HB0021-FAV-DTMG-1-29-21.pdf

Uploaded by: Bartlett, Olivia

Position: FAV

Olivia Bartlett, Co-Lead, DoTheMostGood Maryland Team

Committee: Environment and Transportation

Testimony on: HB0021 – Environment – Recycling – Prohibition on the Chemical Conversion of Plastic

Position: Favorable

Hearing Date: January 29, 2021

Bill Contacts: Delegate Love

DoTheMostGood (DTMG) is a progressive grass-roots organization with more than 2500 members who live in a wide range of communities in Montgomery and Frederick Counties, from Bethesda near the DC line north to Frederick and from Poolesville east to Silver Spring and Olney. DTMG supports legislation and activities that keep all the members of our communities healthy and safe in a clean environment. DTMG strongly supports HB0021 because chemical conversion of plastic will actually make the climate and plastic pollution problems worse, and facilities that do this have no place in Maryland.

In the past few years, chemists at Purdue University and elsewhere have devised new chemical procedures to apply heat, chemicals, and high voltage electricity to turn plastics into back into some form of oil. The chemical and plastics industries have branded these chemical conversion processes "advanced recycling", "chemical recycling" or "chemical conversion" to greenwash a polluting and carbon intensive process. About 50% of the carbon content of waste plastics is typically lost during the chemical conversion as greenhouse gases, which contribute to climate change. Chemical conversion facilities also release toxic chemicals, including lead, arsenic, mercury, bisphenol-A, cadmium, benzene, and volatile organic compounds, into the atmosphere and have a resulting ash that is also full of toxins. The plastics industry has not released any peer reviewed information documenting the environmental impacts of the entire lifecycle for the chemical conversion process.

Furthermore, there is no evidence that these plants will reduce the use of single use plastics or solve the recycling problem. It's not recycling at all. On the contrary, chemical conversion will just feed the demand for continued use of disposable plastics to benefit the petrochemical industry.

HB0021 directly addresses this by defining that in Maryland, "recycling" does not include chemical conversion processes such as pyrolysis, hydropyrolysis, methanolysis, gasification, enzymatic breakdown, or similar processes. In addition, HB0021 will prohibit building facilities for these processes in Maryland. Such facilities would just give the oil and plastic industries a green light to light to keep producing plastics at a time when we must stop extracting fossil fuels and stop burning oil of all kinds in order to reduce greenhouse gas emissions and rein in global warming.

In addition, prohibiting new chemical conversion facilities in Maryland also addresses equity and environmental justice. 79% of waste to energy facilities are located in low-income communities and communities of color which are already impacted by excessive air and water pollution. These facilities expose residents to harmful particulates that cause cancer, respiratory illnesses, and neurological disorders. Maryland does not need any more facilities that release toxins into the air.

Therefore, DTMG strongly supports HB0021 and urges a **FAVORABLE** report on this bill.

Respectfully submitted,

Olivia Bartlett
Co-lead, DoTheMostGood Maryland Team
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240-751-5599

HB0021 MD NARAL SUPPORT.pdf
Uploaded by: Blalock, Isabel
Position: FAV

HB0021 Environment – Recycling – Prohibition on the Chemical Conversion of Plastic
Presented to the Honorable Kumar P. Barve and Members of the Environment and Transportation Committee
January 29, 2021 1:30 p.m.

POSITION: SUPPORT

NARAL Pro-Choice Maryland urges the Environment and Transportation Committee to issue **a favorable report on HB0021 Environment – Recycling – Prohibition on the Chemical Conversion of Plastic**, sponsored by Delegate Love.

Our organization is an advocate for reproductive health, rights, and justice. Climate change is adversely impacting reproductive and sexual health in various ways, with low-income people and communities of color bearing the brunt of the worsening environmental health outcomes. HB0021 bans infrastructure that converts plastic to fuel or feedstock and ensures these processes do not receive recycling incentives or subsidies. It is essential to stand against this infrastructure because, if not, it locks us into plastic production and fossil fuel use, which exacerbate climate change resulting in detrimental effects on human health.

Climate change is impacting reproductive health in a myriad of ways. Research has demonstrated the reproductive health outcomes associated with environmental pollution including infertility, abnormal menstruation and puberty, endometriosis, recurrent pregnancy loss, polycystic ovarian syndrome (PCOS), fetal death, prenatal growth abnormalities, reduced gestational period, low birth weight,[1] pregnancy-induced hypertension and preeclampsia,[2] and genital and breast cancers.[3]Additionally, rising global temperatures are making heat a more serious threat to pregnant persons going forward; exposure to unusually hot temperatures can lead to changes in length of gestation, birth weight, stillbirth rates, and neonatal stress.[4] Furthermore, increased instances of natural disasters result in a disruption of reproductive health services which can lead to

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[1] Rashtian, J., Chavkin, D.E. & Merhi, Z. (2019) Water and soil pollution as determinant of water and food quality/contamination and its impact on female fertility. Reproductive Biology & Endocrinology 17, 5. https://doi.org/10.1186/s12958-018-0448-5

[2] Wang, Aolin et al. "Environmental influences on reproductive health: the importance of chemical exposures." *Fertility and sterility* vol. 106,4 (2016): 905-29. doi:10.1016/j.fertnstert.2016.07.1076

[3] Bhatt, R.V. (2000). Environmental Influence on Reproductive Health. International Journal for Gynecology and Obstetrics, 70: 69-75. https://doi.org/10.1016/S0020-7292(00)00221-6

[4] Bekkar B, Pacheco S, Basu R, & DeNicola N. (2020). Association of Air Pollution and Heat Exposure with Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. JAMA Network Open; 3(6):e208243. doi:10.1001/jamanetworkopen.2020.8243

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unplanned pregnancies; conversely, natural disasters can displace families and leave them financially unstable resulting in reduced fertility.[5] In both cases, individuals lose their reproductive freedom to choose when to become pregnant.

The processes involved in the chemical conversion of plastic to fuel contributes to climate change and increases our reliance on fossil fuels in the long-run. It is imperative that we prohibit these practices in order to mitigate further environmental damage. For these reasons, NARAL Pro-Choice Maryland **urges a favorable committee report on HB0021.** Thank you for your time and consideration.

[5] Tobin-Gurley, J, Peek, L, & Loomis, J. (2011). Displaced Single Mothers in the Aftermath of Hurricane Katrina. International Journal of Mass Emergencies and Disasters 28, no. 2: 170-206.

HB21 - Environment – Recycling – Prohibition on the Chemical Conversion of Plastic
Environment and Transportation Committee
January 29th, 2021
Position: Favorable

Environment Maryland is a citizen-based environmental advocacy organization. We work to protect clean air, clean water, and open space. We have thousands of members across the state and are based in Baltimore.

Maryland PIRG's mission is to deliver persistent, result-oriented public interest activism that protects consumers, encourages a fair, sustainable economy, and fosters responsive, democratic government. We are a Baltimore based, statewide, non-partisan, non-profit, citizen-funded public interest advocacy organization with members across the state.

Environment Maryland, Maryland PIRG, Clean Water Action and the undersigned organizations strongly support this bill to prevent new facilities in Maryland to create a new way to burn fossil fuels. So-called "plastic recycling," or more accurately called "plastic to pollution" is bad for the environment and public health and antithetical to our goals of stopping global warming and moving towards zero-waste.

Burning More Fossil Fuels

This year, we saw wildfires consume half of our country. Flooding worsens in our cities, sea level rise continues to threaten Maryland's coastal communities, summers are hotter, and weather events are more severe. Climate change is here, and it's now. This is why it is absolutely critical that our state legislature takes swift action to stop chemical “recycling” processes from coming to our state. Allowing this infrastructure to take hold here would be devastating for our climate, dangerous to our communities, and will set us back in our fight against plastic pollution and fossil fuel use.

Maryland has set ambitious goals to fight climate change - from renewable energy commitments and banning fracking to reducing our single-use plastic use through a ban on polystyrene foam, we are working hard to protect our state for generations to come.

If you believe that burning fossil fuels is contributing to the climate crisis, and that we need to move away from them as quickly as we can, then you should absolutely vote favorably on this bill. Don’t be fooled as the industry attempts to boil this down to a plastic issue, or as some scientific advancement that will allow us to mitigate the plastic crisis. This is an attempt from both the plastic and fossil fuel industries to ensure that we 1) continue using plastic and 2) continue burning fossil fuels. We do not, in fact, need to be building out infrastructure to do either of those things and we absolutely have better ways to mitigate our plastic crisis and fuel our world.

Chemical Conversion is NOT Recycling.

“Advanced recycling” or “chemical recycling” can cover a variety of different processes that convert plastic to fuel or theoretically turn plastic back into plastic through repolymerization. It is absolutely critical to note here that this bill does not impact those latter processes. If the industry figures out how to turn a bottle back into a bottle, they would absolutely still be allowed to do that. This bill only impacts the processes that take plastic, chemically convert it back into the sum of its parts, and then burn that oil and gas as any other fossil fuel.

Now, is this process recycling? Environmentalists say no, and when pressed on this question, Dow Chemical leadership even replied publicly: “We agree. It is not recycling.”[1] The ACC continues to use the term recycling because it’s good marketing, though they go so far as to note on a fact sheet that chemical recycling facilities, including pyrolysis and gasification, “should be regulated not as recycling but new manufacturing.” This means that their claims that investment in “chemical recycling” will help improve recycling systems are equally bogus. While the industry attempts to prop it up as the silver bullet for managing our plastic crisis, it is little more than an industry hail mary to lock us into plastic use AND fossil fuel use.

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[1] “Should plastics be a source of energy?” Alexander H. Tullo, 2018. Chemical and Engineering News.

Further, A report from GAIA[2] lays out these helpful points:

- "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.

Worsening the Plastic Crisis

The industries that profit off of the plastic pollution crisis will not be the ones to fix it. In reality, the industry[3] has known since the 1970's that recycling would never work, despite spending millions of dollars to convince Americans that recycling would be able to manage our plastic waste with no problem. I am reminded of the adage: "Fool me once, shame on you. Fool me twice, shame on me." The industry isn't looking to solve the plastic crisis, they're ensuring that they can continue to profit off of plastic production. In fact, a recent Greenpeace study found that less than 50% of the projects on the ACC's list of "advanced" recycling met the basic criteria to be deemed credible plastic recycling projects; the rest were either turning plastic into fuel, or other non-reprocessing projects. What about the projects that did meet the criteria? Greenpeace found these facilities would have a total processing capacity of 0.2% of the plastic waste generated in 2017. This means that the taxpayer funding of at least $506 million identified to be invested in these projects is funding a process that will do little to nothing to mitigate plastic pollution. Further, almost 90% of that taxpayer money was going to waste-to-fuel projects.[4]

These processes are expensive, untested, often dangerous, and absolutely awful for our climate. Do not be fooled by yet another industry attempt to tout a false solution to plastic pollution. We urge you to vote favorably on HB 21.

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[2] "All Talk and No Recycling," GAIA. https://www.no-burn.org/chemical-recycling-us/

[3] "How Big Oil Misled the Public Into Believing Plastic would be Recycled, Laura Miller. NPR.

[4] "Deception by the Numbers: Claims about Chemical Recycling Don't Hold Up to Scrutiny." Ivy Schlegel. Greenpeace.

HB 0021 Ban Chemical Conversion of Plastic Testimo
Uploaded by: Chladil, Jesse
Position: FAV

January 27, 2021

Testimony on **HB 0021**
Environment – Recycling – Prohibition on the Chemical Conversion of Plastic
Environment and Transportation Committee

Position: Favorable

Dear Chairman and Committee Members,

Thank you for considering my testimony today. My name is Jesse Chladil, a resident of Baltimore, in District 40. I am a member of the Sunrise Movement Baltimore, a movement led by young people fighting against the climate crisis. This testimony represents my support for HB 0021, Prohibition on the Chemical Conversion of Plastic Act.

Chemical conversion of plastic is simply not recycling. It is turning plastic into oil to burn as a fossil fuel, which contributes to our climate crisis. We already are seeing the flooding, extreme weather, hotter summers, and rising sea levels in Maryland. We should be reducing our use of fossil fuels, not sustaining or increasing it. Converting plastic back to fossil fuels releases huge amounts of CO_2 and other greenhouse gases. Additionally, the toxic pollution from these chemical conversion projects would likely be placed in marginalized communities already overburdened with so many polluting projects. We shouldn't allow chemical conversion of plastic in Maryland, which will only pollute our communities and exacerbate the climate crisis.

In Maryland and around the world we do indeed have a huge plastic problem, but chemical conversion of plastic is only an excuse that will do little to solve the real issue. We find so many plastics on our streets and in our waterways. Yet we can't recycle our way out of this crisis, we have to cut it at its source. We must move beyond plastic and fossil fuel dependency and instead create a circular economy based in reuse. There's a reason the 3 R's of Reduce, Reuse, Recycle start with reduction and reuse. Real recycling nor chemical conversion would be enough to solve our plastic problem. Don't let the industry lobbyists fool you with this faulty solution. Our climate and futures are on the line.

I support this bill because I believe in recycling. The future of our world depends on reducing, reusing and recycling. Chemical recycling is decidedly none of those things. I believe that Maryland should be among the leaders of this nation on this issue. I believe that it can't be overstated that until we eliminate chemical recycling we will never truly reduce carbon emissions and pollution. I beg all senators and delegates alike ot recognize this threat and fight for a safer, more stable future for a

What is in this bill:

- Prohibit facilities that chemically convert plastic into fuels in Maryland
- Exclude certain chemical conversion processes from the definition of recycling

We encourage a FAVORABLE report for this important legislation.

Sincerely,

Jesse Chladil
3732 Roland Ave
Baltimore, MD
District 40

HB21_IndivisibleHoCoMD_FAV_RichardDeutschmann.pdf

Uploaded by: Deutschmann, Richard

Position: FAV

IndivisibleHoCoMD

HB322 – Environment – Recycling – Prohibition on the Chemical Conversion of Plastic

Testimony before Environment & Transportation Committee

January 29, 2021

Position: Favorable

Mr. Chair, Mr. Vice Chair and members of the committee, my name is Richard Deutschmann, and I represent the 700+ members of Indivisible Howard County. We are providing written testimony today in ***support of HB21***, to prohibit the Chemical Conversion of Plastic, and to stop a newly emerging toxic industry in its tracks here in Maryland. Indivisible Howard County is an active member of the Maryland Legislative Coalition (with 30,000+ members).

This bill will prohibit a number of methods of taking mostly single-use plastic produced from fracked gas, turning it back into feedstock. These methods are a sham from the petrochemical industry, generating thousands of tons of toxics into our air and water, and continuing to lock in the extraction of climate-busting fossils fuels. As we move forward with aggressive climate goals in our state, this conversion of plastics waste will make it much more difficult for us to succeed at these goals. Chemical recycling will hurt the emerging green materials business community, by artificially lowering the demand for real alternatives to the use of single use plastics. ***This is also an environmental justice issue, as these toxic facilities are planned to be located in our most vulnerable communities, adding to their burden of air pollution and associated public health effects***.

Thank you for your consideration of this important legislation.

We urge a favorable report on HB21.

Richard Deutschmann
Columbia, MD

HB21-Chemical Recycling- HoCoCA.pdf
Uploaded by: Feighner, Liz
Position: FAV

HoCoClimateAction.org
Howard County, Maryland

Testimony in SUPPORT of HB21 – Prohibition on the Chemical Conversion of Plastic
Hearing Date: January 29, 2021
Bill Sponsor: Delegate Love
Committee: Environment and Transportation
Submitting: Howard County Climate Action

Position: Favorable

HoCo Climate Action -- a 350.org local chapter and a grassroots organization representing more than 1,450 subscribers, and a member of the Howard County Climate Collaboration -- supports HB21 – Prohibition on the Chemical Conversion of Plastic.

According to an International Energy Agency report released in Oct 2018, greenhouse gas emissions from plastics are predicted to sharply rise at a critical time in which we must be reducing emissions. The oil, gas, and petrochemical industries are planning to invest more than $164 million in the US in order to rapidly expand plastic production by 40% over the next decade.

To quell growing concern, the oil, gas, and petrochemical industries are trying to convince the public that they can clean up the plastic pollution problem with technology. This is a distraction tactic to avoid talking about the only safe solution, which is to stop fracking and produce less plastic, especially single-use plastic products.

The Maryland legislature had the forethought to ban fracking to protect Marylanders from the anticipated environmental destruction and health harms. The same forethought is needed to prevent the damage from “chemical recycling” or chemical conversion of plastic.

“Chemical Recycling” is a euphemism for another toxic assault on our state. It’s an environmental health hazard particularly to already overburdened communities and workers. Every step of the process produces toxicants, from the sites where the product is burned to the facilities where the waste is sent. The chemical recycling industry is looking to expand into the same neighborhoods suffering most from the fossil fuel industry’s pollution.

“Plastics are the new villain of the climate fight, and elected officials can’t fall for industry’s claims that they have a silver bullet solution, especially when the evidence does not back up those claims,” said Denise Patel, GAIA’s US/Canada program director. “With the rising crises of climate change, pollution, and economic insecurity under the backdrop of a global pandemic, we have no more time or money to waste on dangerous tech-fixes. Policymakers need to fight climate change at the source, by pursuing policies that place limits on production and support zero waste systems.”

We need to ban this dangerous industry just as we banned fracking to protect Marylanders.

We encourage a FAVORABLE report for this essential legislation.

HoCo Climate Action
HoCoClimateAction@gmail.com
Submitted by Liz Feighner, Steering and Advocacy Committee, Laurel MD
www.HoCoClimateAction.org

HB21-Chemical Recycling-Feighner.pdf
Uploaded by: Feighner, Liz
Position: FAV

Testimony in SUPPORT of HB21 – Prohibition on the Chemical Conversion of Plastic
Hearing Date: January 29, 2021
Bill Sponsor: Delegate Love
Committee: Environment and Transportation
Submitting: Liz Feighner, Laurel MD

Position: Favorable

As a concerned resident of District 13, I support HB21 – Prohibition on the Chemical Conversion of Plastic.

I am the green team chair at my church and ran a 6-month campaign on reducing plastic usage, especially single-use plastic. I also volunteer with my local grassroots organization, HoCo Climate Action and we sponsored a webinar and film screening of the documentary, *The Story of Plastic*. We have not only in a climate crisis, we have a plastic crisis and need to act to reduce the amount of plastic being produced. According to an International Energy Agency report released in Oct 2018, greenhouse gas emissions from plastics are predicted to sharply rise at a critical time in which we must be reducing emissions. The oil, gas, and petrochemical industries are planning to invest more than $164 million in the US in order to rapidly expand plastic production by 40% over the next decade.

The oil, gas, and petrochemical industries are trying to convince the public that they can clean up the plastic pollution problem with technology, to quell growing concern about the plastic pollution crisis. This is a distraction tactic to avoid talking about the only safe solution, which is to stop fracking and produce less plastic, especially single-use plastic products.

I volunteered to help pass the ban on fracking back in 2017 and I am thankful that the Maryland legislature had the forethought to ban fracking to protect Marylanders from the anticipated environmental destruction and health harms. The same forethought is needed to prevent the damage from “chemical recycling” or chemical conversion of plastic.

“Chemical Recycling” is a euphemism for another toxic assault on our state. It’s an environmental health hazard particularly to already overburdened communities and workers. Every step of the process produces toxicants, from the sites where the product is burned to the facilities where the waste is sent. The chemical recycling industry is looking to expand into the same neighborhoods suffering most from the fossil fuel industry’s pollution.

“Plastics are the new villain of the climate fight, and elected officials can’t fall for industry’s claims that they have a silver bullet solution, especially when the evidence does not back up those claims,” said Denise Patel, GAIA’s US/Canada program director. “With the rising crises of climate change, pollution, and economic insecurity under the backdrop of a global pandemic, we have no more time or money to waste on dangerous tech-fixes. Policymakers need to fight climate change at the source, by pursuing policies that place limits on production and support zero waste systems.”

We need to ban this dangerous industry just as we banned fracking to protect Marylanders.

I encourage a FAVORABLE report for this essential legislation.

Liz Feighner, Laurel MD, District 13

hb21, plastic recycle, 1-29-21.pdf
Uploaded by: Hudson, Lee
Position: FAV

Delaware-Maryland Synod
Evangelical Lutheran Church in America
God's work. Our hands.

Testimony Prepared for the
Environment & Transportation Committee
on
House Bill 21
January 29, 2021
Position: **Favorable**

Mr. Chairman and members of the Committee, thank you for the opportunity to testify about care for the creation. I am Lee Hudson, assistant to the bishop for public policy in the Delaware-Maryland Synod, Evangelical Lutheran Church in America. We are a faith community with congregations in three synods in every part of the State.

We believe care of creation is an act of gratitude to the Giver of the natural world, and that stewardship of natural gifts is an ethical mandate. We are called to preserve what is, conserve what is needed, and restore what has been spoiled.

House Bill 21 proscribes an assortment of industrial processes for elimination and conversion of plastic products. Plastic is an exigent environmental problem; waste, disposal, and toxicity to name three public health and safety issues.

Addressing them by burning, converting, or otherwise synthesizing plastics only shifts deleterious effects into more contexts. Public authorization of those processes as recycling is not helpful because it is harmful. It is just another environmental degradation.

Therefore, we support House Bill 21 and ask a favorable report.

Lee Hudson

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HB 0021 Ban Chemical Conversion of Plastic Testimo
Uploaded by: Longabaugh, Katherine
Position: FAV

January 27, 2021

Testimony on **HB 0021**
Environment – Recycling – Prohibition on the Chemical Conversion of Plastic
Environment and Transportation Committee

Position: Favorable

Dear Chairman and Committee Members,

Thank you for considering my testimony today. My name is Katherine, a resident of Baltimore, in District 43. I am a member of the Sunrise Movement Baltimore, a movement led by young people fighting against the climate crisis. This testimony represents my support for HB 0021, Prohibition on the Chemical Conversion of Plastic Act.

Chemical conversion of plastic is simply not recycling. It is turning plastic into oil to burn as a fossil fuel, which contributes to our climate crisis. We already are seeing the flooding, extreme weather, hotter summers, and rising sea levels in Maryland. We should be reducing our use of fossil fuels, not sustaining or increasing it. Converting plastic back to fossil fuels releases huge amounts of CO_2 and other greenhouse gases. Additionally, the toxic pollution from these chemical conversion projects would likely be placed in marginalized communities already overburdened with so many polluting projects. We shouldn't allow chemical conversion of plastic in Maryland, which will only pollute our communities and exacerbate the climate crisis.

In Maryland and around the world we do indeed have a huge plastic problem, but chemical conversion of plastic is only an excuse that will do little to solve the real issue. We find so many plastics on our streets and in our waterways. Yet we can't recycle our way out of this crisis, we have to cut it at its source. We must move beyond plastic and fossil fuel dependency and instead create a circular and regenerative economy based in reuse. There's a reason the 3 R's of Reduce, Reuse, Recycle start with reduction and reuse. Real recycling nor chemical conversion would be enough to solve our plastic problem. Don't let the industry lobbyists fool you with this faulty solution. Our climate and futures are on the line.

Sunrise Movement is a movement to stop the climate crisis and create millions of green and good-paying jobs in the process. We fight against oppression and environmental racism. Allowing chemical conversion of plastic into fuel in Maryland would do the opposite of that. We young people are worried about our futures and our environment and we urge you to put us at the forefront of your decision-making.

Please:

- Prohibit facilities that chemically convert plastic into fuels in Maryland
- Exclude certain chemical conversion processes from the definition of recycling

We encourage a FAVORABLE report for this important legislation.

Sincerely,

Katherine Longabaugh
317 E 30th St
Baltimore, MD 21218
District 43

Love Testimony_HB 21_DLH (002).pdf
Uploaded by: Love , Sara
Position: FAV

Sara N. Love
Legislative District 16
Montgomery County

Environment and Transportation Committee

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THE MARYLAND HOUSE OF DELEGATES
Annapolis, Maryland 21401

HB 21 - Environment –
Recycling – Prohibition on the Chemical Conversion of Plastic

Chair Barve, Vice Chair Stein, members of the Environment and Transportation Committee. I respectfully request a favorable report on House Bill 21, proactive legislation to head off a tactic that the petrochemical industry is promoting but which, quite simply, is awful for the environment.

Introduction

This committee is well aware that we have a plastic problem. Of all of the plastic produced since 1950, 91% has not been recycled.[1] Plastic goes hopefully in the recycling bin, into the trash, or is tossed aside. It ends up in our communities, on our roadways, in our waterways. We are at a point of increased awareness of plastic pollution where people see the waste everywhere, counties are overwhelmed and facing budget problems as a result of the plastic waste, countries are refusing to take our plastic waste, governments are enacting single-use plastic bans, and consumers are choosing alternatives that are not toxic to our environment. In short, the industry is facing a market and public relations problem. But instead of creating products that aren't damaging to our environment, the industry is scaling up their production of plastic while pushing a narrative that they have the magic solution: "chemical" or "advanced recycling." We have seen this before in the 1970s, when the industry pushed "Keep America Beautiful": they continued to produce plastic while blaming the problem on litterbugs and saying everyone should just recycle. It didn't work then - just as the industry knew it wouldn't - and it doesn't work now. We should not be fooled again.

What is HB 21 about?

Chemical conversion is a plastics to pollution chemical process that essentially takes certain recycled plastics and converts them to fossil fuels that will eventually be burned. HB 21 seeks to protect Maryland's air and water from being polluted by these harmful byproducts by prohibiting the construction of any plastic-to-fuel chemical conversion facility in the State. Additionally, it clarifies Maryland's definition of recycling to exclude certain chemical conversion processes.

To be clear, the goal of the bill is to ban plastic-to-fuel processes, *not* plastic-to-plastic processes. The processes the bill addresses take plastic, chemically treat it, and turn it into something is then burned as a fossil fuel.

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[1] Geyer, R., Jambeck, J., & Law, K. (2017). Production, Use, And Fate of All Plastics Ever Made. Science Advances, 3(7), e1700782. https://doi.org/10.1126/sciadv.1700782

Chemical conversion is bad for the environment.

There are many problems with chemical conversion. In essence, they all boil down to the fact that it is bad for the environment. First, it is bad for the environment from the standpoint of carbon emissions and the release of toxic chemicals.

- The chemical conversion process has a large carbon footprint and releases toxic chemicals into the environment.[2]
- Only a small portion of the plastic that goes into the process comes out as a potential fuel. The rest – over half – comes out as toxins.[3]
- Of the small portion that is converted to fuel, that itself is a fossil fuel, burned and sending toxic emissions into our environment.

Second, chemical conversion allows for the continued and increased production of plastic. It continues to feed into and further the narrative that we can continue to extract fossil fuels and produce plastic to our hearts' content with no consequences. This is simply false. There are consequences. In addition to the ones mentioned above:

- It doesn't reduce the waste stream. Our counties and municipalities will still be burdened with having to collect and deal with the plastic waste.
- It doesn't address the plastic pollution that ends up in our communities, on our roads, and in our waterways.
- It gives false hope that all plastics can continue to be produced because they will be 'taken care of' – but this process needs a specific type of plastic. A lot of the single use products – the straws, bags, sachets, utensils, etc. – are not what is feeding the process. So on the one hand the industry can push production of those plastics while on the other hand pushing the narrative that chemical conversion is the answer, when, in fact, chemical conversion doesn't address a lot of these products.

We know how to address the plastic crisis.

We all know the phrase, "reduce, reuse, recycle." Reduce is the first word in this paradigm because it is the most important. In order to address our plastic crisis we must start with reduction. We must reduce our use of plastic. Then, when we do use plastics, we need to reuse them. And finally, after we have used them and reused them, we need to recycle them.

Chemical conversion turns that paradigm on its head, by elevating recycling as the first and only step. If the petrochemical industry can focus our attention on the last part (recycle), maybe we will forget the first part (reduce) and they can continue to pump out plastics. In other words, the industry hopes that if we believe they can convert, there is no need to reduce and they can not only continue production, but increase it.

We have solid, proven answers on how to address the plastic crisis: reduce the amount of plastic used through single-use bans and other policies; producer responsibility systems that bring the

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[2] https://www.no-burn.org/wp-content/uploads/All-Talk-and-No-Recycling_July-28.pdf; see also attached graphic in Annex

[3] https://www.no-burn.org/wp-content/uploads/revised-CR-1-pger.pdf

industry making the product into the solution of how to handle it; incentivizing the market for the reuse of products. These policies work and we should not be fooled by something that sounds like the magical answer. If it sounds too good to be true, it is.

This bill is needed now.

The petrochemical industry is pushing the narrative in federal and state policy. In October 2020, the U.S. Department of Energy announced over $27 million in funding for 12 projects that will support the development of certain plastic technologies, including chemical recycling.[4] Across the country, state by state, the petrochemical lobby is embedding in state law definitional changes that will enable them to build these facilities, use taxpayer dollars, and avoid regulations.[5] They are doing so by using the word "recycling" and convincing legislators that this is an environmentally friendly and exciting new technology that can solve all the plastic problems. It is not environmentally friendly, it is not a new technology, and far from solving the problem, it will only exacerbate it.

In 2017 Maryland banned fracking. This General Assembly passed it and our Republican Governor signed it. But it took years to ban a process that was known all along to be an environmental nightmare. We do not want to be 10 years down the line, millions of taxpayer dollars invested and wasted, only to have to ban this process because it is destroying our environment. We have the opportunity to get in front of this, before it becomes an environmental nightmare.

Final note

One could argue that "chemical recycling" technically meets the criteria in the standard definition of recycling: "the action or process of converting waste into reusable material." However, as a society we understand the term "recycling" to include an ethical component. We understand recycling as an inherently good process because it benefits the earth. This chemical conversion process does not benefit the earth. The industry behind it is cleverly using the language and wrapping themselves up in a PR-friendly package called "advanced recycling." The industry is intentionally obscuring and neglecting the key component of recycling which is that it is good for the environment. So the issue is not whether this fits the definition of recycling, but the fact that chemical conversion is detrimental to the environment and has catastrophic consequences for our planet.

Conclusion

Maryland is a state with bold climate goals, a state that banned fracking, a state that is committed to reducing our carbon footprint through many different policies addressing electrification of our vehicles, incentivizing composting, planting trees, and so much more. These are policies we address every day in our committee in our goal to ensure a healthy planet for us and our children. It is antithetical to this commitment to set up a new petrochemical infrastructure.

For the foregoing reasons, I respectfully request a favorable report on HB 21.

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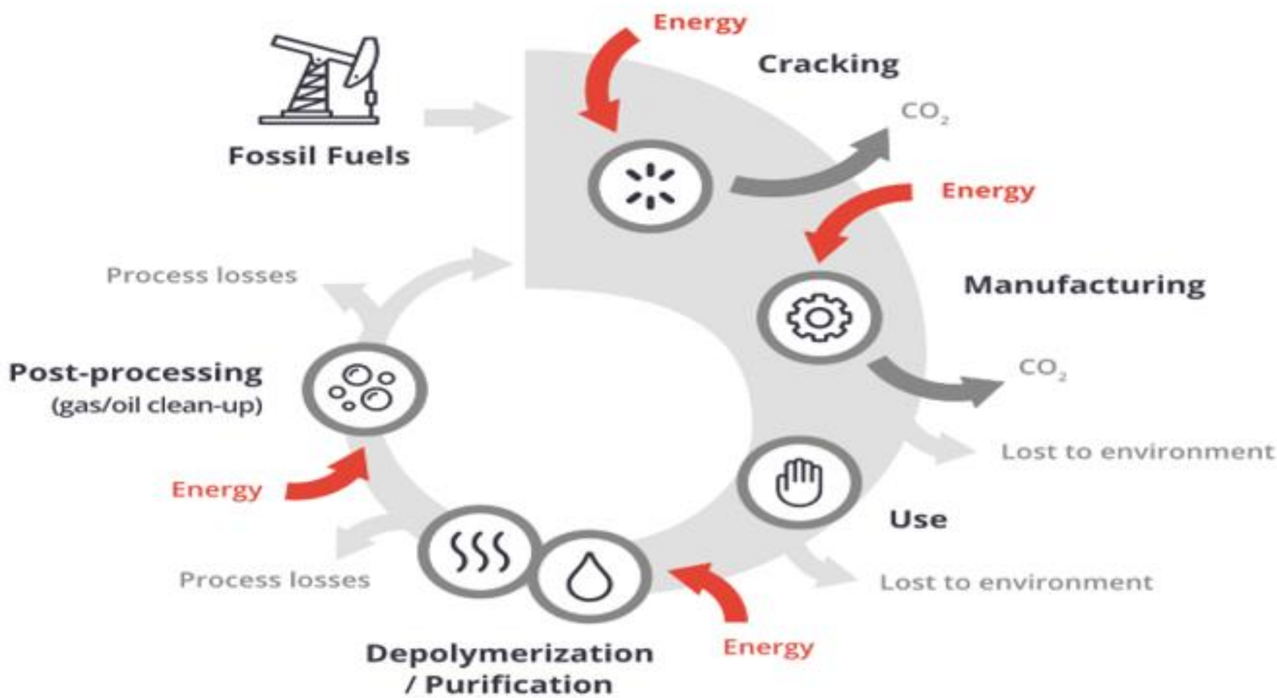
[4] https://www.energy.gov/articles/us-department-energy-announces-27-million-plastics-recycling-research-and-development

[5] https://www.no-burn.org/https-www-no-burn-org-legislativealert/

ANNEX



Energy
Cracking
Fossil Fuels
CO_2
Energy
Manufacturing
Process losses
Post-processing
(gas/oil clean-up)
CO_2
Lost to environment
Energy
Use
Process losses
Lost to environment
Depolymerization
/ Purification
Energy

Love Testimony_HB 21_FAQs_Chemical-Recycling.pdf

Uploaded by: Love , Sara

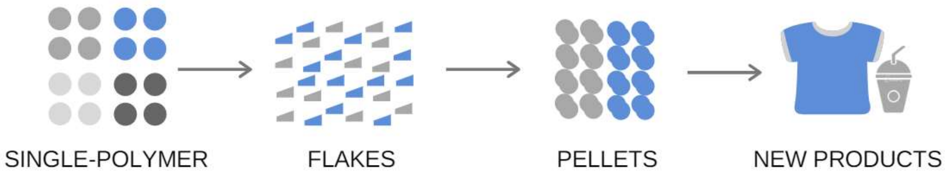
Position: FAV

QUESTIONS AND ANSWERS: CHEMICAL RECYCLING

Q. How is plastic recycled?

A. Plastic is collected, sorted, washed, ground into flakes, sorted again, and then melted into pellets, which are used to make new products. This process is called "mechanical recycling." Recently, the plastics industry has been proposing the use of new technologies that they call "chemical recycling."

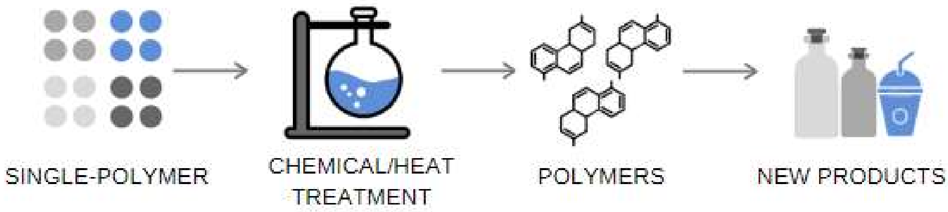
Mechanical Recycling:



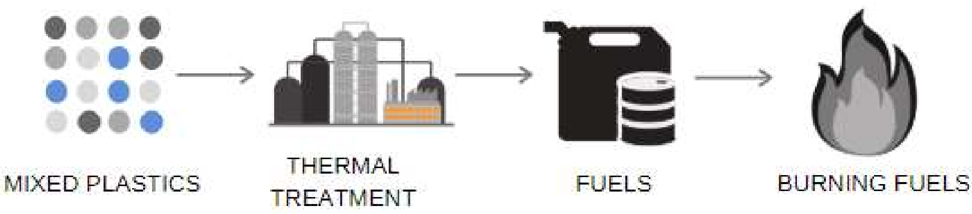
Q. What is chemical recycling?

A. "Chemical recycling" is an industry greenwash term used to lump together various plastic-to-fuel and plastic-to-plastic technologies. These processes turn plastic into liquids or gases which could be used to make new plastic but in practice are usually burned. The terms "pyrolysis", "solvolysis", and "depolymerization" are also used to refer to different technological variants of this process. **Whatever the process is called, if the end-products are burned, it's plastic-to-fuel.**

Repolymerization:



Plastic-to-Fuel:



Q. Why is it called recycling?

A. In principle, the liquids and gases can be turned back into plastic, a process which is better called "repolymerization." However, this is at present technically challenging and uneconomical. Industry uses the term "chemical recycling" to deliberately blur the distinction between recycling (plastic to plastic repolymerization) and incineration (plastic-to-fuel).

Q. Why is it important to distinguish plastic-to-plastic from plastic-to-fuel?

A. Repolymerization produces new plastic, which reduces the demand for fossil fuels, lessening the environmental impact of producing plastic. Turning plastic into fuel to be burned does nothing to address the many forms of pollution created by producing ever-increasing quantities of plastic. The European Union's Waste Framework Directive is crystal clear that producing fuels from waste cannot be labeled or counted as "recycling."

Q. Is plastic-to-fuel climate-friendly?

A. No, almost all plastic is made from oil and natural gas, so **it is still a fossil fuel**. Greenhouse gases are released in the production of plastic, in transforming it into fuel, and in burning the fuel.

Q. Are there other problems with plastic-to-fuel?

A. Plastic-to-fuel facilities are both waste and petrochemical factories, with the ensuing toxic emissions, liquid effluent, and solid waste. In addition, the plastic-derived fuel releases toxic substances when burned. Plastic-to-fuel technology is energy inefficient and costly, and has had several high-profile failures, including facility fires and explosions.

The problems of plastic-to-fuel

Q. Is repolymerization economical?

A. Repolymerization requires collecting post-consumer plastic, cleaning it, and sorting it according to polymer type and additives. This is highly expensive. Meanwhile, new polymer made from fracked natural gas is very cheap, so plastic manufacturers use new polymer rather than recycled polymer, further adding to the plastics and climate crises. Repolymerization is even more expensive than mechanical recycling, which is struggling to find markets.

Q. How does repolymerization compare with traditional (mechanical) recycling?

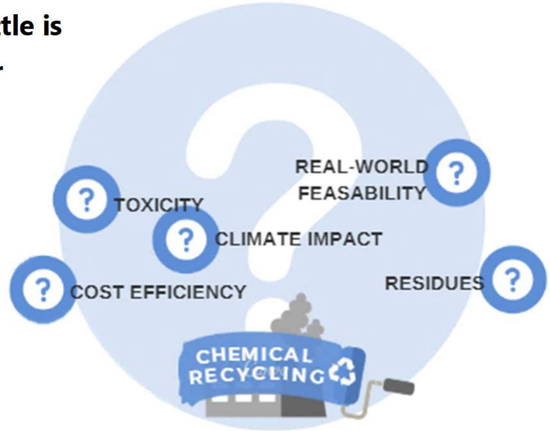
A. Both usually require input streams that consist of a single type of plastic (polymer). Mechanical recycling generally downgrades plastic by shortening the polymer length. It also has trouble with additives and contaminants in the plastic. Repolymerization can produce plastic that is similar in quality to new plastic. It is also more tolerant of some additives and contaminants. However, repolymerization is much more energy-intensive than mechanical recycling, resulting in greater greenhouse gas emissions.

Q. What is the operational history of "chemical recycling"?

A. Most plants that claim to do chemical recycling are turning plastic into fuel. A few pilot-scale projects do produce plastic, but they handle relatively limited inputs, not the full range of plastic waste. Many such plants use pyrolysis, which is not a new technology; it has been around for decades, but has never been technically or commercially successful. Despite the industry hype, the European Union Commission has said that repolymerization technology is at least ten years away from commercial application -- far too long to tackle the climate and pollution issues posed by plastics.

Q. What is the environmental track record for repolymerization?

A. Because the operators are not forthcoming with their emissions data, **little is known about these technologies' toxic air emissions, liquid effluent, or solid waste streams**, but they are probably comparable to other petrochemical facilities. A particular concern is the fate of contaminants and additives, including toxic metals, in the plastic, and their post-processing management. These questions will need to be impartially studied under real-world operating conditions to understand the full environmental impact of repolymerization.



Q. If "chemical recycling" is an immature technology, why are we hearing so much about it?

A. The oil, gas, and petrochemical industries are rapidly expanding plastic production; they aim to increase 40% in the next decade. To quell growing concern, they are trying to convince the public that they can clean up the plastic pollution problem with technology. This is a distraction tactic to avoid talking about the real solution, which is to stop fracking and produce less plastic, especially single-use plastic products.

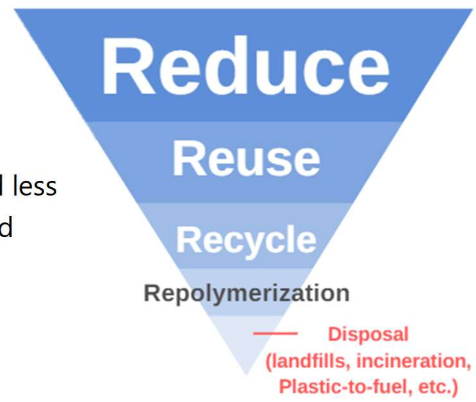
Q. Who is promoting these technologies?

A. The chemical recycling companies are pretty small, but they are financially backed by the oil and gas majors, incineration giants, and large petrochemical firms. For example, a major promoter is the Alliance to End Plastic Waste, which includes BASF, ExxonMobil, Occidental Petroleum, PepsiCo, Reliance Industries, SABIC, Shell Oil, Suez, and Veolia among others.

Q. How should "chemical recycling" be regulated?

A. Regulations should clearly distinguish between repolymerization and plastic-to-fuel. Plastic-to-fuel should be phased out, along with other fossil fuels. Repolymerization should not benefit from subsidies, regulatory incentives, or environmental deregulation. These could help it compete against preferable activities including mechanical recycling, which has a smaller carbon footprint and less toxic byproducts. Such facilities must be carefully monitored for toxic and greenhouse gas emissions, waste and effluent handling.

Repolymerization in the waste hierarchy



Q. What should we do with plastics that cannot be safely recycled?

A. Landfilling plastic is the "least bad" option; plastics in landfills are relatively inert, as long as the landfills do not burn. Incineration and plastic-to-fuel are worse; they release large quantities of greenhouse gases and toxic air emissions. Open dumping of plastic is problematic for other reasons: it creates microplastics, threats to wildlife, water pollution, and more. The real solution is to stop making so much plastic, beginning with hard-to-recycle, disposable, and single-use plastics.

So what is the real solution to the plastic problem?

Make LESS Plastic. It's that simple.

Glossary

- **Depolymerization:** One of several technologies that breaks plastic down into its constituent building blocks.
- **Effluent:** Liquid waste, generally requiring wastewater treatment.
- **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.
- **Pyrolysis:** The process of heating waste in the absence of oxygen to produce a liquid or gas fuel.
- **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.
- **Solvolysis:** Technologies that use solvents to depolymerize plastic.

Resources

- **[Report]** Zero Waste Europe. (2019). El Dorado of Chemical Recycling, State of play and policy challenges.
- **[Report]** GAIA. (2017). Waste Gasification & Pyrolysis: High Risk, Low Yield Processes for Waste Management
- **[Journal article]** Rollinson, A. (2018). Fire, explosion and chemical toxicity hazards of gasification energy from waste. Journal of Loss Prevention in the Process Industries, 54, pp.273-280.
- **[Journal article]** Rollinson, A. and Oladejo, J. (2019). 'Patented blunderings', efficiency awareness, and self-sustainability claims in the pyrolysis energy from waste sector. Resources, Conservation and Recycling, 141, pp.233-242.
- **[Briefing]** GAIA. (2018). False solutions to the plastic pollution crisis
- **[Campaign]** GAIA. (2018). Say NO to Dow's Dirty Energy Bag!

This publication was made possible in part through funding support from the Plastic Solutions Fund.

MD-ChemicalConversionTestimony-1.27.21.pdf

Uploaded by: Ross, Jacob

Position: FAV

OCEANA

Bill: HB 21

Date: January 27, 2021

Position: Support

Prohibition on the Chemical Conversion of Plastic

HB 21

Support

Dear Chair Barve and Members of the Environment and Transportation Committee,

Thank you for the opportunity to testify on behalf of HB 21, a Prohibition on the Chemical Conversion of Plastic. Oceana is the largest international advocacy organization dedicated solely to ocean conservation. With our 17,800 supporters across Maryland, we work to advance science-based policies at the federal, state, and local level that will restore the ocean's abundance and biodiversity. We submit this testimony to share our strong support for SB 21 and urge you to pass this important legislation.

Plastic pollution is a growing threat to the world's oceans, as well as our food, health and climate. Each year, an estimated 33 billion pounds (15 million metric tons) of plastic enters the marine environment.[i] This is roughly equivalent to two garbage trucks full of plastic being dumped into the oceans every minute.

Everything from salt to water to beer has been found to contain plastics.[ii] Plastics are making their way into our food, water and air, and harming our ocean ecosystems and marine species, including here in Maryland. According to a 2014 study, microplastics were found in 59 out of 60 water samples from the

Chesapeake Bay and its tributaries.[iii] In a report published in 2020, Oceana found evidence of nearly 1,800 marine mammal and sea turtles from 40 different species swallowing or becoming entangled in plastic in U.S. waters since 2009.[iv] Of those animals, a staggering 88% were from species listed as endangered or threatened with extinction under the Endangered Species Act

While we begin to realize the extent of plastic pollution's effects, plastic production continues to increase at a rapid rate. Global production of plastic is now projected to increase at least fourfold between 2014 and 2050.[v]

Traditional, mechanical recycling is not enough to solve the plastic pollution crisis, and neither is chemical conversion, or what some call "chemical recycling," when often the products are fuels to be burned. Waste-management solutions have not adequately dealt with plastic pollution in the past and cannot realistically keep up with the rising rates of plastic production. Only 9% of all the plastic waste ever produced has been recycled. [vi] The rest of it ends up either in an incinerator, a landfill or the environment.

Instead of ceasing to manufacture single-use plastic and materials that cannot be recycled with existing technology, the plastics industry is selling the idea of "chemical recycling" as a panacea to our plastic waste crisis. In reality, these technologies would require enormous costs and take decades to bring to scale — in fact, even the petrochemical industry acknowledges that a circular economy based on these technologies is not currently feasible.[vii] Even if ambitious targets for growth are met (600 plants handling 6 million tons per year), as the American Chemical Council predicts, that would handle only *one-fifth* of the plastic waste generated.[viii]

On top of the feasibility issue, chemical conversion poses environmental risks. Plastic products are made with myriad chemicals, many of which pose risks to the environment or human health, so breaking them down will always result in a troublesome stream of contaminants. Chemical recycling methods, such as pyrolysis and gasification expel these contaminants in the form of hazardous emissions and greenhouse gasses, making this "solution" just as irresponsible as incineration.[ix,x,xi,xii,xiii,xiv]

In short, chemical conversion facilities are unproven, costly technologies that face barriers in low recycling collection rates and often result in expensive fuels rather than recycled products while generating toxic waste streams at taxpayer expense.

The most effective way to stem the overwhelming flow of single use plastic into our oceans and communities is to enact policies governing its production and use. We must not lose valuable time, energy, or funds supporting the costly production of chemical conversion facilities, which do not address the problem of plastic pollution and in fact create even more environmental hazards.

We strongly support SB 21, which would safeguard Maryland from the hazards created by chemical conversion facilities and allow lawmakers and communities to continue implement smart policies that address the issue of plastic waste the source.

We thank you for the opportunity to testify and urge you to pass this important legislation to reduce plastic pollution. Thank you.

Sincerely,

Jacob Ross, Mid Atlantic Campaign Organizer, Oceana

jross@oceana.org

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[i] Forrest A, Giacovazzi L, Dunlop S, *et al.* (2019) Eliminating Plastic Pollution: How a Voluntary Contribution From Industry Will Drive the Circular Plastics Economy. *Frontiers in Marine Science* 6: 627.

[ii] Kosuth M, Mason SA and Wattenberg EV (2018) Anthropogenic contamination of tap water, beer, and sea salt. *PLOS ONE* 13. doi: 10.1371/journal.pone.0194970

[iii] Yonkos LT, Friedel EA, Perez-Reyes AC, Ghosal S and Arthur CD (2014) Microplastic in four estuarine rivers in the Chesapeake Bay, U.S.A. *Environmental Science & Technology* 48: 14195-14202. doi: 10.1021/es5036317

[iv] Warner K, Linske E, Mustain P, Valliant M, Leavitt C (2020) Choked, Strangled, Drowned: The plastic crisis unfolding in our oceans. Oceana, Washington, DC. doi: 10.5281/zenodo.4281302

[v] -- (2016) The New Plastics Economy: Rethinking the future of plastics. World Economic Forum. 36p.

[vi] Ibid.

[vii] -- (2018) In My Opinion: Launchpad for circularity. In: Resource Recycling News.

[viii] Royte E (2019) Is burning plastic waste a good idea? In: Environment. Available: https://www.nationalgeographic.com/environment/2019/03/should-we-burn-plastic-waste/. Accessed Aug 28, 2019.

[ix] GAIA (2017) Waste Gasification & Pyrolysis: High Risk, Low Yield Processes for Waste Management. Global Alliance for Incinerator Alternatives.

[x] Conesa JA, Font R, Fullana A, et al. (2009) Comparison between emissions from the pyrolysis and combustion of different wastes. Journal of Analytical and Applied Pyrolysis 84: 95–102. doi: 10.1016/j.jaap.2008.11.022

[xi] Chen D, Yin L, Wang H and He P (2014) Pyrolysis technologies for municipal solid waste: A review. Waste Management 34: 2466–2486. doi: 10.1016/j.wasman.2014.08.004

[xii] Garrido MA, Font R and Conesa JA (2017) Pollutant emissions from the pyrolysis and combustion of viscoelastic memory foam. Science of The Total Environment 577: 183–194. doi: 10.1016/j.scitotenv.2016.10.159

[xiii] Thunman H, Berdugo Vilches T, Seemann M, et al. (2019) Circular use of plastics-transformation of existing petrochemical clusters into thermochemical recycling plants with 100% plastics recovery. Sustainable Materials and Technologies 22: e00124. doi: 10.1016/j.susmat.2019.e00124

[xiv] Zhou H, Wu C, Onwudili JA, et al. (2016) Influence of process conditions on the formation of 2–4 ring polycyclic aromatic hydrocarbons from the pyrolysis of polyvinyl chloride. Fuel Processing Technology 144: 299–304. doi: 10.1016/j.fuproc.2016.01.013

Chemical Conversion of Plastic Act.pdf
Uploaded by: Shangold, Natasha
Position: FAV

Dear Members of the Environment and Transportation Committee,

I am writing to request a favorable report on HB0021 Prohibition on the Chemical Conversion of Plastic.

- **Industry misuses the terms "chemical recycling" or "advanced recycling," when in fact, most facilities are not operational, and the few that are are primarily Plastic-to-Fuel (PTF).** Plastic-derived fuels are fossil fuels that spend a very small portion of their lifecycle as plastic. This is not recycling, it is an expensive and complicated way to burn fossil fuels.
- **"Chemical Recycling" is an industry greenwashing tactic, undermining real solutions to the plastics crisis.** The fossil fuel industry is investing over $164 billion in expanding plastic production in the U.S., 35 times the amount that they claimed to invest in "chemical recycling."
- **"Chemical Recycling" is a bad investment.** "Chemical recycling"(aka plastic-to-fuel) is competing against, *and losing to*, virgin plastic production. High likelihood of technical failure has also squandered investment. As of 2017, similar technologies have wasted at least $2 billion of investments with canceled or failed projects across the globe.
- **"Chemical recycling" has a large carbon footprint**, and poses a climate risk. Over half of the plastic that is processed in these facilities is released as climate pollution (CO_2). That's on top of the emissions from burning the resulting fuel.
- **"Chemical Recycling" is an environmental health risk, particularly to already overburdened communities.** Every step of the process produces toxicants, from the sites themselves, where the product is burned, and at the facilities where the waste from the process goes, oftentimes in environmental justice communities. The chemical recycling industry is looking to expand into the same neighborhoods suffering from fossil fuel industry pollution.

Thank you for your consideration.

Thanks Always,
Natasha Shangold
8937 Skyrock Ct
Columbia, MD 21046

Copy of HB 0021 Ban Chemical Conversion of Plastic

Uploaded by: Sherman, Molly

Position: FAV

January 27, 2021

Testimony on **HB 0021**
Environment – Recycling – Prohibition on the Chemical Conversion of Plastic
Environment and Transportation Committee

Position: Favorable

Dear Chairman and Committee Members,

Thank you for considering my testimony today. My name is Molly Sherman, a resident of Dickerson, in District 15. I am a member of the Sunrise Movement Baltimore, a movement led by young people fighting against the climate crisis. This testimony represents my support for HB 0021, Prohibition on the Chemical Conversion of Plastic Act.

Chemical conversion of plastic is simply not recycling. It is turning plastic into oil to burn as a fossil fuel, which contributes to our climate crisis. We already are seeing the flooding, extreme weather, hotter summers, and rising sea levels in Maryland. We should be reducing our use of fossil fuels, not sustaining or increasing it. Converting plastic back to fossil fuels releases huge amounts of CO_2 and other greenhouse gases. Additionally, the toxic pollution from these chemical conversion projects would likely be placed in marginalized communities already overburdened with so many polluting projects. We shouldn't allow chemical conversion of plastic in Maryland, which will only pollute our communities and exacerbate the climate crisis.

In Maryland and around the world we do indeed have a huge plastic problem, but chemical conversion of plastic is only an excuse that will do little to solve the real issue. We find so many plastics on our streets and in our waterways. Yet we can't recycle our way out of this crisis, we have to cut it at its source. We must move beyond plastic and fossil fuel dependency and instead create a circular economy based in reuse. There's a reason the 3 R's of Reduce, Reuse, Recycle start with reduction and reuse. Real recycling nor chemical conversion would be enough to solve our plastic problem. Don't let the industry lobbyists fool you with this faulty solution. Our climate and futures are on the line.

I want to be able to breathe air and know that it's not toxic for myself, my family, and my livestock. I would like to be able to support businesses and know that my consumption is not contributing to air that harms the people I love in Maryland. I believe that we should, and can, live in a world where our air does not have to be toxic for anyone. And Maryland can do it. So, let's:

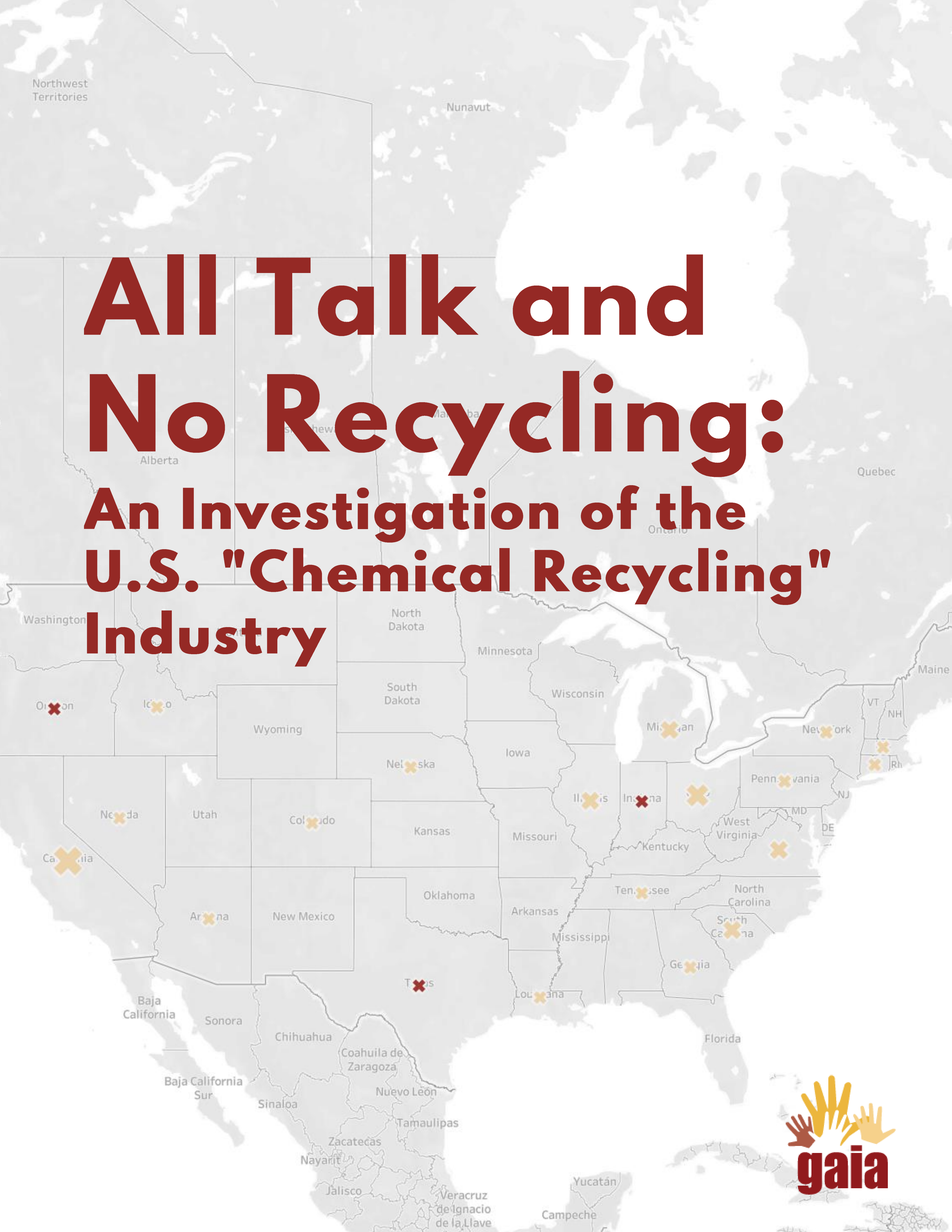
- Prohibit facilities that chemically convert plastic into fuels in Maryland

- Exclude certain chemical conversion processes from the definition of recycling

We encourage a FAVORABLE report for this important legislation.

Sincerely,

Molly Sherman
17410 Ryefield Ct
Dickerson
District 15



All Talk and No Recycling:

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

gaia

ACKNOWLEDGMENTS

This report was authored by Denise Patel, Doun Moon, Neil Tangri, and Monica Wilson. It was edited by Denise Patel and Doun Moon, with additional support from Alexandra Rollings. Andrew Rollinson provided technical analysis of the case study on Agilyx. Jan Dell verified the analysis of all existing chemical recycling projects. Other contributors to this report include Claire Arkin, Kate Bailey, Kate Davenport, Ivy Schlegel, and Janek Vahk.

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Cite this report as: Patel, D., Moon, D., Tangri, N., Wilson, M. (2020). All Talk and No Recycling: An Investigation of the U.S. "Chemical Recycling" Industry. Global Alliance for Incinerator Alternatives.
www.doi.org/10.46556/WMSM7198

Available online at: www.no-burn.org/chemical-recycling-us

1958 University Avenue, Berkeley, CA 94704, USA
www.no-burn.org

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.

Design/layout: Doun Moon
Image sources: ©Freepik

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.

TABLE OF CONTENTS

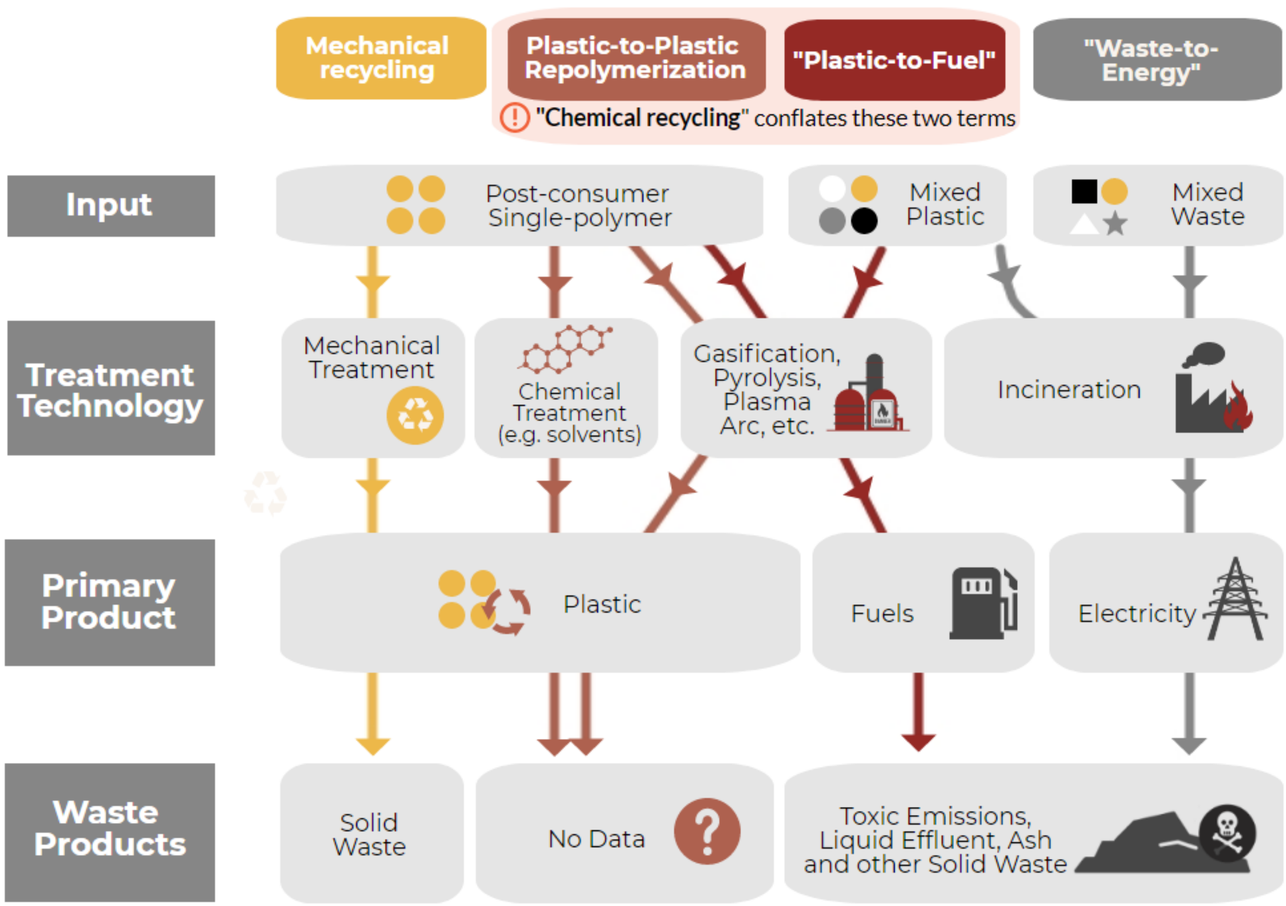
Section I

Section II: Case Studies

“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”

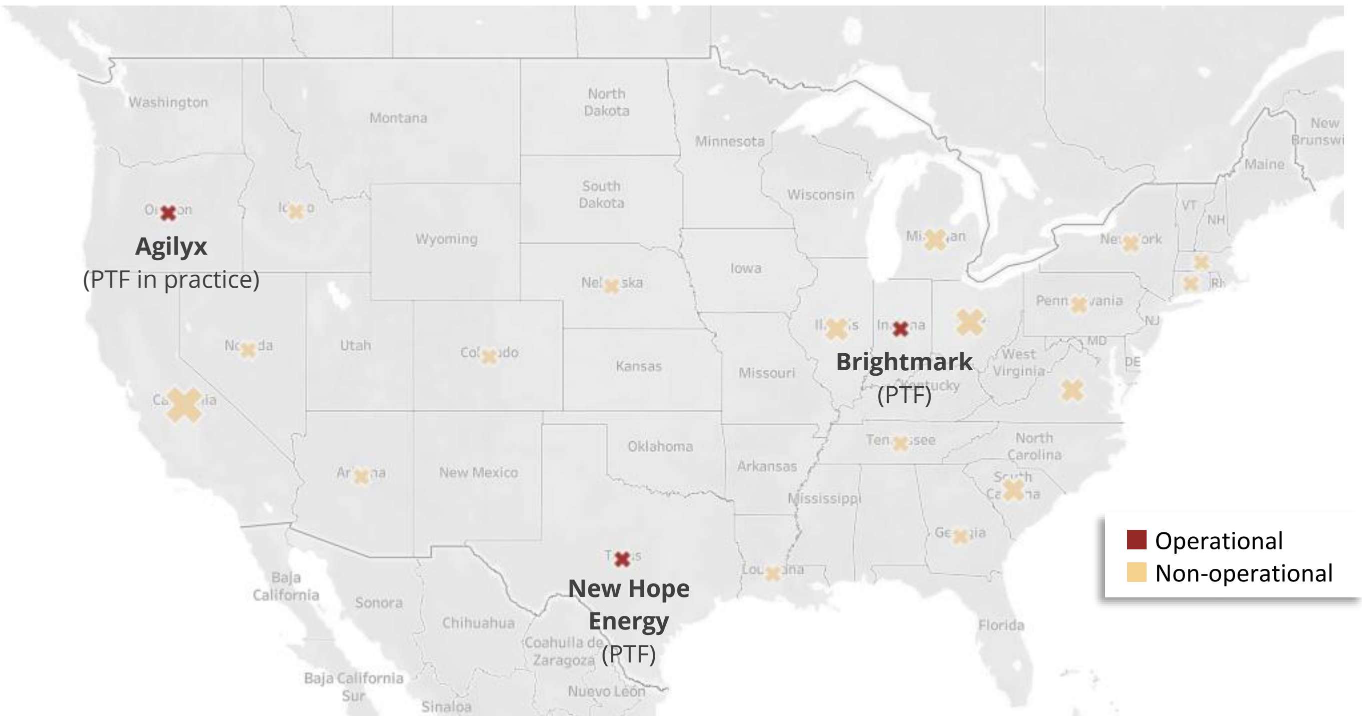


Source: Global Alliance for Incinerator Alternatives. (2019)

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

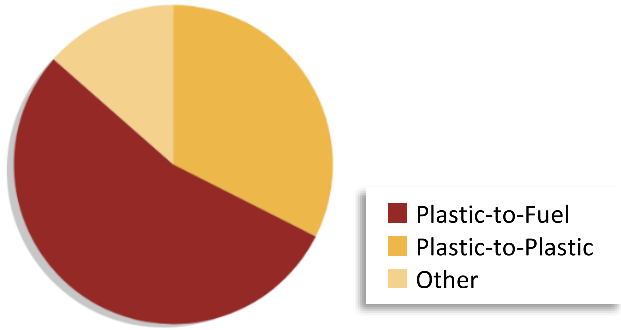
For decades, pyrolysis and gasification companies have promoted themselves as an alternative solution to waste disposal, securing significant funds from investors and governments with no concrete evidence to support their viability claims. Yet pyrolysis and gasification technologies have been around 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.

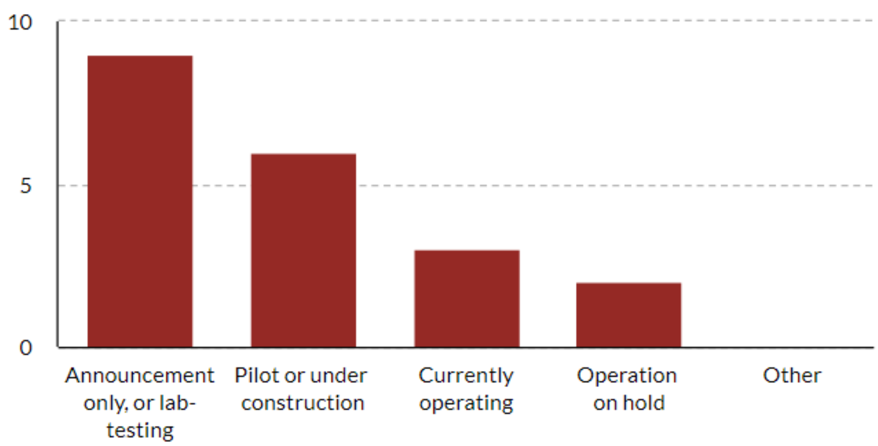


	PTP*	PTF	Other**	Total
Number of facilities	12	20	5	37
Percentage	32%	54%	14%	100%

* 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.

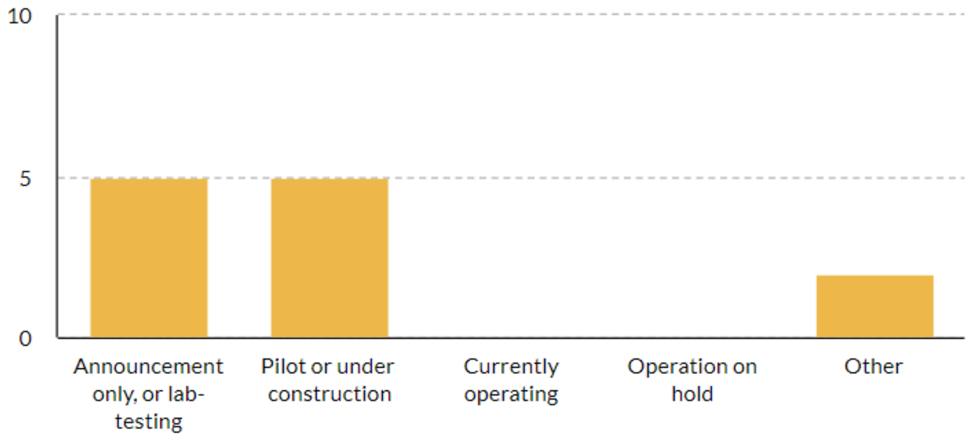
** Projects that appeared in industry/research reports as a "chemical recycling project," but do not represent an independently operating "chemical recycling" facility. These projects are either waste-to-energy facilities or a partner or buyer of a "chemical recycling" company.

[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.

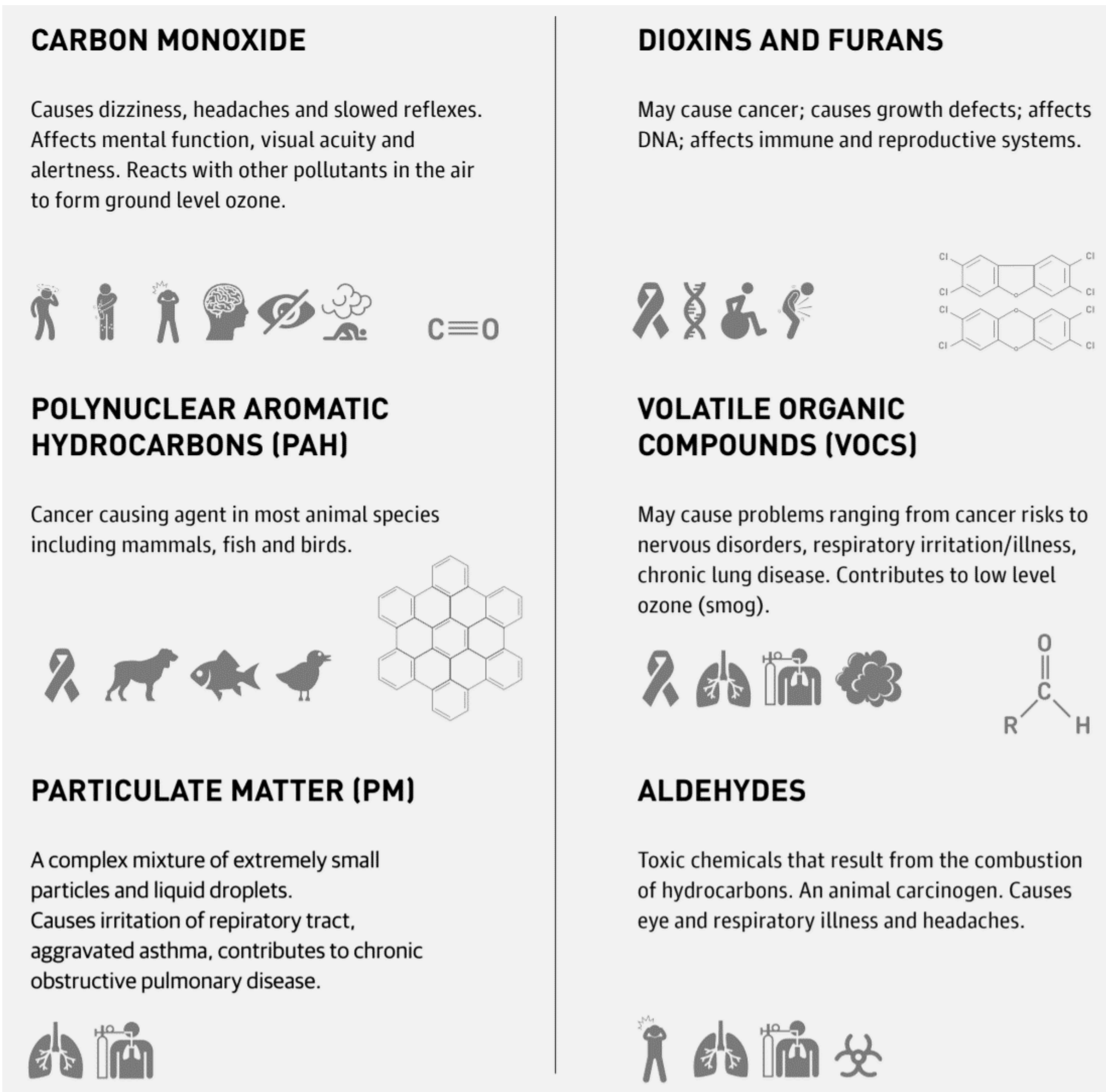
2 Plastic-to-Fuel facilities and their products endanger human health

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



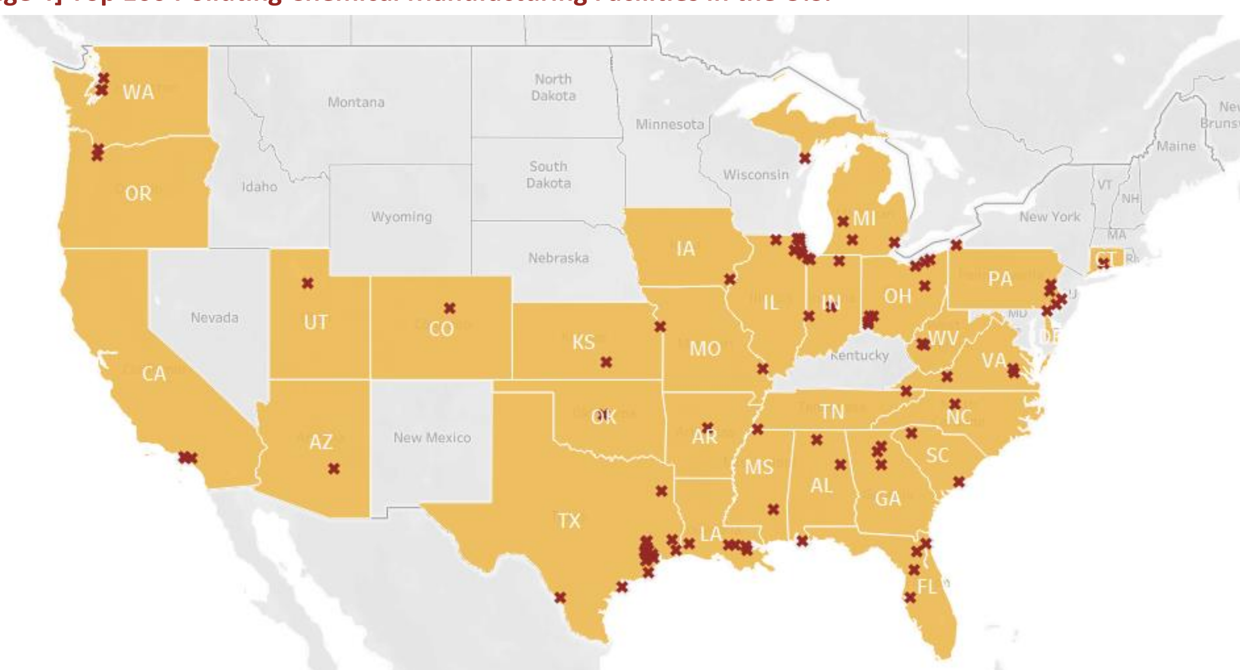
Source: Wilson, M. et al. (2017). Green businesses and cities at risk: How your waste management plan may be leading you in the wrong direction. Global Alliance for Incinerator Alternatives, The Tishman Environment and Design Center at The New School.

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

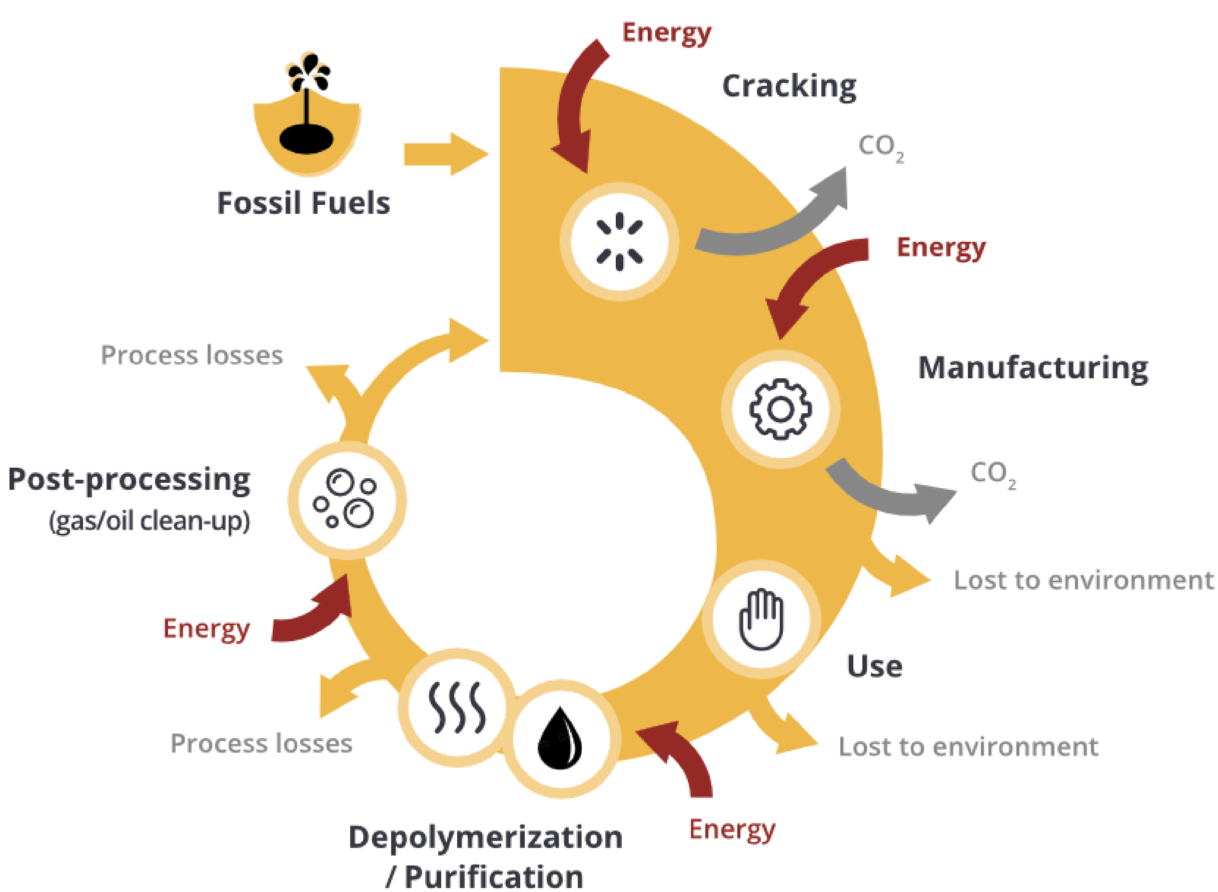
Although industry includes PTF operations under the term “chemical recycling,” recycling properly only refers to processes that result in similar products. PTF is not a form of recycling because it does not replace virgin plastic, does not contribute to a circular economy in plastic, and does not avoid 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]

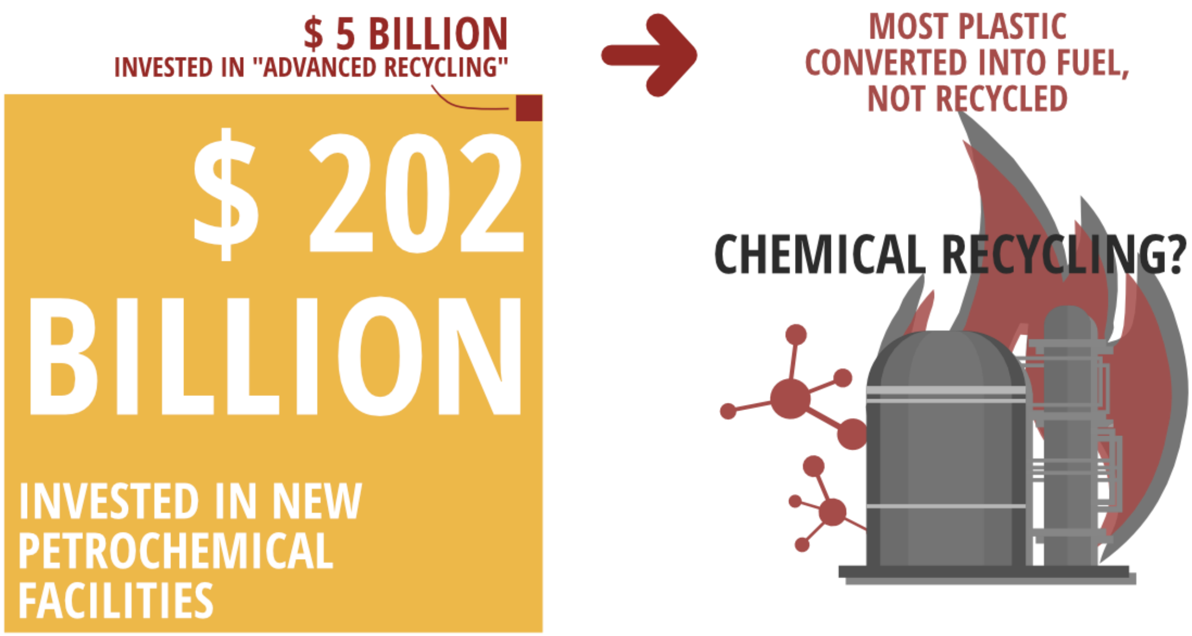
Meanwhile, cheap virgin plastic continues to flood the marketplace in the U.S. and around the world. Much of this material is difficult or impossible to recycle, and the low price of virgin plastic undercuts plastic recycling markets, exacerbating the problem of plastic waste and pollution. That said, 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



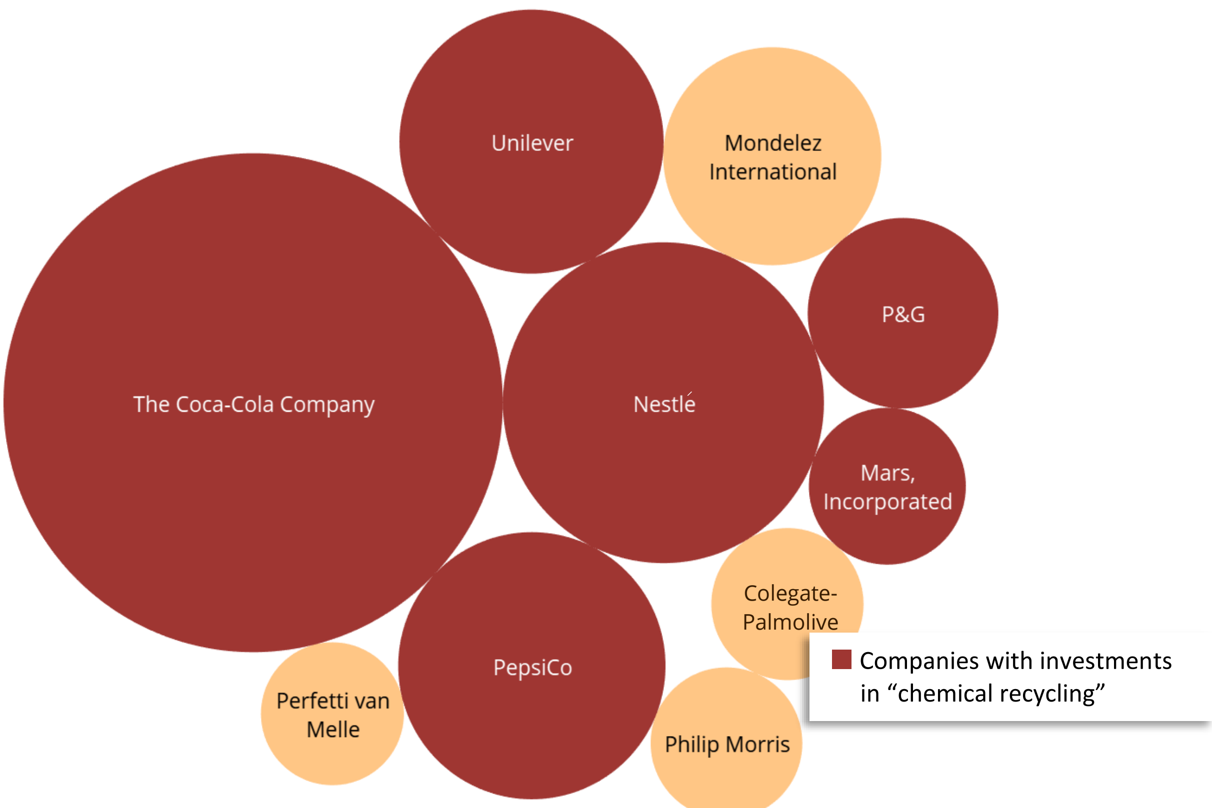
Source: American Chemistry Council (September, 2018). U.S. Chemical Investment Linked to Shale Gas: $202 Billion and Counting [press release].

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.

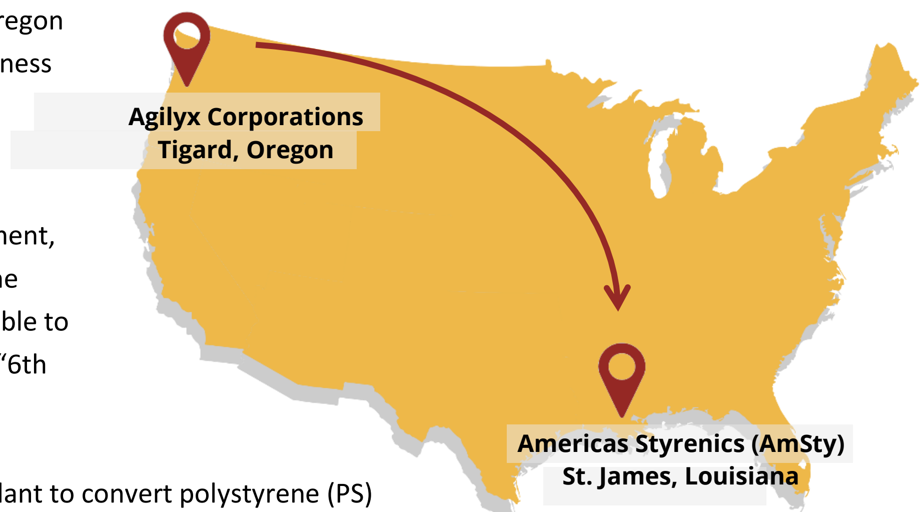
In addition, the economic outlook of the “chemical recycling” industry is highly uncertain and is subject to downside risks. Even before the impact of the COVID-19 pandemic, low oil and gas prices reflected the systemic weakness of the fossil fuel industry in the era of decarbonization. Low fossil fuel 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]

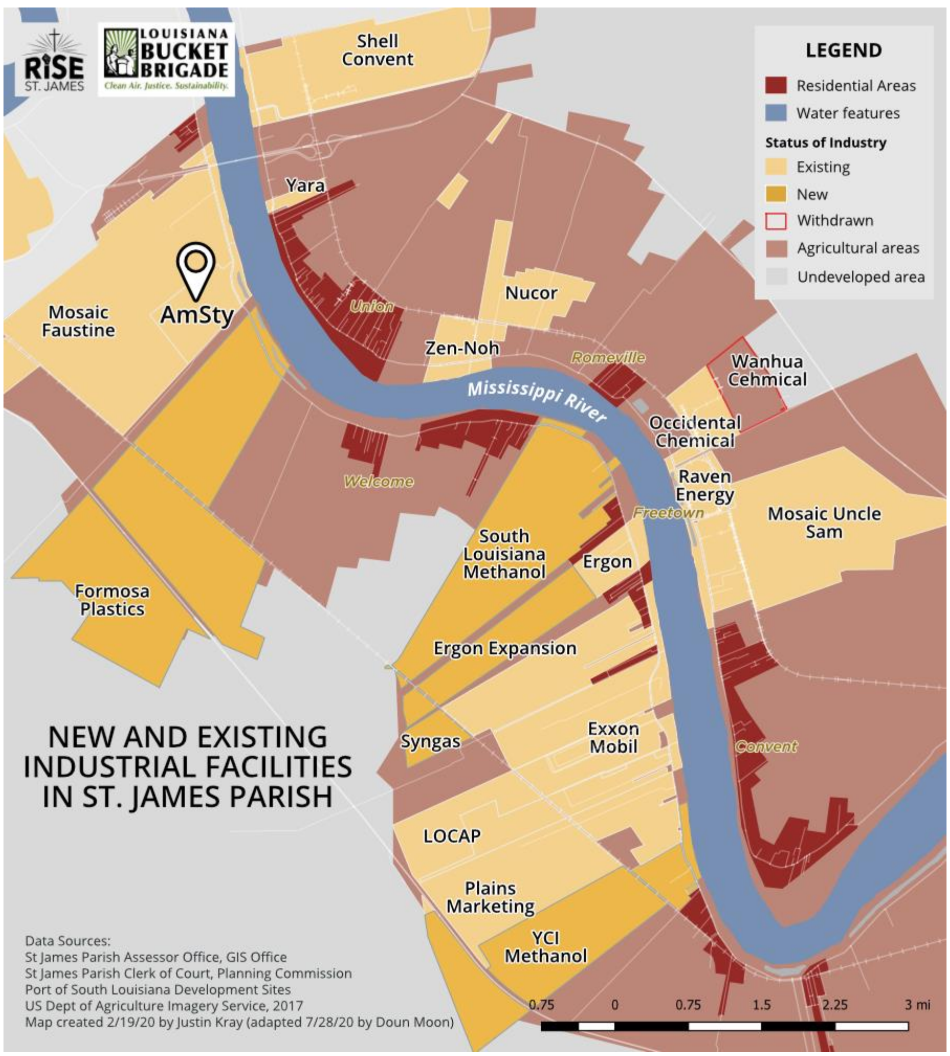
An investigation into the company's project in Oregon reveals a long history of technological false starts that cost investors millions of dollars[65] and did more environmental harm than good. Its first demonstration pyrolysis plant in Tigard, Oregon, was built in 2010 and received at least $25 million 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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Chemical Recycling:

Status, Sustainability, and Environmental Impacts

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01.

INTRODUCTION

The extremely rapid growth of plastic production, combined with the current shortcomings of mechanical recycling and the recent breakdown of global export markets, have left many local and national governments desperate to contain the problem of post-consumer plastic waste. In response, there has been a rapid rise in proposed technologies which are claimed to effectively and sustainably convert waste plastic into either fuel or petrochemical precursors (Closed Loop Partners, 2019). In mid-November 2019, the Executive Vice President of Shell's global chemical business described the concept (Hydrocarbon Processing, 2019):

'We want to take waste plastics that are tough to recycle by traditional methods and turn them back into chemicals - creating a cycle. This makes sense for the environment and for business'.

Yet, many critics question the environmental benefits and sustainability of chemical recycling. For example, at an international conference in October 2019, Professor Peter Quicker described the motives for promoting this technology as '...independent of its ecological sense and rationality' (Quicker, 2019). He went on to describe practical objections (ibid.):

'...according to many experts, the approach of chemical recycling is not the right way. The special value of plastic, the polymerised structure, is decomposed and transformed into an inferior product, such as a low quality oil that has to be treated with great effort in order to turn it back into plastic'.

As society seeks to transition away from fossil fuel consumption and mitigate the threat posed by plastic pollution, governments, citizens, and NGOs currently struggle to assess the concept with little or no independent data available on the technologies or their capabilities. To address the problem, and drawing predominantly from peer-reviewed, non-industry financed literature, this report considers the following questions with regard to chemical recycling of plastic:

1. What are these technologies and how do they compare with other methods for treating plastic waste?
2. What are the environmental implications?
3. Are they sustainable?
4. Is the technology mature or likely to be so in the next ten years?

02.

UNPACKING THE CHEMICAL RECYCLING CONCEPT

- Terminology
- Technology Types
- Comparisons with Established Treatment Technologies
- Synopsis

2.1. Terminology

Chemical Recycling

The term 'chemical recycling' has no formal definition but refers to a diverse set of chemical engineering technologies. In general, these technologies subject plastic waste to a combination of heat, pressure, and/or other chemicals inside some form of reaction vessel. The product of this process can then, theoretically, be made into new plastics or fuel, depending on the technology and post-processing used **(Figure 1)**.

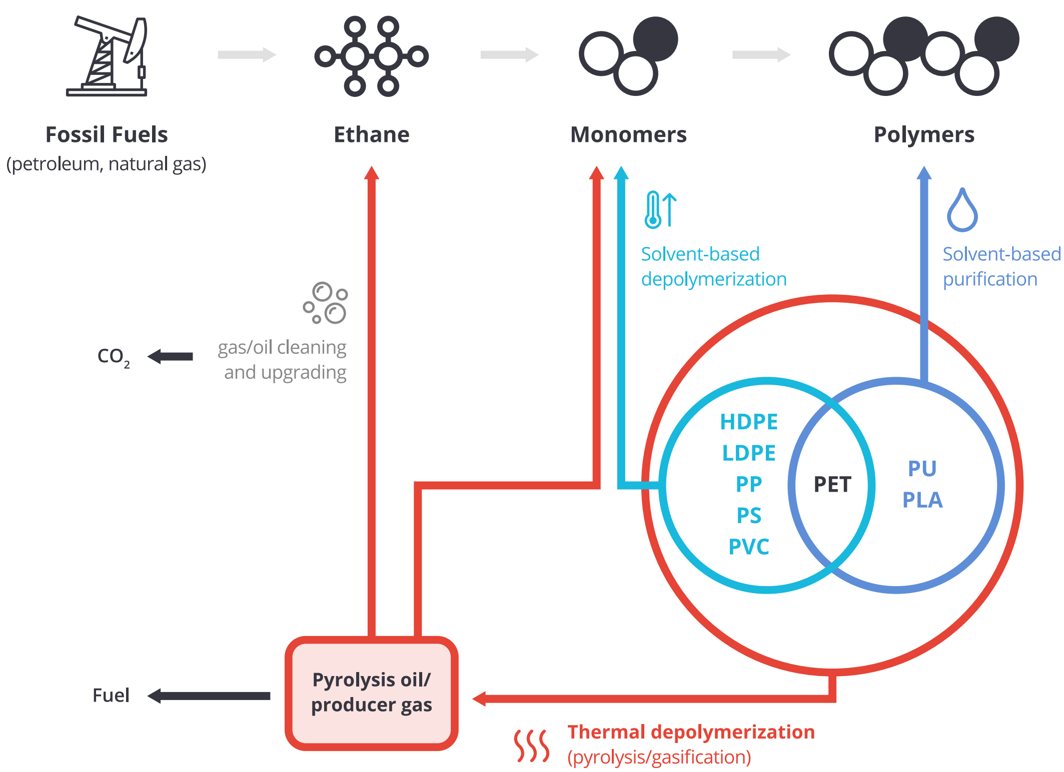


Figure 1. General schematic of chemical recycling processes. For abbreviated plastic types, see Glossary.

Recycling

The European Union defines 'recycling' as:

'Any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels…'.[1]

The Oxford English Dictionary offers a more restrictive definition of recycling:

'to return (material) to a previous stage of a cyclic process'.

In evaluating chemical recycling, there is a critical distinction between turning waste plastic back into plastic of similar quality, and turning it into other products of less utility, such as fuel. The former creates the possibility of a closed material loop in plastic, minimizing both waste disposal and the extraction of natural resources. The latter delivers relatively little environmental benefit (Hopewell et al., 2009).

[1] Article 3(17), Directive 2008/98/EC on waste

Plastic Feedstock

The word 'plastic' comes from a material's capacity to flow or deform under certain conditions of temperature and pressure. As commonly used, 'plastics' are hydrocarbon polymers – long-chain structures of smaller monomers forming branched and cyclic macro-molecules – which flow or deform at some stage in the manufacturing process. The most common types of waste plastic are: polyolefins, including high density polyethylene (HDPE), low density polyethylene (LDPE), and polypropylene (PP); polystyrene (PS); polyethylene terephthalate (PET); polyvinyl chloride (PVC); ethylene-propylene copolymer (EPC); polyamide (PA); polylactic acid (PLA); and polyurethane (PU).

Plastic polymers were initially made from natural cellulose but the vast majority are now made from petrochemicals, with shale gas in particular driving increased production (American Chemistry Council, 2019). The beneficial properties of petrochemical plastics - durability and resistance to natural enzymatic decomposition - are the same properties which constitute their threat to the biosphere. Though biodegradable and biologically-derived plastics are available, they are not widely utilised (Spierling et al., 2018).

In engineering terminology, ‘feedstock’ refers to the material input for a process. This report refers to plastic waste as the feedstock for chemical recycling. Some of the chemical recycling technologies described can only handle a single polymer feedstock. Others are capable of processing different plastics but may require extensive reconfiguration between polymers, meaning that effectively a dedicated facility is needed for each.

2.2. Technology Types

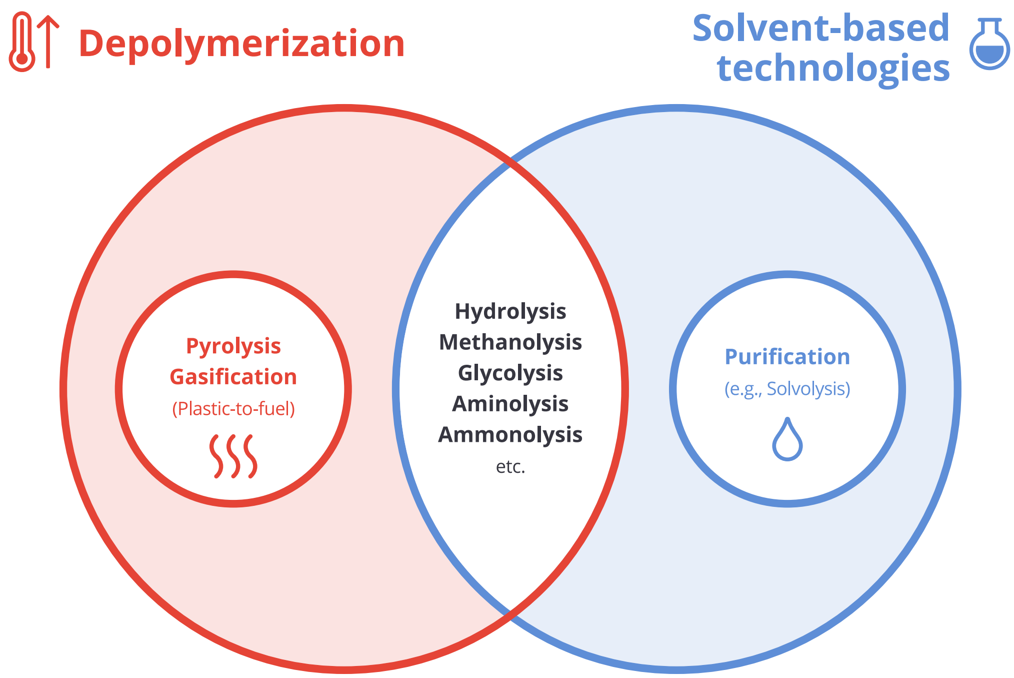


Figure 2. Chemical recycling terminology. Pyrolysis and gasification outputs can be used to produce new plastic after additional upgrading, but are typically burned for energy.

Chemical recycling technologies can be grouped into two categories: thermolysis and solvent-based processes (Figure 2). Thermolysis literally means 'change by heat', and though it broadly encompasses combustion and a wide range of other chemical processes, the only practicable thermolysis methods for chemical recycling are pyrolysis and gasification. They apply high temperatures to the plastic feedstock inside an oxygen-depleted reactor with the aim of breaking the polymers down into smaller fragments, which is why they are also referred to as depolymerisation technologies. These fragments can then, in theory, be repolymerised into new plastic, or simply burnt as fuel with the other outputs. Solvent-based technologies use a variety of media to treat the plastics, often in stages; some depolymerise the plastic while others strip out impurities, leaving the polymer chains relatively intact. Confusingly, many solvent-based technologies also involve high temperatures, but are not considered as thermolysis.

Gasification and Pyrolysis

Gasification and pyrolysis are, at face value, very simple concepts. They were devised over one hundred years ago as technologies for converting woody biomass and coal into gaseous and liquid chemicals along with producing carbon-rich solids. Their names derive from these historical applications.

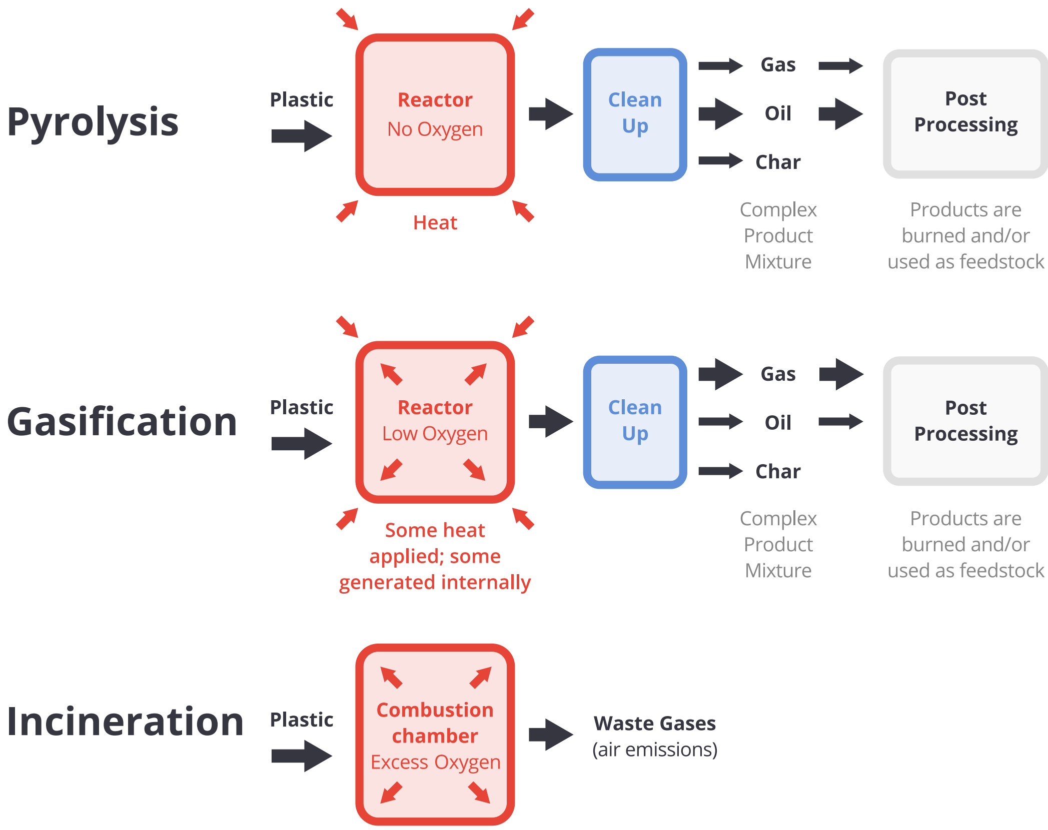


Figure 3. Simplified comparison of thermolysis processes. Pyrolysis (top) heats the plastic waste without oxygen, producing primarily a liquid output (pyrolysis oil) and, secondarily, a gas that is usually combusted. The pyrolysis oil can be burned or upgraded for repolymerization. Gasification (middle) heats the plastic waste with (typically) a reduced amount of oxygen to produce a gas which requires upgrading before use. Incineration (bottom) burns the plastic waste without requiring additional fuels, but the outputs cannot be re-made into plastic. Many minor variations of these processes exist.

Very generally, the low level of oxygen in gasification and pyrolysis differentiate these technologies from combustion (Figure 3). Both pyrolysis and gasification make use of the fact that in all situations when hydrocarbon polymers are initially heated (i.e., by an applied external heat source), a major fraction of the mass is released as a gas. Without oxygen, the gas will not combust. Crucially therefore, conditions are engineered to prevent combustion by applying heat but limiting oxygenation. Pyrolysis and gasification also operate at relatively low temperatures (ca. 500°C to 850°C) and are incorporated either as stand-alone reactors, or as a stage/processing parameter in more novel chemical recycling proposals (Wong et al., 2015).

All the gases produced by a gasifier originate from pyrolysis, however a reactor designed for gasification (a ‘gasifier’) encourages other chemical reactions inside it. To be precise, gasification is not defined by temperature, or the amount of oxygen that is allowed to enter the reactor, but is simply, as its name suggests ‘the conversion of something into a gas’.

The finer details of how pyrolysis and gasification function is however far from simple, with gasification in particular frequently misunderstood and misrepresented in modern waste treatment proposals. A detailed explanation of gasification and pyrolysis is beyond the scope of this report, but information can be found in the following sources (Kaupp, 1984; Reed and Das, 1988; Rollinson, 2018; Rollinson and Oladejo, 2019).

The resulting products of gasification and pyrolysis are a cocktail of unburned and re-synthesised hydrocarbon molecules in a mixture of gaseous, liquid, and solid states. Product quality and operational stability is governed by complex and highly challenging chemical, physical and thermal inter-relations, making gasification and pyrolysis more akin to chemical processing plants than ordinary incinerators (Rollinson, 2018; and Rollinson and Oladejo, 2019).

Gasification

Gasification was optimised over one hundred years ago and found to be achievable only in highly specific reactor types fed only with woody biomass, charcoal or coal (Rollinson, 2018). In these specific cases, it can produce a gas (historically called ‘producer gas’) that is relatively rich in carbon monoxide (CO) and hydrogen (H_2). Methane steam reforming (a method of making hydrogen, usually from natural gas) also produces a gas of similar composition (known as ‘synthesis gas/syngas’), which is a feedstock for plastic manufacture. This has led to the idea that gasification of plastics could be a method of chemical recycling.

Pyrolysis

The root of the word pyrolysis is ’loosening or changing by heat or fire’. It is however conventionally attributed to heating without oxygen in batch reactors. Known since antiquity for the production of useful chemicals such as methanol, acetone and creosote from wood, pyrolysis is an energy consuming (endothermic) process that is much cruder than gasification. It produces a much poorer quality gas that is overly rich in a complex mixture of hydrocarbons along with a higher and more complex liquid (oil/tar) yield (Rollinson and Oladejo, 2019).

Conversion to Plastic (P2P) by Pyrolysis and Gasification

The ultimate aim of pyrolysis and gasification for P2P (plastic to plastic chemical recycling) would be to use the oil and gas products as building blocks for new plastics. However, the nature of gasification and pyrolysis engineering makes it extremely difficult or even impossible to produce oil and gas outputs of the standard required for plastic manufacture. The subsequent repolymerisation stage also involves additional chemical processing and energy input.

Conversion to Fuel (P2F) by Pyrolysis and Gasification

The difference between P2P and P2F is the end use. In P2F, the products of pyrolysis and gasification are used as a feedstock for petroleum refining. This means that they will ultimately be combusted. This is why P2F cannot contribute to a circular economy for plastic waste: it does not produce new plastic.

It is important to recognize a distinction between close-coupled combustion of gasification and pyrolysis products and their later use as a fuel alternative to petroleum and its derivatives. In the former case, the outputs are quickly combusted within the same facility, with the heat either flared, or designated for electricity generation or to supplement some of the pyrolysis energy demands. To all intents and purposes, these facilities are identical to an incineration plant with energy recovery. When plastic-derived fuel is destined for later use, the re-formed fuel is not burned directly but is stored and often transferred off-site. Such fuels will still require additional treatment to meet much higher quality standards, for example when fed to internal combustion engines (Kalargaris et al., 2017; Wong et al., 2015).

Solvolysis/Liquefaction Technologies

Rather than depolymerisation by heat, various solvents have been used to 'loosen or change' the plastic waste in order to produce purified polymers, oligomers or monomers. Many of these processes also include multiple treatment stages, usually involving high pressures and temperatures in the region of several hundred bar and 100 ≤ °C ≤ 350, and with the inclusion of catalysis (Al-Sabagh et al., 2016; Arturi et al., 2018; Sherwood, 2020). No clear consensus exists on how to categorise these alternative technologies; likely evidencing a combination of system complexity, process overlap, and, in some cases, intellectual property restrictions. Here we use a categorisation from Crippa et al. (2019).

Solvent-based Purification

This process seeks to dissolve or liquefy the plastic without damaging the polymeric structure. Often it is chosen for the separation of mixed plastics or the isolation of specific polymers from certain types of plastic composite. It is a multi-stage process involving the removal of dyes, impurities and contaminants followed by filtration, phase extraction, and precipitation of the polymer by an 'anti-solvent' (Sherwood, 2020). The choice of solvent has to be highly specific to a strictly homogeneous feedstock or target compound. Some degradation in product quality follows, meaning that the process is not 'cyclic'; and in this regard, it is more similar to mechanical recycling, since the product cannot cycle infinitely or fully replace virgin polymer (Crippa et al., 2019). Residual toxic contaminants can also remain in the product, and the disposal of spent process chemicals can be problematic (Sherwood, 2020). Practical feasibility remains unclear.

Solvent-based Depolymerisation

A variety of depolymerisation processes dissolve the plastic waste in liquid baths to produce oligomers and monomers. The bath consists of one or more of a variety of liquids, which give their name to the process: water (neutral, acid, or alkaline hydrolysis), methanol (methanolysis), glycol (glycolysis), ammonia (ammonolysis), and various amines (aminolysis), among others. The process is often facilitated by high temperature, pressures and/or catalysis, and adaptations such as hydrogenation and transesterification are used. Of all chemical recycling options, this is the most novel, and information on both product quality and energy expenditure from this category of technologies remains the most under-reported and unresolved.

2.3. Comparisons with Established Treatment Technologies

Apart from landfill and the technologies covered above, the options employed for the management of plastic waste are primarily mechanical recycling and incineration. This section provides brief comparisons of chemical recycling with these options.

Mechanical Recycling vs. Chemical Recycling

Mechanical recycling of plastic waste consists of a number of steps, including pre-sorting, crushing, washing, shredding, and extruding or pelletising of the feedstock. Then melting and physical reshaping can occur, often with the use of additives. These steps, while less energy-intensive than chemical recycling, nevertheless represent a significant energy input relative to the value of the plastic recyclate (Levidow and Raman, 2019). While mechanical recycling aims to replace virgin plastic in similar applications, the variability in quality and transfer of contaminants make closed loop recycling extremely difficult for some plastic waste, particularly packaging. Even with these intensive pre-treatment methods, impurities from both within the plastic structure and from external sources remain. For this reason, industry is currently seeking innovative washing concepts to remove contaminants, odours, labels and water-soluble compounds.

Whereas the objective of depolymerisation technologies is to break down plastic polymers into smaller molecules (monomers or oligomers), mechanical recycling aims to preserve the polymers. In practice, polymer length is generally shortened, resulting in a lower quality plastic than the original (Baytekin et al., 2013). This is known as 'downcycling' or 'open-loop' recycling as it limits the extent to which mechanically recycled polymer can replace virgin polymer; instead, the recycled plastic usually replaces alternative polymers with lower specifications. It is for this reason, and driven by ambitious recycling targets in many countries, that the far less mature chemical recycling concept is being touted (Quicker, 2019). In comparison with mechanical recycling however, chemical recycling suffers from greater novelty and process complexity, while still having the same obstacles of impurities within the feedstock.

Although mechanical recycling has its limitations, a strong argument exists that it is environmentally preferable to chemical recycling. This is because it has lower energy demands, resulting in a smaller carbon footprint, and produces fewer toxic byproducts.

Incineration

The simplest way to depolymerise plastics is to incinerate them (Quicker, 2019). In contrast with pyrolysis, which limits the available oxygen to produce a combustible gas, incineration is intended to achieve complete combustion of the feedstock. This results in ash, carbon dioxide (CO_2) and water vapour (H_2O). With mixed waste incineration, the ash can be highly toxic and despite more than a century of development, processing issues (like acid gas corrosion) remain. Notwithstanding these challenges, incineration is a destructive process, and the product molecules are energetically impractical as either fuels or building blocks for polymers. It does not therefore represent chemical recycling, so will not be discussed further in this assessment.

2.4. Synopsis

All engineering options for chemical recycling described in this report concern only the first (e.g. depolymerisation) stage of a two-stage destruction/restructuring process. This choice is not arbitrary, for the challenge of successfully applying chemical recycling lies in attaining and maintaining a plastic recyclate of sufficient quality and quantity such that it can be used effectively as a feedstock for repolymerisation or as an engine fuel. This is not easy. The product requirements demand highly stringent quality control, and when not attained, the resultant gas or oil is, at best, burnt. Consequently, the distinction between P2P and P2F is often not clear and attempts to conflate the two practices as chemical ‘recycling’ have been associated with claims of 'greenwash' (GAIA, 2019).

03.

CHALLENGES

- :: Low Viability and Lack of Data
- :: Adverse Environmental Impacts
- :: Energy and Carbon Intensity

Plastic thermolysis has been studied experimentally since at least the 1950's and these lab-scale experimental results can be found in standard texts (Fifield and Haines, 2000). Efforts to chemically recycle plastics commercially can be traced back to at least the 1970s (Matsumoto et al., 1975; Porteous, 1975). Since then, and outside of some current media claims, the concept appears to have stagnated in terms of full-scale practical applications.

In order to address the technical challenges of thermolysis, adaptations have been proposed such as using a hydrogen atmosphere and/or catalysts. These variations create extra cost and problems, such as: 1. Difficulty of recovering spent catalyst. 2. Cost of catalyst and/or hydrogen. 3. Disposal or regeneration of spent catalyst (regeneration is energy intensive and creates additional waste byproducts). 4. Catalyst effectiveness declines as soon as the process starts as it gets clogged with plastic particles and surface sites get blocked by carbon deposition (Miskolczi et al., 2004; Lopez et al., 2017).

Experiments have also shown that chemical recycling is not simply a reversible process. When plastics are made to thermally decompose, hydrocarbon fragmentation produces molecules which are different to their component monomers (the 'building blocks' of plastic). For example, from relatively simple PP a high content of benzene, xylene, toluene, plus polycyclic aromatic hydrocarbons (PAHs) is formed (Williams and Williams, 1999). Similarly, with PVC, as chlorine is progressively removed, new carbon bonds are formed, creating aromatics such as indene, naphthalene, and alkylated naphthalenes (Scheirs and Karminsky, 2006). These components, along with many plastic additives (see Section 3.2), are hazardous to human health, meaning facilities would have to be regulated and managed to avoid potentially high risk situations both on and off site. Any amount of plastic that is profitable to process at a single facility would likely produce these chemicals in significant quantities during processing and storage.

3.1. Low Viability and Lack of Data

Many academic reviews on the chemical recycling concept were studied for this report. In all cases, the focus was on design 'innovation', with little or no emphasis given to critical analysis of operational performance (see for example: Butler et al., 2011; Panda et al., 2010; Rageart et al., 2017). Proof of successful status (and failures) remains largely undisclosed outside of laboratory trials, and for the interested party much will be found in theory but little or no substance given to practice. One logical inference from this is that the concept is entirely or largely a white elephant. There is strong evidence to support such a conjecture with regard to pyrolysis and gasification since these technologies have extreme challenges when fed with mixed or non-standard feedstocks and when attempting scale-up (see references contained in Rollinson, 2018 and Rollinson and Oladejo, 2019). Very briefly, the situation is summarised by Wong et al. (2015):

‘While it is possible to produce satisfactory product yield and composition in laboratory scale, it will be a challenge for the industrial developers to maintain the desired result when scaling up polymer pyrolysis’.

The challenge that plastic poses to these technologies is described by Lopez et al. (2017) with respect to P2F:

'Although conventional pyrolysis might seem a convenient method to convert plastic solid waste to fuels, only fuels with low octane values and high residue contents can be obtained at moderate temperatures. For this reason the production of gasoline-range fuels is not efficient…’.

Experimental trials continue to be reported on P2F, such as Kalargaris et al. (2017), who produced oil from plastic pyrolysis and, despite very high processing temperatures of 900°C, the oil still contained a higher density, solid residue, oxygen and PAH concentration than diesel oil. The authors stated that plastic pyrolysis oil requires substantial upgrading before use in transport applications. As evidence of this, when fed to a stationary engine, the oil produced greater quantities of pollutants, with higher nitrogen oxides (NO_X), soot, CO and CO_2 emissions in comparison to diesel.

No evidence was found to support the current claims of technological efficacy of chemical recycling. In fact, independent reviews reported the contrary, extracts from which are as follows in chronological order: In 2011, it was observed that there was not even one successful and widely licenced plastic pyrolysis technology in operation (Butler, et al., 2011). In 2016, the status was described by Miandad et al., 2016:

'Temperature demand may increase up to 700 or 900 °C to achieve high quality products' [but] 'the gaseous products from pyrolysis are also not suitable as a fuel source and they need refining prior to use'.

The authors do not elaborate on why, but this likely refers to low product hydrocarbon quality, despite very high reaction temperatures. They state that the quality of oil is also compromised by the presence of pollutants and they identify how the endothermic nature of pyrolysis makes it a high energy-intensive process.

A year later, Lopez et al. (2017) concluded:

'Although plastic pyrolysis has been widely investigated, most of the studies are of a preliminary nature, with the level of development of pyrolysis units being in general limited'.

The most recent assessment was by Quicker (2019):

'Since there is currently no known pyrolysis plant in (semi)industrial operation that produces relevant amounts [of chemically recycled plastic] for further upgrading, e.g. in the chemical industry, no process examples can be presented here'.

As to the future potential of plastic gasification (Quicker, 2019):

'The fact is that even with essential and sophisticated pretreatment, an economic operation of such a plastic to fuel gasification plant cannot be expected'.

The problem is fundamental. Temperature and gas circulation for optimum reaction kinetics must be maintained while also moderating temperature to avoid secondary and tertiary synthesis of unwanted molecules. If the process operates at a low temperature (and cost), then some lighter monomers will form but incomplete depolymerisation will occur. If the process operates at a higher temperature (and cost) to increase primary depolymerisation, it will increase the formation of heavier aromatic molecules **(Figure 4)**. Gasifiers were designed to manage this trade-off, but only with strictly controlled types of homogeneous feedstock, and not with something 'non-standard' such as plastic waste (Rollinson, 2018). To counter, multiple pre- and post-treatment stages are applied, incurring high costs and energy expenditure, despite which there has been a long history of failed attempts at scale-up with mixed waste or non-standard feedstocks (Quicker, 2019):

'Despite the negative experiences with alternative thermal treatment processes in the past, they are again praised as the solution, this time for plastic recycling'.

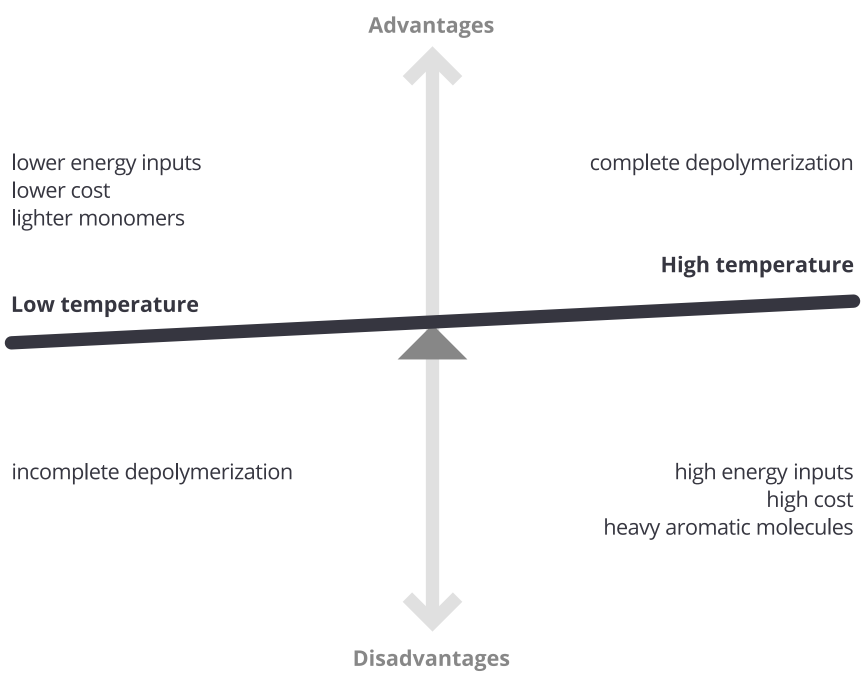


Figure 4. Pyrolysis process trade-offs. Low temperatures (and cost) fail to break down the plastic waste fully, while high temperatures produce unwanted chemical outputs.

With respect to the more novel chemical recycling options, there is also strong evidence that the concept is troublesome and inadequate: Due to the high operating costs, no industrial concepts of hydrogenation are known, while solvolysis is still in development, and catalytic oil bath depolymerisation has been trialled at pilot-scale with high energy expenditure and without satisfactory results (Quicker, 2019). Though there have been systems which have operated for a time at full-scale (such as Vinyloop ®), solvolysis chemical recycling remains currently a lab-scale or pilot-scale technology (Sherwood, 2020). A report by the European Commission recently described the situation (Crippa et al., 2019):

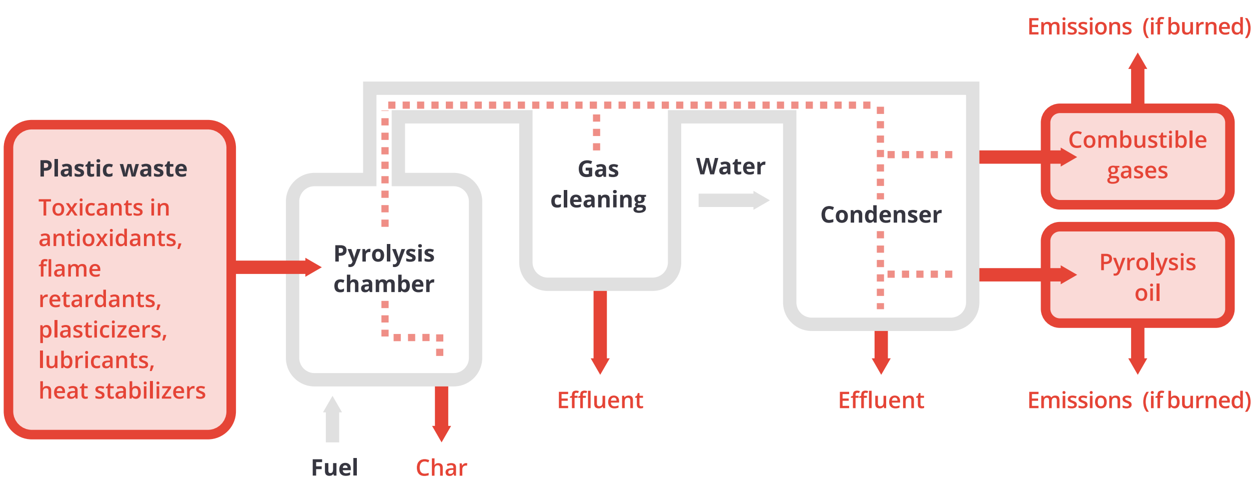
'With one of the few commercial processes (solvent-based PVC purification) recently shut down and most initiatives outlined above at lab scale or pilot level, it is evident that more resources and time investment are needed to improve the technologies'.

Even in the industrial sector, some have estimated that it is 'optimistic to consider that chemical recycling of waste plastics will be viable inside the next decade' (Doherty, 2019). Others suggest a period of 17 years until growth can be achieved (Closed Loop Partners, 2019). This may be too late to address the rapidly growing plastic crisis.

3.2. Adverse Environmental Impacts

Toxicants Inherent in Plastic

Petrochemical plastics are primarily composed of hydrogen and carbon, with significant quantities of oxygen and other chemical elements (known as heteroatoms). Various substances are added to modify the material's properties and production costs, such as antioxidants, flame retardants, plasticizers, lubricants and heat stabilizers. Plastic can also acquire toxic contaminants from its surroundings both during the production process and post-production (Rodrigues et al., 2019). The ultimate fate of these substances, through end of life treatment or unwanted migration, poses a risk of toxicity. Examples of plastic toxicants include: bisphenol-A (BPA), cadmium, benzene, brominated compounds, phthalates, lead, tin, antimony, and volatile organic compounds (VOCs).



Toxicants include: phthalates, BPA, poly-brominated diphenyl ethers, toxic brominated compounds and poly-cyclic aromatic hydrocarbons (PAH), nitrated PAH (N-PAH), oxygenated PAH (O-PAH), and N/S/O – heterocyclic PAHs, As, Sb, Br, Zn, Cu, Hg, Cd, Dioxin, HCN

Figure 5. The sources and fates of plastic toxicants in pyrolysis. Many toxicants are present in the plastic waste; some, such as dioxins, are generated during the process. All are found in one or more of the outputs: pyrolysis oil, producer gas, air emissions, liquid effluent, and solid char.

Antioxidants, mostly used in plastic packaging, delay the degradation of polymers which may occur when exposed to light or other heat sources. They include: arylamines, phenolics and organophosphates such as BPA, tris-nonyl-phenyl phosphate, octylphenol, nonylphenol, and lead and cadmium compounds which are present in concentrations of 0.05 – 3% by mass (Hahladakis et al., 2018).

Flame retardants include: halogenated hydrocarbons, phosphate esters, antimony and aluminium oxides, halogenated phenols, brominated and phosphorus polyols; compounds like polybrominated diphenyl ethers (PBDEs), chlorinated paraffin (MCCP or SCCP), boric acid, and phosphorus compounds (TCEP or TCPP) which exist in concentrations of 0.7 – 25% by mass (ibid.).

Plasticizers, to improve the durability and elasticity of plastic, are present in concentrations of 10 – 70% by mass, and include hydrocarbon-based phthalates (DBP/BBP/DEHP/DHCP), adipates (DAH/HAD/DOA/HOA) and chlorinated paraffins (LCCP/MCCP/SCCP) (ibid.). Numerous studies have confirmed the migration of these substances from host plastic at ambient temperature, with greater migration levels at higher temperatures. This suggests that the use of recycling techniques, particularly higher-temperature technologies, increases the hazards of exposure. Plastics such as polystyrene and polyesters, nylons and polyurethanes can also decompose into monomers and oligomers at ambient to moderate (ca. 200°C) temperatures. These substances, like styrene, formaldehyde, ethylene, epoxy resins of BPA, and vinyl chloride, have also been identified as toxicants.

Process Emissions and Byproducts

Sound engineering practice and regulatory requirements necessitate a comprehensive appraisal of both the direct operational hazards and the volume and toxicity of all products, byproducts, and spent process residues. One might therefore expect that studies on chemical recycling would focus on these risks as a matter of course. Surprisingly, this is not the case. This is also despite the fact that the presence of banned substances in the chemical recycling process and the subsequent need to comply with chemical hazard regulations has been identified as a primary cause of commercial plant closure and an important future consideration (Sherwood, 2020). Yet, when researching this report, no single, detailed review of the environmental impacts of plastic chemical recycling could be found in literature, supporting what has elsewhere been stated - that ‘such knowledge still does not exist’ (Crippa et al., 2019). On the concept of chemical recycling in general, a number of reviews have been published, but they invariably omit coverage of environmental impacts (for example: Butler et al., 2011; Lopez, et al., 2017; Panda et al., 2010; Wong et al., 2015). Only one review was found which made reference to environmental impacts, but here the information provided was old and/or unrelated (Ragaert, 2019). While this no doubt reflects an absence of information accessible to the authors, it does not explain a general lack of consideration given to reporting on emissions and byproduct toxicity in reports which describe both lab and pilot-scale experiments. One reason for this has recently been suggested as being due to a prevailing joint academic/industry competitive funding landscape that encourages a focus only on positive ‘selling points’ (Rollinson and Oladejo, 2019). Whatever the reason, chemical recycling hazard and toxicity is currently under-reported and inadequately assessed. Here we provide a first attempt at such an assessment.

Being an old technology, literature appraisals have been made on pyrolysis (though not specific to plastic feedstock), and it is well known to create toxic organic products (Idowu, et al., 2019). Gasification also has a wealth of literature that discusses its hazards, environmental impacts and risks (Rollinson, 2018). With these technologies, the formation of smoke, CO, and other hazardous substances are well documented. Specifically, from plastic feedstock, phthalates, BPA, poly-brominated diphenyl ethers, toxic brominated compounds and PAHs are produced, many of which are mutagens, carcinogens, and disruptive to respiratory or neurological systems (Verma et al., 2016).

In addition to the inherent toxicants in plastic, toxic gases such as hydrogen cyanide (HCN) and CO are produced, along with new, longer-chain, toxic molecules synthesised during low-oxygen thermolysis, thus increasing product toxicity with respect to the feedstock. Knowledge of these synthesis routes is well established and has been widely studied over the last 100 years (see Kiel et al., 2004; Vreugdenhil and Zwart, 2009). They produce what are collectively called tertiary or high-temperature tars, and these include nitrated PAH (N-PAH), oxygenated PAH (O-PAH), and N/S/O- heterocyclic PAHs, many of which are potent mutagens and carcinogens (Idowu et al., 2019). With plastics, Font et al. (2003) observed that the emission factors of mutagenic PAHs from pyrolysis of polyethylene increased markedly with temperatures above 700ºC. This relates to the trade-off between temperature, depolymerisation, and re-synthesis of unwanted molecules, as discussed in the previous section. The production of these synthesised toxicants is corroborated by other plastic pyrolysis studies (Garrido et al., 2016; Lopez, et al. 2017; Seo and Shin, 2002; Wong, et al., 2015).

There are also known routes for toxicants to accrue in the recyclate following solvolysis. Many of the solvents are themselves highly toxic, flammable or environmentally harmful, such as n-hexane, cyclohexane, and chloroform, and these become trapped in the recyclate (Sherwood, 2020). It is also common for polymer toxicants (such as phthalate esters) to transfer into the solvent, thus imposing additional costs due to the regulatory licenses required for these banned substances (ibid.).

Toxicity of the Resultant Gas, Oil, and Char

Due to systemic contamination of the outputs and industry's ongoing efforts to nevertheless market them as commercial goods, it can often be difficult to make a clear distinction between commodity products and byproducts. toxicants have the potential to be present in all three product phases: gas, liquid, and solid.

Heavy metals in plastic will not be destroyed during depolymerisation but must transfer to one of the outputs or be retained in the spent clean-up materials **(Figure 5)**. This impacts the potential use of these products and byproducts, e.g. subsequent high temperature combustion will release them as airborne particles or vapours, or concentrate them in solid residue. While it is possible for organic toxicants to be depolymerised and hence destroyed, they can equally pass through unaltered, or worse there is a high likelihood that the process will reform them into more toxic molecules. An environmental pathway (and cost) appraisal must include spent scrubbing and capture media from the air and waste-water pollution control equipment. Some examples are provided below:

In a study of mixed plastic pyrolysis, the product oil was found to contain antimony, bromine, zinc, calcium, chlorine, and sulfur, while the gas contained chlorine and bromine, with largest fractions of non-volatiles in the char (Miskolczi et al., 2013). The same research group found appreciable quantities of re-synthesised 'heavy' aromatic polymers in the products, even from substances such as polystyrene which is often claimed to produce monomers under pyrolysis conditions (Miskolczi et al., 2004).

Seo and Shin (2002) analysed the products of mixed plastic pyrolysis and found that the distilled product oil contained significantly more aromatics than engine fuel, amounting to 60-82% of the total hydrocarbons, and that the pyrolysis oils contained few of the branched hydrocarbons desirable by internal combustion engines. They described how many of the aromatics were polynuclear PAHs which were either directly toxic or which were precursors to more toxic substances.

An examination of PAH formation and chlorine distribution in the oil, gas, and char yields from PVC pyrolysis by Cao et al. (2019) found that the PAH content in pyrolysis oil was 'amazingly high' at 95.3%, while chlorine was retained in both oil and char at far greater concentrations than predicted.

Evangelopoulus et al. (2015) studied the pyrolysis of plastics from printed circuit boards and found that low temperature (≤ 700 °C) favours the formation of brominated compounds and BPA, while higher temperature (≥ 700°C) favours PAHs and benzofurans. Similar trends were observed by Iñiguez, et al. (2018), where greater PAHs, chlorobenzenes and chlorophenols were produced from pyrolysis, rather than the combustion of plastic waste.

The presence of inorganic and organo-bromine compounds in chemical recycling products was investigated by Ma et al. (2019) who found that single-step pyrolysis at temperatures of 350-600°C partitioned 25 to 61% of bromine into pyrolysis oil and 34 to 55% into pyrolysis wax, with a maximum of 15.9% bromine retained in solid residues. They described the presence of bromine in pyrolysis products as having 'significant negative impacts on their further application as fuel or chemicals'.

The development of technologies for reducing the formation or emissions of polyhalogenated aromatic hydrocarbons including dioxins and furans is subject to continuing research. There is also a common misperception that pyrolysis conditions negate or inhibit dioxin formation. An insight into the underlying pathways of high dioxin production during low oxygen thermolysis of plastics is evidenced from experiments with automotive shredder residue (ASR). It was clearly shown in a study by Maric et al. (2020) that higher plastic content in the feedstock led to greater production of dioxins, as also did lower reactor temperatures (673°C vs. 831°C) with consequently greater toxicity (TEQ) of the products. This is consistent with previous studies which showed that lower oxygen levels favour the production of both PCDD/Fs and PBDD/Fs and that their retention in the product fractions is also accentuated by the relatively low temperatures required for pyrolysis. Specifically, Rey et al. (2016) studied ASR thermolysis at a range of temperatures and oxygen levels, finding that the maximum TEQ for PBDD/F occurred at oxygen levels in the pyrolysis range and at temperatures of 600˚C (rather than 800°C), with similar patterns of maximum TEQ observed for PCDD/Fs at a wider range and maximum PAHs emitted when oxygen levels were at zero. Elsewhere, during the pyrolysis of ASR by Anzano et al. (2017), due to high TEQ from dioxins and PAHs, it was stated that 'Based on these results, the use of solid residue as a fuel can be excluded'.

Chen et al. (2014) reviewed how dioxins form during the pyrolysis of plastics. Routes exist via transfer of trace levels from the feedstock into the outputs, high temperature gas phase formation from chlorinated precursors, and post-reactor de novo synthesis from particulates, inorganic chlorine, and catalytic metals (Mohr et al., 1997). Based on data from the now defunct Burgau plant and lab-scale experimentation with a synthetic plastic waste feedstock, Mohr et al. (1997) also found that 80% of the PCDD/F product was contained in the pyrolysis oil making its toxicity four times higher than that of the feedstock. They concluded that 'Pyrolysis oil should not therefore be used as an energy source'. Weber and Sakurai (2001) also found that PCDD/F's were formed in all experiments of plastic shredder waste pyrolysis. These studies found considerably higher ratios of PCDD/PCDF in comparison with incineration (corroborating other cited studies), and since more than 90% of the total TEQ was found in the pyrolysis oil and gas, they advised that this should not be condensed for further use.

Following a study of mixed and blended plastic pyrolysis, the resultant char was contaminated with heavy metals (cadmium, lead, zinc, copper, mercury, and arsenic) and classified as both hazardous and ecotoxic (Bernado et al., 2010). Solvent extraction was applied to try to clean up the product, but the metals remained in the char and the eluate (resulting liquid waste) had 'significant toxicity' due to the presence of acquired organics. According to the authors, their results 'underline the need for relating ecotoxicological chemical parameters, including inorganic and organic compounds in the hazard assessment of solid residues'.

Cleaning these toxicants from chemical recycling products can be extremely difficult, expensive, and will create additional toxic waste streams. In comparison to other plastic end of life methods, few works have evaluated this subject for chemical recycling technologies. Mølgaard (1995) determined that pyrolysis had the highest global warming and photochemical ozone formation impacts of all options, and the second largest solid waste impact after landfill.

3.3. Energy and Carbon Intensity

Plastic depolymerisation requires large energy inputs, so no chemical recycling technology can offer a net-positive energy balance, even if the products/ byproducts are burned for energy (Baytekin et al., 2013). Promotional claims of sustainability cannot be reconciled with this fundamental fact. Part of the reason for these discordant claims may be that technology providers often omit the large amounts of auxiliary energy necessary for pre-treatment (sorting, cleaning, and shredding the plastic), and post-treatment product conditioning and clean-up – these are almost never taken into account in energy and cost audits (Vehlow, 2016). But this is only part of the story.

In theory, the Lower Heating Value (LHV) of plastic is relatively high, and from this superficial viewpoint, some research groups suggest that a plastic-to-fuel system can be sustainable (Joshi and Seay, 2019)[2]. Unfortunately, it is apparent that some authors under-report the high energy cost for pyrolysis and exhibit indifference towards the second law of thermodynamics, thus presenting the concept outside of what is physically possible[3] (see discussion by Rollinson and Oladejo, 2019). Interestingly, some studies also combine convoluted methodologies with literature values and theoretical extrapolations, while avoiding the simpler empirical test which would prove or disprove the matter, i.e. providing an actual demonstration. In a wider literature review, no evidence was found of a self-sustaining chemical recycling plant.

These misrepresentations are attributable in part to a misunderstanding of the true energy costs for pyrolysis (Reed and Gaur, 1997). It is not even widely admitted that continuous heat input is required for pyrolysis, though this is fundamental. For batch processes, heat demands are increased by the need to maintain temperature stability during loading and unloading, which impacts on the extent of 'cracking and vaporizing' during these operational periods. This manifests itself in the quality of depolymerised products, evident by whether the oil is black or clear, which in

[2] Following personal correspondence with the editor, the original author confirmed that there were errors in the manuscript as published. A corrected paper was to have been published in the journal's March/April 2020 issue.
[3] The second law of thermodynamics applies to all universal interactions. It can be understood as that whenever there is energy transfer some quantity must always be lost to a system's surroundings (measured as 'entropy').

turn impacts the extent of post-processing that will be needed to create a useful recyclate, which of course would necessitate further energy inputs.

To make matters worse, a common misconception is that a plastic pyrolysis plant could be both self-sustaining and simultaneously produce feedstock for new plastics. This is easily refuted by simple logic: 1. If all of the pyrolysis plant's outputs were burned to make the process as close as possible to self-sustaining, then there is no circularity as no virgin plastic is being displaced. 2. If the pyrolysis oil and/or gas are to be used for reformulating plastic, there is very little energy density left in the waste products to heat the pyrolysis reactor and so it would need to use an external energy source to power the process.

Though it is rare to find reports which include energy balances on thermolysis chemical recycling systems, it is even rarer to find such assessments with respect to solvolysis. Sherwood (2020) stated that 'The electricity demand is too high for chemical recycling to compete with mechanical recycling... [And] start-up and maintenance costs are certainly higher'.

In terms of post-depolymerisation energy demands, two studies have recently illustrated how more processing is needed after what might be considered as 'primary' depolymerisation. Using industry standard components, over 53% of feedstock carbon would be lost in oil upgrading and 48% in gas upgrading (Mamani-Soliz et al., 2020; Seidl et al., 2020). These inefficiencies are on top of energy inputs for pyrolysis (which were excluded from the calculations) and so tend to quash any notion of P2F sustainability **(Figure 6)**. This is even before considering that whenever the products of depolymerisation are burned (as with P2F), equivalent amounts of CO_2 are emitted as if the plastic had been burned directly, thus meaning that the fossil-derived carbon has merely spent a small part of its existence as a plastic product.

When the recyclate is reformed in P2P, the additional and necessary energy demands of repolymerisation are also sizeable, but are again invariably absent from technology appraisals. Baytekin et al., (2013) stated that for each unit of fossil fuel used as plastic feedstock, an equivalent unit is used to provide the manufacturing energy. A more recent report identified the initial plastic resin production stage as being responsible for 61% of all greenhouse gas (GHG) emissions, with a further 30% associated with product manufacture, and with end of life emissions lowest of all (Zheng and Suh, 2019).

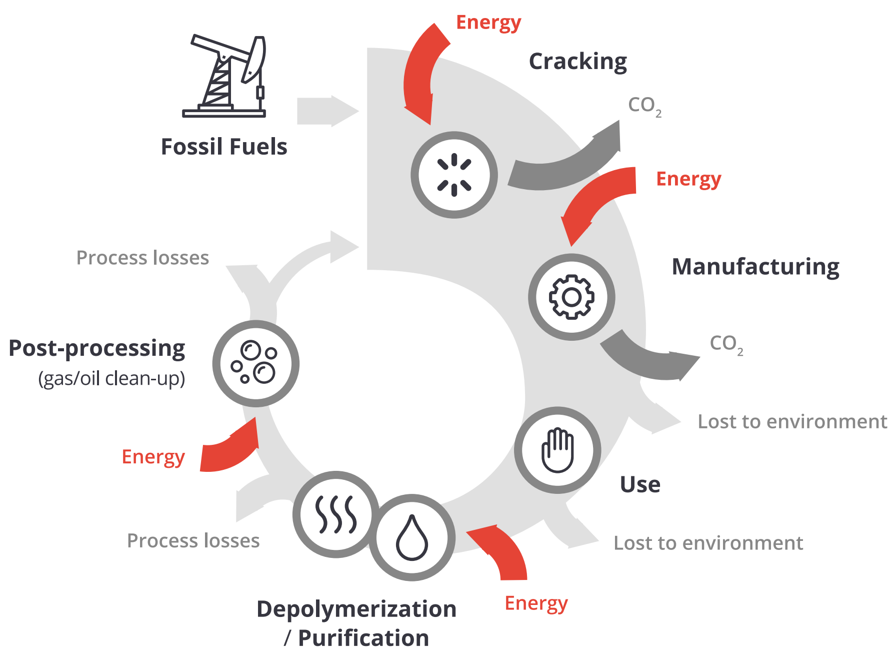


Figure 6. The leaky circular economy in plastic. Chemical recycling is billed as a way to "close the loop" and enable total recovery of plastic waste. In fact, the system is characterized by high energy inputs, process losses, and greenhouse gas emissions; very little of the original material can return to the economy as new plastic.

04.

SYSTEMS PERSPECTIVE

Sherwood (2020) recently provided the following long (and exhaustive) list of factors which are obstacles to the chemical recycling concept: policies and investment for waste collection and separation, product design, consumer choices, business models, resistance by established petrochemical markets, potential increase in complexity of the plastic waste market, greater expense of the recycled polymers, and in terms of technology status: 'The [in]ability to separate combinations of materials...With still much to be done to improve recovery rates of easier to recycle products'. It is interesting that the author identifies 'resistance by established petrochemical markets' as a constraining influence on chemical recycling system uptake. In fact, the technology is heavily promoted by corporate conglomerates including many from the petrochemicals industry. This has led to some criticism of seemingly altruistic associations such as the Alliance to End Plastic Waste, which has pledged to allocate $1.5 billion over five years to mitigate the problem of plastic waste, but include as their members major oil, gas and petrochemical corporations (Laville, 2019). Such scepticism is not helped by the oil and gas industry simultaneously predicting that petrochemicals are to be the fastest growing market over the next twenty years (BP, 2018). So, while industry is planning to greatly increase the use of petroleum for plastic production, the question is: can subsidising research into chemical recycling meet the scale of the problem that the same industry is creating?

Based on these predictions and industry estimates of chemical recycling technology viability provided in this report, the continued pursuit of chemical recycling does not offer a pathway towards sustainability but rather a high likelihood of enabling at least a decade of more fossil fuel extraction. This is a very dangerous trajectory because it is estimated that fossil fuel combustion must be drastically cut back within the next decade in order to avoid existential threats from anthropogenic climate change (IPCC, 2018). On these timescales, it is highly questionable optimism to even consider the concept as a temporary stop-gap for plastic pollution until some better way can be found. Of course, an alternative option already exists, namely to implement the top tiers of the waste hierarchy: 'reduction' and 'reuse' strategies. These can be stimulated by governments simply legislating against single use and unnecessary plastics.

05.

CONCLUSIONS

This report has shown that chemical recycling is not the answer to society's problem of plastic waste. While such a solution may seem ideal, sound engineering practice and common sense appear to have given way to blind optimism in the pursuit of an impossible dream. In some cases, bold claims are being made about technologies that have been repeatedly found over the last one hundred years to be unfit for purpose. In other cases, even industry admits that more novel technologies have yet to be proven at any useful scale and are a long way from reality. On top of these technology failings are the multiple pathways to environmental and human toxicity, which have so far been under-assessed. Similarly, claims of 'sustainability' are widely put forward without satisfactory disclosure of high energy demands and despite the fact that the technology has a negative energy balance. What chemical recycling does offer, however, is a delusion that society can transition to sustainability without implementing the top tiers of the waste hierarchy. It represents a dangerous distraction from the need for governments to ban single use and unnecessary plastics, while simultaneously locking society into a 'business as usual' future of more oil and gas consumption.

We conclude with four findings:

:: Chemical recycling (both thermolysis and solvent-based) is not at present, and is unlikely to be in the next ten years, an effective form of plastic waste management. With the need to dramatically reduce global fossil fuel consumption, chemical recycling appears, in fact, to represent a dangerous distraction for a society that must transition to a sustainable future.

:: Multiple pathways to adverse environmental impact exist and these are grossly under-assessed. Managing these impacts will impose high costs and operational constraints on technology operators. For this reason, chemical recycling should be treated with extreme caution by investors, decision makers, and regulators.

:: Chemical recycling is energy intensive and has multiple intrinsic and ancillary energy demands which render it unsuitable for consideration as a sustainable technology. No chemical recycling technology can currently offer a net-positive energy balance, and there is no evidence to predict that this can improve in the foreseeable future.

:: Grossly inadequate reporting exists on the status of chemical recycling which, along with a lack of independent evidence on the technology, appears to have led to it being portrayed above and well beyond its capabilities. Much greater transparency on operational performance, energy balances, and environmental impact assessment must be provided as standard.

GLOSSARY, ABBREVIATIONS & REFERENCES

Glossary

Aminolysis – A depolymerisation process using amines as the solvent.

Ammonolysis – A depolymerisation process using ammonia as the solvent.

Anti-solvent – Substance that is added to a post solvent-based purification/ depolymerisation mixture in order to precipitate the target compound from the solvent.

Depolymerisation – First stage of chemical recycling which breaks down plastic polymers into oligomers and monomers using a combination of heat, pressure, and/or solvents inside some form of reaction vessel.

Gasification – A chemical recycling process based on pyrolysis where oxygen is restricted so that the plastic thermally decomposes but does not combust. Optimised a century ago as a method of producing gas from coal, charcoal and woody biomass. Found to be highly sensitive and intolerant to other feedstock types, resulting in widespread commercial failures when fed with plastic or other mixed waste.

Glycolysis – Solvent-based depolymerisation process using glycols.

Hydrogenation – A chemical reaction process where the feedstock is treated with hydrogen.

Hydrolysis – Solvent-based depolymerisation process using water at high temperature and pressure, often with chemical additives to make the solvent acidic or alkaline.

Lower Heating Value (LHV) – Measure of the energy density of feedstock/fuel (in this case plastic), usually expressed as $MJ.kg^{-1}$. It represents the maximum amount of energy released per unit mass of plastic when completely combusted. Formerly known as 'net calorific value', it excludes energy recovery from the latent heat of vaporisation of product water.

Methanolysis – Solvent-based depolymerisation process using methanol.

Monomer – A basic single unit molecule that constitutes the building block of plastics. Examples include: ethylene, propylene, styrene, phenol, formaldehyde, ethylene glycol, vinyl chloride.

Oligomer – Small group of monomers. Smaller than a polymer.

Polymer – A large hydrocarbon molecule consisting of many parts. Often described as a 'macromolecule'. Plastics are polymers composed of smaller units called 'monomers'.

Polyolefin – A type of polymer formed from olefin (alkene) monomers. [An alkene is a hydrocarbon molecule with a double carbon bond].

Pyrolysis – A chemical recycling process in which heat is applied but oxygen is restricted so that the plastic thermally decomposes but does not combust. A complex cocktail of molecules can be produced in three product phases - oil, gas, and char. Product quality, depolymerisation and re-synthesis is dependent on many inter-connected physical, chemical and thermal factors.

Repolymerisation – The second stage of chemical recycling in which the products are re-manufactured into new plastic.

Solvolysis – A form of chemical recycling which utilises a range of feedstock specific solvents, often in multiple stages and with other process conditions such as catalysis, high temperature and high pressure. Sub-categorised into:

1. Purification – where the polymer is isolated from contaminants/composite material then collected by further processing and with the use of anti-solvents;

2. Depolymerisation – where the polymer is decomposed into monomers and oligomers.

Thermolysis – Decomposition ('loosening or change') by heat. Used for the first 'depolymerisation' stage of chemical recycling. Technologies include pyrolysis and gasification.

Transesterification – A chemical reaction that converts a type of hydrocarbon molecule called an ester into a different type of ester. The process is made to occur in the presence of alcohol and catalyst.

Abbreviations

ASR – Automotive Shredder Residue

BPA – Bisphenol-A

EPC – Ethylene-propylene copolymer

HDPE – High density polyethylene

LDPE – Low density polyethylene

PA – Polyamide

PAH – Polycyclic aromatic hydrocarbon

PBDD/F – Polybrominated dibenzo-p-dioxins and dibenzofurans

PCDD/F – Polychlorinated dibenzo-p-dioxins and dibenzofurans

PLA – Polylactic acid

PP – Polypropylene

PS – Polystyrene

PET – Polyethylene tetraphthalate

PU – Polyurethane

PVC – Polyvinyl chloride

TEQ – Toxic Equivalency Factor

VOC – Volatile Organic Compounds

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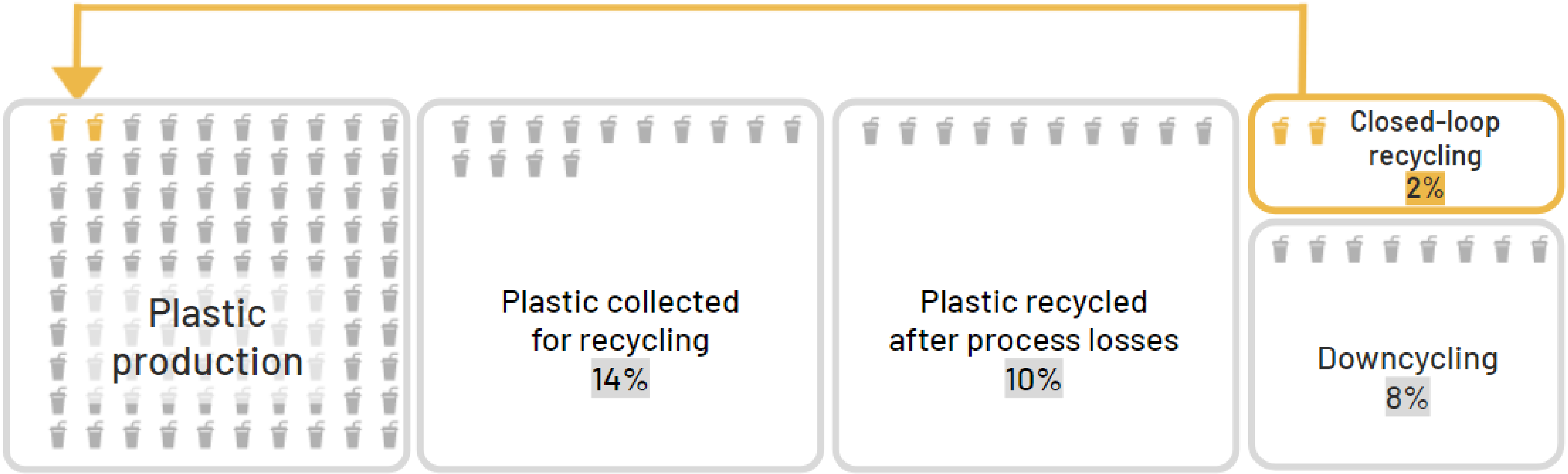
Presentation to Maryland House Committee

Chemical Recycling and the Plastic Problem

29 January 2021

Dr. Neil Tangri, Science and Policy Director, GAIA
neil@no-burn.org

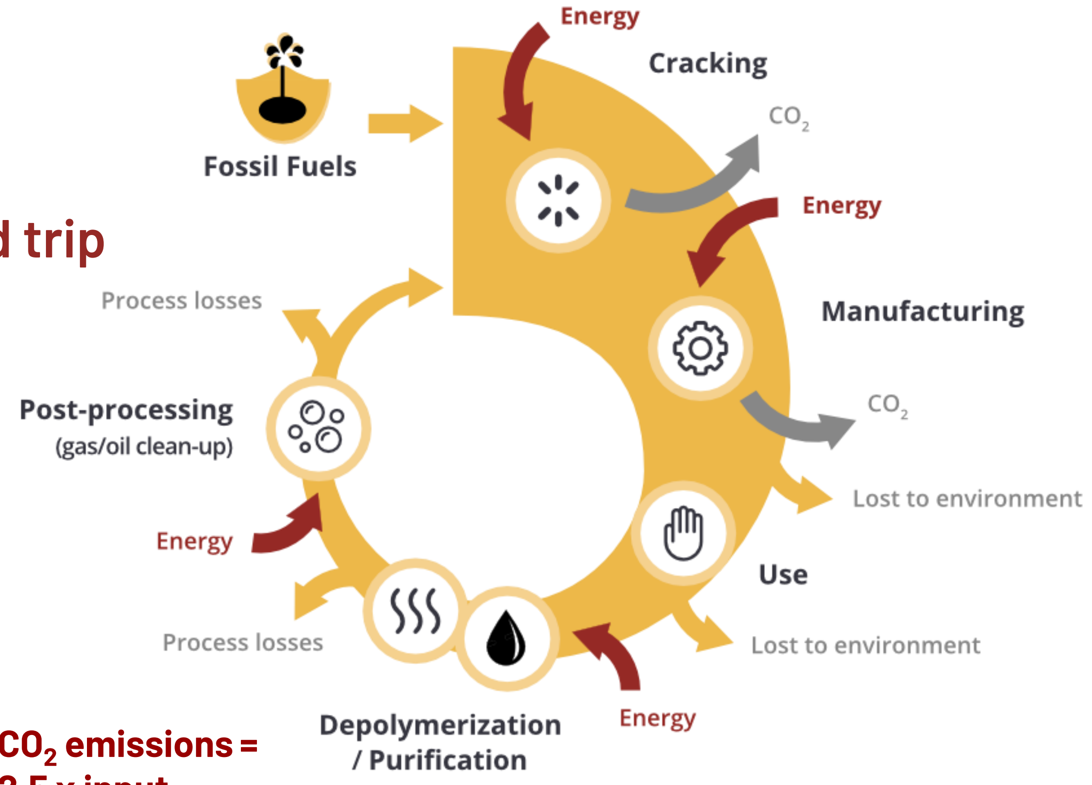
We have a problem with plastic recycling



Source: Ellen MacArthur Foundation (2016). A New Plastic Economy.

No circular economy in plastic

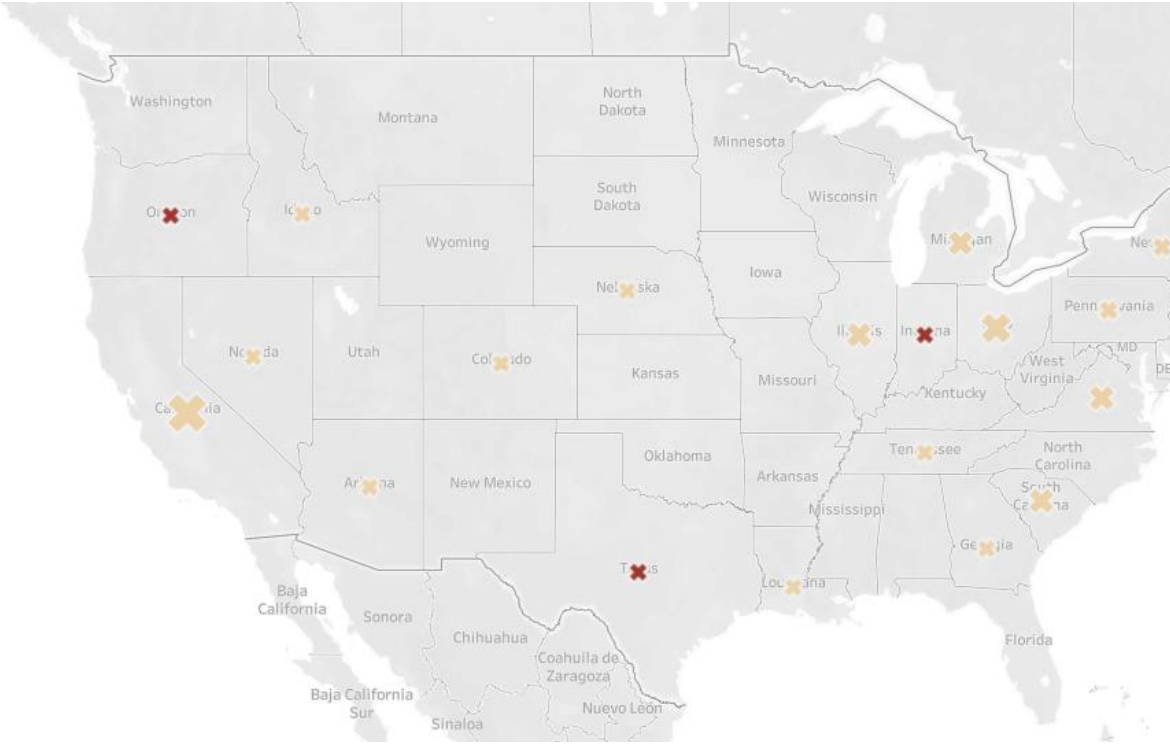
High energy intensity
High carbon emissions
Little plastic makes the round trip



CO_2 emissions = 40% of input

CO_2 emissions = 2.5 x input

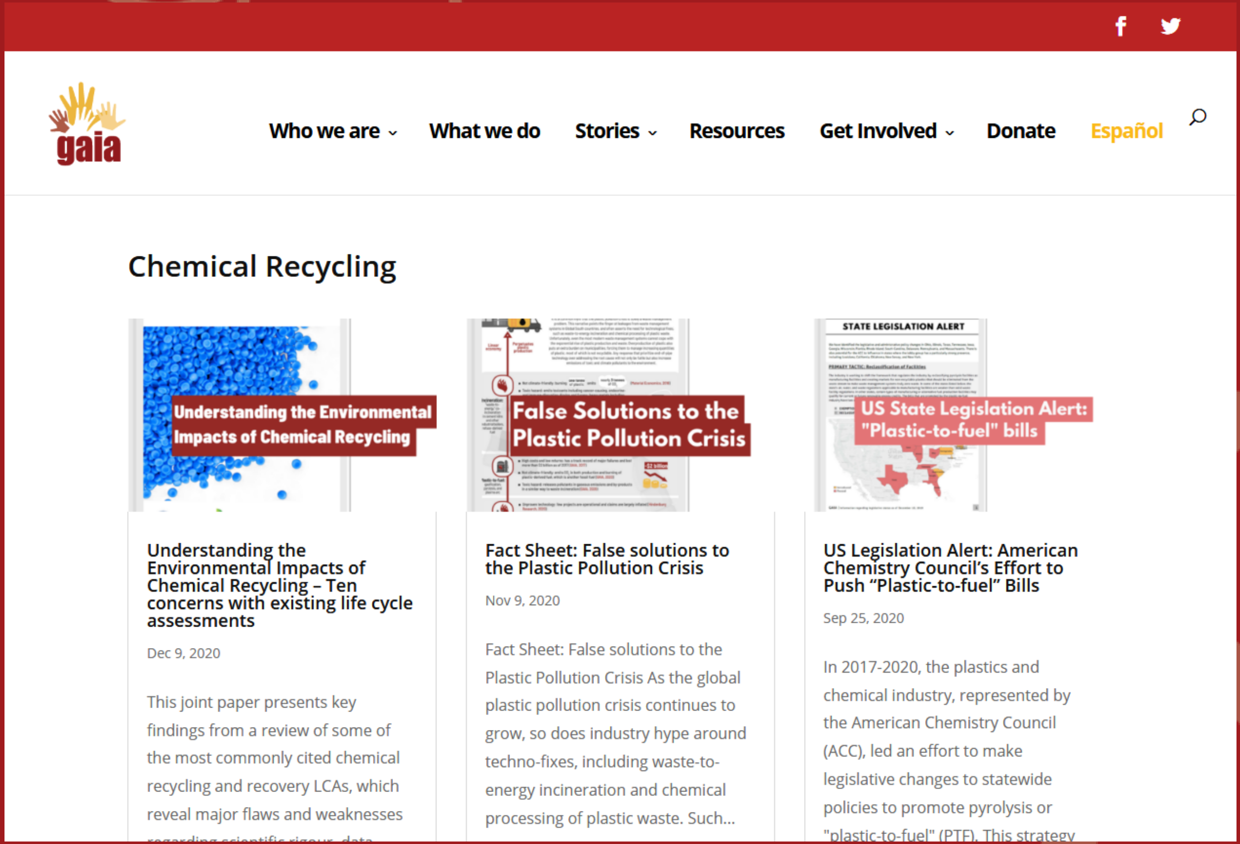
Proposed & existing chemical recycling facilities



Out of the 37 facilities announced in the U.S. since 2000, only 3 are currently operational and none have been proven to successfully recover plastic to make new plastics on a commercial scale.

For more on chemical recycling:
www.no-burn.org/chemical-recycling-resources

gaia



Tangri oral testimony chemical recycling.pdf
Uploaded by: Tangri, Neil
Position: FAV

Global Alliance for Incinerator Alternatives
Global Anti-Incinerator Alliance

Testimony to the Maryland House of Delegates
Environment & Transportation Committee
29 January 2021

By Neil Tangri neil@no-burn.org
Science and Policy Director, GAIA

I'd like to thank the committee and in particular Chairman Barve for this opportunity to speak. My name is Neil Tangri, and I'm the Science and Policy Director at GAIA. We are advocates for Zero Waste and are always excited by the prospect of new recycling techniques and technologies. So we have done a deep dive into chemical recycling, publishing several technical reports; I'll just give you the highlights here.

As you all know, plastic recycling rates are very low – between 2-8%. Although mechanical recycling has technical challenges, the primary problem is economics: collecting, sorting, and cleaning plastic is expensive; virgin plastic is extremely cheap.

Industry proposes that chemical recycling can solve these issues. Our research indicates that it cannot. CR does not work well on mixed plastics; instead, it competes with mechanical recycling for clean, sorted, single-polymer materials. CR is very energy-intensive which translates into high costs. It's carbon intensive – emitting almost 9 lbs of CO_2 to produce 1 lb. of monomer. It's inefficient – more than 60% of the plastic mass is lost in processing. That means it primarily turns plastic into CO_2, not into anything useful. And it still has troubles with the additives and contaminants that bedevil mechanical recycling.

At the end of all that, it still has to compete with extremely cheap virgin plastic. This is why, of the 37 facilities announced in the US since 2000, only 3 are operational, and none turn plastic back into plastic at a commercial scale.

In my opinion, chemical recycling is a distraction. The petrochemical industry is desperate to head off effective policy that would actually tackle the plastic crisis, and they want us to believe that the same companies and same technologies that created the problem will now solve it.

This is nothing new – I have been working in waste management for more than 20 years, and industry always has a shiny, new technology that they claim will solve all our woes. In the 90s, it was incineration; then it was pyrolysis; then gasification. Plasma arc was bandied around at one point. Now it's chemical recycling. Industry would keep us on a hamster wheel of broken promises when the real solutions lie in front of us: reduce the amount and toxicity of plastic we use.

Thank you, Chairman Barve and the entire committee, for your time.

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Testimony for Banning Chemical Recycling 2021(1).p

Uploaded by: Tevelow, Carla

Position: FAV

January 27, 2021

Testimony in SUPPORT of HB21 – Prohibition on the Chemical Conversion of Plastic
Hearing Date: January 29, 2021
Bill Sponsor: Delegate Love
Committee: Environment and Transportation
Submitting: Carla Tevelow
Position: Favorable

My name is Carla Tevelow and am writing in support of the HB 0021 - Prohibition on the Chemical Conversion of Plastic.

According to a detailed report, written in December 2020, “Chem Recycling” by Chem Trust (a collaboration of Chem Trust - a UK registered charity and Chem Trust Europe eV- a charity based in Germany) created by Eunomia (a well-known respected and professional consultancy group), there are myriad of major problems with the industry. These include: a need for pre-sorted good quality plastic; concerns over hazardous chemicals: and substantial energy use.

The plastic industry has misstated and steered the United States into thinking plastic can be recycled and is not a danger to our environment and health. We are finding, not only is it false but plastic has been found on every continent, in every ocean and inside the bodies of almost every living being on this planet.

We are finding plastic is an endocrine disrupter causing humans physical health problems.

Prohibition on the Chemical Conversion of Plastic will be a beginning step to try to correct the trajectory of the way we view plastics and its industries. We need to lessen our plastic dependency and not find alternative ways for its destructive health in our environment.

Please pass HB 0021.

Thank you,
Carla Tevelow
District 12
Columbia, MD

HB21 - Prohibition on the Chemical Conversion of P
Uploaded by: Tulkin, Josh
Position: FAV

7338 Baltimore Ave
Suite 102
College Park, MD 20740

Committee: **Environment and Transportation**
Testimony on: **HB21 "Environment – Recycling – Prohibition on the Chemical Conversion of Plastic"**
Position: **Support**
Hearing Date: January 29, 2021

The Maryland Chapter of the Sierra Club supports HB21, which would prohibit establishment of facilities in Maryland that convert plastic into fuel and would exclude these processes from the definition of recycling in Maryland.

The plastics industry is gearing up to increase production four-fold by 2050 amidst a global plastic pollution crisis that threatens our land, oceans, wildlife, and human health. This crisis was caused largely by excessive production of cheap, single-use plastic with the knowledge decades ago that mechanical recycling of plastic would never be adequate to address plastic waste created.[1]

To put the public at ease, the industry is promoting a new solution to the plastic pollution crisis: "chemical recycling," also referred to as "advanced recycling." These processes[2] break down plastics into their monomer components with heat, pressure, and solvents, in a low-oxygen chamber, after which the components could then be used, in principle, to make new plastic via repolymerization, creating a circular economy in plastic.

In practice, the chemical conversion of plastic is not being used to create new plastic, but to transform plastic back into fossil fuel for combustion, which is not recycling. Despite 50 years of experimentation, the technology for chemical conversion of plastic is not mature and is not delivering on conversion of plastic to plastic.

- According to the Global Alliance for Incinerator Alternatives (GAIA), of 37 chemical recycling projects advertised since 2000, only three are in operation and none of these are transforming plastic-to-plastic.[3] There is no plastic-to-plastic operation that has been taken to scale. Almost all of the plastic in these operations is being transformed back into contaminated fossil fuel and burned.
- A 2020 report by Greenpeace examined projects promoted by the American Chemistry Council to divert plastic waste from landfills, finding that "none of the plastic-to-plastic projects…show promise of becoming viable. This means that very little of this

[1] See two recent documentaries *Plastic Wars* (https://www.pbs.org/wgbh/frontline/film/plastic-wars/), produced by PBS, and *The Story of Plastic* (https://www.storyofplastic.org/), produced by The Story of Stuff Project.
[2] Primarily pyrolysis and gasification.
[3] Global Alliance for Incinerator Alternatives (GAIA). 2020. "All Talk and No Recycling: An Investigation of the U.S. 'Chemical Recycling' Industry. Berkeley, California. www.no-burn.org/chemical-recycling-us.

investment [in chemical recycling] has a chance of reducing plastic production or pollution, and ensures years of fossil-based plastic pollution."[4]

The processes for converting plastic back into fossil fuel are energy intensive, present a large carbon footprint, and create a new waste stream of toxic contaminants, in addition to the environmental impacts of burning the contaminated fossil fuels.[5]

- Just as for mechanical recycling, the plastic still needs to be sorted by type. Additives and contaminants have to be stripped out.
- The process produces a new waste stream of gas products, oil products, and solvent products ("char") for disposal.
- Pyrolysis creates new contaminants, including high concentrations of dioxin, furans, heavy metals (mercury, cadmium, and lead), and particulates.
- Each stage of the process demands a lot of energy, has an enormous carbon footprint, and generates large carbon impacts.

This bill does not preclude the eventual development of plastic-to-plastic technologies. Repolymerization is not banned. However, even if chemical conversion of plastic to plastic worked, it would be much more expensive than mechanical recycling. *The fact is, no form of plastic recycling – mechanical or chemical – will be able to compete economically in a market is flooded with cheap virgin plastic.* [6] **The solution to the plastic pollution crisis going forward is clear: produce less plastic, especially single-use plastic**.

To summarize, plastic is made from fossil fuels, most commonly from fracked gas. Maryland has banned fracking because of its environmental impact. Now the industry wants us to allow a process that breaks plastic into its monomer components to make a heavily contaminated fossil fuel for combustion in Maryland. This is not recycling. Further, the process requires a lot of energy and has a high carbon footprint. The products are low quality and require extensive cleanup. The byproducts are highly contaminated, creating their own toxic waste stream. These processes will add to existing environmental injustices associated with increased extraction of fossil fuels. Let's prevent them from coming to Maryland.

We respectfully request a favorable report on HB21 to ban these processes in Maryland and ensure that they are not classified as recycling.

Martha Ainsworth
Chair, Chapter Zero Waste Team
Martha.Ainsworth@MDSierra.org

Josh Tulkin
Chapter Director
Josh.Tulkin@MDSierra.org

[4] *Deception by the Numbers: American Chemistry Council claims about chemical recycling investments fail to hold up to scrutiny.* Greenpeace Reports, September 9, 2020, p. 3. www.greenpeace.org/use/research/deception-by-the-numbers.

[5] GAIA. 2020. *Op cit*

[6] GAIA. 2018. "Questions and Answers: Chemical Recycling."

MD HB 21 testimony signed.pdf
Uploaded by: Braddon, George
Position: UNF

TEKNIPLEX
Global strength. Superior solutions.

January 21, 2021

RE: MDH.B.0021: Environment – Recycling – Prohibition on the Chemical Conversion of Plastic

Maryland Legislature

Mr. Chairman Barve and Members of the House Environment and Transportation Committee,

We are writing to express our opposition to HB 21. Advanced Recycling (AR) is a viable and scalable technology to reduce plastic entering the environment, including litter, ocean plastic, landfill or waste to energy.

For food packaging applications, mechanical recycling has limitations. One limitation is that the FDA does not allow for certain postconsumer recycled (PCR) material to be included in new food packaging. A second limitation is that each time a material is mechanically recycled, its quality degrades. Both of these limitations make PCR content in food packaging difficult. This is likely the main reason that the market for certain types of PCR is small and recycling rates low.

Through AR, post-consumer food packaging can be processed back into a feedstock for plastic and then used to make new materials. The process removes any possible contaminant allowing the new material to be used in food packaging applications. This is not possible with mechanical recycling.

AR allow plastics to be sourced from the plastics waste stream rather than from fossil fuels, helping to promote the circular economy while reducing the use of fossil fuels. Plastic sourced from plastics can be used again and again without a degradation in quality.

Advance Recycling should be included in the definition of recycling and should be promoted rather than banned.

Tekni-Plex is a globally-integrated company focused on developing and manufacturing products for a wide variety of end markets, including medical, pharmaceutical, food, beverage, personal care, household and industrial uses.

Respectfully urging an unfavorable report.

Respectfully,

George Braddon

Tekni-Plex, Inc.
460 E. Swedesford Rd., Suite 3000 ▪ Wayne, PA 19087 ▪ Phone (484) 690-1520 ▪ Fax (484) 367-7819

HB 21 Testimony_1.29.21.pdf
Uploaded by: Flores, Robert
Position: UNF

RE: MD HB21 – Environment – Recycling – Prohibition on the Chemical Conversion of Plastic

Hello. My name is Robert Flores, and I am the Vice President of Sustainability for Berry Global.

Headquartered in the United States, Berry is a leading global supplier of a wide range of innovative rigid and flexible, plastic packaging as well as nonwoven products used every day within consumer, healthcare and industrial end markets. In Maryland, we proudly employ over 700 team members across three manufacturing sites in Baltimore, Hanover, and Cumberland.

I join you today to share our concerns with House Bill 21. We believe that advanced recycling, including conversion technologies that convert plastic into chemical feedstocks, can and *will*, play a significant role in the transition to a circular economy for plastics.

In fact, just last year Berry publicized two off-take agreements we signed in Europe to purchase recycled plastic made via the advanced recycling techniques HB 21 aims to prohibit. We also announced a partnership with Mondelez International to produce packaging made from this material for Philadelphia, the world's most popular cream cheese.

In addition to these public announcements, we are in active discussions with our suppliers in both Europe and North America in regards to this vital technology. That is because we believe it will play that significant of a role in our future plans.

In 2019 Berry committed that 100% of our fast-moving consumer goods packaging would be reusable, recyclable, or compostable as well as have an average of 10% recycled content by 2025. Advanced recycling is in a unique position to assist with both of these goals – not only creating a new end market for plastic that isn't being recycled today via traditional recycling technologies, but also providing high quality recycled content that is suitable to be used in food contact and other regulated applications that would otherwise prevent the use of recycled content.

Our announcement with Mondelez, using recycled plastic in cream cheese packaging, would not be possible without advanced recycling. Otherwise, there simply is not recycled content available that is suitable for cream cheese containers.

If we want to close the loop and end plastic waste once and for all, while continuing to receive the many benefits plastics provide, such as reducing food waste and optimizing material use, we must encourage the development of breakthrough technologies like advanced recycling. That is why Berry has given these technologies so much attention. We truly believe advanced recycling is critical to achieving a circular economy for plastics.

In summary, we oppose House Bill 21. We do not believe the referenced technologies should be prohibited. We further believe these technologies should be considered recycling, especially when used to create new plastic products.

Thank you for your time.

HB 21_Recycling_Prohibition on the Chemical Conver

Uploaded by: Griffin, Andrew

Position: UNF

MARYLAND
Chamber of Commerce

LEGISLATIVE POSITION:
UNFAVORABLE
House Bill 21
Environment—Recycling—Prohibition on the Chemical Conversion of Plastic
House Environment & Transportation Committee

Friday, January 29, 2021

Dear Chairman Barve and Members of the Committee:

Founded in 1968, the Maryland Chamber of Commerce is the leading voice for business in Maryland. We are a statewide coalition of more than 4,500 members and federated partners, and we work to develop and promote strong public policy that ensures sustained economic recovery and growth for Maryland businesses, employees, and families.

House Bill 21 would alter the definition of recycling to exclude certain chemical conversion processes, pyrolysis, hydropyrolysis, methanolysis, gasification, enzymatic breakdown, or similar processes to be determined by the Maryland Department of Environment. Effectively, this bill amounts to a ban on the utilization of advanced recycling technologies in Maryland.

Advanced plastics recycling, or chemical recycling, refers to a group of technologies that convert post-use plastics into their original building blocks, specialty polymers, and feedstocks for new plastics, waxes, lubricants, and other valuable products. It is these technologies that allow us to keep post-use plastics out of landfills and the environment, and to meet our waste and sustainability goals.

Further, it is a common misconception that plastics are burned during advanced recycling processes. Advanced recycling technologies often use heat, but take place in the absence of oxygen, the key ingredient for combustion. Instead of being combusted, plastics' physical form is altered to form new feedstocks for plastics, chemicals, and other products.

Nine states have passed legislation to encourage these types of technologies, rather than ban them, because they acknowledge their benefits to technology and innovation. What is more, these states recognize the tremendous economic opportunity presented by advanced recycling technologies. Closed Loop Partners, a New York based investment firm, recently found that advanced recycling presents a $120 billion economic opportunity nationwide.

For these reasons, the Maryland Chamber of Commerce respectfully requests an **unfavorable report** on House Bill 21.

MDCHAMBER.ORG
60 West Street, Suite 100, Annapolis 21401 | 410-269-0642

Sealed Air Opposition to HB 21.pdf
Uploaded by: Grill, Terry
Position: UNF

Sealed Air®

January 26, 2021

Regarding Opposition to Recycling: Prohibition on the Chemical Conversion of Plastic - House Bill 21

Dear Chairman Kumar Barve and Members of the House Environment and Transportation Committee:

Sealed Air Corporation recognizes its responsibility as an industry leader in protective packaging to actively champion solutions to mitigate environmental impacts both of plastic packaging as well as the products they protect. We are actively engaged with multiple organizations around the world to improve recycling infrastructure and invest in new solutions to recover value from waste. Sealed Air announced in 2018 a pledge to advance our packaging solutions to be 100% reusable or recyclable by 2025 and to incorporate an average of 50% recycled content in our packaging.

Sealed Air Corporation opposes excluding advanced recycling technologies from the definition of recycling, including, but not limited to, Pyrolysis, Hydropyrolysis, Methanolysis, Gasification, Enzymatic Breakdown, or similar chemical conversion processes. In addition, we encourage the state of Maryland to embrace expansion of the recycling infrastructure to include advanced recycling technologies that are critical to creating a robust path of circularity/recycling for plastic packaging waste currently going to landfill.

Flexible packaging plastic films, in contrast to other materials, offer the high-performance that is essential for maintaining medical sterility and food protection. There are no effective non-plastic replacement products. Most high-performance plastic films cannot be recycled using existing mechanical recycling technology and flexible films that can rarely result in recycled material of a quality useful for food or medical packaging. In fact, mechanical recycling produces products that cannot remain in the chain of circularity indefinitely due to performance reduction. Advanced recycling, on the other hand, allows high quality materials to remain indefinitely in the cycle of use. If we are to reduce our use of virgin materials, reduce plastic waste and maintain or improve food security, health and safety we must be able to utilize advanced recycling to produce high quality starting materials.

It is imperative that these technologies be included in the Maryland definition of “recycling” thus keeping these materials “in play” and not going to landfill or incineration.

We understand that there have been concerns about emissions from waste incineration in Baltimore. We believe that it is critical for all production facilities to meet strict standards for air and ground water contamination so that the health and safety of neighboring communities are maintained. Advanced recycling technologies are distinct from waste-to-energy incineration. Advanced recycling is critical to addressing the challenges of plastic waste and necessary to maintain the availability of virgin quality recycled resins to meet the needs of medical and food applications that have strict Food and Drug Administration guidelines.

Please contact us if we can provide additional information as we work toward a mutually beneficial solution.

Sincerely,

Terry M Grill

Terry Grill, Sustainability Leader Americas
909.641.1162
terry.grill@sealedair.com

cc: Delegate Sara Love

SEE

HB0021_UNF_NWRA_ Recycling - Prohibition Chemical
Uploaded by: Kasemeyer, Pam
Position: UNF

wasterecycling.org

Maryland-Delaware Solid Waste Association
a chapter of the
National Waste & Recycling Association℠
Collect. Recycle. Innovate.

TO: The Honorable Kumar P. Barve, Chair
Members, House Environment and Transportation Committee
The Honorable Sara Love

FROM: Pamela Metz Kasemeyer
J. Steven Wise
Danna L. Kauffman

DATE: January 29, 2021

RE: **OPPOSE** – House Bill 21 – *Environment – Recycling – Prohibition on the Chemical Conversion of Plastic*

The Maryland Delaware Solid Waste Association (MDSWA), a chapter of the National Waste and Recycling Association, is a trade association representing the private solid waste industry in the State of Maryland. Its membership includes hauling and collection companies, processing and recycling facilities, transfer stations, and disposal facilities. MDSWA and its members **oppose** House Bill 21.

House Bill 21 not only excludes from the definition of recycling, new and innovative technologies for processing plastic into usable materials and products, but also prohibits the building of facilities in Maryland that use these technologies. While MDSWA understands that there is significant interest in limiting and/or eliminating plastic materials, they remain a significant component of the current waste and recycling streams. Even if the volume of plastic material is reduced over time, there will still be a need to process and manage plastic as it will remain a material that is essential for many critical products. Conversion of plastic directly into other products or as feedstock for new product development is much more environmentally beneficial than disposal of these materials or, in many instances, recycling of plastics through traditional recycling facilities. To that end, House Bill 21 actually works to impede meaningful recycling and new technology development for processing plastics. For these reasons, an unfavorable report is requested.

For more information call:
Pamela Metz Kasemeyer
J. Steven Wise
Danna L. Kauffman
410-244-7000

Testimony on MD HB21.pdf

Uploaded by: Keane, Alison

Position: UNF

Flexible Packaging Association
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www.flexpack.org

Testimony in OPPOSITION
to
House Bill 21
in
Maryland House Environment and Transportation Committee
on
January 29, 2021

The Flexible Packaging Association (FPA) is submitting testimony in opposition to HB21, "Recycling: Prohibition on the Chemical Conversion of Plastic," which would ban the use of advanced recycling in the state. I am Alison Keane, President and CEO of FPA, which represents flexible packaging manufacturers and suppliers to the industry in the U.S. Flexible packaging represents $33.6 billion in annual sales; is the second largest, and fastest growing segment of the packaging industry; and employs approximately 80,000 workers in the United States. Flexible packaging is produced from paper, plastic, film, aluminum foil, or any combination of these materials, and includes bags, pouches, labels, liners, wraps, rollstock, and other flexible products.

These are products that you and I use every day – including hermetically sealed food and beverage products such as cereal, bread, frozen meals, infant formula, and juice; as well as sterile health and beauty items and pharmaceuticals, such as aspirin, shampoo, feminine hygiene products, and disinfecting wipes. Even packaging for pet food uses flexible packaging to deliver fresh and healthy meals to a variety of animals. Flexible packaging is also used for medical device packaging to ensure that the products packaged, diagnostic tests, IV solutions and sets, syringes, catheters, intubation tubes, isolation gowns, and other personal protective equipment maintain their sterility and efficacy at the time of use. Trash and medical waste receptacles use can liners to manage business, institutional, medical, and household waste. Carry-out and take-out food containers and e-commerce delivery, which are increasingly important during this national emergency, are also heavily supported by the flexible packaging industry.

Thus, FPA and its members are particularly interested in solving the plastic pollution issue and increasing the recycling of solid waste from packaging. We do not believe that HB21 will help to do that. Flexible packaging is in a unique situation as it is one of the most environmentally sustainable packaging types from a water and energy consumption, product-to-package ratio, transportation efficiency, food waste, and greenhouse gas emissions reduction standpoint, but circularity options are limited. There is no single solution that can be applied to all communities when it comes to the best way to collect, sort, and process flexible packaging waste. Viability is influenced by existing equipment and infrastructure; material collection methods and rates; volume and mix; and demand for the recovered material. Single material flexible packaging, which is approximately half of the flexible packaging waste generated, can be mechanically recycled through store drop-off programs, however, end-markets are scarce. The other half can be used to generate new feedstock, whether through chemical recycling, pyrolysis, and gasification, but this infrastructure does not exist in the scale needed, and again, if there are no end markets for the product, these efforts will be stranded.

Developing end-of-life solutions for flexible packaging is a work in progress and FPA is partnering with other manufacturers, recyclers, retailers, waste management companies, brand owners, and other organizations to continue making strides toward total packaging recovery. Some examples include The Recycling Partnership; the Materials Recovery for the Future (MRFF) project; the Hefty® EnergyBag® Program; and the University of Florida's Advanced Recycling Program. All of these programs seek to increase the recycled content of new products that will not only create markets for the products but will serve as a policy driver for the creation of the collection, sortation, and processing of the valuable materials that make up flexible packaging. To increase recycled content in new products, reliable high-quality supply must be available and advanced recycling systems must be built.

FPA believes that a suite of options is needed to address the lack of infrastructure for non-readily recyclable packaging materials, and promotion and support of market development for recycled products is an important lever to build that infrastructure. Advanced recycling is an important emerging technology that helps eliminate packaging wastes, particularly plastic packaging waste, from the environment. Advanced recycling complements traditional (mechanical) recycling and enables us to recycle greater amounts and a wider variety of plastics, helping eliminate plastic waste. While successful recycling infrastructure is in place for plastics such as soda bottles and milk jugs, advanced recycling technologies focus on harder-to-recycle plastics, such flexible packaging. Banning this technology will only serve to increase the amount of plastic going to landfills and potentially leaking into the environment and will strand what could be valuable material for recycled content back into packaging as well as a host of other products.

FPA, headquartered in Annapolis, does not believe that Maryland intends on being a state that distrusts science and technology. Nine other states have recently passed legislation encouraging advanced recycling technology in their states, not only to help eliminate plastic waste and to create markets for recycled content, but to drive green job growth and infrastructure development for their economies. And just last week, FPA supported Maryland HB164, which would require the Recycling Office of the Maryland Department of Environment promote and make recommendations to support market development for recycled products. This cannot be done without innovations like advanced recycling technologies. Thus, FPA believes this bill is misguided and simply reflects a misunderstanding of the technology.

For these reasons, FPA opposes HB21 and urges the Committee to not vote in favor. In advance, thank you for your consideration. If we can provide further information or answer any questions, please do not hesitate to contact me at 410-694-0800 or akeane@flexpack.org

HB 21-Testimony with Attachement.pdf

Uploaded by: MANIS, NICK

Position: UNF

Manis Canning & Associates

January 25, 2021

The Honorable Kumar P. Barve, Chair
House Environment and Transportation Committee
Room 251
House Office Building
Annapolis, Maryland 21401

Dear Mr. Chairman and Members of the Committee:

We are writing on behalf of our client the American Chemistry Council (ACC) to advise you of their opposition to **HB 21 Environment – Recycling – Prohibition on the Chemical Conversion of Plastic**. We along with Steve Wise and Frank Boston represent ACC and we are relinquishing our time to testify at the hearing on January 29, 2021 so that you and the committee members can hear from representatives from ACC, experts in the technology and process as it relates to advanced recycling, Maryland and national companies, and others that are and would be directly impacted by this mandate.

We will be in contact with you and should you have any questions or further information is needed, please do not hesitate to contact us. We have also included in our testimony an article by Marco J. Castaldi, Ph.D., who is a Fulbright Global Fellow and Technical Fellow of the American Society of Mechanical Engineers that provides you additional information on Alternative Recycling.

We appreciate your consideration and ask that you **OPPOSE HB 21 Environment – Recycling – Prohibition on the Chemical Conversion of Plastic**.

Sincerely,

Nick Manis

John Favazza

CC: Delegate Sara Love
Steve Wise
Frank Boston

George N. Manis, Esq. (1929-2014)
Michael F. Canning, APR
Nicholas G. Manis
John F. Favazza, Esq.
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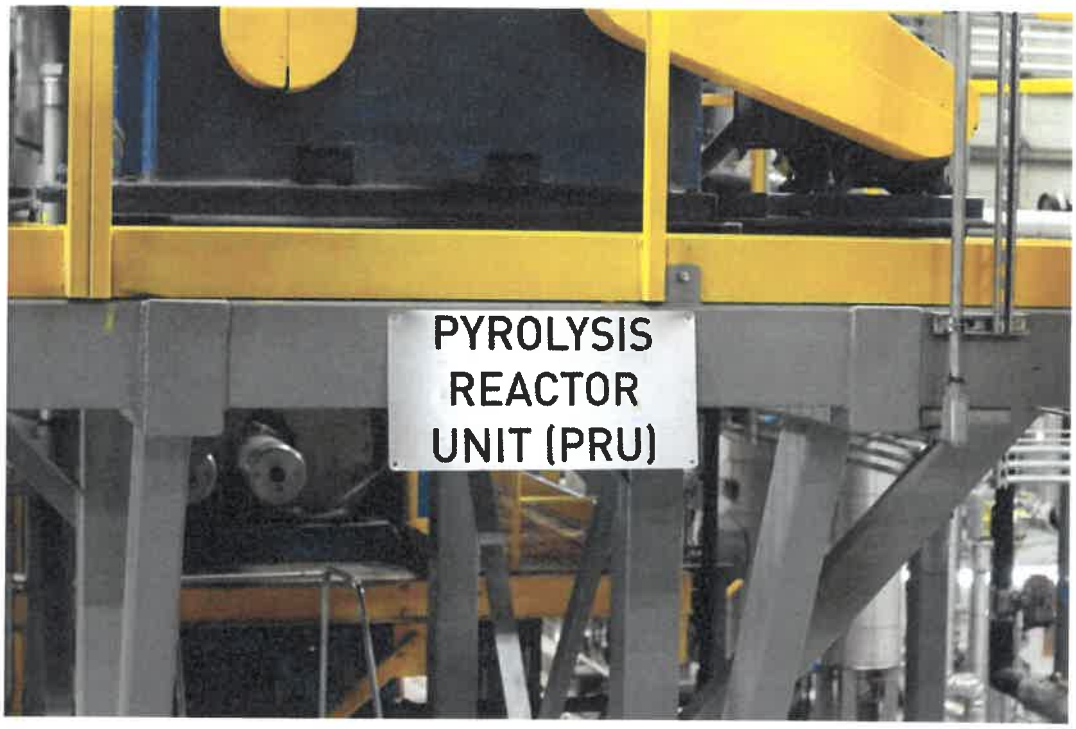
In My Opinion: Industry's tech development must continue

Posted on October 14, 2020

by Marco J. Castaldi, City College of New York



Pyrolysis equipment inside the Agilyx facility in Oregon. | Jared Paben/Resource Recycling, Inc.

If there is one thing I have learned in my career as a practicing engineer, researcher and educator, it is this: You have to actually see, investigate and work with technology to make a credible assessment of its potential impact. Furthermore, impacts should be measured to the extent possible and incorporated into life cycle analyses.

Of course, impacts can be positive or negative. So, the question I'd like to address here is: On a life cycle basis, is the overall environmental impact positive or negative when it comes to using advanced recycling technologies to convert plastic wastes that would otherwise end up in a landfill? The answer is they are positive.

Before I discuss how I know this, I will explain why I am qualified to perform an analysis and draw a conclusion.

My perspective stems from nearly 15 years of in-depth, hands-on research on varied waste conversion technologies related to wastes that would otherwise be destined for landfills.

Prior to taking my current position with the City College of New York, I was an associate professor at Columbia's Earth & Environmental Engineering Department, and before that, I worked in industry for 10 years. I have globally collaborated on wide-ranging research from catalytic reactor development to combustion modeling to technology development. I have seven patents and two pending applications in the areas of catalysis and combustion and have authored over 100 peer-reviewed publications.

It is through these experiences that I am providing this perspective. The reason I am doing so is because, in general, there is far too much mischaracterization of some plastic recycling technologies and processes. The unfortunate result is confusion among policymakers, regulators and potentially the public.

An important aspect is that my team and I physically visit and work closely with the engineers and inventors of operations. We have assessed numerous technology development companies and laboratories all over the world. Many of those companies request that we quantitatively evaluate their system and suggest possible process improvements. To arrive at quantitative assessments of impacts requires site visits and direct contact.

Marco Castaldi

Mentioned above, there are multiple ways to interpret "impact," ranging from positive to negative. Specific to conversion technologies (thermal or chemical), my experience and the data convince me they have a significantly positive environmental impact on managing plastic waste.

Mismatch in supply and demand

Currently, there is a mismatch between the availability of recyclable plastic waste and the ability of markets to absorb it. For example, only 48% of plastics in New York's blue bins get recycled through traditional recycling methods, leaving opportunities for new technologies to use the rest.

What happens to the other 52%? There are only two options: landfill or conversion to some other product such as energy, synthesis gas or pyrolysis oil. Clearly, in this example, it is a positive impact to employ technologies that convert that plastic waste into something useful instead of going to landfill.

It is also important to acknowledge that conversion technologies produce emissions that are released into the environment, resulting in some negative impact (keeping in mind that emissions are produced by all waste management processes, from reuse to mechanical recycling to chemical or thermal conversion to disposal in landfills).

But it serves no good purpose when organizations or uninformed individuals make claims of "toxic emissions" being produced. The real question is what are the emissions and how do they compare to the regulatory limits established by credible institutions such as the EPA and state environmental protection agencies?

A review of the published literature reveals that emissions from conversion processes such as plastics-to-fuels demonstrates they are lower for volatile organic compounds and particulate matter, nitrogen oxides, sulphur oxides, and carbon monoxide than food processing plants, hospitals, universities and automotive manufacturing facilities.

The Earth Engineering Center, which I direct, has reviewed technical reports on numerous gasification and pyrolysis technologies, as well as conducted our own research. The center has found that they all emit below the regulatory limits that have been established for their respective systems.

Back to the ultimate question: On a life cycle basis, would the overall impact on the environment be positive or negative when deciding to use conversion technologies on plastic wastes that cannot be or are not mechanically recycled? Rigorous, peer-reviewed engineering and scientific studies have overwhelmingly found it is a positive impact.

Of course, many of these developing technologies are just that: still developing. All technology takes time to mature into a commercial system robust enough to be launched and relied upon for continuous operation for years at a time.

Technologies that are and have been developed to convert waste into something useful have an additional challenge. The feedstock (i.e. waste stream) is variable and has significantly changed over the years. For example, more attention has been given to collection, sorting and pre-processing systems to extract valuable products. That extraction, though is a positive thing, materially changes the input, thereby requiring adjustments to the conversion technology.

If a mixed waste stream could be completely separated into consistent, mainly pure streams of specific items (e.g. hard plastics, film wrap, paper, corrugated board, etc.) then it would accelerate the development of these technologies. They could be designed to accept a fairly narrow category of feedstock. To date, however, pure stream separation has proven prohibitively expensive and faces significant technology challenges. That doesn't mean we should stop trying. After all, past failures are lessons for future success.

Misunderstanding toxicity

I'd also like to address a false premise about the outputs of conversion technologies used to synthesize waste streams. It goes like this: Materials entering a given system can affect the make-up of the final product; therefore, toxic materials entering the system will result in toxic substances in finished fuels or chemicals. This is not correct.

As with all synthesis processes, the main goal of companies developing conversion technologies is to produce a final product that meets certain specifications. All technology developers recognize that the production of a fuel or chemical that has unacceptably high levels of contaminants, compared to the specifications, will have major implications for a potential buyer and user.

That applies not only to specifications designed to protect the environment, but also those designed to protect the equipment. Specifically, fuels must meet very specific viscosity, smoke point, boiling point, and halogen, oxygen and metal content for engines to perform properly.

Chemicals made from waste streams must also meet stringent specifications for downstream refiners or manufacturers to accept them, because they have billions of dollars of infrastructure at stake and have multiple options for feedstock. From our research, it is clear that conversion processes are designed to deliver products well within these stringent expectations.

We have a waste problem in the world. We need to consider all options to safely and sustainably manage the enormous amount of waste that you and I generate – nearly four pounds per person per day. The decisions we make about which options to use should be backed by reliable scientific data. When misinformation is used to mislead our decision makers and the general public about these options, we run the risk that these options will be taken off the table – and no action or misguided action will be taken to solve our waste problem. Ultimately, the common objective must be to divert as much waste as possible from landfills, recover as much material and energy as possible from the waste stream, and recirculate it through the economy.

Marco J. Castaldi, Ph.D., is a professor of chemical engineering at the City College of New York. He is a Fulbright Global Fellow and Technical Fellow of the American Society of Mechanical Engineers (ASME) and the American Institute of Chemical Engineers (AIChE).

Braven Maryland Testimony 1_29_2021.pdf
Uploaded by: Moreno, Michael
Position: UNF

Braven.

Braven
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January 29, 2021

RE: MD H.B.0021: Environment – Recycling – Prohibition on the Chemical Conversion of Plastic

Maryland Legislature
Mr. Chairman Kumar Barve and Members of the House Environment and Transportation Committee,

We are writing to express our opposition to HB 21. Advanced Recycling (AR) is a proven, scalable and commercially viable technology that can redirect difficult to recycle plastics away from landfills and other traditional disposal options to facilities that can safely and efficiently produce derivative products used by petrochemical companies to make new plastics, therefore supporting the closed-looped plastics economy and reducing the use of traditional fossil fuels to make new plastics.

These difficult to recycle plastics had been, prior to 2018, shipped to China and other markets. Since that has ended, it now needs to be a priority to find alternative solutions of disposal. AR is a part of that solution, complementing mechanical recycling and therefore significantly increasing the secondary useful life of both post-consumer and post-industrial difficult to recycle plastics.

Advanced Recycling should be included in the definition of "recycling" and ways to expand the deployment of the technology should be implemented. It is important to note that advanced recycling technologies, which allow the conversion of plastics in an oxygen deprived environment, are very much distinct from incineration, which involves combustion of a substance in an oxygen rich environment. Advanced recycling will be critical component to addressing the nation’s plastic waste challenges. Therefore, legislation blocking the development and deployment of AR is counterproductive and misguided.

Braven has developed leading AR technology over the last ten years, operates an AR facility in Zebulon, North Carolina, and is building a network of facilities across the country (including the state of Virginia) to directly provide an impactful solution in the disposition of hard to recycle plastics today.

Respectfully urging a blocking of this legislation.

Sincerely,
Michael Moreno
Chief Operating Officer

EMN Testimony.1.29.2021.pdf
Uploaded by: Perry, Brent
Position: UNF

EASTMAN

Bill Title: **House Bill 21 Environment – Recycling – Prohibition on the Chemical Conversion of Plastic**
Committee: **Environment and Transportation**
Date: **January 29, 2021**
Position: **Report Unfavorably**

On behalf of Eastman, thank you for the opportunity to provide comments on House Bill 21 Environment – Recycling – Prohibition on the Chemical Conversion of Plastic (HB 21). As attention increases on the waste plastic crisis, it is vital that representative government, advocates, and private industry collaboratively develop solutions to recycle a broad range of these materials. As a private industry stakeholder, Eastman has great concern that legislation like HB21 will stifle the current progress and ultimately result in less plastic being recycled.

Founded in 1920, Eastman is a global specialty materials company that produces a broad range of products found in items people use every day. As a globally inclusive and diverse company, Eastman employs approximately 14,500 people worldwide and serves customers in more than 100 countries. In Maryland, Eastman operates a manufacturing facility in Chestertown where we produce materials used in building and construction, medical applications and consumer goods.

The current pattern of consumption and disposal of plastics is not sustainable. Approximately 300 million tons of plastic are produced each year globally. At the end of use, 40 percent goes to landfills, 25 percent is incinerated, and 19 percent is disposed in unmanaged dumps or otherwise makes its way into the environment. Only 12 percent is recycled.

While traditional or mechanical recycling is necessary, the infrastructure and capability to process a range of plastics inhibits it from being the singular recycling solution to address the scale of the global waste plastic crisis.

In 2019, Eastman began commercial-scale molecular recycling, a form of material-to-material chemical recycling, for a broad set of waste plastics that would otherwise be landfilled, incinerated, or worse, end up in the environment. We see this as a key early step to address the challenges with today's limited recycling options. Eastman Advanced Circular Recycling technologies are designed to process waste plastics where traditional mechanical recycling methods cannot—including polyesters, polypropylene, polyethylene, and polystyrene—derived from a variety of sources, including single-use plastics, textiles, and carpet. These platforms, which utilize both gasification and methanolysis technologies provide a true circular solution of endless recycling for materials, allowing them to be reused repeatedly, without sacrificing quality and performance.

A circular plastics economy is necessary to address a challenge as great as the global waste crisis. In other words, rather than proceeding on the linear pattern of creating, using and disposing of resources, we should establish a system that harnesses and unlocks the potentially infinite value of materials by keeping them in production – lifecycle after lifecycle – while simultaneously reducing greenhouse gas emissions by reducing dependence on fossil feedstocks. While the "reduce, reuse and recycle principle" remains important to addressing the global waste crisis, our current system has not typically included technologies that can recycle more complex materials. Recognizing the ability of these technologies to create recycled material will go a long way to ensuring these complex materials are recycled in an environmentally responsible way and put back into commerce. The alternative is the continued manufacture of new products, only compounding our waste plastic crisis and perpetuating the use and impact of fossil feedstocks.

Material-to-material recycling technologies, such as Eastman's advanced recycling capability, enable waste plastic not suitable for traditional recycling processes to be broken down and used in the creation of new plastics. Eastman's material-to-material recycling technologies break down plastic waste to its molecular building blocks, identical to virgin plastic's building blocks, for the manufacture of new plastics. Since the waste plastic is reduced to the molecular level and built back up into new plastic, there is no plastic degradation in the new product, which allows the molecules to be reused infinitely in place of virgin raw materials.

HB21 would prohibit materials manufactured using these advanced recycling processes from being defined as recycled. Further, the bill would not allow a facility that utilizes these technologies to be sited in Maryland.

Advanced recycling is critical to increasing recycling rates and preventing discarded plastic from being incinerated or landfilled. It is Eastman's strong desire to steadily replace traditional fossil feedstocks with waste plastic. We take seriously the concept of reduce, reuse, recycle. While we do not manufacture single-use plastics, we can upcycle them to more durable plastic products, like refillable water balls and eyeglass frames. By 2030, we expect to recycle up to 500 million pounds of waste plastic annually.

At the same time, we're actively working to find new ways to reduce our own environmental impact, advocating for the creation of a more robust recycling infrastructure and helping our partners preserve natural resources through molecular recycling. By using plastic waste in place of fossil feedstocks, our technologies show 20-50 percent improvements in carbon footprint in the production of key building blocks.

Eastman advanced recycling technologies are truly circular, allowing for plastic to be recycled on an infinite loop. They are also more sustainable than traditional processes for manufacturing plastic. We believe it would be a mistake for the House of Delegates to close off this important component to the national and global waste plastic problem and urge an unfavorable report from the Committee.

Brent Perry
Government Affairs Director
Eastman

MITA -- HB21.pdf
Uploaded by: Powell, Michael
Position: UNF

HB 21

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January 29, 2021

VIA ELECTRONIC FILING
The Honorable Kumar P. Barve
Chair, Environment and Transportation Committee
Room 251
House Office Building
Annapolis, Maryland 21401

Re: House Bill 21

Dear Chairman Barve:

This letter is written on behalf of the Maryland Industrial Technology Alliance ("MITA"), a non-profit trade association representing industrial, manufacturing, and supporting businesses **opposing House Bill 21**, which would prohibit any person from building a facility in the State of Maryland that converts plastic to fuel through certain advanced recycling processes, including pyrolysis, hydropyrolysis, methanoloysis, gasification, and enzymatic breakdown. MITA opposes this bill and requests an Unfavorable Report for the following reasons:

- Advanced recycling is a natural complement to traditional recycling methods because it allows for effective processing of certain plastics that are not capable of traditional recycling and thus ordinarily would end up in landfills. HB21 would reduce the potential for these types of processes and require more landfilling than otherwise would have been necessary.

- One report estimates that advanced recycling has the potential to grow to a $120 billion industry in the United States and Canada alone. Several MITA members are interested in deploying this technology once commercially viable. HB21 would foreclose Marylanders from benefiting from this economic opportunity, with these facilities simply shifting across state lines.

- Numerous other states have passed legislation promoting advanced recycling, similar to other industries that the General Assembly has promoted as an economic growth opportunity. This legislation is significantly out-of-step with the national trend, halting a brand-new industry in its tracks.

For these reasons, MITA respectfully request that you give HB21 an **Unfavorable Report.**

Very truly yours,

Michael C. Powell

Michael C. Powell

cc: Environment and Transportation Committee Members

MD HB 21 Opposition Coalition Letter.pdf

Uploaded by: Young, Josh
Position: UNF

January 22, 2021

To: Members of the Maryland State House of Representatives

RE: Maryland House Bill 21

We are writing to ask you to oppose Maryland House Bill 21 which would ban use of advanced recycling in the state. Advanced recycling is an important emerging technology that helps eliminate plastic waste from the environment and supports achievement of state and local sustainability and zero waste goals. Banning this recycling innovation would increase the amount of landfilling and materials in the environment, squander potential recycling of valuable material, and forgo economic growth and opportunity.

This innovative technology (sometime referred to as chemical conversion) converts post-use plastics into their original building blocks to produce new plastics, waxes, and other valuable products. It's important to note that plastics are not burned during advanced recycling. Advanced recycling technologies often use thermal energy (heat), but take place in the absence of oxygen, so there is no combustion.

Advanced recycling complements traditional (mechanical) recycling and enables us to recycle greater amounts and a wider variety of plastics, helping eliminate plastic waste. While successful recycling infrastructure is in place for plastics such as soda bottles and milk jugs, advanced recycling technologies focus on harder-to-recycle plastics, such as candy wrappers, plastic tubes, tubs and lids, pouches and many forms of packaging. Banning advanced recycling would mean more landfilling and wasting valuable post-use plastics.

More than 400 global companies have set goals to include more recycled content in their packaging. To get there, organizations are innovating and growing to meet this demand. Since 2017, there have been

$4.3 billion worth of announced advanced recycling projects in the U.S. The economic basis for such investment is clear. A 2019 report by the Closed Loop Partners, an organization that invests in the development of the circular economy, found there is tremendous demand for the products of advanced recycling. The report concluded "Our analysis indicates that these technologies could meet an addressable market with potential revenue opportunities of $120 billion in the United States and Canada alone."

For Maryland to ban these technologies would be like banning electric car or solar power technologies in their early stages. In fact, nine other states have recently passed legislation encouraging new advanced recycling technologies. This bill is misguided, reflects a misunderstanding of the technology, and would set the precedent that Maryland opposes technological innovations.

We encourage you to oppose HB 21. Please feel free to contact Josh Young, Josh_Young@americanchemistry.com, at the American Chemistry Council if you have any questions.

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Uploaded by: Young, Josh
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