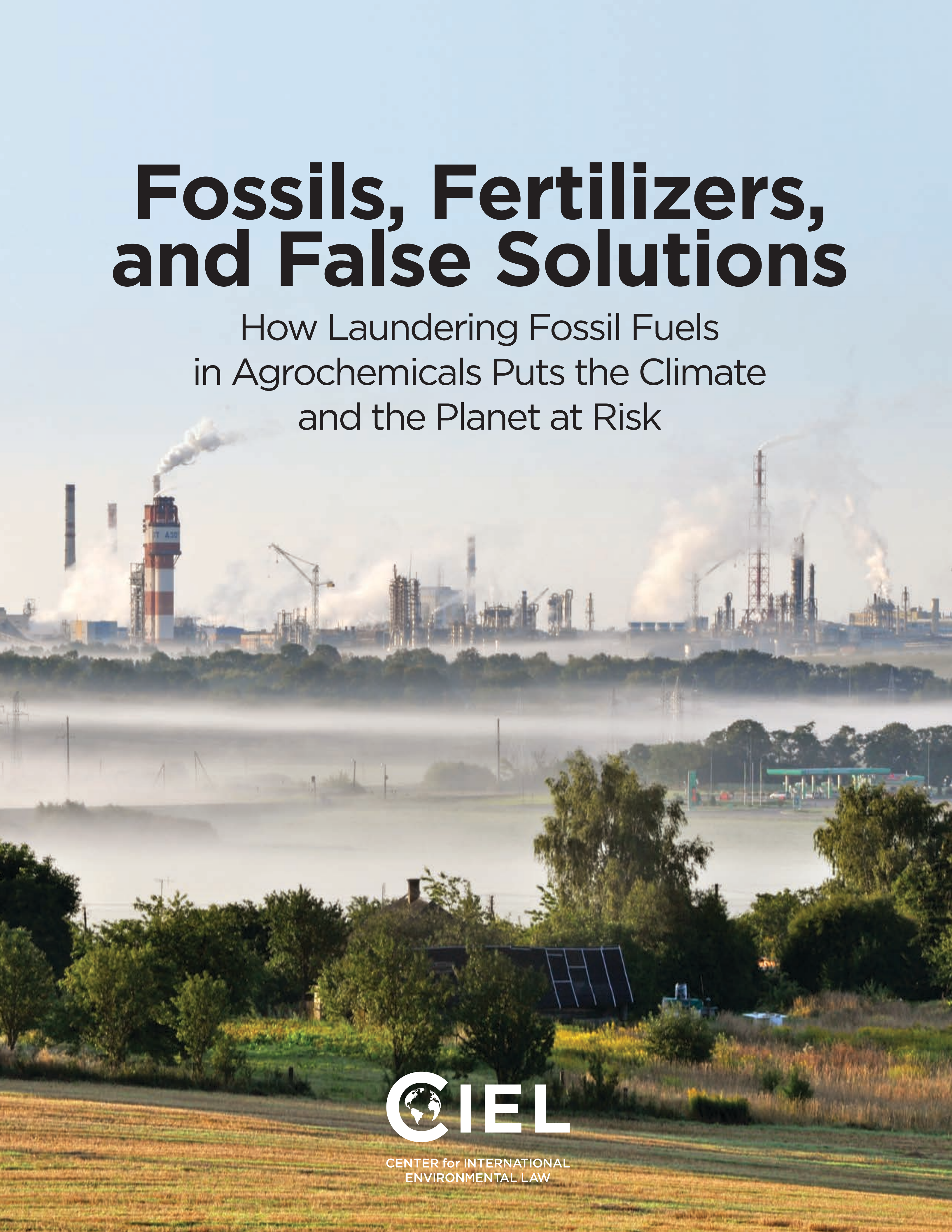

Fossils, Fertilizers, and False Solutions

How Laundering Fossil Fuels in Agrochemicals Puts the Climate and the Planet at Risk

CIEL
CENTER for INTERNATIONAL ENVIRONMENTAL LAW

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ABOUT CIEL

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Contents

PART 2

Acronyms

ADNOC	Abu Dhabi National Oil Company
bcm	billion cubic meters
CCS	Carbon capture and storage
CCUS	Carbon capture, utilization, and storage
CIEL	Center for International Environmental Law
CRF	Controlled-release fertilizers
DDT	Dichloro-diphenyl-trichloroethane
EOR	Enhanced oil recovery
EPA	United States Environmental Protection Agency
FAO	Food and Agriculture Organization
GHG	Greenhouse gas
IATP	Institute for Agriculture and Trade Policy
IEA	International Energy Agency
IFA	International Fertilizer Association
IPCC	Intergovernmental Panel on Climate Change
MENA	Middle East/North Africa
NG	Natural gas
NGL	Natural gas liquids
NIAS	Non-intentionally added substances
NZE	Net-zero emissions
OECD	Organisation for Economic Co-operation and Development
SABIC	Saudi Arabian Basic Industries Corporation

Glossary

Agrochemicals
Chemicals used in agriculture. In the context of this report: synthetic fertilizers and pesticides.

Ammonia (NH_3)
A chemical compound consisting of nitrogen and hydrogen. It is a colorless gas with a distinct odor and is corrosive and acutely toxic. Ammonia is produced both naturally from bacterial processes and synthetically. It is used in many industrial applications, including in the production of synthetic nitrogen fertilizers.

Ammonium nitrate (NH_4NO_3)
A salt compound of ammonia and nitric acid. It is used in explosives and as nitrogen fertilizer.

Biofuel
A fuel source derived from organic matter (biomass) such as plants, algae, or animal waste.

Blue hydrogen; blue ammonia
Hydrogen or ammonia produced from fossil gas where carbon capture and storage has been applied to at least some of the production process.

Carbon capture and storage (CCS); **carbon capture, utilization, and storage (CCUS)**
Processes that collect or "capture" carbon dioxide generated by high-emitting activities such as fossil fuel-based power production or chemical manufacturing and then transport those captured emissions to sites where they are either used for industrial processes or stored underground.

Carbon dioxide equivalent (CO_2e)
A metric for comparing various greenhouse gases by representing quantities of other gases as an amount of carbon dioxide that would have the same global warming potential.

Controlled-release technology
A method in which a physical barrier—typically a polymer coating—slows or modulates the release of the coated chemical ingredient(s). It is used with both fertilizers (controlled-release fertilizers (CRFs)) and pesticides.

Cracker
A facility that converts oil- or gas-based compounds such as naphtha or natural gas liquids into chemical components used to produce plastics.

Enhanced oil recovery (EOR)
A technique through which carbon dioxide—either from natural sources or industrial capture—is injected into underground oil reservoirs to boost oil and gas production from old wells.

Ethanol (C_2H_5OH)
An organic chemical compound and simple alcohol produced from the fermentation of sugars and starches or petrochemical processes. It can be used as a fuel source.

Feedstock
Raw materials used for manufacturing plastics or other chemical products or fuels.

Fertilizer
A substance (either organic or synthetic) that is added to land or soil to increase its productivity. Synthetic fertilizers are derived from mineral or fossil fuel extraction. The three primary nutrients needed for plant growth—nitrogen (N), phosphorus (P), and potassium (K)—form the basis of industrial agricultural fertilizers.

Food sovereignty
A concept describing the rights of peoples to healthy and culturally appropriate food and the right to define their own local and sustainable agricultural production systems.

Fossil fertilizers
Synthetic fertilizers derived from fossil fuels.

Fossil gas
A type of fossil fuel commonly known as "natural gas" that consists primarily of the hydrocarbon methane.

Global warming potential
A measure of the potency of a greenhouse gas, or its cumulative radiative forcing (contributing to global warming), over a specified time horizon.

Gray hydrogen; gray ammonia
Hydrogen or ammonia produced from fossil gas.

Green hydrogen; green ammonia
Hydrogen or ammonia produced with renewable energy through the electrolysis of water molecules.

Haber-Bosch process
An industrial process that enables the industrial-scale production of nitrogen in the form of ammonia. It is named after two German chemists who developed it in the early 20th century.

Hydrocarbons
Chemical compounds consisting of hydrogen and carbon. They are the main components of fossil fuels and are highly combustible, producing carbon dioxide, water, and heat when fully burned (i.e., completely combusted with oxygen).

Hydrogen
A chemical element in the form of a colorless, odorless, and flammable gas. It is a constituent of fossil fuels, which are mixtures of hydrocarbons, and it is one of the two basic elements of water. Hydrogen is the lightest and most common element in the universe.

Industrial agriculture
A large-scale, intensive method of food production dominated by large corporations that is geared towards high yields and involves the use of chemical fertilizers and pesticides.

Methane (CH_4)
A potent greenhouse gas and hydrocarbon compound consisting of one carbon atom and four hydrogen atoms. It is a colorless, odorless, and flammable gas. It is the main material constituent of the fossil fuel known as “natural gas.”

Methanol (CH_3OH)
A toxic chemical and simple alcohol primarily derived from methane and used directly or as a feedstock for polymers, solvents, pesticides, and alternative fuel sources.

Microplastics
Tiny plastic pieces smaller than five millimeters consisting of synthetic polymers. Microplastics can fragment into smaller particles called nanoplastics (usually identified as plastic particles within the 1 to 1,000-nanometer range).

Monoculture
Monocultures are large areas of land cultivated with a single crop, using methods that imply a high level of inputs, such as agrochemicals and machinery.

Naphtha
A liquid, volatile (often flammable) hydrocarbon mixture derived from fossil fuels, used as a chemical feedstock for making plastics and other materials.

Natural gas liquids (NGL)
Liquid hydrocarbons (made from carbon and hydrogen) that are separated from natural gas. Ethane, propane, butane, isobutane, and pentane are all NGLs.

Nitrogen oxides (NOx)
Class of toxic gases, namely nitric oxide (NO) and nitrogen dioxide (NO_2), produced from the reaction of nitrogen and oxygen. The gases are common air pollutants and contribute to the formation of smog and acid rain.

Nitrous oxide (N_2O)
A colorless gas, also known as “laughing gas.” It is used as an anesthetic, among other applications. It is also a potent greenhouse gas emitted from industrial processes, fuel combustion, and, most widely, from agricultural soils treated with nitrogen fertilizers.

Nutrient cycling
The transfer or cycling of nutrients between the physical environment and living organisms.

Pesticides
A chemical substance used to kill, repel, or control insects or other pests (such as fungi, rodents, and unwanted plants or weeds) that are harmful to plants or animals. Insecticides, herbicides, fungicides, and rodenticides are common types of pesticides.

Petrochemicals
Fossil fuel-derived chemicals, some of which are used to produce plastics or agrochemicals.

Planetary boundaries
Geophysical limits to the processes that regulate the stability and resilience of the Earth’s systems. According to the Stockholm Resilience Centre, the current framework consists of nine biophysical processes, and the boundaries for each represent a scientifically based “safe” level of human interference. The boundaries collectively represent the limits of the “safe operating space for humanity.”

Plastic
Material made of synthetic polymers usually containing additives and non-intentionally added substances.

Polymer
Large molecule made up of a chain of repeating units, either natural or synthetic.

Soil biota
The living organisms in the soil environment, such as micro-organisms (bacteria, fungi, etc.), insects, earthworms, and other soil fauna.

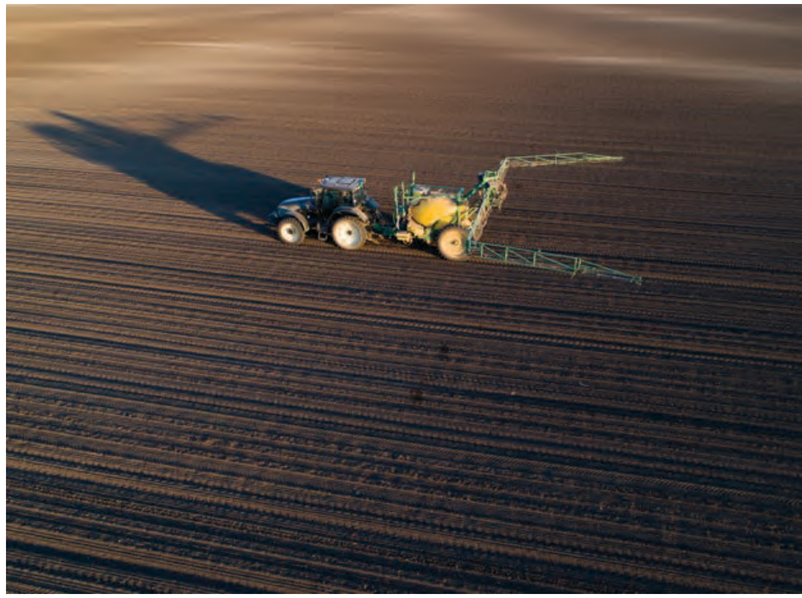
Steam reforming
A process of synthesizing hydrogen by reacting hydrocarbons with water at high temperatures (using steam).

Synthetic nitrogen fertilizer
Inorganic fertilizer derived from ammonia and used primarily in the form of urea or ammonium nitrate.

Urea ($CO(NH_2)_2$)
A nitrogenous compound made from ammonia and carbon dioxide, used for nitrogen fertilizers.

Executive Summary

Over the last six decades, the global production and use of nitrogen fertilizers has grown nearly ninefold, from 12.9 million tonnes in 1961 to more than 123 million tonnes in 2020. High-income countries like Japan, the United States, and parts of western Europe use 85–135 kilograms (kg) (187–298 pounds) of nitrogen fertilizers per capita, with industry now focused on dramatically increasing fertilizer use in the Global South. The production and use of pesticides has followed a similar trajectory, with early dramatic growth in pesticide use in North America and Europe shifting in recent decades to a heavy focus on pesticide exports to the Global South as consumers and regulators in the Global North demand safer alternatives. Since 1960, the value of global pesticide exports increased by 15,000 percent, reaching USD41 billion in 2020.



Overwhelming scientific evidence demonstrates that decades of overuse of synthetic fertilizers and pesticides—collectively agrochemicals—and the pervasive spread of industrial agriculture based on those agrochemicals, is contributing to catastrophic biodiversity collapse and toxic pollution, pushing the Earth beyond critical planetary boundaries, and resulting in widespread violations of human rights, particularly in the Global South. This overuse also impacts fenceline communities in both the Global North and South where agrochemicals are made.

These impacts are compounded by the significant but often-overlooked role of agrochemicals in the accelerating climate crisis. Food systems account for roughly a third of global greenhouse gas (GHG) emissions, and fossil fertilizers—synthetic fertilizers derived from fossil fuels—are an unrecognized contributor to this figure. A peer-reviewed study published in August 2022 found that the global climate impact of nitrogen fertilizer alone exceeds that of commercial aviation, contributing roughly 2 percent of all global GHG emissions. These emissions arise both from emissions-intensive fertilizer production and from ongoing and diverse climate impacts when nitrogen fertilizers are applied to agricultural soils. For example, producing the ammonia (NH_3) on which nitrogen fertilizers are based releases an estimated 450 million tonnes of carbon dioxide (CO_2) per year—equivalent to the total energy system emissions of South Africa. Similarly, agriculture accounts for roughly two-thirds of global emissions of nitrous oxide (N_2O), a greenhouse gas 265 times more potent than carbon dioxide. Agricultural soils treated with nitrogen fertilizers are a dominant source of those emissions. Recent studies report that observed atmospheric concentrations of nitrous oxide are beginning to exceed even the most pessimistic climate models used by the United Nations Intergovernmental Panel on Climate Change (IPCC). In addition, continued overuse of both pesticides and fertilizers could be impairing the soil's own ability to absorb and sequester carbon. Alarmingly, and despite these risks, the Food and Agriculture Organization of the UN (FAO) projects that nitrogen fertilizer use could grow another 50 percent by 2050.

Both the agrochemical and the fossil fuel industries stand to benefit from increasing production of synthetic fertilizers. Already, synthesizing ammonia for nitrogen fertilizers consumes an estimated 3–5 percent of the world's fossil gas. The International Energy Agency (IEA) projects petrochemicals will account for more than two-thirds of global oil demand growth through 2026, and account for more than half (55 percent) of all petroleum usage by 2050. Plastics and fertilizers, which together account for nearly three-quarters (74 percent) of all petrochemicals produced, are the major drivers of that growth. According to the IEA, fertilizers represent the greatest near-term growth sector for petroleum feedstock use, with fertilizer production projected to demand more than 100 billion cubic meters (bcm) of natural gas in 2025, and global ammonia production growing up to 30 percent by 2050.

This convergence of interests is reflected in deep and pervasive interlinkages between the industries themselves. While the pervasive role of oil and gas companies in the petrochemical buildout and the ongoing plastics crisis is well-documented, links between the fossil fuel and agrochemical industries have received far less attention. Of eight leading fertilizer companies examined for this report, seven showed extensive past or current ties to the fossil fuel industry through board interlocks, corporate ownership structures, or direct engagement in fossil fuel production. Notably, this is in addition to well-known historic ties to fossil fuel industries among longtime agrochemical leaders like DuPont and Dow.

Perhaps unsurprisingly, therefore, agrochemical companies are drawing with growing intensity on the fossil fuel playbook to argue that they can make the massive climate impacts of fertilizer production disappear through widespread deployment of carbon capture and storage (CCS) and other false climate solutions. More troublingly—and largely unnoticed by media and civil society watchdogs—oil, gas, and agrochemical companies are partnering on a rapidly growing wave of new projects that would use CCS and related technologies to produce fossil gas-based ammonia (and its hydrogen precursor) not only as a critical fertilizer input, but as a combustible fuel for transport and energy. Fertilizer and fossil fuel companies are operating, developing, proposing, or actively exploring dozens of such blue hydrogen or blue ammonia projects in at least nine countries across the world. This report particularly highlights the buildout plans in the US where projects have been proposed in eight states. Unsurprisingly, the same states and communities that are already experiencing impacts of petrochemical and CCS production are also primary targets for the fossil fertilizer industry's expansion into blue hydrogen and blue ammonia.

Scientific research demonstrates compellingly that such fuels are not only technically and economically infeasible for most uses, they are as bad or worse for the climate than burning fossil gas directly. Nonetheless, by positioning this fossil gas with CCS-derived ammonia as a clean energy source, both industries are maneuvering to exploit not only the marketing potential of allegedly "clean" and sustainable fuels, but also massive government subsidies for infrastructure investments in the name of climate mitigation. Put simply, the fertilizer and fossil fuel industries are increasingly collaborating to launder fossil fuels—particularly gas—as an ever-expanding source of both "clean" energy and "clean" agrochemicals. It is neither. Yet the acceleration of these proposals and the narratives underpinning them threaten to extend and deepen global reliance on both fossil fuels and industrial agriculture in the face of growing global recognition that both must be urgently reduced.

The fertilizer and fossil fuel industries are increasingly collaborating to launder fossil fuels—particularly gas—as an ever-expanding source of both "clean" energy and "clean" agrochemicals. It is neither.

Beyond the threats it poses to biodiversity, human health, and the global climate, the deep integration of fossil fuels and industrial agrochemicals poses profound threats to global food security—as starkly illustrated by the 2022 market shocks in food, fuel, and fertilizer prices. As this report goes to design in mid-September 2022, acute gas shortages and massive near-term price spikes have spurred leading fertilizer companies to announce short-term production cuts even as long-term investment plans expand. Given the global food system's current heavy dependence on chemical inputs, the widespread overuse and inequitable allocation of those inputs, and the disruption of both grain and fertilizer exports caused by Russia's invasion of Ukraine, there is reason to be concerned that a further decline in fertilizer access will compound the near-term threats to food security created by the invasion itself. But the roots of these concerns lie in the systemic flaws of industrial food production, rather than shortages of a product that in actuality does not promote food security but instead undermines food sovereignty. As this report details, there has never been a clearer moment nor a more urgent need to reconsider the current system, especially the role of fossil fertilizers.

As the world must urgently transition away from the fossil economy, it must also confront and abandon the current fossil-based model of intensive, industrial agriculture, with the goal of scaling up resilient, regenerative models that enhance food and energy sovereignty so that the ecosystems and communities that depend on them can thrive. Such transitions can only be achieved by confronting head-on the fossil-fueled system that is pushing the Earth and its inhabitants beyond critical planetary boundaries. Against the present backdrop of intersecting crises, the case for doing so has never been clearer.

Introduction

In April 2022, just six weeks after Russia invaded Ukraine, data from the FAO revealed that in March, global food prices reached the highest levels ever recorded.[1] Six months later, leading fertilizer companies in Europe are citing spiking gas prices as a reason to shut down or curtail production. Norwegian chemical company Yara announced on August 25th that it would only use 35 percent of its ammonia production capacity in Europe.[2] That same week, the Polish chemical company Grupa Azoty said it was halting production of nitrogen fertilizers and cutting ammonium output down to about 10 percent capacity.[3] "The current situation in the natural gas market, which determines the profitability of production, is exceptional, completely independent of the company and impossible to foresee," the company said in a regulatory filing.[4] Other European fertilizer companies have also announced or implemented severe cuts, and more of these announcements can be expected in the coming weeks and months.[5]

The global impacts of Russia's war have laid bare the structural vulnerabilities of fossil fuel-dependent global energy and agricultural systems. But with shrinking production in Europe and still no cuts in countries where per capita fertilizer use is highest, fertilizer companies outside of Europe are seeing the current situation as an opportunity to grow production to fill gaps in the market. This demonstrates that short-term production cuts in one part of the world will do little to transform our systems' underlying structural problems. There has never been a clearer moment or a more urgent need to reconsider the current system, especially the role of synthetic fertilizers derived from fossil fuels—"fossil fertilizers."

The petrochemical inputs needed to sustain the industrial food chain—synthetic fertilizers and pesticides, collectively "agrochemicals"—are fossil fuels in another form. Derivatives of fossil fuels are used in the chemical manufacturing of pesticides, and nitrogen fertilizer is made from fossil fuels, mostly fossil gas. Synthetic nitrogen fertilizer, the principal focus of this report, tethers our food systems to the oil and gas industry's instabilities, yoking food to fuel in a way that exacerbates insecurity and conflict.

Understanding how fossil fuels are at the root of converging crises—from climate catastrophe and biodiversity collapse to plastic pollution and toxic chemicals—is a critical first step to systematically addressing these interconnected environmental and health threats. Petroleum, plastics, and agrochemicals make up a toxic triad centered on fossil fuels.

Russia is not only a major producer of wheat, oil, and gas but also a top exporter of nitrogen fertilizer, exerting significant control over supplies. The decrease in gas supply has spurred fuel price shocks around the world, which have, in turn, driven up the price of fossil fuel-based products and food.[6] The whole industrialized food chain, from production to processing and distribution, retail, and consumption, is entrenched in fossil fuels.

Fossil fertilizers and pesticides are key chemical inputs without which our current industrial food systems would collapse. They are interdependent—one requires the use of the other—and both are designed for a farming system geared towards monocultures and high yields. Synthetic fertilizers and pesticides both result in deleterious effects on soil biota, including disrupting natural nutrient cycling and natural pest control. The effect is that soils become dependent upon greater inputs of synthetic chemicals to maintain yields,[7] shackling food production to harmful petrochemicals. They do little to provide food security;[8] on the contrary, their use creates dependencies along the supply chain that undermine food sovereignty while supporting corporate concentration and control.[9]

Industrial agriculture is playing a significant role in driving us towards climate disaster and ecological collapse. Fossil-fueled agrochemicals are contributing to the crossing of multiple scientifically established "planetary boundaries"—processes that regulate the stability and resilience of the Earth's systems. Loss of biodiversity, land-use change, chemical pollution (through the introduction of "novel entities"), and climate change are among those exceeded boundaries.[10]

Food systems are responsible for roughly one-third of GHG emissions, and fossil fertilizer is an underrecognized contributor to this figure.[11] The food system's dependence on fossil inputs adds to the significant climate impacts from land-use change, deforestation, and industrial livestock production that are currently, and rightly, the main focus of any discourse connecting food systems and climate. This report intends to add to the conversation by highlighting how the chemical inputs to industrial agriculture exacerbate the problem.

Like plastics, agrochemical products impact human and environmental health at every phase of their life cycle, often and more profoundly for communities living next to petrochemical facilities or fields where agrochemicals are used.[12] The toxic fossil fuel-based food system not only poisons the environment but also threatens human rights on a vast scale.[13] The right to life and the right to a healthy environment are increasingly endangered in a rapidly warming world. The right to water is at risk as droughts intensify and as overconsumption of fossil fertilizer results in nutrient pollution that chokes aquatic ecosystems. The UN Special Rapporteur on the right to food notes: "Chemical fertilizers do not ensure food security. Their pervasive use sometimes increases crop production in the short-term, but it creates a longer-term dependency on corporations and trade."[14]

When looking at agrochemicals as fossil fuels in another form, there is much to learn from the recent conversations about plastics as petrochemicals. Plastics are now widely known to be harmful from a climate perspective, generating GHG emissions at every stage of their life cycle.[15] Understanding how fossil fuels are at the root of converging crises—from climate catastrophe and biodiversity collapse to plastic pollution and toxic chemicals—is a critical first step to systematically addressing these interconnected environmental and health threats. Petroleum, plastics, and agrochemicals make up a toxic triad centered on fossil fuels.

We are now at a critical crossroads, and the need to rapidly phase out fossil fuels while transforming our energy and food systems towards decentralized energy and agroecology has been recognized by both academics and policymakers.[16] But political decisions, investments, and policy changes are currently leading us in the opposite direction. To understand this cognitive dissonance, it is important to examine the strategies the fossil fuel industry pursues. Rather than reducing reliance on fossil fuels and fossil fuel-derived inputs, both the

fossil fuel and the fertilizer industries are instead promoting ways to increase or prolong dependence on their products under the guise of climate solutions, profiting from the climate crisis while doubling down on links between food and fossil fuels.

The fossil fuel and fertilizer industries are advancing technologies and alternative fuels that support their core emissions-intensive business activities while allowing them to cash in on generous subsidies. CCS presents the possibility of low-carbon fossil fuels, although it is riddled with failures and cost overruns and does not address most emissions. The industry often presents hydrogen and ammonia as carbon-free fuels for energy production, transportation, and industry, hiding the fact that they are almost entirely made from fossil fuels and simply reshuffle emissions from one part of the life cycle to another. CCS and hydrogen or ammonia paired with CCS allow the two industries to misleadingly present themselves as part of the solution to the climate crisis while, in actuality, perpetuating GHG emissions and delaying the necessary phaseout of chemical fertilizer and, critically, of fossil fuels.

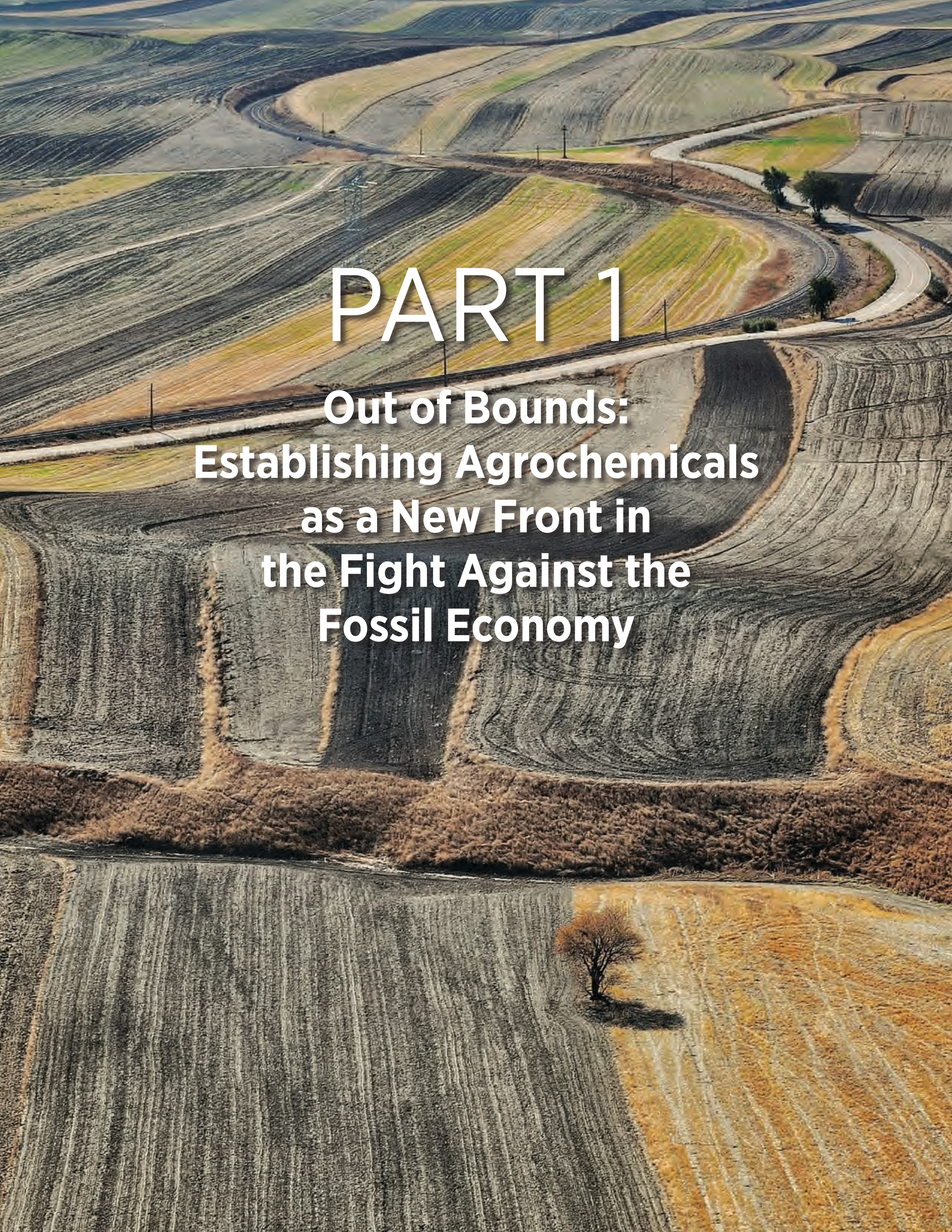
The confluence of interest between fossil fuel and fertilizer companies is rooted in the fact that hydrogen, ammonia, and carbon dioxide are already fundamental aspects of fertilizer production. The fertilizer industry produces hydrogen and ammonia as precursors for fertilizer. Therefore, developing additional markets and government support for both presents a financial opportunity. Moreover, because carbon dioxide is a feedstock for most fertilizers, the industry has a long history of employing carbon capture (but not storage) for use in fertilizer production. It is well-positioned to profit from public subsidies for CCS deployment. Ultimately, the existing core business model for synthetic nitrogen fertilizer production embodies the primary strategies the fossil fuel industry employs to delay a transition from fossil fuels.

What is true for plastics, petrochemicals, and fossil fuels is also true for agrochemicals: These schemes are little more than distractions intended to serve as escape hatches for the industries seeking to maintain their social licenses in an era of accelerated climate breakdown and ecological collapse. At a time of surging fossil fuel and fertilizer prices and related impacts on food and energy security, and with the climate crisis as a backdrop, the case for transitioning away from chemical fertilizer and pesticides, and from fossil fuels overall, has never been clearer.

Part 1 of this report sets the stage by summarizing synthetic fertilizer market trends, describing how chemical fertilizer is tied to fossil fuels through feedstocks, examining the 2022 food and fertilizer market disruptions, and calling attention to the ecological and climate impacts of synthetic fertilizers. It also includes a description of key corporate actors in the fertilizer space, with profiles of major nitrogen fertilizer producers. Part 2 explores how the fertilizer industry and fossil fuel producers are capitalizing on the climate crisis to open new avenues for profit and production through initiatives in CCS, as well as in hydrogen and ammonia. The report finishes with some key messages and conclusions.

PART 1

Out of Bounds: Establishing Agrochemicals as a New Front in the Fight Against the Fossil Economy



The industrial food production system is pushing the world past multiple planetary boundaries, from biodiversity collapse and land conversion to nutrient and chemical pollution. Fertilizers and pesticides are interdependent inputs that fuel this destructive food production model, contributing to GHG emissions, endangering human and ecosystem health, and threatening human rights on a massive scale. Fertilizer use has been rising for decades, increasing nearly ninefold since the 1960s. The FAO projects that consumption will rise a further 50 percent by 2050, a projection that is incompatible with achieving international climate goals and respecting planetary boundaries.

Synthetic nitrogen fertilizer and pesticides are fossil fuels in another form, making them an underrecognized but significant driver of the climate crisis. Synthetic nitrogen fertilizer alone accounts for about 2 percent of global GHG emissions, with more than 38 percent of those emissions coming solely from its production. The fossil fuel industry is banking on a growing petrochemicals market to keep profits flowing as it faces the inevitable energy transition. Along with plastics, fertilizers represent one of the largest groups of products in this market. The close ties between agrochemicals and fossil fuels also mean that industrial food production is vulnerable to the volatility inherent in oil and gas markets. As the 2022 market upheavals, exacerbated by Russia's war in Ukraine, painfully demonstrate, fossil fuel dependency is dangerous in every form. The first part of this report will analyze historical trends and current disruptions to the fertilizer market, expose deep interlinkages between agrochemicals and fossil fuels, and examine the ecological and climate impacts of fossil fertilizers at every stage of their life cycle.

Petrochemical Growth and the Global Fertilizer Market

Nitrogen fertilizer usage has grown substantially since the mid-twentieth century, when the chemical industry converted a post-World War II surplus of nitrogen production capacity previously used to make explosives for the war to fertilizer production.[17] Production and use of chemical fertilizer subsequently skyrocketed, increasing nearly ninefold over the following decades. As the fossil fuel industry stakes greater reliance on non-energy uses of its products (in the form of chemical feedstocks) to boost profits during a time of energy transition away from fossil fuels, it is turning to nitrogen fertilizer as a continued growth pathway for fossil gas.

Potassium, phosphorus, and nitrogen are the three key nutrients needed for plant growth. Of these, synthetic nitrogen fertilizer is the most widely used type of fertilizer, accounting for about 56 percent of the total fertilizer used worldwide.[18] Derived from fossil fuels, nitrogen fertilizer is a central pillar of the petrochemical sector: The fertilizer industry repurposes fossil fuel feedstock, primarily from fossil gas, to make this type of fertilizer. Unlike nitrogen fertilizer, potassium- and phosphorus-based fertilizers represent a smaller portion of global fertilizer use (20 and 24 percent, respectively) and do not rely on fossil gas as a raw material.[19] The term "fertilizer" in this report refers to nitrogen fertilizer derived from fossil fuels, or "fossil fertilizer."

This section highlights the role of petrochemicals as a driver of continued oil and gas use. It describes historical market trends for nitrogen fertilizer, as well as the market outlook prior to the 2022 upheaval.

Petrochemicals Are a Major Driver of Oil and Gas Production

The fossil fuel industry is banking on a growing petrochemicals market to support global oil and gas use. Petrochemicals already account for about 14 percent of global oil and 8 percent of gas usage.[20] According to a 2021 report from the IEA, the petrochemical sector is projected to account for over

two-thirds of global oil usage growth through 2026.[21] In its *2021 Energy Outlook*, the IEA constructed several different scenarios for oil and gas use through 2030 and 2050. According to the IEA, "[o]il use for petrochemicals grows in all scenarios,"[22] including its "net-zero emissions" (NZE) scenario where worldwide oil usage dramatically declines by midcentury. In the NZE scenario, petrochemicals account for over half (55 percent) of total oil usage worldwide in 2050.[23] As the IEA states: "Oil use as a petrochemical feedstock is the only area to see an increase in demand."[24] Oil companies are therefore positioned to increasingly rely on petrochemicals for future growth.

Along with plastics production, the manufacture of synthetic fertilizers is the other major route for the proliferation of petrochemicals. Together, **plastics and fertilizer are the two largest groups of chemical sector products,[25] accounting for over 74 percent of the sector's products.[26]** They are also the most important pillars of growth to keep profits flowing for the oil and gas industry as it faces the inevitable energy transition.[27]

Nitrogen fertilizer, along with plastic precursors and the industrial chemical methanol (CH_3OH), is driving the growth of fossil gas use for chemical feedstocks. As the IEA states in a 2020 report on gas: "Fertiliser represents the greatest growth sector among feedstock uses over the forecast period, increasing by 3.5% annually to reach over 100 bcm in 2025."[28] In the IEA's NZE scenario, by 2050, over half of fossil gas consumption is expected to go towards producing hydrogen, the key ingredient in ammonia that is the chemical base for nitrogen fertilizer.[29] According to the IEA's modeling based on current economic trends, ammonia production is projected to grow by more than 30 percent by 2050.[30]

The Pervasive Overuse of Fossil Fertilizers: Production and Consumption Have Risen for Decades

The Haber-Bosch process, named for two German chemists who developed it in the early 20th century, enables the industrial-scale production of nitrogen in the form of ammonia. During World War II, the munitions industry used this process to manufacture ammonium nitrate (NH_4NO_3) for

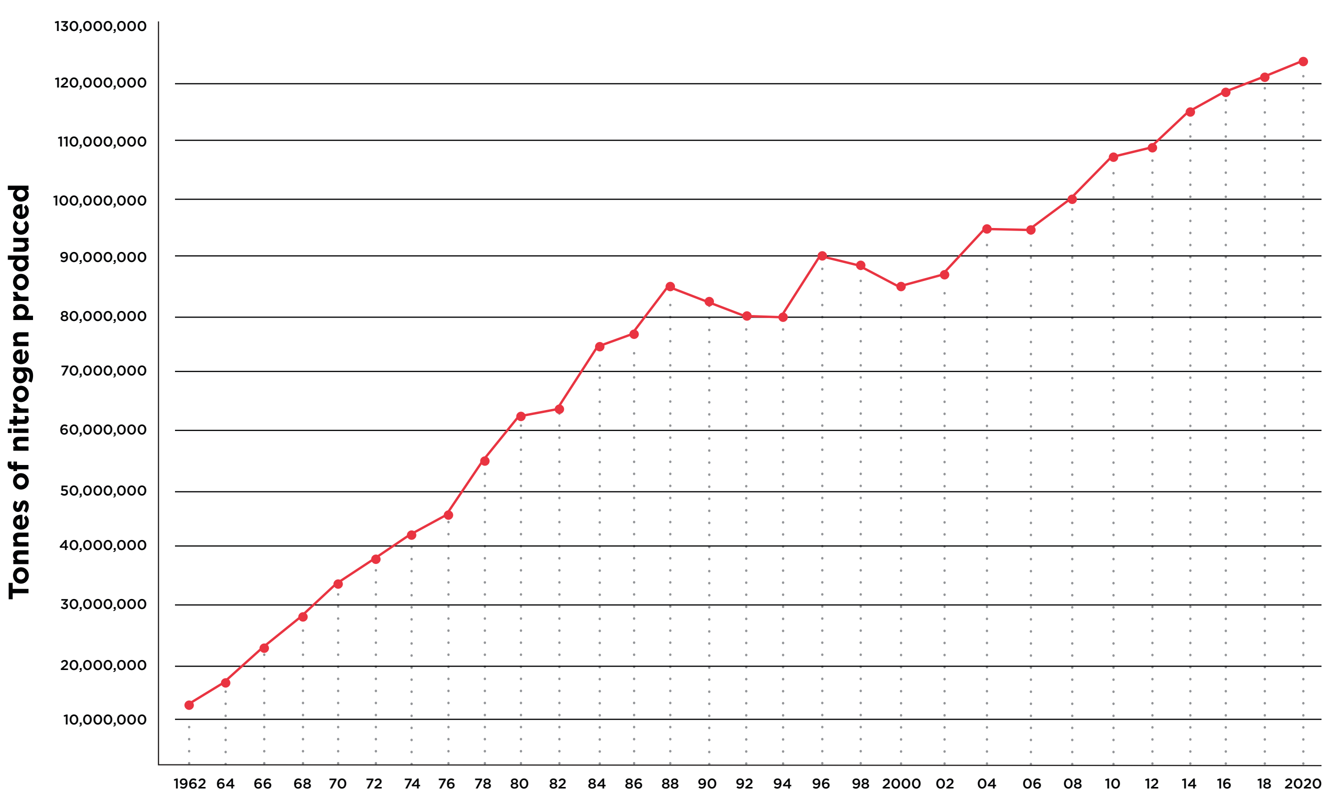
> As the IPCC notes in a 2019 report on climate change and land, nitrogen fertilizer production has increased nearly ninefold since 1961, reaching a staggering 123 million tonnes in 2020.

explosives.[31] Following the war, manufacturers reoriented this capacity for nitrogen production towards producing fertilizer rather than explosives. The same properties that make ammonium nitrate useful for weapons of war also make its production and transport for use in fertilizers highly hazardous.

Fossil fertilizers and other agrochemical inputs have proliferated as a direct result of corporate and political interests promoting the "Green Revolution" in the 1960s. Government programs and subsidies compelled farmers to rely on heavy fertilizer applications to raise crop yields to feed a growing population. The heavy reliance on fertilizers established a vicious cycle in which ever more chemical inputs had to be used to sustain yields, while depleting and poisoning soils,

Figure 1

Global Nitrogen Fertilizer Production by Year



Credit: Data from FAOSTAT.

water, and species. This approach tied food systems to fossil fuels and it displaced other more sustainable and regenerative agricultural approaches that could have maintained ecosystem integrity and supported food sovereignty without reliance on fossil fertilizers.[32]

Industrial agriculture based on monoculture crops and chemical inputs has primarily benefited large corporations. It is no coincidence that the agriculture sector has seen a dramatic increase in corporate concentration along the entire supply chain of commodities.[33] Fossil fertilizer companies have managed to capitalize on a system that allows them to market a chemical feedstock that the petrochemical industry was already producing in massive quantities by improperly equating industrialized monoculture production with food security.[34]

Nitrogen fertilizer production and consumption have risen dramatically over the last several decades. As the IPCC notes in a 2019 report on climate change and land, nitrogen fertilizer production has increased nearly ninefold since 1961, reaching a staggering 123 million tonnes in 2020.[35]

Despite this enormous growth, global fertilizer production remains highly concentrated, not just in the corporate sector but also geographically, with just ten countries producing more than 70 percent of all fossil fertilizers.[36] Just four of these countries—China, India, the United States, and Russia—produce more than half of all nitrogen-based fertilizer worldwide. According to FAO data from 2020, nitrogen fertilizer production totaled approximately 32 million tonnes in China, 13.7 million tonnes in India, 13.2 million tonnes in the US, and 11.2 million tonnes in Russia.[37]

While production and consumption of fossil fertilizer have risen significantly, the number of producers has declined as the industry consolidates. In the US, for example, the number of nitrogen fertilizer companies fell from forty-six in the 1980s to thirteen by the mid-2000s. By 2019, just four firms controlled 75 percent of US domestic production.[38]

Fertilizer production is also geographically concentrated in areas with abundant oil and gas reserves; in the US, approximately 60 percent of production capacity is in the gas-rich states of Louisiana, Oklahoma, and Texas.[39] The industry is planning or has recently completed new construction or expansion of existing facilities in all of these states and in Indiana, Illinois, Mississippi, Alaska, Pennsylvania, Iowa, Kansas, and Nebraska.[40]

Three of the largest producing countries—the US, China, and India—are also major markets for synthetic nitrogen fertilizer. These three countries alone used nearly 58 million tonnes of chemical fertilizers in 2020. While China and India were larger markets by overall volume, per capita fertilizer consumption in the US (31.74 kg per capita) was nearly two times greater than fertilizer use in China (16.47 kg per capita) and more than twice the level of use in India (13.7 kg per capita).[41]

This is emblematic of a wider phenomenon, with Asia as a region using a lower average amount of overall fertilizer (nitrogen, phosphorus, and potassium) in 2020 than the Americas, Europe, and Oceania when measured per capita.[42] According to FAO data, in 2020, the top three countries with the largest use of nitrogen fertilizer *per capita*—New Zealand, Canada, and Ireland—were all members of the Organisation for Economic Co-operation and Development (OECD).[43] Therefore, annual nitrogen fertilizer use has leveled off in higher-income countries such as Japan, the US, and parts of western Europe at around 85–135 kg per capita. At the same time, the per capita consumption levels still far exceed those of lower-income developing countries and regions like India, China, and parts of Africa, where fertilizer use (both per capita and by volume) is increasing.[44] Moreover, although fertilizer use in Africa is rising, the African region remains the smallest user per capita, with an average of 5 kg per capita of total fertilizer usage in 2020.[45]

Several factors contribute to the rising fertilizer usage. Development financiers and agribusiness corporations play a key role in promoting chemical-intensive agriculture in developing regions. For example, the Alliance for a Green Revolution in Africa (AGRA), an initiative driven by donor institutions and chemical industry interests, facilitates input-intensive agriculture for small-scale African farmers, but has produced questionable results for farmers' livelihoods and food security.[46] An AGRA donor-commissioned evaluation report released in February 2022 found "limited rigorous evidence of AGRA's positive impact on food security and resilience"[47] and suggested the program "did not meet its headline goal of increased incomes and food security for nine million smallholders."[48] African civil society organizations are calling for an end to the AGRA program and released an open letter demanding that donors stop funding AGRA.[49]

Reliance on commodity crops like corn and soy also increases chemical fertilizer dependency and usage. In the US, corn production is a major driver of nitrogen fertilizer use, but it does little for global food security. Historically, more than 40 percent of commercial fertilizer used in the US is for corn,[50] and nearly three-quarters (74 percent) of US corn goes towards producing biofuels and animal feed.[51] Federal policy mandates that gasoline be blended with a biofuel like ethanol (C_2H_5OH),[52] and corn-based ethanol accounts for the vast majority of US biofuel production.[53] Therefore, a considerable portion of fertilizer-intensive US corn production (almost 30 percent)[54] goes towards fueling cars instead of feeding people. An even greater portion of corn grown in the US (approximately 46 percent) goes towards animal feed.[55]

Around the world, the production of animal feed—including the incorporated fertilizer production and use—is the second biggest contributor (estimated at 41 percent) to GHG emissions from livestock, an emissions-intensive sector in which cattle by far accounts for the largest climate impact (representing 62 percent of the sector's emissions).[56]

On the other hand, the availability of abundant and cheap fossil fuels contributes to the increased *production* of fossil agrochemicals. According to the IEA, "[a]dditional demand for gas as a fuel for industrial processes principally comes from China, India and other Asian markets, while demand for gas as a feedstock is driven by gas-rich countries and regions such as the US, Russia, North Africa and the Middle East, for manufacturing fertilisers and petrochemicals for both exports and domestic markets."[57]

Despite historical growth patterns for nitrogen fertilizer, continued growth is not inevitable. Fertilizer use is already leveling off in mature markets. Moreover, rising concerns over synthetic fertilizers' climate and environmental impacts are prompting regulations and policies that limit fertilizer use.[58] Finally, the market disruptions exacerbated by Russia's war in Ukraine make it difficult to predict what fertilizer supply and demand will look like over the next few years.[59] This uncertainty suggests that fertilizer producers will be eager to find new market opportunities and applications for their products. As one of the world's largest nitrogen fertilizer producers stated in a press release: "Building on its long experience and leading position within global ammonia production, logistics and trade, Yara aims to capture opportunities within shipping, agriculture and industrial applications, in a market expected to grow by 60 percent over the next two decades."[60] In parallel to the response seen in the gas sector, where governments and companies are scrambling to secure new supplies, disruptions to the fertilizer market have led to calls for increased production outside of Russia.[61] This move would create significant new harm and only exacerbate the fossil fuel reliance at the heart of the crisis.

Agrochemicals Are Fossil Fuels in Another Form

Fossil fuels provide both the energy and the primary feedstock for the production of synthetic nitrogen fertilizers and most pesticides, making agrochemicals a significant driver of global fossil fuel use and its attendant climate and environmental impacts.

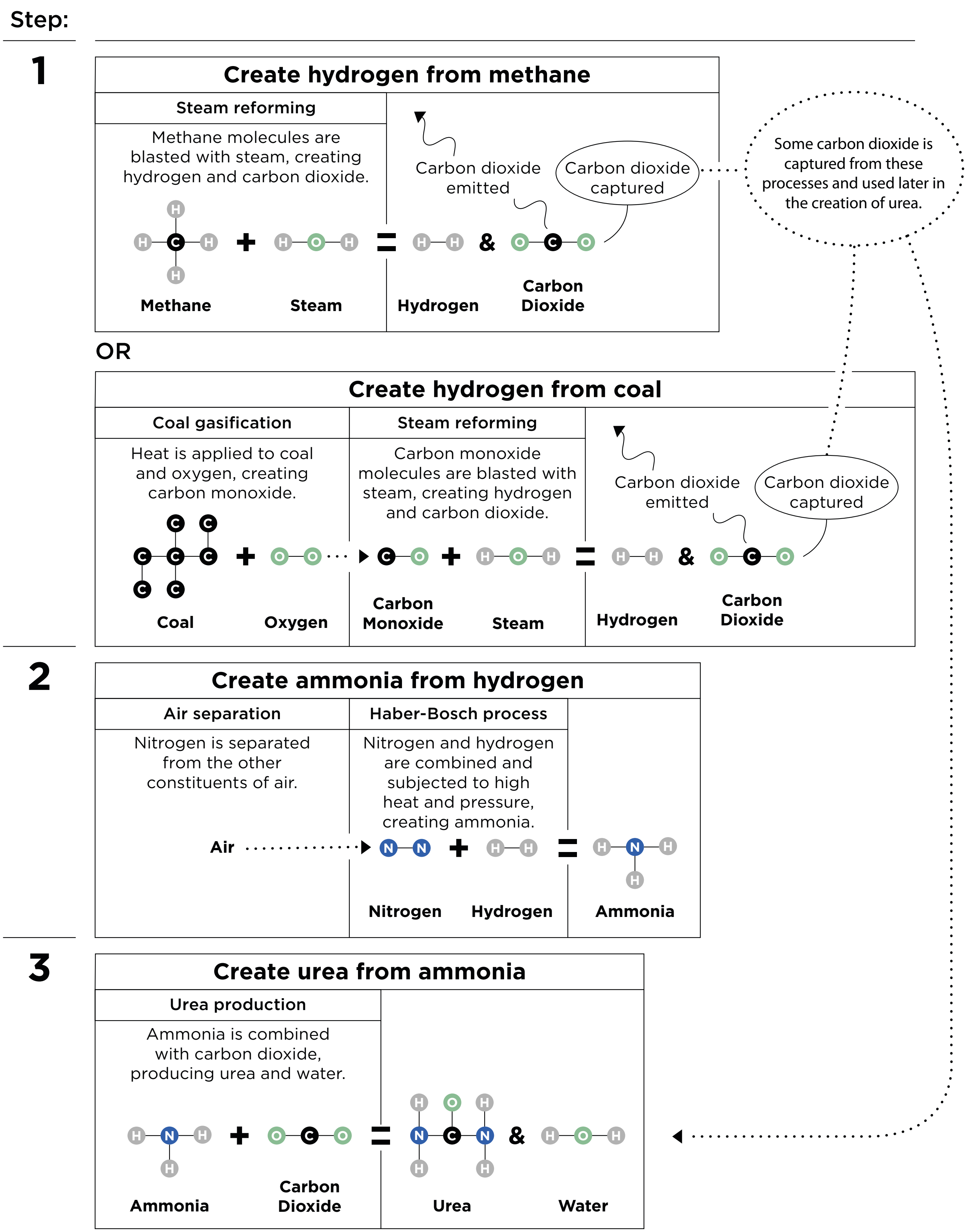
Fossil Fertilizer: Nitrogen Fertilizer from Fossil Gas

Although humans have been practicing agriculture for millennia, the industrialized fossil fuel-based model emerged relatively recently. It was not until the mid-twentieth century that agriculture became a key climate change contributor, with the rise of industrial-scale farming enabled by fossil fuels, particularly with the increasing use of synthetic nitrogen fertilizer.[62]

Nitrogen fertilizer is derived from ammonia, which is synthesized by combining nitrogen from the air with hydrogen from fossil fuels—typically fossil gas. Globally, about 72 percent of the hydrogen used for ammonia production comes from fossil gas (in a process called steam methane reforming), and 26 percent comes from coal.[63] The energy-intensive Haber-Bosch process that produces ammonia accounts for about 5 percent of industrial coal demand (75 million tonnes of coal equivalent) and about 20 percent of industrial gas demand (170 bcm of fossil gas).[64] Fertilizer producers then convert ammonia into ammonium nitrate or urea ($CO(NH_2)_2$) as the base for fertilizer. Urea uses carbon dioxide in its synthesis. The vast majority of ammonia produced globally (around 80 percent) goes to producing urea,[65] the most common type of nitrogen fertilizer.

Therefore, nitrogen-based fertilizer is predominantly produced from fossil gas—which is made up of methane (CH_4), another potent GHG. Approximately **3–5 percent of the world's fossil gas production is used for synthesizing ammonia**.[66] In the US, approximately 6.5 percent of industrial fossil gas consumption went to ammonia production in 2020.[67] The US produced approximately 14 million tonnes of ammonia in 2020,[68] making it the third-largest ammonia producer behind China and Russia.[69] Nearly a quarter (24 percent) of the chemical sector's fossil fuel feedstock input of over 500 million tonnes goes to ammonia production.[70]

Figure 2
Fossil Fuels to Fertilizers



Credit: Information from a policy briefing by the Royal Society and a report by the IEA.

BOX 1

Petroleum-Based Pesticides Pollute and Poison

Pesticides (including, but not limited to, herbicides, insecticides, and fungicides) are among the most toxic substances on the planet, inflicting widespread damage to ecosystems and human health.[71] From dichloro-diphenyl-trichloroethane (DDT), the chemical that spurred Rachel Carson to write *Silent Spring*, to atrazine and neonicotinoids, which are implicated in the decline of amphibian and insect populations, pesticides are threatening species and ecosystems worldwide. And humans are not immune from these risks. Some of the health impacts associated with pesticide exposure include cancers, neurological impairment, immunological and reproductive defects,[72] and endocrine disruption.[73]

Yet pesticide production and use have grown sharply over the last several decades, despite mounting evidence and rising awareness of their individual risks and cumulative impacts. Global pesticide use doubled between 1990 and 2015.[74] This aligns with the extensive growth in synthetic fertilizer usage. That growth trend is expected to continue in the coming years, with combined global sales of synthetic fertilizer and pesticides projected to reach USD309 billion by 2025.[75]

Nearly all synthetic chemicals—99 percent—come from oil and fossil gas.[76] Fossil gas liquids (ethane (C_2H_6), propane (C_3H_8), and butane (C_4H_{10})) and naphtha (from petroleum) are processed or "cracked" under high heat to synthesize gaseous petrochemical feedstocks. These chemicals are then used to produce various products, including pesticides.

Some pesticides are derived from methylamine (CH_3NH_2) via methanol, which comes from fossil gas; some from chlorinated benzene (C_6H_5Cl), which comes from crude oil and coal; and some herbicides from nitrobenzene ($C_6H_5NO_2$), which can also be traced back to crude oil or coal.[77] The insecticide DDT, for example, is synthesized from chlorinated benzene. Many other types of pesticides, such as neonicotinoids, pyrethroids, and glyphosate, can also be traced back to petroleum-based feedstocks.[78]

Familiar names in the oil and gas business are also major players in the petrochemicals business, supplying feedstocks for agrochemicals. ExxonMobil, for example, has a division called ExxonMobil Chemical, which states on its website: "Our portfolio of high-solvency hydrocarbon fluids is designed to help agricultural pesticide producers formulate products."[79] Chevron Phillips Chemical, a joint venture of Chevron and Phillips 66, also notes on its website that it contributes chemicals used in food and agriculture.[80]

Furthermore, fossil fuel companies have historically been on the leading edge of developing new pesticide formulations,

including the highly toxic class of insecticides known as neonicotinoids. Neonicotinoids are synthetic nicotine derivatives designed to target insects' central nervous systems. In the 1970s, Shell Oil, one of the world's largest oil and gas companies, developed the first neonicotinoid compound, nithiazine.[81] The pesticide industry made neonicotinoids commercially available in the 1990s; nithiazine was the lead compound in the synthesis of the first commercially successful neonicotinoids.[82]

Like fertilizers, pesticides also play an underrecognized role in driving the climate crisis. **Pesticide production has a direct carbon footprint**: Fossil fuels are used both for chemical feedstocks and as an energy source during the manufacturing process.[83] However, emissions from pesticide production are difficult to quantify reliably because of data gaps, which are largely due to commercial confidentiality, that allow pesticide producers to avoid disclosing complete information regarding their products' ingredients.[84] Often used in conjunction with fossil fertilizers, pesticides also damage soil health and function, thus hampering soils' capacity to sequester carbon.[85] For example, chemical herbicides can damage beneficial soil microorganisms like mycorrhizal fungi,[86] which help enhance plant nutrient uptake and conserve soil organic matter.[87]

Moreover, one recent study found that pesticides pose a hazard to soil invertebrates[88]—organisms that play an important role in soil carbon sequestration. As the study explains: "Soil invertebrates also form up to half of all soil aggregates by breaking down litter and releasing organically rich casts and feces. The formation of these large soil aggregates allows for greater soil carbon sequestration, thus these ecosystem engineers play a role in offsetting fossil fuel emissions and combating climate change."[89] As a result, pesticides play a significant role in the increasing GHG emissions from agricultural soils, and this emissions impact may be greatly underestimated.[90]

Market Shocks and Misguided Policy Responses Demonstrate the Peril of Tying Food Production to Fossil Fuels

In 2022, fertilizer prices spiked and supplies dwindled, demonstrating the vulnerability of a global food system reliant on chemical inputs[91] and based on the concentrated production of a handful of commodity crops in a few countries.[92] Record food prices stem both from conflict-driven disruptions of grain production and exports and from surging costs of fertilizer and fossil fuels in other food-growing regions—with accelerating climate impacts further straining our food systems. A June 2022 FAO report on global food markets noted that a new measure called the Global Input Price Index (a metric introduced by FAO in November 2021 tracking input prices for energy, fertilizers, pesticides, feed, and seed)[93] set an all-time high, largely due to "record energy and fertilizer prices."[94] Russia's military invasion of Ukraine catalyzed the crisis in food, fuel, and fertilizer markets, although broader supply chain issues and soaring prices preceded this geopolitical turmoil.

Fertilizer costs were already rising before Russia invaded Ukraine on February 24, 2022. For example, nitrogen fertilizer prices rose 95 percent in the US in 2021.[95] According to the FAO, the price of urea, the most common type of nitrogen fertilizer, had more than tripled by the end of 2021.[96] Fertilizer prices spiked due to several factors, including distribution and supply chain disruptions, increased global fertilizer use, and, in particular, rising fossil fuel costs.[97] Spiking prices for fossil gas, the key raw material for producing nitrogen fertilizer, resulted in some fertilizer companies curtailing or even shutting down production,[98] further impacting fertilizer and food markets.

Underlying structural factors in the global food system render it fragile and vulnerable to price shocks. One of those factors is the "financialization of food," a concept marked by the commodification of food and increasing speculation in food markets. A recent report reveals how financial regulators have failed to implement measures against excessive speculation proposed after the last crisis in 2008 and how international banks and retail investors are making profits through speculation against the backdrop of Russia's war.[99] Other structural factors include food import and production dependencies (namely increasing corporate consolidation and control of the food supply chain) and a vicious cycle of poverty, accelerating climate change impacts, conflict, and food insecurities.[100]

In 2022, fertilizer prices spiked and supplies dwindled, demonstrating the vulnerability of a global food system reliant on chemical inputs and based on the concentrated production of a handful of commodity crops in a few countries.

The Russian invasion of Ukraine has significantly compounded these vulnerabilities. Russia and Ukraine are both major exporters of agricultural commodities, and the two countries account for 25 percent of the world's wheat exports.[101] Many countries, particularly in Africa and western Asia, depend on imports for their staple crop needs.[102] Russia is the world's top exporter of nitrogen fertilizer, accounting for roughly 15 percent of total global exports in 2021,[103] including 46 percent of the ammonium nitrate trade.[104] According to the International Fertilizer Association (IFA), Russia also supplies 23 percent of the world's traded volume of ammonia, the primary ingredient in nitrogen-based fertilizers.[105]

Russia is also a key petrostate supplier of fossil fuels, especially to Europe. The European Union receives 45 percent of its coal, 25 percent of its oil, and 31 percent of its gas from Russia.[106] The geopolitical impacts of the ongoing war have left many European governments scrambling for alternative supplies of fossil fuels,[107] while the European fertilizer industry has curtailed production due to steep gas costs.[108] The

European fertilizer lobby, Fertilizers Europe, reports that the industry has had to curtail or close more than ten plants during July 2022 alone.[109] In late August, Fertilizers Europe put out a statement claiming that the European fertilizer industry is a "victim" of the EU's energy crisis. The association asserts that skyrocketing gas prices (rising more than 1,000 percent in the last year) have led to the curtailment of more than 70 percent of European fertilizer production.[110] The statement shows fertilizer producers' reliance on fossil gas supplies, while highlighting their extreme vulnerability to surging gas prices and broader fossil fuel market volatility.

The war-driven market shocks demonstrate the dangers of dependency on fossil fertilizer and, more broadly, of tying food production and prices to oil and gas. According to the IFA, "[t]he war in Ukraine is the biggest geopolitical disruption to hit the global fertilizer market in decades."[111] Reducing reliance not just on Russian energy and fertilizer, but on fossil fuel in all its forms, is imperative to addressing energy *and* food security issues.

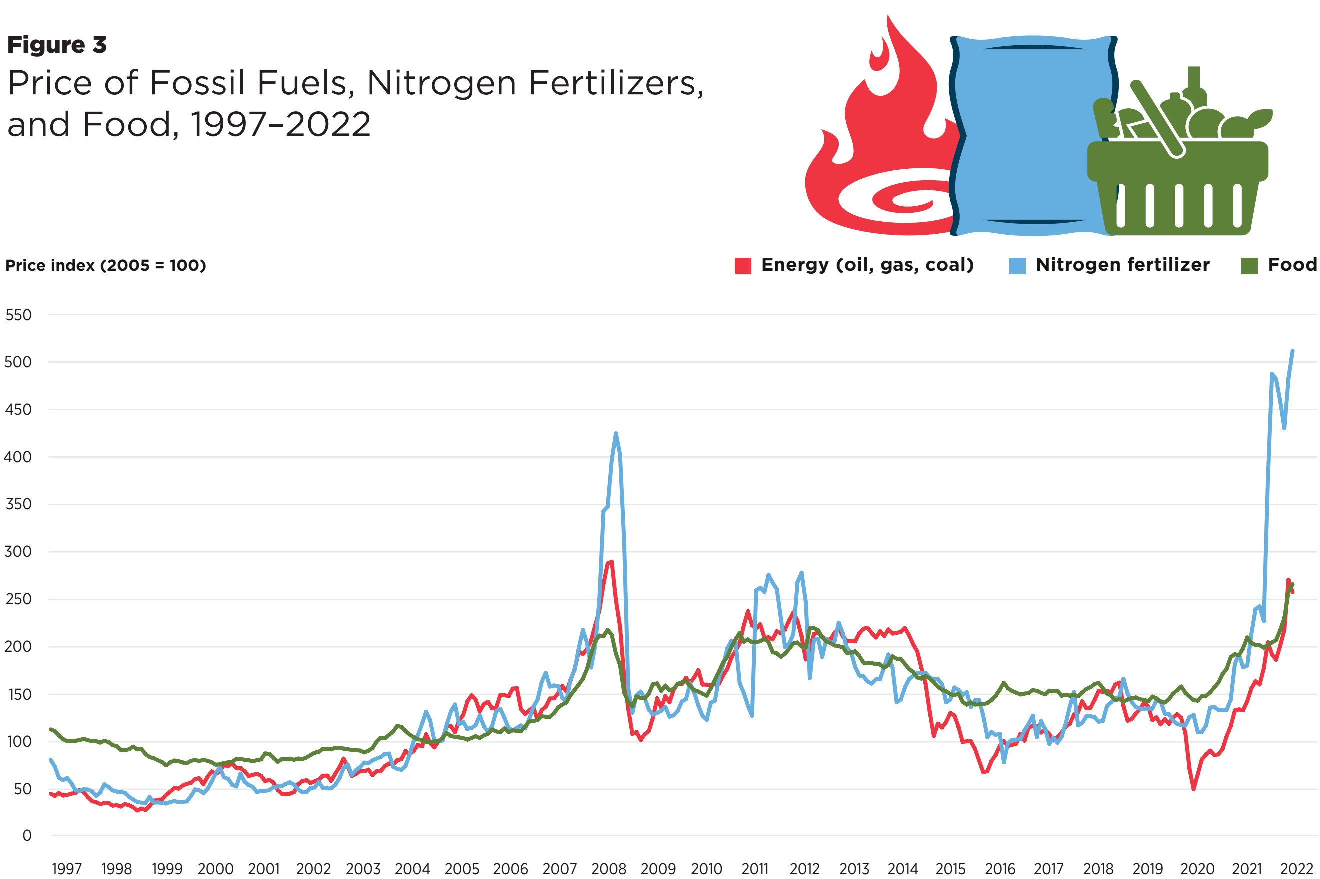
Misguided Policy Responses to the 2022 Food and Fertilizer Crises

A key step to ending fossil fuel addiction is shifting away from the industrialized, chemical-intensive food production system, which relies heavily on fossil fuels.[112] A May 2022 statement[113] from the UN Special Rapporteur on the right to food highlights the underlying drivers of food system vulnerability. In the statement criticizing the response to the 2022 food crisis from the World Bank Group, the World Trade Organization, the International Monetary Fund, and the World Food Programme, Michael Fakhri calls out dependence on chemical fertilizers as particularly problematic: "Moreover, the fundamental problem is not that farmers' access to chemical fertilizers has been disrupted by the war in Ukraine, it is that so many farmers rely heavily on chemical fertilizers in the first place…**In the immediate term, it is important to make sure fertilizers reach farms whose farming system depends on chemical inputs, but the ultimate goal must be to wean them off this dependency as soon as possible.**"[114]

The UN agency responsible for ensuring food security—the FAO—recognizes this dependency and notes that the food system overall accounts for about 30 percent of global energy consumption.[115] More than a decade ago, the FAO warned of the dangers of the industrial food system's dependence on fossil fuels, writing in a 2011 report: "The challenge is to decouple food prices from fluctuating energy prices."[116] It also acknowledged that "[a] new paradigm of agriculture and food

Figure 3

Price of Fossil Fuels, Nitrogen Fertilizers, and Food, 1997–2022



Data: Internatonal Monetary Fund (IMF), 2022

Credit: Reproduced from a study published by INKOTA production is needed."[117] The FAO reiterated this warning in its report on the *State of Food Security and Nutrition in the World 2022,* concluding that current agricultural policies, which heavily emphasize production subsidies and incentives for commodity crops, are undermining food security and nutrition outcomes and are often environmentally harmful.[118]

Analysis by the FAO's High Level Panel of Experts on Food Security and Nutrition further highlights how the overuse of synthetic fertilizers can increase debt risk to small-scale producers while contributing to environmental harms.[119] It recommends that States and intergovernmental organizations (like the FAO) support the transition to diversified and resilient food systems by "strengthening the regulations on the use of chemicals harmful for human health and the environment in agriculture and food systems, promoting alternatives to their use and rewarding practices that produce without them."[120]

In response to the 2022 fertilizer and food crisis, the FAO is calling for using fertilizers more efficiently—such as using digital tools like soil maps[121]—thereby focusing on a short-term measure while ignoring the larger lessons about the need for a longer-term shift from fertilizer dependence. That short-term view is raising concerns: Some civil society organizations are sounding alarms over the FAO's response and the agency's growing coziness with corporate interests.[122] A May 2022 report from FIAN International and Corporate Accountability examines the extent of the FAO's engagement with the private sector and corporate interests, suggesting that the UN agency is increasingly vulnerable to corporate capture.[123] The groups assert that the FAO's promotion of fertilizer efficiency and digital tools, rather than advocating for the phaseout of fossil fuel fertilizer and alternative farming models like agroecology, exemplifies this influence.[124]

Other institutional responses to the fertilizer and food security crisis, particularly by governments, reflect the strong corporate influence on agricultural policy: Institutions are prioritizing short-term chemical-intensive crop production, yet they are also recognizing the need for food system transformation. For example, in June 2022, the US, Canada, Mexico, Argentina, and Brazil issued a joint statement affirming the short-term plan to stabilize food prices and maximize yields and, in the long-term, build "more resilient, safe, and sustainable global food systems."[125] The action plan calls for boosting crop yields, improving the flow of trade, providing humanitarian assistance, and increasing access to fertilizer.[126] The plan adopts industry-promoted narratives around the enhanced efficiency of fertilizer, as well as around "climate-smart" agriculture and "precision agriculture," which involve optimizing agrochemical applications rather than phasing out their usage. One such narrative is a framework the industry calls the "4Rs:" right fertilizer, right rate, right time, and right place. This framework calls for using synthetic fertilizer more *efficiently* instead of curbing its usage, thus ultimately locking in toxic pollution and fossil fuels. The framework also promotes greater reliance on so-called "controlled-release fertilizers," which are often coated in plastic, significantly contributing to plastic pollution in soils.[127]

On the other hand, the European Commission acknowledges the need to reduce overall fertilizer use, at least in principle, in its *Biodiversity Strategy for 2030*[128] and its *Farm to Fork Strategy*.[129] Therefore, the EU's response to the current crisis emphasizes systemic transformation and improving agricultural sustainability and resilience. But the response still includes a short-term focus on conventional agriculture intensification. One of the short-term measures that the European Commission announced in March 2022 is a temporary derogation, allowing the production of any crops for food and feed on fallow land.[130] The Commission claims this derogation is an "emergency measure" for 2022 and that improving diversity and resilience in agricultural production remains a medium-term priority.[131]

The short-term thinking and prioritization of chemical-intensive food production during a time of agricultural market disruptions mirrors many governments' emphasis in the energy sector on increasing fossil fuel production and building out new infrastructure to address the spikes in fuel prices. But rather than doubling down on agrochemicals and fossil fuels and propping up toxic industrialized systems that are structurally prone to shocks, governments and institutions need to work towards systemic transformations that can ensure greater food and energy security and protect human rights.

As a May 2022 report from the International Panel of Experts on Sustainable Food Systems explains, the current crisis "has provided the clearest evidence yet for the need to delink food and fuel by reducing reliance on synthetic fertilizer and fossil fuel energy in agriculture."[132] Already, the fertilizer crisis is causing some farmers to shift to alternative methods, such as using an organic fertilizer like manure, switching to crops that require less fertilizer, or simply reducing nitrogen fertilizer application.[133] Market shocks like the 2021–2022 price spikes in food, fuel, and fertilizer offer a unique opportunity to accelerate the shift away from fossil fertilizer towards more sustainable alternatives, which will not only enhance food security but also reduce reliance on fossil fuels. Such an opportunity should not be squandered.

Chemical Fertilizer Pollutes the Water, Air, and Soil

The overuse of synthetic fertilizers and pesticides results in nutrient and chemical pollution at levels that are exceeding planetary boundaries. Introduced by scientists in 2009, the planetary boundaries framework "defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the stability of the Earth system."[134] The current framework consists of nine biophysical processes, and the boundaries or limits for each indicate scientifically based levels of human interference in the Earth system, beyond which the system becomes "substantially altered,"[135] putting human society at risk.

The planetary boundary for biogeochemical flows (referring to the cycling of nitrogen and phosphorus) is among the boundaries scientists say have been crossed, stemming directly from the extensive use of synthetic fertilizer.[136] Much of the nitrogen and phosphorus from fertilizer application ends up in waterways, creating harmful algal blooms[137] and causing eutrophication (and associated oxygen depletion), changes in species composition, and groundwater contamination.[138] When nitrogen builds up in an aquatic environment, it stimulates algae growth. Bacteria feeding on the algae consume oxygen, leading to oxygen depletion and the formation of "dead zones."[139] Hundreds of these oxygen-starved zones exist worldwide.[140] The largest is in the Arabian Sea, and the second-largest extends over 6,000 square miles (larger than the US state of Connecticut) in the Gulf of Mexico.[141] The overuse of fertilizer intensifies the flow of nitrogen and phosphorus into the biosphere and oceans, disrupting natural cycles and resulting in significant adverse impacts on marine and freshwater ecosystems[142] and the communities that depend on them for subsistence and livelihoods.

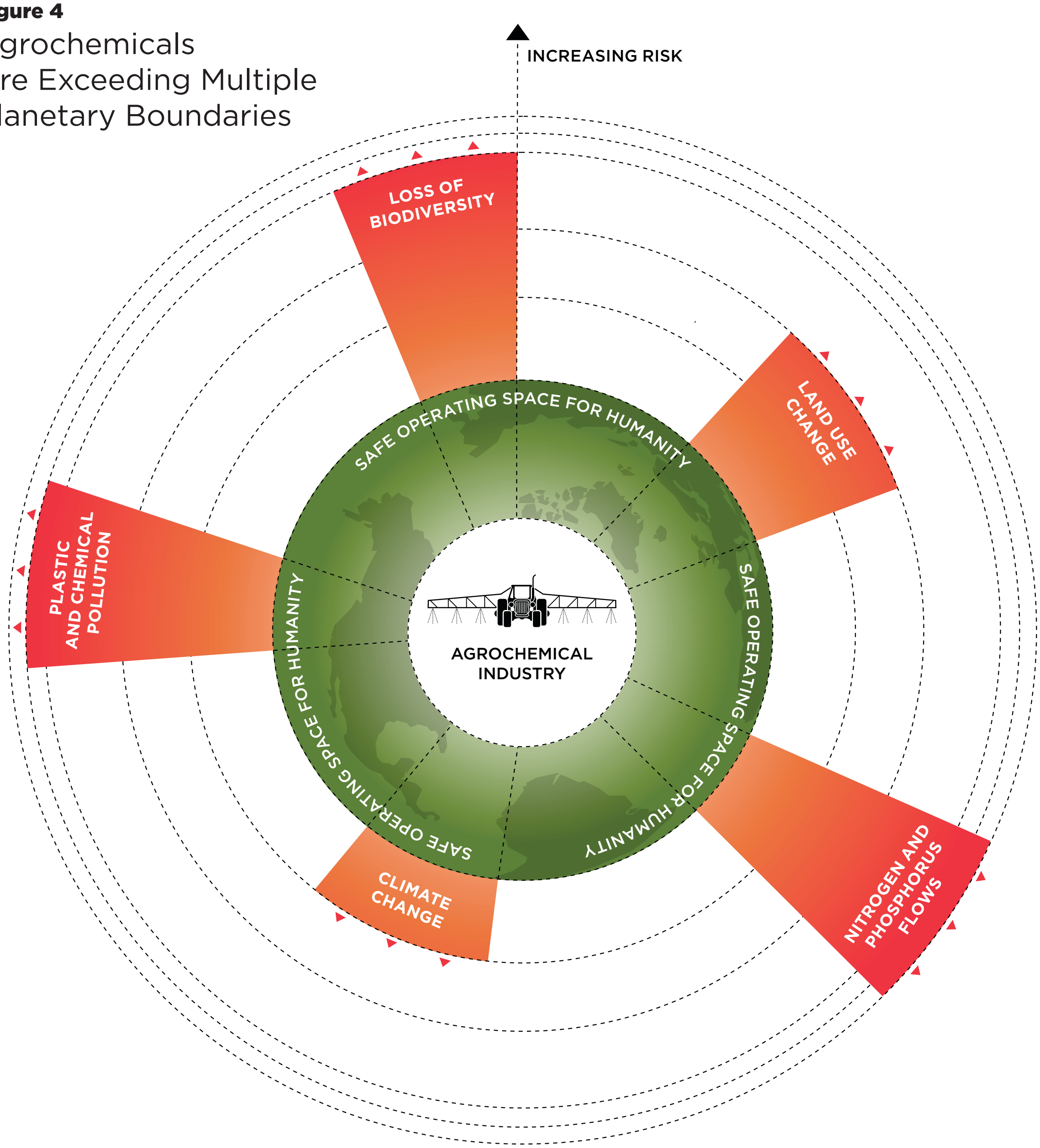
New research published in January 2022 found that chemical pollution has exceeded a planetary boundary as a result of synthetic chemicals, including plastics and pesticides, and is proliferating at unsustainable rates.[143] The study determined that rising production and emissions of chemicals outpace society's ability to manage them with safety assessments and monitoring.[144] Other transgressed planetary boundaries include land-system change, biosphere integrity (loss of biodiversity), and climate change.[145] Restoring and maintaining healthy soils would help alleviate these transgressions, as many of the boundaries—from chemical pollution to climate—relate to soil health and function.[146] But synthetic fertilizer (and pesticide) overuse degrades and pollutes the soil. Excess nitrogen results in soil pollution and may lead to soil salinity[147] and acidification. According to the FAO and the UN Environment Programme (UNEP): "Soil acidification also enhances the mobilization and bioavailability of certain trace elements, increasing the risk to human health and the environment and decreasing crop growth."[148] Fertilizers themselves may contain contaminants such as trace metals, negatively impacting soil quality and posing a risk of the contaminants passing through the food chain.[149]

The use of fossil fertilizers also contributes to air pollution. The application of nitrogen-based fertilizers, particularly urea, may result in gaseous ammonia escaping into the atmosphere in a process called ammonia volatilization.[150] This can be harmful to both ecosystems and human health.

Furthermore, agrochemical companies intentionally manufacture some fertilizers (and some pesticides) with a thin coating or capsule, often made of plastic. This deliberate deployment of plastic material in the design of these products is a direct, growing, and completely preventable source of microplastic pollution in agricultural soils, the food supply, and the wider environment.[151]

Figure 4

Agrochemicals Are Exceeding Multiple Planetary Boundaries



LOSS OF BIODIVERSITY

Industrial agriculture is harming ecosystems and driving species to extinction.

NITROGEN AND PHOSPHORUS

Heavy fertilizer use pollutes waterways and creates harmful algal blooms and oxygen-starved "dead zones."

CLIMATE CHANGE

Fossil fertilizers and pesticides emit GHGs at each stage of their life cycle.

PLASTIC AND CHEMICAL POLLUTION

Production and release of "novel entities" like plastic and pesticides are pushing humanity beyond a safe operating space.

LAND USE CHANGE

Converting land from forests, grasslands, and other vegetation types to monocultures is linked to higher use of agrochemicals.

Credit: Based on the Stockholm Resilience Centre's "Planetary Boundaries Framework." Original by J. Lokrantz/Azote Steffen et al. 2015.

GHG Emissions from Fossil Fertilizer: Agrochemicals Are Heating the Planet

Agrochemicals contribute significantly to the climate crisis, but they have been largely overlooked in climate policy and discussions focused on reducing emissions. Climate impacts occur at every stage of the agrochemical life cycle, from production to end use and disposal.[152] The manufacture of fertilizer and pesticides requires significant energy inputs.[153] An estimated 40 percent of the total energy value of hydrocarbons used in the US agriculture sector are used indirectly in the production of synthetic fertilizers and pesticides, both as an energy source and as a chemical feedstock.[154] But the emissions impact, particularly for nitrogen fertilizer, extends beyond production—occurring even after the chemicals are applied to soils. This section examines how nitrogen fertilizers and other agrochemicals contribute to climate pollution at all stages of their life cycle, from synthesis to soil and crop application.

Both the production and the use of synthetic nitrogen fertilizer emit carbon dioxide and other GHGs into the atmosphere in globally significant quantities. New research released in November 2021 by scientists working with the organizations Greenpeace, GRAIN, and the Institute for Agriculture and Trade Policy (IATP) is the first assessment to account for emissions from the entire fertilizer production chain or life cycle, from manufacture to soil application.[155] The researchers found that **synthetic nitrogen fertilizer contributes to approximately 2 percent of global emissions.**[156] This means the climate footprint of fertilizer exceeds that of commercial aviation—an estimated 1.13 billion tonnes of carbon dioxide equivalent (CO_2e) came from nitrogen fertilizer in 2018, compared to 918 million tonnes of carbon dioxide from aviation.[157] **More than 38 percent of fossil fertilizer emissions come from its production alone, with field emissions and transportation making up the rest.**[158]

Ammonia Production Is Emissions-Intensive

Ammonia, the base for nitrogen fertilizers, is the second-most produced chemical in the world, and this production comes at a steep cost in terms of climate pollution. The production of ammonia through the Haber-Bosch process is highly energy-intensive, requiring substantial amounts of heat and pressure, and accounts for **more carbon dioxide emissions than any other industrial chemical reaction**.[159] Ammonia production accounts for about 2 percent of worldwide fossil fuel energy use[160] and is more emissions-intensive (on a direct carbon dioxide basis) than steel and cement making.[161] According to the IEA: “Direct emissions from ammonia production currently amount to 450 [million tonnes] CO_2—a footprint equivalent to the total energy system emissions of South Africa.”[162] Conventional ammonia production consumes over 30 gigajoules of energy and **emits over 2 tonnes of carbon dioxide equivalent per tonne of ammonia produced**.[163]

Beyond the intensive energy demands of ammonia production, the chemical reactions in the process split hydrogen from the hydrocarbon methane, releasing carbon dioxide. Hydrogen production accounts for more than half of the carbon dioxide emissions from the entire ammonia production process.[164]

The emissions associated with making ammonia are worth noting, considering that the world produces almost 200 million tonnes of ammonia each year.[165]

Methane Emissions Are Vastly Underreported

In addition to carbon dioxide, ammonia production results in emissions of methane—a potent GHG with eighty-six times the warming potential of carbon dioxide over twenty years.[166]

As the IPCC notes in its Sixth Assessment Report, several studies show agricultural nitrous oxide emissions have increased by more than 45 percent since the 1980s, due mainly to the increased use of nitrogen fertilizer.

According to a 2019 study by researchers at Cornell University and the Environmental Defense Fund, methane emissions from the US fertilizer industry are likely much higher than reported figures, and even exceed the US Environmental Protection Agency's (EPA) estimate for methane emissions from the industrial sector overall.[167] The researchers say there is still little understanding of methane emissions from the fertilizer industry despite the industry's significant methane (fossil gas) consumption. The US has only a few dozen ammonia fertilizer plants, and these facilities use fossil gas both for fuel and feedstock. Some methane is inevitably emitted due to incomplete fuel combustion, incomplete chemical reactions in fertilizer production, or leaks. In an attempt to assess the scale of methane emissions from the US fertilizer industry, the researchers used remote sensing technology to measure fugitive methane emissions downwind of six US ammonia fertilizer plants. They calculated the estimated emissions rate at 0.34 percent. Scaled to the entire US fertilizer industry, this rate suggests that the fertilizer industry could emit 28,000 tonnes of methane annually—140 times higher than the fertilizer industry's self-reported figure of 200 tonnes.[168]

Nitrogen Fertilizer Overuse Has Dramatically Raised Nitrous Oxide Levels

In addition to the GHG emissions from the production of nitrogen fertilizer, emissions also occur once producers apply that fertilizer to the soil. When nitrogen fertilizer is applied, some of it is released into the atmosphere as nitrous oxide, a potent GHG. Soils naturally produce nitrous oxide through nitrification and denitrification, and an increase in available nitrogen, such as through the addition of nitrogen fertilizer, boosts these processes and results in more nitrous oxide.[169]

Crops take up only a fraction of the nitrogen in the applied fertilizer; according to the IPCC, approximately 50 percent of the nitrogen applied to agricultural soils is not taken up by crops.[170] This means roughly half of all nitrogen applied ends up polluting soils and waterways or is emitted to the atmosphere as nitrous oxide.

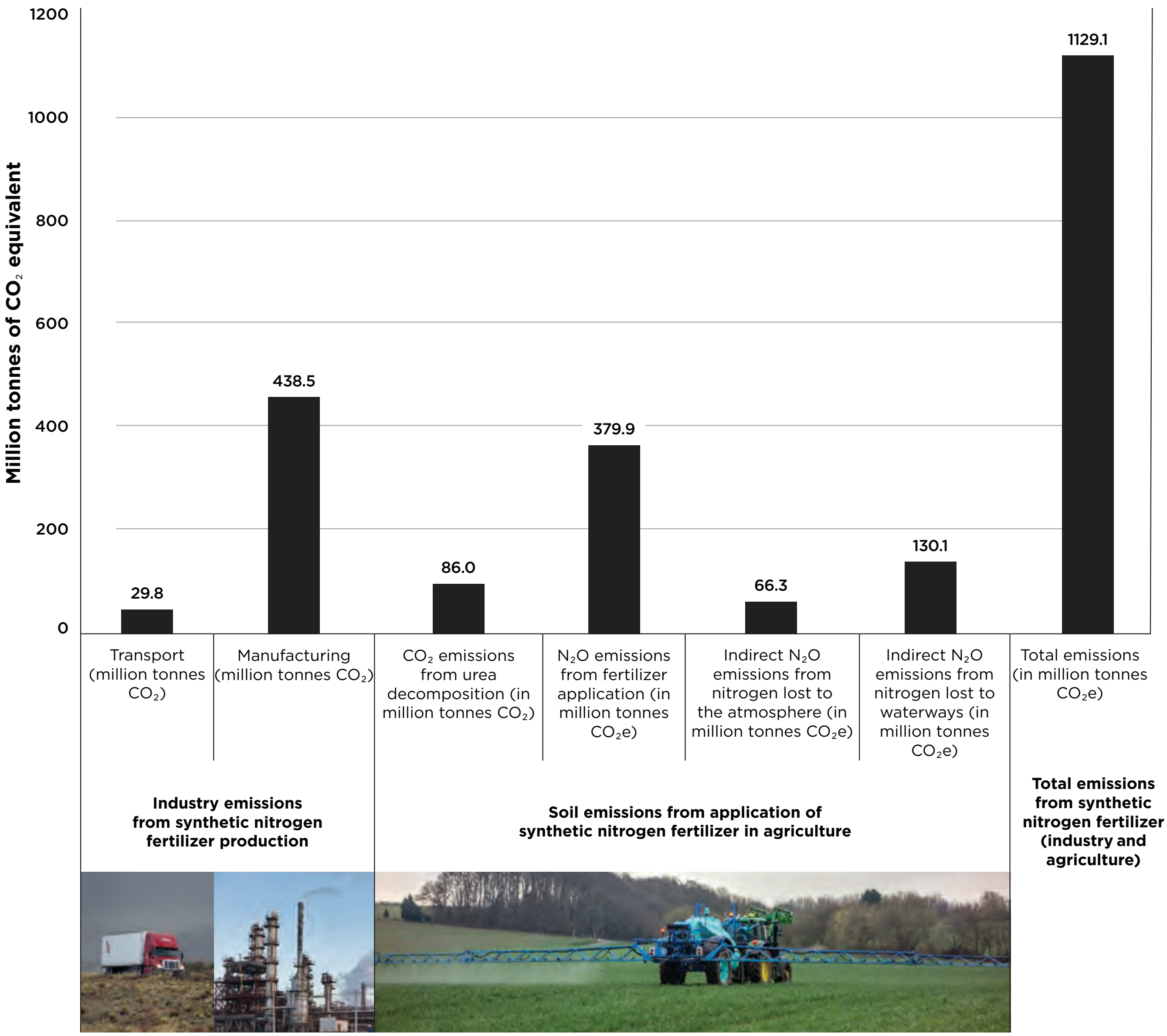
Though it receives less attention than carbon dioxide or methane in discussions on climate mitigation, nitrous oxide is a much more potent GHG with a warming potential of about 265 times that of carbon dioxide over 100 years.[171] About 7 percent of GHG emissions come from nitrous oxide.[172] Agriculture accounts for approximately two-thirds of those emissions, and agricultural soils, in particular, are the dominant source due to the application of nitrogen fertilizers and manure on croplands.[173] Nitrous oxide emissions are rising, driven primarily by increases in synthetic nitrogen fertilizer use and manure production.[174] As the IPCC notes in its Sixth Assessment Report, several studies show agricultural nitrous oxide emissions have increased by more than 45 percent since the 1980s, due mainly to the increased use of nitrogen fertilizer.[175] This increase in emissions tracks with the growing consumption of nitrogen fertilizer: "The latest data document a **41% increase in global nitrogen fertilizer use between 1990 and 2019** corresponding with associated increased N_2O emissions."[176]

Further increases in global nitrogen fertilizer use—and consequently, nitrous oxide emissions—are expected, particularly in emerging economies.[177] The rapid rise (and continuing increase) in nitrous oxide emissions threatens international climate goals established in the Paris Agreement.[178] According to a 2020 study quantifying global nitrous oxide sources and sinks, "[o]bserved atmospheric N_2O concentrations are beginning to exceed predicted levels across all scenarios," including exceeding all Shared Socioeconomic Pathways in climate modeling used by the IPCC in its latest climate assessment.[179] Agricultural soils emit over 3 million tonnes of nitrous oxide each year.[180] These emissions are concerning not only because nitrous oxide is a strong GHG but also because it contributes to stratospheric ozone loss. Moreover, and as discussed further below, nitrogen is not the only GHG emitted by using nitrogen fertilizers.

Urea Decomposition and Loss of Soil Organic Matter: Chemical Fertilizers Emit Carbon Dioxide from Soils

Soils treated with synthetic nitrogen fertilizer in the form of urea are yet another source of carbon dioxide emissions. Urea contains carbon and oxygen (as well as nitrogen and hydrogen); when applied to soils, it emits carbon dioxide as it decomposes and undergoes chemical reactions.

Figure 5
Global Lifecycle GHG Emissions from Nitrogen Fertilizer



Credit: Data from a study in *Scientific Reports*.

Therefore, the carbon dioxide that was fixed in the urea during production is ultimately released into the atmosphere. These emissions are estimated at around 130 million tonnes of carbon dioxide per year globally,[181] or 86 ± 39.1 million tonnes of carbon dioxide equivalent by another estimate.[182] In the US, emissions from urea fertilizers totaled 5.3 million tonnes of carbon dioxide equivalent in 2019, according to US EPA data.[183] Alarmingly, the EPA reports that carbon dioxide **emissions from urea fertilization have risen by 121 percent between 1990 and 2019 due to the increasing application of urea to soils**.[184]

Additionally, chemical fertilizers contribute to the loss of soil organic matter, which is an important carbon sink. Depleting this organic matter means that even more carbon is released into the atmosphere. Applying synthetic fertilizer accelerates the decomposition of soil matter and subsequent release of carbon dioxide by stimulating microbial activity in soils. Soil microbes feed on and decompose soil organic matter, and in the process, they release carbon dioxide. It is estimated that for every kilogram of organic matter decomposed, 1.5 kg of carbon dioxide is released.[185] Scientific observations confirm the impact of nitrogen fertilizer depleting soil carbon. Soil

scientists at the University of Illinois, for example, analyzed historical and present soil samples and found that soil organic carbon had sharply declined over time, in line with increasing inputs of synthetic nitrogen.[186] Their findings bust the myth that nitrogen fertilizers enhance crop residues and build up soil carbon. As the researchers state in the 2007 study: "As opposed to the usual assumption, fertilization was of little, if any, benefit for soil [carbon] sequestration. Rather, the only significant [soil organic carbon] changes detected were net losses."[187]

Reducing soil organic matter not only releases carbon but it makes soils less healthy and productive overall. Soil organic matter facilitates water retention and naturally provides nutrients to plants, and it is critical to healthy soil functioning. Restoring soils with organic matter is therefore vital to sustainably managing soils, protecting biodiversity, *and* lowering atmospheric carbon dioxide.

Agrochemical Dependency Is Disastrous for the Climate

Synthetic fertilizer and pesticide consumption, which proliferated during the twentieth century and continues to grow in some regions, has a significant climate cost. According to the IPCC, the global food system is responsible for "21–37 percent of total GHG emissions," including "9–14 percent from crop and livestock activities."[188] Fertilizers make up a significant portion of those emissions—along their entire supply chain. Energy use in food supply chains, including fertilizer, is considered the largest contributor to carbon dioxide emissions from the food system outside of the farm gate. In 2018, non-carbon dioxide emissions (namely methane and nitrous oxide) accounted for more than three-quarters of total on-farm production emissions, and **synthetic fertilizers were the second-largest contributor**.[189]

As laid out above, synthetic nitrogen fertilizer is especially harmful in terms of its climate impact. Its use has increased nearly 900 percent since 1961, and the FAO projects synthetic nitrogen fertilizer consumption will increase by 50 percent (from 2012 levels) by 2050—a trend that is simply incompatible with achieving international climate goals and respecting planetary boundaries.[190] "There needs to be a global phase-out of N[itrogen] synthetic fertilizers if we are to end agriculture's contribution to the climate and other ecological crises," a research brief from Greenpeace, GRAIN, and IATP explains.[191] But political responses to the current crises lead the world in the opposite direction. To understand the reasons for the lack of effective policies, one needs to analyze how corporate interests stand in the way of accelerating such a phaseout. These interests in the agrochemical industry are more aligned with fossil fuel companies than one might realize, suggesting that the fight against industrialized, chemical-dependent agriculture is the same as the resistance against coal, oil, and gas projects—that is, the fight to end fossil fuel pollution. The second part of this report examines the fertilizer industry's plans to profit from the climate crisis and energy transition through greenwashing gambits like hydrogen or ammonia with CCS, and explores the synergies between the fertilizer and fossil fuel industries in promoting these false climate solutions.

BOX 2

Corporate Producer Profiles: Who Profits from Fossil Fertilizer?

A handful of large corporations control the vast majority of synthetic fertilizer production. Such industry concentration is not unique to fertilizers; corporate consolidation is prominent throughout the industrial food chain, from seeds to pesticides to farm equipment.[192] Other industries have also seen increasing market concentration, including oil and gas.

Fertilizer companies tend to consolidate or merge to profit from economies of scale and account for the limited geographic availability of raw materials used in fertilizer production.[193] Only a handful of countries, including Russia, the US, India, Canada, and China, control the majority of raw materials used to produce the main types of fertilizer (namely nitrogen, phosphorus, and potassium fertilizers).[194] According to the FAO, the biggest nitrogen-producing countries in 2020 were China, India, the US, Russia, and Egypt.[195] State control of fertilizer production is relatively common in the industry, with some national governments, like China, Saudi Arabia, and Norway, owning large shares of fertilizer companies.[196]

As a leading oil and gas producer, the US is also a global hotspot for fossil fertilizer production, with plans underway for both new plants and expansions or upgrades to existing facilities. Just a few companies now largely control this production. As mentioned previously, the number of nitrogen fertilizer producers in the US fell from forty-six to thirteen between the 1980s and mid-2000s. By 2019, just four firms accounted for 75 percent of domestic production.[197]

The following profiles present an overview of some of the biggest nitrogen fertilizer companies. In addition to this list, it is important to recognize that major oil and gas companies, which produce fossil feedstocks for agrochemicals as well as the fossil fuels that power fertilizer production, also stand to benefit and profit from increased production and use of fertilizers.

Nutrien

Headquarters: Saskatoon, Saskatchewan, Canada

Nutrien is a Canadian fertilizer company formed in 2018 from a merger of Agrium and PotashCorp.[198] Nutrien is the **third-largest nitrogen producer in the world,** with over 7 million tonnes of gross ammonia capacity and the capability to produce **over 11 million tonnes of nitrogen** products.[199] Nutrien is also the world's largest potash (potassium chloride (KCl)) fertilizer producer. Nutrien operates thirteen nitrogen production facilities, including six in Canada, six in the US, and one in Trinidad and Tobago.[200] In 2021, Nutrien recorded approximately USD3.2 billion in net earnings[201] and over 10 million tonnes in nitrogen sales volumes.[202]

CF Industries

Headquarters: Deerfield, Illinois, United States

CF Industries is an American company that claims to be the **world's largest manufacturer of ammonia.[203]** CF Industries produces over **10 million short tons of ammonia annually[204]** and **operates nine ammonia and nitrogen production facilities** in Canada, the US, and the UK.[205] In the US, there are five production plants, including two in Oklahoma (Verdigris and Woodward), one in Yazoo City, Mississippi, one in Port Neal, Iowa, and one in Donaldsonville, Louisiana (it is the world's largest). In Canada, there are two facilities—one in Medicine Hat, Alberta, and one in Courtright, Ontario. The facilities in England have recently faced production pauses due to high fossil gas prices,[206] with the plant in Ince expected to close permanently[207] and the Billingham plant once again put on a production halt in August 2022.[208] The nine facilities have a total production capacity of approximately 10.5 million short tons of ammonia.[209] In 2021, the company's net earnings or sales totaled USD6.54 billion.[210]

The company was founded in 1946 as Central Farmers Fertilizer Company and became CF Industries in 1970.[211] The company has traditionally operated as a fertilizer producer, though recently, it adopted a broader strategy of providing hydrogen and ammonia for the energy sector. CF Industries rebranded in March 2021, with a new logo representing a blue and green ammonia molecule and a new strategy and mission emphasizing "clean energy." The company says this is "a natural evolution of our existing strategy and is consistent with our existing business model."[212]

Yara

Headquarters: Oslo, Norway

Yara, which is 40 percent owned by the Norwegian government,[213] is the world's **second-largest ammonia producer.[214]** According to company reporting posted on February 8, 2022, it has an annual ammonia **production capacity of 8.4 million tonnes**.[215] Yara was initially founded in 1905 as Norsk Hydro and became Yara International ASA in 2004.[216] In 2021, the company reported **revenues of USD16.6 billion** and currently operates in sixty countries around the globe.[217]

OCI N.V.

Headquarters: Amsterdam, Netherlands

OCI N.V. is a chemicals company that makes nitrogen fertilizers, nitrogen-based fuels, and methanol.[218] The company started as a construction business in Egypt in 1950 and got into the nitrogen fertilizer business in 2005, establishing itself in fertilizer markets in the US, Europe, and the Middle East/North Africa (MENA) region after that.[219] OCI says it produces **16.2 million tonnes of nitrogen and methanol** and claims to be the **number three global fertilizer producer**.[220] The company operates nine production sites globally.[221] In 2021, OCI reported total **revenues of about USD6.3 billion**.[222] Key OCI subsidiaries that produce nitrogen fertilizer include Fertiglobe, OCI Nitrogen, and Iowa Fertilizer Company. Fertiglobe—formed in 2019 as a joint venture between OCI (58 percent ownership) and the Abu Dhabi National Oil Company (ADNOC) (42 percent ownership)[223]—is the largest producer of nitrogen fertilizers in the MENA region, with an annual production capacity of 6.7 million tonnes of urea and ammonia.[224]

Koch Fertilizer

Headquarters: Wichita, Kansas, United States

Koch Fertilizer is a company under the holding company Koch Ag & Energy Solutions, which is a subsidiary of the conglomerate Koch Industries. Koch Ag & Energy Solutions operates four companies—Koch Fertilizer, Koch Methanol, Koch Energy Services, and Koch Agronomic Services.[225] The rebranding of Koch Fertilizer and the establishment of the holding company occurred in 2014, according to a company announcement, reflecting the broader trend of the fertilizer business expanding into the energy sector.[226] As a Koch executive said in the announcement, Koch Fertilizer has "grown and globalized this business and expanded beyond fertilizer. This name change and reorganization will better position us to continue to innovate and pursue even more strategic growth opportunities within the agriculture and energy sectors."[227]

Koch Fertilizer (and affiliates) has been operating since 1988[228] and claims to produce and distribute **more than 10 million tonnes of fertilizer** annually. Koch Fertilizer operates four production facilities in the US and one in Canada.[229]

Sinofert

Headquarters: Beijing, China

Sinofert is the **largest fertilizer manufacturer in China.** It is a subsidiary of the State-owned petrochemical conglomerate Sinochem.[230] Sinofert is listed on the Hong Kong Stock Exchange, with Sinochem as the controlling shareholder and Nutrien as the second-largest shareholder.[231] According to the firm's website, Sinofert is "devoted to becoming the country's main organizer of the domestic supply chain in the field of nitrogenous fertilizers" and is "aggressively expanding international marketing channels to export greater amounts of fertilizer to markets in South Asia, Southeast Asia, Europe and the Americas."[232]

EuroChem

Headquarters: Zug, Switzerland

EuroChem has produced synthetic nitrogen, phosphorus, and potassium fertilizers since 2001. The enterprise operates globally, serving markets including North America and Africa, and owns production facilities in China, Belgium, Lithuania, and Russia.[233] In 2021, the company reported **19.1 million tonnes of fertilizer sales and USD10.2 billion in revenue**.[234] EuroChem operates several nitrogen production plants in Russia, including the Nevinnomysskiy Azot and Novomoskovskiy Azot plants (the latter of which ranks as Russia's largest urea producer) and the EuroChem Northwest plant, which has an annual production capacity of one million tonnes of ammonia.[235] The company is building a second EuroChem Northwest plant adjacent to the original, with an expected annual production capacity of 1 million tonnes of ammonia.[236] EuroChem is **Russia's largest producer of ammonia, urea, and nitrogen fertilizers**, accounting for 20.8, 21.5, and 20.9 percent of Russia's production in 2021, respectively.[237] Until March 2022, at least 90 percent of shares in EuroChem were beneficially owned by Russian billionaire Andrey Melnichenko, who founded and controls a similar stake in coal energy company SUEK.[238] Melnichenko transferred ownership and control of EuroChem to his wife, Aleksandra Melnichenko, who was added to the European Commission's list of sanctioned individuals in June 2022.[239]

SABIC Agri-Nutrients Company

Headquarters: Riyadh, Saudi Arabia

SABIC (Saudi Arabian Basic Industries Corporation) Agri-Nutrients is **the major fertilizer producer in Saudi Arabia** and was formed in November 2020 under a share purchase agreement with the State-owned petrochemical enterprise, SABIC.[240] It was formerly established as the Saudi Arabian Fertilizer Company (SAFCO). Oil giant Saudi Aramco controls 70 percent of shares in SABIC.[241] In July 2022, it announced a relocation of its headquarters from Jubail Industrial City to the Saudi Arabian capital, Riyadh.[242] The company manufactures mainly ammonia and urea.[243] In 2021, the company reported a **sales volume of roughly 5 million tonnes of fertilizer product**.[244]

PART 2

Laundered Emissions: Fertilizer Companies Are Pushing Blue Hydrogen and Blue Ammonia as False Climate Solutions

As discussed in Part 1 of this report, the agrochemicals industry is at the heart of a toxic system of industrial agriculture that is driving climate change, toxic pollution, biodiversity loss, and ecosystem destruction. Meanwhile, as the global community seeks to address those crises, the fossil fuel sector is betting on a combination of carbon capture and hydrogen production to maintain its extractive business model and expand into new markets. The fossil fertilizer industry and the processes it already uses to make its products hold the keys to this new model that purports to solve the climate challenge of hydrocarbon combustion by using the hydrogen and managing the carbon.

In reality, this proposed model of carbon capture with hydrogen and ammonia production is more of the same, deepening global dependence on fossil fuels and worsening the climate crisis while entrenching the industrial agriculture model. Not only do agrochemical companies stand to profit from this pivot to hydrogen, but they are poised to enable a new generation of fossil fuel reliance under the guise of climate action. This part of the report will explore why the fossil fuel sector is set on a carbon capture and hydrogen strategy, how the fossil fertilizer industry factors into and benefits from that strategy, and how fertilizer companies are aligning themselves with it.

Hydrogen, Ammonia, and Carbon Capture as Fossil Fuel Enablers

The production of nitrogen fertilizer requires the creation of hydrogen, ammonia, and often urea, through carbon capture and utilization. These are the critical techniques that the oil and gas industry hopes to promote to stave off a transition away from fossil fuels. The fertilizer industry is situated to assist that effort and take advantage of it.

The use of and interest in hydrogen, ammonia, and carbon capture differ between the fertilizer and oil and gas industries, but there is still significant overlap. As explained in Part 1, nitrogen is a critical nutrient for plant growth. It is naturally available to crops through ecologically sound farming practices. Still, with input-reliant industrial agriculture, where the soil is degraded from pesticide use and monocrop cultivation, it must be added to the soil with synthetic fertilizers. The fossil fertilizer industry, therefore, is primarily interested in nitrogen. Nitrogen fertilizer is produced by first combining hydrogen with nitrogen from the air via the Haber-Bosch process, creating ammonia. Ammonia is toxic and reactive and needs to be stabilized for use as fertilizer. Most fertilizer is made by then combining ammonia with carbon dioxide to produce urea, which is stable and can be applied to soils. (The other major nitrogen fertilizer is ammonium nitrate, which is also an explosive.) Historically, the fertilizer industry has used hydrogen, ammonia, and carbon capture as a way to get nitrogen out of the air and into stable fertilizers.

The fossil fuel sector, by contrast, promotes carbon capture, hydrogen, and to a lesser extent, ammonia as core pillars of an energy transition that perpetuates or even increases fossil fuel use. The premise of this interrelated set of approaches is that the energy from fossil fuels can be packaged without the carbon dioxide emissions from fossil fuel combustion. The fossil fuel industry's interest in hydrogen and ammonia is in their capacity as energy carriers—ways to transmute the energy from fossil fuels without the carbon in the hydrocarbons

from which they are derived. CCS is the process by which the industry proposes enabling continued production and use of fossil fuels while purporting to eliminate their carbon dioxide emissions.

CCS as a Lifeline for the Fossil Fuel Industry

CCS is a key enabler of continued fossil fuel usage. By its very nature, CCS serves to enable an underlying emitting activity. The oil and gas industry touts CCS as a climate solution and is investing heavily in developing CCS projects around the world.[245]

Carbon capture, *utilization*, and storage (CCUS) is pitched as a way to separate carbon emissions from fossil fuel use. In reality, it fails to do so and instead entrenches the industries whose harms it is meant to ameliorate.[246] CCUS is the central process by which the fossil fuel sector proposes to keep hydrocarbon combustion an integral part of the global economy, as it, in theory, reduces emissions from the process. In practice, carbon capture systems often fail to meet capture targets, exacerbate emissions up- and downstream, and lock into place the fossil fuel system from which the global community needs to transition rapidly.[247]

CCS technology has several steps,[248] each with a track record of unmet promises and failures.[249] First, some of the carbon dioxide is removed from waste streams, such as a smokestack at a coal-fired power plant, usually via a chemical absorbent. Whatever has been removed can be concentrated and pressurized, then transported to a final destination wherein it can either be utilized for some purpose or injected underground for ostensibly permanent storage.

CCS is heavily subsidized, with fossil fuel and other interests seeking additional policy support.[250] In the US, the primary subsidy for CCS is a tax credit generally referred to by its tax code section, 45Q. The tax credit pays per tonne of carbon dioxide captured and either stored or used in a process called enhanced oil recovery (EOR). The newly-enacted Inflation Reduction Act of 2022 significantly boosts carbon capture through the 45Q credit, including raising the credit value (from USD50/tonne to USD85/tonne for geologic sequestration and USD35 to USD60/tonne for usage or EOR), lowering the annual capture threshold requirements, and extending the timeframe for facilities to claim the credits.[251] Beyond Section 45Q, the US government has also directly supported carbon capture research, development, and deployment through loan guarantees and direct grants.[252] The EU does not have a direct per-tonne subsidy of the same kind, but does maintain several other forms of support.[253] Other countries, such as the UK, Canada, and Australia, have some form of government support for CCS deployment to various degrees.[254]

To date, the overwhelming majority of the capacity for carbon dioxide captured for storage has been used for EOR.[255] EOR with carbon dioxide involves injecting pressurized carbon dioxide into tapped oil fields to push out additional oil and has been conducted in the US for over fifty years.[256]

Though EOR can be performed with several techniques, using carbon dioxide is particularly effective, and the oil industry has limited supplies of available and affordable carbon dioxide. Securing supplies of carbon dioxide is a key priority for the oil industry as it seeks new sources of oil.[257] The push for subsidized development of a vast network of CCS facilities and infrastructure is, in large part, an effort to secure cheap and plentiful carbon dioxide.

In practice, carbon capture systems often fail to meet capture targets, exacerbate emissions up- and downstream, and lock into place the fossil fuel system from which the global community needs to transition rapidly.

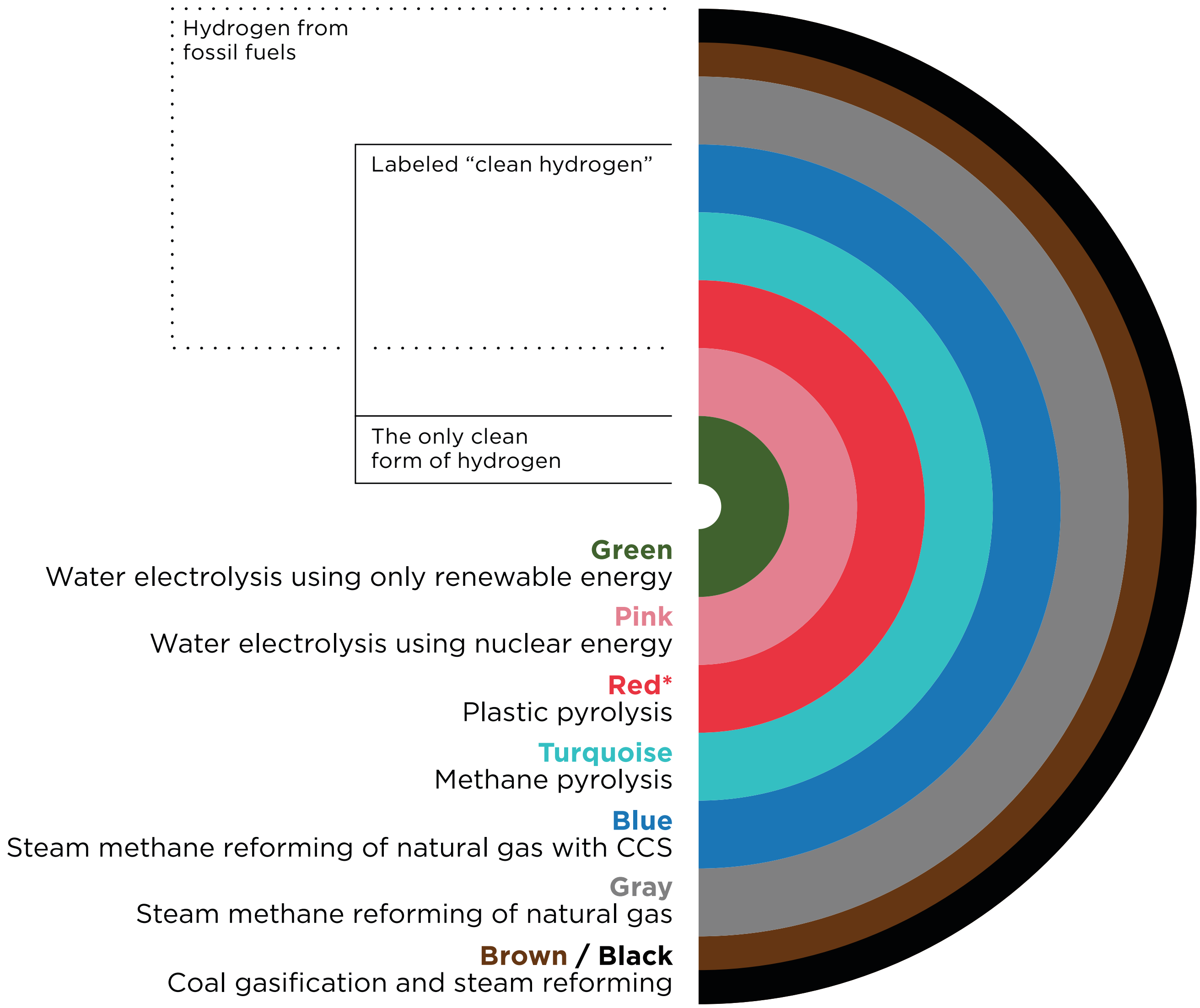
Other than for use in EOR, there is little financial incentive to capture *and* store carbon dioxide from waste streams without subsidies or a regulatory requirement to do so. As will be discussed below, fertilizer companies do capture a fraction of their emissions for use in urea manufacture, but that carbon dioxide is neither the majority of emissions nor is it actually stored, as it is released when the urea decomposes. Moreover, gas separation plants processing raw fossil gas must separate the carbon dioxide from the gas before selling it, but often simply vent the carbon dioxide once separated. To date, the majority of CCS capacity has been applied to carbon dioxide separated during gas processing and, as noted above, used for EOR.[258]

Widespread deployment of carbon capture is not a solution to the climate crisis.[259] The capture process removes only a fraction of emissions from the underlying source—often a smaller fraction than projected by proponents—and is often only deployed for a limited part of a given facility's emissions. Carbon capture also incurs a significant energy penalty,[260] counteracting any capture benefit and *increasing* upstream emissions from oil, gas, and coal production. Finally, by keeping such facilities operating and extending their economic lives, CCS presents a major obstacle to the necessary transition away from fossil fuels.

The industrial agriculture system is bound up in the ongoing effort to develop CCS systems. The cost of carbon capture

Figure 6

Hydrogen Rainbow Spectrum



Credit: Information from H2 Bulletin.

* While shown here as red, hydrogen from plastic waste doesn't have a designated color yet.

(in financial, energetic, and material terms) is closely correlated with the concentration of carbon dioxide in the waste stream from which it is being removed. When carbon dioxide represents all or most of the waste gases in a smokestack, capturing it is comparatively easier than capturing the same amount of carbon dioxide from a waste stream containing other gases and pollutants. The more concentrated the carbon dioxide in the stream, the cheaper the process. Because they produce relatively concentrated waste streams of carbon dioxide, hydrogen, ammonia, and ethanol production are among the more amenable processes to which carbon capture can be applied and are a major component of the current wave of announced and planned carbon capture projects.[261] These projects, particularly in the US, hope to take advantage of generous tax subsidies and provide another source of revenue beyond the marketing of their primary products. Notably, and as discussed below, the four existing fertilizer plants with CCS send their captured carbon dioxide for use in EOR.

Hydrogen and Ammonia as Laundered Fossil Fuel

As the energy, transportation, and industrial sectors turn away from direct use of oil and gas as fuels, they face a choice of energy alternatives. Even carbon capture proponents acknowledge that the applicability of point-source capture is inherently limited, and there will need to be replacements for other current fossil energy uses.[262] Hydrogen and ammonia are proposed as options to decarbonize various facets of industry, energy and power production, and transportation. Because neither hydrogen nor ammonia molecules contain carbon, they do not release carbon dioxide when burned or otherwise combined with oxygen, as in a fuel cell.

Hydrogen has several possible uses as a source of energy and heat; however, very few of these uses outweigh the benefits of other alternatives. Hydrogen can be combusted like methane and create high temperatures, making it suitable for industrial processes that require high heat and significant power. Hydrogen can also be used in a fuel cell, wherein it electrochemically reacts with oxygen to produce electricity rather than directly combusting. Finally, hydrogen can be used as a chemical reactant to make steel, eliminating the need for coke (a coal-based fuel) or other carbon-based agents in the process. While it is true that these processes do not release carbon dioxide *at the point of use,* to determine hydrogen's full climate impact, calculations must consider its entire life cycle and its impacts on the broader transition from fossil fuels.

When made from truly renewable energy, green hydrogen may have a role to play in climate solutions, though that contribution is likely to be modest. So-called "green hydrogen" is produced by running electricity through water to separate it into its constituent parts, hydrogen and oxygen. If powered by renewable energy sources, this hydrogen would, in fact, be untethered to fossil fuels and would produce no GHG emissions during its production. But green hydrogen is expensive to produce, and there are only a limited number of circumstances where it will be a good substitute for fossil fuels relative to other options, especially compared to measures that reduce fossil fuel demand or switch to electrification. Electrolyzing water requires large amounts of energy and water, presenting constraints on how much green hydrogen can and should be produced. It is estimated, for example, that 9 tonnes of water are required to produce 1 tonne of green hydrogen, and if the water needs to be purified, the amount of water required will double.[263]

Moreover, hydrogen, regardless of its provenance, is explosive—it can explode when it mixes with ambient air, for example[264]—and is difficult to transport.[265] Finally, though it does not contain contaminants or particulates, hydrogen produces nitrogen oxides when burned, creating toxic risks if it is used in industrial applications or domestic gas lines. Green hydrogen is, therefore, not a panacea for the energy transition but, rather, one potential solution for a *limited* number of use cases. Any such uses will involve significant risks and tradeoffs; therefore, hydrogen should only be used where there are no better options for electrification or decarbonization.

For now, a green hydrogen economy is nowhere in sight. Currently, nearly all hydrogen is produced from fossil fuels in one form or another and emits significant GHGs throughout production. Nearly 80 percent of hydrogen is made through a process called steam reforming, where fossil gas or gasified coal is blasted with steam to peel hydrogen away from the oxygen and carbon atoms in the coal, gas, and water.[266] Most of the remaining 20 percent of hydrogen comes from high-temperature processes like oil refining or steam cracking, whereby hydrocarbons are rearranged, and some hydrogen is split off in the process.[267] In these cases, the hydrogen is typically fed back into the refinery or cracker, used onsite, and not marketed as a product. In total, 98 percent of all hydrogen used in ammonia production comes from either gas (72 percent) or coal (26 percent).[268]

The steam reforming process is extremely emissions-intensive, releasing GHGs via two routes. Primarily, carbon dioxide is the other chemical product of combining steam and either fossil gas or gasified coal, and so reforming entails significant process emissions. Still more emissions result from the fossil fuels burned to produce the steam itself and power the reforming unit. In the case of coal-to-hydrogen processes, there are additional emissions from coal gasification, which requires large heat and energy inputs as well. Ultimately, fossil-based hydrogen is an extremely emissions-intensive energy source and, even compared to fossil fuels, "lead[s] to higher global emissions in most applications."[269] The US government, however, continues to subsidize fossil-based hydrogen; for example, the Inflation Reduction Act of 2022 contains tax credits for so-called "clean hydrogen," which includes hydrogen production resulting in up to 4 kg of carbon dioxide equivalent emitted per kilogram of hydrogen produced.[270]

The fossil fuel and agrochemicals industries' proposed solution to this problem is so-called "blue" hydrogen—an industry-coined term.[271] Despite the colorful and benign-sounding name, blue hydrogen is produced through the same basic processes as ordinary hydrogen (also called "gray hydrogen"). It is made from the same fossil fuel feedstocks. The "blue" in blue hydrogen refers to the addition of carbon capture to reduce carbon dioxide emissions from the production process. As discussed above, carbon capture is a flawed and false solution to the climate crisis, but in the context of hydrogen production, it has additional notable drawbacks. Because gray hydrogen uses fossil fuel as a feedstock in addition to a power source, the upstream emissions from oil and gas drilling or coal mining represent a significant portion of the overall emissions from hydrogen production. Adding carbon capture equipment (and the "blue hydrogen" label) not only fails to address this source of emissions but also exacerbates it, as the capture process requires additional energy and, therefore, additional fossil fuel production.

The significant lifecycle emissions from blue hydrogen undermine any purported climate benefit. This is particularly true of hydrogen produced from fossil gas, where methane emissions from gas production are an enormous source of GHGs. A seminal study of the lifecycle emissions for blue hydrogen production, including real-world estimates of methane emissions and carbon dioxide capture rates *higher* than those demonstrated in practice, found that replacing direct gas use with blue hydrogen would increase overall emissions once the emissions from gas production were taken into account.[272] Moreover, given the additional gas required to run a carbon capture unit, the study found only modest differences between blue and gray hydrogen lifecycle emissions.[273] The researchers conclude that blue hydrogen "is best viewed as a distraction" and has no role in a carbon-free energy system.[274]

The significant lifecycle emissions from blue hydrogen undermine any purported climate benefit. This is particularly true of hydrogen produced from fossil gas, where methane emissions from gas production are an enormous source of GHGs.

Criticism of the study reveals how blue hydrogen proponents rely on unrealistic assumptions to make the climate math work out. The primary critical response to the study asserts, "**it is possible** for blue hydrogen to have significantly lower equivalent CO_2 emissions than the direct use of N[atural] G[as], **provided that** hydrogen production processes and CO_2 capture technologies are implemented that ensure a high CO_2 capture rate, preferably above 90%, and a low-emission NG supply chain"[275] (emphasis added). Critically, and as noted by the original study authors, the calculations supporting the use of blue hydrogen rely on low supply chain methane emissions and high carbon dioxide capture rates that are simply unfounded in real-world experience.[276] Specifically on the issue of methane, which "dominates the greenhouse gas footprint of blue hydrogen,"[277] the IEA found in a recent report that "methane emissions from the energy sector are about 70% greater than the sum of estimates submitted by national governments."[278]

Governments nonetheless are increasingly promoting and investing in the hydrogen sector, thus further subsidizing fossil fuels since nearly all hydrogen production is currently fossil-based. While some government initiatives or plans may emphasize green hydrogen, blue hydrogen is likely to play a large part in scaling up the hydrogen sector. According to the IEA, seventeen countries had released hydrogen strategies by late 2021 and had committed at least USD37 billion to hydrogen development;[279] around half of these national hydrogen strategies include a significant role for fossil-based hydrogen paired with CCS.[280] Australia and Japan, for example, are committing nearly USD1 billion and roughly USD6.5 billion in public funds, respectively, for hydrogen development that includes both green and blue forms of production.[281] In Canada, the Alberta government is investing USD11.19 million in a blue hydrogen facility developed by Air Products Canada, a project that is also backed by the national government.[282] The US is also overtly subsidizing blue hydrogen. As discussed above, the Inflation Reduction Act of 2022 considers hydrogen production that emits up to 4 kg of carbon dioxide equivalent per kilogram of hydrogen to be "clean" and qualify for tax credits. The Infrastructure Investment and Jobs Act signed into law in 2021 further allocates USD8 billion for constructing "clean hydrogen" hubs, with requirements that at least one hub be dedicated to fossil-based "clean hydrogen" and at least two hubs be located in significant gas-producing regions.[283]

In addition to exacerbating rather than alleviating the climate crisis, the development of blue hydrogen risks increasing global reliance on gas. Converting gas into hydrogen already consumes a significant amount of energy. Because the amount of energy consumed by the hydrogen production process is greater than the energy stored in the hydrogen produced, hydrogen is essentially only used in industrial processes, and only very rarely as an energy carrier. Adding carbon capture to the steam reforming process requires even more energy input to produce the same amount of usable hydrogen. Transitioning activities from fossil fuels to blue hydrogen is, therefore, not only a problem from a climate perspective. In the context of the war in Ukraine, as efforts are made to reduce the world's dependence on gas, blue hydrogen threatens to do just the opposite.

Fossil Fuel Interests Are Boosting Hydrogen and Ammonia

Fossil fuel companies and aligned interests are unsurprisigly suggesting a central role for hydrogen and ammonia in the energy transition. In addition to directly investing in hydrogen projects, oil companies are promoting hydrogen through industry groups and their own modeled scenarios.

Because hydrogen is primarily made from fossil fuels, particularly fossil gas, the existing oil and gas industry has a lot to gain from a rise in hydrogen production. In its *Net Zero by 2050* report, for example, the IEA projects that 40 percent of hydrogen production in 2050 will still come from fossil gas.[284] A 2020 report from the US Department of Energy, relying on an earlier IEA report, *Energy Technology Perspectives 2017*, projected that "by 2050, fossil fuels will remain the primary source of hydrogen for the United States (~75%), Europe (~65%), and Japan (~85%)."[285]

Climate strategies built on hydrogen are heavily influenced by this oil and gas industry agenda. The Hydrogen Council, an industry group that advocates for hydrogen-friendly policy, contains as steering members Shell, BP, Total Energies, Saudi Aramco, Equinor, and ADNOC, among others.[286] Chevron and Shell, among other companies, contributed to a 2020 study of hydrogen deployment in the US by the Fuel Cell and Hydrogen Association—an industry association promoting hydrogen use for energy.[287]

Beyond participating in such joint projects, oil companies are building hydrogen into their business plans. BP, for example, is pursuing hydrogen as a core part of its business strategy. The company predicts that "hydrogen could have more than a 15% share in total global energy consumption by 2050" and is hoping hydrogen can "reinvent" natural gas.[288] BP is planning a major blue hydrogen facility in England and has already signed agreements with four companies to offtake the hydrogen—including CF Fertilisers.[289]

The Norwegian petroleum company Equinor is advancing another blue hydrogen project in England. The Hydrogen to Humber (H2H) Saltend project will involve hydrogen and ammonia production at Saltend Chemicals Park,[290] a petrochemicals cluster that already produces ammonia. The Norwegian fertilizer firm Yara is among the companies also operating there.[291]

The Saudi Arabian oil major Saudi Aramco is also increasingly getting into the hydrogen and ammonia business. In 2020, the company collaborated with fertilizer producer SABIC (Saudi Arabian Basic Industries Corporation) Agri-Nutrients on what was reportedly the world's first shipment of blue ammonia, delivering 40 tons to Japan for power generation. More recently, the two Saudi companies announced in August 2022 that they had received certifications recognizing the production of blue ammonia and hydrogen, including 37,800 tons of blue ammonia from SABIC Agri-Nutrients and 8,075 tons of blue hydrogen from Aramco. The oil major aims to produce up to 11 million tons of blue ammonia annually by 2030.[292]

ExxonMobil has also expressed interest in blue hydrogen. As stated in its *2021 Energy & Carbon Summary*: "As a world leader in both natural gas production and CCS, ExxonMobil is well-positioned to play an important role in this potential area of the energy transition."[293] In March 2022, the company announced plans to construct a blue hydrogen plant in Baytown, Texas, with the intention of using the hydrogen to fuel petrochemical production.[294]

ExxonMobil is eyeing opportunities in ammonia as well. In 2022, the company signed an agreement with three other companies to explore the production and distribution of green hydrogen and ammonia at Exxon's Slagen terminal in Norway. The press release states, "ExxonMobil is exploring opportunities to use ammonia as a low-emission and high-efficiency energy carrier, particularly to ship and store hydrogen over long distances."[295]

Hydrogen and Ammonia Present Significant Risks and Face Significant Challenges

Despite its advantages, hydrogen has many feasibility constraints. Hydrogen as a gas has a very low energy density by volume and requires a massive amount of space for storage. These space constraints can be reduced by liquefying and thus condensing the hydrogen. Unfortunately, hydrogen is extremely hard to liquefy, requiring immense pressure and very low temperatures to do so. This makes hydrogen relatively infeasible for transportation uses where large amounts of fuel must be stored onboard, especially shipping and aviation (the two modes of transport most often considered "hard to abate" from an emissions perspective).[296]

Not only do these companies stand to benefit financially from subsidies for hydrogen and carbon capture, but they can also capitalize on new opportunities for misleading greenwashing of their products.

Ammonia is proposed as a solution to the practical limitations of hydrogen as a transport fuel. Ammonia is produced by combining three parts hydrogen with one part nitrogen, and like pure hydrogen, it can be burned or used in a fuel cell without producing carbon dioxide emissions. Unlike hydrogen, ammonia is stable as a liquid at much higher temperatures and much lower pressures and is, therefore, much easier to condense, transport, and store. Ammonia is, therefore, sometimes referred to as a "hydrogen carrier"—a vehicle to bring the GHG benefits of hydrogen to applications where hydrogen would be unsuitable.

Despite the conceivable possibilities, ammonia is limited in its potential applications due to its complex production process and toxic risks. Hydrogen requires significant energy to produce and ammonia requires more on top of that. This increases the costs and introduces additional sources of emissions. For ammonia to be truly zero-carbon, not only would the hydrogen need to come from electrolysis powered by renewables, but the air separation and Haber-Bosch processes necessary for ammonia production would also need to be renewably powered.[297]

Ammonia is extremely toxic, limiting its uses as a fuel. At moderate concentrations, ammonia irritates the eyes, nose, and respiratory tract. At high concentrations, it is—according to The Fertilizer Institute—"[p]romptly lethal."[298] Exposure of any kind can be dangerous, as ammonia "may be fatal if inhaled, ingested or absorbed through skin."[299] Ammonia is also highly corrosive, adding additional complications to any fuel system in which it is used.[300] Finally, even when combusted as intended, ammonia can release toxic nitrogen oxides, as its constituent nitrogen is combined with oxygen in the air.[301] Ammonia-powered fuel cells, alternatively, are extremely undeveloped and are not likely to be widely commercially available for quite some time, if ever.[302]

The push for an extensive hydrogen economy, therefore, presents two related climate risks. First is that the perceived need for green hydrogen will seem to justify a buildout of blue hydrogen as a "bridge fuel." Given the climate impact of blue hydrogen, the long lifetimes of such projects, and the limited need for hydrogen of any kind, this bridge fuel concept should be rejected outright. Spiking fossil fuel prices and Russia's ongoing invasion of Ukraine further demonstrate the folly of investing in this fossil-based hydrogen, for which prices have risen by over 70 percent since the start of the invasion.[303] Blue hydrogen has no place in the energy transition. Second, the belief in a need for unconstrained green hydrogen and ammonia could itself derail the energy transition, as renewable energy may be diverted into hydrogen production, where direct electrification would be a simpler and safer route.

The push for hydrogen and ammonia also threatens to entrench the synthetic fertilizer industry. Because fertilizer companies already produce hydrogen and ammonia as precursors to fertilizer, they are well-positioned to take advantage of policies and programs supporting their production and use. Not only do these companies stand to benefit financially from subsidies for hydrogen and carbon capture, but they can also capitalize on new opportunities for misleading greenwashing of their products.

Carbon Capture in the Fertilizer Sector

Fertilizer companies are poised to play a major role in broader industry plans to deploy carbon capture globally. Fertilizer producers already employ a limited carbon capture process to make urea, and much of the existing carbon capture capacity in use is for fertilizer production. Moreover, because ammonia production is considered one of the lowest-cost carbon capture opportunities, CCS deployment for hydrogen and ammonia is critical to the larger project of justifying a buildout of carbon capture equipment and infrastructure.

Proponents of carbon capture—including the fertilizer industry—often turn to ammonia production as an example of an industrial process for which carbon capture is well-suited.[304] Ammonia production is considered to have one of the lowest per-ton costs for capturing carbon.[305] Moreover, the industry has a long history of capturing and using carbon dioxide—though at only modest levels. Because carbon dioxide is a key feedstock for urea production, the fertilizer industry captures less than half of the carbon dioxide produced onsite and feeds it back into the production process.[306] Though most carbon that is captured *and stored* has been used for EOR, the fertilizer industry is the largest user of carbon that is *captured but not stored* (and instead re-released into the atmosphere once the urea-based fertilizers decompose).[307] Because the carbon dioxide is not stored, the vast array of fertilizer plants that use their own carbon emissions as a feedstock are not included in most lists of CCS facilities, including, for example, the Global CCS Institute's running list of projects.[308] According to the Global CCS Institute, the global capture capacity for all currently operating CCS projects is 41.5 million tonnes per year of carbon dioxide.[309] By contrast, global fertilizer production uses about 130 million tonnes of carbon dioxide per year.[310]

Carbon capture does not and cannot solve the climate problems inherent in fertilizer production. As a preliminary matter, and as detailed more fully above, carbon capture is expensive and often fails to meet capture targets. It simply *may not work* if installed. But even if it were to work as proponents claim, carbon capture leaves several of fertilizer's climate problems wholly unaddressed. First, carbon capture will not eliminate upstream emissions from oil and gas drilling or coal mining and will, in fact, make them worse, as more energy will be needed to operate the carbon capture equipment. Second, carbon capture is typically only applied to the process stream of the steam methane reformer, a significant—but not the only—source of emissions from fertilizer production. The actual emissions from the steam generation and the energy required for the subsequent processes to make ammonia and urea—energy consumption accounting for nearly half of the emissions from urea production[311]—are often left out.[312] Finally, because the end product is unchanged, the fertilizer produced will still release nitrous oxide and carbon dioxide when applied to soils.

Carbon capture does not and cannot solve the climate problems inherent in fertilizer production. It is expensive and often fails to meet capture targets. It simply *may not* work if installed. But even if it were to work as proponents claim, carbon capture leaves several of fertilizer's climate problems wholly unaddressed.

Despite these shortcomings, the fertilizer industry is aligned with fossil fuel interests in pursuing carbon capture. In addition to the widespread internal use of captured carbon within facilities for urea production, four significant CCS projects are operational at fertilizer plants, with a fifth in advanced development, according to the Global CCS Institute. All four

of the currently operating CCS projects at fertilizer plants sell the captured carbon dioxide for use in EOR.[313] A closer look at the fertilizer plants with CCS reveals deeper connections between fertilizer and the fossil fuel industry.

The Enid fertilizer plant in Oklahoma, owned by the Koch Nitrogen Company since 2003, is the second-oldest CCS project in the world. It has been running CCS operations since 1982. Koch Nitrogen (a subsidiary of Koch Fertilizer) is a part of the broader umbrella of Koch Industries, which also includes significant direct fossil fuel operations. The carbon dioxide captured at the Enid plant is used for EOR.[314]

Nutrien operates two of the four fertilizer plants with CCS. Carbon capture operations have been running at Nutrien's nitrogen plant in Geismar, Louisiana, since 2013 and at its plant in Redwater, Alberta, since 2020. Nutrien's board of directors is full of current or former fossil fuel executives, including links to TC Energy, Direct Energy, Marathon Petroleum, Imperial Oil, and Petróleo Brasileiro.[315] The carbon dioxide captured at these plants is used for EOR.[316]

The fourth fertilizer plant connected to EOR operations is the Coffeyville Resources Nitrogen Fertilizer plant in Coffeyville, Kansas. Coffeyville Resources is a subsidiary of the oil refining company CVR Energy.[317] Rather than using fossil gas as a feedstock, the Coffeyville Resources facility processes petroleum coke, an oil refining byproduct, to make hydrogen and, ultimately, fertilizer.[318]

One CCS project in the fertilizer sector is under active development. The Wabash Valley Resources facility near Terre Haute, Indiana, is a former coal gasification plant that has been converted to ammonia production. Though it is unclear where the captured carbon dioxide will go, the facility claims it will use CCS to capture 1.5–1.75 million short tons of carbon dioxide per year and transport the captured carbon for geologic sequestration.[319] Of the three major partners in the project, one is the Oil and Gas Climate Initiative,[320] a combined investment fund from twelve major oil and gas companies.[321] Notably, recent communication from the company suggests it is either pivoting to hydrogen production or at least branding itself as such.[322] The ability of such projects to shift their focus and framing from agrochemicals to energy demonstrates the increasing convergence of these two sectors.

Two additional projects in the US are in the early stages as part of a broader carbon capture network. The Midwest and Great Plains region—a hub of industrial agriculture dominated by corn, which is used to synthesize ethanol—is currently a major target for a CCS buildout. At least three carbon dioxide pipelines—from developers Summit Carbon Solutions, Navigator CO_2 Ventures, and Wolf Carbon Solutions in partnership with Archer Daniels Midland Co.—are currently planned for the "Corn Belt" to transport emissions from Midwest ethanol and fertilizer production.[323] While the ethanol industry is the main customer for these pipeline projects, fertilizer producers are also in the mix. Iowa Fertilizer Company (a subsidiary of OCI) signed a deal to participate in Navigator's carbon dioxide pipeline.[324] Another fertilizer company called Northern Plains Nitrogen announced a partnership with Summit Carbon Solutions on a new plant to produce blue ammonia (ammonia made with blue hydrogen) in North Dakota to supply "low-carbon" nitrogen fertilizer to farmers in the northern US and Canada. According to the announcement, Summit will transport the captured carbon dioxide to a storage site in central North Dakota.[325] It is unclear (as of publication time) if the project is moving forward.[326]

Finally, CF Industries is pursuing carbon capture at two of its existing US locations, in Yazoo City, Mississippi, and Donaldsonville, Louisiana,[327] as well as a potential new facility in Ascension Parish, Louisiana (where Donaldsonville is located). The company describes its Donaldsonville complex as "the world's largest and most flexible ammonia production facility,"[328] and seeks to produce 1.7 million short tons of blue ammonia there annually.[329] It is unclear whether this ammonia will be intended for fertilizer production or if it will be sold for fuel or energy production. Upon announcing the project, CF Industries' CEO stated: "We believe that ammonia will play a critical role in accelerating the world's transition to clean energy and that demand for blue ammonia for this purpose will grow meaningfully in the coming years."[330] CF Industries is also planning a new USD2 billion blue ammonia facility to be sited in Ascension Parish, Louisiana, with the ammonia intended for export.[331] The other planned project at an existing facility in Yazoo City is estimated to be about a quarter of the size of the Donaldsonville project.[332] Notably, Yazoo County (in which Yazoo City sits) was the site of a major carbon dioxide pipeline leak in 2020 that hospitalized forty-nine people, leaving many with chronic ailments.[333]

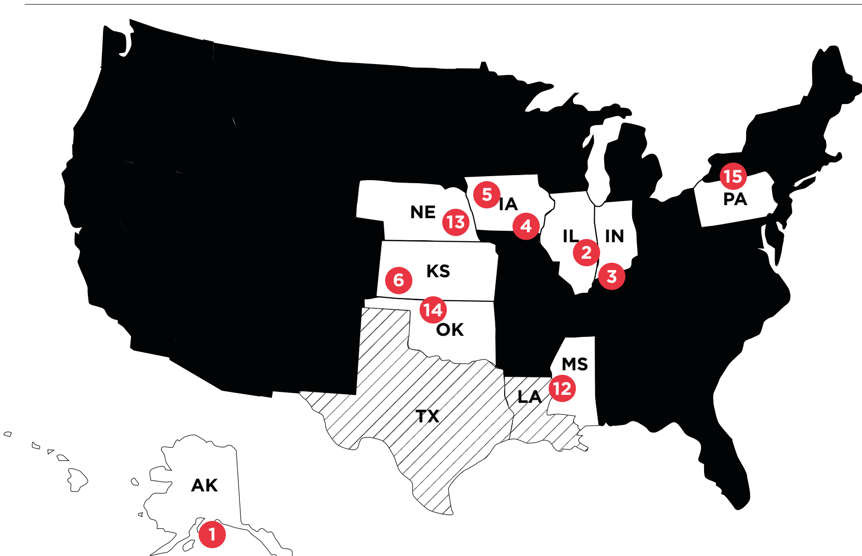
The fertilizer industry is further eyeing CCS opportunities in other countries such as Canada, France, and the Netherlands, among others. An announcement in July 2021, for example, revealed that Yara is partnering with several other companies including Oil Majors ExxonMobil and Total (rebranded as TotalEnergies) and chemical firm Borealis (which makes fertilizer) to develop CCS infrastructure in the industrial basin of Normandy in France, where Yara also operates the Le Havre ammonia production plant.[334] And on August 29, 2022, Yara announced that it had signed a deal with Oil Majors Shell, Equinor, and TotalEnergies to transport and store captured carbon through the oil companies' Northern Lights partnership, which aims to transport captured carbon dioxide to Norway and, starting in 2024, inject it offshore into sub-seabed reservoirs in the North Sea.[335] Per the deal, Yara would supply approximately 800,000 tonnes of carbon dioxide captured from its Sluiskil ammonia plant in the Netherlands starting in 2025.[336]

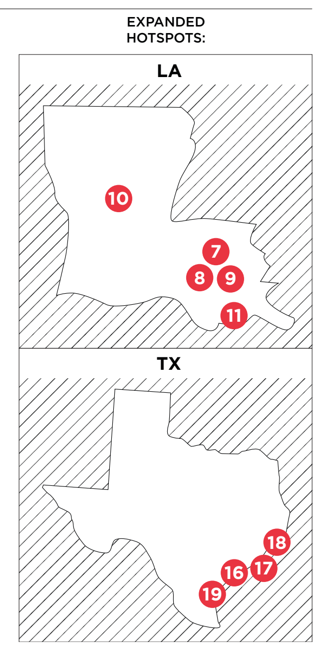
The use of carbon capture remains a clear point of connection and alignment between the fertilizer industry and oil and gas interests. As a poignant example, in an April 2021 letter to the Alberta Environment and Parks agency, the Canadian fertilizer lobby expressed interest in taking advantage of an investment tax credit opportunity for CCUS projects included in Canada's 2021 budget plan.[337] The industry group noted concern that the tax credit excludes EOR projects—suggesting that the interests of the fertilizer industry and the oil industry are linked when it comes to promoting carbon capture. As Fertilizer Canada states in the letter: "This technology not only offers opportunities for the oil and gas industry, but also presents significant opportunities for Alberta's fertilizer industry."[338] The oil industry's experience with CCS has been used to increase production via EOR for decades, and this trend is likely to increase.

Figure 7

US Fossil Fertilizer and Blue Ammonia Buildout Plans

	State:	County:	Facility:	Status:	Project Type:	Classification:	Cost (in USD):
1.	**AK** ALASKA	Kenai Peninsula Borough	Kenai Nitrogen Operations Facility	Pre-Construction	Ammonia/Urea	Restart	$140 million
2.	**IL** ILLINOIS	Douglas	Cronus Ammonia Plant	Pre-Construction	Ammonia/Urea	New Build	$1.762 billion
3.	**IN** INDIANA	Posey	Midwest Fertilizer — Nitrogen Fertilizer Manufacturing Facility	Pre-Construction	Ammonia/Urea	New Build	$2.4 billion
4.	**IA** IOWA	Lee	IFC Fertilizer Complex	Announced	Blue Ammonia	Expansion	
5.	**IA** IOWA	Webster	Fort Dodge Nitrogen Plant	Under Construction	Ammonia/Urea	Expansion	$140 million
6.	**KS** KANSAS	Ford	Dodge City Nitrogen Facility	Announced	Ammonia/Urea	Expansion	$30 million
7.	**LA** LOUISIANA	Ascension Parish	Blue Ammonia Plant	Announced	Blue Ammonia	New Build	$2 billion
8.	**LA** LOUISIANA	Ascension Parish	Nutrien Geismar Ammonia Plant	Announced	Blue Ammonia	New Build	$2 billion
9.	**LA** LOUISIANA	Ascension Parish	Donaldsonville Nitrogen Complex	Announced	Nitric Acid Upgrades, Blue Ammonia, Pilot Green Ammonia	Expansion	$340 million
10.	**LA** LOUISIANA	Grant Parish	TopChem Ammonia Plant	Pre-Construction	Ammonia/Urea	New Build	$265 million
11.	**LA** LOUISIANA	Jefferson Parish	Dyno Nobel Ammonia Production Facility	Pre-Construction	Ammonia/Urea	Expansion	
12.	**MS** MISSISSIPPI	Yazoo	Yazoo City Complex	Announced	Blue Ammonia	Expansion	$85 million
13.	**NE** NEBRASKA	Lancaster	Monolith Olive Creek Plant	Pre-Construction	Ammonia/Urea	Expansion	$1 billion
14.	**OK** OKLAHOMA	Garfield	Koch Fertilizer Plant	Completed in 2022	Ammonia/Urea	Expansion	$150 million
15.	**PA** PENNSYLVANIA	Clinton	KeyState Natural Gas Synthesis Plant	Announced	Blue Ammonia/ Blue Hydrogen	New Build	$400 million
16.	**TX** TEXAS	Galveston	Blue Bayou Ammonia Plant	Announced	Blue Ammonia	New Build	$80 million
17.	**TX** TEXAS	Galveston	Gulf Coast Ammonia Plant	Under Construction	Ammonia/Urea	New Build	$500 million
18.	**TX** TEXAS	Jefferson	OCI Beaumont Blue Ammonia Complex	Pre-Construction	Blue Ammonia	New Build	$2.8 billion
19.	**TX** TEXAS	San Patricio	Enbridge Ingleside Energy Center	Announced	Blue Ammonia/ Blue Hydrogen	Expansion	$2.5 billion





Credit: Data from Environmental Integrity Project's Oil & Gas Watch database. See the Appendix for more information about each of the sites, as well as an overview of buildout plans outside the US.

BOX 3

The Deep and Pervasive Intersections Between the Fossil Fuel and Fertilizer Industries

Existing CCS facilities and potential projects demonstrate many intersections between the fossil fuel and fertilizer industries. On the other side of the petrochemical industry, plastic and polymer production is often more clearly connected to oil and gas, as many of the Oil Majors have chemical divisions that produce polymers from naphtha (an oil refining product) or natural gas liquids (NGL) (a byproduct of gas separation). Fertilizers are primarily—although as demonstrated by the Coffeyville Resources facility, not exclusively—produced from primary products of fossil fuel production, namely gas and coal. As such, the companies that produce fertilizers are often separate—at least superficially—from those that produce or refine fossil fuels.

Nonetheless, the historic and continuing links between the fossil fuel and agrochemical industries are deeper and far more pervasive than widely recognized. As a corporate history of petrochemical and agrochemical giant Dow Chemical succinctly explained: "The road to success for a petrochemical company such as Dow runs right through the oil path. That is where its raw materials, or feedstocks, come from, as well as the fuel gases that provide a key energy source."[339]

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The history of Dow itself is emblematic in this regard. In 1931, Dow created the Ethyl-Dow Company as a joint venture with Ethyl Corp (a joint venture by DuPont-owned General Motors and Standard Oil) to produce the massive quantities of bromine needed to produce leaded "ethyl gas"—the leaded gasoline that engendered a multigenerational public health crisis.[340] Dow entered the oil-field chemical business in 1932 and remains an active player in the industry today.[341] Even as Dow's interest in converting its own waste streams into a new ammonia profit stream increased, its interest in acquiring the technology to convert oil-field methane directly to chemicals led to a major corporate acquisition in 1938 to secure the technology and the staff that pioneered it.[342] By the early 1940s, the company's growing list of petroleum industry clients and its own growing need for energy and feedstocks led to a major expansion of its Gulf Coast operations;[343] as one historian explained, Dow "built the Texas plant on cheap gas." Recognizing the critical role of oil and gas as both a feedstock and product in its own right, Dow began its own oil and gas production and transport business in 1946 and remained active as an oil and gas producer for many decades.[344]

Dow's trajectory is far from unique. Chemical giant E.I. du Pont de Nemours and Company was an early mover in petrochemicals generally and agrochemicals specifically. In the wake of World War I, DuPont leveraged its ties with the US government to secure access to the Haber-Bosch process and other commercial secrets from German agrochemical giant BASF.[345] Like Dow, DuPont also had early and extensive ties to oil and gas production. In addition to partnering with Standard Oil and General Motors on ethyl gasoline, DuPont and the du Pont family invested heavily in the oil and gas sector. By the 1960s, the company, and the family that controlled it held investments in more than a dozen major oil companies.[346]

Similarly, since 1969, BASF has owned a controlling stake in Wintershall, Germany's largest producer of crude oil and natural gas. Wintershall remained a wholly owned subsidiary of BASF until May 2019, when it was merged with Deutsche Erdoel AG, an international oil and gas company. BASF retains a controlling 72 percent stake in the merged company, now called Wintershall Dea.[347]

Koch Industries, which owns both Koch Ag & Energy Solutions and Koch Fertilizer,[348] has extensive investments and operations in oil and gas production, transport, and refining.[349] Through the Koch Family Foundation, Koch Industries' owners spent more than USD145 million to finance climate denial groups between 1997 and 2018.[350]

Prior to being spun off in 2004, Yara was the agrochemical division (Hydro Agri) of Norsk Hydro. Norsk Hydro entered the oil and gas business in the 1960s and became a major producer in the North Sea petroleum industry for nearly four decades. Shortly after Yara was created, Norsk Hydro merged its oil and gas operations into a new entity, StatoilHydro, with Norway's State-owned oil company Statoil (now Equinor). Yara's current and former board members have been directors or executives at Equinor.[351]

Board members overlap between other major fertilizer companies and major oil, gas, and coal producers. The majority of the Nutrien corporate board has direct ties to the oil and gas industry, including current board chair Russell Girling (former CEO of TransCanada Pipeline and TC Energy Corporation) and director Michael Hennigan (current President and CEO of Marathon Petroleum Corporation).[352] Similarly, directors of OCI N.V. are or have been executives at BP, Forest Oil Corporation, and SandRidge Energy,[353] and one of its subsidiaries shares a director with ExxonMobil.[354]

This phenomenon is not limited to companies based in the US and the EU. SABIC Agri-Nutrients is a division of SABIC, which is 70 percent owned by oil and gas giant Saudi Aramco.[355] Chinese fertilizer giant Sinofert is controlled by chemical giant Sinochem, which also produces oil and gas in nine countries, including China, Brazil, Colombia, and the US.[356]

Beyond these direct connections and the use of fossil gas as a feedstock for fertilizer production, several oil and gas companies also have direct stakes in industrial agriculture through their chemicals divisions, particularly those that produce pesticide ingredients. As discussed in Part 1, both ExxonMobil and ChevronPhillips Chemical produce pesticides.[357] Similarly, Shell's Chemicals portfolio includes a wide array of pesticide and agrochemical precursors.[358]

Fertilizer Companies Are Betting on Hydrogen and Ammonia

Hydrogen and ammonia are increasingly receiving attention and investment as an alternative to fossil fuels. As a producer of both hydrogen and ammonia, the fertilizer industry is poised to capitalize on the growing use of these chemicals and sees itself as a key player in a new hydrogen economy—through the potential for massive new subsidies for infrastructure; the expansion of massive, publicly subsidized new markets for their products; and new narratives that give a globally harmful industry a new veneer of sustainability.

As with the oil and gas industry, proposals for the production of green hydrogen and green ammonia (ammonia made with green hydrogen) are limited or misleading, and the pivot to hydrogen amounts to a continuation of much of the same. Moreover, regardless of their source, synthetic nitrogen fertilizers have the same climate and environmental impacts when applied to soils and are inextricably linked to input-intensive agriculture. Replacing nitrogen fertilizers' fossil fuel feedstock with green ammonia does nothing to address emissions from soils, including nitrous oxide and carbon dioxide emitted from decomposing urea. It does, however, provide an enticing marketing opportunity for ammonia producers and a potential pathway to expand their business.

The Fertilizer Industry Sees Opportunity in Hydrogen and Ammonia

The fertilizer industry views new markets for hydrogen and ammonia as an opportunity to expand production and market share. The industry already produces these intermediate products. So it is well-placed to expand production of hydrogen and ammonia if or as markets for them develop.

At present, there is a limited market for either hydrogen or ammonia. The majority of all hydrogen (60 percent) is either used for fertilizer production or for removing sulfur from oil in refineries.[359] Ammonia, similarly, is used primarily for fertilizer production and secondarily for other chemical applications.[360] In both cases, neither hydrogen nor ammonia is currently used at any large scale for storing or producing energy. However, according to one analysis by Citibank as reported by Reuters, for example, green ammonia represents a USD7.25 billion opportunity for fertilizer producers by 2030, an estimate that figures sales of twenty million tonnes annually of clean shipping fuels.[361] (Global ammonia sales currently total 180 million tonnes.)[362] Overall, ammonia usage could increase more than fivefold, reaching over 1,000 million tonnes by 2050, as ammonia producers scale up new markets for their products, such as applications in power storage and shipping fuel. "This would be the largest demand growth of any basic chemical intermediate by 2050," a new report on chemical sector sustainability pathways states.[363]

As a producer of both hydrogen and ammonia, the fertilizer industry is poised to capitalize on the growing use of these chemicals and sees itself as a key player in a new hydrogen economy.

The push for hydrogen and ammonia economies must be understood as efforts to create new markets, not merely the evolution of existing markets and infrastructure. In this new market is where companies see the opportunity. To gain public and government support, blue hydrogen is portrayed as a bridge towards green hydrogen—a claim that is as misleading as calling fossil gas a bridge towards a renewable energy future.[364]

The fertilizer industry's interest in hydrogen and ammonia is clear in statements from industry executives. Dr. Antoine Hoxha, technical director of Fertilizers Europe, describes the fertilizer industry's view of ammonia as a "'missing link' in making decarbonisation a reality."[365] According to an interview with David Herrero Fuentes of Fertiberia (a Spanish fertilizer and ammonia producer) and Tove Andersen (executive vice president at Yara at the time), the fertilizer industry executives view ammonia as an "enabler" of the hydrogen economy. "Ammonia will increasingly be linked to energy, as a carrier for hydrogen, which creates different market dynamics than when it was only used as a fertiliser. We view this as a huge business opportunity," Andersen said.[366] As CF Industries' CEO Tony Will told Reuters: "We absolutely could be known more for being a clean energy company than an ag supplier."[367]

The fertilizer industry is already pushing blue ammonia with multiple projects announced or underway. As previously mentioned, CF Industries is planning a new blue ammonia facility in Louisiana, designed for exporting the ammonia to Asia.[368] Yara is collaborating with partners in Japan to establish a "clean" ammonia (including blue ammonia) global supply chain and domestic distribution network. In June 2022, Yara announced an agreement with the Japanese export credit agency Japan Bank for International Cooperation.[369] Yara previously announced agreements with other Japanese partners, including one in October 2021 involving Japan's largest power company and a Japanese petroleum products supplier, with the intention "to discuss cooperation among major players in the power generation, agriculture, and oil refining industries."[370] In the Middle East, a fertilizer producer called Fertiglobe, formed as a partnership between OCI N.V. and ADNOC, is planning to produce blue ammonia at its existing plant in the Ruwais Industrial Complex in Ruwais, Abu Dhabi. In August 2021, Fertiglobe announced plans to enable the United Arab Emirates' first sale of blue ammonia from that facility to a company in Japan.[371]

Additionally, Fertiglobe is partnering on a planned new blue ammonia facility located in the TA'ZIZ Industrial Chemicals Zone adjacent to the Ruwais Complex.[372] In the Netherlands, the Port of Rotterdam is exploring opportunities to import blue ammonia produced in Norway to support the emerging hydrogen economy for fuel and fertilizer production. Blue ammonia could be shipped to the Port of Rotterdam in 2025 and is expected to be used in industries like fertilizer and shipping.[373]

Fertilizer companies are also interested in hydrogen as a product as well as a feedstock for ammonia. In addition to major oil companies such as ADNOC, BP, Equinor, Shell, and TotalEnergies, both CF Industries and OCI N.V. are steering members of the Hydrogen Council.[374] In evaluating the financial draw of hydrogen, CF Industries expects hydrogen to be a high-value product and its most profitable, with nearly ten times the margin of ammonia fertilizer.[375]

Agrochemical Companies Attempt to Green Their Image

Agrochemical companies, particularly fertilizer companies, are attempting to position themselves as climate champions despite the continued climate impacts of their products. Companies are rebranding as clean energy companies, promoting the use of CCS, and overemphasizing the role of green hydrogen in their business models. A broad review of statements from major fertilizer companies reveals this shift in messaging and business strategy. Moreover, despite claims of shifting to cleaner production practices, the fertilizer industry continues to operate in an emissions-intensive manner. Minor investments in green hydrogen or green ammonia production are touted as signs of a major industry pivot when in reality, they are minute components of overall industry production.

CF Industries is now describing itself (for example, on its website) as a "clean energy" company. In March 2021, it rebranded with a new logo representing a blue and green ammonia molecule.[376] Fertilizers Europe also recently rebranded with a new blue and green logo,[377] a suggestive representation of the broader industry promotion of blue and green ammonia. Despite not currently pursuing any green ammonia projects, Nutrien is actively promoting itself as a low-carbon ammonia producer.[378]

CF Industries is launching the first large-scale green ammonia project in the US at its flagship plant in Donaldsonville, Louisiana, with a gross ammonia production capacity of 4.3 million short tons per year.[379] The project will produce about 20,000 short tons of green ammonia per year[380]—only a small fraction of the site's total ammonia production. CF projects green ammonia production across its network to reach 450,000 short tons by 2026 and 900,000 short tons by 2028, ambitious targets that themselves are still less than one-tenth of CF's current ammonia production of over 10.5 million short tons.[381]

Yara also is pursuing lower-carbon ammonia and expects that this will provide new business opportunities in the emerging hydrogen economy. Yara is a founding partner of the Green Hydrogen Catapult initiative, which strives to scale up green hydrogen fiftyfold over the next six years and drive costs down to below USD2/kg.[382] And in early 2021, the company launched a new business unit called Yara Clean Ammonia to explore growth potential in the green ammonia and hydrogen space.[383]

Moreover, Yara is capitalizing on the green ammonia marketing opportunity by promoting what it calls "green fertilizers," or fertilizers produced from ammonia using renewable electricity instead of fossil fuels.[384] While Yara claims these fertilizers will have an 80–90 percent lower carbon footprint compared to fossil-based fertilizers, the company does acknowledge that they will not be completely fossil-free;[385] indeed, parts of the production process will remain energy-intensive and, therefore, will consume fossil fuels. Furthermore, producing fertilizers from green ammonia fails to address the significant GHG emissions that result from fertilizer usage. And finally, these "green fertilizers" do not even exist yet, nor have they been proven to earn the "green" label. Yara says the first batch of these fertilizers will come from its green ammonia pilot project in Porsgrunn, Norway, which the company aims to have operational by 2023.[386]

Outside of Norway, Yara is developing green ammonia projects in Australia and the Netherlands, among other locations. The Australian project will allow for green hydrogen production at Yara's ammonia facility in Pilbara and will initially produce 3,700 tonnes of green ammonia per year.[387] On average, the Pilbara plant produces over 800,000 tonnes of ammonia per year,[388] so nearly all of the ammonia production will continue to rely on fossil fuels. In the Netherlands, Yara is working with the Danish clean energy firm Ørsted to build a green ammonia project for Yara's ammonia plant in Sluiskil. The green hydrogen to make the ammonia would be made from a 100 megawatt electrolyser powered by offshore wind—developed by Ørsted—and would generate 75,000 tonnes per year of green ammonia. That amount would meet only a small fraction, about 10 percent, of the capacity of one of the ammonia units at the Sluiskil plant.[389] As noted earlier, Yara recently announced a larger blue ammonia deal from the same facility.[390]

Similarly, OCI N.V. proclaims on its website that the company is "[d]riving the decarbonization of food, fuel, and feedstock."[391] Despite this positioning, the company touts the strategic location of its operations near fossil gas fields and pipeline networks,[392] reflecting its continued long-term dependence on fossil gas energy and feedstocks. Of five claimed "Clean Ammonia" projects listed on the OCI website, none is currently operational as of late August 2022.[393] The two largest projects, both in the US, would produce blue fertilizer and ammonia by adding carbon capture to existing fossil gas production processes.[394] A third project in the Netherlands would capture a small amount of methane from waste sources to modestly supplement a standard fossil (gray) hydrogen production plant.[395] Additional blue ammonia projects in the United Arab Emirates, discussed earlier in this report,[396] do not currently appear on OCI's "Clean Ammonia" website. As the present report details, such CCS, blue hydrogen, and blue ammonia projects will further entrench the fossil economy while exacerbating, not mitigating, the climate crisis. Just two projects would produce green ammonia from renewable energy. The ammonia project proposed by the NorthH2 consortium, in collaboration with fossil fuel companies Shell, Equinor, and RWE, and currently in the "feasibility stage," would avoid just 900,000 tonnes of carbon dioxide when it comes online in 2030.[397] The final project, Egypt Green, projected to come online in 2022, would produce just 90,000 tonnes per year of green ammonia at an OCI Fertiglobe facility in Egypt.[398] This represents just 1 percent of Fertiglobe's claimed production capacity of 6.5 million tonnes of urea and ammonia per year.[399]

Since any announced green ammonia projects would amount to only a very small fraction of total ammonia production at given locations, it would not be a stretch to view these initiatives as little more than greenwashing. Despite its claims of becoming cleaner, the fertilizer industry is as emissions-intensive as ever.

Conclusion

As the international community seeks to respond to the interconnected crises of climate, biodiversity, hunger, and pollution, the fundamental role that coal, oil, and gas have played and continue to play in upholding and feeding a destructive system has been overlooked for too long. The ongoing war in Ukraine has laid bare the geopolitical and security risks of relying on fossil fuels and fossil agrochemicals. Deepening that reliance not only enhances the power of fossil companies and their government allies but further pushes us beyond safe planetary boundaries and undermines human rights.

The fossil fertilizer industry is a key player in these intersecting ecological crises. The production and use of fertilizer from gas and coal tie our food system to the instabilities and harms of a fossil fuel economy. Fossil fertilizers represent an enormous source of GHG emissions that is often overlooked when addressing the climate impacts of industrial agriculture. At the same time, excess nitrogen also leads to eutrophication, a process that results in algal blooms, dead zones, and fish kills, pushing society far beyond the planetary boundary for nitrogen pollution. And the petroleum-derived pesticides that fossil fertilizers necessitate—along with the microplastics through which both are increasingly delivered—further erode soil quality, damage ecosystems, and harm human health. Together, these toxic, interwoven, and intrinsic elements of the fossil economy are driving us rapidly (and soon, irreversibly) beyond the planetary safety zones for climate, nitrogen, pollution, and biodiversity loss alike.

For over a decade, Big Oil has been betting on petrochemicals (chief among them fertilizer and plastics) as an escape hatch as energy shifts to renewables. Companies that directly rely on petrochemical feedstocks for their products are portraying themselves as part of the solution rather than as the root of the problem that they are. Fertilizer production is one of the central ways in which the fossil fuel industry seeks to launder its emissions to simulate climate action. Through the pursuit of blue hydrogen and ammonia, fossil fertilizer companies are seeking to cash in on generous subsidies while expanding into new markets for hydrogen and ammonia as energy.

The growing government support threatens to turbocharge the fertilizer industry, providing it with financial windfalls, new markets, and opportunities for greenwashing. Blue hydrogen and blue ammonia will do little to reduce emissions from fertilizer production and threaten to exacerbate emissions from energy systems.

Moreover, as fertilizer companies position themselves as climate-forward companies, they distract from the fundamental unsustainability of their products and the harm that they cause—from additional GHG emissions from fertilizer application to the environmental injustices inflicted on communities living next to production sites or farms, to the eutrophication of waterways due to excessive nitrogen.

The linear, input-reliant model of industrial agriculture is in need of a profound transformation to resilient, regenerative models that enhance food sovereignty while sustaining and restoring ecosystems and the communities that depend on them. This requires urgently reducing our reliance on fossil fertilizers and the pesticides and plastics with which they are increasingly coupled. Chemical inputs in agriculture are not vitally necessary for food security; on the contrary—they undermine food sovereignty.

There are many alternatives to synthetic fertilizer and pesticide usage with sustainable farming models that minimize or eliminate reliance on petroleum-based agrochemicals. From agroecology to organic agriculture to regenerative farming systems, a multitude of alternative models exist to transform agriculture to be healthier and more resilient while feeding communities with better food.

A conversation on how we can achieve those transformations must start long before toxic agrochemicals enter our soils. As with the climate and plastic pollution crises, we have seen that addressing the problem at its roots requires confronting fossil fuel pollution along the entire life cycle. At a time of surging fossil fuel, fertilizer, and food prices, and with the escalating climate crisis as a backdrop, the case for truly transitioning away from fossil fertilizer and fossil fuels altogether has never been clearer.

Appendix

Table 1: **Overview of Planned Fossil Fertilizer and Blue Ammonia Buildout in the US**

State	County (or Borough/ Parish)	Company	Facility	Project Name	Status	Project Type	Classification	Sector	Potential CO_2e (short tons/year)	Cost
AK	Kenai Peninsula Borough	Nutrien	Kenai Nitrogen Operations Facility	Kenai Nitrogen Operations Facility Restart	Pre-Construction	Ammonia/Urea	Restart	Synthetic Fertilizers	2,197,970	USD140 million
IA	Lee	Iowa Fertilizer Company	IFC Fertilizer Complex	IFCo CCS[i]	Announced	Blue Ammonia	Expansion	Synthetic Fertilizers		
IA	Webster	Koch Fertilizer	Fort Dodge Nitrogen Plant	Fort Dodge Ammonia Expansion Project	Under Construction (expected completion in fall 2022)[ii]	Ammonia/Urea	Expansion	Synthetic Fertilizers		USD140 million
IL	Douglas	Cronus Chemicals	Cronus Ammonia Plant	Cronus Ammonia Plant	Pre-Construction	Ammonia/Urea	New Build	Synthetic Fertilizers	1,822,415	USD1.762 billion[iii]
IN	Posey	Midwest Fertilizer Company	Midwest Fertilizer—Nitrogen Fertilizer Manufacturing Facility	Midwest Fertilizer	Pre-Construction	Ammonia/Urea	New Build	Synthetic Fertilizers	1,615,044	USD2.4 billion
KS	Ford	Koch Fertilizer	Dodge City Nitrogen Facility	Dodge City UAN Expansion Project	Announced	Ammonia/Urea	Expansion	Synthetic Fertilizers		USD30 million[iv]
LA	Ascension Parish	CF Industries	Donaldsonville Nitrogen Complex	Donaldsonville Upgrades—including Nitric Acid Upgrades Project and Blue (and a pilot Green) Ammonia Projects	Announced	Several projects: 1) Nitric Acid Upgrades (chemical used in nitrogen fertilizer production); 2) Blue Ammonia; 3) Pilot Green Ammonia	Expansion	Synthetic Fertilizers		USD41 million (Nitric Acid Upgrades); USD199 million (Blue Ammonia); USD100 million (Pilot Green Ammonia)
LA	Ascension Parish	CF Industries	Blue Ammonia Plant		Announced[v]	Blue Ammonia	New Build	Synthetic Fertilizers		USD2 billion
LA	Ascension Parish	PCS Nitrogen Fertilizer (parent company Nutrien)	Nutrien Geismar Ammonia Plant	Nutrien Geismar Ammonia Plant—Blue Ammonia	Announced	Blue Ammonia	New Build	Synthetic Fertilizers		USD2 billion
LA	Grant Parish	TopChem	TopChem Ammonia Plant	TopChem Ammonia Plant	Pre-Construction	Ammonia/Urea	New Build	Synthetic Fertilizers	550,839	USD265 million[vi]
LA	Jefferson Parish	Dyno Nobel	Dyno Nobel Ammonia Production Facility	Dyno Nobel—Boiler Expansion	Pre-Construction	Ammonia/Urea	Expansion	Synthetic Fertilizers	4,260	
MS	Yazoo	CF Industries	Yazoo City Complex	Yazoo City Blue Ammonia Project	Announced	Blue Ammonia	Expansion	Synthetic Fertilizers		USD85 million
NE	Lancaster	Monolith Materials	Monolith Olive Creek Plant	Olive Creek 2	Pre-Construction	Ammonia/Urea (Building an anhydrous ammonia unit to an existing carbon black facility to produce liquid fertilizer)	Expansion	Petrochemicals and Plastics, Synthetic Fertilizers	115,176	USD1 billion
OK	Garfield	Koch Fertilizer	Koch Fertilizer Plant	Enid Nitrogen Plant—UR2 Improvements Project	Completed in 2022[vii]	Ammonia/Urea	Expansion	Synthetic Fertilizers	91,720	USD150 million
PA	Clinton	KeyState Natural Gas Synthesis Energy	KeyState Natural Gas Synthesis Plant	KeyState Natural Gas Synthesis	Announced	Blue Ammonia/Blue Hydrogen	New Build	Synthetic Fertilizers		USD400 million
TX	Galveston	Blue Bayou Ammonia	Blue Bayou Ammonia Plant	Blue Bayou Ammonia—Phases 1-4	Announced	Blue Ammonia	New Build	Petrochemicals and Plastics, Synthetic Fertilizers		USD80 million

State	County (or Borough/ Parish)	Company	Facility	Project Name	Status	Project Type	Classification	Sector	Potential CO_2e (short tons/year)	Cost
TX	Galveston	Air Products Industrial Gas, Gulf Coast Ammonia	Gulf Coast Ammonia Plant	Gulf Coast Ammonia Plant	Under Construction	Ammonia/Urea	New Build	Synthetic Fertilizers		USD500 million[viii]
TX	Jefferson	OCI Clean Ammonia (a project of OCI NV)	OCI Beaumont Blue Ammonia Complex	OCI Beaumont Blue Ammonia	Pre-Construction	Blue Ammonia	New Build	Synthetic Fertilizers		USD2.8 billion[ix]
TX	San Patricio	Enbridge	Enbridge Ingleside Energy Center	Enbridge Ingleside Blue Hydrogen & Ammonia Production Facility	Announced	Blue Ammonia/Blue Hydrogen	Expansion	Synthetic Fertilizers		USD2.5 billion

Source: Environmental Integrity Project's Oil & Gas Watch database unless otherwise noted.

i "IFCo CCS" OCI, accessed September 22, 2022, https://www.oci.nl/ammonia-initiatives/ifco-ccs/.

ii "KF to Invest $140 Million in Fort Dodge Nitrogen Facility," Koch Fertilizer (press release), November 19, 2020, https://kochfertilizer.com/newsroom/KF-to-Invest-140-Million-in-Fort-Dodge-Nitrogen-Facility_2504.aspx.

iii Debra Pressey, "No Work Planned Yet on Cronus Fertilizer Plant in Tuscola," *The News-Gazette* (via The Associated Press), December 12, 2021, https://www.usnews.com/news/best-states/illinois/articles/2021-12-12/no-work-planned-yet-on-cronus-fertilizer-plant-in-tuscola.

iv "KF to Increase UAN Production at Dodge City Facility," Koch Fertilizer (press release), August 16, 2022, https://kochfertilizer.com/newsroom/KF-to-Increase-UAN-Production-at-Dodge-City-Facility_2625.aspx.

v "CF Industries Announces Planned $2 Billion Carbon-Capture Ammonia Complex in Ascension Parish," Office of the Louisiana Governor (press release), August 17, 2022, https://gov.louisiana.gov/index.cfm/newsroom/detail/3792.

vi "Investimus Foris Announces $265 Million Ammonia Plant in Grant Parish," Louisiana Economic Development (news release), July 22, 2015, https://www.opportunitylouisiana.com/led-news/news-releases/news/2015/07/22/investimus-foris-announces-$265-million-ammonia-plant-in-grant-parish.

vii Kelci McKendrick, "Koch wrapping up $150 million investment east of Enid," Enid News & Eagle, February 6, 2022, https://www.enidnews.com/news/progress/koch-wrapping-up-150-million-investment-east-of-enid/article_01b4f340-843a-11ec-875e-7b98bd3c864c.html.

viii "Air Products to Make Largest-Ever U.S. Investment of $500 Million to Build, Own and Operate Its Largest-Ever Hydrogen SMR, a Nitrogen ASU and Utilities Facilities, and Wins Long-Term Contract to Supply Gulf Coast Ammonia's New World-Scale Texas Production Plant," Air Products (news release), January 8, 2020, https://www.airproducts.com/company/news-center/2020/01/0108-air-products-to-build-its-largest-smr-to-supply-gulf-coast-ammonia.

ix Emily Burleson, "Fertilizer co. OCI considers nearly $5B Beaumont expansion with renewable fuels," Houston Business Journal, April 19, 2022, https://www.bizjournals.com/houston/news/2022/04/19/oci-beaumont-renewable-fuels-ammonia.html.

Table 2: **Overview of Planned Blue Ammonia and Blue Hydrogen Buildout Outside the US**

Location	Company	Project Name	Project Type	Description
Europe				
Norway	Horisont Energi, Equinor, and Vår Energi	Barents Blue	Blue Ammonia	Located in northern Norway, the project aims to produce ammonia (production estimated at 1 million tonnes/year) from fossil gas extracted from the Barents Sea, using carbon capture to capture the carbon dioxide and sequester it offshore in the Barents Sea.[i]
Netherlands	OCI N.V.	Port of Rotterdam Ammonia Expansion	Blue Ammonia Import Project	OCI is expanding its existing ammonia import facility at Europe's largest seaport to accommodate a capacity of 1.2 million tonnes/year in the first phase, with expected completion in 2023. OCI is also preparing for a second phase to expand capacity even further, to potentially over 3 million tonnes/year. The terminal is expected to process blue and green ammonia in addition to conventional (gray) ammonia.[ii]
Netherlands	Yara	Yara Sluiskil	Blue Ammonia	Yara plans to produce blue ammonia at its Sluiskil plant by capturing and storing carbon dioxide from the plant. In late August 2022, Yara announced an agreement to work with Northern Lights—a joint venture between Oil Majors Shell, Equinor, and TotalEnergies—on transporting and storing the captured carbon off the coast of Norway in the North Sea. The project aims to start operations in early 2025.[iii]
United Kingdom	Equinor	Hydrogen to Humber (H2H) Saltend project	Blue Hydrogen, Blue Ammonia	Equinor is building a blue hydrogen production facility (called H2H) in the Saltend Chemicals Park in northeast England. Saltend produces ammonia and other chemicals, and Yara is one of the companies operating there. Half of the blue hydrogen produced from the project will go toward producing chemicals and fuel—including ammonia.[iv]
United Kingdom	BP	H2Teesside	Blue Hydrogen	BP is developing a blue hydrogen production facility in Teesside in northeastern England, aiming to produce up to 1 gigawatt of blue hydrogen by 2030. CF Fertilisers is listed as one of the project's potential customers.[v]
Asia/Pacific				
Australia	Yara	Yara Pilbara	Blue Ammonia	In addition to pursuing a small green ammonia demonstration at its Pilbara site in western Australia, Yara is planning to do CCS at its existing Pilbara ammonia plant, thereby producing blue ammonia that the company aims to supply to the Japanese power sector through an agreement with JERA (Japan's largest power company).[vi]
Indonesia	Mitsubishi Corporation, PT Panca Amara Utama (PAU)	PAU Central Sulawesi Clean Fuel Ammonia Production with CCUS	Blue Ammonia	Mitsubishi is leading a joint feasibility study on applying CCUS to the PAU ammonia plant near Luwuk in Central Sulawesi, Indonesia. The plant produces 700,000 tonnes/year of ammonia, of which Mitsubishi is the exclusive offtaker, shipping at least 40,000 tonnes/month on average to markets in northeast Asia.[vii]
Middle East/North Africa (MENA)				
United Arab Emirates	Fertiglobe in partnership with the Abu Dhabi National Oil Company (ADNOC)	Two projects, one in the Ruwais Industrial Complex and one in the adjacent TA'ZIZ Industrial Chemicals Zone, both located in Ruwais, Abu Dhabi.	Blue Ammonia	Middle Eastern fertilizer producer Fertiglobe, formed as a partnership between OCI N.V, and ADNOC, says it will produce blue ammonia at its existing Fertil plant in the Ruwais Industrial Complex, and in August 2021, announced plans to enable the UAE's first sale of blue ammonia from that facility to a company in Japan. Fertiglobe is also partnering with ADNOC in a planned new blue ammonia facility located in the adjacent TA'ZIZ Industrial Chemicals Zone, with a production capacity of 1 million tonnes/year. That project (also involving Mitsui & Co.) could begin production in 2025.[viii]
Egypt	Misr Fertilizers Production Company (MOPCO) and Abu Qir Fertilizers		Blue Ammonia	No project is underway yet, but a Japanese firm (Toyota Tsusho) recently completed a study on blue ammonia potential in Egypt. The study examined capturing carbon dioxide from two Egyptian fertilizer companies.[ix]

Disclaimer: This is not a complete list of all potential projects around the world. The list is meant to give a general sense of the planned expansion of blue ammonia as it relates to the fertilizer sector. Projects listed below mostly pertain to blue ammonia, with hydrogen included if the project has some link to the fertilizer industry. Sources include news reports and company press releases, and information is current as of August 30, 2022.

i See: "Project to Develop Europe's First Large Scale Blue Ammonia Plant," The Maritime Executive, September 10, 2021, https://www.maritime-executive.com/article/project-to-develop-europe-s-first-large-scale-blue-ammonia-plant; Horisont Energi, *Project Barents Blue* (Horisont Energi, 2021), https://www.horisontenergi.no/wp-content/uploads/2021/06/Barents-Blue-Project-Flyer-2021.pdf.

ii See: "OCI N.V. to Expand Port of Rotterdam Ammonia Import Terminal to Meet Emerging Large-Scale Low-Carbon Hydrogen and Ammonia Demand in the Energy Transition,"OCI (news release), June 15, 2022, https://www.oci.nl/news/2022-oci-nv-to-expand-port-of-rotterdam-ammonia-import-terminal/.

iii "Major milestone for decarbonizing Europe," Yara (news release), August 29, 2022, https://www.yara.com/news-and-media/news/archive/news-2022/major-milestone-for-decarbonising-europe/.

iv See: Henrik Anderson, "Building the UK's first at-scale blue hydrogen and ammonia plant," Lloyd's Register, October 14, 2021, https://www.lr.org/en/insights/articles/uk-first-at-scale-blue-hydrogen-and-ammonia-plant/; "Saltend Chemicals Park," Chemical Parks in Europe, accessed August 29, 2022, https://chemicalparks.eu/parks/saltend-chemicals-park; "Key Facts: The H2H Saltend pilot plant," European Commission, Ref. Ares(2020)3577103, July 7, 2020, https://www.asktheeu.org/en/request/8351/response/30254/attach/5/15%20EN%20annexe%20acte%20autonome%20nlw%20part1%20v1.pdf?cookie_passthrough=1.

v "BP bolsters UK blue hydrogen plans by reaching agreements with more potential customers," BP (press release), August 5, 2021, https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-bolsters-uk-blue-hydrogen-plans-by-reaching-agreements-with-more-potential-customers.html.

vi "Yara and JERA plan to collaborate on clean ammonia to decarbonize power production in Japan," Yara (news release), May 11, 2021, https://www.yara.com/corporate-releases/yara-and-jera-plan-to-collaborate-on-clean-ammonia-to-decarbonize-power-production-in-japan/.

vii Richard Ewing, "Mitsubishi signs MOU for clean fuel ammonia production in Indonesia," ICIS, March 19, 2021, https://www.icis.com/explore/resources/news/2021/03/19/10619618/mitsubishi-signs-mou-for-clean-fuel-ammonia-production-in-indonesia/; See also: Global CCS Institute, "CCS Facilities Database," accessed August 29, 2022, https://co2re.co/FacilityData.

viii "ADNOC and Fertiglobe Partner to Sell UAE's First Blue Ammonia to Japan's Itochu," OCI (news release), August 3, 2021, https://www.oci.nl/news/2021-oci-nv-10/; "Fertiglobe Joins TA'ZIZ as Partner in World-Scale Blue Ammonia Project in Ruwais," ADNOC (press release), June 22, 2021, https://www.adnoc.ae/news-and-media/press-releases/2021/fertiglobe-joins-taziz-as-partner-in-world-scale-blue-ammonia-project-in-ruwais; "Mitsui to Participate in Low-Carbon Ammonia Production Project Abu Dhabi, UAE," Mitsui & Co. (press release), June 10, 2022, https://www.mitsui.com/jp/en/topics/2022/1243562_13410.html.

ix Ed Reed, "Toyota Tsusho moves into detailed blue ammonia Egypt plan," Energy Voice, August 15, 2022, https://www.energyvoice.com/renewables-energy-transition/hydrogen/africa-hydrogen/435649/toyota-tsusho-blue-ammonia/.

Endnotes

1 "FAO Food Price Index posts significant leap in March," Food and Agriculture Organization of the United Nations (press release), April 8, 2022, https://www.fao.org/newsroom/detail/fao-food-price-index-posts-significant-leap-in-march/en.

2 "Yara implements further production curtailments in Europe," Yara (news release), August 25, 2022, https://www.yara.com/corporate-releases/yara-implements-further-production-curtailments-in-europe/.

3 Anna Pruchnicka and Mateusz Rabiega, "UPDATE 2-Grupa Azoty unit limits fertiliser output due to gas prices," *Reuters*, August 24, 2022, https://www.reuters.com/article/grupa-azoty-fertilisers-idAFL1N3000AB.

4 Karol Badohal, "Grupa Azoty halts production of fertilizers due to high gas prices," *Reuters,* August 23, 2022, https://www.reuters.com/article/grupa-azoty-fertilizers/grupa-azoty-halts-production-of-fertilizers-due-to-high-gas-prices-idUSL8N2ZZ0QT.

5 Samuel Gebre, "Europe's Fertilizer Industry Shrinks Again as Energy Chaos Bites," *Bloomberg*, August 23, 2022, https://www.bloomberg.com/news/articles/2022-08-23/europe-s-fertilizer-industry-shrinks-again-as-energy-chaos-bites#xj4y7vzkg.

6 See e.g., Peter Levi and Gergely Molnar, "How the energy crisis is exacerbating the food crisis," International Energy Agency, June 14, 2022, https://www.iea.org/commentaries/how-the-energy-crisis-is-exacerbating-the-food-crisis; Alex Gilbert, Morgan D. Bazilian, and Samantha Gross, "The emerging global natural gas market and the energy crisis of 2021-2022," Brookings (policy brief, executive summary), December 2021, accessed September 12, 2022, https://www.brookings.edu/research/the-emerging-global-natural-gas-market-and-the-energy-crisis-of-2021-2022/; Martha C. White, "Rising oil prices could affect thousands of products," *NBC News*, March 7, 2022, https://www.nbcnews.com/business/business-news/rising-oil-prices-affect-thousands-products-rcna18985.

7 See e.g., Richard Schiffman, "Why It's Time to Stop Punishing Our Soils with Fertilizers," *Yale Environment 360*, May 3, 2017, https://e360.yale.edu/features/why-its-time-to-stop-punishing-our-soils-with-fertilizers-and-chemicals; Pesticide Action Network North America, *Pesticides and Soil Health: State of the Science and Viable Alternatives* (PANNA, December 2020), https://www.panna.org/sites/default/files/soil-pesticides-report.pdf.

8 United Nations, General Assembly, *Report of the Special Rapporteur on the issue of human rights obligations relating to the enjoyment of a safe, clean, healthy and sustainable environment, David R. Boyd—Healthy and sustain-able food: reducing the environmental impacts of food systems on human rights*, A/76/179 (July 19, 2021), 8 (at paragraphs 22–23), http://srenvironment.org/sites/default/files/Reports/2021/Food%2C%20Environment%20and%20human%20rights%20A%3A76%3A179.pdf; see also: "Pesticides are 'global human rights concern,' say UN experts urging new treaty," United Nations Human Rights Office of the High Commissioner (press release), March 7, 2017, https://www.ohchr.org/en/press-releases/2017/03/pesticides-are-global-human-rights-concern-say-un-experts-urging-new-treaty (see UN Special Rapporteurs' statement: "excessive use of pesticides are very dangerous to human health, to the environment and it is misleading to claim they are vital to ensuring food security.").

9 See e.g., *Agrifood Atlas: Facts and Figures About the Corporations That Control What We Eat* (Berlin: Heinrich-Böll-Stiftung, Rosa-Luxemburg-Stiftung, Friends of the Earth Europe, 2017), 18—21, https://eu.boell.org/sites/default/files/agrifoodatlas2017_facts-and-figures-about-the-corporations-that-control-what-we-eat.pdf; United Nations, General Assembly, *Report of the Special Rapporteur*, A/76/179, 4—5, 8.

10 See "Planetary Boundaries," Stockholm Resilience Centre, accessed August 16, 2022, https://www.stockholmresilience.org/research/planetary-boundaries.html.

11 Francesco N. Tubiello et al. "Greenhouse gas emissions from food systems: building the evidence base," *Environmental Research Letters* 16, no. 6 (2021), https://iopscience.iop.org/article/10.1088/1748-9326/ac018e; "Food systems account for more than one third of global greenhouse gas emissions," FAO (news release), March 9, 2021, https://www.fao.org/news/story/en/item/1379373/icode/.

12 Nathan Donley et al., "Pesticides and environmental injustice in the USA: root causes, current regulatory reinforcement and a path forward," *BMC Public Health* 22 (2022), 1–3, 5–6 (in PDF version), https://doi.org/10.1186/s12889-022-13057-4.

13 United Nations, General Assembly, *Report of the Special Rapporteur*, A/76/179, 9—17.

14 "Response to joint statement by the leaders of the World Bank Group (WBG), the World Trade Organisation (WTO), the International Monetary Fund (IMF) and the World Food Programme (WFP)," Public statement by the United Nations Special Rapporteur on the right to food, Mr. Michael Fakhri, Geneva, May 20, 2022, 2, https://www.ohchr.org/sites/default/files/2022-05/joint-statement-wto-imf-wfp.pdf.

15 Center for International Environmental Law, *Plastic & Climate: The Hidden Costs of a Plastic Planet* (Washington DC: CIEL, 2019), 1—4, https://www.ciel.org/reports/plastic-health-the-hidden-costs-of-a-plastic-planet-may-2019/.

16 See e.g., "2,900 scientists and academics call for a Fossil Fuel Non-Proliferation Treaty," Fossil Fuel Non-Proliferation Treaty website, accessed July 28, 2022, https://fossilfueltreaty.org/open-letter; "Food security: Commission steps up support for global action to transform food systems via eight Global Coalitions," European Commission (press release), March 23, 2022, https://ec.europa.eu/commission/presscorner/detail/en/IP_22_1971.

17 See e.g., Michael Pollan, "What's Eating America," *Smithsonian Magazine*, July 2006, https://www.smithsonianmag.com/history/whats-eating-america-121229356/.

18 FAO, *World fertilizer trends and outlook to 2022* (Rome: FAO, 2019), 5 (at Table 3), http://www.fao.org/3/ca6746en/ca6746en.pdf.

19 FAO, *World fertilizer trends and outlook to 2022*, 5 (at Table 3).

20 IEA, *The Future of Petrochemicals: Towards more sustainable plastics and fertilisers* (Paris: IEA, 2018), 3, 14, 27, https://www.connaissancedesenergies.org/sites/default/files/pdf-actualites/the_future_of_petrochemicals.pdf.

21 IEA, *Oil 2021: Analysis and forecast to 2026* (Paris: IEA, 2021), 4, 12, 24, 106, https://www.iea.org/reports/oil-2021.

22 IEA, *World Energy Outlook 2021* (Paris: IEA, October 2021), 215, https://www.iea.org/reports/world-energy-outlook-2021.

23 IEA, *World Energy Outlook 2021*, 73.

24 IEA, *World Energy Outlook 2021*, 73.

25 IEA, *The Future of Petrochemicals*, 3.

26 Peter G. Levi and Jonathan M. Cullen, “Mapping Global Flows of Chemicals: From Fossil Fuel Feedstocks to Chemical Products,” *Environmental Science & Technology* 52, no. 4 (2018): 1730, Fig. 1. https://doi.org/10.1021/acs.est.7b04573 (including nitrogen fertilizers (274.7 mtpa), thermoplastics (222.2 mtpa), and thermosets, fibers, and elastomers (107.2 mtpa)). Note that including the portion of solvents and additives utilized in plastics and agrochemicals would increase their share of the petrochemicals market still further.

27 See e.g., Barbara A Demeneix, “How fossil fuel-derived pesticides and plastics harm health, biodiversity, and the climate,” *The Lancet Diabetes & Endocrinology* 8, no. 6 (2020): 464, https://www.thelancet.com/journals/landia/article/PIIS2213-8587(20)30116-9/fulltext.

28 IEA, *Gas 2020* (Paris: IEA, 2020), 37, https://iea.blob.core.windows.net/assets/555b268e-5dff-4471-ac1d-9d6bfc71a9dd/Gas_2020.pdf.

29 IEA, *World Energy Outlook 2021*, 73, 232.

30 IEA, *The Future of Petrochemicals*, 73.

31 Gary Hergert, Rex Nielsen, and Jim Margheim, “WWII Nitrogen Production Issues in Age of Modern Fertilizers,” *Cropwatch,* University of Nebraska-Lincoln Institute of Agriculture and Natural Resources, April 10, 2015, https://cropwatch.unl.edu/fertilizer-history-p3; see also: Kathleen Merrigan, “Fertilizer prices are soaring - and that’s an opportunity to promote more sustainable ways of growing crops,” *The Conversation*, June 14, 2022, https://theconversation.com/fertilizer-prices-are-soaring-and-thats-an-opportunity-to-promote-more-sustainable-ways-of-growing-crops-183418.

32 See United Nations, General Assembly, *Food systems and human rights - Interim report of the Special Rapporteur on the right to food, Michael Fakhri*, A/76/237 (July 27, 2021), 5—6, https://www.ohchr.org/en/documents/thematic-reports/a76237-food-systems-and-human-rights-interim-report-special-rapporteur.

33 See e.g., *Agrifood Atlas* 6, 20—21.

34 “The industrial food system encourages the dominance of large monocultures that decrease agricultural biodiversity, reduce the resilience of food systems and jeopardize food security.” United Nations, General Assembly, *Report of the Special Rapporteur*, A/76/179, 8.

35 IPCC, *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems* (IPCC, 2019), at 40, 56, 79, 86 (in PDF version), https://www.ipcc.ch/srccl/; see also FAOSTAT, “Fertilizers by Nutrient,” data for world production quantity of nitrogen through 2020, last updated July 15, 2022, accessed Sept. 15, 2022, https://www.fao.org/faostat/en/#data/RFN. In roughly the same period, the global value of pesticide exports has grown by more than 15,000%, from approximately $268 million (1961) to $41 billion (2020). FAOSTAT, “Pesticides Trade,” data for total world value of pesticide exports through 2020, last updated July 15, 2022, accessed, Sept. 18, 2022, https://www.fao.org/faostat/en/#data/RT.

36 Keithly Jones and Frank Nti, “Impacts and Repercussions of Price Increases on the Global Fertilizer Market,” USDA Foreign Agricultural Service, June 2022, 3—4 (at Chart 2), https://www.fas.usda.gov/sites/default/files/2022-06/IATR%20Fertlizer%20Final_0.pdf.

37 FAOSTAT, “Fertilizers by Nutrient,” comparing production quantity of nitrogen by country in 2020, http://www.fao.org/faostat/en/#data/RFN (2020 is the most recent year with this data available).

38 Anton Bekkerman, Gary W. Brester, and David Ripplinger, “The History, Consolidation, and Future of the U.S. Nitrogen Fertilizer Production Industry,” *Choices Magazine* (Vol. 35, Quarter 2, 2020), 1, https://www.choicesmagazine.org/UserFiles/file/cmsarticle_742.pdf.

39 Lori E. Apodaca, “Nitrogen (Fixed)—Ammonia,” US Geological Survey, Mineral Commodities Summaries, January 2022, https://pubs.usgs.gov/periodicals/mcs2022/mcs2022-nitrogen.pdf.

40 Data sourced from Oil & Gas Watch database, Environmental Integrity Project, https://oilandgaswatch.org/.

41 CIEL calculation based on 2020 population estimates for the US (331.45 million), China (1.42 billion), and India (1.353 billion) respectively.

42 FAO, *Inorganic Fertilizers—1990-2020*, Analytical Brief, no. 47 (Rome: FAO, 2022), 7 (at Fig. 6), https://www.fao.org/3/cc0947en/cc0947en.pdf.

43 FAO, *Inorganic Fertilizers—1990-2020*, 9 (at Fig. 10).

44 IEA, *The Future of Petrochemicals,* 18.

45 FAO, *Inorganic Fertilizers—1990–2020*, 7 (at Fig. 6).

46 See Abdallah Ramadhani Mkindi et al. *False Promises: The Alliance for a Green Revolution in Africa (AGRA)* (Berlin: Rosa Luxemburg Stiftung, June 2020), 4–5, 18 –26, https://www.rosalux.de/fileadmin/rls_uploads/pdfs/Studien/False_Promises_AGRA_en.pdf.

47 Mathematica, *Partnership for Inclusive Agricultural Transformation in Africa, Final Evaluation: Volume 1 - Final Evaluation Report* (PIATA, February 2022), 43, https://agra.org/piata-evaluation/.

48 Mathematica, *Partnership for Inclusive Agricultural Transformation*, 2.

49 “Press Release: 200 Organisations Urge Donors to Scrap AGRA,” Alliance for Food Sovereignty in Africa, September 7, 2021, https://afsafrica.org/press-release-200-organisations-urge-donors-to-scrap-agra/.

50 “Fertilizer Applied for Agricultural Purposes,” US EPA, Report on the Environment, accessed May 3, 2022, https://cfpub.epa.gov/roe/indicator.cfm?i=55.

51 “Corn Usage by Segment 2021,” National Corn Growers Association, accessed August 15, 2022, https://ncga.com/world-of-corn.

52 See EPA, “Overview for Renewable Fuel Standard,” U.S. Environmental Protection Agency, last updated February 22, 2022, accessed September 14, 2022, https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard; see also: Govind Bhutada, “From feed to fuel: This is how corn is used around the world,” World Economic Forum, June 2, 2021, https://www.weforum.org/agenda/2021/06/corn-industries-sustainability-food-prices.

53 “EIA releases plant-level U.S. biofuels production capacity data,” US Energy Information Administration, September 13, 2021, https://www.eia.gov/todayinenergy/detail.php?id=49516.

54 “Corn Usage by Segment 2021,” National Corn Growers Association.

55 Bhutada, “From feed to fuel: This is how corn is used around the world.”

56 FAO, “Global Livestock Environmental Assessment Model (GLEAM),” FAO, accessed August 15, 2022, https://www.fao.org/gleam/results/en/.

57 IEA, *Gas 2020*, 36.

58 Market Intelligence Service, *Public Summary Medium-Term Fertilizer Outlook 2021-2025*, (International Fertilizer Association, August 2021), 1, 3, https://api.ifastat.org/reports/download/13362.

59 Market Intelligence Service, *Public Summary Medium-Term Fertilizer Outlook 2022-2026* (IFA, July 2022), 3–4, https://www.fertilizer.org/public/resources/publication_detail.aspx?SEQN=6198&PUBKEY=C5D3054A-4F40-4FFD-8F1A-24AD36D4087D.

60 “Yara ready to enable the hydrogen economy with historic full-scale green ammonia project,” Yara (news release), December 7, 2020, https://www.yara.com/corporate-releases/yara-ready-to-enable-the-hydrogen-economy-with-historic-full-scale-green-ammonia-project/.

61 See, e.g., “Putin’s War Should Change the Way the World Farms,” *Bloomberg*, July 21, 2022, https://www.bloomberg.com/opinion/articles/2022-07-21/fertilizer-shortage-shows-how-russia-s-ukraine-invasion-threatens-food-security#xj4y7vzkg.

62 Anna Lappé, *Diet for a Hot Planet: The Climate Crisis at the End of Your Fork and What You Can Do About It* (New York, NY: Bloomsbury USA, 2010), 12.

63 Seyedehhoma Ghavam, Maria Vahdati, I. A. Grant Wilson, and Peter Styring, “Sustainable Ammonia Production Processes,” *Frontiers in Energy Research* 9 (March 2021): 3 (in PDF version), https://doi.org/10.3389/fenrg.2021.580808.

64 IEA, *Ammonia Technology Roadmap: Towards More Sustainable Nitrogen Fertiliser Production* (Paris: IEA, October 2021), 8, https://iea.blob.core.windows.net/assets/6ee41bb9-8e81-4b64-8701-2acc064ff6e4/AmmoniaTechnologyRoadmap.pdf.

65 See e.g., Prachi Patel. “One Step Synthesis of Urea Could Green Up the Fertilizer’s Act,” *Chemical & Engineering News*, June 18, 2020, https://cen.acs.org/synthesis/One-step-synthesis-urea-green/98/i24.

66 Ghavam et al. “Sustainable Ammonia Production Processes,” 3 (PDF version).

67 "Natural Gas Weekly Update," US. Energy Information Administration, April 1, 2021, (see sidebar: "U.S. ammonia production is growing, and becoming less carbon intensive"), https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2021/04_01/.

68 "Nitrogen (Fixed)—Ammonia," US Geological Survey, Mineral Commodity Summaries, January 2021, https://pubs.usgs.gov/periodicals/mcs2021/mcs2021-nitrogen.pdf.

69 "Natural Gas Weekly Update," US Energy Information Administration.

70 Levi and Cullen, "Mapping Global Flows of Chemicals," 1730.

71 UN Environment Programme, *Synthesis Report on the Environmental and Health Impacts of Pesticides and Fertilizers and Ways to Minimize Them* (Geneva: UNEP, 2022), 17–21, https://www.unep.org/resources/report/environmental-and-health-impacts-pesticides-and-fertilizers-and-ways-minimizing; United Nations General Assembly, *Report of the Special Rapporteur on the Right to Food*, A/HRC/34/48 (2017), 4–11, https://www.ohchr.org/en/documents/thematic-reports/ahrc3448-report-special-rapporteur-right-food.

72 UNEP, *Environmental and health impacts of pesticides and fertilizers*, *Summary for Policymakers* (UNEP, January 2021), 3, 16, https://wedocs.unep.org/xmlui/bitstream/handle/20.500.11822/34463/JSUNEPPF.pdf?sequence=13.

73 See e.g., "Widespread Pollutants with Endocrine-disrupting Effects," Our Stolen Future, accessed August 16, 2022, http://www.ourstolenfuture.com/basics/chemlist.htm.

74 UNEP, *Environmental and health impacts of pesticides and fertilizers,* 10.

75 UNEP, *Environmental and health impacts of pesticides and fertilizers*, 3; UNEP, *Global Chemicals Outlook II* (UNEP, 2019), 45, https://www.unep.org/resources/report/global-chemicals-outlook-ii-legacies-innovative-solutions.

76 American Chemistry Council, *2020 Guide to the Business of Chemistry* (American Chemistry Council, 2020), 64, https://www.americanchemistry.com/chemistry-in-america/data-industry-statistics/resources/2020-guide-to-the-business-of-chemistry.

77 American Chemistry Council, *2020 Guide to the Business of Chemistry*, 81–89 (Appendix A: Chemical Chains).

78 Demeneix, "How fossil fuel-derived pesticides and plastics harm health, biodiversity, and the climate," 463.

79 "Crop Protection," ExxonMobil Chemical, accessed May 5, 2022, https://www.exxonmobilchemical.com/en/solutions-by-industry/agriculture/crop-protection.

80 "Food and Agriculture," Chevron Phillips Chemical, accessed May 5, 2022, https://www.cpchem.com/what-we-do/industries/food-agriculture.

81 Josef Seifert, "Neonicotinoids," *Encyclopedia of Toxicology (Second Edition)*, (2005), 196, https://doi.org/10.1016/B0-12-369400-0/00675-X.

82 Seifert, "Neonicotinoids," 196.

83 Zane R. Helsel, "Energy Use and Efficiency in Pest Control, Including Pesticide Production, Use, and Management Options," Farm Energy, April 3, 2019, https://farm-energy.extension.org/energy-use-and-efficiency-in-pest-control-including-pesticide-production-use-and-management-options/.

84 See e.g., "[W]e can only guess at the total volume of petroleum in these pesticides since companies aren't required to divulge the 'inert' ingredients in their products." Lappé, *Diet for a Hot Planet*, 18.

85 "Chemical fertilizers and pesticides disrupt key ecosystem functions of soil biota, decreasing the soils' ability to sequester carbon, cycle nutrients, break down greenhouse gases like methane and maintain water-holding capacity." Pesticide Action Network North America, "Climate Change & Agriculture," *PAN North America*, 2009, 10, https://www.panna.org/sites/default/files/PANmagFall09(3).pdf.

86 Md. Wasim Aktar, Dwaipayan Sengupta, and Ashim Chowdhury, "Impact of pesticides use in agriculture: their benefits and hazards," *Interdisciplinary Toxicology* 2, no. 1 (2009): 6, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2984095/pdf/ITX-2-001.pdf.

87 "Additionally, soil microbial activity, specifically the work of mychorrhizal fungi, plays an important role in helping conserve and slow down the decay of organic matter." Paul Hepperly, "The Organic Farming Response to Climate Change," in *Pesticides and You* 27, no. 1 (Beyond Pesticides, 2007): 15, https://www.beyondpesticides.org/assets/media/documents/infoservices/pesticidesandyou/Spring%202007/hepperly.pdf.

88 Tari Gunstone et al., "Pesticides and Soil Invertebrates: A Hazard Assessment," *Frontiers in Environmental Science* 9 (2021), https://doi.org/10.3389/fenvs.2021.643847.

89 Gunstone et al., "Pesticides and Soil Invertebrates," 2 (in PDF version).

90 "The impact pesticides have on emissions is likely to be underestimated due to the potential for severe effects on soil carbon sequestration and their role in making highly industrial forms of agriculture possible." "Pesticides and climate change," Pesticides Action Network UK (blog), November 4, 2021, https://www.pan-uk.org/pesticides-and-climate-change/.

91 N. Jacobs and J. Clapp, *Another Perfect Storm? How the failure to reform food systems has allowed the war in Ukraine to spark a third global food price crisis in 15 years, and what can be done to prevent the next one* (Brussels: IPES-Food, May 2022), 9, https://ipes-food.org/_img/upload/files/AnotherPerfectStorm.pdf.

92 FAO, "Impact of the Ukraine-Russia conflict on global food security and related matters under the mandate of the Food and Agriculture Organization of the United Nations (FAO)," CL 170/6, May 2022, 3, 6, https://www.fao.org/3/nj164en/nj164en.pdf.

93 See "World food import bill to reach a record high in 2021," FAO (press release), November 11, 2021, https://www.fao.org/newsroom/detail/world-food-import-bill-record-high-2021/en.

94 FAO, *Food Outlook—Biannual Report on Global Food Markets* (Rome: FAO, June 2022), 75, https://www.fao.org/3/cb9427en/cb9427en.pdf.

95 US Department of Agriculture Agricultural Marketing Service, Access to Fertilizer: Competition and Supply Chain Concerns, 87 Fed. Reg. 15192 (March 17, 2022) (Notice, request for public comments), https://www.govinfo.gov/content/pkg/FR-2022-03-17/pdf/2022-05670.pdf.

96 FAO, *Food Outlook—Biannual Report on Global Food Markets*, 71.

97 American Farm Bureau Federation, "Too Many to Count: Factors Driving Fertilizer Prices Higher and Higher," Market Intel, December 13, 2021, https://www.fb.org/market-intel/too-many-to-count-factors-driving-fertilizer-prices-higher-and-higher.

98 See e.g., Stanley Reed, "High natural gas prices lead to a shutdown of British fertilizer plants," *The New York Times*, September 16, 2021, https://www.nytimes.com/2021/09/16/business/natural-gas-prices-britain-fertilizer.html; "Yara curtails production due to increased natural gas prices," Yara (corporate release), March 9, 2022, https://www.yara.com/corporate-releases/yara-curtails-production-due-to-increased-natural-gas-prices/.

99 Ludo Hekman et al. "The Hunger Profiteers," Lighthouse Reports, May 6, 2022, https://www.lighthousereports.nl/investigation/the-hunger-profiteers/.

100 Jacobs and Clapp, *Another Perfect Storm?*, 4; "Response to joint statement by the leaders of the World Bank Group (WBG), the World Trade Organisation (WTO), the International Monetary Fund (IMF) and the World Food Programme (WFP)," Public statement by the United Nations Special Rapporteur on the right to food, Mr. Michael Fakhri, Geneva, May 20, 2022, at 2, https://www.ohchr.org/sites/default/files/2022-05/joint-statement-wto-imf-wfp.pdf.

101 Jacobs and Clapp, *Another Perfect Storm?*, 6.

102 Jacobs and Clapp, *Another Perfect Storm?*, 5.

103 FAO, Information Note: The importance of Ukraine and the Russian Federation for global agricultural markets and the risks associated with the current conflict (Rome: FAO, 2022), 1, https://www.fao.org/fileadmin/user_upload/faoweb/2022/Info-Note-Ukraine-Russian-Federation.pdf; USDA Agricultural Marketing Service, Access to Fertilizer, 15192 at note 15.

104 Alzbeta Klein, *An Unfolding Food Crisis: A Perspective From the Fertilizer Industry* (Paris: IFA, 2022), 8, https://www.fertilizer.org/Public/News___Events/IFA_News/2022_04_21_An_Unfolding_Food_Crisis.aspx.

105 Klein, *An Unfolding Food Crisis*, 8.

106 FAO, *Food Outlook—Biannual Report on Global Food Markets*, 72.

107 Clifford Krauss, "Europe's Russian Oil Ban Could Overhaul Global Energy Market," *The New York Times*, June 1, 2022, https://www.nytimes.com/2022/06/01/business/energy-environment/europe-russia-oil-global-energy.html.

108 Aura Sabudas, "EU industrial consumers brace for gas demand reduction plans," Independent Commodity Intelligence Services, July 20, 2022, https://www.icis.com/explore/resources/news/2022/07/20/10786873/eu-industrial-consumers-brace-for-gas-demand-reduction-plans/.

109 "Fertilizers Europe statement on critical fertilizer prices and gas costs," Fertilizers Europe (press statement), August 2, 2022, https://www.fertilizerseurope.com/wp-content/uploads/2022/08/Fertilizers-Europe-statement-on-critical-fertilizer-prices-and-gas-costs.pdf.

110 "Europe's fertilizer industry victim of EU's energy chaos," Fertilizers Europe (press release), August 26, 2022, https://www.fertilizerseurope.com/wp-content/uploads/2022/08/Fertilizers-Europe-Press-release_Europe-fert-industry-victim-of-EU-energy-chaos-1.pdf.

111 Klein, *An Unfolding Food Crisis*, 8.

112 See e.g., "This [industrial food] system relies heavily on chemicals and fossil fuels..." *Laura Michéle and Ana María Suárez-Franco, The Problem With the Industrial Food System and How to Fix It* (FIAN International, July 2022), 4, https://www.fian.org/files/files/FES-QandA-final.pdf.

113 "Response to joint statement by the leaders of the World Bank Group (WBG), the World Trade Organisation (WTO), the International Monetary Fund (IMF) and the World Food Programme (WFP)," Public statement by the United Nations Special Rapporteur on the right to food, Mr. Michael Fakhri, Geneva, May 20, 2022, https://www.ohchr.org/sites/default/files/2022-05/joint-statement-wto-imf-wfp.pdf.

114 "Response to joint statement," 2.

115 FAO, "'Energy-smart' agriculture needed to escape fossil fuel trap," FAO, November 29, 2011, https://www.fao.org/news/story/en/item/95161/icode/.

116 FAO, *"Energy-Smart" Food For People and Climate* (Rome: FAO, 2011), 49, https://www.fao.org/3/i2454e/i2454e00.pdf.

117 FAO, *"Energy-Smart" Food*, 4.

118 FAO, IFAD, UNICEF, WFP and WHO. 2022. *The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable* (Rome: FAO, 2022), xvi, xx. https://doi.org/10.4060/cc0639en.

119 HLPE, *Agroecological and other innovative approaches for sustainable agriculture and food systems that enhance food security and nutrition. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security* (Rome: HLPE, July 2019), 17, https://www.fao.org/3/ca5602en/ca5602en.pdf.

120 HLPE, *Agroecological and other innovative approaches*, 22.

121 FAO, *Using Soil Maps to Promote Efficient Use of Fertilizers: Learning from the Ethiopian Experience* (Rome: FAO, April 7, 2022), https://www.fao.org/3/cb9452en/cb9452en.pdf.

122 CIEL is a signatory on the campaign opposing FAO's alliance with the pesticide industry lobby group CropLife International. See: "Stop FAO-CropLife #ToxicAlliance," Pesticide Action Network International, accessed August 16, 2022, https://pan-international.org/stop-fao-croplife-toxicalliance/.

123 Ashka Naik, T.J. Faircloth, Charlotte Dreger, and Simone Adler, *Corporate Capture of FAO: Industry's Deepening Influence on Global Food Governance* (Corporate Accountability and FIAN International, May 2022), https://www.fian.org/files/files/CorporateCaptureoftheFAO-EN.pdf.

124 "Stop Corporate Capture of FAO," FIAN International (press release), June 7, 2022, https://www.fian.org/en/press-release/article/stop-corporate-capture-of-fao-2969.

125 "Summit of the Americas Agriculture Producers Declaration," The White House Briefing Room, June 13, 2022, https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/13/summit-of-americas-agriculture-producers-declaration/.

126 "Summit of the Americas."

127 Center for International Environmental Law, *Sowing a Plastic Planet: How Microplastics in Agrochemicals Are Affecting Our Soils, Our Food, and Our Future* (Washington, DC: CIEL, May 2022), https://www.ciel.org/reports/microplastics-in-agrochemicals/.

128 European Commission Communication, The Commission, the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on EU Biodiversity Strategy for 2030: Bringing nature back into our lives, 13, 15 (May 20, 2020), https://eur-lex.europa.eu/resource.html?uri=cellar:a3c806a6-9ab3-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF.

129 European Commission Communication, The European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on A Farm to Fork Strategy for a fair, healthy and environmentally-friendly food system, 6–8 (May 20, 2020), https://eur-lex.europa.eu/resource.html?uri=cellar:ea0f9f73-9ab2-11ea-9d2d-01aa75ed71a1.0001.02/DOC_1&format=PDF.

130 "Commission acts for global food security and for supporting EU farmers and consumers," European Commission (press release), March 23, 2022, https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1963.

131 "Questions and Answers: Commission acts to safeguard global food security and support EU farmers and consumers," European Commission, March 23, 2022, https://ec.europa.eu/commission/presscorner/detail/en/qanda_22_1964.

132 Jacobs and Clapp, *Another Perfect Storm?*, 25.

133 Tom Polansek and Ana Mano, "As sanctions bite Russia, fertilizer shortage imperils world food supply," *Reuters*, March 23, 2022, https://www.reuters.com/business/sanctions-bite-russia-fertilizer-shortage-imperils-world-food-supply-2022-03-23/.

134 Will Steffen et al. "Planetary boundaries: Guiding human development on a changing planet," *Science* 347, no. 6223 (Research Article, 2015): 1259855-1, https://www.science.org/doi/pdf/10.1126/science.1259855.

135 Will Steffen et al. "Planetary boundaries: Guiding human development on a changing planet," *Science* 347, no. 6223 (Research Article Summary, 2015): 736, https://www.science.org/doi/pdf/10.1126/science.1259855.

136 "The nine planetary boundaries," Stockholm Resilience Centre, accessed April 26, 2022, https://www.stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html.

137 "The nine planetary boundaries," Stockholm Resilience Centre.

138 Megha Sud, "Managing the Biodiversity Impacts of Fertiliser and Pesticide Use: Overviews and Insights from Trends and Policies Across Selected OECD Countries," OECD Environment Working Paper N°155, 11, https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/WKP(2020)2&docLanguage=En.

139 Water Resources, "Nutrients and Eutrophication," US Geological Survey, March 3, 2019, https://www.usgs.gov/mission-areas/water-resources/science/nutrients-and-eutrophication.

140 "A 2008 study found more than 400 dead zones exist worldwide." Jenny Howard, "Dead zones, explained," *National Geographic*, July 31, 2019, https://www.nationalgeographic.com/environment/article/dead-zones; see also a 2019 IUCN report finding that over 700 areas in coastal oceans and semi-enclosed seas have problems with low oxygen, or hypoxia. International Union for Conservation of Nature, *Ocean deoxygenation: Everyone's problem. Causes, impacts, consequences and solutions—Summary for Policymakers* (Switzerland, IUCN, 2019), 4, https://portals.iucn.org/library/sites/library/files/documents/2019-048-En-Summ.pdf.

141 Howard, "Dead zones, explained".

142 UNEP, *Global Chemicals Outlook II* (2019), 146–147.

143 Linn Persson et al., "Outside the Safe Operating Space of the Planetary Boundary for Novel Entities," *Environmental Science. & Technology* 56, no. 3 (January 2022): 1510–1521, https://doi.org/10.1021/acs.est.1c04158; see also: Damian Carrington, "Chemical pollution has passed safe limit for humanity, say scientists," *The Guardian*, January 18, 2022, https://www.theguardian.com/environment/2022/jan/18/chemical-pollution-has-passed-safe-limit-for-humanity-say-scientists.

144 Persson et al. "Outside the Safe Operating Space," 1510, 1517.

145 "Planetary boundaries," Stockholm Resilience Centre, accessed August 16, 2022, https://www.stockholmresilience.org/research/planetary-boundaries.html.

146 See e.g., Claire Asher, "The key to averting environmental catastrophe is right beneath our feet," *Mongabay*, June 1, 2021, https://news.mongabay.com/2021/06/the-key-to-averting-environmental-catastrophe-is-right-beneath-our-feet/.

147 Natalia Rodríguez-Eugenio, Michael McLaughlin, and Daniel Pennock, Soil Pollution: a hidden reality (Rome: FAO, 2018), 16, http://www.fao.org/3/i9183en/i9183en.pdf.

148 FAO and UNEP, *Global assessment of soil pollution*, 12.

149 UNEP *Environmental and health impacts of pesticides and fertilizers*, 17-18.

150 See e.g., Scott C. Killpack and Daryl Buchholz, "Nitrogen in the Environment: Ammonia Volatilization," University of Missouri Extension, accessed April 29, 2022, https://extension.missouri.edu/publications/wq257#:~:text=Ammonia%20volatilization%20results%20in%20a,and%20easily%20moves%20with%20water.

151 Center for International Environmental Law, *Sowing a Plastic Planet*.

152 As this report was going in the final hours of copy-editing in mid-September 2022, the International Fertilizer Association (a leading industry trade group) together with consulting firm Systemiq, released a document entitled "Reducing Emissions from Fertilizer Use" that purports to quantify the GHG emissions arising from the use of fertilizers and suggest potential pathways for reducing but not eliminating associated emissions. International Fertilizer Association and Systemiq, *Reducing Emissions from Fertilizer Use* (September 2022), https://www.systemiq.earth/wp-content/uploads/2022/09/Reducing-emissions-from-fertilizer-use-report.pdf. In light of the document's release in the final stages of report preparation, its exclusive focus on emissions from the use of fertilizers rather than their production, and its recommended reliance on unproven and potentially harmful approaches like Bioenergy with Carbon Capture and Storage (BECCS) and increased reliance on Controlled Release Fertilizers to mitigate greenhouse emissions from such fertilizer use, CIEL has not addressed the IFA/Systemiq document in detail in the present analysis. For a recent relevant critique of the reliance on Controlled Release Fertilizers, see CIEL, *Sowing a Plastic Planet* (July, 2022), https://www.ciel.org/wp-content/uploads/2022/07/Sowing-a-Plastic-Planet_final23may22.pdf.

153 See, e.g., "The production of agricultural inputs can be heavily energy-intensive, most notably for fertilisers and pesticides." OECD, *Improving Energy Efficiency in the Agro-Food Chain* (Joint Working Party on Agriculture and the Environment, OECD, May 2017), 26, https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=COM/TAD/CA/ENV/EPOC(2016)19/FINAL&docLanguage=En.

154 "Energy consumption in agriculture increased in 2016, driven mainly by diesel and fertilizer use," Economic Research Service, US Department of Agriculture, last updated March 13, 2018, https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=87964.

155 GRAIN, Greenpeace, and Institute for Agriculture and Trade Policy (IATP), "New research shows 50 year binge on chemical fertilisers must end to address the climate crisis," research brief, November 1, 2021, https://www.iatp.org/sites/default/files/2021-10/FERTILIZER%20BRIEF%20011121.pdf; Stefano Menegat, Alicia Ledo, and Reyes Tirado, "Greenhouse gas emissions from global production and use of nitrogen synthetic fertilisers in agriculture," *Scientific Reports* 12 (2022), https://doi.org/10.1038/s41598-022-18773-w.

156 Menegat, Ledo, and Tirado, "Greenhouse gas emissions," 1, 7 (in PDF version).

157 Menegat, Ledo, and Tirado, "Greenhouse gas emissions," 1; " Brandon Graver, Kevin Zhang, and Dan Rutherford, "CO_2 Emissions from Commercial Aviation, 2018", International Council on Clean Transportation, September 19, 2019, https://theicct.org/publication/co2-emissions-from-commercial-aviation-2018/#:~:text=CO2%20emissions%20from%20all,over%20the%20past%20five%20years.

158 Menegat, Ledo, and Tirado, "Greenhouse gas emissions," 1–2 (in PDF version).

159 See e.g., Patel, "One Step Synthesis of Urea."

160 Xinyu Liu, Amgad Elgowainy, and Michael Wang, "Life cycle energy use and greenhouse gas emissions of ammonia production from renewable resources and industrial by-products," *Green Chemistry* 22, no. 17 (2020): 5751, https://doi.org/10.1039/D0GC02301A.

161 IEA, *Ammonia Technology Roadmap*, 9.

162 IEA, *Ammonia Technology Roadmap*, 9.

163 Ghavam et al. "Sustainable Ammonia Production Processes," 3 (PDF version).

164 See e.g., Leigh Krietsch Boerner. "Industrial ammonia production emits more CO_2 than any other chemical-making reaction. Chemists want to change that," *Chemical & Engineering News*, June 15, 2019, https://cen.acs.org/environment/green-chemistry/Industrial-ammonia-production-emits-CO2/97/i24.

165 See e.g., In 2020 global ammonia production amounted to 185 million tonnes. IEA, *Ammonia Technology Roadmap*, 16.

166 See e.g., Robert W. Howarth and Mark Z. Jacobson, "How green is blue hydrogen?" *Energy Science & Engineering* 9, no. 10 (2021): 1684, https://doi.org/10.1002/ese3.956.

167 Xiaochi Zhou et al. "Estimation of methane emissions from the U.S. ammonia fertilizer industry using a mobile sensing approach." *Elementa: Science of the Anthropocene* 7 (2019): 1, 9 https://online.ucpress.edu/elementa/article/doi/10.1525/elementa.358/112487/Estimation-of-methane-emissions-from-the-U-S.

168 Cornell University. "Fertilizer plants emit 100 times more methane than reported." *ScienceDaily*, June 6, 2019, https://www.sciencedaily.com/releases/2019/06/190606183254.htm.

169 Cecile De Klein et al. "Chapter 11: N_2O Emissions from Managed Soils, and CO_2 Emissions from Lime and Urea Application," in *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, vol. 4: Agriculture, Forestry and Other Land Use (2006), at 11.5–11.6, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf.

170 IPCC, *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*, eds. P.R. Shukla et al. (In press, 2019), 46, 134, https://www.ipcc.ch/site/assets/uploads/sites/4/2021/02/210202-IPCCJ7230-SRCCL-Complete-BOOK-HRES.pdf.

171 The IPCC uses a Global Warming Potential of 265 over 100 years for nitrous oxide. See e.g., IPCC, *Climate Change and Land*, 7.

172 Luana Basso et al., *WMO Greenhouse Gas Bulletin: The State of Greenhouse Gases in the Atmosphere Based on Global Observations through 2020*, No. 17, (World Meteorological Organization, October 2021), 6 (at Figure 5), 7, https://library.wmo.int/doc_num.php?explnum_id=10904.

173 Gert-Jan Nabuurs et al. "Chapter 7: Agriculture, Forestry and Other Land Uses (AFOLU)," in IPCC, 2022: *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. P.R. Shukla et al. (Cambridge, UK and New York, NY: Cambridge University Press, 2022), 7-24, https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_Chapter07.pdf.

174 IPCC, *Climate Change and Land*, 162.

175 Josep G. Canadell et al. "Chapter 5: Global Carbon and other Biogeochemical Cycles and Feedbacks," in *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the 6 Intergovernmental Panel on Climate Change*, eds. V. Masson-Delmotte et al. (Cambridge, UK and New York, NY: Cambridge University Press, 2021), 709, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter05.pdf.

176 Nabuurs et al. "Chapter 7: Agriculture, Forestry and Other Land Uses (AFOLU)," in IPCC, 2022, 7-35.

177 Nabuurs et al. "Chapter 7: Agriculture, Forestry and Other Land Uses (AFOLU)," in IPCC, 2022, 7-35; see also: "Our findings point to growing N_2O emissions in emerging economies, particularly Brazil, China, and India." Hanqin Tian et al. "A comprehensive quantification of global nitrous oxide sources and sinks," *Nature* 586 (2020): 248–256, at 12 (in PDF version), https://www.nature.com/articles/s41586-020-2780-0.

178 University of East Anglia, "Nitrous oxide emissions pose an increasing climate threat, study finds," *ScienceDaily*, October 7, 2020, https://www.sciencedaily.com/releases/2020/10/201007123131.htm.

179 Tian et al. "A comprehensive quantification of global nitrous oxide sources and sinks," at 12–13 (in PDF version).

180 IPCC, *Climate Change and Land*, 46, 134.

181 IEA, *The Future of Petrochemicals*, 59.

182 Menegat, Ledo, and Tirado, "Greenhouse gas emissions," 2 (in PDF version).

183 Environmental Protection Agency, "Chapter 5: Agriculture," in *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2019* (US EPA, 2021), 5–48, https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-chapter-5-agriculture.pdf.

184 EPA, "Chapter 5: Agriculture," 5-48.

185 GRAIN, "Earth matters — Tackling the climate crisis from the ground up," *Seedling*, October 28, 2009, 11, https://grain.org/media/W1siZiIsIjIwMTE-vMDcvMjEvMDRfMjNfMDJfODZfb3JpZ2luYWwucGRmIl1d.

186 S.A. Khan, R.L. Mulvaney, T.R. Ellsworth, and C.W. Boast, "The myth of nitrogen fertilization for soil carbon sequestration," *Journal of Environmental Quality* 36, no. 6 (2007): 1821–1832, https://doi.org/10.2134/jeq2007.0099.

187 S.A. Khan, R.L. Mulvaney, T.R. Ellsworth, and C.W. Boast, "The myth of nitrogen fertilization," 1823.

188 IPCC, *Climate Change and Land*, 58.

189 Francesco N. Tubiello et al., "Greenhouse gas emissions from food systems: building the evidence base," *Environmental Research Letters* 16, no. 6 (2021): 6 (in PDF version), https://doi.org/10.1088/1748-9326/ac018e.

190 Menegat, Ledo, and Tirado, "Greenhouse gas emissions," 1, 6 (in PDF version).

191 GRAIN, Greenpeace, and IATP, "New research shows 50 year binge on chemical fertilisers must end," 4.

192 ETC Group and IPES-Food, *Too Big To Feed: The Short Report* (ETC Group, August 2018), 8, https://www.etcgroup.org/content/too-big-feed-short-report.

193 ETC Group and IPES-Food, *Too Big To Feed*, 13; IPES-Food, *Too Big To Feed: Exploring the Impacts of Mega-Mergers, Consolidation, and Concentration of Power in the Agri-Food Sector* (IPES-Food, 2017), 25, https://www.ipes-food.org/_img/upload/files/Concentration_FullReport.pdf.

194 ETC Group and IPES-Food, *Too Big To Feed*, 13.

195 FAO, *Inorganic Fertilizers—1990–2020*, 8 (at Fig. 8).

196 ETC Group, *Food Barons 2022: Crisis profiteering, digitalization and shifting power* (ETC Group, September 2022), 44, https://www.etcgroup.org/content/food-barons-2022.

197 Anton Bekkerman, Gary W. Brester, and David Ripplinger, "The History, Consolidation, and Future of the U.S. Nitrogen Fertilizer Production Industry," *Choices Magazine* (Vol. 35, Quarter 2, 2020), 1, https://www.choicesmagazine.org/UserFiles/file/cmsarticle_742.pdf.

198 "Agrium and PotashCorp Merger Completed Forming Nutrien, a Leader in Global Agriculture," Nutrien (press release), January 2, 20218, https://www.nutrien.com/investors/news-releases/2018-agrium-and-potashcorp-merger-completed-forming-nutrien-leader-global.

199 "Nitrogen," Nutrien, accessed July 6, 2022, https://www.nutrien.com/what-we-do/our-business/nitrogen.

200 "Nitrogen Operations," Nutrien, accessed July 6, 2022, https://www.nutrien.com/locations/nitrogen-operations.

201 Nutrien, *Annual Report 2021* (Saskatoon, SK: Nutrien, 2022), 4, https://nutrien-prod-asset.s3.us-east-2.amazonaws.com/s3fs-public/uploads/2022-03/2021%20Nutrien_Annual%20Report_Enhanced_PDF.pdf.

202 Nutrien, *Annual Report 2021*, 3.

203 "Our Business," CF Industries, accessed July 6, 2022, https://www.cfindustries.com/who-we-are/cf-at-a-glance.

204 "Ammonia," CF Industries, accessed July 6, 2022, https://www.cfindustries.com/products/ammonia; CF Industries Holdings, Inc. *Form 10-K For the Fiscal Year Ended December 31, 2021* (Deerfield, Illinois: CF Industries, February 2022), 4, https://d18rn0p25nwr6d.cloudfront.net/CIK-0001324404/fb3473c7-b8f5-4d86-a17d-e1fc25046f58.pdf (see "Gross Ammonia" production capacity as of December 31, 2021).

205 CF Industries Holdings, Inc. *Form 10-K For the Fiscal Year Ended December 31, 2021*, 4.

206 See "CF Industries Holdings, Inc. Announces Halt of Operations at UK Facilities," Business Wire, September 15, 2021, https://www.businesswire.com/news/home/20210915006088/en/CF-Industries-Holdings-Inc.-Announces-Halt-of-Operations-at-UK-Facilities.

207 See "CF Fertilisers UK Announces Proposals to Restructure Operations to Enable Continued Supply of Fertiliser, Carbon Dioxide and Other Industrial Products to Customers in the UK," CF Industries (news release), June 8, 2022, https://www.cfindustries.com/newsroom/2022/ukrestructuring proposals.

208 "CF Fertilisers UK Announces Intention to Temporarily Halt Ammonia Production at Billingham Complex; Company Will Import Ammonia to Produce AN Fertiliser and Nitric Acid at Site," CF Industries (news release), August 24, 2022, https://www.cfindustries.com/newsroom/2022/billingham-import-ammonia.

209 CF Industries Holdings, Inc. *Form 10-K*, 4.

210 CF Industries Holdings, Inc. *Form 10-K*, 1.

211 CF Industries Holdings, Inc. *Form 10-K*, 2.

212 "Who We Are," CF Industries, accessed July 6, 2022, https://www.cfindustries.com/who-we-are.

213 "Our main shareholders," Yara, last updated August 31, 2022, accessed September 15, 2022, https://www.yara.com/investor-relations/share-and-debt-information/shareholders/.

214 Yara, *Yara Integrated Report 2021* (Oslo: Yara International, 2022), 14, https://www.yara.com/siteassets/investors/057-reports-and-presentations/annual-reports/2021/yara-integrated-report-2021.pdf/.

215 Yara, "Annual Production Capacity in Million Tonnes," February 8, 2022, https://www.yara.com/siteassets/investors/057-reports-and-presentations/other/2022/8-feb-2022/yara-production-capacities-per-segment-december-2021-pdf.pdf/.

216 "Yara At A Glance," Yara, accessed July 6, 2022, https://www.yara.com/this-is-yara/yara-at-a-glance/.

217 "Yara At A Glance," Yara.

218 "Our products," OCI, accessed July 6, 2022, https://www.oci.nl/operations/our-products/.

219 "About OCI," OCI, accessed July 6, 2022, https://www.oci.nl/about/.

220 "Operations," OCI, accessed July 6, 2022, https://www.oci.nl/operations/.

221 "At A Glance," OCI fact sheet (2020), https://www.oci.nl/media/1786/oci-fact-sheet-2020.pdf.

222 OCI, *Annual Report 2021* (Amsterdam: OCI N.V., 2022), 4, https://www.oci.nl/media/2021/oci-annual-report-2021-vf.pdf.

223 "OCI NV and ADNOC Close Strategic Partnership Agreement, Establishing Fertiglobe, A New Global Nitrogen Fertilizer Leader," OCI (press release), September 30, 2019, https://www.oci.nl/news/2019-oci-nv-and-adnoc-close-strategic-partnership-agreement-establishing-fertiglobe-a-new-global-nitrogen-fertilizer-leader/.

224 "About Us," Fertiglobe, accessed August 24, 2022, https://fertiglobe.com/about-us/.

225 "Koch Ag & Energy Solutions Companies," Koch Ag & Energy Solutions, accessed July 6, 2022, https://kochagenergy.com/Companies/.

226 "Koch Fertilizer Announces New Holding Company," Koch Ag & Energy Solutions, accessed July 6, 2022, https://kochagenergy.com/Newsroom/Koch-Fertilizer-Announces-New-Holding-Company_621.aspx.

227 "Koch Fertilizer Announces New Holding Company," Koch Ag & Energy Solutions.

228 "About Our Company," Koch Ag & Energy Solutions, accessed July 6, 2022, https://kochagenergy.com/About/.

229 "About Us," Koch Fertilizer, accessed July 6, 2022, https://www.kochfertilizer.com/about/.

230 "Top Ten Fertilizer Manufacturers in China," BizVibe (blog), January 22, 2022, https://blog.bizvibe.com/blog/agriculture/top-10-fertilizer-manufacturers-in-china.

231 "Sinofert Holdings Ltd." Sinochem, accessed August 24, 2022, http://www.sinochem.com.cn/s/1570-4799-11892.html.

232 "Introduction to nitrogenous fertilizer products," Sinofert, accessed August 31, 2022, http://www.sinofert.com/5708.html.

233 See "Global Operations," EuroChem, accessed August 24, 2022, https://www.eurochemgroup.com/about-us/global-operations/.

234 EuroChem, *Integrated Report 2021* (Zug, Switzerland: Eurochem, 2021), 2, https://www.eurochemgroup.com/wp-content/uploads/2021/08/21344_eurochem-ar2021_13_spreads-1.pdf.

235 "Global Operations," EuroChem.

236 EuroChem, *Integrated Report 2021*, 9.

237 "About Uralchem," Uralchem, accessed August 24, 2022, https://www.uralchem.com/about/.

238 "David Gauthier-Villars and Gabriela Baczynska, "EXCLUSIVE How a Russian billionaire shielded assets from European sanctions," *Reuters*, June 1, 2022, https://www.reuters.com/world/europe/exclusive-how-russian-billionaire-melnichenko-shielded-assets-european-sanctions-2022-05-27/.

239 Tom Brown, "European Commission adds Eurochem's Aleksandra Melnicheko to sanctions list," ICIS, June 6, 2022, https://www.icis.com/explore/resources/news/2022/06/06/10772124/european-commission-adds-eurochem-s-aleksandra-melnichenko-to-sanctions-list/; see also: Brenna Hughes Neghaiwi, "Eurochem must show sanctions compliance after those imposed on Melnichenko, Swiss say," *Reuters*, June 10, 2022, reproduced at https://www.nasdaq.com/articles/eurochem-must-show-sanctions-compliance-after-those-imposed-on-melnichenko-swiss-say.

240 "SAFCO Transforms to 'Sabic Agri-Nutrients Company'—Strategic Path for Sustainable Growth and Global Leadership," SABIC (news release), November 22, 2020, https://www.sabic.com/en/news/24794-safco-transforms-to-sabic-agri-nutrients-company.

241 "Aramco completes its acquisition of a 70% stake in SABIC," SABIC (news release), June 17, 2020, https://www.sabic.com/en/news/23722-saudi-aramco-completes-share-acquisition.

242 See "SABIC Agri-Nutrients Co. Announcement the Relocation of the Company's Head Office," SABIC Agri-Nutrients (news release), July 19, 2022, https://www.sabic-agrinutrients.com/en/news/36421-sabic-agri-nutrients-co-announcement-the-relocation-of-the-company-s-head-office

243 "Products," SABIC Agri-Nutrients, accessed August 24, 2022, https://www.sabic-agrinutrients.com/en/products.

244 SABIC Agri-Nutrients Company, Board of Directors Report: Performance and Activities of the Company for the Fiscal Year 2021 (SABIC Agri-Nutrients Co., 2021), 30, https://www.sabic-agrinutrients.com/en/Images/Board%20Annual%20Report%202022_ENG_v2_tcm1039-33346.pdf.

245 See e.g., "OGCI launches the CCUS Hub platform to share learnings and identify new hubs," Oil and Gas Climate Initiative (press release), March 3, 2022, https://www.ogci.com/ogci-launches-the-ccus-hub-platform-to-share-learnings-and-identify-new-hubs/; Tsvetana Paraskova, "Will Big Oil's Huge Carbon Capture Bet Pay Off?" *Oilprice.com,* April 21, 2021, https://oilprice.com/Energy/Energy-General/Will-Big-Oils-Huge-Carbon-Capture-Bet-Pay-Off.html.

246 Center for International Environmental Law, *Confronting the Myth of Carbon-Free Fossil Fuels: Why Carbon Capture Is Not a Climate Solution* (Washington DC: CIEL, 2021), https://www.ciel.org/reports/carbon-capture-is-not-a-climate-solution/.

247 Center for International Environmental Law, *Confronting the Myth of Carbon-Free Fossil Fuels*.

248 "Understanding CCS," Global CCS Institute, last accessed Aug. 31, 2022, https://www.globalccsinstitute.com/about/what-is-ccs/.

249 See e.g., Joe Smyth, "Petra Nova carbon capture project stalls with cheap oil," Energy and Policy Institute, August 6, 2020, https://www.energyandpolicy.org/petra-nova/; "If Chevron, Exxon, and Shell can't get Gorgon's carbon capture and storage to work, who can?" Institute for Energy Economics and Financial Analysis, April 26, 2022, https://ieefa.org/articles/if-chevron-exxon-and-shell-cant-get-gorgons-carbon-capture-and-storage-work-who-can.

250 See e.g., "Institute Welcomes Australian Government Funding for CCS Hubs, Stresses Need for Policy Confidence," Global CCS Institute (news release), September 30, 2021, https://www.globalccsinstitute.com/news-media/press-room/media-releases/institute-welcomes-australian-government-funding-for-hubs-stresses-need-for-policy-confidence/.

251 See Inflation Reduction Act of 2022, Pub. L. No. 117-169, § 13104 (2022); see also: Shearman & Sterling LLP, "Inflation Reduction Act: Key Green and Blue Hydrogen and CCUS Provisions," JD Supra, August 15, 2022, https://www.jdsupra.com/legalnews/inflation-reduction-act-key-green-and-5006460.

252 See e.g., White House Fact Sheet stating: "[Department of Energy's] Loan Programs Office (LPO) has $8.5 billion in funding for carbon capture projects through LPO's Title 17 Innovative Energy Loan Guarantee Program." "FACT SHEET: Biden Administration Outlines Key Resources to Invest in Coal and Power Plant Community Economic Revitalization," The White House, April 23, 2021, https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/23/fact-sheet-biden-administration-outlines-key-resources-to-invest-in-coal-and-power-plant-community-economic-revitalization/; see also: "DOE Invests $45 Million to Decarbonize the Natural Gas Power and Industrial Sectors Using Carbon Capture and Storage," US Department of Energy (press release), October 6, 2021, https://www.energy.gov/articles/doe-invests-45-million-decarbonize-natural-gas-power-and-industrial-sectors-using-carbon.

253 See "EU funding for CCS and CCU" under web page titled "Carbon capture, use and storage," European Commission, accessed August 19, 2022, https://ec.europa.eu/clima/eu-action/carbon-capture-use-and-storage_en#eu-funding-for-ccs-and-ccu.

254 See e.g., "UK carbon capture, usage and storage," UK Government website, last updated February 1, 2019, https://www.gov.uk/guidance/uk-carbon-capture-and-storage-government-funding-and-support; "Carbon capture, utilization, and storage," Natural Resources Canada, last modified July 7, 2022, https://www.nrcan.gc.ca/our-natural-resources/energy-sources-distribution/carbon-capture-utilization-and-storage/4275; "Reducing emissions through carbon capture, use and storage," Australian Government, Department of Climate Change, Energy, the Environment and Water, accessed August 19, 2022, https://www.dcceew.gov.au/climate-change/emissions-reduction/carbon-capture-use-storage; see also: Dominic Rassool, *Overview of Organisations and Policies Supporting the Deployment of Large-Scale CCS Facilities* (Global CCS Institute, March 2020), 12–21, https://www.globalccsinstitute.com/wp-content/uploads/2020/06/Overview-of-Organisations-and-Policies-Supporting-the-Deployment-of-Large-scale-CCS-Facilities-1.pdf.

255 Global CCS Institute, *Global Status of CCS 2021* (Global CCS Institute, 2021), 62–63 (Appendix 5.1), https://www.globalccsinstitute.com/wp-content/uploads/2021/10/2021-Global-Status-of-CCS-Report_Global_CCS_Institute.pdf.

256 See Patrick Falwell and Brad Crabtree, "Understanding the National Enhanced Oil Recovery Initiative," Center for Climate and Energy Solutions, January 2015, https://www.c2es.org/document/understanding-the-national-enhanced-oil-recovery-initiative/.

257 See Falwell and Crabtree, "Understanding the National Enhanced Oil Recovery Initiative".

258 Global CCS Institute, *Global Status of CCS 2021*, 62–63 (Appendix 5.1).

259 Center for International Environmental Law, *Confronting the Myth of Carbon-Free Fossil Fuels*.

260 See Leon Clarke et al. "Chapter 6: Energy Systems," in IPCC, 2022: *Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. P.R. Shukla et al. (Cambridge, UK and New York, NY: Cambridge University Press, 2022), 6-38, (noting that the energy penalty from CCUS "increases the fuel requirement for electricity generation by 13–44%"), https://report.ipcc.ch/ar6wg3/pdf/IPCC_AR6_WGIII_FinalDraft_Chapter06.pdf; Sara Budinis et al., "An assessment of CCUS costs, barriers and potential," *Energy Strategy Reviews* 22 (November 2018): 67–68 (discussing energy and efficiency penalty estimates for coal and gas), https://doi.org/10.1016/j.esr.2018.08.003.

261 Global CCS Institute, *Global Status of CCS 2021*, 63–66 (Appendix 5.1).

262 See e.g., Energy Transitions Commission, *Carbon Capture, Utilisation and Storage in the Energy Transition: Vital but Limited* (Energy Transitions Commission, July 2022), https://www.energy-transitions.org/publications/carbon-capture-use-storage-vital-but-limited/.

263 Abbe Ramanan. "Five Reasons to Be Concerned About Green Hydrogen," Clean Energy Group fact sheet, September 7, 2021, 3, https://www.cleanegroup.org/ceg-resources/resource/five-reasons-to-be-concerned-about-green-hydrogen/.

264 See "Hydrogen," IPCS INCHEM (Internationally Peer Reviewed Chemical Safety Information), April 2014, https://inchem.org/documents/icsc/icsc/eics0001.htm.

265 See Etienne Rivard, Michel Trudeau, and Karim Zaghib, "Hydrogen Storage for Mobility: A Review," *Materials* 12, no. 12 (2019): 11 (in PDF version), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6630991/; Russell McCulley, "Hydrogen success must overcome transportation challenges," *Upstream*, September 15, 2021, https://www.upstreamonline.com/hydrogen/hydrogen-success-must-overcome-transportation-challenges/2-1-1067911.

266 Jose M. Bermudez and Ilkka Hannula, *Hydrogen* (Paris: IEA, November 2021), https://www.iea.org/reports/hydrogen.

267 Bermudez and Hannula, *Hydrogen*.

268 Ghavam et al. "Sustainable Ammonia Production Processes" 3 (in PDF version).

269 Bermudez and Hannula, *Hydrogen*.

270 Inflation Reduction Act of 2022, Pub. L. No. 117-169, § 13204(c)(2)(A) (2022).

271 The company Air Liquide (a supplier of industrial gases) refers to blue hydrogen as an "Air Liquide initiative" and a trademarked term in a 2014 corporate document. See: Air Liquide, *2014 Reference Document Including the Corporate Social Responsibility and Sustainable Development Report* (Paris: Air Liquide, 2014), 56, https://www.airliquide.com/sites/airliquide.com/files/2015/03/17/air-liquide_2014-reference-document_en.pdf.

272 Robert W. Howarth and Mark Z. Jacobson, "How green is blue hydrogen?" *Energy Science & Engineering* 9, no. 10 (2021): 1676-1687, https://doi.org/10.1002/ese3.956.

273 Howarth and Jacobson, "How green is blue hydrogen?" 1676–1687.

274 Howarth and Jacobson, "How green is blue hydrogen?" 1685.

275 Matteo C. Romano et al. "Comment on 'How green is blue hydrogen?'" *Energy Science & Engineering* (2022): 1945, https://onlinelibrary.wiley.com/doi/pdf/10.1002/ese3.1126.

276 Robert W. Howarth and Mark Z. Jacobson, "Reply to comment on 'How green is blue hydrogen?'" *Energy Science & Engineering* (2022): 1955–1960, https://onlinelibrary.wiley.com/doi/full/10.1002/ese3.1154.

277 Howarth and Jacobson, "Reply to comment," 1955.

278 IEA, *Global Methane Tracker 2022* (Paris: IEA, 2022), https://www.iea.org/reports/global-methane-tracker-2022/overview.

279 IEA, *Global Hydrogen Review 2021* (Paris: IEA, 2021), 5–6, https://www.iea.org/reports/global-hydrogen-review-2021.

280 IEA, *Global Hydrogen Review 2021*, 25.

281 IEA, *Global Hydrogen Review 2021*, 27–28.

282 See Energy Policy Tracker, "Alberta Net-Zero Hydrogen Production Investment," announced June 9, 2021, https://www.energypolicytracker.org/search-results/?_sfm_policy_category=fossil%20conditional-%2C-fossil%20unconditional&_sfm_energy_type=hydrogen.

283 See 42 U.S.C. § 16161a(c)(3)(A), and 42 U.S.C. § 16161a(c)(3)(D).

284 IEA, *Net Zero by 2050: A Roadmap for the Global Energy Sector* (Paris: IEA, May 2021), 161, https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.

285 Office of Fossil Energy, US Department of Energy, *Hydrogen Strategy: Enabling a Low-Carbon Economy* (Washington DC: US Dept. of Energy, 2020), 1, https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf.

286 "Frequently Asked Questions," Hydrogen Council, accessed August 22, 2022, https://hydrogencouncil.com/en/faq/.

287 Fuel Cell & Hydrogen Energy Association, Road Map to a US Hydrogen Economy: Reducing Emissions and Driving Growth Across the Nation (Fuel Cell & Hydrogen Energy Association, 2020), https://static1.squarespace.com/static/53ab1feee4b0bef0179a1563/t/5e7ca9d6c8fb3629d399fe0c/1585228263363/Road+Map+to+a+US+Hydrogen+Economy+Full+Report.pdf.

288 Carolyn Davis, "BP Looking to Hydrogen Expansion to 'Reinvent' Natural Gas," *Natural Gas Intelligence*, June 28, 2021, https://www.naturalgasintel.com/bp-looking-to-hydrogen-expansion-to-reinvent-natural-gas/

289 "BP bolsters UK blue hydrogen plans by reaching agreements with more potential customers," BP (press release), August 5, 2021, https://www.bp.com/en/global/corporate/news-and-insights/press-releases/bp-bolsters-uk-blue-hydrogen-plans-by-reaching-agreements-with-more-potential-customers.html.

290 See Henrik Anderson, "Building the UK's first at-scale blue hydrogen and ammonia plant," Lloyd's Register, October 14, 2021, https://www.lr.org/en/insights/articles/uk-first-at-scale-blue-hydrogen-and-ammonia-plant/.

291 "Saltend Chemicals Park," Chemical Parks in Europe, accessed August 25, 2022, https://chemicalparks.eu/parks/saltend-chemicals-park.

292 "Aramco and SABIC Agri-Nutrients Receive World's First TÜV Certificate of Accreditation for 'Blue' Hydrogen and Ammonia Products," SABIC (news release), August 4, 2022, https://www.sabic.com/en/news/36507-aramco-and-sabic-agri-nutrients-receive-world-s-first-tuv-certificate.

293 ExxonMobil, *Updated 2021 Energy and Carbon Summary* (Irving, Texas: ExxonMobil, April 2021), 26, https://corporate.exxonmobil.com/-/media/Global/Files/energy-and-carbon-summary/Energy-and-Carbon-Summary.pdf.

294 "ExxonMobil planning hydrogen production, carbon capture and storage at Baytown complex," ExxonMobil (press release), March 1, 2022, https://corporate.exxonmobil.com/News/Newsroom/News-releases/2022/0301_ExxonMobil-planning-hydrogen-production-carbon-capture-and-storage-at-Baytown-complex.

295 "ExxonMobil, Grieg Edge, North Ammonia, GreenH to assess low-emission hub at Slagen terminal in Norway," ExxonMobil (press release), June 24, 2022, https://corporate.exxonmobil.com/News/Newsroom/News-releases/2022/0624_ExxonMobil-GriegEdge-NorthAmmonia-GreenH-to-assess-low-emission-hub-at-Slagenterminal-in-Norway.

296 See e.g., Leigh Collins, "Special Report: Why shipping pure hydrogen around the world might already be dead in the water," *Recharge*, January 27, 2022 (updated April 4, 2022), https://www.rechargenews.com/energy-transition/special-report-why-shipping-pure-hydrogen-around-the-world-might-already-be-dead-in-the-water/2-1-1155434.

297 See The Royal Society, *Ammonia: zero-carbon fertiliser, fuel and energy store* (The Royal Society, 2020), 15, https://royalsociety.org/-/media/policy/projects/green-ammonia/green-ammonia-policy-briefing.pdf.

298 The Fertilizer Institute, *Health Effects of Ammonia* (Washington DC: The Fertilizer Institute), 10, https://www.tfi.org/sites/default/files/documents/HealthAmmoniaFINAL.pdf.

299 "Ammonia (Compound)," PubChem, accessed August 22, 2022, https://pubchem.ncbi.nlm.nih.gov/compound/Ammonia#section=Substance-of-Very-High-Concern-(SVHC).

300 Julia Hansson, Selma Brynolf, Erik Fridell, and Mariliis Lehtveer**,** "The Potential Role of Ammonia as Marine Fuel—Based on Energy Systems Modeling and Multi-Criteria Decision Analysis," *Sustainability* 12 (2020) https://mdpi.com/2071-1050/12/8/3265/pdf.

301 Hideaki Kobayashi, Akihiro Hayakawa, K.D. Kunkuma A. Somarathne, and Ekenechukwu C.Okafor, "Science and technology of ammonia combustion," *Proceedings of the Combustion Institute* 37, no. 1 (2019): 109–133, https://doi.org/10.1016/j.proci.2018.09.029.

302 See Georgina Jeerh, Mengfei Zhang, and Shanwen Tao, "Recent progress in ammonia fuel cells and their potential applications," *Journal of Materials Chemistry A* 9 (2021): 747, https://pubs.rsc.org/en/content/articlepdf/2021/ta/d0ta08810b.

303 See "Cheap, secure, and renewable—Europe bets on green hydrogen to fix energy woes," Rystad Energy (press release), March 21, 2022, https://www.rystadenergy.com/news/cheap-secure-and-renewable-europe-bets-on-green-hydrogen-to-fix-energy-woes.

304 See e.g., this industry document stating: "In the ammonia production process, a highly concentrated CO_2 stream is already produced, making it a low hanging fruit for CCS." Fertilizers Europe, *Carbon Capture and Utilization in the European Fertilizer Industry* (Brussels: Fertilizers Europe, 2019), 3, https://www.fertilizerseurope.com/wp-content/uploads/2019/10/Carbon-Capture-def-version-1.pdf.

305 See IEA, "Levelized cost of CO_2 capture by sector and initial CO_2 concentration, 2019" IEA, last updated November 8, 2021, https://www.iea.org/data-and-statistics/charts/levelised-cost-of-co2-capture-by-sector-and-initial-co2-concentration-2019.

306 IEA, *The Future of Petrochemicals*, 51.

307 IEA, *The Future of Petrochemicals*, 52.

308 Global CCS Institute, *Global Status of CCS 2021*, 62-63 (Appendix 5.1).

309 Global CCS Institute, *Global Status of CCS 2021*, 62-63 (Appendix 5.1).

310 IEA, *The Future of Petrochemicals*, 51.

311 IEA, *The Future of Petrochemicals*, 52, at Fig. 3.4.

312 The Royal Society, *Ammonia*, 14.

313 Global CCS Institute, *Global Status of CCS 2021*, 62-63 (Appendix 5.1).

314 Global CCS Institute, *Global Status of CCS 2021*, 62 (Appendix 5.1); Global CCS Institute, *The Global Status of CCS. Special Report: Introducing Industrial Carbon Capture and Storage* (Melbourne: Global CCS Institute, 2016), 11, https://www.globalccsinstitute.com/wp-content/uploads/2019/08/Introduction-to-Industrial-CCS.pdf.

315 "Board of Directors," Nutrien, accessed August 23, 2022, https://www.nutrien.com/what-we-do/leadership/board-directors.

316 Global CCS Institute, *Global Status of CCS 2021*, 62–63 (Appendix 5.1).

317 "CVR Partners, LP," CVR Energy, accessed September 7, 2022, https://www.cvrenergy.com/NitrogenFertilizerOperations/index.html.

318 "Nitrogen Fertilizer Operations," CVR Partners LP, accessed August 23, 2022, https://www.cvrpartners.com/Operations/index.html.

319 Wabash Valley Resources, "The largest US carbon capture and sequestration project to be developed by Wabash Valley Resources with funding support from OGCI Climate Investments," PR Newswire, May 20, 2019, https://www.prnewswire.com/news-releases/the-largest-us-carbon-capture-and-sequestration-project-to-be-developed-by-wabash-valley-resources-with-funding-support-from-ogci-climate-investments-300852906.html.

320 "Meet Our Team," Wabash Valley Resources, accessed August 23, 2022, https://www.wvresc.com/team/.

321 "Who We Are," Oil and Gas Climate Initiative, accessed August 23, 2022, https://www.ogci.com/about-us/who-we-are/.

322 According to reporting from Energy News Network, a Wabash Valley Resources official "said the company switched its focus from ammonia to hydrogen production as hydrogen became more desirable in the clean energy economy." Kari Lydersen, "An Indiana carbon storage project wants the state to help protect it from lawsuits," *Energy News Network*, Jan. 20, 2022, https://energynews.us/2022/01/20/an-indiana-carbon-storage-project-wants-the-state-to-help-protect-it-from-lawsuits/.

323 See Donnelle Eller, "What we know about three carbon capture pipelines proposed in Iowa," *Des Moines Register*, November 28, 2021, https://www.desmoinesregister.com/story/money/business/2021/11/28/what-is-carbon-capture-pipeline-proposals-iowa-ag-ethanol-emissions/8717904002/.

324 "Navigator and OCI Sign Agreement for Provision of CO_2 Transportation and Storage Services through Heartland Greenway," *Business Wire*, November 29, 2021, https://www.businesswire.com/news/home/20211129005153/en/Navigator-and-OCI-Sign-Agreement-for-Provision-of-CO2-Transportation-and-Storage-Services-through-Heartland-Greenway.

325 "Summit Carbon Solutions Partners With Blue Ammonia Project to Decarbonize Ag Supply Chain," Summit Carbon Solutions (press release), January 10, 2022, https://summitcarbonsolutions.com/summit-carbon-solutions-partners-with-blue-ammonia-project-to-decarbonize-ag-supply-chain/.

326 See entry in Oil & Gas Watch database listing the project status as "on hold." Environmental Integrity Project, "Grand Forks Fertilizer Plant," Oil & Gas Watch, accessed August 23, 2022, https://oilandgaswatch.org/facility/886.

327 "Blue Ammonia Production," CF Industries, accessed August 23, 2022, https://sustainability.cfindustries.com/energy-emissions-and-climate-change/decarbonizing-our-network/blue-ammonia.

328 "Donaldsonville Complex," CF Industries, accessed August 23, 2022, https://www.cfindustries.com/who-we-are/locations/donaldsonville.

329 "CF Industries Announces $198.5 Million Carbon Capture Project At Donaldsonville Complex," Office of the Louisiana Governor (news release), August 5, 2022, https://gov.louisiana.gov/index.cfm/newsroom/detail/3773.

330 "CF Industries Announces $198.5 Million Carbon Capture Project," Office of the Louisiana Governor.

331 "CF Industries Announces Planned $2 Billion Carbon-Capture Ammonia Complex in Ascension Parish," Office of the Louisiana Governor (news release), August 17, 2022, https://gov.louisiana.gov/index.cfm/newsroom/detail/3792.

332 The Yazoo City Complex is projected to capture 500,000 tons of carbon dioxide per year, versus 2 million tons for Donaldsonville. See Environmental Integrity Project, "Yazoo City Complex," Oil & Gas Watch, accessed August 23, 2022, https://oilandgaswatch.org/facility/4866.

333 Dan Zegart, "The Gassing of Satartia," *HuffPost*, August 26, 2021, https://www.huffpost.com/entry/gassing-satartia-mississippi-co2-pipeline_n_60ddea9fe4b0ddef8b0ddc8f.

334 "Air Liquide, Borealis, Esso, TotalEnergies and Yara collaborate to help decarbonize the industrial basin of Normandy in France," ExxonMobil (press release), July 12, 2021, https://corporate.exxonmobil.com/News/Newsroom/News-releases/2021/0712_Air-Liquide_Borealis_Esso_TotalEnergies_Yara-collaborate-on-decarbonization.

335 "Major milestone for decarbonizing Europe," Yara, accessed August 30, 2022, https://www.yara.com/news-and-media/news/archive/news-2022/major-milestone-for-decarbonising-europe/.

336 "Major milestone for decarbonizing Europe," Yara.

337 Fertilizer Canada, "Re: Review of Alberta's Technology, Innovation and Emissions-Reduction program," letter to Alberta Environment and Parks, April 23, 2021, https://fertilizercanada.ca/wp-content/uploads/2021/04/Fertilizer-Canada-Alberta-Technology-for-Heavy-Industry-and-Biosolutions-Consultation-Response_Final.pdf.

338 Fertilizer Canada, "Re: Review of Alberta's Technology," 2.

339 E.N. Brandt, *Growth Company: Dow Chemical's First Century* (Michigan State Univ. Press, 1997), 186.

340 Brandt, *Growth Company*, 154-55. See also, Joseph C. Robert, Ethyl: *A History of the Corporation and the People Who Made It* (University Press of Virginia, 1982), 143; Jack Doyle, *Trespass Against Us: Dow Chemical & The Toxic Century*, (Environmental Health Fund, 2004), 24–25.

341 Brandt, *Growth Company*, 156; and see, e.g., "Oil and Gas Exploration," Dow, accessed August 30, 2022, https://www.dow.com/en-us/market/mkt-oil-gas-mining/sub-ogm-oil-gas-exploration.html.

342 Brandt, *Growth Company*, 154, 162.

343 Brandt, *Growth Company*, 179–183.

344 Brandt, *Growth Company*, 187, 190.

345 Gerard Colby, *Du Pont Dynasty: Behind the Nylon Curtain* (Lyle Stuart Inc. 1984), 212.

346 Colby, *Du Pont Dynasty*, 421, 705.

347 See "125 years of Wintershall: Headquartered in Germany, but at home all over the world," Wintershall Dea, November 13, 2019, accessed September 8, 2022, https://wintershalldea.com/en/newsroom/125-years-wintershall-headquartered-germany-home-all-over-world; "Non-Integral Shareholding in Wintershall Dea," BASF, last updated June 13, 2022, accessed August 30, 2022, https://www.basf.com/global/en/investors/calendar-and-publications/factbook/segments/wintershall-dea.html.

348 See "Koch Ag & Energy Solutions," Koch Industries, accessed August 30, 2022, https://www.kochind.com/companies/koch-ag-and-energy-solutions.

349 See "Companies," Koch Industries, accessed August 30, 2022, https://www.kochind.com/companies.

350 "Koch Industries: Secretly Funding the Climate Denial Machine," Greenpeace, accessed August 29, 2022, https://www.greenpeace.org/usa/fighting-climate-chaos/climate-deniers/koch-industries/ (includes multiple reports and records of donations to more than 90 climate denial organizations).

351 "Management and Board," Yara, accessed August 23, 2022, https://www.yara.com/this-is-yara/management-and-board; "CVs for Equinor's Board of directors," Equinor, accessed August 23, 2022, https://www.equinor.com/about-us/board-of-directors-cvs?12400d5721f9=0&24acb42c1c89=0&4fb7beeee769=0&7a956f8d0b26=0&c69295663b85=0&d842c8411a6f=0.

352 See "Board of Directors," Nutrien, accessed August 30, 2022, https://www.nutrien.com/what-we-do/leadership/board-directors (see biographical sketches for Russell Girling, Christopher Burley, Maura Clark, Michael Hennigan, Miranda Hubbs, and Nelson Luiz Costa Silva).

353 "Our leadership," OCI, accessed August 30, 2022, https://www.oci.nl/about/our-leadership/ (see biographical sketches for Heike van de Kerkhof, Dod Fraser, and Michael Bennett).

354 See Jeffrey W. Ubben credentials that include a current directorship with Fertiglobe. "ExxonMobil Board of Directors," ExxonMobil, accessed August 23, 2022, https://corporate.exxonmobil.com/About-us/Who-we-are/Corporate-governance/ExxonMobil-board-of-directors#ExxonMobilCorporationBoardofDirectors.

355 "Aramco Completes Its Acquisition of a 70% Stake in SABIC," SABIC, June 16, 2020, https://www.sabic.com/en/news/23722-saudi-aramco-completes-share-acquisition.

356 See "Energy Business," Sinochem, accessed August 30, 2022, https://www.sinochem.com/english/1399.html.

357 See "Crop Protection," ExxonMobil Chemical, accessed August 23 2022, https://www.exxonmobilchemical.com/en/solutions-by-industry/agriculture/crop-protection; "Food and Agriculture," Chevron Phillips Chemical, accessed August 23, 2022, https://www.cpchem.com/what-we-do/industries/food-agriculture; see also: "Chevron Chemical Company Trademarks," JUSTIA Trademarks, accessed August 30, 2022, https://trademarks.justia.com/owners/chevron-chemical-company-10768/.

358 "Chemicals Products Portfolio," Shell, accessed August 29, 2022, https://www.shell.com/business-customers/chemicals/our-products.html (See, e.g., entries for Aromatics (benzene, xylene), Chemical Solvents (glycol ethers and acetates), GTL Fluids and Solvents, and Hydrocarbon Solvents (aromatic solvents)).

359 IEA, *The Future of Hydrogen* (Paris: IEA, 2019), 89–90, https://www.iea.org/reports/the-future-of-hydrogen.

360 IEA, *Ammonia Technology Roadmap*, 1.

361 Rod Nickel and Victoria Klesty. "Facing green push on farm, fertilizer makers look to sea for growth," *Reuters*, January 20, 2021, https://www.reuters.com/article/us-agriculture-fertilizers-hydrogen-focu/facing-green-push-on-farm-fertilizer-makers-look-to-sea-for-growth-idUSKBN29P1EF.

362 Rod Nickel and Victoria Klesty. "Facing green push on farm, fertilizer makers look to sea for growth," *Reuters.*

363 Center for Global Commons and SYSTEMIQ, *Planet Positive Chemicals: Pathways for the Chemical Industry to Enable a Sustainable Global Economy* (Center for Global Commons and SYSTEMIQ, September 2022), 14, https://www.systemiq.earth/wp-content/uploads/2022/09/Main-report-v1.20-2.pdf.

364 See e.g., Howarth and Jacobson, "How green is blue hydrogen?" 1685; Seth Mullendore, "Op-ed: We don't have time for another fossil fuel bridge," *Environmental Health News*, September 21, 2021, https://www.ehn.org/carbon-capture-climate-change-2655065048/the-carbon-capture-boondoggle.

365 Dr. Antoine Hoxha, "Ammonia: The other hydrogen," *Euractiv*, July 16, 2020, https://www.euractiv.com/section/energy-environment/opinion/ammonia-the-other-hydrogen/.

366 Frédéric Simon and Kira Taylor. "Fertiliser industry execs: 'We see ammonia as a battery for hydrogen,'" *Euractiv*, March 2, 2021, https://www.euractiv.com/section/energy/interview/fertiliser-industry-execs-we-see-ammonia-as-a-battery-for-hydrogen/.

367 Nickel and Klesty. "Facing green push on farm," *Reuters*.

368 "Mitsui & Co., Ltd. and CF Industries Announce Plans for New Blue Ammonia Capacity in the United States," CF Industries, May 3, 2022, https://www.cfindustries.com/newsroom/2022/cf-mitsui-update; "CF Industries Announces Planned $2 Billion Carbon-Capture Ammonia Complex in Ascension Parish," Office of the Louisiana Governor.

369 "Yara and Japan Bank for International Cooperation explore strategic collaboration in Japan," Yara (news release), June 15, 2022, https://www.yara.com/news-and-media/news/archive/news-2022/yara-and-japan-bank-for-international-cooperation-explore-strategic-collaboration-in-japan/.

370 "Yara, JERA and Idemitsu Kosan explore clean ammonia bunkering and distribution collaboration in Japan," Yara (news release), October 5, 2021, https://www.yara.com/corporate-releases/yara-jera-and-idemitsu-kosan-explore-clean-ammonia-bunkering-and-distribution-collaboration-in-japan/.

371 "ADNOC and Fertiglobe Partner to Sell UAE's First Blue Ammonia to Japan's Itochu," OCI (news release), August 3, 2021, https://www.oci.nl/news/2021-oci-nv-10/.

372 "Fertiglobe Joins TA'ZIZ as Partner in World-Scale Blue Ammonia Project in Ruwais in Abu Dhabi," OCI (news release) June 22, 2021, https://www.oci.nl/news/2021-oci-nv-7/.

373 "Rotterdam Explores Importing Norwegian Blue Ammonia," The Maritime Executive, August 5, 2021, https://www.maritime-executive.com/article/rotterdam-explores-importing-norwegian-blue-ammonia.

374 "Frequently Asked Questions: What is the Hydrogen Council?" Hydrogen Council, accessed August 23, 2022, https://hydrogencouncil.com/en/faq/.

375 Nickel and Klesty, "Facing green push on farm," *Reuters*.

376 Who We Are," CF Industries, accessed August 23, 2022, https://www.cfindustries.com/who-we-are.

377 "Fertilizers Europe New Visual Identity," Fertilizers Europe, accessed August 23, 2022, , https://www.fertilizerseurope.com/newvisualidentity/.

378 Nutrien, *Ammonia: Transitioning to a Net-Zero Future* (Saskatoon: Nutrien, March 2022), 4, https://www.greenbiz.com/whitepaper/ammonia-transitioning-net-zero-future.

379 For the 4.3 million tons gross ammonia capacity figure, see e.g., C.F. Industries Holdings, Inc., *Form 10-K For the Fiscal Year Ended December 31, 2021* (Deerfield, Illinois: CF Industries, February 2022), 4, https://d18rn0p25nwr6d.cloudfront.net/CIK-0001324404/fb3473c7-b8f5-4d86-a17d-e1fc25046f58.pdf.

380 "CF Industries Signs Engineering and Procurement Contract with thyssenkrupp for Green Ammonia Project," *Business Wire*, April 21, 2021, https://www.businesswire.com/news/home/20210421005948/en/CF-Industries-Signs-Engineering-and-Procurement-Contract-with-thyssenkrupp-for-Green-Ammonia-Project.

381 Nickel and Klesty, "Facing green push on farm," *Reuters*; CF Industries Holdings, Inc. *Form 10-K For the Fiscal Year Ended December 31, 2021*, 4.

382 Climate Champions, "Green Hydrogen Catapult," Race to Zero, UNFCCC, December 8, 2020, https://racetozero.unfccc.int/green-hydrogen-catapult/.

383 "Yara proposes NOK 20 per share dividend, establishes clean ammonia unit," Yara (news release), Feb. 9, 2021, https://www.yara.com/corporate-releases/yara-proposes-nok-20-per-share-dividend-establishes-clean-ammonia-unit/.

384 "Green fertilizers," Yara, accessed August 26, 2022, https://www.yara.com/crop-nutrition/products-and-solutions/green-fertilizers/.

385 "Green fertilizers: everything you need to know," Yara, accessed August 26, 2022, https://www.yara.com/crop-nutrition/products-and-solutions/green-fertilizers/what-you-need-to-know-about-green-fertilizers/.

386 "Green fertilizers: everything you need to know," Yara.

387 "Renewable hydrogen and ammonia production—YARA and ENGIE welcome a A$42.5 million ARENA grant," Yara (news release), May 5, 2021, https://www.yara.com/news-and-media/news/archive/2020/renewable-hydrogen-and-ammonia-production-yara-and-engie-welcome-a-a$42.5-million-arena-grant/.

388 "Yara Pilbara," Yara, accessed August 23, 2022, https://www.yara.com.au/about-yara/about-yara-australia/pilbara/#abd0e896-528e-46df-8ce2-94322baa42d3.

389 "Ørsted and Yara seek to develop groundbreaking green ammonia project in the Netherlands," Ørsted (news release), October 5, 2020, https://orsted.com/en/media/newsroom/news/2020/10/143404185982536.

390 "Major milestone for decarbonizing Europe," Yara.

391 OCI N.V., accessed August 29, 2022, https://www.oci.nl/.

392 See, e.g., "OCI Beaumont," accessed August 29, 2022, https://www.oci.nl/operations/oci-beaumont/ ("OCI Beaumont has connections to one major interstate and three major intrastate natural gas pipelines that provide access to significantly more natural gas supply than the facility requires and flexibility in sourcing natural gas feedstock."); and "Natgasoline, LLC," accessed August 29, 2022, https://www.oci.nl/operations/natgasoline-llc/ ("The plant is located near six existing natural gas pipelines and receives natural gas from two pipelines that run through the project site.").

393 See "Clean Ammonia," OCI, accessed August 29, 2022, https://www.oci.nl/hydrogen/clean-ammonia/.

394 "IFCo CCS," OCI, accessed August 29, 2022, https://www.oci.nl/ammonia-initiatives/ifco-ccs/ (as discussed elsewhere in this report, this project would connect to the proposed Navigator carbon dioxide pipeline in the midwestern US); "OCIB Blue Ammonia," OCI, accessed August 29, 2022, https://www.oci.nl/ammonia-initiatives/blueam/.

395 "Project FUREC," OCI accessed August 29, 2022, https://www.oci.nl/ammonia-initiatives/furec/.

396 "ADNOC and Fertiglobe Partner," OCI (news release), August 3, 2021; "Fertiglobe Joins TA'ZIZ as Partner," OCI (news release), June 22, 2021.

397 "OCI Partners with NortH2 with the Intent to Develop the First Large-Scale Green Ammonia and Methanol Value Chains in the Netherlands," OCI (news release), March 31, 2022, https://www.oci.nl/news/2022-oci-partners-with-north2/; "OCI Partners with NortH2," OCI, accessed August 29, 2022, https://www.oci.nl/ammonia-initiatives/oci-partners-with-north2/.

398 "Egypt Green," OCI, accessed August 29, 2022, https://www.oci.nl/ammonia-initiatives/egypt-green/.

399 "Fertiglobe," OCI, accessed August 29, 2022, https://www.oci.nl/operations/fertiglobe/.

Fossils, Fertilizers, and False Solutions

How Laundering Fossil Fuels in Agrochemicals Puts the Climate and the Planet at Risk

Fertilizers and pesticides are interdependent inputs to a destructive food production model that contributes to catastrophic biodiversity collapse, toxic pollution, and the violation of human rights. But there is an often-overlooked dimension of the threat posed by these agrochemicals: their fossil fuel origins. Synthetic nitrogen fertilizer and pesticides are fossil fuels in another form, making them an underrecognized but significant driver of the climate crisis. Further, the close ties between agrochemicals and fossil fuels mean that industrial food production is vulnerable to the volatility inherent in oil and gas markets, as starkly illustrated by the 2022 market shocks in food, fuel, and fertilizer prices.

For over a decade, the fossil fuel industry has been betting on petrochemicals (namely, plastics) to maintain profits as the world moves away from oil and gas as fuels. *Fossils, Fertilizers, and False Solutions* exposes how fossil fuel and fossil fertilizer companies are aligning to pursue a new escape hatch: one that purports to solve the climate challenge of hydrocarbon combustion by using the hydrogen and managing the carbon.

The fertilizer industry and the processes it already uses to make its products hold the keys to this new model. Largely unnoticed by media and civil society watchdogs, oil, gas, and agrochemical companies are partnering on a rapidly growing wave of new projects that would use carbon capture and storage (CCS) to produce fossil gas-based "blue" ammonia (and its "blue" hydrogen precursor), not only as a critical fertilizer input but as a combustible fuel for transport and energy. Through such approaches, the fertilizer and fossil fuel companies seek to greenwash their polluting business, cash in on generous new subsidies for CCS, and access new markets as "clean energy companies."

The corporate-controlled, input-reliant model of industrial agriculture requires a profound transformation to resilient, regenerative models that enhance food and energy sovereignty so that the ecosystems and communities that depend on them can thrive. The need for such a fundamental transformation is as urgent and as compelling as the global energy transition, the transition away from plastic pollution, and the transition to a world free of toxic chemicals. Achieving those transitions depends on removing the common roadblock: a fossil-fueled system that has captured politics and is burning, polluting, and poisoning people and the planet. At a time of surging fossil fuel, fertilizer, and food prices, and with the escalating climate crisis, the case for transitioning away from fossil fertilizer and from fossil fuels has never been clearer.

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