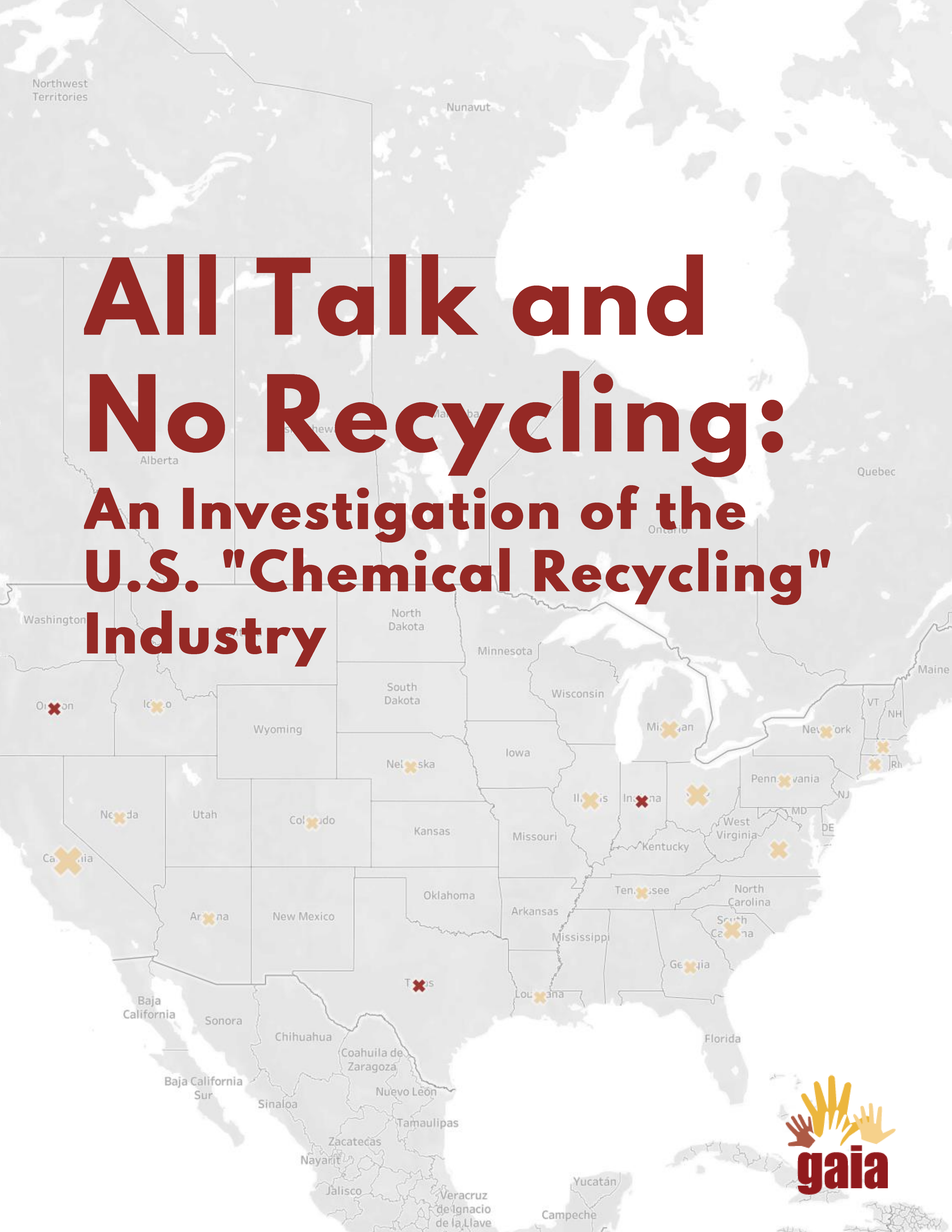

All Talk and No Recycling:

An Investigation of the U.S. "Chemical Recycling" Industry

gaia

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GAIA is a global network of more than 800 grassroots groups, NGOs, and individuals. We envision a just, Zero Waste world built on respect for ecological limits and community rights, where people are free from the burden of toxic pollution, and resources are sustainably conserved, not burned or dumped. We work to catalyze a global shift towards environmental justice by strengthening grassroots social movements that advance solutions to waste and pollution.

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EXECUTIVE SUMMARY

The United States has a plastic problem. Of all of the plastic produced since 1950, 91% have never been recycled.[1] After being tossed into trash cans or wishfully into recycling bins, most plastic ends up in landfills or incinerators, here and overseas.[2] The reality is that the amount of plastic produced in the United States cannot be reasonably recycled. In addition, many of the types of plastic that are produced cannot be recycled into useful new products.[3]

As a result of increased public awareness of plastic pollution, the plastic and fossil fuel industries are facing increasing market constraints and widespread consumer backlash. These industries have faced increased pushback from consumers who are choosing reusable alternatives, China and other Asian countries rejecting plastic waste exports, and governments instituting bans on single-use plastic. But rather than taking responsibility for their plastic waste, these industries are pushing forward plans to produce additional billions of tons of plastic that reach beyond the planet's ecological capacity and put the health of communities and workers at risk.

While the petrochemical industry has flooded the world with even more plastic, it has also maintained that the answer to the plastic pollution problem is not making less of it, but rather investing in downstream techno-fixes. One in particular has risen to buzzword status in the plastic scene: "chemical recycling." It is a term often used by the petrochemical industry that conflates plastic-to-plastic and plastic-to-fuel technologies as a form of recycling. In this report, we use the term "chemical recycling" to refer to the technology behind both plastic-to-plastic (PTP) and plastic-to-fuel (PTF) operations, although only the former truly qualify as recycling operations and we reject the use of the term for plants that mainly produce plastic-to-fuel.

A recent review of scientific and technological evidence called "Chemical Recycling: Status, Sustainability, and Environmental Impacts" shows the chemical recycling industry is riddled with technical, economic, and environmental problems.[4] The key findings are:

- **"Chemical recycling" releases toxic chemicals into the environment.**
- **"Chemical recycling" has a large carbon footprint.**
- **"Chemical recycling" has not yet been proven to work at scale.**
- **"Chemical recycling" cannot compete in the market.**
- **"Chemical recycling" does not fit in a circular economy.**

In May 2020, GAIA released "Chemical Recycling: Distraction, Not Solution."[5] This report serves as an important and timely assessment of the prospects of "chemical recycling" in light of its promotion by the plastic and fossil fuel industry as the silver bullet to solve the plastic crisis. This report takes a look at the state of the industry in the U.S. and concurs with the conclusion of the May 2020 briefing paper:

> **"In a society that urgently needs to transition from an extractive, fossil fuel economy to a circular one, chemical recycling is a distraction at best. Far more mature and viable solutions are to be found in upstream, zero waste strategies which focus on reducing the production and consumption of plastic."**

This report provides an assessment of failed, proposed, and existing projects in the United States and demonstrates that the industry is once again proposing to build a new network of waste and burn facilities. Under the guise of "chemical" or "advanced" recycling, the industry is lobbying for and advancing development of plastic-to-fuel (PTF) facilities that will only make the plastic crisis worse while diverting public and private investment dollars away from real solutions.

KEY FINDINGS:

1. Of the 37 plastic "chemical recycling'' facilities proposed since the early 2000's, based on publicly available information, only 3 are currently operational and none are successfully recovering plastic to produce new plastic. Our report finds that the chemical industry continues to advance plastic-to-fuel technologies while mislabeling them as "chemical recycling," asserting that they are the solution to the global plastic pollution crisis.

2. Plastic-to-fuel (PTF) facilities place a heavy toxic burden on communities and workers, impacting people at plastic waste processing sites, in the end use of the products they produce, and at the facilities where the waste created by the process is dumped, destroyed, or treated.

3. PTF carries a large carbon footprint that is not compatible with a climate safe future. It only adds to global carbon emissions created by the fossil fuel industry.

4. With increased instability in the fossil fuel market, public demand for plastic alternatives, and more stringent climate policies, "chemical recycling" and PTF technologies are risky and not environmentally friendly. Yet, industry continues to wield its political power to advance policies that enable development of the technology and markets.

5. Fast-moving consumer goods companies can and should play a critical role in the development of "chemical recycling" and should act quickly to implement real solutions to the plastic problem that do not further harm human health and the environment.

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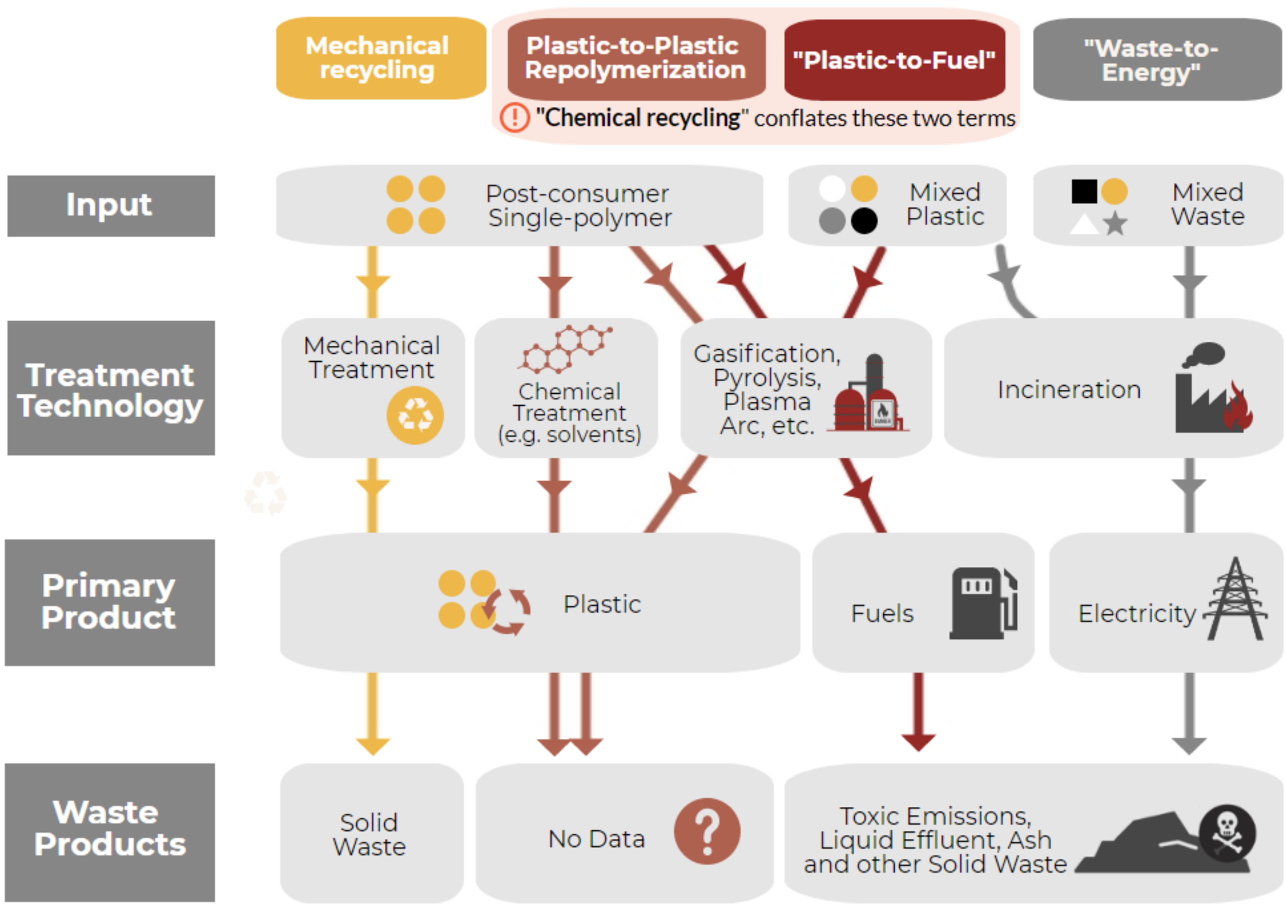
“Chemical Recycling” in the U.S.

“Chemical recycling” encompasses a number of processes that involve breaking plastic down into its component parts using pressure and/or heat in a low-oxygen environment; some also use catalysts or chemical solvents. Although the term “recycling” should only apply to processes that turn plastic back into plastic,[6] the petrochemical industry has popularized terms such as “chemical recycling” or “advanced recycling,” that conflate both plastic-to-plastic and plastic-to-fuel conversion as a recycling solution. In reality, most pyrolysis and gasification processes that are referred to as “chemical recycling” produce fuels and not new plastic, as the process of turning plastic into plastic is complex and expensive.[7]

[Image 1] Technologies conflated as “chemical recycling”

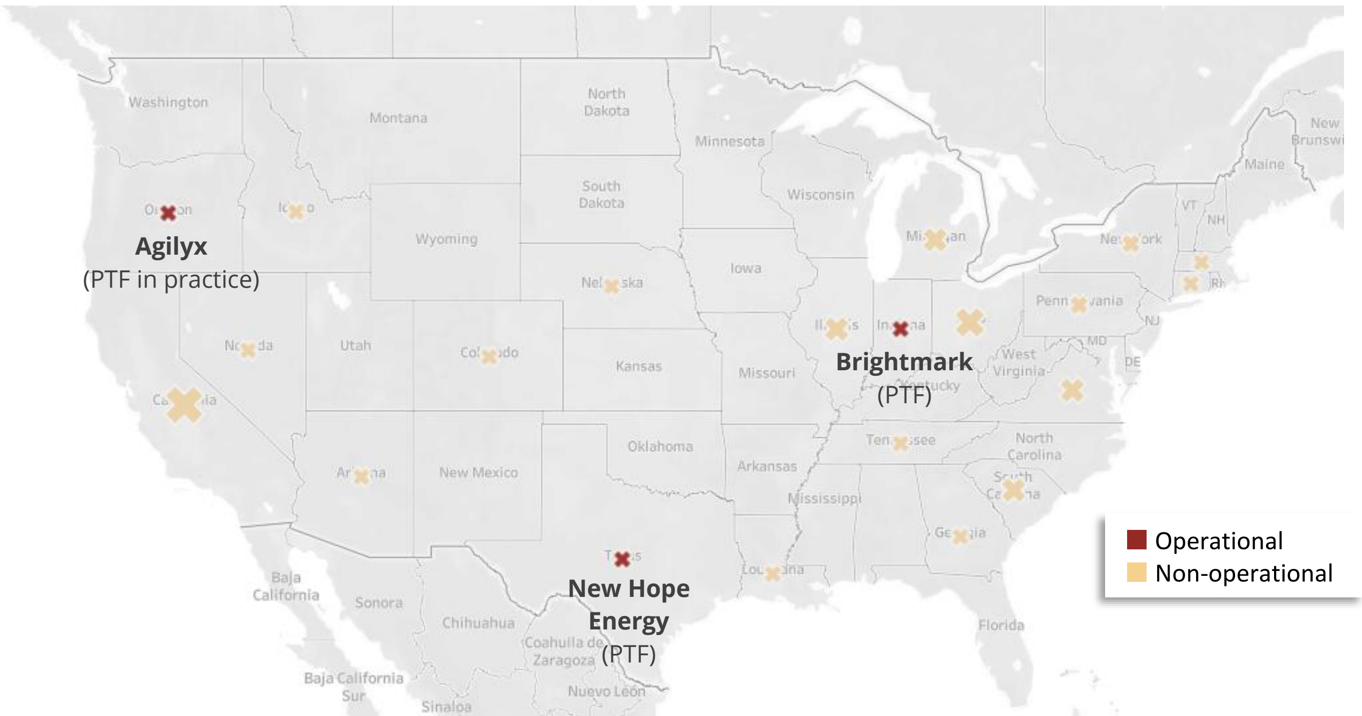


Source: Global Alliance for Incinerator Alternatives. (2019)

In addition to gasification and pyrolysis, some projects aim to break down or purify plastic feedstock using solvent and/or catalysts. Among the 37 projects in the U.S. that were selected for our assessment, 12 facilities purported to use solvent/catalyst-based processes or a combination of heat and solvents/catalysts. All but one of these remain in an early stage of development (announcement only or at a pilot phase). Thus, this report primarily focuses on gasification and pyrolysis facilities, specifically the 20 plastic-to-fuel projects that are announced, planned, or operating in the U.S.

This assessment finds that there are many unknowns regarding the potential impacts of the commercialization of the PTF technologies. However, if the industry is allowed to develop, available evidence indicates that it will have significant impacts on existing mechanical recycling markets, the climate, human health, and the environment.

[Image 2] Map: Projects Proposed as "Chemical Recycling" in the U.S.



Source: See Appendix 1 for a list of the 37 projects assessed in this report. Location is based on the company's headquarters except for 7 projects that are detectable with a physical address.

1 Plastic-to-Fuel is an Industry Shell Game

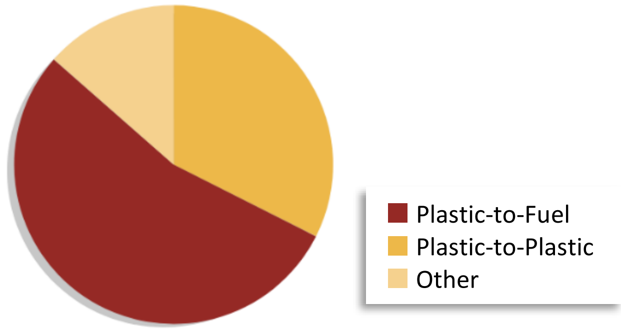
For decades, pyrolysis and gasification companies have promoted themselves as an alternative solution to waste disposal, securing significant funds from investors and governments with no concrete evidence to support their viability claims. Yet pyrolysis and gasification technologies have been around since the 1950s and attempts to use these thermal treatments to recover plastic waste streams began in the 1970s.[8]

These empty promises of pyrolysis and gasification proponents resulted in a track record of high-profile failures across the globe, along with reports of fires, explosions, and financial losses. Since the early 2000s, at least 37 projects have been announced in the United States (see Appendix 1). Of these 37 projects, the majority of PTP and PTF projects are under development, 14 of which are mere announcements and 11 are at a pilot stage or under construction. Twelve projects claiming to have developed a plastic-to-plastic (PTP) process are at varying levels of maturity, but none at commercial stage. Twenty are PTF projects, and thus do not qualify as recycling. Only three projects– Agilyx, Brightmark, and New Hope Energy– are currently commercially operational. Brightmark and New Hope Energy are PTF projects; they do not produce plastic or feedstocks for plastic. Agilyx is frequently upheld as a model of plastic-to-plastic recycling, but our investigation indicates that the majority of its output is sent for combustion in cement kilns (see case study). Based on public information, not one of the 37 "chemical recycling" projects announced in the U.S. in the last 20 years has been proven to successfully recycle plastic at a commercial scale. One facility, Renewlogy, suspended its operation less than a year after it opened to upgrade equipment. Meanwhile, bags of waste are shipped to cement kilns or sit outside the facility in the hopes that it will reopen.[9] As of 2017, the technologies have wasted at least $2 billion of investments with canceled or failed projects across the globe.[10] Many cases identified fragile revenue models, complications around obtaining permits, and high operating costs as the main cause of such failures.[11]

Major operational and financial issues include:

- Technical challenges remain unsolved at each stage of the process: sorting and cleaning highly contaminated plastic waste feedstock (pre-treatment), optimizing the temperature during the conversion processes by large energy inputs, removing impurities from the products in order to meet the standards necessary for use (post-processing), and managing toxins present in solid and liquid residues.
- Heavy investments are required for the construction of a facility in addition to the technological challenges directly contributing to a large financial toll.
- The immaturity of the technology increases waste management costs and compliance risks associated with regulation of toxic emissions and byproduct disposal.
- Securing appropriate plastic feedstocks is a growing concern for "chemical recycling" companies.[12] Despite the claimed capability of treating low-grade mixed plastic waste being the main selling point of pyrolysis technologies, the process requires additional treatment beyond traditional sorting and washing, increasing the costs.[13]

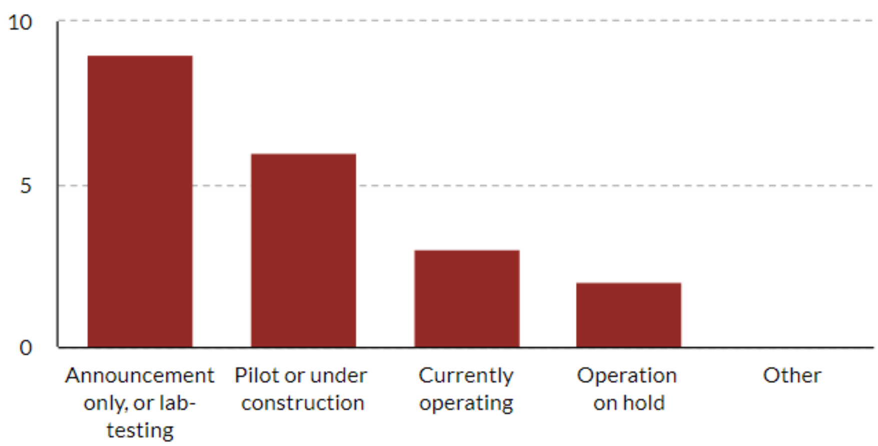
[Table 1] Types of Projects Proposed as "Chemical Recycling" in the U.S.



	PTP*	PTF	Other**	Total
Number of facilities	12	20	5	37
Percentage	32%	54%	14%	100%

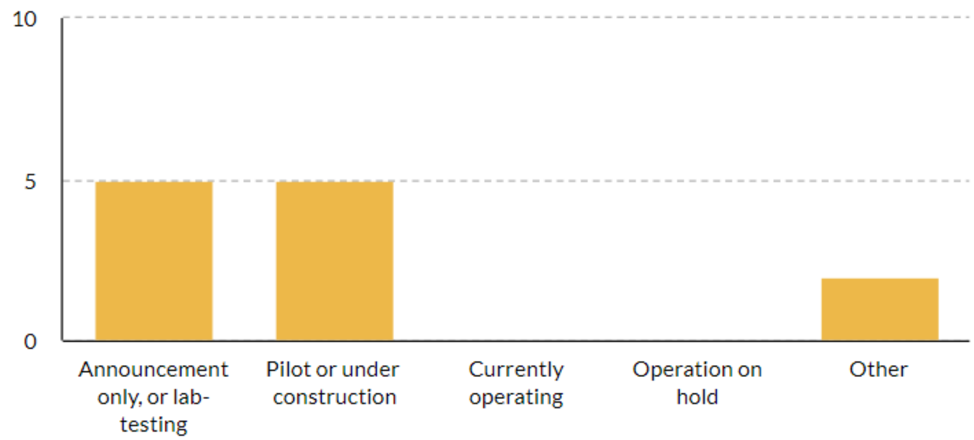
* Includes proposals of 8 solvent or catalyst-based processes and 4 pyrolysis projects. Of the 12 projects, 11 have not reached operational status and Eastman's PTP operation lacks publicly available evidence to substantiate its status.
** Projects that appeared in industry/research reports as a "chemical recycling project," but do not represent an independently operating "chemical recycling" facility. These projects are either waste-to-energy facilities or a partner or buyer of a "chemical recycling" company.

[Table 2] Status of Proposed PTF Projects in the U.S.



	Announcement only, or lab-testing	Pilot or under construction	Currently operating*	Operation on hold**	Other***	Total
Number of PTF projects	9 (45%)	6 (30%)	3 (15%)	2 (5%)	-	20 (100%)

[Table 3] Status of Proposed PTP Projects in the U.S.



	Announcement only, or lab-testing	Pilot or under construction	Currently operating*	Operation on hold**	Other***	Total
Number of PTP projects	5 (42%)	5 (42%)	0 (0%)	-	2 (16%)	12 (100%)

* Agilyx, Brightmark, and New Hope Energy

** Renewlogy suspended its operation in June, 2019; Plastic2Oil has been inactive since the company announced a plan to resume fuel sales in August, 2018.

*** Eastman claims to have a PTP operation, but no evidence is publicly available; Geo-Tech Polymers is not a "chemical recycling" facility and only provides consulting services.

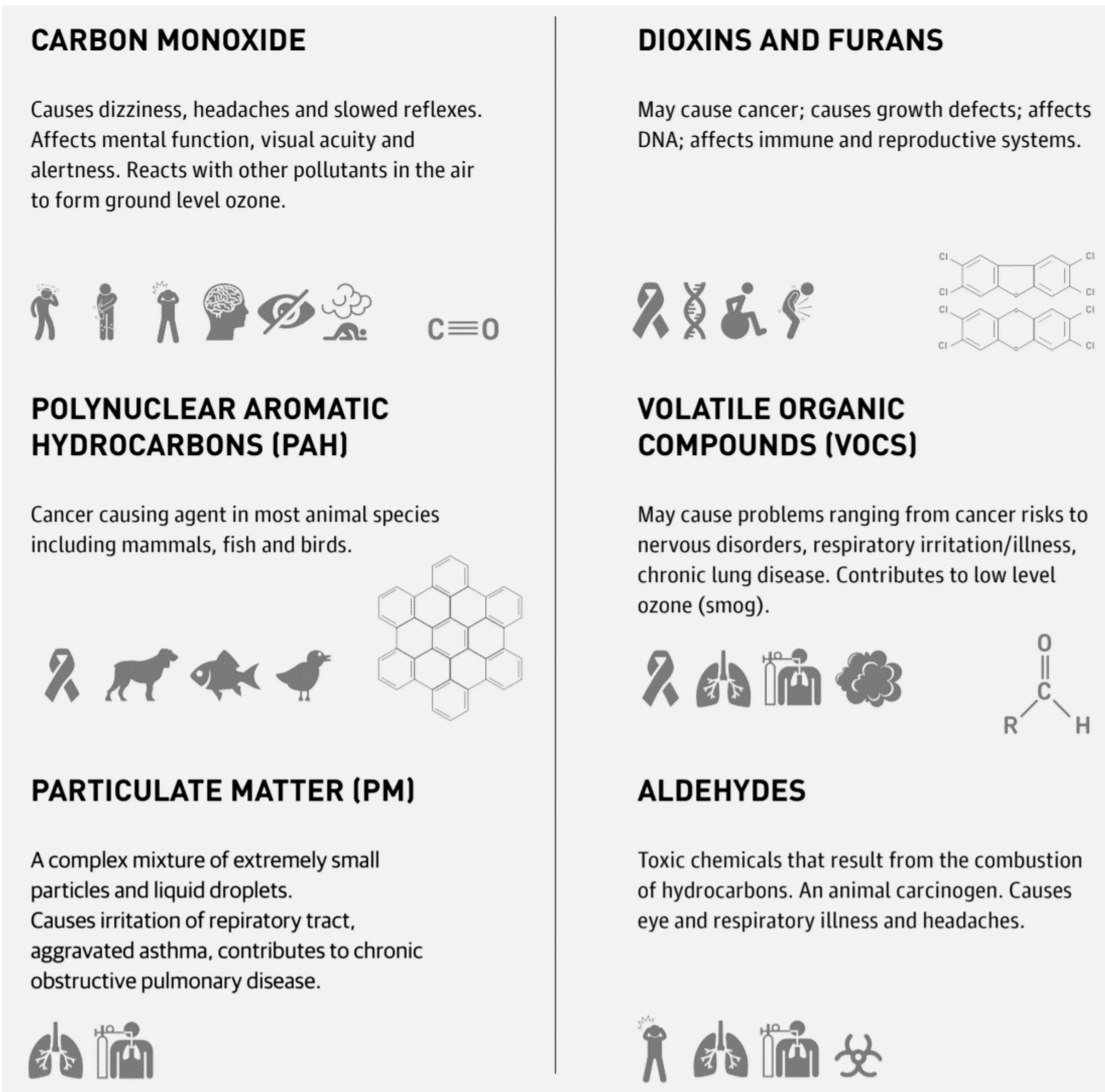
2 Plastic-to-Fuel facilities and their products endanger human health

Plastic is used in a range of products from bottles and toys to medical equipment and car parts. To make these products pliable or rigid, flame retardant and durable, or non-reactive to certain oils and chemicals, the plastic polymers are combined with other elements such as oxygen, nitrogen, chlorine, fluorine, or silicon that can be harmful to human health. These additives produce chemical waste that requires disposal during the PTF manufacturing process. Much like oil refineries, some PTF facilities produce a number of chemical products that are sold to other chemical manufacturing facilities. Contaminants can remain in those final products and may be released when burned or converted into yet another chemical product.[14] While the environmental impacts of PTF processing and its end products are not well-documented, enough is known to cause concern for workers, communities, and the environment. For example, Brightmark Energy's facility in Ashley, Indiana, plans to convert plastic waste into fuel, naphtha, and waxes for candles and other consumer products. We have been unable to find results of any tests on these fuels and products for toxicity. The Agilyx facility in Tigard, Oregon, sent over 49,000 tons of waste styrene, a highly toxic chemical, to burn in cement kilns located in low-income and people of color communities across the country in 2018.

Regulatory requirements for chemical manufacturing and preventing toxic exposures have historically had a "build first, sell now, protect health later" approach that has resulted in polluted communities and recalled consumer products. PTF facilities operate similarly to other industrial facilities that release toxic emissions, produce toxic effluents, and in some operations, pose a danger to the community from explosion or catastrophic toxic chemical releases. After years of BPA-laden baby bottles and toys dominating their respective markets, plastic producers and consumer goods companies faced a significant backlash when it was discovered that they could cause developmental and reproductive problems later in life. Plastic pellets, also known as nurdles, are often used as feedstock for PTF processes. Some companies, such as Brightmark, will use mixed plastic waste sourced from regional, commercial, and municipal waste programs and turn them into pellets before feeding them into the chemical processing system. Similar to mechanical recycling, this process typically involves sorting, shredding, cleaning, and washing the plastic which can release microplastics and wastewater laden with potentially toxic dyes and chemicals that require proper disposal. The presence of microplastics in the environment has become so ubiquitous that it is now found in the most remote glaciers and in the air we breathe.[15] Considering these factors, exposures to toxic chemicals and microplastics that are formed and released during the PTF process and the toxic chemicals that remain in the final product or process waste should be prevented.

Of the three operating PTF facilities in the US, environmental review documents are only available for two: the Agilyx facility in Tigard, Oregon, and a recently constructed Brightmark facility in Ashley, Indiana, just south of the Indiana-Michigan border. A review of publicly available emissions reports from these facilities from local environmental agencies and the EPA provides little information about emissions and relies heavily on selfreporting by the industry. Brightmark's permit request documents filed with the Indiana Department of Environmental Quality claim that the level of air emissions from their process would be negligible or below reporting thresholds. If the plant expands or larger facilities are built at a scale comparable to the massive amounts of plastic waste already plaguing the world, it will be too late to prevent or manage the unknown and/or unverified emission risks. Industrial accidents are also a concern, and a fire at New Hope Energy's Trinity Oaks PTF plant in Tyler, TX raises flags about the safety of PTF facilities.[16] Only in operation since July 2019, the $150 million facility processes 960 tons of post-consumer plastic per day to produce 4,500 barrels/day of fuels and chemical feedstocks and is one of the three currently operating PTF facilities in the country.[17]

[Image 3] Pollutants Generated from Burning of Plastic



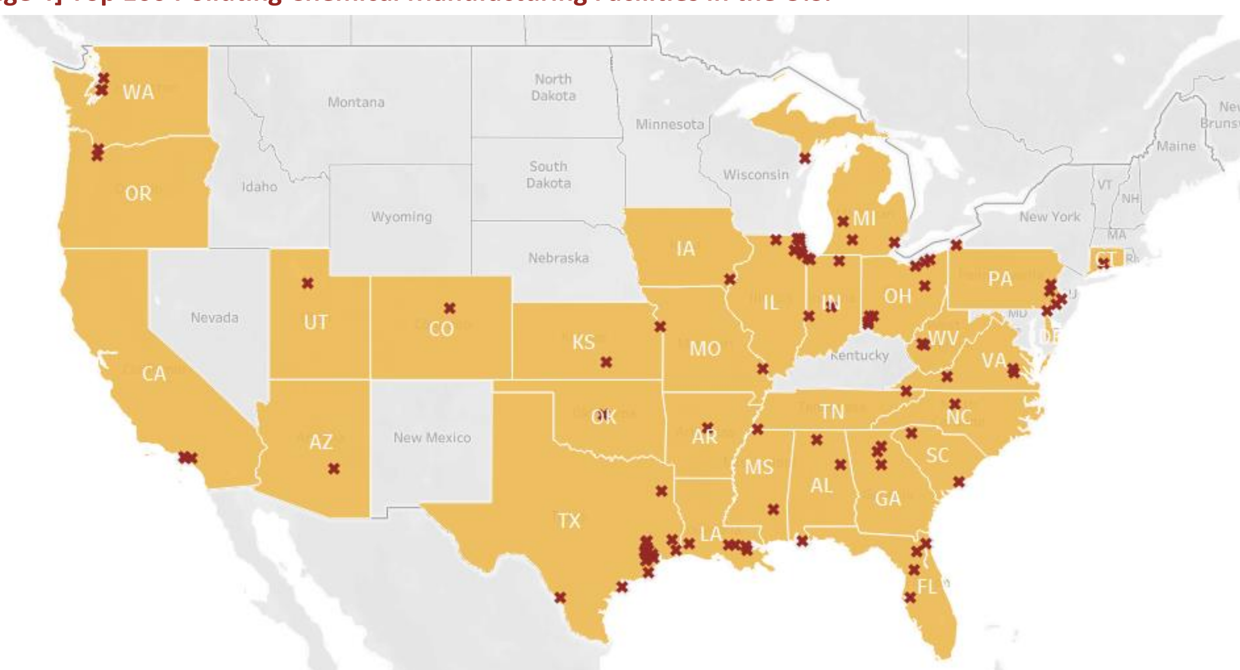
Source: Wilson, M. et al. (2017). Green businesses and cities at risk: How your waste management plan may be leading you in the wrong direction. Global Alliance for Incinerator Alternatives, The Tishman Environment and Design Center at The New School.

Plastic-to-Fuel Increases Toxic Pollution in Environmental Justice Communities

The building of PTF facilities in existing petrochemical corridors is particularly concerning and threatens to add to the cumulative burden of toxic exposures on environmental justice communities. Brightmark has already begun searching for possible locations to expand its business in Florida, Georgia, New Jersey, New York, Pennsylvania, Louisiana, and Texas.[18] Locations considered "ideal" by Brightmark are already overburdened by pollution and industry. Petrochemical hubs, such as Monroe County, Pennsylvania, where one Agilyx facility is planned, are most accessible by rail, highways, natural gas inputs, and electrical utilities and are already occupied by other highly hazardous petrochemical facilities. Agilyx's Tigard facility delivers styrene products to its partner, Americas Styrenics, in St. James Parish, Louisiana, to be converted into polystyrene. St. James Parish is a majority people of color and low-income community located in Louisiana's Cancer Alley.[19]

In a survey by the Environmental Integrity Project, researchers reviewing data from the EPA's 2018 Toxic Release Inventory found emissions from all industrial facilities reporting to the EPA amounted to 4.7 billion tons.[20] The top 100 most polluting facilities, representing less than 1% of all facilities reporting to TRI, released 1.8 billion tons of toxic chemicals, or 38% of all releases.[21] Many of these facilities include chemical plants and oil refineries and their locations put 134 million Americans at risk in the event of a toxic chemical disaster.[22] These communities are also disproportionately Black or Latino and have higher rates of poverty, lower income, and lower property values compared to the overall U.S. population.[23]

[Image 4] Top 100 Polluting Chemical Manufacturing Facilities in the U.S.



Source: U.S. EPA. Toxic Release Inventory 2018 data. Mapping based on national ranking of Risk-Screening Environmental Indicators score of the facilities in the chemical manufacturing sector.

Evironmental Health Impacts of "Chemical Recycling" Operations

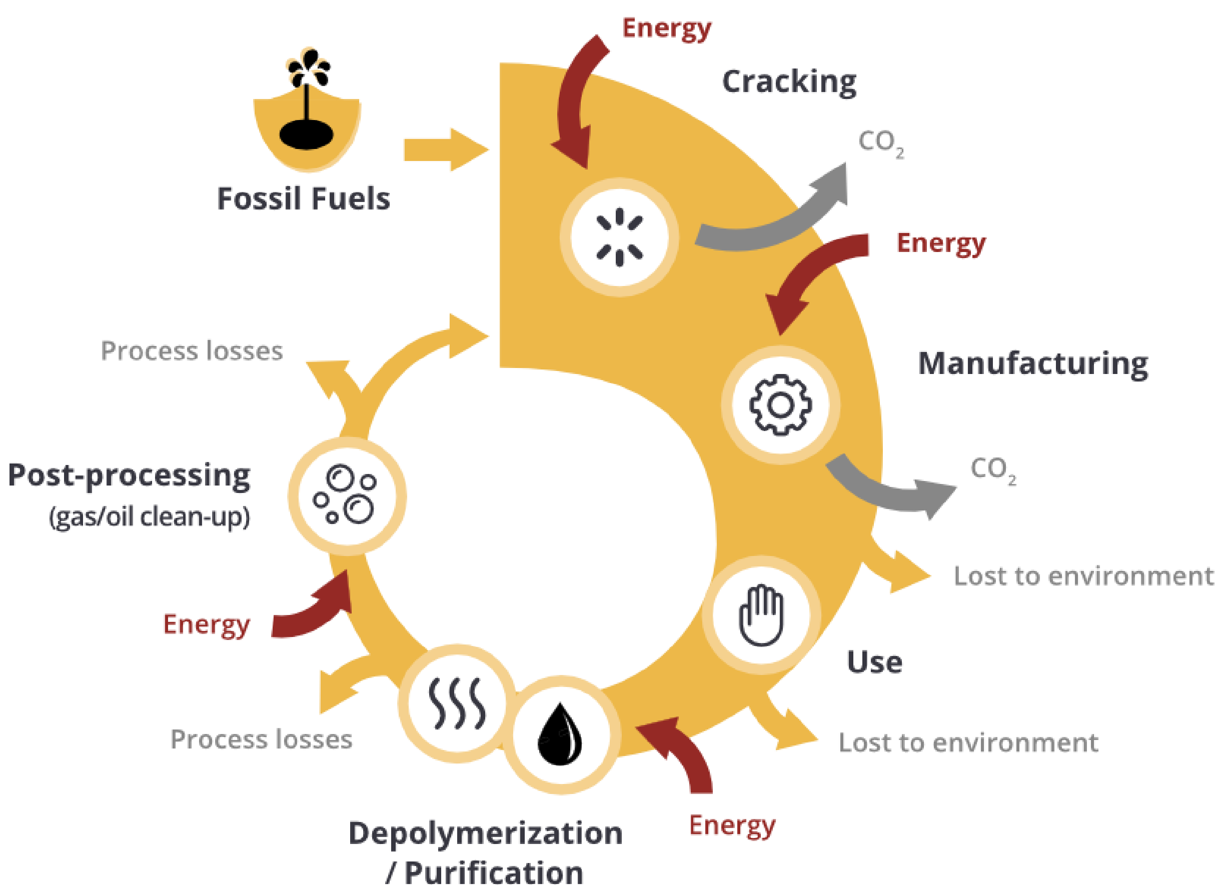
Although industry includes PTF operations under the term "chemical recycling," recycling properly only refers to processes that result in similar products. PTF is not a form of recycling because it does not replace virgin plastic, does not contribute to a circular economy in plastic, and does not avoid the environmental harms of plastic production. On the contrary, plastic-derived fuels are fossil fuels that spend a very small portion of their lifecycle as plastic. Since many of these fuels are then burned in operations that routinely dispose of hazardous waste (see the Agilyx case study), PTF might be better described as a plastic-to-hazardous waste operation. The only thing PTF recycles is toxic chemicals.

- Plastic often contains toxic additives and contaminants that are known to be harmful to human health and are not effectively filtered out from the "chemical recycling" process or may form during the process, risking exposure to workers, communities near facilities, consumers, and the environment. For example, hormone disruptors and carcinogens such as bisphenol-A (BPA), phthalates, benzene, brominated compounds, and volatile organic compounds (VOCs) are found in plastic and not effectively filtered out from end products including fuel.[24] Depending on the type of plastic being processed, other chemicals may form and end up in the final product, such as benzene, toluene, formaldehyde, vinyl chloride, hydrogen cyanide, PBDEs, PAHs, and high-temperature tars, among many others.[25]
- Heavy metals, such as cadmium and lead, cannot be destroyed during chemical processing and are therefore recombined into the final product or released in the waste byproducts. Heavy metal exposure is of greatest risk to workers in a facility; however, small amounts of lead exposure to children, directly or prenatally from exposed mothers can cause neurological damage leading to cognitive dysfunction, lower IQ, and behavioral issues.[26] Excess exposure to cadmium can damage kidney function and bones if ingested or cause pneumonia and emphysema if inhaled.[27]
- Waste produced from "chemical recycling" requires appropriate disposal of ash, liquid effluent, and containment of air emissions; it nevertheless threatens communities living near dump sites, incinerators, and cement kilns.[28]
- In particular, diesel and waxes produced from the process are more contaminated with solid residues, dioxins, and PAHs than regular diesel or an equivalent.[29] The diesel requires substantial refinement to be used as a fuel, as it produces greater quantities of NO_x, soot, CO, and CO_2 emissions compared to conventional diesel when burned.[30] Cleaning the toxins from end products is extremely difficult, expensive, and creates additional toxic waste streams.[31]
- Burning waste produced in the PTF process in cement kilns and hazardous waste incinerators transfers toxic pollution from communities where the PTF plant is built to other communities. Persistent organic pollutants such as dioxins, heavy metals, and particulate matter are common pollutants emitted from cement kilns.[32] Cement kilns have lower reporting requirements for emissions than other burn facilities, such as coal plants and incinerators, and are often not required to notify nearby communities when emissions occur. Many of these facilities do not monitor for dioxins created by burning plastic like PVC. Dioxins are highly toxic and can cause reproductive and developmental problems, damage the immune system, interfere with hormones, and cause cancer.[33]

3 Plastic-to-Fuel has a Goliath-Sized Carbon Footprint

The process of converting plastic waste to fuel demands considerable energy, which is supplied by burning fossil fuels. Burning the resulting fuel releases additional greenhouse gas emissions. Instead of conserving the material in a circular process, burning plastic-derived fuel adds to the carbon footprint of the plastic lifecycle and stimulates further virgin plastic production to replace the plastic lost as fuel. In 2019 alone, the global production and incineration of plastic accounted for more than 850 million metric tons of greenhouse gases released to the atmosphere, approximately equal to the emissions from 189 five-hundred-megawatt coal power plants,[34] and incineration was the primary source of GHG emissions in the management of plastic waste.[35] PTF increases the climate impact of plastic disposal, as it releases carbon stored in the plastic into the atmosphere and requires external energy inputs throughout the processes.

[Image 5] GHG emissions from PTF processes



Source: Rollinson, A., Oladejo, J. (2020). Chemical Recycling: Status, Sustainability, and Environmental Impacts. Global Alliance for Incinerator Alternatives.

What is clear is that PTF results in a wide range of direct and indirect GHG emissions from pre-processing (hauling, sorting, washing, and shredding of plastic feedstock), thermal processing through gasification or pyrolysis, and post-processing treatment (cleaning and upgrading the fuel). While industry claims that PTF has a lower carbon footprint compared to conventional fossil fuels, such claims either lack independent verification or are based on incomplete, partial life-cycle assessment (LCA) models.[36] LCA models designed in favor of plastic fuel producers can misrepresent the climate impact of gasification and pyrolysis processes by neglecting emissions associated with raw material use and unnecessary packaging. GHG emissions from the extraction, refining, and manufacturing of plastic feedstock are rarely taken into account in the partial LCAs. LCAs of the carbon footprint vary with a number of additional factors that could be skewed in industry data: the discretion of researchers in selecting the baselines and parameters; the types of selected cases; scale and the efficiency of the selected process; and regional electricity grid generation mix.

The actual climate impact of gasification or pyrolysis has not been well quantified, in part because PTF companies do not make their data public. There are claims that PTF has a much lower carbon footprint compared to conventional fossil fuels. Quantafuel, a plastic-to-fuel company based in Norway, claims that its fuel product can reduce greenhouse gas emissions by 90% compared to conventional fossil fuels.[37] Another plastic-to-fuel company Renewlogy, in Salt Lake City, Utah, presented a 75% lower carbon footprint of the plastic fuel compared to traditional fossil fuels.[38] Neither claim has been independently verified. In contrast, the one set of publicly-accessible data from a US-based company indicates an order of magnitude higher emissions than from conventional fuel. In 2019, more than one-third of the carbon in the polystyrene processed at Agilyx was lost during processing. For each kilogram of styrene Agilyx produced, it emitted 3.23 kilograms of carbon dioxide, not counting the emissions from burning the styrene itself. This means that Agilyx's operation largely turns plastic into greenhouse gas emissions, while producing a relatively small quantity of styrene, which might or might not be recycled. The plant accepts feedstock from suppliers across the nation, including one in Florida, further contributing to its overall carbon footprint.[39]

In addition, gasification and pyrolysis are energy intensive processes. PTF facilities require continuous energy inputs to ensure and maintain thermodynamic stability during the high-temperature operation, plus additional energy inputs to ensure products meet industrial standards. According to one study, half of the carbon in the plastic waste is emitted as carbon dioxide in a single step -- upgrading the plastic-derived fuel to industrial standards (53% in pyrolysis and 48% in gasification).[40] No successful self-sufficient systems have been reported and the energy recovery capacity is unlikely to be improved in the next few decades.[41] Burning low-quality products as a fuel results in GHG emissions, despite its minimal contribution as an energy source. Even if the PTF process can be made more energy-efficient, it still results in the production of an additional fossil fuel at a time when the world is desperate to wean itself off fossil fuels and demand for them is crashing. When viewed from a climate perspective, PTF is incompatible with reaching global and national greenhouse gas emissions goals.

4 The Industry is Grasping at Straws to Save Itself

As the future of the fossil fuel industry becomes more and more precarious, companies are looking to plastic production as a lifeline. Public pressure has pushed international institutions and national governments to tighten climate policies that restrict or end financial support for fossil fuel extraction.[42] Oil and gas prices have been in a freefall for over a decade.[43] In recent years, low gas prices have fueled increased production of plastic and the industry has been planning 264 new or expanded US plastic facilities at a cost of $164 billion.[44] This strategy may be doomed to fail, however. A recent report by Center for International Environmental Law shows that "dovetailing trends of lowered plastic resin prices, increased plastic regulation, and decreased capital spending threaten the fundamentals of the petrochemical industry" and argues that plastic will not be the salvation of oil and gas companies.[45]

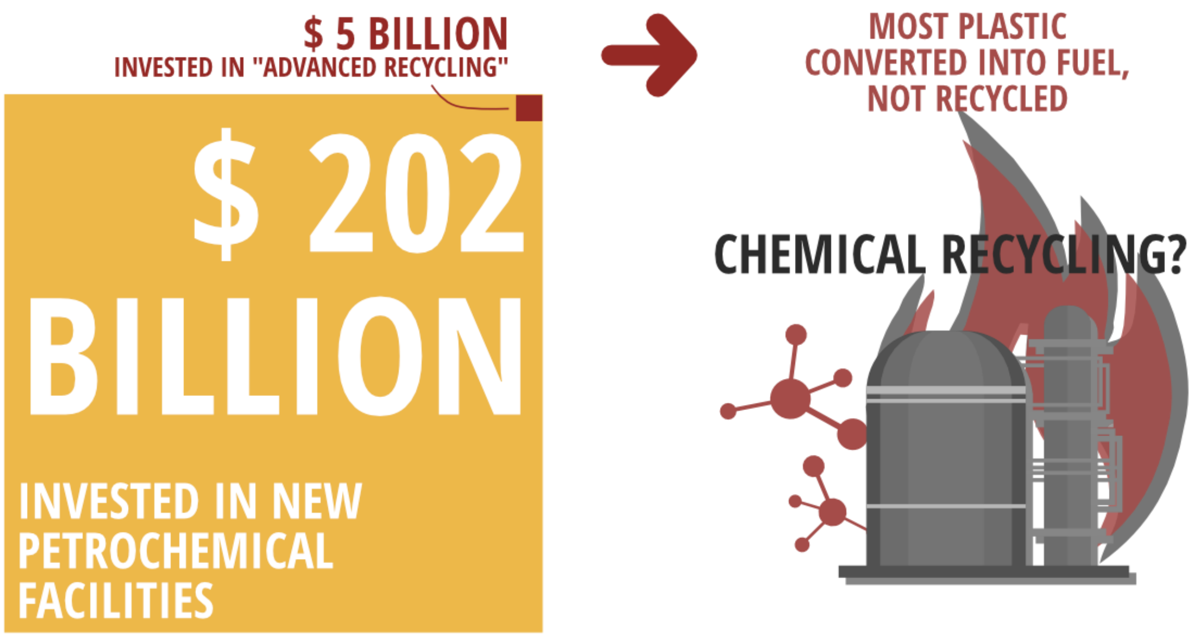
Meanwhile, cheap virgin plastic continues to flood the marketplace in the U.S. and around the world. Much of this material is difficult or impossible to recycle, and the low price of virgin plastic undercuts plastic recycling markets, exacerbating the problem of plastic waste and pollution. That said, the momentum to prevent plastic pollution is growing through government bans on plastic bags and other single use items and advocates, and even commitments by some industry partners, who are increasingly demanding strategies to address plastic production.

The petrochemical industry has pushed back on plastic bans and other policies to curb plastic use,[46] even exploiting the COVID-19 pandemic to tout single-use plastic as safer and more hygienic than plastic alternatives.[47] Meanwhile, many petrochemical companies point to PTF and "chemical recycling" as key solutions to the plastic waste crisis and the American Chemistry Council (ACC), Dow, Shell, and others give financial backing to projects like Hefty® EnergyBag®.[48] ACC also recommends PTF and "chemical recycling," which it calls "advanced recycling," over other plastic pollution interventions, as seen in the association's response to the Consumer Brands Association May 2020 proposal for a new virgin plastic resin fee. [49]

According to petrochemical industry associations, the industry may spend up to $5 billion on plastic recycling in the U.S., about 80 percent of the announced investments going toward "chemical recycling."[50] The ACC affiliate America's Plastic Makers® gives a figure of $4.6 billion spent in the past three years.[51] The ACC is also connected to the international "Alliance to End Plastic Waste", which includes oil, gas, petrochemical, and waste companies (BASF, Braskem, DSM, ExxonMobil, Henkel, Procter & Gamble, Suez, Veolia, among others). AEPW touts commitments by its member companies to spend $1.5 billion on projects that include "chemical recycling."[52] A much smaller amount of U.S. government funding is available: the U.S. Department of Energy is providing $4 million in grants for "chemical recycling," and "chemical recycling" is eligible for a $25 million plastic recycling grant program.[53] Considering how many operations called "chemical recycling" are in fact PTF operations, it is likely that most of these funds will be spent on plastic-to-fuel efforts. The investment in the expansion of new plastic production dwarfs that invested in "chemical recycling," and reveals where the priorities of the industry truly lie.

In addition, the petrochemical industry is using its significant financial and political influence to shift public policy in their favor. Through an effort led by the American Chemistry Council, industry is lobbying for legislation to create new markets that it has failed to attract. For example, legislation introduced in 15 states would no longer define post-consumer plastic as solid waste and reclassify "chemical" or "advanced recycling" facilities to be regulated as chemical manufacturing facilities rather than solid waste management.[54] The net effect of these regulations is to provide a largely unregulated escape route for plastic waste and to undermine traditional mechanical recycling markets by creating a supply chain that leads more plastic waste to PTF facilities.

[Image 6] Industry Investments in Plastic Recycling Compared to Petrochemical Infrastructure



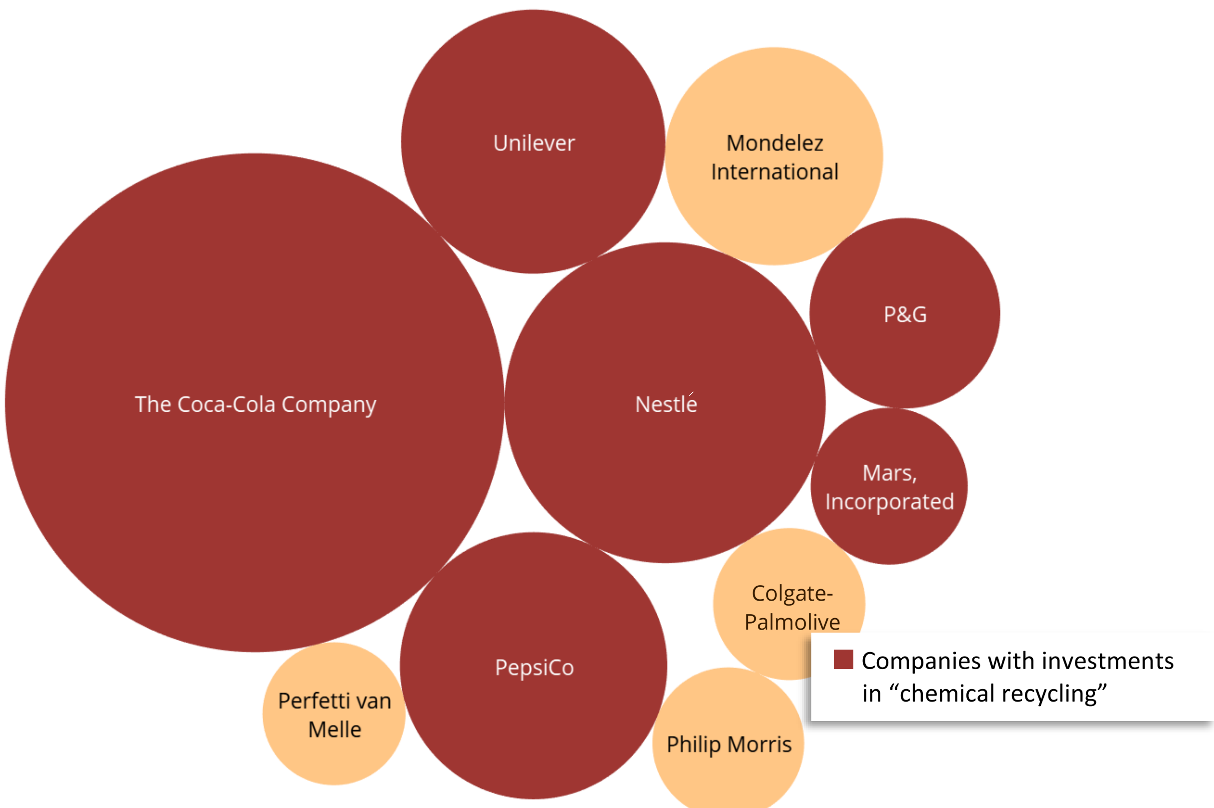
Source: American Chemistry Council (September, 2018). U.S. Chemical Investment Linked to Shale Gas: $202 Billion and Counting [press release].

Consumer Goods Companies Need to Act Fast

As noted earlier in the report, most so-called "chemical recycling" operations burn their outputs as fuel, and even in the few facilities that attempt plastic-to-plastic recycling, very little of the waste plastic actually becomes new plastic. Fast moving consumer goods (FMCG) companies are responsible for millions of tons of plastic packaging[55] and billions of individual, non-recyclable, single-use, and multi-layered plastic packets annually.[56] Growing pressure from the public has pushed many large corporations to pledge to make packaging 100% recyclable by 2030.[57]

While the technological and economic viability of these "chemical recycling" projects has never been proven, the tendency of relying on new techno-fixes has been growing among many FMCG companies and unfortunately some of them have been relying on the false promise of "chemical recycling." For example, Coca-Cola and Unilever, both among the top ten polluters according to Break Free From Plastic's 2019 Brand Audit, are partnering with "chemical recycling companies."[58] When not coupled with commitments for source reduction, the focus on downstream approaches puts pledges by the companies at risk of failure and only perpetuates the over-production and consumption of plastic packaging. As of July 2020, no FMCG company has committed to phasing out single-use plastic packaging through a systemic shift toward reusable and refillable delivery options.[59] In the meantime, the FMCG packaging industry is planning to grow by 3.2% each year over the next five years.[60] If FMCG companies want to show that they are committed to solving the problem of plastic pollution, they need to turn away from "chemical recycling" and toward real reduction solutions now.

[Image 7] Top Plastic Polluters among transnational FMCG companies in 2019



Source: Break Free From Plastic. (2019). Global Brand Audit Report. Based on the ranking of the amount of plastic waste among consumer brands whose packaging waste was collected in more than 10 countries. See Appendix 3 for the list of associated "chemical recycling" projects.

Conclusion

The petrochemical industry has promoted the idea of recycling plastic into plastic for decades.[61] However, the evidence is lacking. As of today, after decades of development, there is no public evidence that any facility in the U.S. is successfully recovering waste plastic to produce new plastic on a commercial scale.

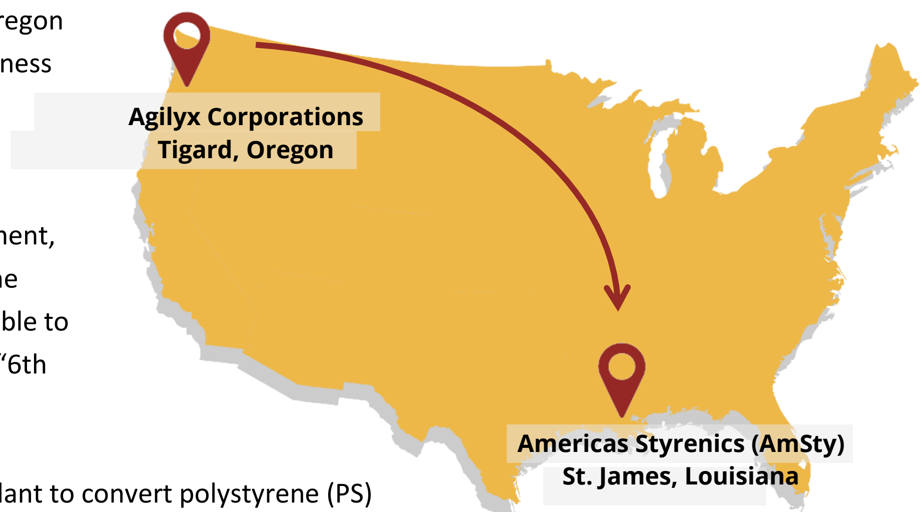
In addition, the economic outlook of the “chemical recycling” industry is highly uncertain and is subject to downside risks. Even before the impact of the COVID-19 pandemic, low oil and gas prices reflected the systemic weakness of the fossil fuel industry in the era of decarbonization. Low fossil fuel prices will continue to keep the production costs of new polymers low, damaging the market value of recycled plastic. While this is a challenge faced by both mechanical recycling and “chemical recycling” industries, “chemical recycling” is exposed to greater risks as the technology is much less established compared to mechanical recycling, requiring costly investments for infrastructure and market development. Plastic-to-fuel operations are especially fragile when oil prices drop, as seen in the case of the shutdown of Agilyx’s Tigard plant in 2016.[62] Finally, the trend of divestments from the fossil fuel and plastic industries will likely continue as more investment firms and banks recognize the long-term social and financial risks, further lowering oil and gas prices and undermining secondary plastic manufacturing markets.

Public involvement in siting decisions and rigorous regulatory oversight along the entire chain of the industry is needed to protect communities and workers and prevent further harm to overburdened communities. If left unchecked, the industry will continue to build a network of polluting waste and burn facilities that exacerbate the climate and plastic waste crisis. As policy makers push industry to move away from fossil fuels and plastic, the future of the plastic-to-fuel industry is at best questionable and at most a distraction from addressing the root cause of the world’s plastic waste crisis. The “chemical recycling” industry has struggled with decades of technological difficulties and poses an unnecessary risk to the environment and health, and a financially risky future that is incompatible with a climate safe future and circular economy.

1 Agylix & Americas Styrenics – Tigard, Oregon to St. James, Louisiana

Agilyx claims to be the world's first chemical recycling company that would "fully recycle post-consumer polystyrene materials back to new polystyrene products"[63], but in reality their primary business is PTF. The company currently has one facility in operation in Tigard, Oregon, which converts polystyrene into styrene, and a planned facility in partnership with Monroe Energy in Trainer, Pennsylvania, which would produce jet fuel for Delta Airlines. The company also has a partnership with Ineos styrolution to build a PTF facility in Channahon, Illinois, with operation scheduled for 2022.[64]

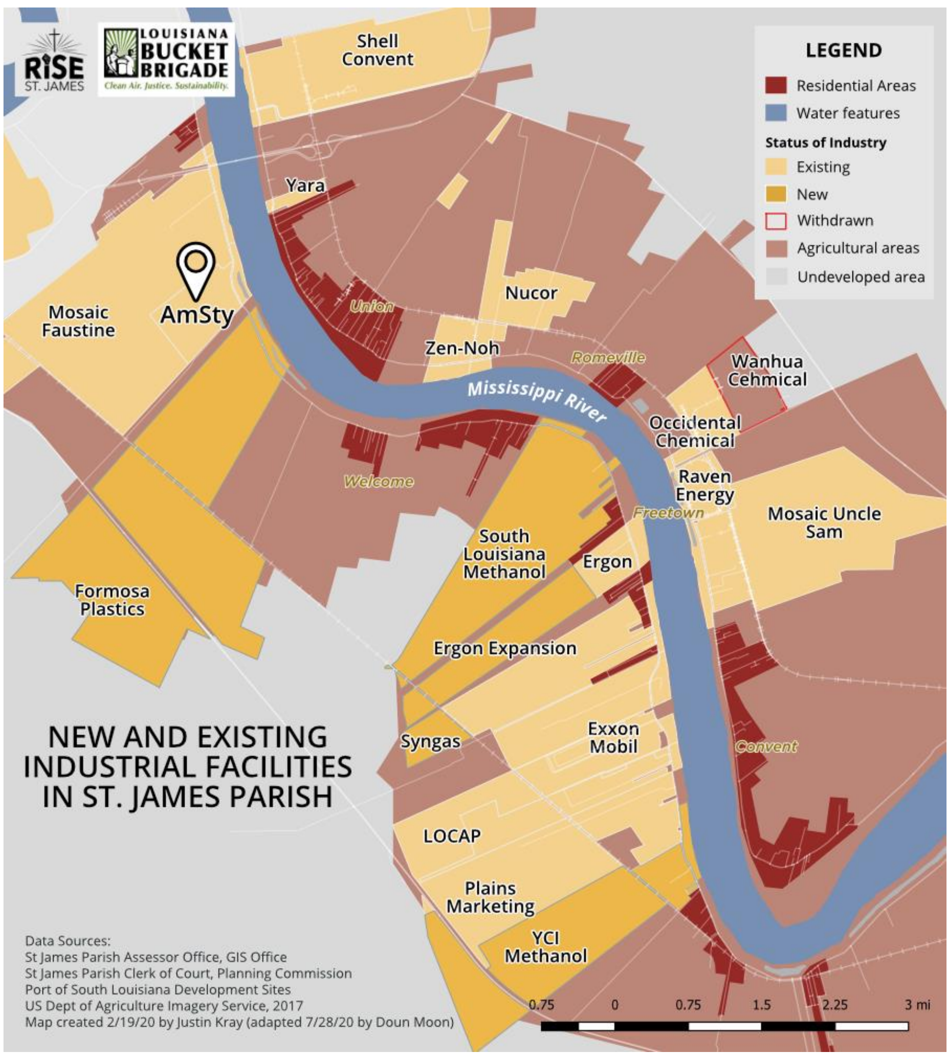
An investigation into the company's project in Oregon reveals a long history of technological false starts that cost investors millions of dollars[65] and did more environmental harm than good. Its first demonstration pyrolysis plant in Tigard, Oregon, was built in 2010 and received at least $25 million in private investment by 2011. Some of these investments went down the drain in 2016 when the company was forced to temporarily shut the plant down after its product failed to compete with the low price of oil.[66,67] In addition, Agilyx received over half a million dollars in tax credits from the Oregon Department of Energy through the Business Energy Tax Credit (BETC) program in 2013 to build a facility in Portland, which was owned and operated by Waste Management.[68] Waste Management, also an investor in Agilyx, abandoned the Portland facility after the plant was unable to overcome technical difficulties with its "6th generation" technology.[69]



Agilyx has since retrofitted the Tigard plant to convert polystyrene (PS) into styrene and reopened. The company has championed itself as the only company in the U.S. that turns post-consumer polystyrene back into virgin-quality plastic and is widely acclaimed by industry groups for this pioneering work using a "chemical recycling" technology, in this case, pyrolysis. However, Agilyx's own regulatory reporting does not back up this claim. In 2018, the last year for which complete data is available, Agilyx processed 216.82 tons of polystyrene waste to produce 24.23 tons of styrene, resulting in a material loss of 89%. In the same year, a similar amount of styrene (24.86 tons) was sent to be burned in cement kilns (see table below).[70] Cement kilns are commonly used to burn hazardous waste, implying that the styrene Agilyx produced was either too contaminated or of too low quality to be turned back into plastic.

In 2019, Agilyx reported its first truckload of styrene sent to its partner Americas Styrenics, a chemical plant in St. James Parish, Louisiana, to be converted into polystyrene. However, it is not known if that shipment was in fact turned into plastic or also burned. Despite repeated requests, Agilyx has not disclosed how much of its styrene output was recycled into polystyrene and how much was combusted in 2019. Based on the regulatory reporting, virtually all of the styrene produced at the Agilyx plant in 2018 was burned rather than converted into plastic, and our assessment is that the facility is effectively a plastic-to-fuel plant. To the extent that any of its output is recycled into polystyrene, Agilyx's business is still contributing to environmental burdens on the community where its partner firm is located. St. James Parish, Louisiana, is home to a petrochemical industrial zone in Louisiana's Cancer Alley, with a population that is 41.6% people of color.[71] According to EPA's Environmental Justice Screening tool, there are 13 facilities in the industrial zone with a combined output of over 300 stationary sources of air pollution, water dischargers, hazardous waste treatment, storage, and disposal facilities, and toxic release sites.[72]

[Image 8] New and Existing Industrial Facilities in St. James Parish



Source: stated in the map

Without greater transparency from Agilyx, it is impossible to verify the company's claim that some of its styrene is in fact being recycled into polystyrene. In addition, the available data reveal several other startling failures. Most shockingly, it has a huge carbon footprint. In 2018, the vast majority (approximately 89%) of the carbon in the plastic feedstock was lost in the process, presumably as CO_2. The remainder was emitted as CO_2 when the styrene product was burned in cement kilns. In 2019, more than a third of the carbon in the polystyrene was lost during processing. For each kilogram of styrene Agilyx produced, it emitted 3.23 kilograms of carbon dioxide, not counting the emissions from burning the styrene itself. This means that Agilyx's operation largely turns plastic into greenhouse gas emissions, while producing a relatively small quantity of styrene, which might or might not be recycled. The plant's overall poor performance is attested to by the fact that in 2019, it operated at only 26% of its claimed capacity.[73] The plant accepts feedstock from suppliers across the nation, including one in Florida, which adds to the carbon footprint.[74] In 2019, Agilyx processed 641 tons of polystyrene. At this pace, the U.S. would need 875 such facilities to process the 560,000 tons of polystyrene container/packaging waste generated in the U.S. each year.[75]

While often praised by industry as a company that is successfully developing plastic-to-plastic technology, after several false starts, Agilyx's technology, business model, and impacts on health and climate come nowhere close to a proven solution to mitigate the industry's plastic waste problem.

[Table 4] List of facilities that received styrene from Agilyx's Tigard plant for "energy recovery" in 2018

Facility Receiving Styrene from Agilyx - Tigard	Quantity (pounds)	In an EJ community*	Violation records**
Green America Recycling (owned by Continental Cement Co LLC) Hannibal, MO 6% minority, 33% below poverty level	44,452	Yes	Multiple Resource Conservation and Recovery Act violations since 2018; Significant Non-Compliance under Clean Water Act in 2019[76]
Tradebe Treatment and Recycling, LLC. (provides services for chemical reuse (including styrene) and energy recovery/fuel blending in cement kilns East Chicago, IN 80% minority, 57% below poverty level	320	Yes	High Priority Violations under Clean Air Act in 2017; Significant Non-Compliance under Resource Conservation and Recovery Act in 2018 and 2019[77]
Burlington Environmental LLC Tacoma (registered as Stericycle Environmental Solutions) Tacoma, WA 42% minority, 31% below poverty level	1,036	Yes	Significant Non-Compliance under Resource Conservation and Recovery Act since 2017[78]

Systech Environmental (sends by-products and waste materials to be burned at 22 cement kilns across North America, in partnership with its sister company Geocycle. Both are affiliates of LafargeHolcim) Fredonia, KS 7% minority, 45% below poverty level	3,904	Yes	No records available for Clean Air Act; two resolved Clean Water Act non -compliance cases were reported in 2019[79]
Total	49,712		

Source: U.S. EPA. Toxic Release Inventory.[80]

* Two factors were used to determine whether the facility is located in an EJ community: (a) the percentage of people living below the federal poverty rate is above 25 percent OR (b) the percentage of people who identify as "minority" is above 25 percent, based on the demographics of the population within a 3-mile radius of the facility.[81]

** According to the U.S. EPA, Significant Non-Compliance is the designation for the most serious level of violations and noncompliance events which pose risks to the environment or program integrity."[82]

Note: According to the company, its 2019 Toxic Release Inventory data was submitted to the EPA before the deadline of July 1, 2020. However, the EPA has not yet made it publicly available and as of our publication deadline, Agilyx had not responded to our request for updated information.

2 Brightmark Energy – Ashley, Indiana

In April 2019, Brightmark Energy, a waste management company based in San Francisco, took majority ownership in RES Polyflow and closed a $260 million financing package to finalize the construction of a plant in Ashley, Indiana that aims to convert plastic waste into fuel, naphtha, and waxes for candles and other consumer products.[83] While initially stating that the company would rely on rejected plastic collected from recycling and trash haulers in Chicago, parts of Ohio and southern Indiana for the Indiana facility,[84] the company now says it will take all plastic #1-7 for future sites, diverting even plastic that could otherwise be mechanically recycled.[85]

The now operational Brightmark facility began with significant delays and public investments to get off the ground.[86] The Indiana project initially began as an effort by Renewable Energy Solutions by Polyflow (RES Polyflow, LLC) to commercialize its plastic-to-fuel conversion technology in 2011 and received significant public funding in 2012 to support its efforts.[87] RES Polyflow is a joint venture between Polyflow, LLC, an Ohio-based plastic-to-fuel company, and Indiana-based private equity firm Ambassador Enterprises. The venture was supported through a State of Ohio Third Frontier Advanced Energy Program grant.[88] Since its formation, the company received at least two loans - in 2011 and 2018 - from Steuben County, Indiana.[89] In 2016, Indiana State's lead economic development agency, the Indiana Economic Development Corporation (IEDC) also offered up to $1 million for a project in Ashley, Indiana, including $900,000 in conditional tax credits and $100,000 in training grants for 136 employees to be hired by 2021.[90] The financing package for the project included $185 million of Exempt Facility Revenue Bonds (Green Bonds) issued by the Indiana Finance Authority and underwritten by Goldman Sachs & Co.[91] Brightmark projects 136 full-time jobs will be created at this facility though the agreement with IEDC made no commitments for employee retention over time.[92] In 2018, the company entered an agreement with the British oil and gas company BP, to sell fuels to be produced in the Ashley plant.[93]

The plant finally began operations in May 2020 and plans to reach its goal of processing 100,000 tons of plastic by 2021 from across the region.[94] While it is yet unclear if the company can produce what is claimed, especially given the challenges in treating mixed low-grade plastic waste, Brightmark has announced a call for community partnerships in 2019, looking to build more facilities in the U.S. and globally. In the U.S, the company's targeted states include Florida, Georgia, New Jersey, New York, Pennsylvania, Louisiana, and Texas.[95]

[Table 5] List of investments provided to Brightmark

Year	Grantor	Program	Amount
2011, 2018	Steuben County	Tax abatement	$1.5 million
2016	Indiana Economic Development Cooperation	Economic Development for a Growing Economy (EDGE) - Payroll Tax Credit and Skills Enhancement Fund (SEF) - Workforce Training Grant	$1 million ($900,000 in EDGE, $100,000 in SEF)
2019	Indiana Finance Authority	Exempt Facility Revenue Bonds (Green Bonds)	$185 million
2019	Brightmark	Capital from Brightmark Energy and prior development contributions by the Company	$75 million
Financial support from taxpayer funds (72%)			$187.5 million
Financial support from private sector (28%)			$75 million
Total			$262.5 million

Source: Stephens Inc. (2020). Investment Banking Update; Press releases and media reports cited in this report.

3 Renewlogy – Salt Lake City, Utah

Renewlogy is a plastic-to-fuel company in Salt Lake City, Utah. Since 2018, the company has been working in partnership with Dow Chemical to support its HeftyBag Campaign, a curbside collection program which collects "hard-to-recycle" plastic waste in orange bags to burn or convert into fuels. The program launched in Boise, Idaho, in April 2018, with an agreement to send collected plastic waste to Renewlogy's Salt Lake plant. However, in the first quarter of 2019, the plant stopped accepting the collected waste due to equipment upgrades, which the company said would be finished in the beginning of 2020.[96] While the plant idles, the city continued to collect the orange bags so as not to confuse residents, stockpiling the plastic waste. In May 2020, the city of Boise announced that it will send the stockpiled plastic waste to a cement kiln in Utah to be burned as fuel until the Renewlogy plant reopens in September.[97] According to a representative of Dow's Hefty Energy Bag program, the material efficiency of Renewlogy's processes was 50-75% before the plant stopped operation.[98] This means that between 25-50% of the collected waste could not be converted into fuels and remained as waste. The City of Boise says they have shipped 400,000 bags of plastic waste 340 miles to Renewlogy,[99] which in total means that 100,000-200,000 of those bags of waste have become waste in Utah while the rest are being burned in cement kilns.

GLOSSARY

- Catalyst: A substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change.
- Depolymerization: One of several technologies that breaks plastic down into its constituent building blocks.
- Effluent: Liquid waste, generally requiring wastewater treatment.
- Fast Moving Consumer Goods Company: Company that produces products that are sold quickly and at a relatively low cost.
- Feedstock: Raw material to supply or fuel a machine or industrial process.
- Gasification: Similar to pyrolysis, heating waste in a low-oxygen environment.
- Repolymerization: The process of turning plastic waste back into plastic by breaking it down into its constituents and reconstructing the plastic polymers.
- Naphtha: A flammable oil containing various hydrocarbons, obtained by the dry distillation of organic substances such as coal, shale, or petroleum.
- Plastic-to-fuel: A process for turning plastic into a liquid or gas that is then burned for energy.
- Polymer: One of several distinct types of plastic, each with its own chemical structure. Different polymers generally cannot be recycled together.
- Polystyrene: a hard, stiff, brilliantly transparent synthetic resin made from styrene. It is primarily used for packaging and insulating materials.
- Pyrolysis: The process of heating waste in the absence of oxygen to produce a liquid or gas fuel.
- Solvent: A substance that dissolves a material into a solution. A solvent is usually a liquid but can also be in a solid or gas form.
- Styrene: primarily a synthetic chemical that is used extensively in the manufacture of plastic, rubber, and resins.

ABBREVIATIONS

- EPA: Environmental Protection Agency
- FMCGs: Fast-Moving Consumer Goods
- PTF: Plastic-to-Fuel
- PTP: Plastic-to-Plastic
- TRI: Toxic Release Inventory
- WTE: Waste-to-Energy

APPENDICES

[Appendix 1] List of Projects Proposed as "Chemical Recycling" in the U.S.

Count	Company	Province/City (site of the facility)	Project Type	Current status*
1	Agilyx	Tigard, Oregon	PTF in practice (according to available data)	5 - Operating plant
2	Agilyx and Monroe Energy	Trainer, Pennsylvania	PTF (thermal)	0 - Project not started. No budget or schedule announced.
3	Ambercycle	Los Angeles, California	PTP (solvent/catalyst-based)	2- Pilot scale operation
4	Americas Styrenics (Amsty)	St. James, Louisiana	N/A	X- Not a chemical recycling facility. Accepts recycled plastic from Agilyx.
5	BioCellection Inc.	Menlo Park, California	PTP (solvent/catalyst-based)	2- Pilot scale operation
6	BP Infinia	Naperville, Illinois	PTP	4 - Project announced with site, budget, and schedule information.
7	Braven	Cumberland County, Virginia	PTF	4 - Project announced with site, budget, and schedule information.
8	Brightmark (former RES Polyflow) (partners with BP)	Ashley, Indiana	PTF	5 - Operating plant
9	Climax Global Energy	Allendale, South Carolina	PTF	0 - Announcement only
10	Cogent Energy Systems	Unknown	PTF	2 - Pilot project completed. No progress since 2018 found.
11	Eastman	Kingsport, Tennessee	PTP (thermal)	X – Data not available
12	Ecofuel technologies (partners with Save Our Oceans Foundation)	Livonia, Michigan	PTF	0 - Announcement only

13	Encina	Unknown	PTP	0 - Announcement only
14	Fulcrum Bioenergy	Storey County, Nevada	WTE	X - Not a Chemical Recycling facility. Waste-to-Energy.
15	Geo-Tech Polymers (a division of Western Advantage Inc.)	Waverly, Ohio	PTP (water-based)	X - Not a chemical Recycling facility. Provides consulting services.
16	Golden Renewable Energy	Yonkers, New York	PTF	4 - Project announced with site and budget information.
17	Illinois Sustainable Technology Center	Unknown	PTF with PTP (solvent-based purification and pyrolysis)	1 - Lab-scale
18	Ineos Styrolution	Channahon, Illinois	PTP (using Agilyx technology)	0 - Announcement only
19	Inline Plastics	Shelton	N/A	X - Not a chemical recycling facility. Buys recycled plastic from other companies to use in manufacturing.
20	Loop Industries	Spartanburg	PTP (solvent/catalyst-based)	3 - Site and schedule announced
21	METT USA	Virginia	PTF	0 - Announcement only
22	NatureWorks (jointly owned by PTT Global Chemicals and Cargill)	Omaha, Nebraska	N/A	X - Not a chemical recycling facility. A PLA production process.
23	New Hope Energy	Tyler, Texas	PTF	5 - Operating plant. Facility fire in May 2020.
24	Nexus Fuels (partners with Shell)	Atlanta, Georgia	PTF	2 - Pilot plant operational. No budget or schedule announced for commercial plant.
25	PennState	Pennsylvania	PTF	1 - Lab-scale. No project progress found since 2014.
26	Plastic2Oil	Niagara Falls, New York	PTF	X - On hold. Company does not appear to be actively developing new projects.
27	Pure Cycle technologies (partners with P&G)	Hanging Rock, Ohio	PTP (solvent/catalyst-based)	4 - Project construction started. Schedule for commercial completion delayed to 2022.
28	Quad City Innovations LLC	Livonia, Michigan	PTF	3 - Site and schedule announced

29	Reclaimed EcoEnergy	Newport Beach, California	PTF	0 - Announcement only
30	Renewlogy	Boise, Idaho (Salt Lake City plant site)	PTF	X - Plant shutdown since early 2019. Process undergoing improvement.
31	Renewlogy	Phoenix, Arizona	PTF	0 - Announcement only
32	Resinate Materials Group	Plymouth, Michigan	PTP (glycolysis - both)	0 - Announcement only
33	Resynergi	Santa Rosa, California	PTF	2 - Pilot
34	Sierra Energy	Monterey County, California	WTE	X - Not a Chemical Recycling facility. Waste-to-Energy.
35	University of Massachusetts, Lowell	Massachusetts	PTP (solvent/catalyst-based)	1 - Lab-scale
36	U.S. DOE National Renewable Energy Laboratory (NREL)	Golden, Colorado	PTP (solvent/catalyst-based)	1 - Lab-scale
37	VADXX (member of ACC and PTF and Petrochemical Alliance (PFPA)	Akron, Ohio	PTF	0 - Announcement only

Source: Closed Loop Partners. (2019). Accelerating Circular Supply Chains for Plastics: A Landscape of Transformational Technologies that Stop Plastic Waste, Keep Materials in Play and Grow Markets; 52 Advanced Recycling Projects List from American Chemistry Council; press releases and media reports.

* Stages of project maturity: 0 (Announcement only), 1 (Lab-scale), 2 (Pilot plant operational), 3 (Site and schedule announced), 4 (Construction started), 5 (Operating plant), X (Other)

[Appendix 2] Analysis of the performance of Agilyx's plant in Tigard, Oregon

INPUTS (2018)	AMOUNT	UNIT	NOTES
Mass (Poly)Styrene Input	196,663.039	kg	Permit report p.20
Carbon in Polystyrene Input	181,407.304	kg	
Natural Gas Used	231,631.424	m3/yr	Permit report p.4
OUTPUTS (2018)			
Mass Styrene Output	21,974.839	kg	Permit report p.20
Carbon in Styrene Output	20,270.186	kg	
C Out in CO	0.506	kg	
C Out in VOC	Undetermined	kg	Negligible
C Out in Solid Waste	0.000	kg	Negligible
Carbon Balance	161,136.612	kg C	Process Carbon Lost
Carbon Process Loss	590,834.246	kg CO2	Process Carbon Lost As CO2
Natural Gas Emissions	455,399.935	kg CO2	CO2 Emissions from Natural Gas Combustion
Facility Co2 Emissions	1,046,234.181	kg CO2	Does Not Include Electricity, Diesel Use
Co2 From Styrene Burned	1,271,412.064	kg CO2	Burned in Cement Kilns
Total Co2 Emissions	2,317,646.245	kg CO2	
EFFICIENCY (2018)			
Process Efficiency	11.174	%	
Carbon Footprint	47.611	kg/kg	CO2 emissions per kg of styrene produced

INPUTS (2019)	AMOUNT	UNIT	NOTES
mass (poly)styrene input	581,157.370	kg	Permit report p.13
carbon in polystyrene input	536,075.270	kg	
natural gas used	265,045.248	m3/yr	Permit report p.4
OUTPUTS (2019)			
Mass Styrene Output	376,136.902	kg	Permit report p.13
Carbon in Styrene Output	346,958.848	kg	
C Out In CO	7.778	kg	
C Out In VOC	Undetermined	kg	Negligible
C Out in Solid Waste	0.000	kg	Negligible
Carbon Balance	189,108.643	kg C	Process Carbon Lost
Carbon Process Loss	693,398.359	kg CO2	Process Carbon Lost As CO2
Natural Gas Emissions	521,093.325	kg CO2	CO2 Emissions from Natural Gas Combustion
Facility CO2 Emissions	1,214,491.684	kg CO2	Does Not Include Electricity, Diesel Use
CO2 From Styrene Burned	Unknown	kg CO2	Burned in Cement Kilns
Total CO2 Emissions	Undetermined	kg CO2	
EFFICIENCY (2019)			
Process Efficiency	64.722	%	
Carbon Footprint	3.229	kg/kg	CO2 emissions per kg of styrene produced

Source: U.S. Environmental Protection Agency (EPA). (2019). Toxic Release Inventory Form R Reports; Agilyx. (2019). Air Quality Permit Detail Report; Analysis provided by Andrew Rollinson, PhD.

[Appendix 3] Top 10 plastic polluters

Company	Results of 2019 Brand Audits	Involvement in "Chemical Recycling"	Commitments for Single-Use Plastic Alternatives[100]
Coca-cola	11,732 pieces of plastic found in 37 countries	Granted a loan to Ioniqa Technologies and announced the project produces the first batch of plastic bottles made of ocean plastic in October, 2019[101]; in partnership with Enval for recycling of laminated packaging through microwave induced pyrolysis.[102]	N/A; announced goals for its packaging to be 100% recyclable by 2025, and to make bottles with an average of 50% recycled material by 2030.[103]
Nestlé	4,846 pieces of plastic found in 31 countries	Recycling Technologies Ltd. partnering with Project STOP, an initiative co-founded by Borealis and SYSTEMIQ104; in partnership with Enval for recycling of laminated packaging through microwave induced pyrolysis105; partners with PureCycle Technologies106; joined a partnership with Recycling Technologies, Ltd. to build a "chemical recycling" plant in France.[107]	N/A; announced in 2018 a commitment to making 100% of its packaging recyclable or reusable by 2025.[108]
Pepsico	3,362 pieces of plastic found in 28 countries	Signed a multi-year supply contract with Loop Industries Inc.[109]	N/A; Reduce virgin plastic use across beverage portfolio by 35%by 2025.[110]
Mondelēz	1,083 pieces of plastic found in 23 countries	N/A	N/A; Announced goals for its packaging to be 100% recyclable by 2025.[111]
Unilever	3,328 pieces of plastic found in 21 countries	Signed a 5-year contract with Viridor and Ineos[112]; partners with Ioniqa for PET recycling113; partners with CreaCycle GmbH for sachet recycling in Indonesia.[114]	N/A; Halve its use of virgin plastic by 2025.[115]
Mars, Incorporated	543 pieces of plastic found in 20 countries	Partners with Pure Cycle and Indorama; Joined a partnership with Recycling Technologies, Ltd. to build a chemical recycling plant in France.[116]	N/A; 25% reduction in virgin plastic use by 2025.[117]
Procter & Gamble	1,160 pieces of plastic found in 18 countries	Partners with PureCycle Technologies[118]; has a supply contract with Indorama for recycled PET.[119]	N/A; Pledged to reduce the use of virgin petroleum plastic in packaging by 50% by 2030.[120]

Colgate-Palmolive	642 pieces of plastic found in 18 countries	N/A	N/A; Pledged to increase recycled content for plastic to 25 percent by 2025.[121]
Philip Morris International	2,239 pieces of plastic found in 17 countries	N/A	N/A[122]
Perfetti	1,090 pieces of plastic found in 17 countries	N/A	N/A[123]

Source: Break Free From Plastic. (2019). Global Brand Audit Report. www.breakfreefromplastic.org/globalbrandauditreport2019.

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[6] The European Union's Waste Directive explicitly excludes energy recovery and waste-derived fuel from the definition of 'recycling', recognizing that plastic-to-fuel adds to the overall carbon footprint of plastics. Article 3(17), Directive 2008/98/EC on waste.
[7] See Glossary for a brief definition of gasification and pyrolysis. For more technical details, refer to: Rollinson, A., Oladejo, J. (2020). Chemical Recycling: Status, Sustainability, and Environmental Impacts. Global Alliance for Incinerator Alternatives. https://www.doi.org/10.46556/ONLS4535
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