EXPERT REPORT
OF
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Kelsey Cascadia Rose Juliana; Xiuhtezcatl Tonatiuh M.,
through his Guardian Tamara Roske-Martinez; et al.,
Plaintiffs,

v.

The United States of America; Donald Trump,
in his official capacity as President of the United States; et al.,
Defendants.

IN THE UNITED STATES DISTRICT COURT
DISTRICT OF OREGON

(Case No.: 6:15-cv-01517-TC)

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TABLE OF CONTENTS

Table of Contents ii
Table of Acronyms and Abbreviations iii
Introduction 1
Qualifications and Compensation 2
Executive Summary 3
Expert Opinion 4
I. The U.S. is Responsible for Substantial Quantities of CO_2 Emissions 4
II. Territorial-Based GHG Emissions Accounting Underestimates U.S. Responsibility for Global Climate Change 5
III. Federal Government Fossil Fuel Subsidies and Leasing Expand Oil Production and Increase Global CO_2 Emissions 13
Conclusion and Recomendations 20

TABLE OF ACRONYMS AND ABBREVIATIONS

API:	American Petroleum Institute
BLM:	U.S. Bureau of Land Management
BOEM:	U.S. Bureau of Ocean Energy Management
CEQ:	U.S. Council on Environmental Quality
CH_4:	methane
CO_2:	carbon dioxide
DEFRA:	U.K. Department for Environment, Food and Rural Affairs
DOE:	U.S. Department of Energy
DOI:	U.S. Department of Interior
EIA:	Energy Information Administration
EPA:	U.S. Environmental Protection Agency
GAO:	U.S. Government Accountability Office
G20:	Group of Twenty
GHG:	greenhouse gas
ICLEI:	International Council of Local Environmental Initiatives
IDC:	intangible drilling costs
IEA:	International Energy Agency
IPCC:	Intergovernmental Panel on Climate Change
LULUCF:	land use, land use change, and forestry
MRIO:	multi-regional input-output
NDC:	nationally determined contribution
N_2O:	nitrous oxide
OECD:	Organisation for Economic Co-operation and Development
PEIS:	Programmatic Environmental Impact Statement
SEI:	Stockholm Environment Institute
UNFCCC:	United Nations Framework Convention on Climate Change

INTRODUCTION

I, Peter A. Erickson, have been retained by Plaintiffs to provide expert testimony about the historic and current amounts of greenhouse (GHG) emissions in the U.S., the adequacy of the Federal Government's GHG emissions accounting, and the effects of federal fossil fuel subsidies and leasing on carbon dioxide (CO_2) emissions. I have worked in environmental research and consulting for 18 years, with a focus on climate change and GHG emissions for 10 years. I am currently a Senior Scientist with Stockholm Environment Institute – U.S., a 501(c)(3) organization based in Somerville, Massachusetts, where I have been employed since 2008. Stockholm Environment Institute – U.S. is affiliated with the Stockholm Environment Institute (SEI) based in Stockholm, Sweden. My office is in Seattle, Washington.

Generally, I have been asked to render an opinion about the amount of GHG emissions from the U.S. and whether the Federal Government has fully accounted for its responsibility of GHG emissions. Based upon my review of the U.S. GHG accounting, I conclude that the U.S. government, by using only *territorial-based* GHG emissions accounting, underestimates U.S. responsibility for global climate change, ignoring other contributions of the U.S. to global GHG emissions, specifically the emissions associated with imported goods and services and exported fossil fuels. Even using the Federal Government's estimate of emissions, the U.S. is responsible for a large share of global emissions, both historic and current.

I have also been asked to render an opinion as to what kind of accounting methods the U.S. could reasonably undertake that would more fully reflect the amount of GHG emissions for which the U.S. is responsible. To more fully account for its emissions responsibility, it is my opinion that the Federal Government Defendants should also undertake supplemental, *consumption*- and *extraction*-based GHG emissions inventories. By *supplemental*, I mean that territorial accounting should remain the central metric for setting and evaluating progress towards U.S. climate goals, but that these other methods, which I discuss within this report, should also be used to provide a more complete picture. These methods are reasonably available and have been used by other governments to account for their GHG emissions.

Finally, I have been asked to render an opinion about how federal fossil fuel subsidies and leases have affected the country's production of fossil fuels. I conclude that these subsidies and leases lead the U.S. to produce more fossil fuels than it otherwise would have, and that this leads to increased CO_2 emissions.

QUALIFICATIONS AND COMPENSATION

During the last ten years, my professional focus has been on GHG emissions accounting and the role of policy mechanisms in reducing GHG emissions. Specifically, I have conducted and led research projects on these topics on behalf of numerous partners and clients, including international institutions (e.g., the United Nations Framework Convention on Climate Change, the World Bank), the U.S. government (U.S. Environmental Protection Agency), state governments (e.g., State of Washington, State of Oregon), and local governments (e.g., City of Seattle, King County). These and other projects are documented in my curriculum vitae (C.V.), attached hereto as **Exhibit A**.

Especially relevant for this report is my work on GHG emissions accounting and fossil fuel subsidies. I have led projects to conduct GHG inventories for state government (the State of Oregon, a consumption-based GHG inventory) and local governments (e.g., City of Seattle and King County, Washington), as well as contributed to reviews of project-scale GHG emissions accounting for the United Nations Framework Convention on Climate Change. I have also served on national and international committees devoted to GHG emissions accounting: one convened by the International Council of Local Environmental Initiatives (ICLEI) to create a U.S. Community-scale GHG Emissions Accounting and Reporting Standard, as well as one convened by the Greenhouse Gas Protocol to create the Greenhouse Gas Mitigation Goals Standard. In 2016 and 2017, I led a major research effort to evaluate the effects of U.S. federal and state subsidies on oil production and CO_2 emissions.

I have published research in numerous working papers and reports, as well as peer-reviewed articles in *Carbon Management*, *Climate Policy*, *Climatic Change*, *Energy Policy*, *Environmental Research Letters*, *Environmental Science and Technology*, *Greenhouse Gas Measurement and Management*, *Nature Climate Change*, and *Nature Energy*. A list of publications I authored or co-authored within the last ten years is shown in **Exhibit B**. I have reviewed numerous documents in order to prepare this report. My report contains citations to all documents that I have used or considered in forming my opinions, which are also listed in **Exhibit C**. My hourly rate is $147/hour for the time spent on this report, as well as for time spent in depositions and providing trial testimony, all of which I am deferring until the case is concluded and if fees are awarded by the court.

The opinions expressed in this report are my own and are based on the data and facts available to me at the time of writing, as well as based upon my own professional experience and expertise. All opinions expressed herein are accurate to a reasonable degree of scientific certainty, unless otherwise specifically stated. Should additional relevant or pertinent information become available, I reserve the right to supplement the discussion and findings in this expert report in this action.

EXECUTIVE SUMMARY

This report describes the amount of historic and current greenhouse gas (GHG) emissions emitted from the U.S., how the U.S. Federal Government has accounted for national GHG emissions, and how that accounting could be improved and made more comprehensive. The report also describes how the Federal Government supports production of fossil fuels through subsidies and by leasing public lands and waters for fossil fuel production, and how these practices increase global GHG emissions.

First, on GHG emissions accounting, the U.S. Federal Government has estimated its GHG emissions using a *territorial* accounting approach that counts the carbon dioxide (CO_2) and other GHGs emitted from within U.S. national borders. Using this approach, the U.S. is responsible for a substantial amount of global GHG emissions.

Second, this territorial-based approach, exemplified by the U.S. Environmental Protection Agency's (EPA's) annual GHG inventory, provides an important indicator of U.S. responsibility for global climate change, but it alone is not sufficient. The U.S. also contributes to global GHG emissions through its participation in international trade. Namely, by importing goods and services from other countries, the U.S. bears some responsibility for GHG emissions released in the countries that produce those items. Further, because the U.S. exports fossil fuels, the dominant anthropogenic source of global CO_2 emissions, the country also bears some responsibility for emissions from burning those fuels internationally. The Federal Government does not conduct an inventory of GHGs associated with imports of goods and services, or exports of fossil fuels. However, methods are readily available to do so, using approaches called *consumption-based* and *extraction-based* GHG emissions accounting. To more fully reflect its contribution to global climate change, it is my opinion that the Federal Government should also regularly conduct both a consumption-based and an extraction-based GHG emissions inventory.

Third, the Federal Government Defendants "admit that they permit, authorize, and subsidize fossil fuel extraction, development, consumption, and exportation."[1] Research indicates that this support increases profits to fossil fuel producers and also leads to greater fossil fuel production and, therefore, CO_2 emissions. Curtailing leasing and phasing out fossil fuel subsidies—especially for coal and oil—would help reduce U.S. and global CO_2 emissions. In contrast, expanding support for coal, oil, and gas – in line with President Trump's plan for "Energy Dominance"[2] – would increase domestic and global CO_2 emissions.

[1] Federal Defendant's Answer to First Amended Complaint for Declaratory and Injunctive Relief, in *Juliana et al. v. United States et al.*, Case No. 6:15-cv-01517-TC, Doc. No. 98 (Jan. 13, 2017), ¶ 7.
[2] The White House, "President Donald J. Trump Unleashes America's Energy Potential," June 27, 2017, https://www.whitehouse.gov/the-press-office/2017/06/27/president-donald-j-trump-unleashes-americas-energy-potential.

EXPERT OPINION

I. The U.S. is Responsible for Substantial Quantities of CO_2 Emissions

Federal Defendants admit that from 1850-2012 "the United States is responsible for more than a quarter of global historic cumulative CO_2 emissions."[3]

As displayed in **Figure 1**, the U.S. was the largest annual CO_2 emitter from 1850 until the mid-2000s, when it was surpassed by China. The U.S. remains the world's second largest emitter, and has been responsible for about 15% of global CO_2 emissions since 2010.

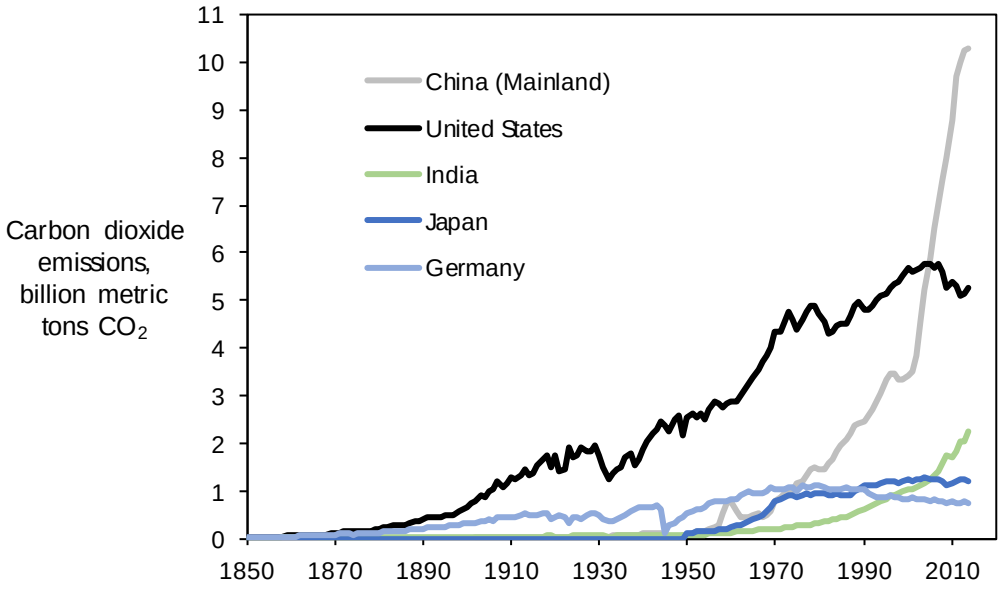

Figure 1. Annual CO_2 emissions from fossil fuel burning, cement manufacture, and gas flaring, 1850-2014, for the top five cumulative emitters over the period. Source: Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory (ORNL) (Boden et al 2017).[4]

[3] First Amended Complaint for Declaratory and Injunctive Relief, in *Juliana et al. v. United States et al.*, Case No. 6:15-cv-01517-TC, Doc. No. 7 (Sept. 10, 2015), ¶ 7; Federal Defendant's Answer to First Amended Complaint for Declaratory and Injunctive Relief, ¶ 7.

[4] T. Boden, R. Andres, and G. Marland, "Global, Regional, and National Fossil-Fuel CO2 Emissions (1751 - 2014) (V. 2017)" (Carbon Dioxide Information Analysis Center (CDIAC), Oak Ridge National Laboratory (ORNL), Oak Ridge, TN (United States), 2017), https://doi.org/10.3334/CDIAC/00001_V2017.

II. Territorial-Based GHG Emissions Accounting Underestimates U.S. Responsibility for Global Climate Change

For several decades, countries have used a standard method of accounting for GHG emissions to identify their responsibility for GHG emissions and track their own progress towards emission-reduction goals. This standard approach, sometimes referred to as territorial- or production-based GHG emissions accounting, has been developed and documented by the Intergovernmental Panel on Climate Change (IPCC).[5] Under this approach, countries that are Parties to the United Nations Framework Convention on Climate Change (UNFCCC) estimate the emissions of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and other trace GHGs (all on a CO_2-equivalent basis) released from within country borders in a given year, using standard formulas and calculations provided by the IPCC's guidance documents.[6] This standardized approach allows for comparison among countries using a consistent method, and is the approach portrayed in **Figure 1**, above.

Using this approach, the U.S. EPA has compiled and issued an annual inventory of territorial, in-boundary GHG emissions for the U.S.[7] This annual report includes estimates of GHGs emitted each year since 1990, as well as "sinks" that represent CO_2 sequestered, or removed, from the atmosphere, through tree growth and other biological processes. Following IPCC guidance, the EPA reports emissions of GHGs in five categories of emissions sources: energy; industrial processes and product use; agriculture; waste; and land use, land use change, and forestry (LULUCF), as shown in **Table 1**. In most cases, GHG emissions for each source are estimated by multiplying activity data (e.g., tons of coal combusted, tons of cement produced, tons of fertilizer applied to cropland, tons of waste disposed in a landfill, acres of land planted in forest) by emission factors associated with each activity (e.g., carbon content of a ton of coal, process CO_2 released by a chemical reaction in making cement, N_2O per ton of fertilizer, CH_4 per ton of landfilled waste, and CO_2 sequestered by an acre of new forest). Given the diverse and widespread sources of anthropogenic GHG emissions, direct measurement (e.g., using scientific measuring equipment), though used to develop the emissions factors, is rarely employed for conducting GHG emissions inventories.

[5] IPCC, *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, ed. HS Eggleston et al. (Hayama, Japan: Institute for Global Environmental Strategies (IGES) on behalf of the Intergovernmental Panel on Climate Change, 2006), http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html.
[6] IPCC; UNFCCC, "Decision 24/CP.19: Revision of the UNFCCC Reporting Guidelines on Annual Inventories for Parties Included in Annex I to the Convention." (Warsaw, Poland: United Nations Framework Convention on Climate Change, 2013), http://unfccc.int/resource/docs/2015/cop21/eng/10a02.pdf#page=25.
[7] U.S. EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015" (Washington, DC: U.S. Environmental Protection Agency, February 14, 2017), https://www.epa.gov/ghgemissions/draft-inventory-us-greenhouse-gas-emissions-and-sinks-1990-2015.

IPCC Sector and Gas	1990	2015
Energy	**5.33**	**5.55**
CO_2	4.91	5.23
CH_4	0.37	0.28
N_2O	0.05	0.04
Industrial processes and product use	**0.34**	**0.38**
CO_2	0.21	0.17
CH_4	<0.01	<0.01
N_2O	0.03	0.02
HFCs, PFCs, SF_6, NF_3	0.10	0.18
Agriculture	**0.50**	**0.52**
CO_2	0.01	0.01
CH_4	0.22	0.24
N_2O	0.27	0.27
Waste	**0.20**	**0.14**
CH_4	0.20	0.13
N_2O	<0.01	0.01
TOTAL OF EMISSIONS ABOVE	**6.36**	**6.59**
Land use, land use change, and forestry (LULUCF)	**(0.82)**	**(0.76)**
CO_2	(0.83)	(0.78)
CH_4	0.01	0.01
N_2O	<0.01	0.01
NET EMISSIONS (SOURCES AND SINKS)	**5.54**	**5.83**

Note: numbers may not add to totals due to rounding

Table 1. U.S. Greenhouse Gas Emissions and Sinks by IPCC Sector and Gas in 1990 and 2015 (Billion metric tons CO_2e). Source: U.S. EPA.

As described in the EPA's inventory, the largest source of CO_2, and of overall GHG emissions, was fossil fuel combustion for energy, accounting for 93% of CO_2 emissions and 77% of all GHG emissions in 2015.

Methane (CH_4) emissions, which made up 10% of 2015 U.S. greenhouse gas emissions, resulted primarily from enteric fermentation (in domestic livestock), natural gas systems, and decomposition of wastes in landfills.

Agricultural soil management, manure management, mobile source fuel combustion, and stationary fuel combustion were the major sources of N_2O emissions, which make up 5% of 2015 U.S. greenhouse gas emissions.

Table 1 shows emissions organized by IPCC category, but the EPA also reports emissions according to commonly used economic sector categories: residential, commercial, industry, transportation, electricity generation, and agriculture. From that perspective – and when electricity-related emissions are reported according to the economic sector that used the

electricity – transportation activities becomes the largest sector, accounting for 34% of U.S. CO_2 emissions from fossil fuel combustion in 2015.

In addition to the EPA, The U.S. Department of Energy (DOE)'s Energy Information Administration (EIA) has also published estimates of annual energy-related CO_2 emissions by economic sector.[8] The DOE provides data for the EPA's more comprehensive inventory, and for this reason the EPA and DOE estimates of energy-related CO2 emissions are very similar.

The EIA also creates projections of future U.S. energy-related CO_2 emissions. As displayed in **Figure 2** below, EIA foresees energy-related CO_2 emissions in its *Reference Case* holding fairly steady at about 5 billion metric tons CO_2 annually for the next few decades.

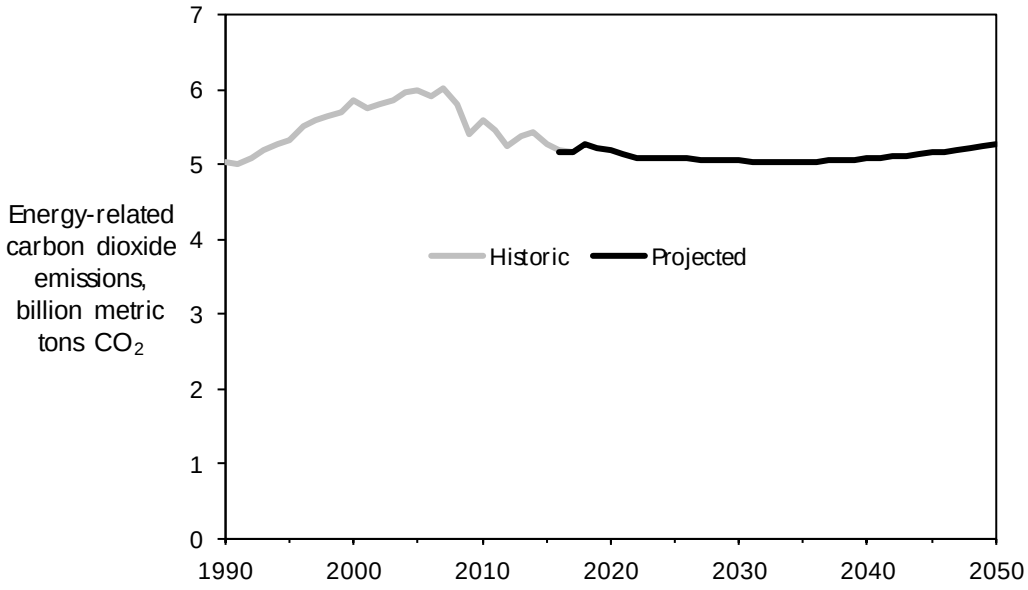

Figure 2. Annual energy-related CO_2 emissions, historic and projected**.**
Source: U.S. DOE Energy Information Administration Monthly Energy Review[9] (historic) and Annual Energy Outlook 2018[10] (projected).

The territorial, or production-based, approach to GHG accounting used by the Federal Government has served the UNFCCC process by providing a consistent standard that can be used to compare the emissions of different countries and assess individual countries' progress in reducing emissions over time. For example, when countries committed in the 2015 Paris Agreement to reduce their GHG emissions through "nationally determined contributions"

[8] U.S. EIA, "U.S. Energy-Related Carbon Dioxide Emissions, 2015" (Washington, DC: U.S. Energy Information Administration, March 2017), https://www.eia.gov/environment/emissions/carbon/pdf/2015_co2analysis.pdf.
[9] U.S. EIA, "Monthly Energy Review, January 2017" (Washington, DC: U.S. Energy Information Administration, January 2017), http://www.eia.gov/totalenergy/data/monthly/archive/00351605.pdf.
[10] U.S. EIA, "Annual Energy Outlook 2018" (Washington, DC: U.S. Energy Information Administration, 2018), http://www.eia.gov/forecasts/aeo/.

(NDCs),[11] they were committing to lowering, over time, their emissions as accounted for in their territorial-based GHG inventories. For example, in its NDC to the Paris Agreement, the U.S. committed "to achieve an economy-wide target of reducing its GHG emissions by 26-28 percent below its 2005 level in 2025," as measured by EPA's annual GHG inventory on a "net" basis (i.e., including emissions and sequestration from land use, land use change, and forestry).[12]

At the same time, territorial GHG accounting has limitations. One limitation is that territorial GHG emissions accounting may not reflect the entirety of a nation's responsibility for climate change. In particular, this accounting method under-estimates the responsibility of nations that are net importers of emissions-intensive goods or services. This is because the emissions released during the production of those imported goods and services are instead counted in the territorial emissions inventory of other countries. For example, emissions released in China to produce appliances and household goods for use by U.S. households are counted in the territorial GHG emissions inventory of China, not that of the U.S., effectively transferring responsibility for the associated emissions from the U.S. to China.

Consumption-based GHG accounting provides an alternative way to count a country's emissions in a manner that ascribes emissions to a country based on its consumption of goods and services.[13] In consumption-based accounting, a country would include emissions released internationally to produce imported goods and services, like the appliance example above. Likewise, the country would also *exclude* emissions released domestically to produce exports. Emissions released within the country for home heating and personal transportation would be included, just as in territorial accounting.

To illustrate this limitation and the conceptual difference between territorial GHG accounting and a consumption-based accounting, **Figure 3** below shows what is included in each type of inventory. (A third type of accounting – extraction-based accounting – will be discussed below.)

[11] UNFCCC, "Decision 1/CP.21: Adoption of the Paris Agreement" (Bonn, Germany: United Nations Framework Convention on Climate Change, December 12, 2015), http://unfccc.int/resource/docs/2015/cop21/eng/10a01.pdf.
[12] Government of the United States, "Intended Nationally Determined Contribution," 2015, http://www4.unfccc.int/ndcregistry/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf.
[13] Glen P. Peters, "From Production-Based to Consumption-Based National Emissions Inventories," *Ecological Economics* 65, no. 1 (2008): 13–23, https://doi.org/10.1016/j.ecolecon.2007.10.014; Steven J. Davis and Ken Caldeira, "Consumption-Based Accounting of CO2 Emissions," *Proceedings of the National Academy of Sciences* 107, no. 12 (March 23, 2010): 5687–92, https://doi.org/10.1073/pnas.0906974107.

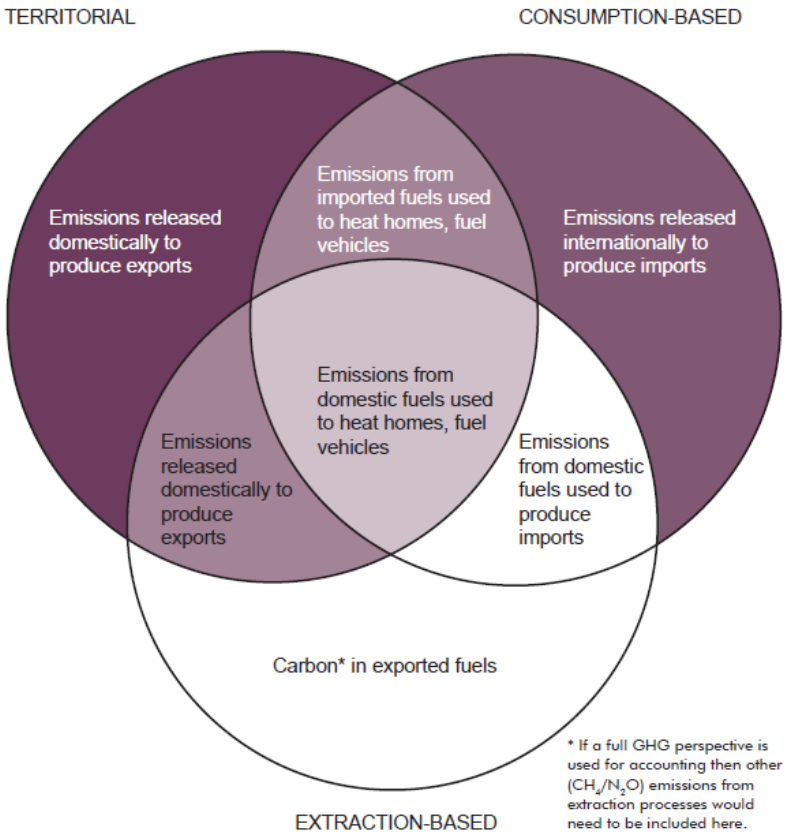

Figure 3: Differences between territorial, consumption-based, and extraction-based GHG emissions inventories. Source: Erickson and Lazarus (2013).[14]

Researchers at the University of Sydney have estimated consumption-based GHG emissions for many of the world's countries over time. They find that consumption-based GHG emissions for the U.S. in recent years have been over 20% higher than territorial-based GHG emissions. (See **Figure 4**, below).[15] U.S. emissions from a consumption-based perspective have been higher than territorial emissions since about the mid-1980s, as growth in U.S consumption of goods has outpaced growth in manufacturing.

[14] Peter Erickson and Michael Lazarus, "Accounting for Greenhouse Gas Emissions Associated with the Supply of Fossil Fuels," SEI Discussion Brief (Seattle, WA: Stockholm Environment Institute, 2013), http://www.sei-international.org/publications?pid=2419.

[15] Manfred Lenzen et al., "Building EORA: A Global Multi-Region Input–output Database at High Country and Sector Resolution," *Economic Systems Research* 25, no. 1 (March 1, 2013): 20–49, https://doi.org/10.1080/09535314.2013.769938.

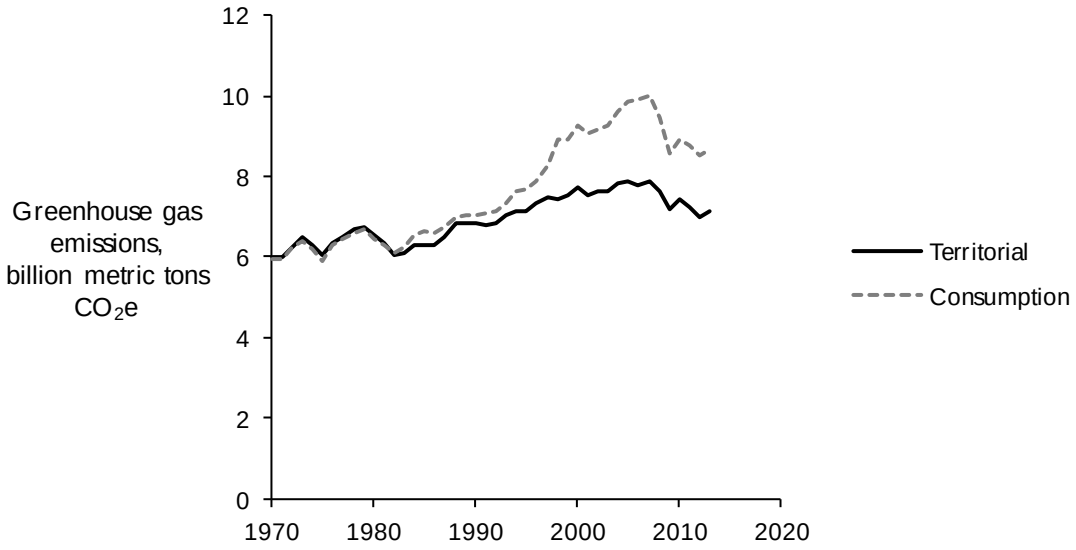

Figure 4: Estimated territorial and consumption-based greenhouse gas emissions for the U.S., 1970-2013, in billion tons of carbon dioxide equivalent**.** Source: Lenzen et al.[16]

Because territorial GHG emissions accounting does not include emissions associated with imported goods and services, it can also give a misleading impression of a nation's progress towards meeting GHG emission goals or commitments. This could occur, for example, if climate change policy were to cause a shift, or "leakage," in emissions-generating activities (such as from steel or cement manufacturing) to another country, giving the appearance that the nation had reduced GHG emissions even as global emissions may remain unchanged.[17] In such a scenario, a territorial GHG inventory would show that the nation had reduced the emissions from cement or steel production, for example, whereas it may have just moved those industries overseas. The shift in industrial activity between the U.S. and other countries – especially in Asia – is partly what accounts for the slowing growth of U.S. territorial-based GHG emissions in the 1990s and 2000s (see **Figure 4**), while consumption-based GHG emissions rose dramatically.

Consumption-based GHG emissions accounting and inventories therefore provide an important complement to traditional, territorial approaches, in that they provide an expanded, more complete, view of domestic responsibility for causing and remedying GHG emissions and, in turn, climate change.

[16] Lenzen et al.
[17] Glen P. Peters and Edgar G. Hertwich, "CO2 Embodied in International Trade with Implications for Global Climate Policy," *Environmental Science & Technology* 42, no. 5 (2008): 1401–7, https://doi.org/10.1021/es072023k; Glen P. Peters et al., "Growth in Emission Transfers via International Trade from 1990 to 2008," *Proceedings of the National Academy of Sciences of the United States of America* 108, no. 21 (April 25, 2011): 8903–8, https://doi.org/10.1073/pnas.1006388108; John Barrett et al., "Consumption-Based GHG Emission Accounting: A UK Case Study," *Climate Policy* 13, no. 4 (July 1, 2013): 451–70, https://doi.org/10.1080/14693062.2013.788858.

Due to advances in the availability of trade and other economic data, consumption-based GHG inventories are not difficult to produce – especially at the national level, even as the concepts and models used to produce them can be complex. The most common approach is to use global trade data, assembled in a multi-regional input-output (MRIO) model, to estimate the flow of materials, goods, and services throughout the world in order to fulfill the consumption of a given country.[12,13]

By using trade data from an MRIO model and the GHG-intensity of products from other countries' (widely available) territorial emissions inventories, it is a relatively straight-forward process to estimate the emissions associated with a country's consumption of goods and services. By *straight-forward*, I mean that the steps to take are relatively clear, and have been thoroughly documented in the research literature. Numerous research efforts around the world have taken such an approach, providing an extensive and robust literature from which a consumption-based inventory could be developed for the U.S.[18] The process, though clear, is time-consuming, as the individual categories of emissions within territorial emissions inventories must be matched to the categories of purchasing and trade data, both within the country of focus (e.g., which sources of *agricultural* GHG emissions in the U.S. are for making food versus for making industrial products?) and for countries that export to it (e.g., which industrial emissions in China are for producing exports to the U.S.?). Nevertheless, there is precedent for governments conducting a consumption-based inventory and accounting to complement the territorial inventory. For example, the governments of the United Kingdom[19] and the U.S. State of Oregon[20] have both done so, using the MRIO approach described here.

In addition to helping account for "leakage" of GHG emissions to other countries via trade, and supplementing the accounting of a nation's responsibility for GHG emissions, consumption-based GHG inventories have other benefits. Chiefly, they can bring to light a wider array of response strategies to help reduce GHG emissions. This is because consumption-based inventories quantify the GHG emissions associated with particular types of goods and services, and in so doing can help clarify (compared to a territorial inventory) how reducing consumption of GHG-intensive items could help reduce overall GHG emissions.

For example, household consumption of food and other goods is associated with substantial GHG emissions from producing these items, but that is not obvious when emissions are organized into economic sectors, such as *transportation*, *industry*, or *agriculture*, in territorial

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[18] Lenzen et al., "Building EORA: A Global Multi-Region Input–output Database at High Country and Sector Resolution"; Stavros Afionis et al., "Consumption-Based Carbon Accounting: Does It Have a Future?," *Wiley Interdisciplinary Reviews: Climate Change* 8, no. 1 (January 1, 2017): n/a-n/a, https://doi.org/10.1002/wcc.438; G. P. Peters, S. J. Davis, and R. Andrew, "A Synthesis of Carbon in International Trade," *Biogeosciences* 9, no. 8 (August 23, 2012): 3247–76, https://doi.org/10.5194/bg-9-3247-2012; Kirsten S. Wiebe and Norihiko Yamano, "Estimating CO2 Emissions Embodied in Final Demand and Trade Using the OECD ICIO 2015," OECD Science, Technology and Industry Working Papers (Paris: Organisation for Economic Co-operation and Development, September 3, 2016), http://www.oecd-ilibrary.org/content/workingpaper/5jlrcm216xkl-en.

[19] DEFRA, "UK's Carbon Footprint 1997 – 2013" (London: UK Department for Environment, Food and Rural Affairs, 2015), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/542558/Consumption_emissions_May16_Final.pdf.

[20] Oregon Department of Environmental Quality, "Oregon 2005-2014 Consumption-Based Greenhouse Gas Emissions" (Portland, OR, March 1, 2016).

GHG emissions inventories.[21] More specifically, where *agriculture* accounts for 8% of U.S. territorial emissions,[22] *food* is responsible for nearly twice as much—about 15%—of U.S. consumption-based emissions.[23] In a consumption-based GHG inventory, emissions attributed to *food* include not only emissions from fertilizer application and livestock raising that are categorized as *agriculture* in a territorial GHG inventory, but also emissions associated with food processing and transportation that are categorized as part of the *industry* and *transportation* sectors in a territorial-based emissions inventory. This type of information—as well as data on the relative GHG-intensity of alternative food choices—can help inform strategies to shift consumption to more deeply low-carbon choices and ultimately inform federal policy.[24]

There is also a third type of GHG emissions accounting (also depicted in **Figure 3**) – *extraction-based* emissions accounting.[25] In this approach, CO_2 emissions from burning fossil fuels are attributed to the country where those fuels are extracted, which may not be the country where the emissions are actually released. Like consumption-based accounting, this approach can help account for changes in GHG emissions responsibility due to international trade.[26] In particular, this approach can help track the emissions associated with fossil fuels exported to other countries. For example, as U.S. coal consumption has declined (and, with it, CO_2 emissions from coal combustion), there has been increasing pressure to export coal to other countries.[27] Extraction-based emissions accounting would estimate emissions associated with burning this exported coal in China, Korea, or other end markets throughout the world.

Extraction-based accounting is perhaps the easiest to implement of the approaches discussed here, because it can be performed simply from countries' fossil fuel production statistics, carbon contents of those fuels (whether standard factors from the IPCC or country-specific factors), and adjusting for the estimated fraction of each fuel that is not combusted but is instead used for non-energy uses such as to make plastics.

In summary, because the Federal Government has only done traditional, territorial GHG emissions accounting, it has not fully accounted for the GHG emissions associated with the U.S.

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[21] Christopher L. Weber and H. Scott Matthews, "Quantifying the Global and Distributional Aspects of American Household Carbon Footprint," *Ecological Economics* 66, no. 2–3 (2008): 379–91; Christopher L. Weber and H. Scott Matthews, "Food-Miles and the Relative Climate Impacts of Food Choices in the United States," *Environmental Science & Technology* 42, no. 10 (2008): 3508–13, https://doi.org/10.1021/es702969f; Christopher M. Jones and Daniel M. Kammen, "Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities," *Environmental Science & Technology* 45, no. 9 (May 1, 2011): 4088–95, https://doi.org/10.1021/es102221h; Peter Erickson et al., "A Consumption-Based GHG Inventory for the U.S. State of Oregon," *Environ. Sci. Technol.* 46, no. 7 (2012): 3679–3686, https://doi.org/10.1021/es203731e.

[22] U.S. EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015."

[23] Jones and Kammen, "Quantifying Carbon Footprint Reduction Opportunities for U.S. Households and Communities."

[24] Weber and Matthews, "Food-Miles and the Relative Climate Impacts of Food Choices in the United States."

[25] Steven J. Davis, Glen P. Peters, and Ken Caldeira, "The Supply Chain of CO2 Emissions," *Proceedings of the National Academy of Sciences* 108, no. 45 (November 8, 2011): 18554–59, https://doi.org/10.1073/pnas.1107409108.

[26] Peters, Davis, and Andrew, "A Synthesis of Carbon in International Trade."

[27] Thomas Michael Power and Donovan S. Power, "The Impact of Powder River Basin Coal Exports on Global Greenhouse Gas Emissions" (Missoula, MT: Prepared for The Energy Foundation, May 2013), http://www.powereconconsulting.com/WP/wp-content/uploads/2013/05/GHG-Impact-PRB-Coal-Export-Power-Consulting-May-2013_Final.pdf.

economy and for which it therefore bears responsibility. In my opinion, in addition to its territorial GHG emissions inventory, the Federal Government should also regularly conduct both a consumption-based GHG inventory and an extraction-based GHG inventory. Both of these other approaches complement traditional, territorial GHG emissions approaches, providing a more complete picture of a region's responsibility for climate change, while also bringing new potential policy solutions to the fore. Methods for conducting them have been widely studied and developed in the research literature, and consumption-based inventories have already been completed by other governmental entities. In my opinion, few if any technical barriers would prevent the Federal Defendants in this case, especially the U.S. EPA or U.S. DOE, from conducting both consumption-based and extraction-based GHG inventories for the U.S.

III. Federal Government Fossil Fuel Subsidies and Leasing Expand Oil Production and Increase Global CO_2 Emissions

For decades, the U.S. government has supported domestic fossil fuel production in at least two ways. One form of support is providing tax incentives and other measures of financial support for investment and production of fossil fuels. The other is by making available public lands (and waters) for the exploration and production of fossil fuels, largely through leases, which the Federal Defendants largely admit to in their Answer to Plaintiffs' First Amended Complaint.[28]

Numerous federal tax provisions support private investment in fossil fuel infrastructure and production. In 2015, in a "self-review" of fossil fuel subsidies submitted to the Group of Twenty (G20), the U.S. Treasury Department listed sixteen such provisions (**Table 2**) that total $4.8 billion annually. Other reviews have identified additional (non-tax) measures, such as public funding for the U.S. Strategic Petroleum Reserve, that represent significant subsidies to fossil fuel production, suggesting the total value of subsidies is higher than reflected in **Table 2**.[29]

[28] Federal Defendant's Answer to First Amended Complaint for Declaratory and Injunctive Relief, ¶¶ 110, 111, 117, 165-168, 170.

[29] Doug N Koplow et al., *Mapping the Characteristics of Producer Subsidies a Review of Pilot Country Studies* (Winnipeg, Man.: International Institute for Sustainable Development, 2010); OECD, *Inventory of Estimated Budgetary Support and Tax Expenditures for Fossil Fuels 2013* (Paris, France: Organisation for Economic Co-operation and Development, 2013), http://www.oecd-ilibrary.org/content/book/9789264187610-en.

	Subsidy	Annual cost (million USD)	Fossil fuel supported
1	Expensing of Intangible Drilling Costs	1,629	Oil, gas
2	Percentage Depletion for Oil and Natural Gas Wells	966	Oil, gas
3	Domestic Manufacturing Deduction for Fossil Fuels	1,049	Oil, gas, coal, lignite, oil shale
4	Two-Year Amortization Period for Geological and Geophysical Expenditures	288	Oil, gas
5	Percentage Depletion for Hard Mineral Fossil Fuels	209	Coal, lignite, oil shale
6	Expensing of Exploration and Development Costs for Hard Mineral Fuels	53	Coal, lignite, oil shale
7	Capital Gains Treatment for Royalties of Coal	31	Coal, lignite
8	Deduction for Tertiary Injectants	10	Oil
9	Exception to Passive Loss Limitation for Working Interests in Oil and Natural Gas Properties	19	Oil, gas
10	Enhanced Oil recovery (EOR) Credit	*	Oil
11	Marginal Wells Credit	*	Oil, gas
12	Corporate Income Tax Exemption for Fossil Fuel Publicly Traded Partnerships	342	Oil, gas, coal
13	Excise Tax Exemption for Crude Oil derived from Tar Sands	52	Tar sands
14	Royalty-Exempt Beneficial Use of Fuels	39	Gas, oil
15	Royalty-Free Flaring and Venting of Natural Gas	70	Gas
16	Liability Cap on Natural Resource Damages	N/A	Oil, gas
	Total	**4,757**	

* Annual cost of this measure is included under the cost for expensing of intangible drilling costs (#1).

Table 2. Fossil Fuel Producer Subsidies Identified in the U.S. Self-Review Submitted to the G20 in 2015. Source: U.S. Government[30]

There is evidence that these tax measures positively affect fossil fuel industry profits and investment, particularly through the expensing of intangible drilling costs (IDC), the percentage depletion allowance (for oil, gas, and coal), the domestic manufacturing deduction for fossil fuels, the two-year amortization period for geological and geophysical expenditures, and the corporate income tax exemption for fossil fuel publicly traded partnerships.[31]

[30] U.S. Government, "United States Self-Review of Fossil Fuel Subsidies" (Submitted December 2015 to the G-20 Peer Reviewers, December 2015), http://www.oecd.org/site/tadffss/publication/.

[31] Joseph Aldy, "Eliminating Fossil Fuel Subsidies," in *15 Ways to Rethink the Federal Budget*, ed. Michael Greenstone et al., The Hamilton Project (Washington, DC: Brookings Institution Press, 2013), http://www.hamiltonproject.org/papers/15_ways_to_rethink_the_federal_budget.

Research on the effect of the largest measures, all of which are tax expenditures, has fallen into two main groups of findings. One group of findings, largely from industry associations, suggests that these tax measures (especially the ability to deduct intangible drilling costs) have a major influence on investment decisions and production levels. For example, Wood Mackenzie, in a report for the American Petroleum Institute (API), found that without subsidies to oil producers, "many projects will no longer meet investment criteria," and thus their elimination would have a "significant impact" on future production.[32] The Wood Mackenzie study tends to rely on detailed, producer-level data to look at the effect on individual investment projects, using proprietary models and tools.

By contrast, university and research institute studies tend to find that most of the major subsidies go directly to producer profits, with relatively little effect on investment or production levels.[33] These studies tend to look at industry-wide effects using peer-reviewed models, but with less resolution for individual producers or investment decisions.

One recent study, for which I was lead author, attempted to bring together the methodological strengths of each group of studies. This new analysis, conducted by myself and other researchers at the Stockholm Environment Institute (SEI)'s U.S. Center, took an investment perspective.[34] Following the industry approach, we looked at how the tax provisions noted above would affect individual project cash flow and, ultimately, investment decisions in new oil fields. We documented our methodology publicly in detail, soliciting peer review in the development of a working paper[35] and, subsequently, a scientific journal article.[36]

At high oil prices ($75/barrel), similar to the average price over the last decade, our analysis largely confirmed prior findings: most subsidy value, including the oil industry's share of the tax expenditures in **Table 1**, would go directly to "extra" producer profits, over and above what would be needed for producers to break even and earn a normal return on their investment. More than 90% of new oil investment and drilling in the U.S. would proceed regardless of subsidies. In other words, less than 10% of new oil resources in the U.S. would be dependent on subsidies to proceed in that scenario.

However, our study found a very different outcome if oil prices were to remain near recent levels of about $50 per barrel. At that price level, we found that 47% of new U.S. oil investment would depend on subsidies to proceed. The expensing of intangible drilling costs (the first subsidy in

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[32] Wood Mackenzie, "Impacts of Delaying IDC Deductibility (2014-2025)" (Washington, DC, July 2013), http://www.api.org/~/media/files/policy/taxes/13-july/api-us-idc-delay-impacts-release-7-11-13.pdf.

[33] Aldy, "Eliminating Fossil Fuel Subsidies"; Maura Allaire and Stephen P.A. Brown, "U.S. Energy Subsidies: Effects on Energy Markets and Carbon Dioxide Emissions" (Washington, DC: Resources for the Future, 2012), http://www.pewtrusts.org/en/research-and-analysis/reports/2012/08/13/us-energy-subsidies-effects-on-energy-markets-and-carbon-dioxide-emissions; Gilbert Metcalf, "The Impact of Removing Tax Preferences for U.S. Oil and Gas Production" (Council on Foreign Relations, August 2016), http://www.cfr.org/energy-policy/impact-removing-tax-preferences-us-oil-gas-production/p38150.

[34] Peter Erickson et al., "Effect of Subsidies to Fossil Fuel Companies on United States Crude Oil Production," *Nature Energy* 2, no. 11 (2017): 891–98, https://doi.org/10.1038/s41560-017-0009-8.

[35] Peter Erickson et al., "Effect of Government Subsidies for Upstream Oil Infrastructure on U.S. Oil Production and Global CO2 Emissions," Working Paper (Seattle, WA: Stockholm Environment Institute (U.S.), January 2017), https://www.sei-international.org/publications?pid=3036.

[36] Erickson et al., "Effect of Subsidies to Fossil Fuel Companies on United States Crude Oil Production."

Table 1) has the largest effect of any measure and would be responsible for over half of the increase in project returns among all the (both federal and non-federal) subsidies assessed. At about $50 per barrel, projects depend much more strongly on the boost from the subsidies to meet minimum investor criteria, i.e., a 10% return on investment. (Historically, prices above $50 per barrel in inflation-adjusted dollars are very rare,[37] indicating that this subsidy-dependence may historically be more the norm than the exception.)

Our findings indicate that, with prices at or near $50 per barrel, the U.S. government is substantially expanding the country's future oil production, relative to if these subsidies were not in place. This has both fiscal and environmental implications. As has long been argued, using taxpayer revenues to support oil industry profits could be a sub-optimal use of resources, since doing so may come at the expense of other national priorities.[38] At the same time, the portion of subsidy value that does push new oil drilling projects to be developed increases U.S oil production and global CO_2 emissions higher than it would be otherwise.

Based on my understanding from conducting this research, it is my professional opinion that, at least for oil, Federal Government subsidies are likely to both increase oil industry profits and increase U.S. oil production. Both of these outcomes make it more difficult for the U.S. to transition to a low-carbon economy and meet domestic and international climate goals, a phenomenon known as "carbon lock-in."[39]

The Federal Government has also supported U.S. fossil fuel production by making federal lands (and waters) available for fossil fuel extraction. As reported by the U.S. Department of Energy, about one-quarter of all fossil fuels extracted in the U.S. come from federal lands (and waters), including two-fifths of all coal.[40] Companies obtain leases for extraction activities on these lands from the U.S. Department of Interior through bids and auctions, and they pay fees, rents and royalties that are shared by the Federal Government.[41]

These leasing systems have been around for decades, and the process the Federal Government uses to issue the leases has remained fairly consistent. Leases are generally made available to the

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[37] James D. Hamilton, "Understanding Crude Oil Prices," *The Energy Journal* 30, no. 2 (April 1, 2009): 179–206, https://doi.org/10.5547/ISSN0195-6574-EJ-Vol30-No2-9.

[38] Aldy, "Eliminating Fossil Fuel Subsidies."

[39] Karen C. Seto et al., "Carbon Lock-In: Types, Causes, and Policy Implications," *Annual Review of Environment and Resources* 41, no. 1 (2016): 425–52, https://doi.org/10.1146/annurev-environ-110615-085934; Peter Erickson, Michael Lazarus, and Kevin Tempest, "Carbon Lock-In from Fossil Fuel Supply Infrastructure," SEI Discussion Brief (Seattle, WA: Stockholm Environment Institute, September 2015), http://www.sei-international.org/publications?pid=2805; Peter Erickson et al., "Assessing Carbon Lock-In," *Environmental Research Letters* 10, no. 8 (2015): 084023, https://doi.org/10.1088/1748-9326/10/8/084023; Gregory C Unruh, "Understanding Carbon Lock-In," *Energy Policy* 28, no. 12 (October 1, 2000): 817–30, https://doi.org/10.1016/S0301-4215(00)00070-7.

[40] U.S. EIA, "Sales of Fossil Fuels Produced from Federal and Indian Lands, FY 2003 through FY 2014" (U.S. Energy Information Administration, July 2015), http://www.eia.gov/analysis/requests/federallands/pdf/eia-federallandsales.pdf.

[41] Adam Vann, "Energy Projects on Federal Lands: Leasing and Authorization" (Washington, DC: Congressional Research Service, February 1, 2012), https://www.fas.org/sgp/crs/misc/R40806.pdf; Adam Vann, "Offshore Oil and Gas Development: Legal Framework" (Washington, DC: Congressional Research Service, September 26, 2014), https://www.fas.org/sgp/crs/misc/R40806.pdf; U.S. GAO, "Oil and Gas Resources: Actions Needed for Interior to Better Ensure a Fair Return" (Washington, DC: U.S. Government Accountability Office, December 2013).

highest bidder, though the government occasionally changes the general parameters regarding areas available for lease, the leasing process, and lease terms.[42] Consideration of CO_2 emissions or, more broadly, climate change, historically has not been a criterion for leasing or a factor in the payments due, e.g., royalties, until recently under the Obama Administration.[43]

Late in the Obama Administration, the Federal Government for the first time began to reconsider the leasing process for fossil fuels and its role in CO_2 emissions and climate change. In his 2016 State of the Union Address, President Obama announced an intention "to change the way we manage our oil and coal resources, so that they better reflect the costs they impose on taxpayers and our planet."[44] Soon after, the Department of Interior (DOI) announced its intention to prepare a Programmatic Environmental Impact Statement (PEIS) of the federal coal program. Among the goals was to consider "adjustments to the scale and pace of leasing," including the possibility of a "declining schedule consistent with the United States' climate goals and commitments."[45] Nearly a year later, the DOI outlined in greater detail its plans to study several policy alternatives for coal leasing, including using a fixed "budget" of CO_2 emissions, accounting for damages caused by CO_2 emissions through an increased royalty rate, and implementing a moratorium on new coal leasing activity.[46] President Obama also withdrew the Arctic (and parts of the Atlantic) oceans from new oil and gas leasing activity, citing the inconsistency of oil and gas production in these areas with "national and global climate and environmental goals."[47] President Trump has since directed the DOI to lift these restrictions.[48] Specifically, as part of President Trump's goal of "Energy Dominance," the Trump Administration announced plans to allow new offshore oil and gas drilling in virtually all (98%) of U.S. coastal waters during 2019-2024.[49] In February 2018, the DOI's offer of 77 million acres for oil and gas exploration and development off the coasts of Texas, Louisiana, Mississippi,

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[42] Vann, "Energy Projects on Federal Lands: Leasing and Authorization"; Vann, "Offshore Oil and Gas Development: Legal Framework."

[43] Alan Krupnick et al., "Putting a Carbon Charge on Federal Coal: Legal and Economic Issues" (Washington, DC: Resources for the Future, March 2015), http://www.rff.org/research/publications/putting-carbon-charge-federal-coal-legal-and-economic-issues.

[44] Barack Obama, "Remarks of President Barack Obama – State of the Union Address As Delivered" (Washington, DC: The White House, January 12, 2016), https://obamawhitehouse.archives.gov/the-press-office/2016/01/12/remarks-president-barack-obama-%E2%80%93-prepared-delivery-state-union-address.

[45] BLM, "Notice of Intent to Prepare a Programmatic Environmental Impact Statement to Review the Federal Coal Program and to Conduct Public Scoping Meetings" (Washington, DC: U.S. Department of the Interior, Bureau of Land Management, March 24, 2016), https://federalregister.gov/a/2016-07138.

[46] BLM, "Federal Coal Program: Programmatic Environmental Impact Statement - Scoping Report" (Washington, D.C.: U.S. Department of the Interior, Bureau of Land Management, January 11, 2017), https://eplanning.blm.gov.

[47] The White House, "United States-Canada Joint Arctic Leaders' Statement," December 20, 2016, https://obamawhitehouse.archives.gov/the-press-office/2016/12/20/united-states-canada-joint-arctic-leaders-statement; DOI, "Fact Sheet: President Obama Protects 125 Million Acres of the Arctic Ocean" (U.S. Department of Interior, December 2016), https://www.doi.gov/sites/doi.gov/files/uploads/2016_arctic_withdrawal_fact_sheet_for_release.pdf.

[48] DOI Secretarial Order 3348 (March 29, 2017) (terminating the moratorium on federal coal leasing as well as development of the PEIS of the federal coal leasing program); Juliet Eilperin and Brady Dennis, "Trump, Reversing Obama, Will Push to Expand Drilling in the Arctic and Atlantic - The Washington Post," *The Washington Post*, April 27, 2017, https://www.washingtonpost.com/politics/trump-reversing-obama-will-push-to-expand-drilling-in-the-arctic-and-atlantic/2017/04/27/757fa06c-2aae-11e7-b605-33413c691853_story.html?utm_term=.1619e7a11f20.

[49] DOI, Bureau of Ocean Energy Management, 2019-2024 National Continental Shelf Oil and Gas Leasing, Draft Proposed Program (Jan. 2018). https://www.regulations.gov/document?D=BOEM-2017-0074-0001.

Alabama, and Florida was the largest oil and gas sale in U.S. history.[50] President Trump has also announced that he is "dramatically reducing restrictions on the development of natural gas."[51]

Relatively few analyses have considered how restricting U.S. fossil fuel production or extraction—whether through federal leasing or other means—would affect incremental CO_2 emissions.[52] Among those that have, there is widespread agreement that the effects would take place via changes to fossil fuel markets.[53] Following the rules of basic microeconomics, if the supply of coal, oil, or gas were constrained, price for that fuel would increase, leading to decreased consumption of that fuel and in turn increased consumption of alternative fuels.[54]

How the changes in fuel prices would translate into change in net CO_2 emissions is more complicated, and depends on one's view of how fuel markets operate. The effects are perhaps clearest for oil. Since the oil market is essentially global, a supply constraint in one area (e.g., were the U.S. to stop issuing leases for offshore oil) will increase price levels and, in turn, decrease consumption levels, around the world.[55] Though economists debate just how much a given change in supply will affect price, and how much an increase in price will affect consumption, generally, the effect of increased price and reduced consumption is widely accepted.[56] This means that limiting oil supply from the U.S. would lead to an increase in global oil prices and decrease in global oil consumption, and in turn lead to a decrease in global CO_2 emissions.

The effect of constraining coal supply, such as if the U.S. were to stop issuing leases for coal production in Wyoming's Powder River Basin, is also fairly straight-forward, at least in the U.S. Domestic power companies are the main market for U.S. coal (whether from federal or other lands), and they are price-sensitive, especially given recent competition from low-cost natural

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[50] DOI, Interior Announces Date for Largest Oil and Gas Lease Sale in U.S. History (Feb. 16, 2018), at https://www.doi.gov/pressreleases/interior-announces-date-largest-oil-and-gas-lease-sale-us-history.
[51] White House, Remarks by President Trump at the Unleashing American Energy Event (June 29, 2017), at https://www.whitehouse.gov/briefings-statements/remarks-president-trump-unleashing-american-energy-event/.
[52] The Trump Administration's direction that the Council on Environmental Quality (CEQ) withdraw its Final Guidance on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in NEPA reviews makes it likely that the Federal Government will continue not to consider the extent to which the federal fossil fuel extraction and production programs cause GHG emissions. 82 Fed. Reg. 16576 (April 5, 2017).
[53] Todd Gerarden, W. Spencer Reeder, and James H. Stock, "Federal Coal Program Reform, the Clean Power Plan, and the Interaction of Upstream and Downstream Climate Policies," Working Paper (National Bureau of Economic Research, April 2016), http://www.nber.org/papers/w22214; Spencer Reeder and James H. Stock, "Federal Coal Leasing Reform Options: Effects on CO2 Emissions and Energy Markets," Executive Summary (Seattle, WA: Vulcan, Inc., February 2016); Jason Bordoff and Trevor Houser, "Navigating the U.S. Oil Export Debate" (New York: Columbia University, Center on Global Energy Policy and Rhodium Group, January 2015), http://rhg.com/reports/navigating-the-us-oil-export-debate; Power and Power, "The Impact of Powder River Basin Coal Exports on Global Greenhouse Gas Emissions"; BOEM, "Economic Analysis Methodology for the 2017-2022 Outer Continental Shelf (OCS) Oil and Gas Leasing Program" (Bureau of Ocean Energy Management, November 2016); E Wolvovsky and W Anderson, "OCS Oil and Natural Gas: Potential Lifecycle Greenhouse Gas Emissions and Social Cost of Carbon" (Sterling, VA: U.S. Department of Interior, Bureau of Ocean Energy Management, November 2016), https://www.boem.gov/OCS-Report-BOEM-2016-065/.
[54] Jeffrey M Perloff, *Microeconomics*, 4th ed. (London, UK: Pearson, 2007).
[55] Peter Erickson and Michael Lazarus, "Impact of the Keystone XL Pipeline on Global Oil Markets and Greenhouse Gas Emissions," *Nature Climate Change* 4, no. 9 (August 10, 2014): 778–81, https://doi.org/10.1038/nclimate2335.
[56] Hamilton, "Understanding Crude Oil Prices."

gas and renewables.[57] As a result, any constraints on coal supply are expected to affect prices and lead to reduced coal consumption for power generation, which would be substituted by both natural gas and renewables, either of which releases less CO_2 per unit of electricity generated than coal.[58]

The effect of constraining gas supply on net CO_2 emissions is ambiguous. Gas can substitute both for higher-carbon coal and lower-carbon renewables, and so the net effect on CO_2 emissions depends on the mix of coal and renewables that it displaces. Studies in both the U.S. and internationally have generally found that, over the next two to three decades, these two effects are expected to roughly balance each other out, meaning increasing or decreasing gas supply would have little net effect on net CO_2 emissions.[59] In later decades, natural gas is more likely to compete with low-carbon energy sources, especially if nations such as the U.S. and China continue to move away from coal, meaning that any avoided natural gas supply would be more likely to be made up with renewables, providing a CO_2 emissions benefit.[60] Therefore, in the longer term, constraints on U.S. natural gas production – such as by limiting federal leasing or subsidies – would be more likely to lead to decreased CO_2 emissions.[61]

Together, these examples of fossil fuel subsidies and federal land leasing practices show how the Federal Government plays a significant role in aiding and facilitating U.S. fossil fuel extraction.

In summary, curtailing leasing and phasing out fossil fuel subsidies—especially for coal and oil—would help reduce U.S. and global CO_2 emissions. Removing support for gas production would offer less CO_2 emissions reductions over the next couple decades, but in the longer term could help aid the transition to a deeply low-carbon economy. In contrast, expanding support for coal, oil, and gas – in line with President Trump's plan for "Energy Dominance"[62] – would increase global CO_2 emissions.

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[57] Trevor Houser, Jason Bordoff, and Peter Marsters, "Can Coal Make a Comeback?" (New York: Columbia University, Center on Global Energy Policy and Rhodium Group, April 2017), http://energypolicy.columbia.edu/publications/report/can-coal-make-comeback.

[58] Vulcan/ICF, "Federal Coal Leasing Reform Options: Effects on CO2 Emissions and Energy Markets" (Fairfax, VA: A Vulcan Philanthropy | Vulcan, Inc. report with analysis supported by ICF International, January 26, 2016).

[59] Stephen P.A. Brown, Alan J. Krupnick, and Margaret A. Walls, "Natural Gas: A Bridge to a Low-Carbon Future" (Washington, DC: Resources for the Future, 2009), http://www.rff.org/publications/pages/publicationdetails.aspx?publicationid=20972; U.S. EIA, "Annual Energy Outlook 2014 with Projections to 2040" (Washington, DC: U.S. Energy Information Administration, 2014), http://www.eia.gov/forecasts/aeo/; Christine Shearer et al., "The Effect of Natural Gas Supply on US Renewable Energy and CO2 Emissions," *Environmental Research Letters* 9, no. 9 (September 1, 2014): 094008, https://doi.org/10.1088/1748-9326/9/9/094008; Haewon McJeon et al., "Limited Impact on Decadal-Scale Climate Change from Increased Use of Natural Gas," *Nature* 514, no. 7523 (October 23, 2014): 482–85, https://doi.org/10.1038/nature13837; Michael Lazarus et al., "Natural Gas: Guardrails for a Potential Climate Bridge" (Stockholm and Seattle: Stockholm Environment Institute, 2015), http://static.newclimateeconomy.report/wp-content/uploads/2015/05/NCE-SEI-2015-Natural-gas-guardrails-climate-bridge.pdf; Richard G. Newell and Daniel Raimi, "Implications of Shale Gas Development for Climate Change," *Environmental Science & Technology*, April 22, 2014, https://doi.org/10.1021/es4046154.

[60] IEA, "World Energy Outlook 2016" (Paris, France: International Energy Agency, November 15, 2016), http://www.worldenergyoutlook.org/publications/weo-2016/.

[61] Peter Erickson and Michael Lazarus, "Would Constraining US Fossil Fuel Production Affect Global CO2 Emissions? A Case Study of US Leasing Policy," *Climatic Change* in press. (2018), https://doi.org/10.1007/s1058.

[62] The White House, "President Donald J. Trump Unleashes America's Energy Potential."

Lastly, there are other Federal Government permitting, policy, and regulatory decisions not discussed in this report that also affect fossil fuel supply and GHG emissions. For example, the federal permit for the Keystone XL pipeline could, to the extent the pipeline enables expanded production of Canadian oil sands, also increase global CO_2 emissions.[63]

CONCLUSION AND RECOMENDATIONS

This report has described how the U.S. Federal Government has estimated its greenhouse gas (GHG) emissions using a *territorial* accounting approach that counts the carbon dioxide (CO_2) and other GHGs emitted from within U.S. national borders. This approach, exemplified by the U.S. Environmental Protection Agency's annual GHG inventory, provides an important indicator of U.S. responsibility for global climate change and shows that GHG emissions coming from the U.S. are substantial. However, my conclusion is that this approach alone is not sufficient.

To more fully account for U.S. responsibility for global GHG emissions associated with domestic consumption and extraction, I recommend that the Federal Government should also regularly conduct both a *consumption-based* and an *extraction-based* GHG emissions inventory.

The U.S. Federal Government supports fossil fuel extraction and production through subsidies and federal leasing, and this support increases fossil fuel industry profits and fossil fuel production levels that, in turn, increase global CO_2 emissions. In my professional opinion, eliminating subsidies to fossil fuel producers and phasing out leasing of federal lands for fossil fuel extraction would result in a decrease of global CO_2 emissions.

Signed this 12th day of April, 2018 in Seattle, Washington.

Peter Erickson

[63] Erickson and Lazarus, "Impact of the Keystone XL Pipeline on Global Oil Markets and Greenhouse Gas Emissions."

EXHIBIT A: CURRICULUM VITAE

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Professional Summary

- More than 15 years in environmental policy research and consulting, supported by funders such as UNFCCC, European Commission, World Bank, U.S. EPA, Bloomberg Philanthropies, Energy Foundation, KR Foundation, NextGen Climate, C40 Cities, World Resources Institute, NRDC, SIDA, U.S. states of Washington and Oregon, Western Climate Initiative, City of Seattle, City of Chicago, King County
- Skilled in economic and financial analysis, modeling, writing, public speaking, project management, communication
- Broad expertise in greenhouse gas abatement and policy analysis

Professional Experience

2008-Present STOCKHOLM ENVIRONMENT INSTITUTE – U.S., SEATTLE, WA

Staff Scientist 2008-2011; Senior Scientist 2012-2018

Selected Projects and Research

- **Emissions implications of new fossil fuel supply infrastructure.** Researching the GHG implications and lock-in of investments in new infrastructure for supplying fossil fuels, such as oil pipelines and coal export facilities.
- **GHG emissions abatement potential of the world's cities.** Led a research effort, funded by Bloomberg Philanthropies, on the GHG emissions abatement potential of urban-scale policy levers worldwide.
- **GHG and green energy planning in Mongolia.** Researcher on alternative scenarios of Mongolia's energy development.
- **Framework for city-scale GHG abatement analyses in global cities.** Led research effort funded by C40 Cities Climate Leadership Group focused on a framework for GHG abatement analysis in the world's megacities. Supported a World Bank workshop in Singapore on sharing lessons learned from climate action planning in Beijing, Shanghai, Jakarta, Ho Chi Minh, and Bangkok. Writing summary report with lessons learned.
- **Net emissions impact of the CDM.** Lead researcher for the UNFCCC's High Level Panel on the CDM Policy Dialogue focused on additionality and over- or under-crediting in the CDM. With Michael Lazarus, contributed chapter to major research report.
- **Implications of international offsets on global climate mitigation.** Researched and modeled the supply and environmental efficacy of alternative sources and methods of crediting greenhouse gas offsets from developing countries in this project, funded in part by the Energy Foundation, and with a series of working papers in 2010 and 2011.
- **Scenarios of domestic offset supply in a U.S. cap-and-trade system.** Peter was the lead researcher, with Michael Lazarus, on a partnership between SEI and the World Resources Institute on the economics of domestic agriculture and forestry greenhouse gas offsets and the

importance of program design and offset protocols in ensuring environmental effectiveness. Publication in *Climate Policy* summer 2011.

- **Embodied emissions in international trade.** Led a research initiative on the embodied emissions in international trade and assessing opportunities to shift trade for both emissions and development benefits.
- **Emissions leakage and the CDM.** With Michael Lazarus, conducted an assessment of the potential for the CDM to induce activity or emissions leakage in the cement, steel, and aluminum sectors.
- **King County (WA) consumption-based GHG inventory and GHG measurement framework**. Led effort to conduct geographic and consumption-based greenhouse gas inventories and recommend a new measurement framework for King County.
- **Role of behavior and consumption in global climate mitigation.** Developed a method to estimate the GHG reductions for a nation or community due to shifts in consumption behaviors. Working paper published summer 2012.
- **City of Seattle (WA) carbon neutral scenario analysis**. Contributing to a technical scenario analysis of how the Seattle community could reduce greenhouse gas emissions to near zero in the next few decades, with a focus on the buildings and transportation sectors.
- **State of Oregon consumption-based GHG inventory**. Peter was the project manager on this effort to develop a consumption-based (rather than production- or geographic-based) GHG inventory for the State of Oregon. Published in *Environmental Science and Technology* in 2012.
- **Europe deep GHG emissions reduction scenario.** Peter developed a deep greenhouse gas reduction scenario for the EU-27's transportation, buildings, and agriculture sectors – the deepest reduction scenario proposed EU-wide at the time of its publication.
- **Greenhouse gas mitigation potential in developing countries (US EPA).** Peter was the lead researcher on a study of greenhouse gas mitigation potential and policies in six developing countries for the U.S. EPA. Published as working paper, June 2009.
- **Industry greenhouse gas benchmarking**. Peter led an assessment of benchmarking as a policy tool for reducing industrial GHGs. Funded by the Washington Department of Ecology and the Energy Foundation.

2000-2008 CASCADIA CONSULTING GROUP, SEATTLE, WA
Senior Associate (2006-2008); Associate (2002-'05); Project Assistant ('00-'01)

Selected Projects - 2008

- **Climate Change Policy Initiatives (Seattle City Council).** Peter led the development of a legislative agenda to address climate change
- **Energy Efficiency Policy Study (Seattle Office of Sustainability and Environment).** Led a study of energy efficiency policies for existing buildings in Seattle to support Mayor Greg Nickels' Green Building Task Force.
- **Carbon Footprint Calculator (Seattle Office of Sustainability and Environment)** Updated the City of Seattle's greenhouse gas footprint tool for businesses to include a greater focus on business supply chain (included upstream, embedded emissions) and year-to-year tracking.
- **Greenhouse Gas Inventory (Pierce County, Washington).** Oversaw Pierce County's greenhouse gas inventory process.

Selected Projects – Pre-2008

- **Carbon Footprint Calculator (Seattle Office of Sustainability and Environment)** Peter created the City of Seattle's greenhouse gas footprint tool for businesses
- **Other Carbon Footprint Calculators (Various clients).** Peter adapted the Seattle carbon footprint calculator for use by several other state and local jurisdictions
- **Oregon Waste Prevention Strategy (Oregon Department of Environmental Quality).** Peter contributed to research in support of DEQ's Waste Prevention Strategy.
- **Zero Waste Plan (City of Chicago).** Led several tasks of the development of a Zero Waste Plan for the City of Chicago.

Committees

2015 Compact of Mayors, City Mitigation Goals – Member of aggregation technical advisory group.

2012-2014 WRI GHG Protocol Mitigation Accounting Initiative. Member of the mitigation goals accounting technical working group.

2010-2012 ICLEI-US Community Greenhouse Gas Protocol. Member of the lifecycle technical advisory committee

Education

1994-1998 Carleton College, Northfield, Minnesota, USA
B.A with major in geology

Magna Cum Laude, Phi Beta Kappa, with distinction in major; GPA: 3.83

EXHIBIT B: LIST OF EXPERT PUBLICATIONS

Below is a list of publications I have authored or co-authored in the last ten years.

Erickson, Peter, and Michael Lazarus. "How Limiting Oil Production Could Help California Meet Its Climate Goals." Stockholm Environment Institute, February 27, 2018. https://www.sei.org/publications/limiting-oil-production-california/

Erickson, Peter, and Michael Lazarus. "Would Constraining US Fossil Fuel Production Affect Global CO_2 Emissions? A Case Study of US Leasing Policy." Climate Change, January, 2018.

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Erickson, P., & Lazarus, M. (2018). Towards a climate test for industry: Assessing a gas-based methanol plant. Seattle, WA: Stockholm Environment Institute. Retrieved from https://www.sei-international.org/publications?pid=3292

Broekhoff, D., Piggot, G., & **Erickson, P.** (2018). Building thriving, low-carbon cities: the role of national policies. Stockholm Environment Institute. Retrieved from https://www.sei-international.org/press/press-releases/3862

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Down, Adrian, and **Peter Erickson.** "Norwegian Oil Production and Keeping Global Warming 'well below 2°C.'" Discussion Brief. Stockholm Environment Institute, 2017. https://www.sei-international.org/publications?pid=3113.

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Erickson, P. (2017). Final Obama administration analysis shows expanding oil supply increases CO2. Stockholm Environment Institute blog, 30 January. https://www.sei-international.org/blog-articles/3617.

Erickson, P., Down, A., Lazarus, M. and Koplow, D. (2017). Effect of Government Subsidies for Upstream Oil Infrastructure on U.S. Oil Production and Global CO2 Emissions. Stockholm Environment Institute (U.S.), Seattle, WA. https://www.sei-international.org/publications?pid=3036. Working Paper.

Erickson, P. (2017). Obama's Arctic oil ban advances key climate test. Seattle Times, 1 January. Seattle, WA. http://www.seattletimes.com/opinion/obamas-arctic-oil-ban-advances-key-climate-test/.

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Erickson, Peter, and Michael Lazarus. "Today's Oil Drilling Fuels Tomorrow's Political and Economic Problems." The Guardian, September 28, 2015, sec. Guardian Sustainable Business. http://www.theguardian.com/sustainable-business/2015/sep/28/arctic-oil-drilling-carbon-obama-shell-goldman-sachs.

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Erickson, Peter, Sivan Kartha, Michael Lazarus, and Kevin Tempest. "Assessing Carbon Lock-In." Environmental Research Letters 10, no. 8 (2015): 084023. doi:10.1088/1748-9326/10/8/084023.

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Spalding-Fecher, Randall, Amrita Narayan Achanta, **Peter Erickson,** Erik Haites, Michael Lazarus, Neha Pahuja, Nimisha Pandey, Stephen Seres, and Ritika Tewari. 2012. Assessing the Impact of the Clean Development Mechanism. Report

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Erickson, Peter, David Allaway, Michael Lazarus, and Elizabeth A. Stanton. 2012. "A Consumption-Based GHG Inventory for the U.S. State of Oregon." *Environ. Sci. Technol*. doi:10.1021/es203731e. http://pubs.acs.org/doi/abs/10.1021/es203731e.

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