impact of Each Ton of Methane That Is Emitted

As explained above, DOE understates the quantity of methane that would be emitted as a result of U.S. LNG exports. DOE also understates the impact of each ton of methane emitted, by understating the global warming potential of methane, and by focusing on the 100-year, rather than 20-year, timeframe.

The climate impact of methane is commonly understood in terms of methane's "global warming potential," which expresses warming caused by a greenhouse gas relative to the warming caused by an equivalent mass of carbon dioxide.[46] Global warming potential allows emissions of non-CO_2 pollutants to be expressed in terms of CO_2-equivalent. We support the decision, in the Export LCA, to use the most recent IPCC data on methane's global warming potential, and the adherence to IPCC's recommendation to adjust global warming potentials for fossil, rather than biogenic, methane.[47] DOE must clarify, however, that it does in fact accept the IPCC's 2013 figures as the best available. The DOE Addendum, Gas LCA, and Unconventional Production

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[43] Export LCA at 3, 8; *see also* Gas LCA at 24-25.
[44] Export LCA at 3.
[45] Intergovernmental Panel on Climate Change. *2006 IPCC Guidelines for National Greenhouse Gas Inventories*. Vol. 2 Ch. 4, at 4.46; http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_4_Ch4_Fugitive_Emissions.pdf, attached as Exhibit 9.
[46] IPCC, Climate Change 2013: Physical Science Basis, Annex III: Glossary, 1455.
[47] Export LCA at 2; *see also* IPCC, Climate Change 2013: Physical Science Basis, Anthropogenic and Natural Radiative Forcing, 714.

Report all use, at times, older methane global warming potentials.[48] These analyses must be updated to consistently reflect the best available science.

Even in the Export LCA, DOE errs, however, by using the IPCC estimates that do not incorporate climate-carbon cycle feedbacks. A climate carbon feedback involving changes in the properties of the land and ocean carbon cycle in response to climate change. For example, changes to ocean temperature and circulation could affect the CO2 balance between the oceans and the atmosphere.[49] The IPCC explains that "it is likely that including the climate–carbon feedback for non-CO_2 gases as well as for CO_2 provides a better estimate of the metric value than including it only for CO_2."[50] As DOE has properly recognized the IPCC report as reflecting the scientific consensus on methane's potency, DOE should use the estimates that the IPCC states to be more accurate. Thus, DOE should use 20-year and 100-year fossil methane global warming potentials of 87 and 36, respectively.[51]

Similarly, while we support DOE's inclusion of calculations using the 20-year global warming potential as well as the 100-year global warming potential, DOE errs by using the 100-year time frame as the "default."[52] The IPCC projects that warming may reach the commonly agreed upon 2 °C target within decades, rather than a century, and reveals that urgent action on short-acting pollutants like methane is needed in addition to reductions in CO_2.

IV. DOE Must Consider the Impact, in Addition to the Amount, of GHG Emissions

DOE must do more than merely quantify the likely increase in greenhouse gas emissions that would result from U.S. LNG exports. DOE must also explain the effect of these emissions in relevant social and policy contexts. U.S. LNG exports will hinder, if not preclude, U.S. attainment of the administrations' stated emission targets and international commitments. U.S. LNG exports are inconsistent with the U.S.'s policy of encouraging other nations to reduce greenhouse gas emissions. Finally, the social and environmental cost of these emissions must be incorporated into DOE's assessment of the economic impact of LNG exports.

A. Exports Are Inconsistent with U.S. Greenhouse Gas Emission Targets

President Obama has set the goal of reducing U.S. greenhouse gas emissions, relative to 2005, by at least 17% by 2020, 42% by 2030, and 83% by 2050. These targets were announced in

[48] *See, e.g.*, DOE Addendum at 20 ("Methane is a greenhouse gas (GHG) more than 20 times as potent as carbon dioxide (CO2)."), Unconventional Production Report at 46-49.
[49] IPCC, Climate Change 2013: Physical Science Basis, Annex III: Glossary, 1450.
[50] *Id.* at 714. "Likely" is a technical term as used in the IPCC reports, defined to mean at least a 66% probability. *Id.* at 36 (Figure 1.11).
[51] *Id.* at 714.
[52] Export LCA at 2.

Copenhagen in 2009,[53] the President committed to them in Cancún in 2010, [54] and the President reiterated the 2020 goal in the Climate Action Plan announced in 2013.[55] While these targets will require concerted effort, when measured against the goal of limiting warming to 2 °C, they are if anything too modest. The IPCC stated that meeting the 2020 targets announced in Cancún will not, without significant further reductions in following years, be likely to limit warming to less than 2 °C. Yet LNG exports, and the drastic expansion in domestic gas production that these exports would cause, will make it difficult (if not impossible) for the U.S. to attain even its 2020 target.

Under the most optimistic projections from the EPA and EIA regarding the current trajectory of U.S. greenhouse gas emissions, the U.S. will exceed the Administration's 2020 target by over 800 million metric tons of CO_2-equivalent.[56] As demonstrated by the EIA's LNG Export Study and other models of U.S. LNG exports, the majority of gas exported from the U.S. would come from new natural gas production (*i.e.* production that would not occur if the U.S. did not export LNG). The Export LCA recognizes that natural gas production has significant greenhouse gas emissions, and as we explain above, a growing body of published research indicates that these emissions are much higher than DOE acknowledges. LNG exports will therefore lead to additional production-related increases in greenhouse gas emissions at a time when the U.S. must take every available step to reduce greenhouse gas emissions.

For purposes of compliance with Cancún commitments, DOE cannot argue that emissions from export-induced production will be offset by displacement of fossil fuels that would otherwise be produced elsewhere. The Cancún commitments were adopted under the auspices of the United Nations Framework Convention on Climate Change ("UNFCCC").[57] The guidelines for the

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[53] United States Department of State, Letter to Executive Secretary of United Nations Framework Convention on Climate Change Confirming U.S. Copenhagen Targets, (Jan. 28, 2010), *available at* https://unfccc.int/files/meetings/cop_15/copenhagen_accord/application/pdf/unitedstatescphaccord_app.1.pdf, attached as Exhibit 10.

[54] United States Framework Convention on Climate Change, Compilation of economy-wide emission reduction targets to be implemented by Parties included in Annex I to the Convention (June 7, 2011), *available at* http://unfccc.int/resource/docs/2011/sb/eng/inf01r01.pdf, attached as Exhibit 11.

[55] Executive Office of the President, *The President's Climate Action Plan* (June 2013).

[56] This estimate is calculated from table 5-1 of the 2014 U.S. Climate Action Report to the UN Framework Convention on Climate Change. http://www.state.gov/documents/organization/218993.pdf, attached as Exhibit 12. Table 5-1 uses outdated global warming potentials for methane and other non-CO2 pollutants taken from the IPCC's 1996 Second Assessment Report. This same report explains, however, that going forward, the U.S. will make reports using the IPCC's 2007 Fourth Assessment Report estimates of 100-year global warming potentials. *First Biennial Report of the United States of America*, Table 1, *available at* http://www.state.gov/documents/organization/219039.pdf, attached as Exhibit 13. *See also* http://www.state.gov/e/oes/rls/rpts/car6/ (summary page with links to each chapter of this report). While we have used these global warming potentials for consistency with Climate Action Report's stated intentions with regard to reports made under this program, we note that the actual global warming potentials are likely to be significantly higher, as reflected in the IPCC's 2013 Fifth Assessment Report.

[57] *See supra* n.52.

UNFCC reporting program instruct countries to report emissions within their borders.[58] Requiring the U.S. to account for production-related emissions of all fuel produced in the U.S., regardless of whether the fuel is ultimately consumed elsewhere, is a sound policy judgment. The U.S. can only directly regulate emissions within its borders. DOE has asserted that the U.S. will derive economic benefits from this additional gas production, so the U.S. should be held to account for the associated environmental cost. Estimates of emissions from activities within the U.S. are also likely to be more accurate than estimates that seek to trace the lifecycle of fuels combusted in an end use country.

The administration's Cancún and Climate Action Plan greenhouse gas reduction targets set an ambitious but necessary challenge. DOE cannot approve LNG exports without determining the effect exports would have on this important federal policy. Because of the emissions associated with gas production and liquefaction, it is unlikely, at least, that the U.S. can meet its emission reduction commitments while also expanding gas production to supply and export market.

B. Exports Are Inconsistent with U.S. Efforts to Assist Other Countries in Transitioning to Low Carbon Energy Infrastructure

As explained in the IPCC's Fifth Assessment Report, avoiding catastrophic climate change will require significant emission reductions worldwide. The President's Climate Action Plan, in addition to setting domestic goals, states that the U.S. will assist other nations in reducing their greenhouse gas emissions.[59]

In particular, it is important to ensure that investments in long-lived energy infrastructure in other nations do not lock in emission trajectories that are incompatible with the reductions needed. The President's Climate Action Plan recognizes this by calling for a halt to U.S. financing of coal plants overseas.[60] Indeed, encouraging the construction of new, long-lasting, high-emitting infrastructure such as coal fired power plants abroad works at cross purposes with domestic efforts to phase out coal fired electricity generation.

DOE's Export LCA and these comments reveal that foreign use of U.S. LNG, like foreign use of coal, is inconsistent with the emission reductions necessary to avoid catastrophic climate change. The U.S. must be especially careful to avoid development that would lock in high emitting activities over long time scales. Infrastructure built around U.S. LNG is precisely this type of problematic infrastructure. Thus, for the same reasons underlying the President's "first, do no

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[58] *See, e.g.*, IPCC, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 1, p. 8.4 (corrected as of June 2010), available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_8_Ch8_Reporting_Guidance.pdf, attached as Exhibit 14. The other chapters and volumes of this report are available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.
[59] Executive Office of the President, *The President's Climate Action Plan* (June 2013).
[60] *Id.* at 20.

harm" policy regarding investment in foreign coal-fired power plants, DOE should reject proposals to export U.S. LNG.

Admittedly, the Climate Action Plan suggests promoting natural gas use abroad as a way to reduce other countries' greenhouse gas emissions. One of the purposes of environmental review under NEPA, however, is to take a hard look at whether, in terms of environmental impacts, federal actions will in fact achieve their intended results. The President's Climate Action Plan recognizes the broad policy goal of significantly reducing the carbon intensity of international energy supply and use.[61]

C. DOE's Assessment of the Economic Impact of LNG Exports Must Account for The Social Cost of Greenhouse Gas Emissions

Finally, DOE must evaluate the social cost of exports' greenhouse gas emissions.

DOE has used economic analyses, including cost benefit analysis, to weigh the non-environmental impacts of exports.[62] DOE cannot base its decisions on exports on a projection of economic benefit without also giving weight to the impact of exports' environmental impact. At a minimum, DOE's cost/benefit analysis must consider the available estimates of the social cost of carbon dioxide and methane, the primary greenhouse gases that would be emitted by export approvals.[63]

The Federal Interagency Working Group on the Social Cost of Carbon has developed an estimate of the social cost of carbon dioxide emissions, typically shortened to "the social cost of carbon."[64] This group's most recent estimate of the present value of the social cost of a ton of carbon dioxide emitted in 2030 (roughly the midpoint of the life of the 20-year periods for which most applicants seek export authorization) is $52.[65] While this study represents the most comprehensive analysis of this issue conducted thus far, Sierra Club and other environmental organizations have commented elsewhere that this significantly underestimates the true social cost of carbon, possibly by several orders of magnitude.[66]

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[61] Climate Action Plan at 18.
[62] For reasons stated in the comments of Sierra Club, *et al.*, on the NERA Macroeconomic study and in the dockets for these individual applications, commenters contend that these economic analyses were themselves flawed.
[63] *High Country Conservation Advocates, et al. v. United States Forest Service, et al.*, No. 1:13-cv-01723-RBJ, 2014 WL 2922751 (D. Colo. June 27, 2014).
[64] Interagency Working Group on Social Cost of Carbon, United States Government, *Technical Support Document: Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (Nov. 2013), *available at* http://www.whitehouse.gov/sites/default/files/omb/assets/inforeg/technical-update-social-cost-of-carbon-for-regulator-impact-analysis.pdf, attached as Exhibit 15.
[65] *Id.* at 3. $52 is the estimate under a 3.0% discount rate, which is the middle of the three rates provided.
[66] *See* Sierra Club, *Comments on the Interagency Working Group's (IWG) Technical Support Document: Social Cost of Carbon (SCC) for Regulatory Impact Analysis Under Executive Order 12866* (Docket Not. OMB-2013-0007-0083) (Feb. 25, 2014), *available at* http://www.regulations.gov/#!documentDetail;D=OMB-2013-0007-0083, attached as Exhibit 16; EDF, NRDC, *et al.*, *Comments on the Interagency Working Group's (IWG) Technical*

Although a comprehensive estimate of the social cost of methane has not yet been developed, a peer-reviewed analysis by EPA economists recently estimated the social cost of a short ton of methane emitted in 2015 at $880.[67] This figure was derived using the same methodology used for the estimates of the social cost of carbon. Subsequent research indicates that this estimate is also too low. Since the social cost of methane paper's publication, two inputs to that study—estimates of methane's global warming potential and the 2010 estimate of the social cost of carbon—have been revised dramatically upward. The social cost of methane study used the IPCC Fourth Assessment Report's estimates of methane's global warming potential, [68] but the IPCC Fifth Assessment Report increased the estimate of methane's global warming potential by 21% to 44%. The social cost of methane analysis also used an older, 2010 estimate of the social cost of carbon: the 2013 study discussed above increased estimates by 50%.[69] As noted above, even this revised figure is too low. For these reasons, the true social cost of methane likely exceeds $880 per short ton.

These tools enable DOE to estimate the social cost of the greenhouse gas pollution that would result from U.S. LNG exports. The social cost of added greenhouse gas pollution will diminish, if not completely overcome, the estimates of economic benefit that would result from LNG exports. Of course, greenhouse gas emissions are only one aspect of the environmental harm that would be caused by exports. DOE's assessment of the overall impact of exports must not ignore other environmental and social costs of increased domestic production of natural gas, including potentially less monetizable costs. Many of these costs are discussed on in our separate comment on the draft environmental addendum.

V. Conclusion

Extracting, transporting, and burning natural gas—whether through domestic pipelines or through international trade in LNG—releases harmful climate pollution. The Export LCA and Gas LCA demonstrate that LNG is even more carbon intensive than domestic pipeline gas, although DOE understates the lifecycle emissions of both. Yet neither document examines the

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Support Document: Social Cost of Carbon (SCC) for Regulatory Impact Analysis Under Executive Order 12866 (Docket No. OMB-2013-0007-0140) (Feb. 26, 2014), *available at* http://www.regulations.gov/#!documentDetail;D=OMB-2013-0007-0140, attached as Exhibit 17.

[67] *See* Marten, A.L., and Newbold, S.C., *Estimating the social cost of non-CO_2 GHG emissions: Methane and nitrous oxide*, 51 Energy Policy 957 (2012). As with the social cost of carbon, this estimate uses a 3% discount rate, attached as Exhibit 18.

[68] *Id.* at 16.

[69] *Compare id.* at 13 (citing Interagency Working Group on Social cost of Carbon, *Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866* (Feb. 2010)), *available at* http://www.whitehouse.gov/sites/default/files/omb/inforeg/for-agencies/Social-Cost-of-Carbon-for-RIA.pdf), attached as Exhibit 19 *with* the 2013 update to this document, *supra* n.62, at 3. Under the middle 3% discount rate, the 2013 study's estimate of the social cost of a ton of carbon emitted in 2010 is 50% higher than the 2010 study's estimates, and the 2013 study's estimates increase by even greater percentages for subsequent years.

climate impact that US LNG exports would have. To avoid catastrophic global warming, the U.S. must drastically reduce domestic emissions, and we must do everything we can to aid others in doing the same. LNG exports are inconsistent with these goals, because LNG exports will induce increases in U.S. gas production and associated emissions and LNG exports will displace investments in renewable energy and efficiency in importing markets. Instead of building LNG export infrastructure that will entrench high emission levels for decades to come, the U.S. must adopt and promote carbon free clean, renewable energy.

Sincerely,

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