

Greenhouse Gases from Oil, Gas, and Petrochemical Production

U.S. Fracking Boom Fuels Rise in Greenhouse Gases and Health-Damaging Pollutants



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THE ENVIRONMENTAL INTEGRITY PROJECT

The Environmental Integrity Project

(<http://www.environmentalintegrity.org>) is a nonpartisan, nonprofit organization established in March of 2002 by former EPA enforcement attorneys to advocate for effective enforcement of environmental laws. EIP has three goals: 1) to provide objective analyses of how the failure to enforce or implement environmental laws increases pollution and affects public health; 2) to hold federal and state agencies, as well as individual corporations, accountable for failing to enforce or comply with environmental laws; and 3) to help local communities obtain the protection of environmental laws.

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President Donald J. Trump participates in a walking tour of Cameron LNG Export Terminal Tuesday, May 14, 2019, in Hackberry, La., Flickr/The White House. Deer Park refinery, Garth Lenz iLCP.

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Executive Summary

In less than a decade, fracking and other new drilling techniques have turned the United States into the largest producer of oil and gas in the world. Historically a fossil fuel importer, the U.S. is now on the cusp of becoming a net fossil fuel exporter. This surge of oil and gas production has led to a significant rise in greenhouse gases from the oil, gas, and petrochemical sectors. This report examines the growth of greenhouse gas emissions from three sectors, based on data reported to the U.S. Environmental Protection Agency from existing sources, the Department of Energy's estimate of future oil and gas production, and from permits that authorize increased emissions from proposed oil, gas, and chemical projects.

Facilities in these sectors reported emitting 764 million tons of greenhouse gases (carbon dioxide equivalent tons) in 2018, an eight percent increase since 2016. Expected growth in oil and gas production and large new and expanded oil, gas, and chemical plants have the potential to add up to 227 million additional tons of greenhouse gases by 2025 (Table A). That could bring total emissions to nearly one billion tons, equivalent to the greenhouse gas output from more than 218 large coal-fired power plants operating around the clock at full capacity.¹ The estimates in Table A likely understate emissions growth from the oil, gas, and petrochemical sectors, as explained below.

Table A. Actual and Potential Greenhouse Gas Emissions from the U.S. Oil, Gas, and Petrochemical Industries (million short tons per year)

Industry Sector	2012 ^a	2016	2018	Potential Increases ^b	Projected total by 2025
Petroleum and Natural Gas Systems	249.0	307.8	348.7	137.1	485.8
Oil and gas drilling	109.3	102.6	128.9	36.1 ^c	165.0 ^c
Liquefied natural gas (LNG)	0.7	2.2	7.4	79.8	87.2
Other petroleum and natural gas systems	139.1	203.0	212.4	21.2	233.6
Chemical Manufacturing	182.1	193.9	209.2	77.0	286.2
Petrochemicals and plastics	73.8	76.5	80.1	63.5	143.6
Ammonia fertilizers	27.7	31.3	39.5	13.5	53.0
Other organic chemicals	80.6	86.2	89.7	1.4	91.1
Refineries	197.2	204.8	205.7	12.8	218.5
TOTAL	628.3	706.5	763.6	226.9	990.5

a. Does not include emissions from gathering systems or transmission pipelines, which did not begin reporting until 2016.

b. New emissions from additional gas production and major new infrastructure projects that are expected to begin operating between 2019 and 2025 (based on new permits and pending permit applications). Excludes potential additional emissions from new or expanded projects that began partially operating by the end of 2018.²

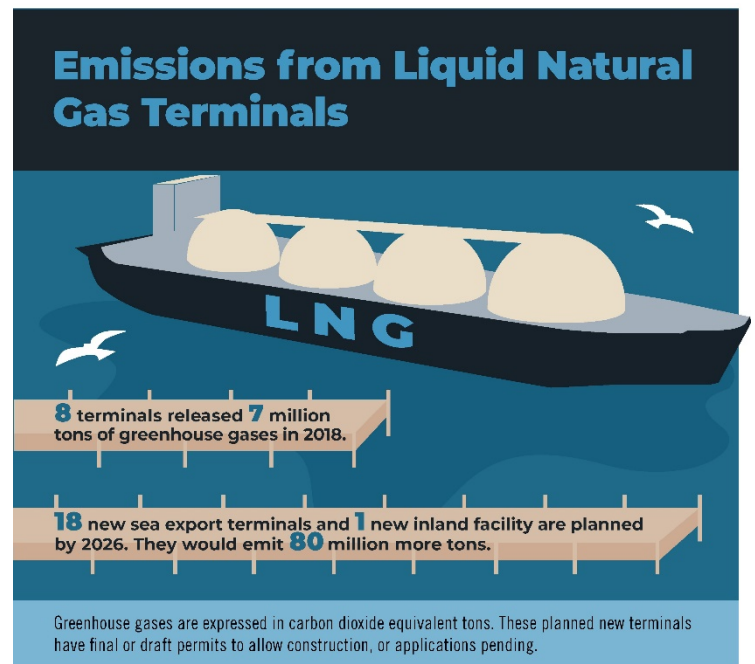
c. Based on the Energy Information Administration's estimate of natural gas production in 2025.³

Petroleum and natural gas systems include drilling operations as well as storage tanks and boosters and compressors that move gas through pipelines. This category also includes processing plants that separate gas from liquids, and large liquefied natural gas—“LNG”—plants that liquefy gas, primarily for export. Some major findings for this sector are:

- Greenhouse gas emissions from petroleum and natural gas systems rose from 308 to 349 million tons between 2016 and 2018, a 13 percent increase over two years. The data for earlier years are incomplete (most gathering and transmission systems did not report emissions until 2016), which makes longer-term comparisons impossible.
- The Energy Information Administration (EIA) predicts U.S. oil and gas production will increase by 31 and 24 percent, respectively, between 2018 and 2025. Based on the EIA’s annual projections for gas production alone, greenhouse gas emissions from drilling operations could reach 165 million tons in 2025, an increase of 27.4 percent above 2018 levels.
- Liquefied natural gas (LNG) companies have requested or received authorization from state agencies to add 80 million tons of greenhouse gases from 18 liquefied natural gas export sea terminals and one inland facility that are planned.

Oil refineries process crude oil into gasoline and other transportation fuels.

- Refinery greenhouse gas emissions were largely unchanged over the past two years, with a reported 204.8 million tons in 2016 versus 205.7 million tons in 2018. Refiners reported 197.2 million tons in 2012.



- Permits for 15 new refinery projects that are not yet fully operational could add another 12.8 million tons of greenhouse gases from this sector.

The **Chemical** sector includes plants that rely on oil, gas, or natural gas liquids as feedstock to manufacture petrochemicals, plastic resins, adhesives, rubber products, fertilizers, and industrial gases like hydrogen.

- Reported greenhouse gas emissions from these manufacturers rose from 193.9 to 209.2 million tons between 2016 and 2018, for a 15 million ton or eight percent increase over two years. Emissions from this sector were about 15 percent higher in 2018 than they were in 2012, when chemical plants reported 182.1 million tons of

greenhouse gases. These estimates do not include the relatively small contribution to emissions from inorganic chemical plants that do not rely on oil and gas as raw material for production.

- Permits issued to or requested for 37 major petrochemical and plastics projects that are still under construction or the planning stage would authorize another 63.5 million tons of emissions per year.

Our analysis is based on a review of greenhouse gas emissions reported by companies to the EPA, the Energy Information Administration's projections of growth in oil and gas drilling, and Clean Air Act construction permits requested or issued for new or expanded oil, gas, and chemical infrastructure projects. We converted "actual" reported emissions from metric to short tons. We adjusted sector- and sub-sector totals to account for discrepancies in how companies report from year to year and to improve upon how EPA categorizes certain types of facilities in ways that make it difficult to tell how they fit within the oil, gas, or chemical industries. For example, our totals for the chemical sector include emissions from resin, rubber, and plastics manufacturers that are reported under the catch-all "Other Manufacturing" category on EPA's website. These plants are closely tied to chemical manufacturing, and include many new projects that are in planning stages or under construction and will manufacture both petrochemicals and plastic resins. On the other



In 2018, the U.S. registered the largest annual increase in oil and gas production ever recorded by a single country.

hand, our report excludes plants within the chemical sector that do not rely upon oil or gas as primary raw material for manufacturing. For more information about our methodology, see Appendix A.

Projected emission increases from oil and gas drilling are based on EIA projections for natural gas production between 2019 and 2025. We also include estimated emission increases from 157 future projects that were not yet operating by the end of 2018, based on the amounts allowed under permits

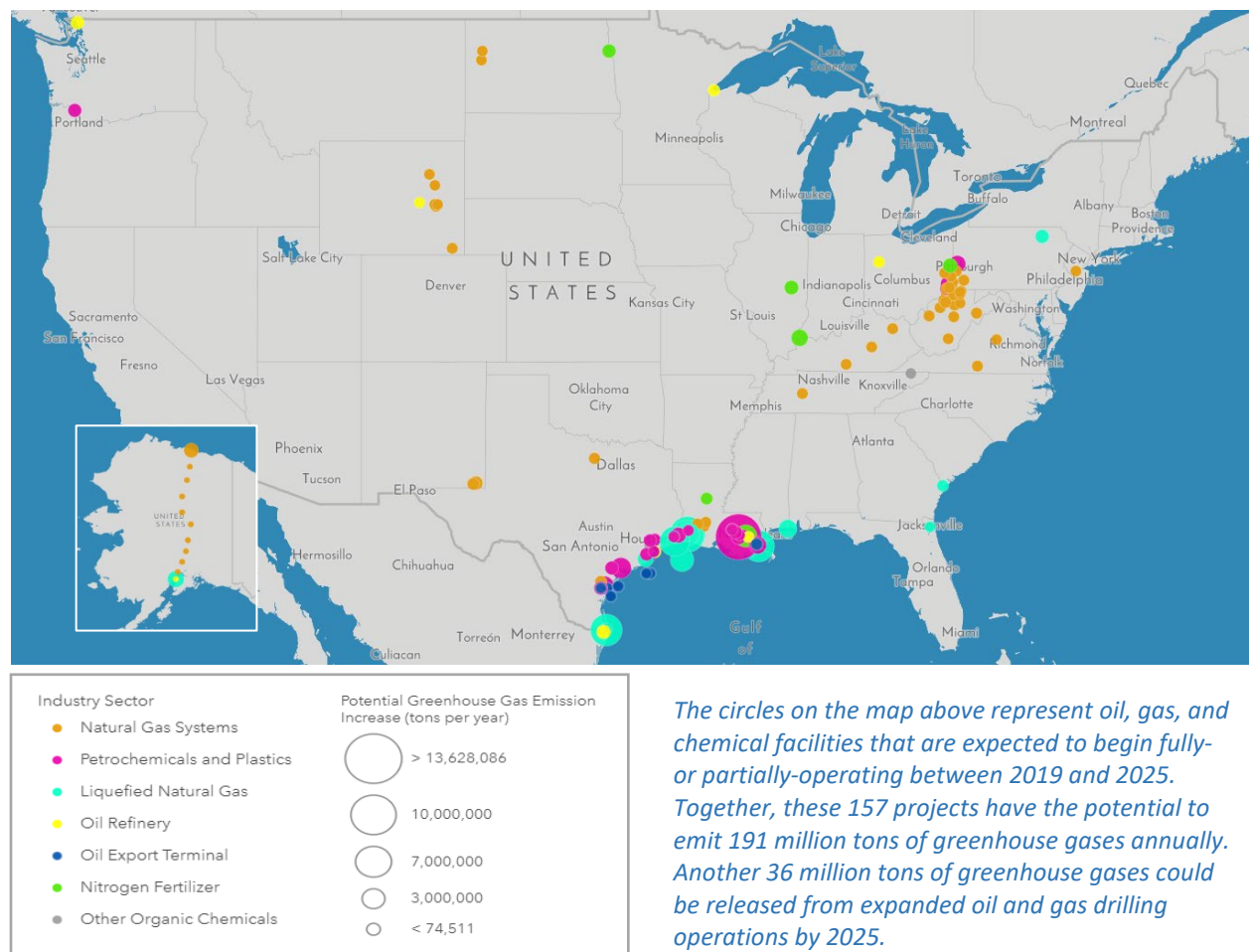
already issued or requested in applications still pending. Clean Air Act construction permits are required for large new or expanded sources of greenhouse gas emissions that also exceed permit thresholds for other pollutants, like smog forming chemicals or sulfur dioxide. In some cases, actual emissions from new projects may prove to be lower than the maximums amounts their permits allow. However, the estimates presented in Table A are more likely to under-estimate the growth in greenhouse gas emissions flowing from oil and gas development.

For example, Table A does not include future emissions from thousands of newly permitted sources that are not required to obtain greenhouse gas permits under the Clean Air Act because their emissions of other pollutants fall below Clean Air Act thresholds for major sources. These include, for example, hundreds of small or mid-size compressor stations, gas processors, storage terminals and petrochemical buildouts. Multiple studies have shown that

methane leaks from many small and large projects are undetected or unmeasured, and therefore unreported. Nor do we estimate potential emissions from product use, such as emissions from cars that run on gasoline or diesel, or from commercial power plants that use natural gas, liquefied natural gas (LNG), or oil as fuel.

New projects large enough to require greenhouse gas permits are supposed to limit emissions of carbon dioxide and other global warming pollutants based on the best available pollution control methods, which can be very cost-effective. Examples include recycling and reusing waste gases to conserve heat or minimize flaring, or superior leak detection practices that can identify and fix methane leaks from tanks and other equipment. These requirements have been largely ignored by EPA and by the state agencies that are charged with issuing most of the permits for the 157 new projects we identified. Based on our review, the permit limits for greenhouse gases assume plants will maximize their combustion or processing of oil and natural gas without considering cost-effective, common-sense methods that could limit emissions, and save money by reducing fuel consumption and product loss. As a result, the emission limits set for large facilities often represent the greenhouse gas emissions one would get from “business as usual” operations.

Figure I. Locations of Future Emission Sources from the Oil, Gas, and Chemical Sectors in the U.S., 2019-2025



New and expanded facilities also have the potential to emit large quantities of other pollutants known to harm human health and the environment. According to their Clean Air Act permit documents, the 157 new or expansion projects included in this analysis also have the potential to increase annual emissions by up to 11,100 tons of fine particulate matter (PM_{2.5}), 47,200 tons of nitrogen oxides (NO_x), 8,800 tons of sulfur dioxide (SO₂), 101,000 tons of carbon monoxide (CO), and 119,000 tons of volatile organic chemicals (VOCs). These pollutants are regulated by health-based air quality standards established under the Clean Air Act to prevent asthma, respiratory diseases, heart disease, preterm birth, cancer, and other adverse health effects.

In 2018, the U.S. registered the largest annual increase in oil and gas production ever recorded by a single country in history.⁴ This glut of oil and gas is fueling growth in industries that release significant amounts of greenhouse gases, such as plastics manufacturing and other petrochemical production. The U.S. is already struggling to meet climate commitments and transition to a low-carbon future. The industries responsible for driving fossil fuel extraction and production need to be held more fully accountable for their actions and the consequences of those actions.

Recommendations:

- The states and EPA should issue stronger permits that include cost-effective measures to minimize greenhouse gas pollution, as the Clean Air Act requires. EPA should also look harder at the substantial increases in emissions of smog forming chemicals, sulfur dioxide, nitrogen oxides, particulates and hazardous air pollutants that are routinely approved by state permitting authorities, determine whether these increases are lawful, and analyze their impact on public health in communities downwind. States should better monitor concentrations of sulfur dioxide and other pollutants near oil and gas drilling sites.
- Both Congress and the states should fund EPA and state environmental agencies sufficiently so they can provide appropriate monitoring, oversight and environmental enforcement. Government leaders in key oil and gas growth areas—Texas, Louisiana, and Pennsylvania—have reduced funding to their state agencies charged with enforcing environmental protections and issuing Clean Air Act permits. For example, Louisiana cut its environmental agency workforce by 30 percent between 2008 and 2018, while Pennsylvania lost 15 percent of its staff and Texas lost nine percent over the same period.
- EPA needs to require much more accurate methods to monitor emissions of greenhouse gases and other pollutants from leaking tanks, process equipment, and flares with poor combustion efficiency. The agency needs to make clear that facilities must quantify and report the amount of greenhouse gases and other pollutants released during accidents, or as a result of maintenance, startup, or shutdown.

- Permits should require fenceline monitoring to help identify and reduce dangerous concentrations of toxic gases before they cross plant boundaries. These systems would allow community members and health and emergency professionals access to important information about the health impacts of air emissions, as well as provide companies with information needed to correct otherwise invisible or undetected problems at a plant that result in considerable emissions of harmful air pollutants and greenhouse gases.

Analysis

The Environmental Integrity Project relied on three datasets for this analysis. We evaluated the historical greenhouse gas emissions⁵ that companies reported to the U.S. Environmental Protection Agency's Greenhouse Gas Reporting Program (GHGRP) from 2012 to 2018, the most recent data available.⁶ We relied on the Energy Information Administration's (EIA) 2019 Annual Energy Outlook reference case scenario to estimate projected growth in natural gas production through 2025. We also evaluated Clean Air Act construction permits issued or requested for new or expanded oil, gas, and petrochemical infrastructure projects between 2012 and November 2019.⁷ Together, these datasets provide information about actual emission trends since 2012 and the potential emission increases from expanded oil and gas production and new facilities and expansions that have not yet started operating or reporting emissions to the EPA.

Our estimates of historical emission trends focus on industrial categories defined by the EPA as petroleum and natural gas systems, refineries, and chemicals.

The historical reported emissions characterized in this report differ slightly from EPA's results because of differences in how the facilities and emissions are categorized into industrial sectors and subsectors. We believe our figures more accurately represent



Fueled by the fracking boom, oil and gas-related industries across the U.S. are planning to build 157 new or expanded plants over the next five years that could release as much greenhouse gas pollution as 50 new coal-fired power plants.

emissions by sector because we have accounted for inconsistencies in facilities' reporting and aggregated facility-level emissions where EPA unnecessarily splits them across different categories. For more information about our methods, see Appendix A.

The EPA categorizes emissions reported by facilities that emit greenhouse gases directly to the air into nine industry segments, which they break down further into 33 source categories.⁸ EPA categorizes facilities into catch-all categories called 'others'

when they only report emissions from stationary fuel combustion, but do not report process emissions from any of the 33 source categories. In order to apportion emissions from the facilities that reported under ‘other’ categories, we reviewed facilities that reported to the ‘other petroleum and natural gas systems,’ ‘other chemicals,’ ‘other manufacturing,’ and ‘other-other’ sub-sectors.

We analyzed company websites to better understand the products, outputs, industrial activities, and infrastructure that characterize each facility, and relied upon the North American Industry Classification System (NAICS)⁹ codes reported by facilities to the EPA as indicators for classifying primary business operations. Finally, we examined facilities’ reporting history to identify years in which process emissions were reported under a different source category, if any. Many facilities we reviewed reported to an ‘others’ category for only a few years, indicating that their grouping was the result of reporting irregularities or temporary operational changes. For example, 8.2 million tons of greenhouse gases released by petrochemical manufacturing facilities in 2018 were reported to the ‘other manufacturing’ sub-sector; another three million tons of greenhouse gases from captive power plants found at chemical facilities were reported to the power plants sector. We reapportioned these emissions to the chemical sector to better reflect greenhouse gas emissions associated with the production of these energy-intensive chemicals.

The oil, gas, and chemicals industries are becoming increasingly integrated and complex. Many of the facilities reporting to EPA serve multiple purposes, and may be co-located at industrial complexes that reclaim energy or raw materials produced by neighboring plants. These operational characteristics make it increasingly difficult to classify facilities into restrictive industrial groupings, and to apportion emissions in a way that holistically accounts for structural changes in the ways that products are manufactured.

We relied on EIA’s 2019 Annual Energy Outlook to estimate projected emission increases from oil and gas drilling through 2025. We used the Outlook’s “reference case” scenario for dry natural gas production to scale emissions. EIA estimated that dry natural gas production would increase by 24 percent between 2018 and 2025, with the growth rate peaking in 2019. Scaling emissions according to production rate changes does not account for relatively higher or lower rates of gas venting, flaring, and leaks, or improved measurement and reporting of methane emissions. Use of satellite and aerial remote sensing could improve reporting for big, unrecognized and previously un-reported releases of methane, such as the 2015-2016 Aliso Canyon leak in Southern California and a 2018 well blowout in Belmont County, Ohio.¹⁰

Our analysis of potential greenhouse gas emissions from new or expanded oil, gas, and chemical projects is based on a review of Clean Air Act construction permits issued or requested between 2012 and November 2019. The data and permit documents are available on [EIP’s website](#), and they are updated periodically.¹¹ This dataset is limited to new or expanding facilities that have the potential to increase emissions by up to 75,000 tons per year of greenhouse gases and air pollutants, like soot (particulate matter), volatile organic compounds (VOCs), nitrogen oxides (NOx), sulfur dioxide (SO₂), and carbon monoxide (CO) over thresholds established by the Clean Air Act. For this report, we only included projects that were expected to begin operating, or began operating, after 2018 as sources of future emissions because their actual emissions have not yet been reported to the EPA. We

excluded projects that began partially operating before the end of 2018 but are still expected to expand in coming years. We excluded these from our future projection to avoid double counting reported emissions from partially operating projects.

The potential emission increases from the new projects we have identified are estimates based on the maximum amounts allowed under their permits; actual emissions from all oil, gas, and chemical infrastructure may be lower once these new or expanded facilities begin operating. While the potential emission increases from permits could over-estimate emissions from the largest new projects, estimates of future emissions do not include the much larger number of smaller projects at oil and gas wells, storage terminals, tank batteries and other emissions sources that are not required to obtain permits that limit greenhouse gas emissions. It also omits emissions growth from incremental expansions at some of the largest compressor stations, gas processing plants, natural gas liquids fractionators, or petrochemical projects that keep emissions just below the thresholds that would trigger greenhouse gas permitting requirements.

The following results characterize actual emission trends and potential, future emission growth from petroleum and natural gas systems, refineries, and chemical manufacturing. All greenhouse gas emissions in this report are displayed in short tons of carbon dioxide equivalents, using the Intergovernmental Panel for Climate Change's (IPCC) 2007 global warming potentials from its fourth assessment (AR4).¹² The IPCC increased the global warming potential for methane and reduced it for nitrous oxide in its Fifth Assessment Report (2014).¹³ We use the fourth assessment global warming potentials because the detailed information in permits needed to convert potential emissions of methane and nitrous oxide to carbon dioxide equivalents using the fifth assessment's global warming potentials was not uniformly available. For this reason, the greenhouse gas emissions in this report may underestimate totals coming from methane and over-estimate emissions from nitrous oxide.

For a database listing all of the projects by state and their emissions, visit:
<https://www.environmentalintegrity.org/wp-content/uploads/2020/01/Database-of-Greenhouse-Gases-from-Oil-Gas-and-Petrochemical-Production.xlsx>

Definitions of Industrial Sectors Included in this Analysis

Petroleum and natural gas systems: Facilities reporting to the Petroleum and Natural Gas Systems category perform a wide range of operations, from the production and processing of natural gas and petroleum liquids, to the transmission, storage, and distribution of natural gas and its constituent products. It includes on- and off-shore oil and gas wells; gathering and transmission pipelines; compressor stations; gas processing plants that separate and treat natural gas for pipeline use; natural gas liquids fractionators that separate natural gas liquids into ethane, propane, and other compounds; liquefied natural gas import and export terminals; natural gas storage facilities; and natural gas local distribution companies. This is one of the most complicated sectors covered by the GHGRP because of its scope and technical complexity. The EPA's introduction of new reporting requirements in 2016 for hydraulic fracturing, onshore gas gathering and boosting systems, and transmission pipelines makes direct comparisons between certain sub-segments and reporting years difficult.

Refineries: After extraction, crude oil and other petroleum-based derivatives are sent to refineries and processed by distillation or catalytic cracking and reforming. Facilities reporting to the refineries sector manufacture products such as transportation fuels (gasoline, diesel, and jet fuel), naphtha, kerosene, distillate fuel oils, residual fuel oils, lubricants, and asphalt. This sector also includes facilities that manufacture petroleum coke, which is used for the production of cement, aluminum, and steel. Some emissions from refineries in EPA's GHGRP are categorized under "electricity generation," another industry sector. EIP included these emissions as associated with refineries when the refinery reported on-site electricity generation, as the electricity and any cogenerated steam is used to power or provide heat for refining processes.

Chemicals: The EPA divides the chemicals sector into eleven sub-categories, but this report only considers chemical products and intermediates that are produced from hydrocarbon feedstocks. These include petrochemicals, ammonia and nitric acid, adipic acid, hydrogen, certain "other" chemicals. We also included plastics and tire manufacturing plants that reported emissions under EPA's "other manufacturing" source category. Petrochemical production includes facilities that manufacture benzene, toluene, and xylene (also called aromatics), ethylene, propylene, and butadiene (known as olefins), and methanol. These bulk petrochemicals are precursors to a wide variety of chemical intermediates, which are converted downstream into an extensive range of industrial and consumer goods. Petrochemicals form the base for most plastics and can be found in everything from plastic packaging and insulation to laundry detergent and auto parts. Ammonia is a key ingredient in the manufacturing of nitrogen fertilizers. Nitric acid is not as widely used for fertilizer, but it can be neutralized with ammonia to create ammonium nitrate and is used in the production of explosives. It's also used as an oxidant in the production of adipic acid, a precursor to nylon. The other chemicals category includes facilities that manufacture a wide range of inorganic and industrial chemicals, including facilities that manufacture industrial gasses, namely nitrogen, oxygen, and argon. Hydrogen, which is used for desulphurization in refining and chemicals production, is the most prevalent industrial gas and is considered in a separate reporting category.

Table B: Reported Greenhouse Gas Emissions from Refineries, Oil and Gas Systems, and Chemicals

	2012	2016	2018	Difference (2012- 2018)	% Change (2012-2018)	Difference (2016- 2018)	% Change (2016-2018)
Petroleum and Natural Gas Systems	249,030,413	307,829,352	348,665,436	N/A	N/A	40,836,084	13%
Petroleum & Natural Gas Production (Onshore + Offshore) ^o	109,248,820	102,599,495	128,894,612	N/A	N/A	26,295,117	26%
Liquefied Natural Gas Imp/Exp Equipment	732,797	2,206,498	7,422,045	6,689,248	913%	5,215,547	236%
Other Petroleum and Natural Gas Systems	139,048,797	203,023,360	212,348,779	73,299,982	53%	9,325,419	5%
Natural Gas Transmission/Compression	26,678,945	24,770,305	30,846,640	4,167,695	16%	6,076,335	25%
Liquefied Natural Gas Storage	3,746	53,376	60,817	57,071	1524%	7,441	14%
Natural Gas Processing	67,175,279	61,353,987	64,355,667	-2,819,612	-4%	3,001,680	5%
Other Oil and Gas	26,395,378	7,687,360	8,453,278	-17,942,100	-68%	765,918	10%
Underground Natural Gas Storage	1,758,490	1,625,551	1,598,743	-159,747	-9%	-26,808	-2%
Natural Gas Local Distribution Companies	17,036,960	15,309,986	14,297,444	-2,739,516	-16%	-1,012,542	-7%
Onshore Petroleum & Natural Gas Gathering & Boosting*	N/A	88,840,686	89,598,711	N/A	N/A	758,024	1%
Onshore Natural Gas Transmission Pipelines*	N/A	3,382,107	3,137,480	N/A	N/A	-244,627	-7%
Refining (incl. on-site power generation)	197,230,941	204,819,032	205,692,804	8,461,863	4%	873,772	0%
Chemicals	182,085,224	193,938,950	209,226,295	27,141,070	15%	15,287,345	8%
Petrochemical and Plastics Production (incl. on-site power generation)	73,816,428	76,452,987	80,095,214	6,278,786	9%	3,642,227	5%
Ammonia Manufacturing	27,697,379	31,297,663	39,468,197	11,770,817	42%	8,170,534	26%
Other Organic Chemical Production	80,571,417	86,188,300	89,662,884	9,091,467	11%	3,474,583	4%
Nitric Acid Production	12,170,951	11,417,494	10,792,608	-1,378,343	-11%	-624,886	-5%
Hydrogen Production	44,171,667	49,479,704	50,514,863	6,343,196	14%	1,035,160	2%
Adipic Acid Production	7,671,946	9,617,165	13,259,379	5,587,433	73%	3,642,214	38%
Other Organic Chemicals	16,556,854	15,673,939	15,096,034	-1,460,819	-9%	-577,904	-4%
TOTAL	628,346,579	706,587,334	763,584,535	N/A	N/A	56,997,201	8%

Source: U.S. Environmental Protection Agency, Greenhouse Gas Reporting Program, October 2019

Note: The totals presented in this table slightly differ from those recorded in the GHGRP. For more information, please refer to the Methods section of this report.

^o shore production facilities began reporting emissions from oil well completions and workovers with hydraulic fracturing in 2016. The on- and off-shore segments are considered together.

* Facilities in the Gathering & Boosting and Onshore Gas Transmission Pipelines industry segments began reporting in 2016. Some facilities may have reported in the 'other petroleum & natural gas systems' sub-sector from 2012-2015.

Petroleum and Natural Gas Systems

Reported greenhouse gas emissions from petroleum and natural gas systems reached 348.7 million tons in 2018, a 13 percent increase over 2016 levels. Emissions from this sector as a whole are not directly comparable to those reported in 2012 because EPA added two new reporting categories in 2016 to account for emissions from gathering and boosting facilities and natural gas transmission pipelines. Oil and gas drillers accounted for the largest share of emissions from petroleum and natural gas systems in 2018, reporting 128.9 million tons of greenhouse gases. That could increase 24 percent by 2025, based on 2019 projections of future growth in natural gas production from the Energy Information Administration. Liquefied natural gas export terminals have the greatest potential for growth in coming years, with 19 new projects in planning or construction that have the potential to increase greenhouse gas emissions by 79.8 million tons by the time they are fully operating.

EPA required two new source categories to start reporting greenhouse gas emissions in 2016. The gathering and boosting source category covers emissions from infrastructure used to collect oil and gas at production wells and transport it to processing plants or larger transmission pipelines, including compressor stations that add pressure to the gas stream to keep it moving. The transmission segment covers pipeline blowdowns, meaning the emissions associated with a release of gas caused by a reduction in pressure as it moves between compressor stations. In addition to adding two new source categories in 2016, the EPA expanded the scope of reporting requirements under the existing onshore production segment to include oil well completions and workovers associated with hydraulic fracturing. This revision better accounts for changes in production practices that have resulted in higher rates of associated gas venting and flaring.

Production activities and resulting emissions are geographically concentrated around shale basins in Texas and Louisiana (Permian and Gulf Coast Basin), Oklahoma (Anadarko Basin), North Dakota (Williston Basin), and Pennsylvania (Appalachian Basin). The Permian Basin in Southeast New Mexico and West Texas, which is now the most productive oil field in the world, produced over 4.3 million barrels per day on average in 2019 and accounted for approximately 50 percent of U.S. oil production.¹⁴

Gas Flaring and Venting at Oil and Gas Production Sites in the Permian Basin

While most drilling in the Permian basin targets oil, producers often have to manage associated natural gas and natural gas liquids that need to be processed or transported to downstream users. Without the proper infrastructure in place (like gas plants, gathering systems, and transmission pipelines), or when prices are unfavorable, producers flare or vent the associated gas on site. According to the Texas Railroad Commission (RRC), average flaring and venting rates in 2018 increased from 213 to 488 million cubic feet per day in the Texas portion of the Permian alone, a drastic increase from the 33 million cubic feet per day vented or flared in the first quarter of 2012.¹⁵ Yet flaring rates continue to rise. The average volume of gas vented or flared in 2019 climbed past 600 million cubic feet per day and as high as 752 million cubic feet per day by the third quarter of 2019 according to estimates

from Rystad Energy.¹⁶ That's more than enough gas needed to power every home in Texas. These extremely high flaring rates have also been criticized by the chairman of the Texas Railroad Commission,¹⁷ which issues flaring permits that are valid for 180 days, as well as oil and gas companies that are taking measures to reduce flaring.¹⁸

Reported basin-wide emissions from companies operating in the Permian Basin have more than doubled from 10.5 million tons to 25.3 million tons between 2012 and 2018. Over the same period, emissions from flaring and venting have nearly tripled from 3.4 million tons to 9.4 million tons of greenhouse gases. Emissions from venting and flaring accounted for 37 percent of total emissions reported by producers in the Permian in 2018, up from 32 percent in 2012.¹⁹ With skyrocketing venting and flaring rates in 2019, it is likely that reported emissions will see a large jump. For context, flaring one million standard cubic feet of dry natural gas with a 98 percent destruction efficiency rate results in approximately 60 tons of greenhouse gases, according to EPA emission factors.²⁰ Companies that reported the highest emissions from venting and flaring in the Permian are listed in Table C.

Table C. Top 10 Companies that Reported the Most Greenhouse Gas Emissions from Venting and Flaring in the Permian Basin, 2018

Company – Facility Name (GHGRP ID)	Total Reported Emissions (tons greenhouse gases)	Emissions from Venting & Flaring (tons greenhouse gases)	Percent of Total
Devon Energy Corp – 430 Permian Basin DEC (1008290)	1,418,802	1,111,789	78%
WPX Energy Inc. – WPX Energy Permian LLC (1009039)	1,527,561	988,717	65%
ExxonMobil Corp – XTO Energy Inc 430 Permian Basin (1009390)	1,737,570	857,170	49%
Concho Resources, Inc.— COG Operating LLC 430 Permian Basin (1009707)	1,546,922	678,995	44%
Surge Operating LLC – Surge Energy 430 Permian Basin (1013106)	588,483.6	476,843	81%
Occidental Petroleum Corp – Oxy Permian Basin – 430 (1008141)	857,912	412,765	48%
Jagged Peak Energy LLC – Jagged Peak Permian Basin (430) Operations (1012542)	617,650	386,431	63%
BHP Billiton – BPX Energy Permian Basin, AAPG Basin 430 (1008632)	673,556	368,984	55%
Resolute Energy Corp. – Resolute Natural Resources Company, LLC 430 Permian Basin (1011735)	415,819	366,072	88%
Encana Oil & Gas (USA) Inc – Encana Oil & Gas – Permian Basin (1008331)	802,725	333,016	41%

Source: U.S. Environmental Protection Agency, Greenhouse Gas Reporting Program, October 2019

Emissions from venting, flaring and oil and gas production may also be significantly under-reported. Independent reviews of satellite remote sensing imagery suggest that Permian

Basin operators have historically under-reported the amount of gas they have vented and flared by as much as a factor of two.²¹ Similarly, researchers have used satellite and aerial remote sensing to highlight the role that accidents and poorly run facilities play in driving up methane emissions, yet these emissions are often not accounted for in reported emissions or emission inventories.²² For example, emissions from the Aliso Canyon natural gas storage blowout in 2015 and 2016, and a large 2018 well blowout at an ExxonMobil XTO Energy wellhead in Belmont County, Ohio, were not reported or were grossly underreported to EPA's Greenhouse Gas Reporting Program.²³ Remote sensing studies of these events estimated that they released 2.7 million and 1.6 million tons of greenhouse gases, respectively.²⁴

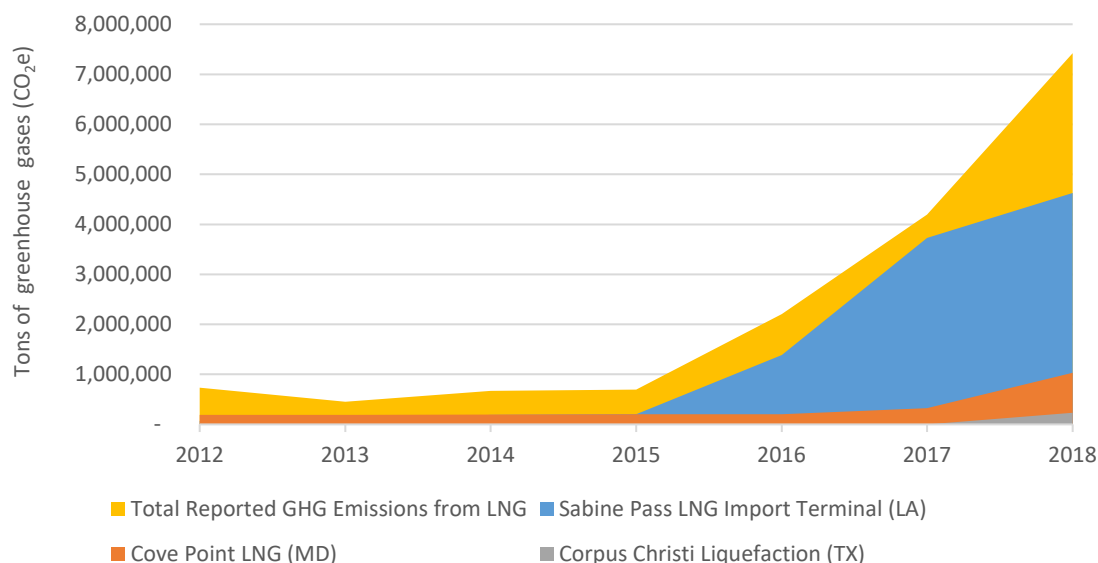
Self-reported data are also rarely completely free of errors. For example, 26 (38 percent) of the 68 companies that reported greenhouse gas emissions from oil and gas production in the Permian failed to verify their data by August 4, 2019 as required by EPA. EPA in 2019 also failed to review data from nine of the 68 companies by that same deadline. Similarly, it is unclear whether EPA reviews state-level data to corroborate reported emissions. At least five of eight companies that reported no emissions from venting and flaring in 2018 in fact reported the amount of gas they vented and flared in the Permian to the Texas Railroad Commission that year.²⁵ These companies include Diamondback Energy, Endeavor Energy Resources LP, Sheridan Production Co LLC, J Cleo Thompson & James Cleo Johnson Jr LP, and Fasken Oil & Ranch LTD.

Liquefied Natural Gas

Reported greenhouse gas emissions from liquefied natural gas import and export equipment have grown the fastest since 2012, with a nearly ten-fold increase from 0.7 to 7.4 million tons of greenhouse gases between 2012 and 2018. We estimate that emissions from LNG export terminals and liquefaction plants have the potential to increase to 87.2 million tons if 19 new and expanded terminals are constructed and begin operating.

Emissions from liquefied natural gas began to increase sharply in 2016 when manufacturing "trains" 1 and 2 of the Sabine Pass LNG Terminal in Cameron Parish, Louisiana, began operating. Liquefaction trains cool natural gas into a liquid so it can be loaded onto large ships. The new liquefaction trains that now enable liquefied natural gas to be exported from Sabine Pass are being constructed in phases. When the expansion project is completed, the terminal will have six liquefaction trains that are each capable of processing over 81 thousand tons of liquefied natural gas per day. Ultimately, the terminal will be able to export up to 27 million tons of liquefied natural gas per year.²⁶ After the first two trains became operational in 2016, reported facility-wide emissions increased by over 2.3 million tons of greenhouse gases. Two more trains began operating in 2018, increasing facility-wide reported emissions to 4.6 million tons of greenhouse gases.²⁷

Figure II: Reported Greenhouse Gas Emissions from LNG Import and Export Terminals (2012 - 2018)



Source: U.S. Environmental Protection Agency, Greenhouse Gas Reporting Program, October 2019

U.S. exports of liquefied natural gas are expected to double by 2025, according to industry estimates.²⁸ Because of their size and complexity, liquefied natural gas terminals are often constructed in stages or phases, one or two “trains” at a time. Emissions from these plants ramp up as they begin operating, and depending on the size of the project, it could take years before a project is fully constructed and fully operating.

EIP tracks 22 new or expanding large liquefied natural gas plants and export terminals that have sought Clean Air Act approvals since 2012. In total, they have the potential to increase greenhouse gas emissions by 99 million tons of greenhouse gases per year, just from facility operations. They also have the potential to emit over 4,000 tons PM_{2.5}, 23,700 tons of VOCs, 20,400 tons of NO_x, 41,100 tons of CO, and 1,300 tons of SO₂, according to permit documents.

Three of the 22 liquefied natural gas projects began fully or partially operating before the end of 2018: Sabine Pass LNG in Cameron Parish, Louisiana; Corpus Christi Liquefaction in San Patricio County, Texas; and Dominion Cove Point in Calvert County, Maryland. These plants are authorized to emit a total of 19.2 million tons of greenhouse gases when fully operational, but they reported emitting only 5.3 million tons in 2018 as two of the three plants are not fully operating.²⁹ In 2019, two more, Freeport LNG in Brazoria County, Texas, and Cameron LNG in Cameron Parish, Louisiana began partially operating, and another, an expansion at Southern Liquefaction Company’s Elba Liquefaction Terminal in Savannah County, Georgia, began commissioning. These three are authorized to emit up to 10.9 million tons of greenhouse gases and are expected to report emissions for 2019 in 2020. Another 16 liquefied natural gas projects are expected to start up between 2020 and 2025 (Table D) and have the potential to add another 68.9 million tons of greenhouse gases. In

all, 19 LNG plants, 18 of which are export terminals, have yet to start reporting their actual emissions, and together have the potential to emit up to 79.8 million tons of greenhouse gases once operating at full capacity (Table D).

The Driftwood LNG terminal in Calcasieu Parrish, Louisiana, has the highest potential greenhouse gas emissions—9.5 million tons per year. The terminal is expected to start up in 2023, though construction has not yet begun. Two projects, Alaska Gasline Development Corp and Qilak LNG’s Export Terminal have been proposed for Alaska as a means for exporting gas from the northern slope oil fields to markets in Asia. The Quilak LNG Export Terminal project intends to ship liquefied natural gas on ice-breaking tankers but has not yet applied for a Clean Air Act permit.³⁰ One land-locked liquefaction plant, New Fortress Energy’s Marcellus LNG plant, has been permitted in Bradford County, Pennsylvania, in order to send Marcellus natural gas to markets in New York and Massachusetts by truck.³¹

Reported and potential emissions from these facilities only represent operational emissions. But emissions from liquefied natural gas do not stop at the plant. Burning liquefied natural gas as fuel or using it to manufacture other products (i.e. fertilizer) downstream could also result in greenhouse gas and other air emissions. One estimate from the Institute for Policy Integrity calculated that downstream emissions from existing and planned U.S. liquefied natural gas exports could add up to 841.8 million tons of greenhouse gases per year, assuming that all exported LNG is combusted.³²

The U.S. Department of Energy conducted lifecycle assessments of liquefied natural gas exports and found that exporting and using U.S. liquefied natural gas for power in Europe and Asia from certain places in the U.S. would not increase greenhouse gas emissions compared to using coal over a 100-year time horizon.³³ However, the assessments were limited to displacing coal for electricity generation and did not address or compare emissions to those from renewables.

The liquefied natural gas buildout is overwhelmingly concentrated on the Gulf Coast, where processing, storage, and transport infrastructure is already somewhat developed and where politics are favorable. Fifteen of the 19 forthcoming liquefied natural gas projects are located in Gulf states. Fifteen of the 19 forthcoming liquefied natural gas projects are located in Gulf states (Texas, Louisiana, and Mississippi).

Table D. Potential Future Emissions from Liquefied Natural Gas Facilities

Facility/Project (County, State)	New or Expansion	Capacity (million metric tons per annum)	Potential to Emit (tons greenhouse gases)	Operational Status	Start- up Date
Driftwood LNG LLC (Calcasieu, LA)	New	27.6	9,513,442	Pre-construction	2023
Cameron LNG- Cameron LNG Liquefaction (Cameron, LA)	Expansion	24.9	8,478,228	Partially operating	2019-2020

Facility/Project (County, State)	New or Expansion	Capacity (million metric tons per annum)	Potential to Emit (tons greenhouse gases)	Operational Status	Start- up Date
Rio Grande LNG (Cameron, TX)	New	27	8,198,227	Pre- construction	2023
Venture Global Plaquemines LNG, LLC (Plaquemines, LA)	New	24	8,144,463	Pre- construction	2022
Alaska Gasline Development Corp. (Kenai Peninsula, Alaska)*	New	20	7,863,113	Pre- construction	2025
Port Arthur LNG, LLC* (Jefferson, TX)	New	13.5	7,419,530	Pre- construction	2025
Delfin LNG, LLC/Fairwood Peninsula Energy Corporation Deepwater Port* (Offshore, LA)	New	12	4,958,424	Pre- construction	2022
Golden Pass LNG Terminal, LLC (Jefferson, TX)	Expansion	15.6	4,940,072	Under construction	2024- 2025
Lake Charles LNG, LLC (Calcasieu, LA)	Expansion	16.45	4,513,540	Pre- construction	2025
Venture Global Calcasieu Pass, LLC (Cameron, LA)	New	12	3,906,336	Under construction	2022
Gulf LNG* (Jackson, MS)	Expansion	10.85	2,885,787	Pre- construction	2024
Magnolia LNG, LLC (Calcasieu, LA)	New	8.8	2,506,994	Pre- construction	2024
Freeport LNG Development, LP – Freeport LNG Liquefaction and Pretreatment Project (Brazoria, TX)	New	20.4	2,037,896	Partially operating	2019- 2021
Jordan Cove Energy Project, LP LNG Terminal* (Coos, OR)	New	7.8	1,951,410	Pre- construction	2024
New Fortress Energy LLC Marcellus LNG ** (Bradford, PA)	New	4.745	1,107,679	Pre- construction	2021
Texas LNG Brownsville, LLC* (Cameron, TX)	New	4	604,087	Pre- construction	2023
Southern Liquefaction Company, LLC (Kinder Morgan and EIG Global Energy Partners) Elba Liquefaction Terminal (Chatham, GA)	Expansion	2.5	378,453	Partially operating	2019
Annova LNG Brownsville* (Cameron, TX)	New	6.95	353,072	Pre- construction	2023
Eagle LNG Partners Jacksonville, LLC LNG Facility (Duval, FL)	New	1	74,511	Under construction	2021
TOTAL		260.4	79,835,264		

Source: Environmental Integrity Project. Emission Increase Database. November 2019.

* Draft permit or pending permit application (as of December 15, 2019).

** Land-locked liquefaction plant

Petroleum Refineries and Crude Oil Export Terminals

The majority of crude oil produced in the United States is consumed domestically and refined into petroleum products, including transportation fuels such as gasoline, diesel, and jet fuel, and certain feedstocks for making chemicals, plastics, and synthetic rubbers. According to the EIA's Refinery Capacity Report, U.S. operable crude oil distillation capacity also reached a new record at the onset of 2019.³⁴ An increasing number of oil export terminals have been proposed in recent years after the Obama administration lifted the ban on oil exports in 2015.³⁵ The United States is projected to remain the world's largest refiner and products exporter over the next several years, with the Gulf Coast expected to become a net crude oil export hub.³⁶

Some refineries report emissions associated with chemical manufacturing or electricity generation. For this analysis, we included emissions categorized under electricity generation as part of refining if they occurred on-site at a refinery. Emissions from chemical manufacturing at refineries are characterized in the chemical section later in this report.

One hundred and forty refineries reported emissions associated with refining in 2018, a slight decrease from the 147 that reported emissions in 2012. However, emissions increased from 197.2 million tons to 205.7 million tons (4.3 percent) over that same time period, largely driven by upgrades, expansions, and restarts at existing facilities and heavier crude oil that requires more energy to refine.

Four refineries reported increasing emissions by over one million tons of greenhouse gases between 2012 and 2018. These include:

- Motiva Enterprises' Port Arthur Refinery in Jefferson County, Texas, which increased emissions from refining from 3.8 million tons to 6.1 million tons, a 2.3 million ton increase.
- Marathon Petroleum's Los Angeles Refinery in Los Angeles County, CA, which increased emissions from refining from four million tons to 6.1 million tons, a 2.1 million ton increase.
- Exxon Mobil's Baytown Refinery in Harris County, Texas, increased emissions from 10.6 million tons to 11.8 million tons, a 1.2 million ton increase.
- Citgo's Corpus Christi East and West Refineries, which together increased emissions from refining from 364,326 tons to 1.8 million tons, a 1.4 million ton increase. The large increase was due to the restart of the East Refinery.

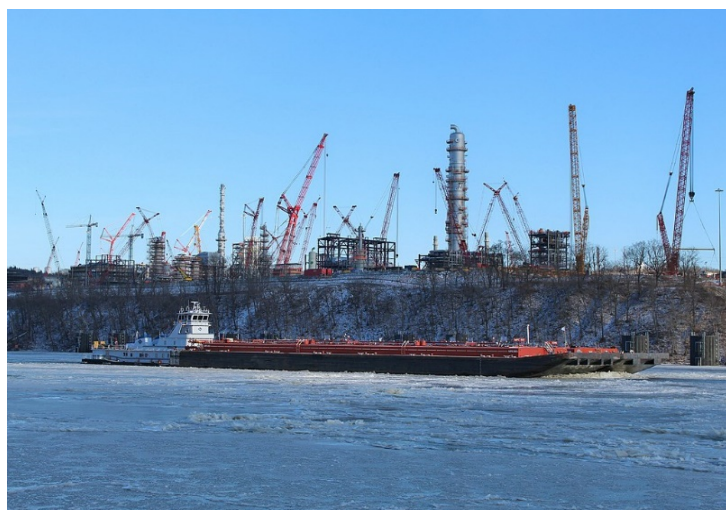
The ExxonMobil Baytown Refinery emitted the most greenhouse gases in 2018, with 11.8 million tons of greenhouse gases. The Galveston Bay Refinery in Galveston County, Texas, released the second highest amount, 7.7 million tons, followed by the ExxonMobil Baton Rouge Refinery in East Baton Rouge Parish, LA, which emitted seven million tons.

Sixteen future refinery expansion projects have the potential to increase greenhouse gas emissions by up to 12.8 million tons. The largest of which is an expansion of the Motiva Port Arthur Refinery in Port Arthur, Texas, which has the potential to add 4.2 million tons of greenhouse gas emissions per year.

U.S. crude oil exports increased from 24,693 thousand barrels in 2012 to 747,540 thousand barrels in 2018.³⁷ The largest export destination in 2018 was Canada, followed by South Korea, China, and the United Kingdom.³⁸ Emissions from existing crude oil export terminals are difficult to quantify using EPA's greenhouse gas reporting program data. However, eight proposed crude oil export terminals, several of which would be located offshore in the Gulf of Mexico, have the potential to add another 1.6 million tons of greenhouse gases per year.

Chemicals

Hydrocarbons are essential to the production of chemicals. The chemicals industry is the largest single industrial user of natural gas, and accounts for nearly nine percent of all U.S. petroleum products consumption.³⁹ The EPA divides the chemicals sector into 11 categories,⁴⁰ but this report only considers chemical products and intermediates that are produced from hydrocarbon feedstocks. These industry sub-segments include petrochemicals, ammonia and nitric acid, adipic acid, hydrogen, and other chemicals. We also included facilities that manufacture plastic resins and rubber, as they are closely tied to petrochemicals.



The first new ethane cracker in Appalachia, Shell's Pennsylvania Petrochemicals Complex, will process ethane into 1.7 million tons of polyethylene and is authorized to release over two million tons of greenhouse gases per year.

Oil and natural gas are not used directly as raw materials by most of the chemical industry, but are first converted into natural gas liquids or other products, like naphtha. The most abundant natural gas liquids in the U.S. are ethane and propane, which together accounted for approximately two-thirds of U.S. natural gas liquids production in 2018.⁴¹ Unlike liquefied natural gas, which is primarily composed of methane that has been cryogenically cooled to a liquid state, natural gas liquids are separated from the natural gas stream at refineries, natural gas processing plants, or natural gas liquids fractionators.⁴²

These raw materials are refined or “cracked” into bulk petrochemicals like benzene, toluene, and xylene (known as aromatics), ethylene, propylene, and butadiene (known as

olefins), and methanol (an alcohol).⁴³ Bulk petrochemicals are precursors to a wide variety of organic intermediates, which are later converted into an extensive range of industrial and consumer goods. Petrochemicals form the base for most plastics and can be found in everything from insulation to laundry detergent to auto parts.

Demand for natural gas liquids is expected to grow by 32 percent between 2018 and 2050 due to higher demand from the global petrochemical industry.⁴⁴ While oil production and associated emissions are mostly concentrated in the Southwestern United States, the largest growth in natural gas liquids production has occurred in the Appalachian region. The natural gas found in the Appalachian Basin, specifically the Marcellus and Utica shale formations, contains high concentrations of natural gas liquids. Proximity to these raw materials is key to the production of bulk petrochemicals.

In addition to the manufacturing of petrochemicals, natural gas is used as a direct input in the manufacturing of ammonia and nitric acid. Approximately 88 percent of the ammonia produced in the United States is consumed domestically as fertilizer.⁴⁵ Nitric acid can be also be neutralized with ammonia to create ammonium nitrate fertilizer, but is also used in the production of explosives and as an oxidant in the manufacturing of adipic acid, which is used to make nylon.

Chemicals that require vast supplies of natural gas and natural gas liquids, like those used to make plastics and fertilizers, are subject to cycles of boom and bust when natural gas prices fluctuate. High natural gas prices in the early 2000s resulted in the idling or decommissioning of about 40 percent of U.S. ammonia capacity and 15 percent of ethylene capacity.⁴⁶

The EPA's 'other chemicals' source category includes facilities that manufacture a wide range of inorganic and industrial chemicals, including facilities that manufacture industrial gases (namely nitrogen, oxygen, and argon). Not only is the production of industrial gases energy intensive, but these basic chemicals serve as process gas feedstocks in refining and petrochemicals manufacturing. Hydrogen, which is used for desulphurization in refining and chemicals production, is the most prevalent industrial gas and is considered in a separate reporting category.

Chemical production is energy intensive and some facilities, such as ethylene crackers, have dedicated power plants located on-site. When accounting for emissions from the petrochemicals industry, we included greenhouse gases from onsite power plants that generate steam or electricity for the exclusive use of two petrochemical plants. We did not include other power plants that generate electricity or steam for petrochemical plants but are located offsite and may sell to the grid or serve multiple customers. For example, the Channelview Cogeneration sells steam and electricity to a large industrial customer, but also sells electricity to the Electric Reliability Council of Texas (ERCOT) market.⁴⁷ Due to uncertainties in allocating their emissions, we excluded this and similar facilities from consideration.

It is important to note, however, that the figures reported by industry to the EPA may significantly underestimate sector-wide totals by excluding greenhouse gases released when burning fossil fuels to power industrial equipment. Allocating emissions from power generation becomes even more complicated when taking into account the number of emission sources, like hydrogen plants, which can be co-located and co-owned within a single industrial complex.

Plants that manufacture chemicals from hydrocarbon feedstocks—petrochemicals, ammonia, nitric acid, adipic acid, hydrogen, and plastics and rubber manufacturers—reported releasing 209.2 million tons of greenhouse gases in 2018, an increase of eight percent above 2016 levels and 15 percent above amounts reported in 2012. This growth was led by petrochemical and plastics and fertilizer manufacturers, which added the largest reported quantities of greenhouse gas emissions.

Petrochemicals and Plastics

Reported greenhouse gas emissions from petrochemicals and plastics manufacturers increased nine percent from 73.8 to 80.1 million tons between 2012 and 2018. Ninety percent of emissions reported to this sector in 2018 came from facilities in the U.S. petrochemical hub along the Texas and Louisiana Gulf Coast. Facilities in the petrochemical sector that reported the largest growth in greenhouse gas emissions since 2012 are shown in Table E. The largest emitters were Ascend Performance Materials in Escambia County, Florida, which emitted 11.9 million tons, and CF Industries' Donaldsonville Nitrogen Complex in Louisiana, which emitted 8.3 million tons.

Table E: Top 10 Chemical and Plastics Plants that Reported the Largest Emission Increases between 2012 and 2018

Company – Facility Name (County, State)	Total Reported Emissions in 2018 (tons greenhouse gases)	Percent Change (2012 – 2018)
Exxonmobil Corp – Exxonmobil Beaumont Refinery (Jefferson County, TX)*	124,186	223%
Westlake Chemical Corp – Westlake Vinyls Co LP (Ascension Parish, LA)	240,948	169%
Chevron Corp – Chevron Phillips Chemical Company LP Cedar Bayou Plant (Harris County, TX)	2,781,374	164%
Styrolution America LLC – INEOS NOVA LLC Texas City Site (Galveston County, TX)	131,990	141%
OCI USA Inc – OCI Beaumont LLC (Jefferson County, TX)	680,115	134%
Michelin North America Inc – Michelin NA Lexington (Lexington County, SC)	112,423	105%

Company – Facility Name (County, State)	Total Reported Emissions in 2018 (tons greenhouse gases)	Percent Change (2012 – 2018)
Exxonmobil Corp – Exxonmobil Chemical Mont Belvieu Plastics Plant (Chambers County, TX)	87,093	103%
Hexcel Corp – Hexcel Corporation (Morgan, AL)	83,703	100%
Berkshire Hathaway Inc – Shaw Industries Group Inc. Plant 8s (Lexington County, SC)	61,961	95%
TPC Group – TPC Group LLC (Jefferson County, TX)	156,709	80%

Source: U.S. Environmental Protection Agency, Greenhouse Gas Reporting Program, October 2019

Note: This table omits 15 (out of 201) facilities that did not report in 2012.

* Limited to emissions reported to the chemical sector only. This refinery functions as both a refinery and a chemical plant.

EIP tracks the potential emission increases from 37 new and expanding petrochemical and plastics projects with the cumulative potential to increase greenhouse gas emissions by 63.5 million tons per year, based on permits requested or authorized between 2012 and November 2019. Thirteen of these projects involve building or expanding ethylene crackers, which have the potential to emit up to 39.5 million tons of greenhouse gases per year. Nine of these thirteen projects also involve construction or expansions to co-located plants that use ethylene as a feedstock, such as plastic resin manufacturing plants or chemical plants. Seven of the 37 projects involve the restart, new construction, or expansion of methanol plants, with the potential to emit up to 15.5 million tons of greenhouse gases per year. Table F provides more information about the ten projects with the highest potential greenhouse gas emissions that are expected to begin operating after 2019.

One important way to enforce environmental protections at new and existing chemical plants is to adequately fund state environmental pollution control agencies. Doing so gives them the resources and staff to properly permit new and expanding facilities as well as enforce emissions laws at operating plants. Unfortunately, as EIP's 2019 report, "The Thin Green Line: Cuts to State Pollution Control Agencies" documented, many states where the petrochemical industry is thriving are actually slashing pollution control budgets and staff. The problem is exacerbated by similar cuts to federal pollution control resources: The White House and Congress reduced EPA's funding and staffing for pollution control and science programs by 16 percent from 2008 to 2018, when adjusted for inflation. Over the same period, 30 states cut funding for their own environmental agencies and 40 reduced their staffing.⁴⁸

Table F. Ten Future Petrochemical and Plastics Projects that Have the Potential to Emit the Most Greenhouse Gases

Project (County or Parish, State)	New or Expansion	Project Type	Status as of November 2019	Potential Greenhouse Gas Emissions (tons per year)
FG LA, LLC (Formosa) – FG LA Complex (St. James, LA)*	New	Ethylene, Plastic Resin, Chemicals	Pre-construction	13,628,086
Lake Charles Methanol, LLC – Lake Charles Methanol Gasification Facility (Calcasieu, LA)	New	Methanol	Under construction	6,014,977
Motiva Enterprises, LLC – Port Arthur Ethane Cracker (Jefferson, TX)*	New	Ethylene, Plastic Resin	Pre-construction	3,993,017
Gulf Coast Growth Ventures (ExxonMobil/SABIC)– Petrochemical and Plastics Manufacturing Complex (San Patricio, TX)	New	Ethylene, Plastic Resin, Chemicals	Pre-construction	2,933,595
IGP Methanol – Gulf Coast Methanol Complex (Plaquemines, LA)	New	Methanol	Pre-construction	2,533,377
Shell Chemical Appalachia – Petrochemical Complex (Beaver, PA)	New	Ethylene, Plastic Resin	Under construction	2,248,293
Big Lake Fuels, LLC (G2X Energy) – Big Lake Fuels Methanol Plant (Calcasieu, LA)	New	Methanol	Under construction	2,094,765
PTTCG America LLC – IS Petrochemical Complex Project (Belmont, OH)	New	Ethylene, Plastic Resin	Pre-construction	1,785,000
INEOS Olefins & Polymers U.S.A. – Chocolate Bayou Plant (Brazoria, TX)	Expansion	Ethylene, Plastic Resin	Under construction	1,772,804
Chevron Phillips Chemical Company LP – CP Chemical Orange Polyethylene Plant (Orange, TX)*	New	Ethylene, Plastic Resin	Pre-construction	1,737,346

Source: Environmental Integrity Project. Emission Increase Database. November 2019.

* Draft permit or pending permit application (as of December 15, 2019).

Formosa's massive new complex in St. James Parrish, Louisiana, has the highest potential greenhouse gas emissions of over 13.6 million tons of greenhouse gases per year not only within the chemical sector, but across all oil, gas, and petrochemical infrastructure that EIP tracks. The new complex, operated by Formosa subsidiary FG LA LLC, also has the potential to add 342 tons of fine particulates (PM_{2.5}), 1,243 tons of nitrogen oxides (NO_x), 1,669 tons of volatile organic compounds (VOCs), 83 tons of sulfur dioxide (SO₂), and 2,769 tons of carbon monoxide (CO), according to its draft Clean Air Act Prevention of Significant Deterioration (PSD) permit issued on May 28, 2019. This plant is located in a deeply impoverished area that is also threatened by a daunting number of other potential new and expanded chemical plants and related infrastructure.

Petrochemical and plastics production, which accounts for roughly one-third of potential future emissions, is concentrated in Texas and Louisiana. These two states are responsible for 90 percent of anticipated emissions, with states in the Appalachian Basin (Ohio, Pennsylvania, and West Virginia) making up the remainder.

The most mature fractionation and processing hub for natural gas liquids (NGLs) in the United States is currently located in Mont Belvieu, Texas. Seven projects with the potential to emit over four million tons of greenhouse gases per year have sought or obtained permits to expand natural gas liquids processing capacity in Mont Belvieu since 2012—roughly the same amount of carbon dioxide released from generators powering every home in Houston for one year.⁴⁹

The natural gas found in the Marcellus and Utica shale formations contains relatively high concentrations of natural gas liquids and is turning Appalachia into a prospective hub for petrochemical production. The first new ethane cracker in the region, Shell's Pennsylvania Petrochemicals Complex in Beaver County, is expected to become operational in 2021. The Shell Complex will process ethane into 1.7 million tons of polyethylene⁵⁰ and is authorized to release over two million tons of greenhouse gases per year. Once constructed, the facility will increase regional demand for ethane on the scale of a medium-size pipeline.⁵¹ According to a recent report by the American Chemistry Council, as many as nine ethane crackers could be supported in the region.⁵² Authorizing the buildout of petrochemical plants in Appalachia will increase regional demand for ethane and result in massive growth in greenhouse gas emissions, not only from ethane cracking, but from the necessary expansion in gas and liquids production and downstream processing of ethane into derivative products like plastics.

Ammonia manufacturing is the third largest source of greenhouse gas emissions in the chemicals sector after petrochemical and hydrogen production. Reported greenhouse gas emissions from ammonia manufacturing increased from 27.7 million tons in 2012 to 39.5 million tons in 2018, an increase of 42 percent. About half of all ammonia production in the United States is concentrated in Louisiana, Oklahoma, and Texas. One of the largest fertilizer plants in the United States,⁵³ the Iowa Fertilizer Company's new ammonia facility in Lee County, Iowa, began operating in 2017 and reported emitting 1.7 million tons of greenhouse gases to the EPA in 2018.

While nitric acid emissions have slightly declined since 2012, total U.S. nitrogen production has been steadily increasing. Although emission from hydrogen production did not increase as steeply as in other chemical sectors, last year facilities reported 50.5 million tons of greenhouse gas emissions—second only to petrochemical production.

Other Air Impacts from New and Expanded Oil, Gas, and Chemical Infrastructure

New and expanded oil, gas, and petrochemical infrastructure projects also have the potential to increase emissions of other forms of air pollution, such as nitrogen oxides, volatile organic chemicals, sulfur dioxide, soot (particulate matter), and carbon monoxide. The 157 projects expected to start coming online by 2025 could release over 11,000 tons of fine particulate matter (PM_{2.5}), 47,000 tons of nitrogen oxides (NO_x), 8,800 tons of sulfur dioxide (SO₂), 101,000 tons of carbon monoxide (CO), and 119,000 tons of volatile organic chemicals (VOCs). Not only are these compounds regulated pursuant to health-based air quality standards established under the Clean Air Act, but, according to the National Institutes of Health, air pollution exposure is associated with a wide array of health effects, including “respiratory diseases (including asthma and changes in lung function), cardiovascular diseases, adverse pregnancy outcomes (such as preterm birth), and even death.”⁵⁴

Recommendations

Strengthen Permits

The Clean Air Act requires companies that are planning to build large new or expanded sources of air pollution to obtain construction permits under the New Source Review program. These permits require companies to install the best available control technologies to reduce emissions of greenhouse gases and pollutants regulated by health-based national ambient air quality standards. Based on our review, virtually all permits assume maximum greenhouse gas emissions from combustion, process, and storage units, running at their full capacity, and do not reflect the use of cost-effective control methods that could reduce these releases.

Boilers, turbines, furnaces, heaters, and flares are some of the largest sources of greenhouse gas emissions at many oil, gas, and chemical facilities and plants. Some commonsense, affordable best available control technologies and practices include:

- Continuous emission monitoring to accurately measure emissions and enable companies to detect and address operational anomalies quicker.
- Regular leak detection and repair to reduce methane leaks.
- Energy efficient design like the use of economizers to return heat from exhaust to preheat feedwater to boilers or steam to furnaces; condensate recovery to return hot

condensate to use as boiler feedwater; and installation of redundant systems to reduce unnecessary flaring or provide additional heat recovery where applicable.

- Good operating and maintenance practices like oxygen trim control to maximize thermal efficiency (clean burning requires a sufficient amount of oxygen), regular tune-ups, and regular cleaning (i.e. decoking heat transfer surfaces in furnaces to enable better heat transfer).

Improve Monitoring and Reporting

The EPA's Greenhouse Gas Reporting Program should make clear that sources are required to report all greenhouse gases released due to major accidents or plant malfunctions, and during startup, shutdown, or maintenance activities. For instance, emissions from accidents like the 2015-2016 Aliso Canyon natural gas storage cavern leak in southern California and a 2018 wellhead blowout at an ExxonMobil subsidiary (XTO Energy) well in Belmont County, Ohio—which together released methane equivalent to 4.3 million tons of greenhouse gas pollution—were apparently not reported to EPA's emission inventory. Satellite and aerial remote sensing offer significant promise for measuring emissions from these kinds of events, and other methods (such as materials accounting) could be used to quantify emissions from events that are difficult to evaluate on the ground.

Similarly, EPA should require better monitoring of dangerous air pollutants in remote areas where wasteful gas venting and flaring has become commonplace, especially when the gas coming up out of the ground is sour and has dangerous levels of hydrogen sulfide, like in the Permian Basin. Flaring hydrogen sulfide can result in large quantities of sulfur dioxide, which is subject to national ambient air quality standards. Data are needed to define the potential public health hazards from this practice, and obtaining reliable information is the first step in holding companies accountable for their actions.

Low-cost technologies now exist for monitoring around the fencelines of facilities that emit chemicals like benzene or ammonia. Fenceline monitoring systems should be required at new, expanding or poorly performing petrochemical manufacturing plants. These systems would allow community members and health and emergency professionals access to important information about the health impacts of air emissions, as well as provide companies with information needed to correct otherwise invisible or undetected problems at a plant. Refineries are already required to install fenceline monitoring systems to detect benzene levels that exceed background concentrations.

Increase Funding to State Environmental Agencies

Many states where the petrochemical industry is thriving are actually cutting pollution control budgets and staff. EIP's recent report, "The Thin Green Line: Cuts to State Pollution Control Agencies," found that between 2008 and 2018, 30 states cut funding for their own environmental agencies and 40 reduced their staffing, including oil and gas industry hubs like Texas, Louisiana and Pennsylvania.⁵⁵

Governors and state lawmakers should fund state environmental agencies sufficiently to allow them to hire enough inspectors, permit writers, scientists, engineers, and other professionals to implement federal laws that protect public health, clean air, and clean water. States unable to muster the political will to adequately fund their own environmental agencies are less likely to make the hard decisions required to stand up to powerful lobbyists and hold polluters accountable.

Conclusion

In short, reported emissions from oil, natural gas, and chemical infrastructure have increased in recent years, and new infrastructure that is still in the pipeline has the potential to increase emissions even more. Reported emissions from petroleum and natural gas systems increased by 14 percent since 2016, and emissions from refining and chemical plants that use petroleum and natural gas products as feedstocks increased by 19 percent since 2012. Since 2018, at least 157 of the largest new or expanded oil, gas, and chemical infrastructure projects still in the pipeline have the potential to increase emissions by up to 190.8 million tons of greenhouse gases per year. These new facilities also have the potential to add 286,800 tons of other smog-forming and health harming pollutants to the atmosphere. Emissions from oil and gas drilling have the potential to add 36.1 million tons of greenhouse gases per year, based on projected natural gas production rates from EIA.

This glut of oil and gas is fueling growth in industries that release significant amounts of greenhouse gases, such as liquefied natural gas export terminals, plastics manufacturing and other petrochemical production. The U.S. is already struggling to meet climate commitments and transition to a low-carbon future. The industries responsible for driving fossil fuel extraction and production need to be held more fully accountable for their actions and the consequences of those actions.

Appendix A: Data and Methods

EPA's Greenhouse Gas Reporting Program

The U.S. Environmental Protection Agency requires the largest direct-emitting facilities report annual emissions data to its Greenhouse Gas Reporting Program. Large emission sources are defined as those that emit over 25,000 metric tons of greenhouse gases per year as a direct result of fuel combustion or processing.⁵⁶ The EPA categorizes emissions reported by direct-emitting facilities into nine industry segments, which are further broken down into thirty-three source categories. Facilities are categorized as 'others' when they report emissions from stationary fuel combustion, but do not report process emissions from any of the thirty-three source categories. For this report, we only considered source categories that process natural gas or natural gas liquids, or that use oil or natural gas as a primary feedstock for the manufacture of fuel or chemical products. This narrowed our selection to include Refineries and Petroleum and Natural Gas Systems, and six of the 11 chemical subsectors (petrochemicals, ammonia and nitric acid, adipic acid, hydrogen and other chemicals). We also included select facilities that reported under "other manufacturing" or "other-other" categories, as defined by the EPA.

We analyzed greenhouse gas emissions reported to these sectors between 2012 and 2018. We obtained all facility-level data from the EPA's Facility Level Information on Greenhouse Gases Tool ([FLIGHT](#)). Companies submit annual reports each year that represent emissions from the previous calendar year. 2018 reported emissions were published by the EPA on October 3, 2019 and includes all facility-level activity data and emissions calculations submitted before August 4, 2019.⁵⁷

Emissions from the petroleum and natural gas systems sector are not directly comparable across all sectors and reporting years due to changes in reporting requirements and methods. The EPA added two new reporting categories to the GHGRP in 2016: Onshore petroleum and natural gas gathering and boosting, and onshore natural gas transmission pipelines. The gathering and boosting segment covers emissions from infrastructure used to collect oil and gas at production wells and transport it to processing plants or larger transmission pipelines, including compressor stations that add pressure to the gas stream to keep it moving. The transmission segment covers pipeline blowdowns, meaning the emissions associated with a release of gas caused by a reduction in pressure as gas moves between compressor stations. In addition to adding two new source categories in 2016, the EPA expanded the scope of reporting requirements under the existing onshore production segment to include oil well completions and workovers associated with hydraulic fracturing. This revision better accounts for changes in production practices that have resulted in higher rates of associated gas venting and flaring.

As a result of these amendments to EPA's reporting methodology, emissions from these three sub-sectors are only comparable from 2016 onwards. Because EPA's reporting methods for the Refineries and Chemicals sectors have remained constant, we are able to directly compare emissions reported to these two sectors since 2012.

The EPA groups some facilities that only report emissions from stationary combustion as ‘others.’ In order to apportion emissions from the facilities that reported under ‘other’ categories, we reviewed facilities that reported to the ‘other petroleum and natural gas systems,’ ‘other chemicals,’ ‘other manufacturing,’ and ‘other-other’ sub-sectors to avoid underestimating sector-wide totals.

In order to do this, we included in the chemical sector any facilities that reported to the ‘other manufacturing’ segment if they performed business operations associated with NAICS codes 325211 (Plastics Material and Resin Manufacturing), 325212 (Synthetic Rubber Manufacturing), 325220 and 325222 (Artificial and Synthetic Fibers and Filaments Manufacturing), 326113 (Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing), 326121 (Unlaminated Plastics Profile Shape Manufacturing), and 326211 (Tire Manufacturing (except Retreading)). In total, we included emissions reported by 110 facilities reporting under the ‘other manufacturing’ segment and added them to petrochemicals.

We re-categorized facilities that reported to the ‘other-other’ segment if they performed business operations associated with NAICS codes 213112 (Support Activities for Oil and Gas Operations), 221210 (Natural Gas Distribution), and 493190 (Bulk Petroleum and Other Warehousing and Storage). Seventeen facilities reporting as ‘other-others’ were moved to the ‘other petroleum and natural gas systems’ sub-sector. These primarily included gathering networks and bulk liquids handling terminals that store and distribute chemicals and petroleum products. Emissions reported by three facilities were allocated to the ‘liquefied natural gas storage’ sub-segment; one facility was grouped with ‘liquefied natural gas import/export equipment’ and one with ‘natural gas processing.’

Emission from six compressor stations that reported to the ‘other petroleum and natural gas systems’ sub-sector were reapportioned to ‘natural gas transmission/compression.’ We re-categorized five additional facilities under ‘natural gas processing.’ We recategorized emissions from another 29 facilities that reported under the ‘other chemicals’ sub-sector. We added 27 to petrochemical production, one to adipic acid production, and one to ammonia manufacturing.

In instances where a facility reported process emissions to another source category for any year between 2012 and 2018, we grouped emissions from stationary combustion that the EPA categorized as ‘other’ with process emissions reported to a specific industry segment. For example, the Point Comfort Gas Plant in Calhoun County, Texas reported process emissions to the Natural Gas Processing sub-segment from 2013-2018, but only reported emissions from stationary combustion to Other Petroleum & Natural Gas Systems in 2012. We grouped emissions reported in 2012 into the same sub-sector as those reported from 2013 to 2018.

When accounting for emissions from petrochemicals and refineries, we included emissions associated with electricity generation for six facilities that reported having power plants on-site. The power plants that generate electricity or steam for petrochemical manufacturers

and refineries are substantial sources of greenhouse gases. However, they are sometimes located off-site, report as distinct entities to the EPA, and simultaneously sell electricity to regional wholesale markets. Because of these uncertainties, we could only include power sector emissions for the six facilities that reported to the power sector under identical facility identification numbers.

Estimating Potential Emission Increases

EIP tracks potential emissions of greenhouse gases and other harmful pollutants in its Emission Increase database and permit documents, available online at <https://www.environmentalintegrity.org/oil-gas-infrastructure-emissions/>. This database lists the largest new and expansion projects that have obtained or are seeking Clean Air Act construction permits since 2012. These projects have the potential to increase greenhouse gas emissions by over 75,000 tons per year and also exceed permit requirement thresholds for other chemicals like nitrogen oxides, sulfur dioxide, particulate matter, volatile organic chemicals, and carbon monoxide set by the Clean Air Act.

The potential emission increases and project descriptions included in this database were obtained from permit documents—draft and final permits, permit applications, and technical fact sheets issued by state and federal agencies—and environmental impact statements where available. We obtained these documents from government agency websites and from freedom of information act requests. Operating dates for each project are based on a review of publicly available information such as press releases, news articles, company websites, financial filings, and state agency records. Permits are frequently modified, renewed, extended, or cancelled, and project status and projected operation dates are subject to change. Each project is somewhat of a moving target, and the data in this report represents information current as of November 2019.

We only considered emissions projects that came online during or are expected to come online in 2019 or later as “future” emission increases because they had not yet started reporting emissions in 2018. If the operating date for a project was unclear, we assumed the project would move forward by 2025. We grouped potential emissions increases from these ‘unknown’ projects together with those that are expected to come online after 2018. We excluded new or expanded facilities that began partially operating by the end of 2018 in order to avoid double counting emissions.

We estimated potential greenhouse gas emission increases from increased oil and gas drilling using the Energy Information Administration’s 2019 Annual Energy Outlook for natural gas production. The 2019 reference case scenario predicted that natural gas production rate would increase by 24 percent over 2018 levels by 2025, with production rates peaking in 2019. We used annual production rate changes to scale emissions each year between 2018 and 2025 and ultimately project a net 27 percent increase in emissions by 2025. This method does not account for increased rates of venting, flaring, or leaks, and it assumes that monitoring and measuring methods remain as they were in 2018.

Appendix B:

Reported greenhouse gas emissions from refineries, oil and gas systems, and chemicals

	Tons of Carbon Dioxide Equivalent Emissions						
	2012	2013	2014	2015	2016	2017	2018
Petroleum and Natural Gas Systems	249,030,413	251,608,300	259,779,017	260,591,460	307,829,352	314,787,541	348,665,436
Petroleum & Natural Gas Production (Onshore + Offshore) ^o	109,248,820	114,966,643	119,503,074	119,931,945	102,599,495	112,724,839	128,894,612
Liquefied Natural Gas Imp/Exp Equipment	732,797	453,155	673,452	696,031	2,206,498	4,193,860	7,422,045
Other Petroleum and Natural Gas Systems	139,048,797	136,188,502	139,602,491	139,963,484	203,023,360	197,868,842	212,348,779
Natural Gas Transmission/Compression	26,678,945	25,594,355	25,157,763	25,501,255	24,770,305	26,621,360	30,846,640
Liquefied Natural Gas Storage	3,746	2,023	538	66,694	53,376	58,846	60,817
Natural Gas Processing	67,175,279	65,717,316	66,420,598	65,337,397	61,353,987	61,878,767	64,355,667
Other Oil and Gas	26,395,378	26,423,285	29,800,306	31,763,059	7,687,360	8,266,946	8,453,278
Underground Natural Gas Storage	1,758,490	1,753,019	1,940,102	1,759,526	1,625,551	1,614,313	1,598,743
Natural Gas Local Distribution Companies	17,036,960	16,698,505	16,283,184	15,535,553	15,309,986	14,884,913	14,297,444
Onshore Petroleum & Natural Gas Gathering & Boosting*	N/A	N/A	N/A	N/A	88,840,686	81,709,105	89,598,711
Onshore Natural Gas Transmission Pipelines*	N/A	N/A	N/A	N/A	3,382,107	2,834,592	3,137,480
Refining (incl. on-site power generation)	197,230,941	199,129,110	200,094,144	200,286,111	204,819,032	202,661,564	205,692,804
Chemicals	182,085,224	184,931,885	189,279,736	190,930,883	193,938,950	198,487,408	209,226,295
Petrochemical and Plastics Production (incl. on-site power generation)	73,816,428	75,391,395	76,344,491	77,328,019	76,452,987	75,561,547	80,095,214
Ammonia Manufacturing	27,697,379	27,559,207	26,831,906	28,351,326	31,297,663	36,521,517	39,468,197
Other organic chemical production	80,571,417	81,981,283	86,103,339	85,251,539	86,188,300	86,404,345	89,662,884
Nitric Acid Production	12,170,951	12,332,897	12,300,682	13,024,205	11,417,494	10,768,598	10,792,608
Hydrogen Production	44,171,667	46,331,928	48,839,402	48,693,524	49,479,704	50,593,283	50,514,863
Adipic Acid Production	7,671,946	6,293,148	7,966,438	6,754,216	9,617,165	9,981,099	13,259,379
Other Chemicals	16,556,854	17,023,310	16,996,817	16,779,593	15,673,939	15,061,364	15,096,034
TOTAL	628,346,579	635,669,294	649,152,896	651,808,455	706,587,334	715,936,513	763,584,535

Source: 2019 US EPA GHGRP; Note: The totals presented in this table differ from those in the GHGRP. For more information, please refer to the Methods section of this report.

^o Onshore production facilities began reporting emissions from oil well completions and workovers with hydraulic fracturing in 2016. The on- and off-shore segments are considered together.

* Facilities in the Gathering & Boosting and Onshore Gas Transmission Pipelines industry segments began reporting in 2016. Some facilities may have reported in the 'other petroleum & natural gas systems' sub-sector from 2012-2015.

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