[6450-01-P]

DEPARTMENT OF ENERGY

FE Docket Nos.

Sabine Pass Liquefaction, LLC	**[FE Docket No. 10-111-LNG]**
Freeport LNG Expansion, L.P. et al.	**[FE Docket No. 10-161-LNG]**
Lake Charles Exports, LLC	**[FE Docket No. 11-59-LNG]**
Dominion Cove Point LNG, LP	**[FE Docket No. 11-128-LNG]**
Freeport LNG Expansion, L.P. et al.	**[FE Docket No. 11-161-LNG]**
Cameron LNG, LLC	**[FE Docket No. 11-162-LNG]**
Southern LNG Company, LLC	**[FE Docket No. 12-100-LNG]**
Gulf LNG Liquefaction Company, LLC	**[FE Docket No. 12-101-LNG]**
Jordan Cove Energy Project, L.P.	**[FE Docket No. 12-32-LNG]**
CE FLNG, LLC	**[FE Docket No. 12-123-LNG]**
Golden Pass Products, LLC	**[FE Docket No. 12-156-LNG]**
Lake Charles LNG Export Co.	**[FE Docket No. 13-04-LNG]**
MPEH LLC	**[FE Docket No. 13-26-LNG]**
Cheniere Marketing LLC and Corpus Christi Liquefaction, LLC	**[FE Docket Nos. 13-30-LNG, 13-42 LNG, & 13-121-LNG]**
Venture Global Calcasieu Pass, LLC	**[FE Docket Nos. 13-69-LNG, 14-88-LNG, & 15-25 LNG]**
Eos LNG LLC	**[FE Docket No. 13-116-LNG]**
Barca LNG LLC	**[FE Docket No. 13-118-LNG]**
Magnolia LNG, LLC	**[FE Docket No. 13-132-LNG]**
Delfin LNG, LLC	**[FE Docket No. 13-147-LNG]**
Commonwealth LNG, LLC	**[FE Docket No. 13-153-LNG]**
SCT&E LNG, LLC	**[FE Docket No. 14-98-LNG]**
Pieridae Energy (USA) Ltd.	**[FE Docket No. 14-179-LNG]**
Bear Head LNG Corporation and Bear Head LNG (USA)	**[FE Docket No. 15-33-LNG]**
G2 LNG LLC	**[FE Docket No. 15-45-LNG]**
Texas LNG Brownsville LLC	**[FE Docket No. 15-62-LNG]**
Sabine Pass Liquefaction, LLC	**[FE Docket No. 15-63-LNG]**
Cameron LNG, LLC	**[FE Docket No. 15-90-LNG]**
Port Arthur LNG, LLC	**[FE Docket No. 15-96-LNG]**
Cameron LNG, LLC	**[FE Docket No. 15-167-LNG]**
Rio Grande LNG, LLC	**[FE Docket No. 15-190-LNG]**
Venture Global Plaquemines LNG, LLC	**[FE Docket No. 16-28-LNG]**
Freeport LNG Expansion, L.P., et al.	**[FE Docket No. 16-108-LNG]**
Lake Charles LNG Export Co.	**[FE Docket No. 16-109-LNG]**
Lake Charles Exports, LLC	**[FE Docket No. 16-110-LNG]**
Driftwood LNG LLC	**[FE Docket No. 16-144-LNG]**
Fourchon LNG, LLC	**[FE Docket No. 17-105-LNG]**
Galveston Bay LNG, LLC	**[FE Docket No. 17-167-LNG]**
Freeport LNG Expansion, L.P., et al.	**[FE Docket No. 18-26-LNG]**

Corpus Christi Liquefaction Stage III, LLC **[FE Docket No. 18-78-LNG]**
Mexico Pacific Limited LLC **[FE Docket No. 18-70-LNG]**
Energía Liquefaction, S. de R.L. de C.V. **[FE Docket No. 18-144-LNG]**
Energía Costa Azul, S. de R.L. de C.V. **[FE Docket No. 18-145-LNG]**
Annova LNG Common Infrastructure, LLC **[FE Docket No. 19-34-LNG]**
Cheniere Marketing LLC and Corpus Christi Liquefaction, LLC **[FE Docket No. 19-124-LNG]**
Sabine Pass Liquefaction, LLC **[FE Docket No. 19-125-LNG]**
Commonwealth LNG, LLC **[FE Docket No. 19-134-LNG]**

Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update – Response to Comments

AGENCY: Office of Fossil Energy, Department of Energy.

ACTION: Notice of response to comments.

SUMMARY: On September 19, 2019, the Office of Fossil Energy (FE) of the Department of Energy (DOE) gave notice of the availability of a study entitled, *Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update* (LCA GHG Update or Update), in the above-referenced proceedings and invited the submission of public comments on the Update. DOE commissioned the LCA GHG Update to inform its decision on pending and future applications seeking authorization to export domestically produced liquefied natural gas (LNG) from the lower-48 states to countries with which the United States does not have a free trade agreement (FTA) requiring national treatment for trade in natural gas, and with which trade is not prohibited by U.S. law or policy (non-FTA countries). The LCA GHG Update includes three principal updates to DOE's 2014 LCA GHG Report. In this document, DOE responds to the seven public comments received on the LCA GHG Update and summarizes its conclusions on the Update. The LCA GHG Update and the public comments are posted on the DOE website at: *https://fossil.energy.gov/app/docketindex/docket/index/21*.

DATES: Applicable on December 19, 2019.

FOR FURTHER INFORMATION CONTACT: Amy Sweeney, U.S. Department of Energy (FE-34), Office of Regulation, Analysis, and Engagement, Office of Fossil Energy, Forrestal Building, Room 3E-042, 1000 Independence Avenue, SW., Washington, DC 20585; (202) 586-2627; *amy.sweeney@hq.doe.gov*; Cassandra Bernstein or Kari Twaite, U.S. Department of Energy (GC-76), Office of the Assistant General Counsel for Electricity and Fossil Energy, Forrestal Building, Room 6D-033, 1000 Independence Ave. SW., Washington, DC 20585; (202) 586-9793 or (202) 586-6978; *cassandra.bernstein@hq.doe.gov* or *kari.twaite@hq.doe.gov*.

SUPPLEMENTARY INFORMATION:

Acronyms and Abbreviations. Acronyms and abbreviations used in this document are set forth below for reference.

API	American Petroleum Institute
AR5	Fifth Assessment Report
Bcf/d	Billion Cubic Feet per Day
Bcf/yr	Billion Cubic Feet per Year
CLNG	Center for Liquefied Natural Gas
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalents
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
FE	Office of Fossil Energy, U.S. Department of Energy
FTA	Free Trade Agreement
GHG	Greenhouse Gas
GWP	Global Warming Potential
IEA	International Energy Agency
IECA	Industrial Energy Consumers of America
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Analysis

LNG	Liquefied Natural Gas
MWh	Megawatt-Hour
NETL	National Energy Technology Laboratory
NEPA	National Environmental Policy Act of 1969
NGA	Natural Gas Act of 1938

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I. Background

A. DOE Export Authorizations Under Section 3 of the Natural Gas Act

DOE is responsible for authorizing exports of domestically produced natural gas to foreign countries pursuant to section 3 of the Natural Gas Act (NGA), 15 U.S.C. 717b.[1] In relevant part, section 3(c) of the NGA applies to applications for exports of natural gas, including LNG, to countries with which the United States has entered into a FTA requiring national treatment for trade in natural gas, and with which trade is not prohibited by U.S. law or policy (FTA countries).[2] Section 3(c) was amended by section 201 of the Energy Policy Act of 1992 (Pub. L. 102-486) to require that FTA applications "shall be deemed to be consistent with the public interest" and granted "without modification or delay."[3] Therefore, DOE approves applications for FTA authorizations without modification or delay.[4] None of the comments or discussion herein apply to FTA authorizations issued under NGA section 3(c).

For applications to export natural gas to non-FTA countries, section 3(a) of the NGA sets forth the following standard of review:

> [N]o person shall export any natural gas from the United States to a foreign country or import any natural gas from a foreign country without first having secured an order of the [Secretary of Energy[5]] authorizing it to do so. The [Secretary] shall issue such order upon application, unless after opportunity for hearing, [he] finds that the proposed exportation or importation will not be consistent with the public interest. The [Secretary] may by [the Secretary's] order

[1] The authority to regulate the imports and exports of natural gas, including LNG, under section 3 of the NGA (15 U.S.C. 717b) has been delegated to the Assistant Secretary for FE in Redelegation Order No. 00-002.04G issued on June 4, 2019.

[2] 15 U.S.C. 717b(c). The United States currently has FTAs requiring national treatment for trade in natural gas with Australia, Bahrain, Canada, Chile, Colombia, Dominican Republic, El Salvador, Guatemala, Honduras, Jordan, Mexico, Morocco, Nicaragua, Oman, Panama, Peru, Republic of Korea, and Singapore. FTAs with Israel and Costa Rica do not require national treatment for trade in natural gas.

[3] 15 U.S.C. 717b(c).

[4] Unless otherwise stated, all references to exports of LNG herein refer to natural gas produced and liquefied in the lower-48 states. Additionally, DOE uses the terms "authorization" and "order" interchangeably.

[5] The Secretary's authority was established by the Department of Energy Organization Act, 42 U.S.C. 7172, which transferred jurisdiction over imports and export authorizations from the Federal Power Commission to the Secretary of Energy.

> grant such application, in whole or part, with such modification and upon such terms and conditions as the [Secretary] may find necessary or appropriate.[6]

DOE—as affirmed by the D.C. Circuit—has consistently interpreted NGA section 3(a) as creating a rebuttable presumption that a proposed export of natural gas is in the public interest.[7] Accordingly, DOE will conduct an informal adjudication and grant a non-FTA application unless DOE finds that the proposed exportation will not be consistent with the public interest.[8] Before reaching a final decision, DOE must also comply with the National Environmental Policy Act of 1969 (NEPA), 42 U.S.C. 4321 *et seq*.

B. Public Interest Review for Non-FTA Export Authorizations

Although NGA section 3(a) establishes a broad public interest standard and a presumption favoring export authorizations, the statute does not define "public interest" or identify criteria that must be considered. In prior decisions, DOE has identified a range of factors that it evaluates when reviewing an application to export LNG to non-FTA countries. These factors include economic impacts, international impacts, security of natural gas supply, and environmental impacts, among others. To conduct this review, DOE looks to record evidence developed in the application proceeding.

DOE's prior decisions have also looked to certain principles established in its 1984 Policy Guidelines.[9] The goals of the 1984 Policy Guidelines are to minimize federal control and

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[6] 15 U.S.C. 717b(a) (emphasis added).

[7] *See Sierra Club v. U.S. Dep't of Energy*, 867 F.3d 189, 203 (D.C. Cir. 2017) ("We have construed [NGA section 3(a)] as containing a 'general presumption favoring [export] authorization.'") (quoting *W. Va. Pub. Serv. Comm'n v. U.S. Dep't of Energy*, 681 F.2d 847, 856 (D.C. Cir. 1982)).

[8] *See id.* ("there must be 'an affirmative showing of inconsistency with the public interest' to deny the application" under NGA section 3(a)) (quoting *Panhandle Producers & Royalty Owners Ass'n v. Econ. Regulatory Admin.*, 822 F.2d 1105, 1111 (D.C. Cir. 1987)). As of August 24, 2018, qualifying small-scale exports of natural gas to non-FTA countries are treated differently—specifically, they are deemed to be consistent with the public interest under NGA section 3(a). *See* 10 CFR 590.102(p); 10 CFR 590.208(a); *see also* U.S. Dep't of Energy, Small-Scale Natural Gas Exports; Final Rule, 83 FR 35106 (July 25, 2018).

[9] New Policy Guidelines and Delegations Order Relating to Regulation of Imported Natural Gas, 49 FR 6684 (Feb. 22, 1984) [hereinafter 1984 Policy Guidelines].

involvement in energy markets and to promote a balanced and mixed energy resource system. Specifically, the 1984 Policy Guidelines state that "[t]he market, not government, should determine the price and other contract terms of imported [or exported] gas," and that DOE's "primary responsibility in authorizing imports [or exports] should be to evaluate the need for the [natural] gas and whether the import [or export] arrangement will provide the gas on a competitively priced basis for the duration of the contract while minimizing regulatory impediments to a freely operating market."[10] Although the Policy Guidelines are nominally applicable to natural gas import cases, DOE held in DOE/FE Order No. 1473 that the 1984 Policy Guidelines should be applied to natural gas export applications.[11]

In Order No. 1473, DOE stated that it was guided by DOE Delegation Order No. 0204-111. That delegation order directed the regulation of exports of natural gas "based on a consideration of the domestic need for the gas to be exported and such other matters as the Administrator [of the Economic Regulatory Administration] finds in the circumstances of a particular case to be appropriate."[12]

Although DOE Delegation Order No. 0204-111 is no longer in effect, DOE's review of export applications has continued to focus on: (i) the domestic need for the natural gas proposed to be exported, (ii) whether the proposed exports pose a threat to the security of domestic natural gas

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[10] *Id*. at 49 FR 6685.

[11] *Phillips Alaska Natural Gas Corp.*, *et al*., DOE/FE Order No. 1473, FE Docket No. 96-99-LNG, Order Extending Authorization to Export Liquefied Natural Gas from Alaska (Apr. 2, 1999), at 14 (citing *Yukon Pacific Corp.*, DOE/FE Order No. 350, Order Granting Authorization to Export Liquefied Natural Gas from Alaska, 1 FE ¶ 70,259, 71,128 (1989)).

[12] DOE Delegation Order No. 0204-111 (Feb. 22, 1984), at 1 (¶ (b)); *see also* 1984 Policy Guidelines, 49 FR 6690 (incorporating DOE Delegation Order No. 0204-111). In February 1989, the Assistant Secretary for Fossil Energy assumed the delegated responsibilities of the Administrator of the Economic Regulatory Administration. *See* Applications for Authorization to Construct, Operate, or Modify Facilities Used for the Export or Import of Natural Gas, 62 FR 30435, 30437 n.15 (June 4, 1997) (citing DOE Delegation Order No. 0204-127, 54 FR 11436 (Mar. 20, 1989)).

supplies, (iii) whether the arrangement is consistent with DOE's policy of promoting market competition, and (iv) any other factors bearing on the public interest described herein.

Under this public interest standard, DOE has issued 38 final long-term authorizations to export domestically produced (or U.S.) LNG or compressed natural gas to non-FTA countries.[13] The cumulative volume of approved non-FTA exports under these authorizations is 38.06 billion cubic feet per day (Bcf/d) of natural gas, or 13.9 trillion cubic feet per year.[14] Each of these non-FTA orders authorize an export term of 20 years.

C. 2014 Life Cycle Greenhouse Gas Report (LCA GHG Report)

In 2014, DOE commissioned the National Energy Technology Laboratory (NETL), a DOE applied research laboratory, to conduct an analysis calculating the life cycle greenhouse gas (GHG) emissions for LNG exported from the United States. DOE commissioned this life cycle analysis (LCA) to inform its public interest review of non-FTA applications, as part of its broader effort to evaluate different environmental aspects of the LNG production and export chain.

DOE sought to determine: (i) how domestically-produced LNG exported from the United States compares with regional coal (or other LNG sources) for electric power generation in Europe and Asia from a life cycle GHG perspective, and (ii) how those results compare with natural gas sourced from Russia and delivered to the same markets via pipeline. In June 2014, DOE published NETL's report entitled, *Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States* (2014 LCA GHG Report or 2014 Report).[15] Subsequently, DOE received public comments on the 2014 LCA GHG Report and responded to those comments in

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[13] *See Venture Global Plaquemines LNG, LLC*, DOE/FE Order No. 4446, FE Docket No. 16-28-LNG, Opinion and Order Granting Long-Term Authorization to Export Liquefied Natural Gas to Non-Free Trade Agreement Nations, at 43 (Oct. 15, 2019).
[14] *See id*.
[15] Dep't of Energy, Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas From the United States, 79 FR 32260 (June 4, 2014). DOE announced the availability of the LCA GHG Report on its website on May 29, 2014.

non-FTA orders.[16] DOE has relied on the 2014 Report in its review of all subsequent applications to export LNG to non-FTA countries.[17]

D. Judicial Decisions Upholding DOE's Non-FTA Authorizations

Beginning in 2015, Sierra Club petitioned the U.S. Court of Appeals for the District of Columbia Circuit (D.C. Circuit or the Court) for review of five long-term LNG export authorizations issued by DOE under the standard of review described above. Sierra Club challenged DOE's approval of LNG exports to non-FTA countries from projects proposed or operated by the following authorization holders: Freeport LNG Expansion, L.P., *et al*.; Dominion Energy Cove Point LNG, LP (formerly Dominion Cove Point LNG, LP); Sabine Pass Liquefaction, LLC; and Cheniere Marketing, LLC, *et al*. The D.C. Circuit subsequently denied four of the five petitions for review: one in a published decision issued on August 15, 2017 (*Sierra Club I*),[18] and three in a consolidated, unpublished opinion issued on November 1, 2017 (*Sierra Club II*).[19] Sierra Club subsequently withdrew its fifth and remaining petition for review.[20]

In *Sierra Club I*, the D.C. Circuit concluded that DOE had complied with both NGA section 3(a) and NEPA in issuing the challenged non-FTA authorization. Freeport LNG Expansion, L.P. and its related entities (collectively, Freeport) had applied to DOE for authorization to export LNG to non-FTA countries from the Freeport Terminal located on Quintana Island, Texas. DOE granted the application in 2014 in a volume equivalent to 0.4 Bcf/d of natural gas, finding that Freeport's

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[16] *See, e.g., Golden Pass Products LLC*, DOE/FE Order No. 3978, FE Docket No. 12-156-LNG, Opinion and Order Granting Long-Term, Multi-Contract Authorization to Export Liquefied Natural Gas by Vessel From the Golden Pass LNG Terminal Located in Jefferson County, Louisiana, to Non-Free Trade Agreement Nations, at 102-28 (Apr. 25, 2017) (description of LCA GHG Report and response to comments).

[17] *See, e.g., Venture Global Plaquemines LNG, LLC*, DOE/FE Order No. 4446, at 14-15, 38-41.

[18] *Sierra Club vs. U.S. Dep't of Energy*, 867 F.3d 189 (Aug. 15, 2017) (denying petition of review of the LNG export authorization issued to Freeport LNG Expansion, L.P., *et al*.).

[19] *Sierra Club v. U.S. Dep't of Energy,* Nos. 16-1186, 16-1252, 16-1253, 703 Fed. Appx. 1 (D.C. Cir. Nov. 1, 2017) (denying petitions of review of the LNG export authorization issued to Dominion Cove Point LNG, LP; Sabine Pass Liquefaction, LLC; and Cheniere Marketing, LLC, *et al*., respectively).

[20] *See Sierra Club v. U.S. Dep't of Energy*, No. 16-1426, Per Curiam Order (D.C. Cir. Jan. 30, 2018) (granting Sierra Club's unopposed motion for voluntarily dismissal).

proposed exports were in the public interest under NGA section 3(a). DOE also considered and disclosed the potential environmental impacts of its decision under NEPA. Sierra Club petitioned for review of the Freeport authorization, arguing that DOE fell short of its obligations under both the NGA and NEPA. The D.C. Circuit rejected Sierra Club's arguments in a unanimous decision, holding that, "Sierra Club has given us no reason to question the Department's judgment that the [Freeport] application is not inconsistent with the public interest."[21]

As relevant here, the D.C. Circuit rejected Sierra Club's challenge to DOE's analysis of the potential "downstream" GHG emissions resulting from the transport and usage of U.S. LNG abroad, set forth in the 2014 LCA GHG Report.[22] The Court pointed out that Sierra Club did not challenge the method employed in the LCA GHG Report to evaluate such GHG emissions, but instead argued that DOE "should have evaluated additional variables" as part of the analysis.[23] Specifically, Sierra Club asserted that DOE should have considered the potential for LNG to compete with renewable sources of energy (or "renewables"), which Sierra Club argued are prevalent in certain import markets. The D.C. Circuit rejected this argument, finding that "Sierra Club's complaint 'falls under the category of flyspecking.'"[24] The Court further held there was "nothing arbitrary about [DOE's] decision" in the 2014 LCA GHG Report to compare emissions from exported U.S. LNG to emissions of coal or other sources of natural gas, rather than a variety of other possible fuel sources with which U.S. LNG might compete in importing nations.[25]

In the consolidated opinion in *Sierra Club II* issued on November 1, 2017, the D.C. Circuit ruled that "[t]he court's decision in [*Sierra Club I*] largely governs the resolution of the [three]

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[21] *Sierra Club I*, 867 F.3d at 203.
[22] *Id*. at 201-02.
[23] *Id*. at 202.
[24] *Id*. (citing *Myersville Citizens for a Rural Cmty., Inc. v. FERC*, 783 F.3d 1301, 1324 (D.C. Cir. 2015)).
[25] *Id*.

instant cases."[26] Upon its review of the remaining "narrow issues" in those cases, the Court again rejected Sierra Club's arguments under the NGA and NEPA, and upheld DOE's actions in issuing the non-FTA authorizations in those proceedings.[27]

The D.C. Circuit's decisions in *Sierra Club I and II*—including the Court's holding on the 2014 LCA GHG Report—continue to guide DOE's review of applications to export LNG to non-FTA countries.

II. *Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update* (LCA GHG Update)

In 2018, DOE commissioned NETL to conduct an update to the 2014 LCA GHG Report, referred to as the LCA GHG Update.[28] As with the 2014 Report, the LCA GHG Update compares life cycle GHG emissions of exports of domestically produced LNG to Europe and Asia, compared with alternative fuel sources (such as regional coal and other imported natural gas) for electric power generation in the destination countries. Although core aspects of the analysis—such as the scenarios investigated—are the same as the 2014 Report, NETL included three principal updates in the LCA GHG Update. In this section, we summarize the scope of the LCA GHG Update, as well as its methods, limitations, and conclusions.

[26] *Sierra Club*, 703 Fed. Appx. 1 at *2.
[27] *Id*.
[28] Nat'l Energy Technology Laboratory, *Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas from the United States: 2019 Update* (DOE/NETL 2019/2041) (Sept. 12, 2019), *available at*: *https://www.energy.gov/sites/prod/files/2019/09/f66/2019%20NETL%20LCA-GHG%20Report.pdf*. Although the LCA GHG Update is dated September 12, 2019, DOE announced the availability of the LCA GHG Update on its website and in the *Federal Register* on September 19, 2019.

A. Overview of the LCA GHG Update

In commissioning the LCA GHG Update, DOE sought information on the same two questions presented in the 2014 LCA GHG Report:

- How does domestically produced LNG exported from the United States compare with regional coal (or other LNG sources) used for electric power generation in Europe and Asia, from a life cycle GHG perspective?

- How do those results compare with natural gas sourced from Russia and delivered via pipeline to the same European and Asian markets?[29]

To evaluate these questions on the basis of more current information, NETL made the following three updates to the 2014 LCA GHG Report:

- Incorporated NETL's most recent characterization of upstream natural gas production, set forth in NETL's April 2019 report entitled, *Life Cycle Analysis of Natural Gas Extraction and Power Generation* (April 2019 LCA of Natural Gas Extraction and Power Generation);[30]

- Updated the unit processes for liquefaction, ocean transport, and regasification characterization using engineering-based models and publicly-available data informed and reviewed by existing LNG export facilities, where possible; and

- Updated the 100-year global warming potential (GWP) for methane (CH_4) to reflect the current Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5).[31]

In all other respects, the 2019 LCA GHG Update is unchanged from the 2014 Report.

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[29] *See id*. at 1.

[30] Nat'l Energy Technology Laboratory, *Life Cycle Analysis of Natural Gas Extraction and Power Generation* (DOE/NETL-2019/2039) (Apr. 19, 2019), *available at*: *https://www.netl.doe.gov/energy-analysis/details?id=3198* [hereinafter April 2019 LCA of Natural Gas Extraction and Power Generation].

[31] *See* LCA GHG Update at 1 (citing IPCC. 2013. Climate Change 2013 The Physical Science Basis. Intergovernmental Panel on Climate Change, *available at: http://www.climatechange2013.org/report/*).

B. The April 2019 LCA of Natural Gas Extraction and Power Generation

The primary component of natural gas is methane, a type of GHG. The methane emission rate—sometimes referred to as the methane leakage rate[32]—represents methane emissions released to the air through venting, fugitives, combustion, or other sources per unit of natural gas delivered to end users. For example, emissions of methane during the production, processing, transmission, and delivery of natural gas were 25% of total U.S. methane emissions in 2016 (the most recent year for which adequate data are available), and were 2.8% of all GHGs when comparing GHGs on a 100-year time frame.[33] The methane emission rate varies with the source of natural gas, due to the variability among geographic locations of natural gas-bearing formations and the different technologies used to extract natural gas.[34]

To evaluate changes in the scientific knowledge of methane and other GHG emissions associated with natural gas systems, NETL updates its LCA of Natural Gas Extraction and Power Generation every two to three years. NETL published the most recent version of this LCA on April 19, 2019.[35] The April LCA informs the LCA GHG Update in this proceeding, which in turn was published on September 12, 2019.[36]

Expanding upon NETL's previous LCAs of natural gas systems, the April 2019 LCA of Natural Gas Extraction and Power Generation provides a complete inventory of emissions to air and water, water consumption, and land use change.[37] It also evaluates the GHG emissions across

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[32] Because Sierra Club uses the term "methane leakage rate" instead of methane emission rate in its Comments, we use the terms interchangeably for purposes of this document.
[33] *See* April 2019 LCA of Natural Gas Extraction and Power Generation, at 3 (citation omitted).
[34] *See id*. at 1, 3-4, 76.
[35] *See supra* at note 30.
[36] *See, e.g.*, LCA GHG Update at 1, 4.
[37] *See* April 2019 LCA of Natural Gas Extraction and Power Generation at 3 (stating that "GHGs are not the only metric that should be considered when comparing energy options, so this analysis also includes a full inventory of air emissions, water use and quality, and land use.").

the entire natural gas supply chain—including production, gathering and boosting, processing, transmission and storage, and distribution of natural gas to consumers.

For this LCA, NETL developed 30 scenarios as a way to better understand variability in natural gas systems. The results were generated using a model made up of 140 sources of emissions to account for different types of variability. Among other findings, NETL determined that the top contributors to carbon dioxide and methane emissions are combustion exhaust and other venting from compressor systems.[38] Additionally, NETL calculated a national average methane emission rate (or leakage rate) of 1.24%.[39] However, if the modeling boundaries end after pipeline transmission—which is the case for large-scale end users like power plants and liquefaction terminals—NETL calculated an average methane emission rate of 1.08%.[40]

C. Purpose of the LCA GHG Update

At the time of the 2014 LCA GHG Report, NETL considered one medium-distance destination (a location in Europe) and one long-distance destination (a location in Asia), since the exact destination countries for U.S. LNG exports could not be predicted at the time.[41] Specifically, NETL applied its LCA model to represent: (1) unconventional natural gas production and transportation to a U.S. Gulf Coast liquefaction facility (Gulf Coast facility), (2) liquefaction of the natural gas at the Gulf Coast facility, (3) transportation of the LNG to an import terminal in Rotterdam, Netherlands, to represent a European market; and (4) transportation of the LNG to an

[38] *Id*. at 1.
[39] *Id*. (95% confidence interval ranging from 0.84% to 1.76%); *see also id*. at 76-77 & Exh. 6-2.
[40] *Id*. at 77 (Exh. 6-2).
[41] *See* LCA GHG Update at 2 n.1.

import terminal in Shanghai, China, to represent Asian markets.[42] At the time of the LCA GHG Update, those choices were still valid based on U.S. LNG exports to date.[43]

NETL determined that one of the most likely uses of U.S. LNG is to generate electric power in the destination countries. Accordingly, NETL used a parametric model for the scenarios to account for variability in supply chain characteristics and power plant efficiencies. In considering sources of fuel other than U.S. LNG, NETL assumed that producers in Europe and Asia could generate electricity in the following ways: (1) by obtaining natural gas from a local or regional pipeline, (2) by obtaining LNG from a LNG producer located closer geographically than the United States, or (3) by using regional coal supplies, foregoing natural gas altogether.[44]

Using this framework, NETL developed four study scenarios, identified below. To compare scenarios, NETL used a common denominator as the end result for each scenario: one megawatt-hour (MWh) of electricity delivered to the consumer, representing the final consumption of electricity. Additionally, NETL considered GHG emissions from all processes in the LNG supply chains—from the "cradle" when natural gas or coal is extracted from the ground, to the "grave" when electricity is used by the consumer. This method of accounting for cradle-to-grave emissions over a single common denominator is known as a life cycle analysis, or LCA.[45]

Using this LCA approach, NETL's objective was to model realistic LNG export scenarios—encompassing locations at both a medium and long distance from the United States—while also

[42] *See id*.
[43] *See, e.g.*, U.S. Dep't of Energy, LNG Annual Report 2018, at 1-2 (Feb. 15, 2019), *available at*: *https://www.energy.gov/fe/downloads/lng-annual-report-2018* (shipments of domestically produced LNG delivered from February 2016 through December 2018).
[44] *See* LCA GHG Update at 2-3.
[45] The data used in the LCA GHG Update were originally developed to represent U.S. energy systems. To apply the data to this study, NETL adapted its natural gas and coal LCA models. The five life cycle stages used by NETL (or "LC Stages"), ranging from Raw Material Acquisition to End Use, are identified in the LCA GHG Update at 2.

considering local fuel alternatives. The purpose of the medium and long distance scenarios was to establish likely results for both extremes (*i.e.*, both low and high bounds).[46]

D. Study Scenarios

NETL identified four modeling scenarios to capture the cradle-to-grave process for both the European and Asian cases. The scenarios vary based on where the fuel (natural gas or coal) comes from and how it is transported to the power plant. For this reason, the beginning "cradle" of each scenario varies, whereas the end, or "grave," of each scenario is the same because the uniform goal is to produce 1 MWh of electricity. The first three scenarios explore different ways to transport natural gas; the fourth provides an example of how regional coal may be used to generate electricity, as summarized in Table 1:

Table 1: LCA GHG Scenarios Analyzed by NETL[47]

Scenario	Description	Key Assumptions
1	• Natural gas is extracted in the United States from Appalachian Shale. • It is transported by pipeline to an LNG facility, where it is cooled to liquid form, loaded onto a LNG tanker, and transported to a LNG port in the receiving country (Rotterdam, Netherlands, for the European case and Shanghai, China, for the Asian case). • Upon reaching its destination, the LNG is re-gasified, then transported to a natural gas power plant.	The power plant is located near the LNG import site.
2	• Same as Scenario 1, except that the natural gas comes from a regional source closer to the destination. • In the European case, the regional source is Oran, Algeria, with a destination of Rotterdam.	Unlike Scenario 1, the regional gas is produced using conventional extraction methods, such as vertical wells that do not use hydraulic fracturing. The LNG tanker transport distance is adjusted accordingly.

[46] *See id*. at 2 n.1.
[47] The four scenarios are set forth in the LCA GHG Update at 2-3 and also discussed at 4-5.

	• In the Asian case, the regional source is Darwin, Australia, with a destination of Shanghai, China.	
3	• Natural gas is produced in the Yamal region of Siberia, Russia, using conventional extraction methods.[48] • It is transported by pipeline directly to a natural gas power plant in either Rotterdam or Shanghai.	The pipeline distance was calculated based on a "great circle distance" (the shortest possible distance between two points on a sphere) between the Yamal district in Siberia and a power plant located in either Rotterdam or Shanghai.
4	• Coal is extracted in either Europe or Asia. It is transported by rail to a domestic coal-fired power plant.	This scenario models two types of coal widely used to generate steam-electric power: (1) surface mined sub-bituminous coal, and (2) underground mined bituminous coal. Additionally, U.S. mining data and U.S. plant operations were used as a proxy for foreign extraction in Germany and China.

In all four scenarios, the 1 MWh of electricity delivered to the end consumer is assumed to be distributed using existing transmission infrastructure.[49]

E. GHGs Reported as Carbon Dioxide Equivalents

Recognizing that there are several types of GHGs, each having a different potential impact on the climate, NETL normalized GHGs for the study. NETL chose carbon dioxide equivalents (CO_2e), which convert GHGs to the same basis: an equivalent mass of carbon dioxide. CO_2e is a metric commonly used to estimate the amount of global warming that GHGs may cause, relative to

[48] Yamal, Siberia, was chosen as the extraction site because that region accounted for 82.6% of natural gas production in Russia in 2012. LCA GHG Update at 5.
[49] *See id*. at 3.

the same mass of carbon dioxide released to the atmosphere.[50] NETL chose CO_2e using the GWP of each gas set forth in the IPCC's AR5, published in 2013.[51]

GWP is an impact category that comprises carbon dioxide, methane, and nitrous oxide (N_2O). All three of these gases have the ability to trap heat in the atmosphere, but each one has a unique heat trapping capacity and atmospheric decay rate, thus requiring an impact assessment method that allows aggregation of their impacts to a common basis. Without multiplying each of these gases by an equivalency factor (*e.g.*, a GWP), there is no way to directly compare them. Therefore, the IPCC uses the relative radiative forcing of these gases, the secondary effects of their decay, and feedback from the ecosystem—all of which are a function of a specified time frame—to develop the GWP equivalency factors.

In the Update, NETL notes that the IPCC AR5 gives the GWPs on a 20- and 100-year time frame that includes climate-carbon feedback.[52] NETL used a 20-year methane GWP of 87 and a 100-year methane GWP of 36. Because climate carbon effects are included in these GWP values, they are slightly higher than the GWP values used in the 2014 LCA GHG Report (which were 85 and 30, respectively). As a result, the LCA GHG Update reflects the most current GWP for methane as set forth in the IPCC AR5.[53]

F. Natural Gas Modeling Approach

NETL's natural gas model is flexible, allowing for the modeling of different methods of producing natural gas. For Scenario 1, all natural gas was modeled as unconventional gas from the Appalachian Shale, since that shale play reasonably represents new marginal gas production in the United States. For Scenarios 2 and 3, the extraction process was modeled after conventional

[50] *See id*.
[51] *See id*.
[52] *See id*. & n.2 (discussing the IPCC AR5's GWPs).
[53] *See id*.

onshore natural gas production in the United States. This includes both the regional LNG supply options that were chosen for this study (Algeria for Europe and Australia for Asia) and extraction in the Siberian region of Russia for pipeline transport to the power plants in Europe and Asia.[54]

In the above three natural gas scenarios, the natural gas is transported through a pipeline, either to an area that processes LNG (Scenarios 1 and 2) or directly to a power plant (Scenario 3). NETL's model also includes an option for all LNG steps—from extraction to consumption—known as the LNG supply chain. After extraction and processing, natural gas is transported through a pipeline to a liquefaction facility. The LNG is loaded onto an ocean tanker, transported to an LNG terminal, re-gasified, and fed to a pipeline that transports it to a power plant. NETL assumed that the natural gas power plant in each of the import destinations already exists and is located close to the LNG port, such that no additional pipeline transport of natural gas is modeled in the destination country.[55]

The amount of natural gas ultimately used to make electricity is affected by power plant efficiency. Therefore, the efficiency of the destination power plant is an important parameter required for determining the life cycle emissions for natural gas power. The less efficient a power plant is, the more natural gas it consumes and the more GHG emissions it produces per unit of electricity generated. The LCA GHG Update used a natural gas power plant efficiency of 46.4%, the same efficiency used in the 2014 Report.[56] This efficiency is consistent with the efficiencies of currently installed, large-scale natural gas power plants in the United States, as detailed in the

[54] LCA GHG Update at 4.
[55] *See id*.
[56] Originally calculated using the U.S. Environmental Protection Agency's (EPA) Emissions and Generation Resource Integrated Database (eGRID), this 46.4% figure represents the average efficiency of natural gas power plants operating in the United States in 2009. More background on this efficiency is provided in NETL's Natural Gas and Power LCA Model Documentation (NETL, 2014).

Update.[57] NETL also assumed that the efficiencies used at the destination power plants (in Rotterdam and Shanghai) were the same as those used in the U.S. model, which are representative of fleet baseload power plants.[58]

G. Coal Modeling Approach

NETL modeled Scenario 4, the regional coal scenario, based on two types of coal: bituminous and sub-bituminous. Bituminous coal is a soft coal known for its bright bands. Sub-bituminous coal is a form of bituminous coal with a lower heating value. Both types are widely used as fuel to generate steam-electric power. NETL used its existing LCA model for the extraction and transport of sub-bituminous and bituminous coal in the United States as a proxy for foreign extraction in Germany and China. Likewise, NETL modeled foreign coal production as having emissions characteristics equivalent to average U.S. coal production. No ocean transport of coal was included to represent the most conservative coal profile (whether regionally sourced or imported).[59]

The heating value of coal is the amount of energy released when coal is combusted, whereas the heat rate is the rate at which coal is converted to electricity by a power plant. Both factors were used in the model to determine the feed rate of coal to the destination power plant (or the speed at which the coal would be used). For consistency, the LCA GHG Update used the same range of efficiencies that NETL used in the 2014 LCA GHG Report for the modeling of coal power in the United States. The Update also assumed the same range of power plant efficiencies for Europe and Asia as the U.S. model, which are representative of fleet baseload power plants.[60]

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[57] *See* LCA GHG Update at 19 (Exh. 5-13). In Exhibit 5-13, the two citations to the NETL, 2019 reference should cite the NETL, 2014a reference, as shown in the third row of that column. Although these two NETL references were incorrectly cited, the numbers used in the LCA GHG Update were correct.
[58] *See id*.
[59] *See id*. at 6.
[60] *See id*. at 6-7.

H. Key Modeling Parameters

NETL modeled variability among each scenario by adjusting numerous parameters, giving rise to hundreds of variables. Key modeling parameters described in the LCA GHG Update include, but are not limited to: (1) lifetime well production rates, (2) emission factors for non-routine (or episodic) emissions,[61] (3) the flaring rate for natural gas,[62] (4) coal type (sub-bituminous or bituminous), (5) transport distance (ocean tanker for LNG transport, and rail for coal transport), and (6) the efficiency of the destination power plant.[63] To account for uncertainty, NETL developed distributions of low, expected, and high values when the data allowed. Otherwise, NETL gave an expected value for each parameter.[64]

NETL noted that the results of the LCA GHG Update are sensitive to these key modeling parameters—particularly changes in coal type, coal transport distance, and power plant net efficiency (*i.e.*, performance).[65] NETL also identified several study limitations attributable to challenges with LNG market dynamics and data availability in foreign countries, including that: (1) NETL had to model foreign natural gas and coal production based on U.S. models; (2) NETL had to model foreign power plant efficiencies based on data from U.S. power plants; and (3) the specific LNG export and import locations used in the Update represent an estimate for an entire region (*e.g.*, New Orleans representing the U.S. Gulf Coast).[66]

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[61] The key modeling parameters for the natural gas scenarios are provided in the LCA GHG Update at Exhibits 5-1 through Exhibit 5-6 (LNG and Russian natural gas). *See* LCA GHG Update at 8-14.
[62] Flaring rate is a modeling parameter because the GWP of vented natural gas can be reduced if it is flared, or burned, to create carbon dioxide. *See id*. at 8.
[63] *See generally id*. at 8-19 (key modeling parameters).
[64] *Id.* at 9.
[65] *See id*. at 18-19.
[66] *See id*. at 32 (summary and study limitations).

I. Results of the LCA GHG Update

As with the 2014 LCA GHG Report, two primary conclusions may be drawn from the LCA GHG Update.[67] First, use of U.S. LNG exports to produce electricity in European and Asian markets will *not* increase GHG emissions on a life cycle perspective, when compared to regional coal extraction and consumption for power production.[68] As shown below in Figures 1 and 2, the Update indicates that, for most scenarios in both the European and Asian regions, the generation of power from imported natural gas has lower life cycle GHG emissions than power generation from regional coal.[69] The use of imported coal in these countries would only increase coal's GHG profile. Given the uncertainty in the underlying model data, however, it is not clear if there are significant differences between the corresponding European and Asian cases other than the LNG transport distance from the United States and the pipeline distance from Russia.[70]

[67] For detailed study results, *see* LCA GHG Update at 20-31.
[68] *See id*. at 32.
[69] Although these figures present an expected value for each of the four scenarios, the figures should not be interpreted as the most likely values due to the wide range of scenario variability and data uncertainty. Rather, the values allow an evaluation of trends only—specifically, how each of the major processes (*e.g.*, extraction, transport, combustion) contribute to the total life cycle GHG emissions. *See id*. at 20.
[70] *See id*. at 22.

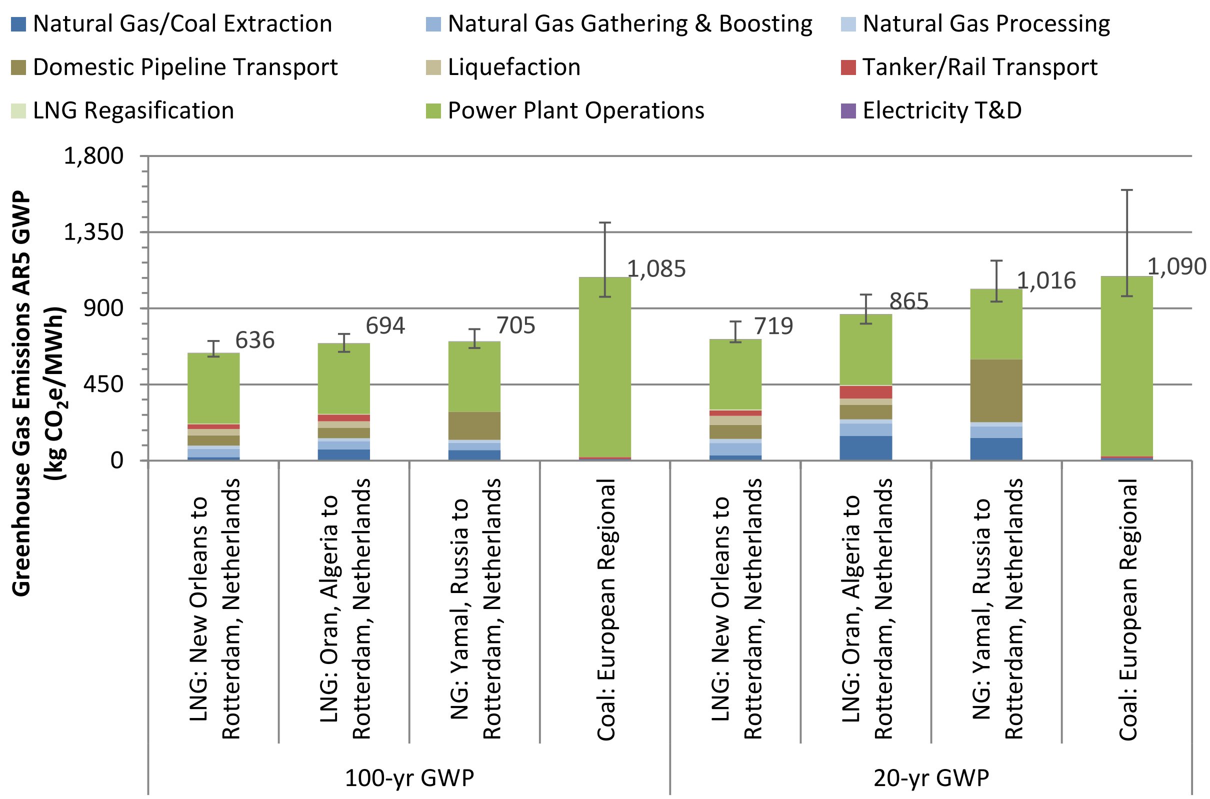

Figure 1: Life Cycle GHG Emissions for Natural Gas and Coal Power in Europe[71]

[71] *See id*. at 20 (Exh. 6-1).

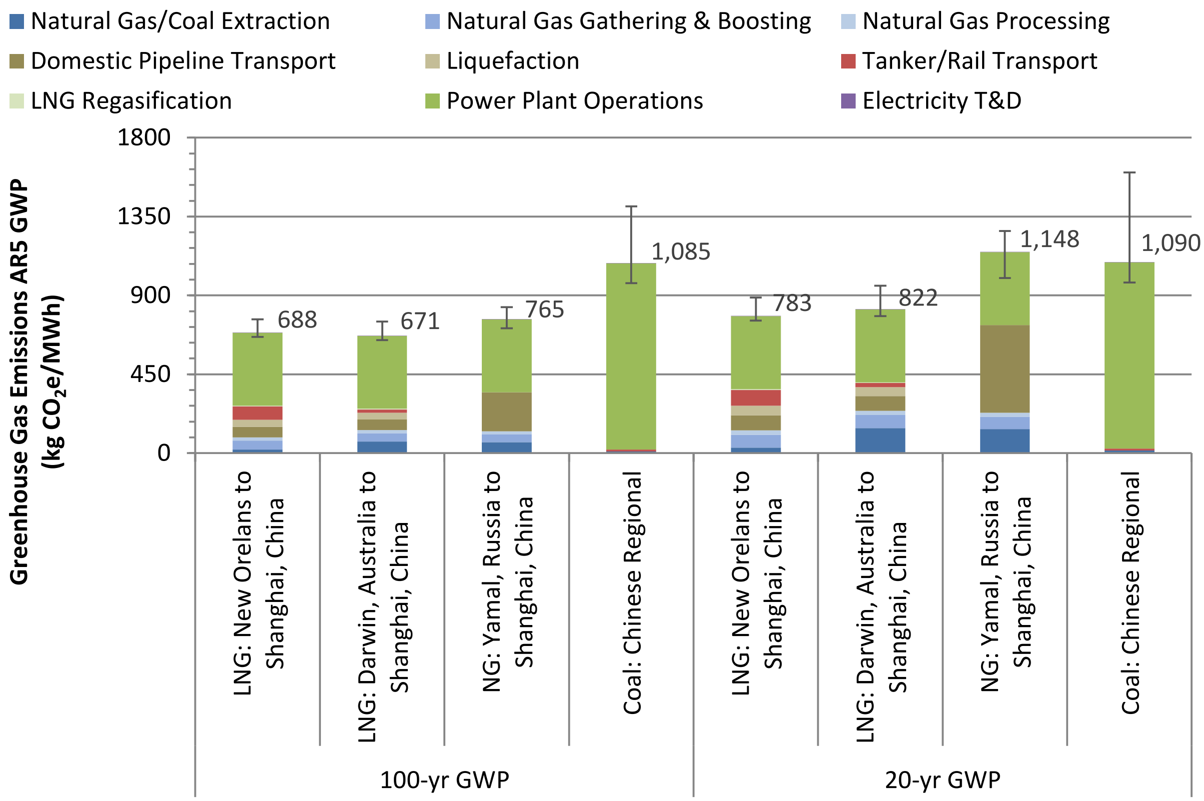

Figure 2: Life Cycle GHG Emissions for Natural Gas and Coal Power in Asia[72]

Second, on a 100-year GWP timeframe, there is an overlap between the ranges in the life cycle GHG emissions of U.S. LNG, regional alternative sources of LNG, and natural gas from Russia delivered to the European or Asian markets. Any differences are considered indeterminate due to the underlying uncertainty in the modeling data. Therefore, on a 100-year GWP timeframe, the life cycle GHG emissions among these sources of natural gas are considered similar, and no significant increase or decrease in net climate impact is anticipated from any of these three scenarios.[73]

When using a 20-year GWP timeframe, the Russian scenario (which transports natural gas via pipeline) has higher life cycle GHG emissions than the LNG scenarios, with no overlapping of error bars. Further, on a 20-year GWP time frame, the error bars for the Russian scenario overlap those for the regional coal scenarios for both Europe and Asia.

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[72] *See id*. at 21 (Exh. 6-2).
[73] LCA GHG Update at 21, 32.

For additional information, please see the LCA GHG Update available on DOE's website at: *https://www.energy.gov/sites/prod/files/2019/09/f66/2019%20NETL%20LCA-GHG%20Report.pdf*.

III. Notice of Availability of the LCA GHG Update

On September 19, 2019, DOE published notice of availability (NOA) of the LCA GHG Update and a request for comments.[74] The purpose of the NOA was "to provide additional information to the public and to inform DOE's decisions regarding the life cycle greenhouse gas emissions of U.S. [LNG] exports for use in electric power generation."[75] DOE stated that "any person may file comments addressing the LCA GHG Update."[76]

Publication of the NOA began a 30-day public comment period that ended on October 21, 2018. DOE received seven comments in response to the NOA. Three commenters supported the LCA GHG Update: (1) LNG Allies, the U.S. LNG Association (LNG Allies), (2) the American Petroleum Institute (API), and (3) the Center for Liquefied Natural Gas (CLNG). Three commenters opposed the LCA GHG Update, or otherwise criticized aspects of the Update: (1) John Young, (2) the Industrial Energy Consumers of America (IECA), and (3) Sierra Club. The final comment, submitted by Croitiene ganMoryn, was non-responsive. Ms. ganMoryn did not address the LCA GHG Update but rather stated her opposition to exports of LNG generally.

The NOA and comments received on the NOA are available on DOE's website at: *https://fossil.energy.gov/app/docketindex/docket/index/21*.

IV. Comments on the LCA GHG Update and DOE Responses

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[74] *See* U.S. Dep't of Energy, Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas From the United States; Notice of Availability of Report Entitled Life Cycle Greenhouse Gas Perspective on Exporting Liquefied Natural Gas From the United States: 2019 Update and Request for Comments, 84 FR 49278 (Sept. 19, 2019).
[75] *Id*. at 84 FR 49279.
[76] *Id*. at 84 FR 49280 (also stating that persons with an interest in individual docket proceedings already have been given an opportunity to intervene in or protest those matters).

DOE has evaluated the comments received during the public comment period. In this section, DOE discusses the relevant comments received on the LCA GHG Update and provides DOE's responses to those comments. DOE does not address comments outside the scope of the LCA GHG Update, such as concerns related to hydraulic fracturing (or "fracking") and the geopolitical aspects of exporting U.S. LNG.[77]

A. Scope of the LCA GHG Update

1. Comments

Commenters supporting the LCA GHG Update express support for NETL's study design. For example, LNG Allies supports NETL's transparency in presenting the LCA approach, the modeling scenarios used, and other aspects of the Update.[78] LNG Allies further states that the assumptions used in the LCA GHG Update track other peer-reviewed studies published between 2015 and 2019—which, LNG Allies asserts, found that exports of U.S. LNG yield "substantial net positive global GHG benefits."[79] CLNG states that NETL's updates to the 2014 LCA GHG Report reflect the latest science and understanding of new technology, including a comprehensive upstream LCA model and updated shipping and regasification modules.[80] Similarly, API expresses support for DOE's decision to provide updates to the assumptions and methodologies used in the 2014 Report, and notes that the overall conclusions in the Update remain the same.[81]

Sierra Club observes that "comparing the lifecycle emissions of US LNG with other fossil fuels can provide a useful perspective on the climate impacts of potential LNG exports."[82] Sierra Club, however, also criticizes the scope of the LCA GHG Update for this same comparison.

[77] *See* Comments of John Young at 1-2.
[78] Comments of LNG Allies at 1.
[79] *Id*. at 1-2.
[80] Comments of CLNG at 2-3.
[81] Comments of API at 1-2.
[82] Comments of Sierra Club at 5.

In Sierra Club's view, comparing the lifecycle emissions of electricity generated in foreign markets using various fossil fuels "does not answer the question of how *DOE's* decision to approve *additional* US LNG exports, generally for 20-year licenses, will affect global greenhouse gas emissions throughout the approved project lifetimes."[83] Sierra Club argues that the LCA GHG Update fails to account for two factors: (1) that U.S. LNG exports allegedly will, to some extent, displace renewables or increase overall energy consumption, rather than only displacing other fossil fuels, and (2) that increasing LNG exports will cause "domestic gas-to-coal switching," and thus result in an increase in coal use.[84] We address the domestic gas-to-coal switching argument in section IV.C.

As to the first point, Sierra Club asserts that the LCA GHG Update ignores the effect that exports of U.S. LNG will have on renewable sources of energy and overall energy consumption.[85] Sierra Club maintains that increasing international trade in LNG to increase global availability of natural gas will cause natural gas to displace use of wind, solar, or other renewables that would otherwise occur. Further, according to Sierra Club, "recent peer reviewed research concludes that US LNG exports are likely to play only a limited role in displacing foreign use of coal … such that US LNG exports are likely to increase net global GHG emissions."[86]
Mr. Young similarly questions whether exports of U.S. LNG will delay or reduce the transition to renewable sources of energy, and whether LNG will replace or be added to coal generated power.[87]

[83] *Id*. at 1 (emphasis in original).
[84] *Id*.
[85] *Id.* at 3 (and section heading).
[86] *Id*. at 4 (citing Gilbert, A.Q. & Sovacool, B.K., *U.S. liquefied natural gas (LNG) exports: Boom or bust for the global climate?* Energy (Dec. 15, 2017) [hereinafter Gilbert & Sovacool]).
[87] Comments of John Young at 1.

2. DOE Response

The 2019 LCA GHG Update was a timely update to the 2014 LCA GHG Report and maintained the same analytical structure. As with the 2014 Report, the boundaries of the 2019 Update were developed with respect to questions about two fossil fuels—natural gas and coal—and where they come from. Although Sierra Club criticizes the Update for "not looking at the whole picture,"[88] the purpose of the LCA was to understand the life cycle GHG emissions from natural gas-fired power and how it varies with changes to natural gas sources, destinations, and transport distances. The LCA included coal-fired power as a comparative scenario because coal is currently the most likely alternative to natural gas-fired power for baseload power generation.

Additionally, the LCA is an attributional analysis, meaning that the natural gas and coal scenarios are considered independent supply chains. Therefore, the LCA does not account for supply or demand shifts caused by the use of one fuel instead of another fuel (or types of fuels).

For these reasons, the LCA GHG Update (like the 2014 Report) does not provide information on whether authorizing exports of U.S. LNG to non-FTA nations will increase or decrease GHG emissions on a global scale. Recognizing there is a global market for LNG, exports of U.S. LNG will affect the global price of LNG which, in turn, will affect energy systems in numerous countries. DOE further acknowledges that regional coal and imported natural gas are not the only fuels with which U.S.-exported LNG will compete. U.S. LNG exports may also compete with renewable energy, nuclear energy, petroleum-based liquid fuels, coal imported from outside East Asia or Western Europe, indigenous natural gas, synthetic natural gas derived from coal, and other resources. However, to model the effect that U.S. LNG exports would have on net global GHG emissions would require projections of how each of these fuel sources would be affected in each LNG-importing nation. Such an analysis would not only have to consider market dynamics in each

[88] Comments of Sierra Club at 3.

of these countries over the coming decades, but also the interventions of numerous foreign governments in those markets. Moreover, the uncertainty associated with estimating each of these factors would likely render such an analysis too speculative to inform the public interest determination in DOE's non-FTA proceedings.

Although Sierra Club expresses concern with the scope of the LCA GHG Update, the D.C. Circuit held in 2017 that there was, in fact, "nothing arbitrary about the Department's decision" to compare emissions from exported U.S. LNG to emissions of coal or other sources of natural gas, rather than renewables or other possible fuel sources.[89] The Court's decision in *Sierra Club I* guided our development of this Update.[90]

Nonetheless, Sierra Club asserts that DOE could now conduct a more careful and informative analysis than it did in the 2014 Report.[91] Sierra Club does not cite any study that provides the sort of analysis it urges DOE to undertake. Rather, Sierra Club cites projections from the U.S. Energy Information Administration (EIA) that "global energy consumption will steadily increase in the coming decades, and that this increase will be satisfied by growth in renewables and [natural] gas,"[92] as well as projections by the International Energy Agency (IEA) that exports of LNG are likely to supply increased demand rather than displace existing generation.[93] Sierra Club also points to a study by Gilbert and Sovacool which, according to Sierra Club, concludes that U.S. LNG is "likely to play only a limited role in displacing foreign use of coal."[94]

As explained previously, NETL's LCA GHG Update uses the most current data and methodology to assess GHG emissions. The materials cited by Sierra Club do not provide any new

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[89] *Sierra Club I*, 867 F.3d at 202 (finding that "Sierra Club's complaint 'falls under the category of flyspecking'") (citation omitted).
[90] *See supra* at § I.D.
[91] Comments of Sierra Club at 4.
[92] *Id*. (citing U.S. Energy Info. Admin., *International Energy Outlook 2019*, at 31).
[93] *Id*. at 3-4.
[94] *Id*. at 4 (citing Gilbert & Sovacool, *supra*).

analysis to evaluate how exports of U.S. LNG may affect global GHG emissions. The market projections by EIA and IEA cited by Sierra Club simply provide a case of continued exports of U.S. LNG to support global energy demands. Conclusions by other analysts (such as the Gilbert and Sovacool study) provide a different analysis, but they do not provide new data or tools beyond what NETL already has integrated into the Update.

The reality is that, although it may be straightforward to model simplified cause-and-effect relationships between energy options (such as the direct displacement of coal with natural gas), the modeling of complex market interactions in different countries introduces significant uncertainty, while at the same time expanding study boundaries and hindering accurate comparisons.[95] For these reasons, DOE finds that Sierra Club has not provided new evidence to justify changes to the scope of the LCA GHG Update.

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[95] For example, in one recent study (cited with approval by LNG Allies), Kasumu *et al.* mention the interaction among fuel options for electricity generation (*e.g.*, LNG vs. renewables), but this study likewise did not model a complex cause-and-effect relationship between LNG and other fuels. *See* Kasumu, A. S., Li, V., Coleman, J. W., Liendo, J., & Jordaan, S. M. (2018). Country-level life cycle assessment of greenhouse gas emissions from liquefied natural gas trade for electricity generation. *Environmental Science & Technology*, 52(4), 1735-1746.

B. Roles of Natural Gas and Renewable Energy

1. Comments

In challenging the scope of the LCA, Sierra Club states that the "primary question" facing international markets that may import U.S. LNG is "whether to meet increasing energy needs through [natural] gas or renewables."[96]

CLNG states, however, that natural gas is an "ideal partner" to renewable energy resources in global energy markets.[97] According to CLNG, when countries increase their use of natural gas for power generation, they both reduce their GHG emissions by switching to natural gas *and* have the opportunity to increase their use of renewable energy. CLNG asserts that, for every 1% increase in natural gas-powered electric generation, renewable power generation increases by 0.88%, further reducing emissions.[98] CLNG thus argues that natural gas is helping the transition to a lower-carbon future.[99]

2. DOE Response

Projections by IEA from November 2019 indicate that the question of how to meet the demand for global energy should not be framed as natural gas *or* renewables, as suggested by Sierra Club.[100] IEA's World Energy Model predicts medium to long-term energy trends, using simulations to replicate the inner-workings of energy markets.[101] In that Model, the Sustainable Development Scenario models the behavior of energy markets in reaction to holding the increase in global average temperature below a 2°C increase from pre-industrial levels. The Sustainable Development Scenario projects that global CO_2 emissions will peak around 2020, then steeply

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[96] Comments of Sierra Club at 4.
[97] Comments of CLNG at 4.
[98] *Id*. (citing National Bureau of Economic Research, "Bridging the Gap: Do Fast Reacting Fossil Technologies Facilitate Renewable Energy Diffusion?" (July 2016)).
[99] *Id*.
[100] *See* Comments of Sierra Club at 4.
[101] Internat'l Energy Agency, World Energy Model (Nov. 2019), *available at: https://www.iea.org/weo/weomodel/*.

decline by 2040. Although renewable energy sources will comprise much of this change—as renewables are projected to provide over 65% of global electricity generation by 2040—the use of natural gas remains part of the portfolio through 2040.[102] As a result, DOE concludes that natural gas is one part of an environmentally-preferable global energy portfolio.

C. Domestic Natural Gas-to-Coal Switching

1. Comments

Sierra Club asserts that the LCA GHG Update is flawed because it does not consider that increasing LNG exports will cause natural gas-to-coal switching in the United States.[103] Citing EIA's 2012 and 2014 LNG Export Studies for DOE, Sierra Club argues that some of the additional U.S. LNG to be exported will not be supplied by new production, but instead will be supplied by diverting natural gas from domestic consumers—which allegedly will cause an increase in domestic natural gas prices.[104] According to Sierra Club, these price increases will cause domestic consumers to switch to using coal for power generation. Sierra Club therefore claims that the LCA GHG Update should have evaluated how increasing U.S. LNG exports will lead to an increase in domestic coal use and, in turn, how global GHG emissions will change based on DOE's decision to approve LNG export applications.[105]

2. DOE Response

The purpose of the Update was to conduct a life cycle analysis of GHG emissions in Europe and Asia, not to predict future coal usage by U.S. consumers. This argument is thus beyond the scope of this proceeding.

[102] *See id*. at *https://www.iea.org/weo/weomodel/sds/* and *https://www.iea.org/weo2018/scenarios/*. Table A3 (at page 679) shows the Sustainable Development Scenario World Energy Demand for the years 2030 and 2040. In 2040, natural gas is projected to be 17% of total world electricity demand and meet 24% of total world primary energy demand under the Sustainable Development Scenario.
[103] Comments of Sierra Club at 1.
[104] *Id*. at 5.
[105] *Id*. at 1, 5.

Nonetheless, we note that the current price of natural gas in the United States is historically low, at less than $3.00/MMBtu. There would have to be substantial price increases before domestic consumers would switch from natural gas to coal. In 2018, however, DOE issued the 2018 LNG Export Study, which found that "'[i]ncreasing U.S. LNG exports under any given set of assumptions about U.S. natural gas resources and their production leads to only small increases in U.S. natural gas prices.'"[106] The 2018 LNG Export Study also refuted the concern that LNG exports would negatively impact domestic natural gas production.[107] Further, EIA's Reference Case in the *Annual Energy Outlook 2019* (AEO 2019) shows decreasing levels of coal consumption through 2050, falling from 677 million short tons (MMst) in 2018 to 538 MMst in 2050.[108] Although Sierra Club participated in the 2018 LNG Export Study proceeding, it did not raise concerns about gas-to-coal switching in that proceeding.[109] Sierra Club also does not acknowledge the findings of the 2018 LNG Export Study or EIA's projections in AEO 2019 in its comments on the LCA GHG Update.

We also note that, in prior LNG export proceedings, Sierra Club raised this natural gas-to-coal switching argument under the National Environmental Policy Act (NEPA). In *Sierra Club I,* the D.C. Circuit rejected this argument by Sierra Club. The Court agreed with DOE that "the economic causal chain between its [non-FTA] export authorization and the potential use of coal as a substitute fuel for gas 'is even more attenuated' than its relationship to export-induced gas production."[110]

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[106] *See* U.S. Dep't of Energy, Study on Macroeconomic Outcomes of LNG Exports; Response to Comments Received on Study, 83 FR 67251, 67258 (quoting 2018 LNG Export Study), 67272 (same) (Dec. 28, 2018).
[107] *Id*. at 83 FR 62273.
[108] *See* U.S. Energy Info. Admin., *Annual Energy Outlook 2019* (with projections to 2050) (Jan. 24, 2019), *available at*: *https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf*.
[109] *See* Sierra Club, Comments on the 2018 LNG Export Study (July 27, 2018), *available at: https://fossil.energy.gov/app/DocketIndex/docket/DownloadFile/582*.
[110] *Sierra Club I*, 867 F.3d at 201 (quoting DOE's order on rehearing) (denying Sierra Club's petition with respect to coal usage).

D. Global Warming Potential of Methane

1. Comments

Although CLNG states that it supports the conclusion of the LCA GHG Update, it contends that NETL used an incorrect 100-year Global Warming Potential (GWP) for methane of 36.[111] CLNG argues that this GWP value is out of line with most LCA practitioners and that, if NETL instead used a lower GWP of 28 or 30, the LCA GHG Update would show even greater benefits of U.S. LNG exports.[112]

2. DOE Response

Although the 2014 LCA GHG Report used a 100-year methane GWP of 30, that value is no longer appropriate today. In the LCA GHG Update, NETL used the 100-year methane GWP of 36, as set forth in the IPCC's Fifth Assessment Report (or AR5). The GWP value of 36 captures climate carbon feedbacks not reflected in lower GWP values for methane, and thus represents the current consensus of the international scientific and policy communities. DOE commissioned the LCA GHG Update in part to recognize this updated GWP value.[113]

E. Methane Emission Rate of U.S. Natural Gas Production

1. Comments

Sierra Club challenges the methane emission rate (also called the methane leakage rate) for U.S. natural gas production used in the LCA GHG Update. As explained previously, the methane emission rate measures the amount of methane that is emitted during the production, processing,

[111] Comments of CLNG at 3 n.3.
[112] *Id*.
[113] LCA GHG Update at 3 & n.2; *see also supra* at § II.E. Insofar as CLNG argues that the 100-year methane GWP of 36 skews the results of the LCA GHG Update, we refer CLNG to our prior proceedings, where we explained that a 100-year methane GWP of 36 versus 30 would not have materially affected the conclusions of the 2014 LCA GHG Report. *See, e.g.*, *Sabine Pass Liquefaction, LLC*, DOE/FE Order No. 3792-A, FE Docket No. 15-63-LNG, Opinion and Order Denying Request for Rehearing, at 37-38 (Oct. 20, 2016).

and transportation of natural gas to a U.S. liquefaction facility.[114] Sierra Club points out that, in the Update, NETL used a methane leakage rate of 0.7% of the natural gas delivered. Sierra Club states that this figure underestimates the methane leakage rate of domestic natural gas production, and thus underestimates the lifecycle GHG emissions of U.S. LNG.[115]

First, Sierra Club argues that the 0.7% leakage rate is not consistent with NETL's supporting documentation. Sierra Club points to NETL's April 2019 LCA of Natural Gas Extraction and Power Generation, which found a national average methane emission rate of 1.24%.[116] Sierra Club further states that, even if it is appropriate to use a regional (as opposed to national) value representing natural gas coming from the Appalachian Shale (as NETL did in the Update), NETL's supporting documentation provides a leakage rate of 0.88% for Appalachian Shale production.[117]

Second, Sierra Club maintains that the 0.7% leakage rate is far lower than "top-down" measurements, which it contends provide a more accurate leakage rate. Top-down studies measure methane emissions by measuring—through aerial flyovers—atmospheric measurements where oil and natural gas activity is occurring. Sierra Club criticizes NETL's 0.7% leakage rate because it is taken from "bottom-up" measurement studies, which use measurements of methane emissions taken "on the ground" at natural gas production facilities.[118] We note that this choice is consistent with the 2014 Report, in which NETL also used a methane emission rate derived from bottom-up measurement studies.

Sierra Club argues that methane leakage rates from top-down measurement studies are more common in the published literature, and that bottom-up estimates are "systemically too low."[119]

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[114] *See supra* at § II.B.
[115] Comments of Sierra Club at 6 (citing LCA GHG Update at 27).
[116] *Id*.
[117] *See id*.
[118] *See id*. at 6-8.
[119] *Id*. at 7.

According to Sierra Club, "the likely average leak rate for U.S. natural gas production is 2.3% or more."[120] Therefore, in Sierra Club's opinion, the 0.7% leakage rate used in the Update significantly understates the likely climate impact of U.S. LNG exports.[121]

2. DOE Response

The average methane leakage rate estimated in the LCA GHG Update, at 0.7%, is based on NETL's analyses and relevant scientific literature.

As a starting point, NETL used Appalachian Shale in the Update to represent the upstream emissions from U.S. LNG exports. NETL chose this scenario because Appalachian Shale is a growing share of the U.S. natural gas supply, currently representing approximately 30% of U.S. natural gas production.[122] NETL's April 2019 LCA of Natural Gas Extraction and Power Generation showed a methane emission rate (or leakage rate) of 0.88% from cradle through distribution. This rate, like all GHG emissions in NETL's results, was bounded by wide uncertainty bounds that are driven by the variability in natural gas systems. The upper error bound for Appalachian Shale natural gas, from cradle through transmission, is 1.21%. When the boundaries of this emission rate are modified to represent natural gas production through *transmission* only (*i.e.*, not including distribution to the end consumer), the average methane emission rate is reduced to 0.7%. This boundary modification is necessary because LNG liquefaction terminals pull natural gas directly from the natural gas transmission network to supply exports—meaning the natural gas does not pass through local distribution networks to U.S. consumers (which would increase the leakage rate). Accordingly, NETL's choice of a 0.7% leakage rate is representative of natural gas produced in the Appalachian Shale region for purposes of this export-focused analysis.

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[120] *See id*. at 8.
[121] Comments of Sierra Club at 8.
[122] *See*, *e.g.*, LCA GHG Update at 4, 9-11.

Second, we note that the studies cited by Sierra Club were generally published between 2012 and 2014.[123] Sierra Club cites two more recent studies: a study published by Tong, *et al.* in 2015,[124] and a study published by Alvarez, *et al.* in 2018.[125] DOE addressed Sierra Club's argument based on several of the earlier studies in connection with the 2014 LCA GHG Report, and we incorporate by reference DOE's prior response.[126]

Turning to the Tong study, DOE notes that this study presents a LCA for fuel pathways for vehicles. Although the study includes a 2015-era estimates of methane emissions from the natural gas supply chain, its primary focus is *transportation*. Specifically, for natural gas supply chain emissions, the Tong study estimates a baseline methane leakage rate ranging from 1.0% to 2.2%, then multiplies this baseline rate by 1.5 to account for "superemitters." ("Superemitters" is an expression that has been adopted by natural gas analysts to describe a small number of emission sources that contribute a disproportionately large share of emissions to the total U.S. natural gas emission inventory.) The methodology used in the Tong study, however, is neither as specific nor as current as NETL's 2019 methodology, which characterizes upstream natural gas production using data published by NETL in the April 2019 LCA of Natural Gas Extraction and Power Generation.[127]

Likewise, the Alvarez study—which used a bottom-up approach—evaluates measurements taken between 2012 and 2016. These measurements covered the natural gas supply chain, from

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[123] *See* Comments of Sierra Club at 6-8.
[124] Tong, *et al.*, *Comparison of Life Cycle Greenhouse Gases from Natural Gas Pathways for Medium and Heavy-Duty Vehicles*, 49 Environ. Sci. Technol. 12 (2015), *cited in* Comments of Sierra Club at 6 n.16 & Exh. 11 [hereinafter Tong study].
[125] Alvarez, *et al.*, *Assessment of methane emissions from the U.S. oil and gas supply chain,* 361 Science 186 (July 13, 2018), *cited in* Comments of Sierra Club at 6 n.16 & Exh. 10 [hereinafter Alvarez study].
[126] *See, e.g.*, *Sabine Pass Liquefaction, LLC*, DOE/FE Order No. 3792-A, *supra* note 113, at 31-35 (stating, *inter alia*, that "[t]he top-down studies cited by Sierra Club represent valuable research that advance our understanding of methane emissions, but do not form a robust basis for estimating the leakage rate from U.S. natural gas systems in the aggregate.").
[127] LCA GHG Update at 1, 4-5; *see also supra* at § II.B (discussing the April 2019 LCA).

production through distribution, and included methane emissions from petroleum production. Nonetheless, most of these measurements were collected at the facility level, and do not provide information on component-level emission sources within the fence-lines of facilities. On this basis, the Alvarez study calculated an average methane emission rate (or leakage rate) of 2.3%. This rate is higher than the rate in EPA's Greenhouse Gas Inventory, which shows an average methane emission rate of 1.4% for all U.S. natural gas from production through distribution.[128] The Alvarez study further concluded that traditional inventory methods underestimate total methane emissions because they do not account for emissions from abnormal events, although the study did not provide data on what constitutes an abnormal event. Therefore, although the Alvarez study assembles emissions to a national level, its results do not provide insight on how methane emissions vary geographically or temporally.

Unlike the Tong and Alvarez studies, the LCA GHG Update accounts for methane emissions at the component level (*i.e.*, specific pieces of supply chain equipment) and accounts for geographic and temporal variability. To address the discrepancies between top-down and bottom-up measurement studies, NETL accounted for geographic and component variability in its April 2019 LCA on Natural Gas Extraction and Power Generation—which, in turn, was used as part of the 2019 Update. Specifically, NETL stratified EPA's Greenhouse Gas Reporting Program data into 27 scenarios that represent four extraction technologies and 12 onshore production basins ("techno-basins"). This approach allowed NETL to factor in the regional differences in natural gas production methods and geologic sources across the country, with regional variability in methane

[128] *See* U.S. Envt'l Protection, 2018. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016. EPA 430-R-18-003 (Apr. 12, 2018), *cited in* LCA GHG Update at 33.

emission profiles.[129] The average life cycle methane emissions across NETL's techno-basins range from 0.8% to 3.2% (production through distribution).[130]

NETL's methodology thus acknowledges that there are combinations of natural gas extraction technologies and geographical regions that both exceed the methane emission rate (or leakage rate) calculated in the Alvarez study *and* that have upper error bounds that include the leakage rates from top-down studies. The existence of higher leakage rates does not undermine NETL's use of 0.7% as the methane emission rate because part of NETL's analysis in the Update sought to address the discrepancies between the two types of measurements.

Further, as noted, NETL chose the Appalachian Shale scenario because the Appalachian Shale represents a growing share of U.S. natural gas production and is currently supporting the U.S. LNG export market. The other, higher leakage rates cited by Alvarez are merely indicative of the type of irregular behavior expected in highly variable natural gas systems, which have many contributors with skewed probability distribution functions (*e.g.*, superemitters).[131]

In sum, top-down and bottom-up methods are complementary, and more research and analysis are necessary to reconcile them. NETL has continued to update its LCA of Natural Gas Extraction and Power Generation with the current state of the science, inclusive of *both* top-down and bottom-up measurement data. By characterizing the variability inherent in EPA's Greenhouse Gas Reporting Program data, NETL's bottom-up method provides results that are comparable to top-down studies.[132] For these reasons, DOE concludes that a higher methane leakage rate derived

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[129] *See*, *e.g.*, LCA GHG Update at 1, 4-5, 8-9.
[130] April 2019 LCA of Natural Gas Extraction and Power Generation, at 79 (Exh. 6-4).
[131] *See, e.g.*, Brandt, A. R., Heath, G. A., & Cooley, D. (2016). Methane leaks from natural gas systems follow extreme distributions. *Environmental science & technology*, *50*(22), 12512-12520.
[132] As one example, NETL has accounted for variability between top-down and bottom-up methods by evaluating liquids unloading. NETL produced a multivariable model that simulates liquids unloading at a basin level and generates methane emission rates that are comparable to top-down measurements (Zaimes, *et al.*, 2019). This method is included in NETL's latest work, including in the LCA GHG Update and the April 2019 LCA of Natural Gas Extraction and Power Generation.

through top-down studies is not inherently more accurate than the 0.7% rate calculated by NETL on the basis of its bottom-up method.

F. Other Aspects of NETL's Natural Gas Modeling Approach

1. Comments

Sierra Club and IECA assert that the LCA GHG Update either underestimates certain categories of GHG emissions (including methane) present at other stages of the LNG lifecycle or does not include them at all. Neither commenter explains how or to what extent these alleged deficiencies in NETL's natural gas modeling approach would affect the conclusions of the Update. However, both commenters assert that the Update must account for these emissions.[133]

First, Sierra Club contends that it was improper for NETL to assume that the natural gas power plant in each of the import destinations is located close to the LNG port, so that no additional pipeline transport of natural gas was modeled in the destination country.[134] Citing an article in *Bloomberg Business*, Sierra Club states that, "in China, LNG is being transported from terminal to end users by *truck*, a process that presumably entails significant emissions even greater than transportation by pipeline."[135]

Second, Sierra Club contends that the LCA GHG Update should account for the fact that LNG may not proceed directly from the import facility to regasification due to an emerging LNG resale market.[136] Sierra Club states that resale (or re-export) of U.S. LNG in the destination country may involve additional steps in storing, moving, and shipping LNG, beyond the direct shipping routes assumed by NETL in its national gas modeling approach.[137]

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[133] *See* Comments of Sierra Club at 8-9; Comments of IECA at 1.
[134] Comments of Sierra Club at 8 (discussing LCA GHG Update at 4).
[135] Comments of Sierra Club at 8 & n.26 (citing Dan Murtaugh, *Welcome to Gas Pipelines on Wheels*, Bloomberg Business (Nov. 5, 2018)).
[136] *Id*. at 9.
[137] *Id*.

Next, IECA identifies the following five types of emissions that, it states, should be included in the LCA GHG Update:

(1) GHG emissions from natural gas electricity consumption to compress the natural gas into LNG and to operate the liquefaction facility;

(2) GHG emissions from the LNG liquefaction process inside-the-fence line, including CO_2, methane, and GHG emissions emitted during the refrigeration process;

(3) Methane emissions inside-the-fence line, including those emitted during the loading and unloading of LNG;

(4) Methane emissions from pipelines used to serve the LNG facility, using the EIA/EPA national average methane leakage rates; and

(5) National average EIA/EPA GHG emissions from drilling oil and natural gas wells, plus any related power generation.[138]

Additionally, API states that the Update likely overestimated the emissions associated with the natural gas extraction and processing stage, citing the availability of new, low-leak equipment.[139] CLNG likewise asserts that NETL overestimated the GHG emissions associated with compressor stations and, by extension, pipelines.[140]

2. DOE Response

Addressing Sierra Club's first concern, DOE notes that the LCA GHG Update intentionally did not account for natural gas transmission between regasification facilities and power plants. This was a modeling simplification—the same one used in the 2014 Report—based on an assumption that large-scale natural gas power plants are located close to LNG import terminals.

As a way of testing the effect of this assumption, NETL has approximated the marginal increase in life cycle GHG emissions by adding 100 miles of natural gas pipeline transmission between the regasification facility and power plant. The April 2019 LCA of Natural Gas

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[138] Comments of IECA at 1.
[139] Comments of API at 2.
[140] Comments of CLNG at 3 n.3 (referencing Exhibit 6-3 of the April 2019 LCA of Natural Gas Extraction and Power Generation).

Extraction and Power Generation, at Exhibit 6-1, shows that there are approximately 6 kilograms (kg) of CO_2e emitted from natural gas transmission per megajoule (MJ) of delivered natural gas. These emissions comprise approximately 4.5 grams of CO_2 and 1.5 grams of methane (in 100-year methane GWPs). NETL's life cycle natural gas model uses an average transmission distance of 971 kilometers (km) and a natural gas combustion emission factor of approximately 2.7 kg CO_2/kg natural gas. This information allows the computation of a transmission energy intensity of 0.0017 g NG fuel/MJ-km and a transmission emission intensity factor of 0.0062 g CO_2e/MJ-km. After balancing these intensity factors with upstream natural gas losses and downstream power plant demands, DOE finds that an additional 100 miles of transmission between regasification and power generation increases the life cycle GHG emissions for NETL's New Orleans-to-Rotterdam scenario by only 1.8% (from 636 to 648 kg CO_2e/MWh). The magnitude of this increase would be similar for all LNG scenarios, and such a small increase would not change the conclusions of the LCA GHG Update.

With regard to truck transport, DOE agrees that trucks are another potential option for moving natural gas between import terminals and end users, including power plants. However, because truck transport of LNG is still relatively new and transport by pipeline remains the dominant way to move LNG to end users, NETL did not model LNG tanker truck transport for purposes of this analysis. In a fully developed LNG supply chain, we expect that LNG importers will invest in efficient, cost-effective infrastructure, like pipelines, to transport natural gas to end users. Sierra Club does not provide evidence, other than the *Bloomberg Business* article, to support this point, and we decline to make any changes to the LCA GHG Update on this basis.[141]

[141] Among other observations about Sierra Club's truck argument, we note that imports of U.S. LNG as modeled in the LCA GHG Update would be delivered in large-scale LNG carriers capable of delivering the equivalent of more than three billion cubic feet of natural gas. Those deliveries would serve power plants on a scale requiring continuous supply of natural gas that would make deliveries by truck impracticable. Additionally, Sierra Club claims that LNG

As to Sierra Club's concern regarding emissions potentially associated with the resale or re-export of U.S. LNG in importing countries, this issue is outside the scope of this proceeding. Nonetheless, in December 2018, DOE found that re-exports of U.S. LNG cargoes represent a "very small percentage" of global LNG trade.[142]

DOE next addresses the concerns raised by IECA, API, and CLNG concerning the alleged deficiencies or errors in NETL's natural gas modeling approach. First, IECA contends that the Update overlooks GHG emissions from natural gas electricity consumption to compress the natural gas into LNG and to operate the liquefaction facility. NETL's model, however, has a unit process that accounts for all inputs and outputs from liquefaction, including the portion of natural gas that a liquefaction facility sends to gas-fired turbines to generate power for the liquefaction trains.[143]

Second, IECA claims that the Update does not account for GHG emissions from the LNG liquefaction process inside-the-fence line, including GHG emissions released during the refrigeration process. In fact, NETL's unit process for liquefaction accounts for all GHG emissions from both onsite energy generation at the liquefaction facility and the operation of ancillary equipment at the facility. The unit process also includes fugitive methane emissions as reported by facility operators to EPA.[144]

Third, IECA contends that the Update does not account for methane emissions inside-the-fence line, including those emitted during the loading and unloading of LNG. IECA is correct that the Update does not account for this emission source, but NETL has conducted a screening analysis

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transported from terminals to end users by truck "accounts for 12 percent of China's LNG use." Comments of Sierra Club at 8-9. Sierra Club cites the *Bloomberg Business* article for this statistic. We are unable to evaluate this statistic, however, as it is appears to be taken from a Wood Mackenzie report that is not part of the record. Finally, Sierra Club's argument is based on the assumption that all truck transport of LNG in China involves *imported* LNG. We note, however, that China produces its own natural gas, and also receives natural gas by pipeline from neighboring countries. These supplies of natural gas could be liquefied in China for delivery by truck.

[142] U.S. Dep't of Energy, Eliminating the End Use Reporting Provision in Authorizations for the Export of Liquefied Natural Gas; Policy Statement, 83 FR 65078, 65079 (Dec. 19, 2018) (citation omitted).

[143] LCA GHG Update at App. B (Unit Process Descriptions).

[144] *See id*.

based on the length of a LNG tanker loading arm connector. This screening analysis determined that the scale of these emissions are miniscule in comparison to the fugitive emissions already accounted for in the liquefaction unit process.

Fourth, IECA asserts that the Update does not account for the methane emissions from pipelines used to serve the LNG facility, using the EIA and EPA national average methane leakage rates. NETL's unit process for transmission, however, is representative of a 971 km natural gas pipeline with fugitive emissions of methane, as well as intentional methane releases through routine blowdown and other pipeline maintenance events.[145] The data for these methane emissions are representative of industry reporting to EPA and emission factors used by EPA's Greenhouse Gas Inventory.

Finally, IECA contends that the LCA GHG Update does not account for national average EIA and EPA GHG emissions from drilling oil and natural gas wells, plus any related power generation. On the other hand, API and CLNG state that the Update likely overestimates other categories of GHG emissions in the natural gas supply chain. NETL's LCA, however, is a detailed, engineering-based life cycle model of the U.S. natural gas supply chain. It includes well drilling energy and emissions, as well as all ancillary systems used by the natural gas supply chain. It uses data from EIA, EPA, and other government sources, as well as data from peer-reviewed literature and fundamental engineering concepts to represent the energy and material flow of the entire natural

[145] *See* April 2019 LCA of Natural Gas Extraction and Power Generation, at 21 (Exh. 3-7), 62-64 (Exhs. 4-4 and 4-6).

gas supply chain.[146] DOE also believes that the uncertainty bounds strengthen the LCA by accounting for variability in natural gas systems.[147]

V. Discussion and Conclusions

Since August 2014, DOE's 2014 LCA GHG Report has been an important part of DOE's decision-making in numerous non-FTA orders issued to date. Although Sierra Club challenged DOE's conclusions based on the 2014 LCA GHG Report, the D.C. Circuit ruled in favor of DOE in 2017.[148] In 2018, DOE commissioned NETL to undertake the LCA GHG Update to ensure that the conclusions of the 2014 Report were still valid based on newer information, including the IPCC's updated 100-year GWP for methane.

NETL's detailed analysis, set forth in the LCA GHG Update dated September 12, 2019, is based on the most current available science, methodology, and data from the U.S. natural gas system to assess the GHGs associated with exports of U.S. LNG. The Update demonstrates that the conclusions of the 2014 LCA GHG Report have not changed. Specifically, the Update concludes that the use of U.S. LNG exports for power production in European and Asian markets will not increase GHG emissions from a life cycle perspective, when compared to regional coal extraction and consumption for power production.[149]

The LCA GHG Update estimates the life cycle GHG emissions of U.S. LNG exports to Europe and Asia, compared with certain other fuels used to produce electric power in those importing countries. While acknowledging uncertainty, the LCA GHG Update shows that, to the extent U.S.

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[146] *See, e.g.*, LCA Update at 1-9; April 2019 LCA of Natural Gas Extraction and Power Generation, at 57-58 (Exh. 4-1). With regard to CLNG's concern about emissions from gathering and boosting stations within the natural gas value chain, NETL modeled these emissions based on the current state of science at the time of analysis. Field measurement activities and related research are currently focused on improving the understanding of methane emissions and the representativeness to regional operations. DOE agrees that this is an area of continual scientific research to improve upon previous understandings of the contribution of gathering and boosting operations to the total life cycle analysis.

[147] *See, e.g.*, LCA GHG Update at 9, 32.

[148] *See supra* at § I.D (discussing *Sierra Club I*, 867 F.3d at 202).

[149] LCA GHG Update at 32.

LNG exports are preferred over coal in LNG-importing nations, U.S. LNG exports are likely to reduce global GHG emissions on per unit of energy consumed basis for power production. Further, to the extent U.S. LNG exports are preferred over other forms of imported natural gas, they are likely to have only a small impact on global GHG emissions.[150] The key findings for U.S. LNG exports to Europe and Asia are summarized in Figures 1 and 2.[151]

Sierra Club continues to express its concern that exports of U.S. LNG may have a negative effect on the total amount of energy consumed in foreign nations and on global GHG emissions. The conclusions of the LCA GHG Update, combined with the observation that many LNG-importing nations rely heavily on fossil fuels for electric generation, suggest that exports of U.S. LNG may decrease global GHG emissions, although there is substantial uncertainty on this point, as indicated above.[152] Further, based on the evidence, we see no reason to conclude that U.S. LNG exports will increase global GHG emissions in a material or predictable way. Neither Sierra Club nor the other commenters opposing the LCA GHG Update have provided sufficient evidence to rebut or otherwise undermine these findings.

In sum, DOE finds that the LCA GHG Update is both fundamentally sound and supports the proposition that exports of LNG from the lower-48 states will not be inconsistent with the public

[150] *See id*. at 21, 32.
[151] *See supra* at § II.I.
[152] *See* LCA GHG Update at 32.

interest. As stated, DOE will consider each pending and future non-FTA application as required under the NGA and NEPA, based on the administrative record compiled in each individual proceeding.

Signed in Washington, D.C., on December 19, 2019.

Steven Winberg,
Assistant Secretary,
Office of Fossil Energy.

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