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Fueling Plastics

Untested Assumptions and Unanswered Questions in the Plastics Boom

- The infrastructure to produce new plastics is growing rapidly. Massive investments in new plastics infrastructure rest on two critical but as yet unquestioned assumptions: (1) that demand will increase continuously and (2) that supplies of cheap feedstocks will remain available for decades.
- Demand growth is specifically projected among two segments of the population: millennials and consumers in the Global South.
- Evidence of shifting consumer attitudes against single-use, disposable plastic casts doubt on industry assumptions of indefinite demand growth.
- Because plastic production depends heavily on cheap fossil fuel feedstocks and energy, the coming phase-out of fossil fuels will force plastic producers to bear more of their upstream costs, dramatically altering the investment risk facing their production facilities.
- Alternative plastics, such as bio-based and electricity-based plastics, entail their own economic and environmental challenges, and require distinct production processes not found in investments currently being planned.
- To date, industry assumptions have received little critical attention despite their central importance to the long-term prospects for these investments and for the plastics industry as a whole.
- Investors and analysts should ask whether the current plastics boom poses the same risks to assets that it poses to communities, ecosystems, and the planet.

To address the urgent threat of climate change, the global community must rapidly reduce its use of fossil fuels as a source of energy. Almost all plastics are made from fossil fuels, and the two product chains are intimately linked. Even small changes in the price of oil or gas can have significant consequences for the plastics industry. It should be expected, therefore, that a major shift in fossil fuel markets, and an eventual phase-out of fossil fuels as an energy source, will fundamentally affect the long-term economic prospects of the plastics industry. Moreover, plastic production is itself a carbon-intensive process and is likely to be impacted by regulation that applies a cost to carbon.

Despite these factors, plastics manufacturers are accelerating their investments in new production facilities under the assumption that supplies of their feedstocks and demand for their products will both increase for decades. Recent social, political, and economic changes call these assumptions into question, and the rationale underlying these investments is not being adequately vetted or tested. Stakeholders, including investors in these projects and members of the communities where they are being built, should demand answers to the many questions raised around the viability of these new projects.

Industry Expectations

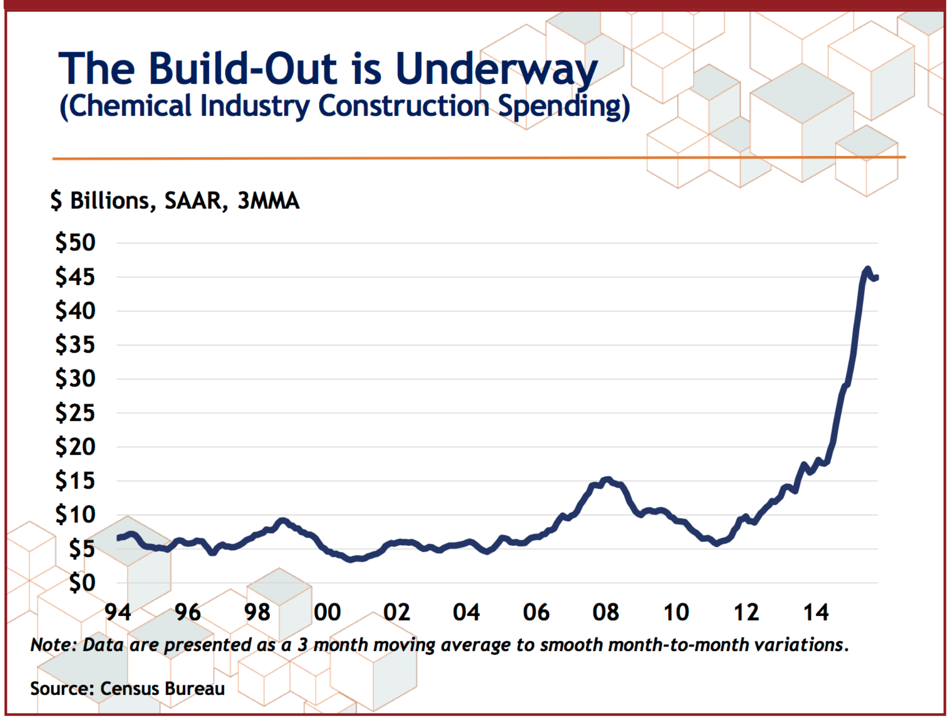
The plastics industry expects continual, unfettered growth in plastic production and consumption over the next several decades. Saudi Aramco is investing heavily in petrochemicals;[1] ExxonMobil projects that naphtha and natural gas liquids will be used primarily as feedstocks through 2040.[2] The International Energy Agency's New Policies Scenario — which predicts significant increases in greenhouse gas emissions from oil use for transportation — forecasts that 44% of the increase in crude oil consumption through 2040 will be for petrochemical production.[3]

Put simply: the natural gas boom in the US has made plastic feedstocks really, really cheap.

The plastics and fossil fuel industries are investing heavily in new capacity to increase ethylene and propylene production over the next several decades. As of December 2017, the chemical industry has already announced over $185 billion of new investments in the United States alone, mostly in "chemistry and plastics products."[4] Other observers "expect China to invest more than $100 billion in coal-to-chemicals technology in the next five years."[5] These investments, as well as those in other parts of the world, lead analysts to expect production capacity for both ethylene and propylene to increase by one-third between 2016 and 2025.[6] In the United States, producers of polyethylene are expecting to increase production capacity by as much as 75% by 2022.[7]

The petrochemical industry expects two large groups of consumers to create the demand for increasing supplies of single-use, disposable plastics: millennials in the United States and European Union[8] and consumers in the Global South whose incomes are rising.[9] These assumptions, however, ignore the proliferation of social and political changes that call into question

Trends in Chemical Industry Growth



American Chemistry Council, Shale Gas and New U.S. Chemical Industry Investment: $164 Billion and Counting, slide 9 (Apr. 2016), *available at* https://www.slideshare.net/MarcellusDN/acc-shale-gas-and-new-us-chemical-industry-investment-164-billion-and-counting.

industry assumptions of unfettered growth in plastic demand and consumption.

In North America and Europe, action is being taken at the local, national, and supranational level to reduce plastic consumption and waste. Over the past several years, bans on plastic bags,[10] plastic microbeads,[11] and plastic buds (the stems of cotton swabs)[12] have multiplied. Moreover, in January 2018, the European Commission announced a Europe-wide strategy to reduce plastic pollution and ensure that all plastic in Europe is recyclable by 2030,[13] and the United Kingdom pledged to eliminate all avoidable plastic waste by 2042.[14]

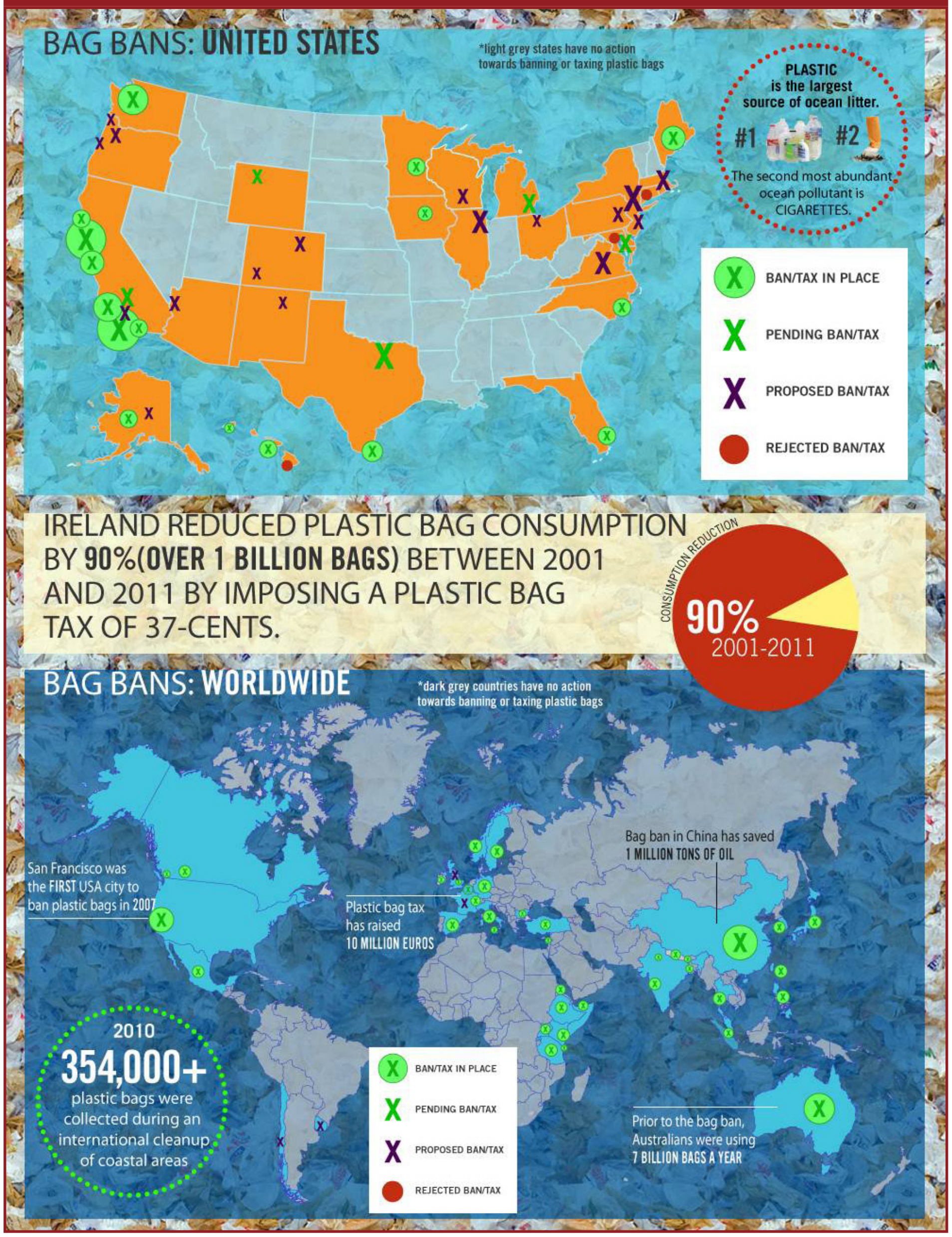
Importantly, these efforts are not solely being pursued in the United States and Europe, but are also taking place in the very markets the industry hopes to exploit. So far, a dozen African countries have banned, partially banned, or taxed disposable or single-use plastic bags.[15] Taiwan has announced a ban on microbeads beginning in mid-2018,[16] a ban on plastic straws in 2019,[17] and the intent to ban all single-use plastic by 2030.[18] China has banned imports of several kinds of plastic waste.[19]

Finally, on the international stage, the plastics crisis is attracting attention and concern.[20] As evidence of the pervasiveness and severity of plastics pollution becomes inescapable, nations of the world are demanding — and now actively pursuing — a global response.

From December 4 to 6, 2017, the United Nations Environmental Assembly (UNEA) met in Nairobi, Kenya.[21] At this meeting, UNEA decided to create an expert group to look at options to address marine litter and microplastic, including the possibility of a new legally binding agreement.[22] Significantly, governments specifically acknowledged "the challenges of addressing marine plastic pollution in the face of increasing production and consumption of plastic in products and packaging."[23] Accordingly, UNEA urged that all countries and stakeholders "endeavo[r] to reduce unnecessary plastic use."[24]

None of these developments by themselves signal an immediate end to the plastics economy — particularly given the limited control people have over packaging choices in much of the world. Viewed together, however, they demonstrate a growing resistance in many parts of the

Plastic Bag Bans in the US and the World



Plastic Bag Bans in the World, REUSETHISBAG.COM, https://www.reusethisbag.com/reusable-bag-infographics/plastic-bag-bans-world.php (last visited Mar. 14, 2018).

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world, and among the international community, to the continued expansion of plastics use at the scale envisioned and demanded by the current wave of plastic infrastructure investments.

In addition to anticipated increases in demand, the plastics industry expects that plastic feedstocks will remain cheap and abundant for the next several decades. As will be discussed below, however, global efforts to reduce fossil fuel consumption threaten these assumptions and are likely to raise the cost of plastic production significantly. Together, these converging forces raise fundamental questions about the long-term profitability (and viability) of these multi-billion dollar investments.

Relationship between Fossil Fuels and Plastic Production

Fossil fuels (oil, gas, and coal) comprise the primary feedstocks for plastics, with nearly all plastic derived from fossil sources. Typically, the bulk of the fossil material is processed to become fuel for combustion, and another part is sent for use in chemical production, especially the production of plastics. The production processes of plastics and fossil fuels are therefore closely linked, both in the product chains and in physical location.

Originally, petrochemicals (plastics) were a way for fossil fuel companies to make money from their waste streams. However, when fossil fuel production materials will no longer be used for energy in the not-too-distant future, plastics producers will need to adapt their supply chains and industry economics to be are fundamentally different.

Natural Gas is the primary source of chemicals for plastic production in North America and the Middle East.[25] Natural gas is composed of mostly methane, as well as ethane, propane, butane, and other chemicals. Typically, the methane is used as fuel, while the remaining chemicals ("natural gas liquids" or NGLs) are separated out. Some of the NGLs are used for fuel as well, while the ethane and some propane are used to make petrochemicals. Natural gas is typically 90-95% methane, although it can have a greater share of NGLs.[26]

These materials — natural gas liquids from gas development and naphtha from oil refining — exist in abundance because there is demand for the other components of the gas and oil.

All of the chemicals in NGLs can be combusted, like methane, so their floor price is determined by the relative amount of energy one can create by burning the heavier NGL molecules. Typically, petrochemical producers will buy these NGLs to make plastics and other products, raising the price above the floor value. However, there is so much available natural gas in the United States that some ethane is being sent into the fuel stream with methane (a process called "ethane rejection") and is currently trading at its floor heating value. Put simply: the natural gas boom in the US has made plastic feedstocks extremely cheap.[27]

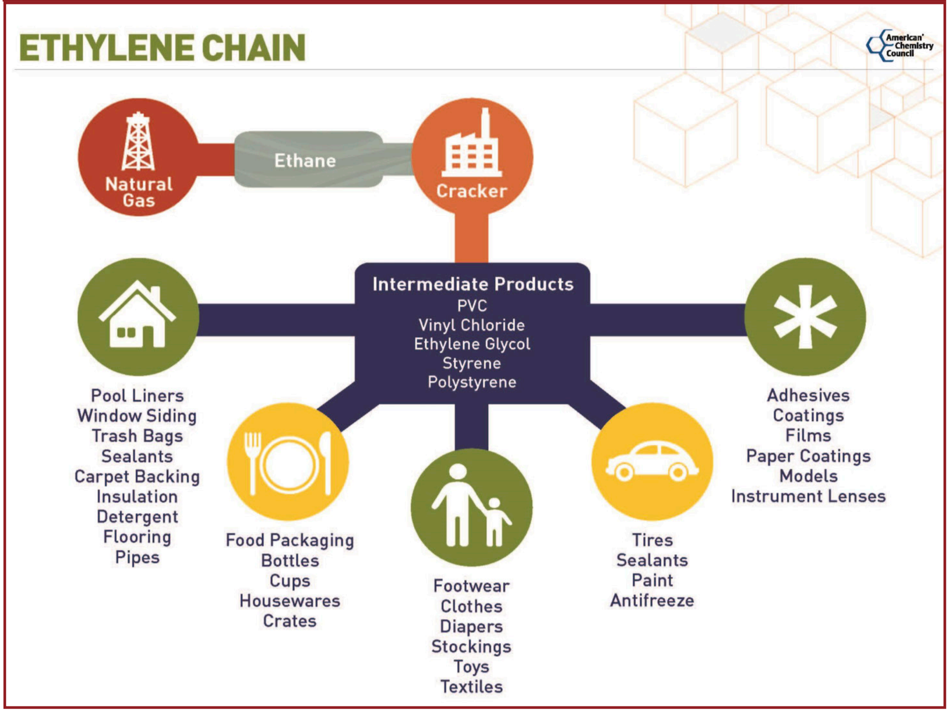
Oil is the primary source of chemical feedstocks for plastics in Europe and Asia,[28] although the importation and use of natural gas liquids is growing.[29]

During the refining process, oil is heated to different temperatures and separated by boiling point. One of the products of this process is naphtha, which is used to make ethylene, propylene, and gasoline, as well as other petrochemicals.[30] Depending on the type of oil, naphtha can represent between one sixth and one third of the total production from a refinery.[31]

Because naphtha is a product of the oil refining process, its price is directly and powerfully linked to the price of oil.[32] Currently between 4% and 8% of global oil production is used to make plastic. Business-as-usual projections reflect industry assumptions that, by 2050, plastic's share of global oil use will be around 20%.[33]

Europe's reliance on oil as a plastic feedstock is an important reason the shale gas boom has given the US a massive competitive advantage in plastics production in recent years.

Plastic Supply Chain



American Chemistry Council, Shale Gas and New U.S. Chemical Industry Investment: $164 Billion and Counting, slide 5 (Apr. 2016), *available at* https://www.slideshare.net/MarcellusDN/acc-shale-gas-and-new-us-chemical-industry-investment-164-billion-and-counting.

Coal can be turned into plastics, although the process is typically more expensive than processes that use naphtha or natural gas liquids. This point is emphasized by a Deutsche Bank report, which states, "China's coal-to-olefins and/or coal-to-urea do not make economic sense in a world awash in low-cost natural gas. Notwithstanding, China continues to grow its coal-to industries; maybe on the prospect that the world's growing supplies of cheap natural gas could be short-lived. … The world does not use coal to produce industrial quantities of olefins … only China uses its coal for these purposes."[34]

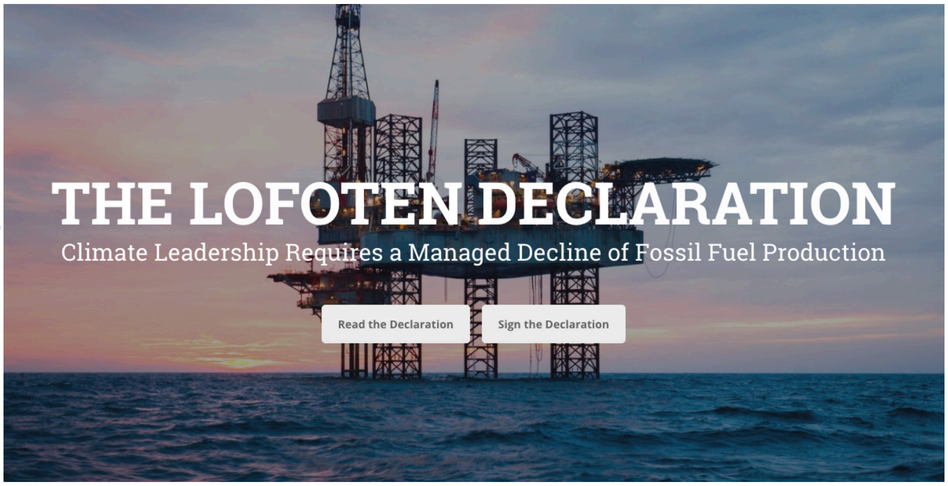
The process of producing olefins (ethylene and propylene) from coal is also extremely carbon-intensive, even when compared to other olefin-producing processes.[35] Efforts to reduce, or add a cost to, emissions will make an already expensive process even more so.

The Phase-Out of Fossil Fuels

In December 2015, over 190 countries signed the Paris Agreement, determined to limit atmospheric warming to well below 2 degrees Celsius and to strive to keep temperature increases to no more than 1.5 degrees.[36] This agreement signaled an understanding by the global community of the need to phase out fossil fuels as an energy source and their commitment to do so.

Despite this commitment, plastic producers and fossil fuel companies, which are often the same companies, are investing heavily in new production capacity, especially in the United States.[37] Recent developments, however, cast significant doubt on the assumptions underlying these investments.

To achieve the goals of the Paris Agreement, the transition away from fossil fuels must necessarily be rapid. A 2016 analysis from Oil Change International found that potential future emissions from currently operating oil and gas fields



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and coal mines would bring atmospheric warming beyond 2 degrees; reserves of oil and gas alone would take us past 1.5.[38]

The divergence between what is necessary to achieve the goals of the Paris Agreement and a business-as-usual scenario is stark. Fossil fuel company projections — even those that claim to account for aggressive climate action — predict growth in production and consumption for decades to come.[39] These projections, and the assumptions underlying them, are the bedrock upon which new investments in ethane crackers and other petrochemical production capacity are being built.

Public pressure to meet the Paris Agreement's goals from businesses, public officials, and civil society is growing. In August 2017, hundreds of civil society organizations signed the Lofoten Declaration, calling for a managed decline of fossil fuel production to avoid the worst impacts of climate change.[40] The United States Conference of Mayors released a statement supporting the Paris Agreement and "vow[ing] that the nation's mayors will continue their commitment to reduce greenhouse gas emissions."[41] Over one hundred major companies have committed, through the RE100 initiative, to transition their operations to 100% renewable energy.[42] Finally, investors, from individuals to large institutions with total assets of over $6 trillion, have committed to divest their portfolios from fossil fuels.[43]

This accelerating pressure does not exist in a vacuum. Recent announcements from governmental and industry actors indicate that the shift away from oil as a fuel for transportation may happen more rapidly than expected. In June 2017, India announced that it would ban the sale of non-electric cars by 2030.[44] The following month, France announced that it would ban sales of gasoline- and diesel-powered cars by 2040,[45] and two weeks later, the United Kingdom announced it would do the same.[46] Then, in October, Paris, France, announced that it would ban fossil-powered cars ten years sooner, by 2030.[47] The same month, China announced that it was pursuing a similar ban.[48] Wang Chaunfu, Chairman of Chinese car manufacturer BYD, expects the electrification of all vehicles in the country to be complete by 2030.[49] Other countries, including Austria, Denmark, Ireland, Japan, the Netherlands, Portugal, Korea, and Spain, along with eight US states, have also declared goals for electric car sales.[50] In addition to their direct regulatory impacts, these national targets in major markets will create powerful incentives for automotive manufacturers to reduce their reliance on internal combustion engines.

Not surprisingly, therefore, 2017 also saw a wave of announcements from major car manufacturers about

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their plans to produce electric vehicles. General Motors revealed a plan to introduce 20 all-electric vehicles by 2023, stating that the company "believes in an all-electric future."[51] Volvo announced that by 2019 all of its new cars would contain an electric motor;[52] Jaguar Land Rover would do the same by 2020.[53] The VW Group announced it would invest $84 billion in batteries and electric cars;[54] Daimler will invest another $10 billion.[55] Announcements from Ford,[56] Hyundai,[57] Renault, Nissan, and Mitsubishi,[58] as well as Toyota and Mazda,[59] similarly indicate plans to shift the focus to electric vehicles.

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These and other changes are likely to reduce demand for oil below forecast levels in the coming decades. Similarly, changes in the market for natural gas suggest future demand may not simply continue to expand, as many expect.

Due to the shale gas boom in the United States, natural gas has increased in availability and come down in price. However, optimistic assumptions about the future of natural gas are being challenged by changes to energy economics, as well as an evolving understanding of natural gas's true environmental cost.

A key claim for the necessity of natural gas is that it can be used in peak demand scenarios, responding to a rapid increase in the need for energy. The performance of quick-dispatch batteries serves to undermine expectations about the need for natural gas to serve this function. In December 2017, a major battery installation in South Australia managed to successfully dispatch power milliseconds after a coal plant outage, thus performing the exact "peaking" function for which gas plants are touted.[60] The neighboring state of Victoria is now planning to install a similar battery pack.[61]

These developments are not restricted to Australia. In the United States, for example, California has already deployed a massive battery pack,[62] and a new report in Minnesota predicts that grid-scale storage will become cheaper than new natural gas plants beginning in 2019.[63]

Subsequently, a ruling by the US Federal Energy Regulatory Commission noted that energy storage companies will be able to compete with traditional power plants by 2020.[64] As noted by business analytics firm IHS Markit: "The question is no longer if batteries will disrupt the power sector … but rather how much and how fast?"[65]

The significance of these economic changes bears repeating. One of the key arguments for the continued necessity — and success — of natural gas as an energy source is the ability of "peaker" plants to respond to needs on the electric grids. The fact that batteries and grid-scale storage can serve that same function as cheaply or more cheaply than gas massively undercuts those optimistic projections.

These changes have not gone unnoticed. Continually increasing price competition from renewables has led to a dramatic and unexpected decline in the market for new gas turbines. General Electric, the largest gas turbine installer in the world, is expecting 2018 to be its worst year of turbine installations in 15 years.[66] Siemens, another major supplier of gas turbines, noted a 30% drop-off in orders in 2017 as well.[67]

Forecasters in 2010 expected global sales of 300 large gas turbines per year.[68] In 2013, 212 were ordered, and in 2017, just 122.[69]

Many proponents of natural gas also claim that it has a lower greenhouse gas emissions profile than coal and is therefore a climate-friendly fuel option. However, a recent NASA study confirmed that, when methane leakage is properly accounted for, natural gas is no better — and perhaps much worse — than coal as far as the climate is concerned.[70] As such, continued and accelerating action to reduce greenhouse gas emissions and combat climate change could further impact the economic viability of natural gas as an energy source.

The foregoing social, political, and economic developments, taken together, undermine the rosy predictions of future fossil fuel use relied on, and promoted by, the fossil fuel and plastics industries.

Effects on the Plastic Supply Chain

As the global community phases out fossil fuels, markets for oil, gas, and coal — the feedstocks for plastics — will necessarily be affected. While it is difficult to predict exactly how this will happen, there are some predictable consequences of such a significant shift in the markets for fossil fuels.

In the short term, sociopolitical and economic changes that reduce demand for fossil fuels may help plastics manufacturers. Dow Chemical (now DowDuPont), an American company that uses natural gas to produce plastics, revealed as much in a statement to the United States Congress.[71] In the statement, Dow made its interests clear: It wanted the price of natural gas as low as possible.[72]

This potential price decrease only helps plastic manufacturers if the total amount of supplied fossil fuels can satisfy the demand for feedstocks. As stated before, only a fraction of oil and gas is efficient for use in the production of plastics. These materials — natural gas liquids from gas development and naphtha from oil refining — exist in abundance *because* there is demand for the other components of the gas and oil.

To illustrate this point, it's instructive to compare the capital expenditure for ExxonMobil's upstream (the segment which explores for and drills for crude oil and gas) and chemical segments. In 2016, Exxon's upstream activities earned almost $200 million in profits, compared to over $4.6 billion for the chemical segment.[73] However, capital expenditures for ExxonMobil's upstream exploration and production amounted to over $14.5 billion, whereas expenditures for the chemical segment were only $2.2 billion.[74] While it is beyond the scope of this paper to attempt to apportion costs of upstream activities to chemical production, the disparity in the scale of expenses for the different segments illustrates the degree to which upstream fossil fuel production subsidizes downstream chemical production.

If the market for burnable fossil fuels diminishes, plastics producers must either absorb all fossil fuel production and disposal costs or change their production processes to use the various components of fossil fuels.

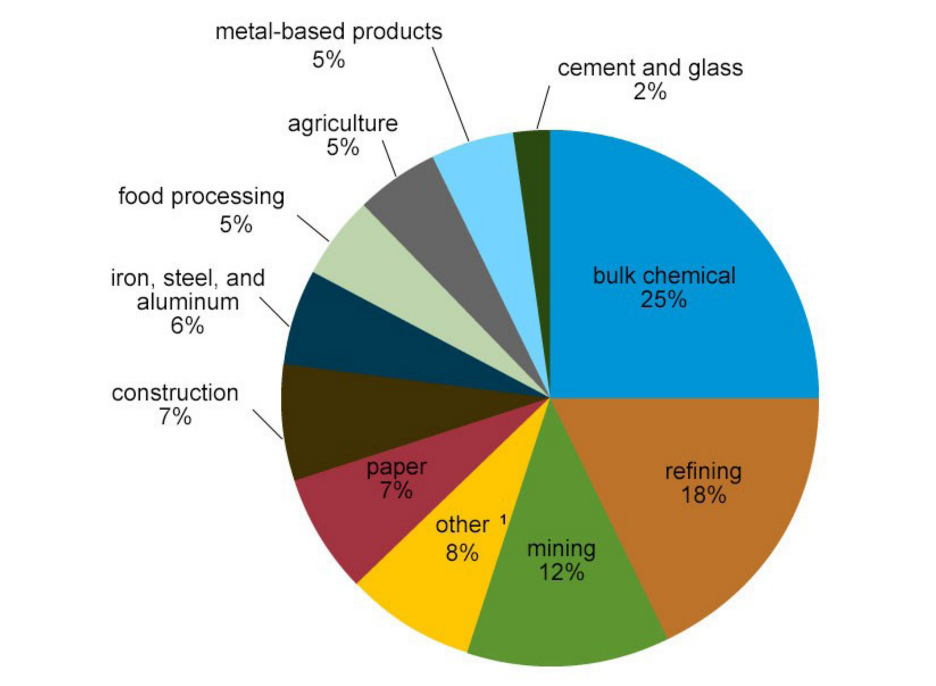
This dynamic poses a fundamental challenge to plastics producers, as they need demand for fossil fuels to drive the large-scale production of their preferred feedstocks. As the market for burnable fossil fuels is dramatically reduced, plastics producers have three choices: They must absorb more of the cost of production of fossil fuels *and* the disposal cost of the majority of unused material, change their production processes to use different components of fossil fuels, or switch to alternative feedstocks.

If the source of feedstock is natural gas, it is possible to use the methane in natural gas to produce feedstock chemicals for plastics. Theis method, called the Fischer-Tropsch process, is similar to the coal-to-olefins process used in China.[75] However, it is considerably more expensive than using ethane and other larger chemicals.[76]

The non-naphtha components of oil can also be cracked and refined to make precursor chemicals for plastics.[77] However, as is the case with natural gas, the most efficient processes are the ones already in use, and if the industry is required to use other parts of the oil mix, it will make the process more expensive.

In addition to changes in production costs and processes, changes will also be necessary for plants and equipment. Many facilities that are now operational or are being planned perform specific functions and cannot easily be repurposed. The most extreme examples are the new ethane crackers in the United States, which are designed specifically to produce ethylene from ethane, a process that produces virtually no propylene.[78] If plastic producers are required to use new feedstocks and new production processes, their production facilities — which require massive investments of time

US Industrial Sector Energy Consumption by Type of Industry, 2016



Note: Together, bulk chemicals and refining account for 43% of US industrial sector energy consumption. Emissions from both sectors are relevant when considering the impacts of plastic production.
Use of Energy in the United States Explained: Energy Use in Industry, Energy Information Administration (last visited Mar. 19, 2018), https://www.eia.gov/energyexplained/index.cfm?page=us_energy_industry.

and capital — will have to change as well.

Because of this need, it is important to note both the enormous size of individual facilities and the risk inherent in their construction. A typical ethane cracker in the US Gulf Coast formerly cost between $1.5 and $2 billion to construct.[79] However, shortages of labor and materials are significantly driving up costs. In 2017, the total project cost of new ethane crackers rose 19% to $2.5 billion, a nearly 40% increase over projections at the beginning of this wave of US petrochemical construction.[80]

Other estimates place the cost even higher. According to the American Chemistry Council, "[a] new natural gas-based ethane cracker could have an annual capacity of 1.5 million metric tons or more, with a price tag of well over $4 billion."[81] At present, ExxonMobil and Saudi Arabia Basic Industries Corp. are partnering on a $9.3 billion ethane cracker in Texas.[82]

The wisdom of constructing new ethane plants in the United States is being questioned by some within the chemical industry itself, who are warning that a supply glut could depress ethylene prices.[83] Moreover, swings in oil and gas prices, key determinants of the relative competitiveness of individual crackers, have already caused delays and project cancellations, especially in the Northeastern United States.[84]

Finally, before the industry sees fundamental changes to its supply chain, plastic production may be challenged in the short term as efforts to combat climate change apply a price to carbon. Two thirds of the cost of plastic production is its energy input,[85] and the production process itself is enormously carbon-intensive. As noted in an American Chemistry Council report, "The business of chemistry is energy-intensive; in fact, it is the second largest user of energy (fuel and nonfuel) in manufacturing sectors (petroleum and coal products is the largest). Within the chemical industry, this is especially the case for basic chemicals," including ethylene, propylene, and plastic resins.[86] Regulations that make greenhouse gas emissions more expensive will make plastic production more expensive as well.

A 2016 report from the Environmental Integrity Project underscores how emission-intensive these new petrochemical projects are.[87] In 2015 alone, the emissions from 44 planned or permitted petrochemical projects would amount to 19 coal-fired power plants.[88] The largest ethane cracker in St. James, Louisiana, has projected CO_2-equivalent emissions of more than 10 million tons per year.[89] By comparison, the average 500-megawatt coal-fired power plant emits 4.6 million tons of carbon dioxide per year when operated continuously.[90]

Additional investigation and analysis are needed to project exactly how the production costs will change as the global community shifts away from fossil fuel combustion as a source of energy. It is well understood, however, that the chemical feedstocks for plastic production are abundant because of fossil fuel development and that the fundamentals of the industry will be radically changed when this is no longer the case. Plastic production will be more expensive as fossil fuels phase out.

Alternative Feedstocks are More Expensive

As the global community begins to phase out fossil fuels, some have suggested that plastics manufacturers switch to alternative, low-carbon methods of plastic production,[91] including recycled plastics, bio-based plastics, and plastics formed from electricity. As a preliminary matter, it bears note that most of these alternative feedstocks require substantially different production processes and technologies than existing fossil-based plastics. Accordingly, these technologies would be unlikely to improve the economic prospects of existing or proposed petrochemical investments even if they were widely deployed. More fundamentally, these purported solutions present several of the same environmental problems as traditional plastics and cost more to produce.

Proponents of bio-based plastic suggest that, by using organic carbon instead of fossil carbon to produce plastics, the industry can wean itself of its dependence on fossil fuels.[92] These plastics are considerably more expensive to produce, and many (because they are chemically identical to fossil-based plastics) still present the same challenges of waste disposal and plastic pollution.[93]

Another alternative to fossil-based plastic is to use electricity to form the chemical feedstocks for plastics by pulling carbon dioxide out of the air.[94] This process requires enormous energy inputs, even when compared to traditional plastic production, which is itself energy-intensive. The plastics produced in this way would be considerably more expensive, with production costs for ethylene and propylene doubling or tripling. As one observer noted, "Using electricity and carbon dioxide as the main feedstock for ethylene and propylene production will only make sense under a very strict climate policy where fossil feedstock is completely phased out."[95]

Finally, proponents of recycling — especially in Europe, where the EU has committed to circular economy principles — argue that the industry can increase the share of plastic that gets re-used to reduce its dependence on fossil fuels.[96] According to a report by GAIA and Zero Waste Europe, however, even the best available recycling technology, fully deployed, could only process a maximum of 53% of the current plastic mix.[97] (To date, only 9% of plastic has ever been recycled.)[98] Therefore, it is extremely unlikely that the recycling process could absorb the current plastic waste stream, much less planned increases in plastic production. Recycled plastics also present other major challenges, such as recirculating various persistent organic pollutants that are banned under international law in the biosphere.[99] Nevertheless, setting aside concerns about the feasibility of creating a circular plastics economy while maintaining projected levels of output, recycled plastic requires different facilities to produce than virgin plastic,[100] raising further questions about the prudence of building new ethane crackers.

Switching to alternative feedstocks or recycled plastics, even if plausible in the short term, would not solve the industry's problem of growing opposition to plastic pollution. Plastics made from alternative feedstocks (but with the same chemical properties) would pose many of the same long-term hazards and would likely be subject to the same social and political opposition as modern plastics.

Moreover, and as noted above, the technologies and processes required

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for these alternative feedstocks differ substantially from the technologies used to produce virgin plastic resins from fossil fuels. Accordingly, increased adoption and use of alternative feedstocks would neither benefit nor justify the petrochemical-based plastics infrastructure that is the focus of current investment.

Conclusion

Plastics manufacturers and fossil fuel companies are currently investing hundreds of billions of dollars in new production facilities, with the heaviest investments focused in the Northeastern US and the US Gulf Coast. With plastics production capacity in the US already far exceeding domestic demand, and global capacity exceeding existing global plastics demand, these investments assume producers will reach new and steadily growing markets for their products, and that production processes will be subsidized for the foreseeable future by steady demand for and supply of fossil fuel feedstocks.

To date, these assumptions have received little critical attention despite their central importance to the long-term prospects for these investments and for the plastics industry as a whole. The foregoing analysis suggests this is a significant oversight, which raises serious questions about whether project proponents and investors are adequately considering the risks of imminent and potentially significant changes in both the supply chains of their feedstocks and the demand for their products.

Plastics manufacturers assume demand for disposable plastics will continue to rise, despite evidence that global awareness of plastic pollution is growing and cultural attitudes are changing. Industry investments reflect a further underlying assumption that supplies of cheap hydrocarbons will remain the norm for decades to come, even as the global community has begun to phase out the very fossil fuels upon which plastics producers depend. Proposed alternatives to virgin fossil-based plastics, in addition to facing their own economic and environmental challenges, will in no circumstances have positive economic impacts on the current wave of investments in petrochemical-based plastics infrastructure.

Plastics producers are depending on increasing demand and abundant feedstock supply to fuel their industry for the next several decades. These assumptions may be unfounded and unjustified.

There is compelling evidence that the rush to build new plastics infrastructure poses massive risks for communities, ecosystems, and the planet. Investors and analysts need to ask whether the plastics boom is putting assets at risk as well.

Endnotes

1. *See* Anjli Raval & Andrew Ward, *Saudi Aramco Plans for a Life After Oil*, Financial Times (Dec. 10, 2017), https://www.ft.com/content/e46162ca-d9a6-11e7-a039-c64b1c09b482.

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4. *See* Fact Sheet, American Chemistry Council, U.S. Chemical Investment Linked to Shale Gas: $185 billion and Counting (Dec. 2017), *available at* https://www.americanchemistry.com/Shale_Gas_Fact_Sheet.aspx. *See also* American Chemistry Council, Shale Gas and New U.S. Chemical Industry Investment: $164 Billion and Counting (Apr. 2016), *available at* https://www.slideshare.net/MarcellusDN/acc-shale-gas-and-new-us-chemical-industry-investment-164-billion-and-counting.

5. *See* Gerald Ondrey, *Methanol-to-Olefins Plant Starts Up in China*, Chemical Engineering (Feb. 22, 2017), http://www.chemengonline.com/methanol-to-olefins-plant-starts-up-in-china.

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