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The Trans-Atlantic Plastics Pipeline: How Pennsylvania's Fracking Boom Crosses the Atlantic

America's oil and gas rush is now coming to Europe, polluting both sides of the pond, contributing to climate change and threatening coastal wildlife. Over the past decade, the US fossil fuel industry has surged by employing new techniques and technologies that combine horizontal drilling and hydraulic fracturing (or fracking) to extract oil and gas from shale and other underground rock formations. Fracking, which causes many negative public health and environmental impacts, injects large quantities of water, sand and chemicals under high pressure to release oil or gas tightly held in rock layers.¹

The boom, combined with low-priced fossil fuel-based natural gas, also spawned a resurgence in North American petrochemical and plastics manufacturing — and the pollution that comes with it.² Wall Street investor-funded US fracking produced an oversupply of cheap gas and ethane in the past few years.³ The volume of gas pumped out of US wells has risen by one-third, and the industrial price for gas fell by half over the same period from 2007 to 2016.⁴ Collapsing prices undermined the profitability of oil and gas companies, but all that additional gas has been a boon to the US plastics industry.⁵

Ethane is a hydrocarbon present in gas and a primary raw material for petrochemical manufacturing. Due to its low costs, in 2012 chemical companies began aggressively investing in petrochemical plants and export facilities to capitalise on the ethane glut.⁶ Less than four years later, ethane derived from US fracked gas was exported to Europe for the first time.⁷

The new ethane export route connects Pennsylvania fracking with European petrochemical manufacturing. The Europe-bound ethane is produced in Pennsylvania by the US oil and gas companies CONSOL Energy and Range Resources, and is carried by Sunoco's Mariner East pipeline to its Marcus Hook export facility near Philadelphia. From there, large vessels dubbed "dragon ships" carry the ethane more than 5,600 kilometres across the Atlantic Ocean to ethane crackers in Norway and Scotland owned by Ineos, a European chemical company founded by billionaire Jim Ratcliffe. The crackers turn ethane into ethylene for the production of finished petrochemicals — such as plastics.⁸

In May 2017, Ineos' Grangemouth petrochemical facility in Scotland had a substantial ethylene leak that forced the evacuation of employees, scrambled emergency responders and caused the lockdown of a local elementary school.⁹ The resurgent plastics production

fuelled by Pennsylvania fracked gas could put even more communities at risk of industrial accidents.

As with fracking, transforming ethane into plastics and other products can be toxic, polluting the environment and exposing workers and nearby communities to public health risks. European countries must protect the environment and public health and reject America's headlong rush to fracking and cracking pollution and environmental damage.

Converting Fracked Gas Into Petrochemicals

The US fracked gas boom has spurred a related plastics manufacturing resurgence. The petrochemical industry produces hydrocarbon-based chemicals derived primarily from processed natural gas and, to a lesser extent, crude oil. Petrochemicals are the building blocks for manufacturing a wide range of goods — including plastic packaging, beverage bottles, tyres and more.¹⁰

Although natural gas primarily contains methane and smaller amounts of other hydrocarbons, including natural gas liquids (NGLs), what the industry calls “wet” natural gas has higher concentrations of these NGLs.¹¹ NGLs are the raw materials used to manufacture petrochemicals — predominantly ethane but also propane, butane, isobutane and pentanes.¹²

The fracking boom across the Midwest and Northeast United States has produced large volumes of ethane.¹³ A few shale plays — including portions of the Utica and Marcellus Shale gas reserves underlying vast portions of Appalachia — contain more “wet” natural gas.¹⁴ The wet gas drilled in the US state of Pennsylvania has become the key source of the ethane being transported to Norway and Scotland.¹⁵

Turning ethane into plastic is an energy-intensive process that requires separation from the other hydrocarbons present in natural gas. A petrochemical facility known as a cracker plant applies steam (or just heat) processes to “crack” ethane into ethylene, which creates the most common type of plastic.¹⁶ Petrochemical companies convert ethylene into small plastic pellets (called polyethylene resin) through another chemical procedure called polymerisation. The resin pellets are used to manufacture plastic products.¹⁷

The Polluting Perils of Plastics Production

Plastic represents the worst of our overly disposable society, and most plastic is just wasted — used once and discarded. Most plastic manufacturing goes into packaging, which creates materials that are immedi-



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Pre-production plastic pellets called nurdles are frequently found in areas of marine debris concentration.

ately thrown away.¹⁸ Much of this plastic waste ends up in our oceans and surface waters. A 2015 study estimated that nearly 200 coastal countries generated over 275 million tonnes of plastic waste in 2010 — and as much as 4.8 million to 12.7 million tonnes ended up in the oceans.¹⁹ In the central Pacific Ocean, a “plastic soup” circulates among four major ocean currents. Dubbed the “Great Pacific Garbage Patch”, it is the world’s largest dump.²⁰

A 2017 study found that plastic — mainly in the form of small pellets called nurdles — has littered 73 percent of the United Kingdom’s (UK) 279 shorelines.²¹ For example, near Ineos’ Grangemouth petrochemical complex, the Firth of Forth’s beaches and old fishing towns have been polluted by “worryingly large” amounts of nurdles, and scientists have found that 15 percent of endangered puffins in the area contain these pellets in their stomachs.²² In 2017, one scientist filmed the moment when plankton ingests plastic, documenting how it enters the food chain.²³ The fracking-driven industry expansion will likely generate even more coastal and ocean plastic pollution as ethane crackers produce more plastic resins.

The petrochemical boom does more than generate plastic that is overfilling our landfills and spilling into the oceans; the manufacturing process itself releases pollutants into our air. In the United States, for example, the Houston Ship Channel in Texas produces



about one-quarter of America's petrochemicals.²⁴ In 1999, when Houston's ozone levels were the highest in the country, the state conducted several studies that found large industrial leaks. The worst originated from cracker plants producing ethylene and propylene. "The plants were having 1,000-pound releases, 5,000-pound releases, 20,000-pound releases, in one case 200,000-pound releases", explained a now-retired University of North Carolina chemist who analysed Houston's air pollution problem.²⁵ These studies led regulators to specifically target the petrochemical industry, and despite some temporary progress, Houston continued through 2015 to fail to meet federal ozone standards.²⁶

Similarly, monitoring stations at petrochemical plants in Gela, Italy recorded sulphur dioxide — an air pollutant that can affect the lungs and respiratory health — as well as high concentrations of toxic heavy metals in road dust. In soil and water, various carcinogenic pollutants were recorded at levels that exceeded allowable limits. For example, arsenic concentrations were 7,000 times the allowable amount in local water, and mercury concentrations exceeded the permitted threshold by 6,600. Another Gela-based study found that a petrochemical plant appeared responsible for raised levels of metals including nickel, sulphur, selenium, zinc and arsenic in atmospheric particulate matter.²⁷

And according to the European Environment Agency, ozone pollution could worsen in the future from increasing activity in certain sectors, including the petrochemical industry.²⁸ As a result, smog pollution can form if ozone combines with particulate matter — such as from shipping traffic emissions and petrochemical facilities, which has been observed near major harbours in Europe.²⁹ Smog is linked to asthma and to low birthweight in babies.³⁰

The Players and the Plan: Getting Pennsylvanian Fracked Gas to Europe

In June 2010, Ineos launched its brainchild project — importing ethane from the United States to Norway and the UK — in part because it is cheaper than purchasing European ethane, but also because gas supplies from the North Sea are declining.³¹ But shipping fracked ethane from the United States to Europe proliferates fracking's toxic legacy in Pennsylvania and threatens human health, the climate and the environment — not just through the gas drilling and production, but also through the plastics manufacturing.

Ineos Constructs the Fracking-Cracking Cross-Atlantic Connection

Headquartered in Switzerland for tax purposes, the chemical giant Ineos (originally called Inspec Ethylene Oxide and Specialities) was the UK's largest privately owned company in 2010.³² It operates 65 manufacturing facilities in 16 countries worldwide, including 9 sites in Europe.³³ The controversial billionaire owner of Ineos, Jim Ratcliffe, has been one of the UK's 10 richest men, owns a "super yacht" and won a confrontational union battle at the company's biggest factory.³⁴

In a 2016 *BBC* interview Ratcliffe sloughed off concerns about environmental safety, comparing these problems to getting a flat tyre: "...it is not perfect. It is like a puncture in your car — occasionally you get a puncture and occasionally we have an accident in chemicals."³⁵ Ineos also pushed to be exempt from complying with climate fees and policies under Brexit and the fees that polluters pay to support green energy in the UK.³⁶

Ratcliffe, also the primary shareholder of Ineos, is one of the biggest fracking boosters in the UK and throughout Europe and is the biggest owner of shale licences in the UK.³⁷ In addition to pursuing shale gas in the Sherwood National Forest in Nottinghamshire, England, Ineos is pressing the Scottish Government to lift its current moratorium on fracking — which is seemingly moving towards a permanent ban.³⁸

Drilling and fracking in the UK is only in the exploratory phases in some parts of the country. But a January 2017 briefing paper by the House of Commons highlighted that the "recent approval of two planning decisions in Lancashire and North Yorkshire suggest that the UK is getting closer to commercial shale gas exploitation".³⁹ Moreover, there is widespread and growing opposition to fracking throughout the UK.⁴⁰

In 2012, Ineos struck a deal with US companies, including Range Resources and Sunoco Logistics, to become the first European petrochemical company to import US ethane feedstocks. The companies would provide ethane derived from shale gas for an Ineos cracker plant in Rafnes, Norway.⁴¹ A year later, Ineos entered into a 15-year contract with the Danish ship operator Evergas, which had the ships built in China.⁴² In 2014, Ineos secured even more Pennsylvania ethane under an agreement with Pittsburgh, Pennsylvania-based CONSOL Energy.⁴³ It also expanded its agreement with Evergas to increase the number of ships carrying ethane to Rafnes as well as to a facility in Grangemouth, Scotland.⁴⁴

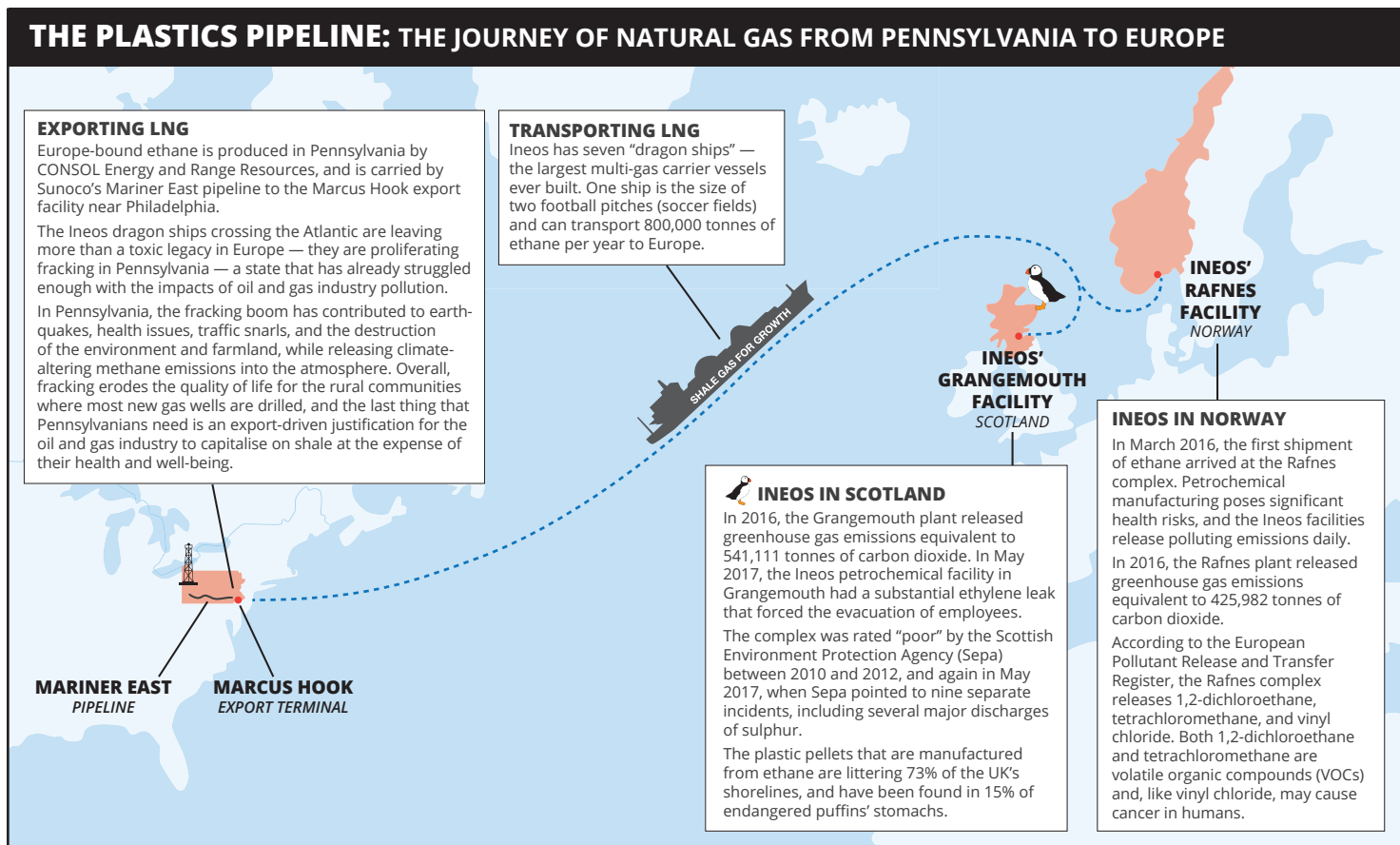
Shipping Ethane to Norway and Scotland

Ineos started with four “dragon ships”; it now has seven and is aiming for a fleet of eight — creating a virtual pipeline of ethane from US fracking facilities to Europe.⁴⁵ Each ship is between 180 and 240 metres long (200 and 260 yards) — the size of two football fields — and the vessels are the largest multi-gas carrier ships ever built.⁴⁶ Each vessel is capable of transporting 800,000 tonnes of ethane (or liquefied natural gas (LNG) or liquefied ethylene gas) a year to Norway or Scotland.⁴⁷

The engines can run on diesel, LNG or the ships’ other gaseous cargo — as it does when transporting ethane from Pennsylvania.⁴⁸ Although LNG-powered ships have lower emissions of some pollutants, the impact on climate is outweighed by emissions of methane, a powerful greenhouse gas.⁴⁹ Ethane, however, is an extremely flammable gas. In the event of a collision, as much as 27,500 cubic metres of liquid ethane could explode.⁵⁰ And if boat personnel have direct contact with liquid ethane, they could develop frostbite.⁵¹

In March 2016 the first shipment of ethane arrived at Ineos’ Rafnes petrochemical complex.⁵² Ineos owns a 50 percent stake in the Rafnes cracker as well as three polyolefin plants at nearby sites in Bamble, Norway — a location that Ineos dubbed a “petrochemical cluster”.⁵³ The Rafnes cracker is equipped with 10 small and 2 large furnaces that process up to 650,000 tonnes of ethane annually to create ethylene. The ethylene is manufactured into plastics at both a Rafnes chlorine/vinyl chloride monomer (VCM) plant and an Ineos’ facility in Bamble, Norway; a portion of the ethylene is also exported.⁵⁴

The new supply of US ethane allowed Ineos to re-open a cracker unit at its Grangemouth, Scotland complex — its biggest manufacturing site — after being largely mothballed for eight years.⁵⁵ Ineos capitalised on its new hydrocarbon supply to ink a deal with ExxonMobil



and Shell to deliver ethane manufactured from US fracked gas to the Fife Ethylene plant (which is operated by Exxon and co-owned by Shell) in Scotland beginning in 2017.⁵⁶ Ineos' Grangemouth also was the scene of a bitter 2013 labour dispute where the company used lockouts and threatened shutdowns to force extreme concessions from workers — including pay freezes, elimination of final salary pensions, prohibiting on-site union officials and a three-year strike moratorium.⁵⁷

In September 2016 the Grangemouth site received its first delivery of ethane, and the facility will process 315,000 tonnes annually,⁵⁸ potentially releasing a significant source of ozone-creating volatile organic compounds (VOCs).⁵⁹ The complex also contains Scotland's only oil refinery, producing a majority of the country's fuels.⁶⁰ On top of that, Ineos' ethane crackers in Norway and Grangemouth are co-located with other chemical manufacturing operations,⁶¹ potentially compounding existing pollution. Ineos' plastic resins are supplied to distributors that ultimately sell products worldwide to other manufacturers in North America, Europe, the Middle East, Africa and Asia.⁶²

Pollution, Public Health and Safety

Petrochemical manufacturing poses significant human health risks. In May 2017, for instance, the Ineos' Grangemouth petrochemical plant in Scotland was partially evacuated after ethylene gas leaked from a pipeline at its on-site Kinneil Gas plant.⁶³ But even beyond industrial accidents, the plants that convert natural gas into petrochemicals are known to emit massive amounts of air and climate pollutants including polycyclic aromatic hydrocarbons, carbon dioxide and ozone-creating VOCs (such as benzene and toluene) and nitrogen oxide.⁶⁴ Prolonged contact with ground-level ozone is linked to asthma and chronic obstructive pulmonary disease. When mixed with particulate matter, which has been linked to various cancers, smog forms.⁶⁵ The Ineos plants at Grangemouth and Rafnes had total climate change-accelerating greenhouse gas emissions equivalent to 967,093 tonnes of carbon dioxide in 2016.⁶⁶

More generally, chronic exposure to air pollution can cause various illnesses, including cognitive deficits.⁶⁷ Several studies have demonstrated that people's exposure to petrochemical facility pollutants is associated with heightened cancer risks, acute irritative symptoms (such as nausea and eye and throat irritation) and respiratory-related illnesses, especially for children.⁶⁸

The Ineos facilities regularly release emissions into the air during daily operations. According to the European

Pollutant Release and Transfer Register, the Rafnes complex releases 1,2-dichloroethane, tetrachloromethane, and vinyl chloride,⁶⁹ and the Bamble location releases non-methane VOCs.⁷⁰ The Grangemouth facility releases a vaster spectrum of pollutants, including VOCs, carbon dioxide, methane, particulate matter and more.⁷¹ These chemicals, however, can endanger both the environment and public health. Both 1,2-dichloroethane and tetrachloromethane are VOCs and, like vinyl chloride, may cause cancer in humans.⁷² With increased ethylene production, it is conceivable that emissions could compound and worsen.

The Scottish facility also has a disturbingly checkered environmental record. The Scottish Environment Protection Agency (Sepa) found that the pollution performance at Ineos' Grangemouth oil refinery was "poor" between 2010 and 2012 — noting that there was "unabated emissions via an unauthorised emission point". Sepa also said that in 2011 there was a "significant breach of the permit due to poor operational control during a plant upset". And between January and March 2015 there were nearly 400 safety incidents and over 20 work-related injuries.⁷³ An investigative story on the Grangemouth complex uncovered that between 2011 and 2014 the government's Health and Safety Executive served Ineos with 11 legal enforcement notices for breaking the rules on 34 different occasions, compared to 3 enforcement notices in the previous four years.⁷⁴ More recently in 2016, the air quality management area including the Grangemouth petrochemical complex reported sulphur dioxide emissions that exceeded legal limits.⁷⁵

US Frackers Fueling Ineos' Plastics Push

The Ineos dragon ships crossing the Atlantic draped with "Shale Gas for Europe" banners⁷⁶ are leaving more than a toxic legacy in Europe — they are proliferating fracking in Pennsylvania, a state that already has struggled enough with the impacts of oil and gas industry pollution.

Pennsylvania has been ground zero of the fracking boom, with just over 10,000 shale gas wells drilled between 2005 (when commercial production first began) and 2016.⁷⁷ The number of new wells drilled has tapered off considerably as the price of natural gas has fallen. After the early and dramatic increase in drilling, from 9 wells in 2005 to 1,957 in 2011, the number dropped to 504 in 2016.⁷⁸ The US gas industry is promoting exports to maintain fracking's profitability, and more gas exports would drive additional drilling and gas extraction.⁷⁹

Once a well is fracked, during oil or gas production, methane can escape from the well and mix with nitrogen oxide emissions from diesel-fuelled vehicles and drilling equipment to form ground-level ozone.⁸⁰ When combined with particulate matter of a certain size (less than 2.5 micrometres), ozone can form smog. Chronic exposure can lead to asthmatic conditions and chronic pulmonary disease.⁸¹

Shale gas is about 90 percent methane,⁸² and escaping methane emissions from oil and gas operations, including pipeline transmission, are the leading human-caused source of methane pollution in the United States — and the second largest source worldwide. Science shows that kilo-for-kilo, methane is over 86 times more potent than carbon dioxide at trapping heat over 20 years, and over 34 times more potent than carbon dioxide at trapping heat over 100 years.⁸³ These widespread methane leaks from the fracking industry mean that gas cannot be considered a low-carbon fuel — it must receive the same treatment as coal and oil. Fossil fuel-based gas is incompatible with EU climate objectives, with the obligations resulting from the Paris Agreement and with the need to act quickly to tackle climate change. Ethane can also leak during shale development. When ethane is in the atmosphere it forms ozone through a reaction between sunlight and other molecules — a major contributor to human-caused global warming.⁸⁴

Overall, fracking causes many public health, climate and environmental problems,⁸⁵ and Pennsylvanians will likely endure increased shale gas development — all to benefit oil and gas companies at home and abroad.

Range Resources: Range Resources was the first company to drill and frack a modern Marcellus shale well in Pennsylvania, and it contracted to supply Ineos with ethane through the Mariner East pipeline in 2012.⁸⁶ The company may be most notoriously known for contaminating drinking water in Parker County, Texas in 2010.⁸⁷ Now, it primarily operates in Pennsylvania, where the Pennsylvania Department of Environmental Protection (DEP) has fined it nearly \$21 million for harming the environment.⁸⁸ Between 2005 and 2016, the DEP charged Range Resources with 516 environmental health and safety violations.⁸⁹

CONSOL Energy: Pittsburgh-based CONSOL Energy (CONSOL) contracted to deliver Ineos Pennsylvania ethane in 2014.⁹⁰ CONSOL used to be primarily a coal mining company, but it is now refocusing its business solely on oil and natural gas development.⁹¹ The Ineos deal may right CONSOL's ailing balance sheet, but



given CONSOL's dubious environmental track record, increased production may mean increased violations.

Since 2005 the DEP has fined CONSOL Energy's subsidiaries — CONSOL Gas and CONSOL PA Coal LLC — \$224,350 for harming the environment. And between 2005 and 2016, these subsidiaries were slapped with 34 environmental, health and safety violations.⁹² These violations may not reflect the full extent of the environmental damage that CONSOL has imposed, as the company has been involved in many coal pollution-related lawsuits. In August 2016, for example, CONSOL was charged \$3 million due to allegations that one of its mines polluted streams in southwestern Pennsylvania.⁹³

Sunoco: In 2011, Sunoco began rebuilding its infrastructure necessary to transport ethane to Europe by revamping its retired Marcus Hook, Pennsylvania oil refinery facility and developing its Mariner East pipeline system to bring NGLs to Marcus Hook.⁹⁴ At the end of 2011, Sunoco inked a deal to deliver ethane to Ineos.⁹⁵

Sunoco, a subsidiary of Energy Transfer Partners (the company behind the Dakota Access pipeline), owns both the Mariner East pipeline and the Marcus Hook facility.⁹⁶ The newly minted, American Petroleum Institute (API)-backed US Secretary of Energy, Rick Perry, was a former board member of both Sunoco and Energy Transfer Partners.⁹⁷ API highlighted Perry's "opportunity to encourage increased exports of domestically produced natural gas" in its official endorsement.⁹⁸

According to a *Reuters* analysis, Sunoco has had a higher rate of oil spills compared to its competitors, with more than 200 leaks since 2010.⁹⁹ The company released 4.5 million litres of hazardous liquids into the environment, causing over \$53 million in property

damages from 2006 to 2016, according to the Pipeline and Hazardous Materials Safety Administration (PHMSA).¹⁰⁰

Marcus Hook: The Marcus Hook facility is located near what the Pennsylvania DEP identifies as an “environmental justice area”.¹⁰¹ The old refinery had a troubled history of spewing large amounts of pollution. Between 2000 and 2008 it was one of the top three US refineries with the largest benzene emission increases.¹⁰²

The refinery shut down in 2011, but Sunoco developed a scheme to revive it into a “world-class NGL Hub”.¹⁰³ Now operating as the Marcus Hook Industrial Complex, the facility encompasses an 324-hectare site along the Delaware River near Philadelphia. It includes an export terminal for liquefied petroleum products and crude oil, a comprehensive petroleum and processing complex, storage facilities with capacity for roughly 5 million barrels of NGLs, and an ethane-loading facility that is capable of exporting up to 1.9 million tonnes annually.¹⁰⁴ The export terminal went into operation in March 2016, when it first shipped ethane to Norway.¹⁰⁵

Mariner East: The Mariner East pipeline project was a building block to Sunoco’s Marcus Hook revitalisation.¹⁰⁶ The project connects pipelines across the Mid-Atlantic fracking belt that will transport large quantities of NGLs to Marcus Hook. Mariner East 1 is a 480-kilometre pipeline that can carry about 70,000 barrels per day (bpd) of propane and ethane to Marcus Hook.¹⁰⁷ Mariner East 2, the second phase, is a \$2.5 billion construction project that runs parallel to the existing Mariner 1. Mariner 2 will initially increase the pipeline systems’ capacity to 275,000 bpd and eventually up to 450,000 bpd.¹⁰⁸

In 2017 Pennsylvania granted approval for Sunoco to begin construction on Mariner East 2.¹⁰⁹ A possible third phase could increase the total capacity to over 700,000 bpd.¹¹⁰ The approval of permits by the Pennsylvania DEP for Mariner East 2 came as a blow to some communities.¹¹¹ According to the grassroots group Middletown Coalition for Community Safety, “The public has been disenfranchised throughout the process, with no public comment period on the current application submission and no public hearing ever held in Delaware County, despite the fact that 11½ miles of the proposed route traverse our communities.”¹¹² Now, communities along the pipeline route are shifting to strategies focused on blocking the pipeline through local municipal governments.

Conclusion and Recommendations

In Pennsylvania, the fracking boom has contributed to earthquakes, health issues, traffic snarls and the destruction of the environment and farmland, while releasing climate-altering methane emissions into the atmosphere.¹¹³ Overall, fracking erodes the quality of life for the rural communities where most new gas wells are drilled,¹¹⁴ and the last thing that Pennsylvanians need is an export-driven justification for the oil and gas industry to capitalise on shale at the expense of their health and well-being.

Shipping fracked NGLs from the United States to Europe makes no sense for the climate, the environment or human health. We do not need more plastics, petrochemicals or fracked hydrocarbons. What we do need is fresh air, clear drinking water and an intact environment. Rather than continually investing in fossil fuels and chemical industries, we must act swiftly and with determination and invest in clean, renewable energy. Climate change demands action, and here are our recommendations:

- Fracking should be banned everywhere — in the United States and across Ireland, Scotland and throughout the United Kingdom.
- The United States must stop fossil fuel exports and the construction of infrastructure to support these exports.
- The EU should not accept fossil fuel imports and should stop the expansion of LNG infrastructure.
- People should limit their purchases of non-biodegradable plastic products that effectively support and finance the oil and gas industry, as well as working for public policies that discourage the use of these plastics.
- Both the United States and the EU should enact aggressive energy conservation policies, including large public transport investments and widespread deployment of other energy-saving solutions.
- Both the United States and the EU should establish ambitious programmes for deploying and incentivising existing renewable energy and energy efficiency technologies in order to slash fossil fuel demand to reach 100 percent clean renewable energy by 2035, while modernising electrical grids to cater to distributed renewable power generation.
- Both the United States and the EU should invest in research and development to overcome technological barriers to the next generation of clean energy and energy efficiency solutions.

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