Chemical recycling of plastics: Viability, environmental impacts and regulation

Friday 10 June | 1:15 - 2:45 pm | Room C

With: Dr Andrew Rollison, GAIA chemical engineer
Lee Bell, IPEN Mercury and POPs Policy Advisor and
Lauriane Veillard, ZWE Chemical Recycling Policy Officer

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‘CHEMICAL RECYCLING’ OF PLASTICS
What is it and what impacts for the environment?

SPEAKERS

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With the support of the
‘Chemical recycling’ of plastics – What is it and what impacts for the environment?
CHEMICAL RECYCLING IS A UNICORN

YOU MUST BELIEVE IN UNICORNS IF YOU BELIEVE INDUSTRY’S CHEMICAL RECYCLING / ADVANCED RECYCLING FAIRYTALE

IPEN
for a toxic-free future
In Reality, Chemical Recycling:
- is old, outdated technologies, rebranded
- produces huge hazardous waste streams

“There is a residual solid waste stream of 10-30% that contains contaminant” – Chemical Recycling Europe (trade association)

The Basel Convention Plastic Waste Guidelines should not include Chemical Recycling / Advanced Recycling. It is not an environmentally sound, commercially viable technology.

Visit us online for IPEN’s research and projects that reveal hazardous substances in all stages in the life-cycle of plastics. https://ipen.org/policy/toward-a-plastics-treaty
'Chemical recycling' of plastics – What is it and what impacts for the environment?
Global Alliance for Incinerator Alternatives

‘Chemical recycling’ of plastics: viability, environmental impacts and regulation

The energy needs and environmental impacts of chemical recycling of plastics

Dr Andrew N Rollinson
CHEMICAL RECYCLING

WARNING: IMPACT UNCLEAR

LET THE PLASTIC INDUSTRY TAKE YOU FOR A RIDE!
What is ‘Chemical Recycling’?

- Lab’ trials in 1950s
- Been failing commercially since the 1970s
- A collection of concepts, no accepted definition
- Molecular not mechanical process
Depolymerisation

Pyrolysis and Gasification

- All organic matter when heated without oxygen will release a complex mixture of volatile organic molecules – this is “pyrolysis”

- Pyrolysis practised for thousands of years. Gasification technology developed in the 1800s

http://www.gekgasifier.com/info/gasification-basics/gasification-explained

Photo creative commons: Lars plougmann
Pyrolysis and Gasification

Attempts to manage dirty gases now 100 years old

- Incomplete combustion products, most of which are environmental toxins
- Polycyclic Aromatic Hydrocarbons (PAHs) - tar and soot


>All Pyrolysis and Gasification Reactors produce tar!
Solvent-based Technologies

- High temperature
- Highly solvent specific
- Large volumes of toxic waste solvent
- Plastic toxins go into solvents and products
Findings: Environmental Impacts

High energy intensity
High carbon emissions

“Pyrolysis oil should not be used as an energy source”
Mohr et al. 1997

Findings: Environmental Impacts

- When plastics decompose it is not simply a reversible process
- Unwanted molecules are produced

“All these contaminants are known to cause corrosion issues, increase coke formation, destroy expensive reactor tubes, or deactivate catalysts in the separation section of a steam cracker.”

“In a nutshell, today the quality of crude plastic pyrolysis oils is unacceptable as feedstocks for industrial steam crackers.”

Findings: Environmental Impacts

- Presence of banned substances and subsequent need to comply with chemical hazard regulations has been the primary cause of plant closure.¹

- Common for polymer toxins (such as phthalate esters) to transfer into the solvent.¹

Following a study of plastic pyrolysis, the resultant char was contaminated with heavy metals (As, Cd, Pb, Cu, Hg, Zn), and classified as both hazardous and ecotoxic.²

Findings: Energy

The leaky circular economy in plastics

- High fossil fuel consumption
- Little plastic makes the round trip

“No chemical recycling technology can offer a net-positive energy balance, even if the products/by-products are burned for energy”

The majority of facilities are not recycling any plastics
- The facilities generate large quantities of hazardous waste
- They release hazardous air pollution

Reviewed eight ‘chemical recycling’ facilities in the U.S.
Nearly 500,000 pounds of hazardous waste were reported in 2019 from one “chemical recycling” facility alone. Data from the EPA shows that Agilyx generated nearly 500,000 pounds of hazardous waste in 2019 alone, sending most of it off site to be burned (Table 2). This waste consisted primarily of benzene, along with other toxics such as lead, cadmium, and chromium (Table 2).25

- **Hazardous waste sent off-site by Agilyx:**
  Lead, cadmium, selenium, benzene, chromium, vinyl chloride, barium.
- **Hazardous air pollutants associated with multiple facilities:**
  Styrene, benzene, toluene, mercury, arsenic, dioxins, ethyl benzene, xylene, naphthalene, acetaldehyde, formaldehyde, hydrochloric acid, hexane.
California U.S. Attorney General

Investigation into public mis-information campaigns about the efficacy of recycling over several decades.

Attorney General Bonta Announces Investigation into Fossil Fuel and Petrochemical Industries for Role in Causing Global Plastics Pollution Crisis

Press Release / Attorney General Bonta Announces Investigation into Fossil F...

Thursday, April 28, 2022
Contact: (916) 210-6000, agpressoffice@doj.ca.gov

Subpoenas ExxonMobil for information relating to decades-long plastics deception campaign

LOS ANGELES – California Attorney General Rob Bonta today announced an investigation into the fossil fuel and petrochemical industries for...
“...the pellet yield is only around 22 per cent of the original input material.” (Veolia Executive)
Conclusions

- No evidence that chemical recycling is ‘Environmentally sound’. All evidence is to the contrary
- Energy balance is negative. Climate impacts
- Fifty years of commercial failure
- Large quantities of toxic residues produced
- Toxins go into products and by-products
- The operating facilities recycle little or no plastics
- Lock in to decades more fossil fuel consumption...
- ...hence heavily promoted by petrochemicals industry
Thank you for joining us!

Get in touch

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Read more at www.no-burn.org
'Chemical recycling' of plastics – What is it and what impacts for the environment?
Chemical recycling of plastics: Viability, environmental impacts and regulation.

Pyrolysis and gasification: Low viability with high public relations potential.
Chemical recycling: Pyrolysis and Gasification

Feedstock recycling, also known as chemical recycling, aims to convert plastic waste into chemicals that can eventually be converted into new plastic.

- The vast majority of chemical recycling projects are based on these two technologies
- Waste plastics are heated between 400–800°C in pyrolysis and 1,200°C – 1,500°C in gasification plants under very low or no oxygen levels. The goal is that the polymer is thermally decomposed into hydrocarbon building blocks including monomers that can then be used again as a raw materials in chemical processes including plastic manufacture. The main outputs of the process are an oil product and carbon char.
- Neither of these processes are new or advanced and have operated, mostly unsuccessfully, for decades
- However, many plastics contain oxygen which lead to the formation of POPs in the processes.
Chemical depolymerization

This chemical recycling process is essentially the opposite of polymerization and produces single monomer molecules or shorter fragments called oligomers. The process only operates efficiently with highly selective inputs requiring careful source segregation and is well suited to PET and purified terephthalic acid (PTA) but is also applicable to PA, PU, PLA, PHA, PEF, and PC and a range of polyesters.
Solvolysis

- Solvolysis is a purification process based on dissolving polymers in proprietary solvents, separating contaminants and reconstituting the target polymer.

- In general, the solvent-based purification works by dissolving the polymer in a specific solvent followed by the removal of contaminants such as additives, pigments, and non-intentionally added substances (NIAS) through filtration or phase extraction, and then precipitating the polymer using an anti-solvent in which the polymer is insoluble (Crippa et al., 2019).

- Its main application has been to remove brominated flame retardants and other additives from polystyrene allowing the target polymers to be purified and used as direct feedstock in new polystyrene production.

- This is very different to pyrolysis and gasification and could be supported, but also does have a waste stream generated by removing additives from the target polymers when large volumes are processed. It should be limited to polystyrene and not mixed wastes.
Why is it being promoted as the solution to global plastic waste solution?

- The fossil fuel industry is being forced to pivot away from fuel manufacture due to their carbon liabilities and are shifting fossil fuels in plastic production.

- Mechanical recycling of plastic was heavily promoted in the 1980s when the plastic manufacturers were last under major pressure over plastic pollution. It has failed to stem the tide of plastic pollution with only about 9% of all plastic ever produced having been recycled. The rest had either been dumped or incinerated.

- Plastic producers don’t want limits imposed on plastic production but cannot now claim mechanical recycling will resolve the crisis and so are vigorously promoting chemical recycling as the solution that will allow plastic production and profits to continue unabated.
Additives in plastic waste generate a large hazardous waste stream from chemical recycling

• However, most plastics contain chemical additives, including POP, that may have functions as colorants, UV stabilisers, plasticisers, and fillers. These additives either go on to contaminate the output of the pyrolysis and gasification plants or become part of the hazardous waste stream from these processes. The more the outputs of these processes are purified the more hazardous waste is generated as solid waste or emissions.

• The useful output of hydrocarbon chemicals from these processes can be oils, waxes and synthetic gases (syngas). In most cases these outputs are too contaminated to be used directly as feedstock. They are often too contaminated to be used as fuels. With further clean up they can be used as low-grade fuels. It is very expensive to clean them to the point they can be used as chemical feedstock.
Is chemical recycling viable?

IPEN argues that chemical recycling, particularly pyrolysis and gasification, is not viable due to:

- Its inability to compete economically with virgin plastics.
- Costs of filtering out chemical additives in primary treatment and subsequent costs of post treatment purification of outputs.
- Low yields and high hazardous waste disposal costs.
- High energy consumption costs.
- High carbon footprint liability.
- Need for clean homogenous plastic inputs.
- Cost of emissions controls and compliance.
- Environmental impacts.

Billions are being invested by plastic companies who need to be seen to have a solution to plastic pollution to avoid production limits.

Petrochemical and consumer-goods companies called the Alliance to End Plastic Waste, including Exxon, Dow, Total, Shell, Chevron Phillips, and Procter & Gamble, committed to spending $1.5 billion over five years.
European plastics manufacturers plan 7.2 billion euros of investment in chemical recycling

Indorama to invest $8 billion in chemical recycling and more

Published: March 30, 2022

Billion investment in plastic recycling in Sweden

Swedish Plastic Recycling (Svensk Plaståtervinning) is investing in building the world’s largest and most modern facility for plastic recycling, Site Zero.
European Government is not convinced.

“there is significant uncertainty about whether building a pyrolysis infrastructure to recycle plastics will actually lead to new materials, or only to fuels. Such a linear lock-in is clearly not in line with the basic principles of a circular economy and is one of the major concerns when considering the role of pyrolysis in the plastics economy” (European Commission 2018).
Journalists even less so…
Researchers were able to “quantify that the toxicity rating of PCDD/DF products from pyrolysis was three times the input at full operational performance and eleven times the input at pilot scale, and that these toxins were also present in both gas and oil” (Chen et al., 2014).

Using mixed inputs of plastic waste has been demonstrated to generate toxic substances in char and emissions such as polyaromatic hydrocarbons (PAHs) and dioxins (Crippa et al., 2019, Rollinson and Oladejo 2019).

Low quality contaminated outputs expensive to decontaminate
Plastic Additives 4-6% CAGR represents a massive waste stream if chemical recycling is widely adopted

Attractive Opportunities in the Plastic Additives Market

Increasing demand for consume goods and automotives are attributed to increase the demand for plastic additives in APAC.

<table>
<thead>
<tr>
<th>Year</th>
<th>Value (USD Billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021</td>
<td>45.6</td>
</tr>
<tr>
<td>2026</td>
<td>59.9</td>
</tr>
</tbody>
</table>

CAGR of 5.6% of the plastic additives is projected to reach 59.9 USD billion by 2026, registering a CAGR of 5.6% during the forecast period.

The global market growth is attributed to increasing demand from packaging industry.

New product launches may offer lucrative opportunities for market players in the next five years.

Rise in use of plastic molded parts for vehicle production is attributed to increase the demand for plastic additives within automotive industry.

Major waste industries understand the problem.

Veolia clearly rejects the chemical recycling of plastic waste

Waste group does not want to pursue pyrolysis in particular

"And this is precisely the risk for our industry: without proof of safe, reliable and sustainable mode of operation on an industrial scale, without a transparent database for life cycle analyses from sources that are as neutral sources as possible, without critical consideration of the proven and the new, we run the risk of being used as a stirrup holder for a vision of the petrochemical industry,“

"From the sequence of process steps in chemical recycling, the result is a material pellet yield of only about 22 percent,"
Veolia has publicly pulled out of chemical recycling

Veolia Germany quoted

- 78% waste
- 22% yield
Large toxic waste streams low yield

European Chemical Recycling Assoc.

- 70% Yield
- 20% waste
- 10% waste
100 million tonnes of additives to be produced 2020-2025 could all become waste with 100% chemical recycling of plastic.

Saviour technology or cynical public relations ploy?

Timothy Glaz, Head of Public Affairs - Werner & Mertz (Germany)

“Because it has been proven to harm the climate and the environment. This would give the Ministry of Economic Affairs a great opportunity to do something right for the environment and block a completely nonsensical technology."

"Pure lobbying project of the major plastic and chemical manufacturers"
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Thanks for your attention.

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‘Chemical recycling’ of plastics – What is it and what impacts for the environment?
Chemical recycling and recovery
Defining a legislative framework

Lauriane Veillard - Policy Officer on Chemical Recycling and Plastic-to-Fuels

June 7th 2022
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Zero Waste Europe

The European member of GAIA

Support NGOs, local groups and communities

Change European Policies

Mentor cities towards a Zero Waste transition
What about chemical recycling and recovery?

There is a significant lack of knowledge about the overall life cycle impacts of chemical recycling on the environment. There are indications, however, that chemical recycling works only under very specific and narrow conditions and that it consumes energy, water and chemical resources that increase the pollution of water, air and land.

European Environment Agency (EEA), 2021
Definition and position in the waste hierarchy

- The term ‘chemical recycling’ has no formal definition and is used in different ways.
- The term ‘recycling’ in the EU Waste Framework Directive does **not** include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.
- Harmonized legal definitions needed to distinguish between ‘**chemical recycling**’ and ‘**chemical recovery**’ in order to:
  - Clarify positions in waste hierarchy, with mechanical recycling being favoured.
  - Exclude feedstock recovery from recycling targets.
- Chemical recovery = pyrolysis and gasification technologies resulting in oils, syngas and feedstock recovery for the petrochemical industry.

**Definitions and position in the waste hierarchy must be based on well-founded scientific knowledge of environmental impacts.**
Now, let’s talk about cake!
On the horizon: the ‘mass balance approach’
Determining recycled content in plastic products

Chain of Custody (CoC) According to ISO 22095

- **Traceability, strength of claim, physical**

**Segregation**
- Physical separation of material to ensure that recycled content is physically present in the output

**Controlled Blending**
- Known proportions

**Mass Balance**
- Unknown proportions

Physical separation of material means no guarantee of recycled content physically present in the output

- Recycled
- Virgin
- Mixed
- Certified
On the horizon: the ‘mass balance approach’ - continued

- All goods from this batch are sold as containing at least 33% recycled content, reflecting the true content.

- This batch is sold as fully recycled despite containing majority virgin material.

- This batch is sold without specification on recycled content.

- In reality, both batches contain the same amount of recycled content.
Key policy recommendations

- **Environmental and health impacts** of chemical recycling & recovery need to be evaluated at the industrial level prior to incentivisation.
- Review waste legislation to introduce definitions of recycling technologies that exclude fuel production.
- A process keeps at least 80% of the carbon content of plastic waste until the transformation into new products in order to be qualified as a recycling technology.
- Clarify the legal status of chemical recycling and recovery technologies in the waste hierarchy.
- Put in place safeguards to avoid competition with mechanically recyclable waste.
- Establish a robust methodology for calculating the climate impact of chemical recycling, including all indirect and direct emissions caused by the process.
- Develop ambitious standards for determining the actual recycled content in plastics.
- Chemical recycling products are monitored to ensure toxic-free outputs in line with the highest requirements of chemical legislative framework.
- EU funds should only support processes with a lower carbon footprint than the production of plastic from virgin feedstock.
Thank you!

Lauriane Veillard - Policy Officer on Chemical Recycling and Plastic-to-Fuels

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OF PLASTICS
What is it and what impacts for the environment?

THANK YOU!

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COPs SIDE EVENT

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