



# Towards circular & sustainable plastics - A global perspective

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# Plastic pollution – a global crisis



[1]

## Facts from the Global Plastic Outlook: <sup>[2]</sup>

- Plastic production doubled since 2000
- Plastic waste more than doubled since 2000
- Only 9 % effective recycling rate
- 22 % disposed in uncontrolled dumpsites
- Contributes to global GHG emissions



We have reached a plastic crisis

2

[1] **Von Wong**, <https://www.vonwong.com/>

[2] **OECD**, Global Plastic Outlook, Economic Drivers, Environmental Impacts and Policy Options, 2022



SCI4CLIMATE  
.NRW



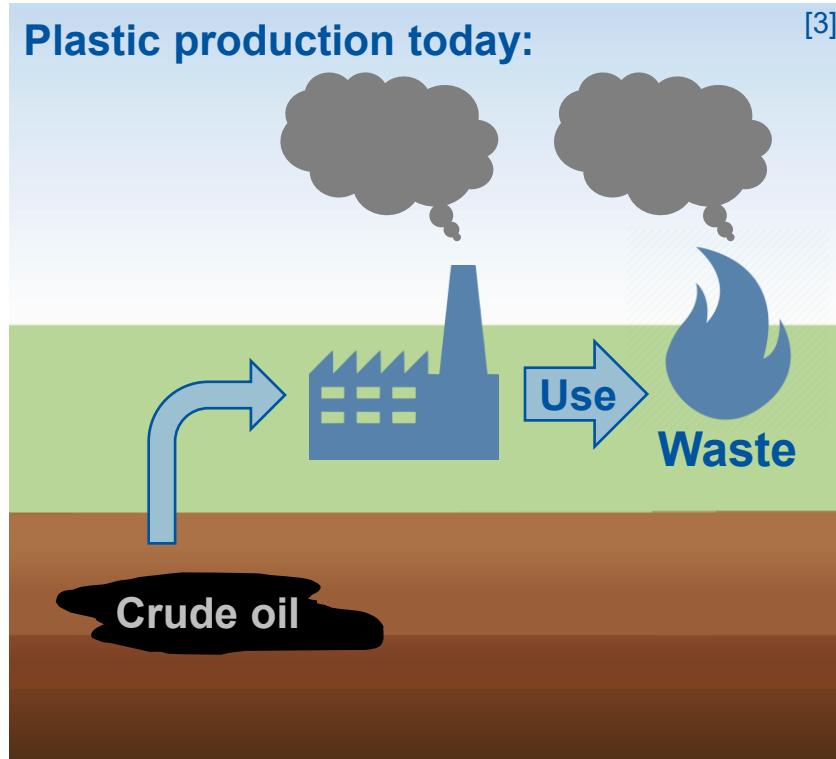
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# Greenhouse gas emissions of the plastics industry

## Plastic production today:

[3]

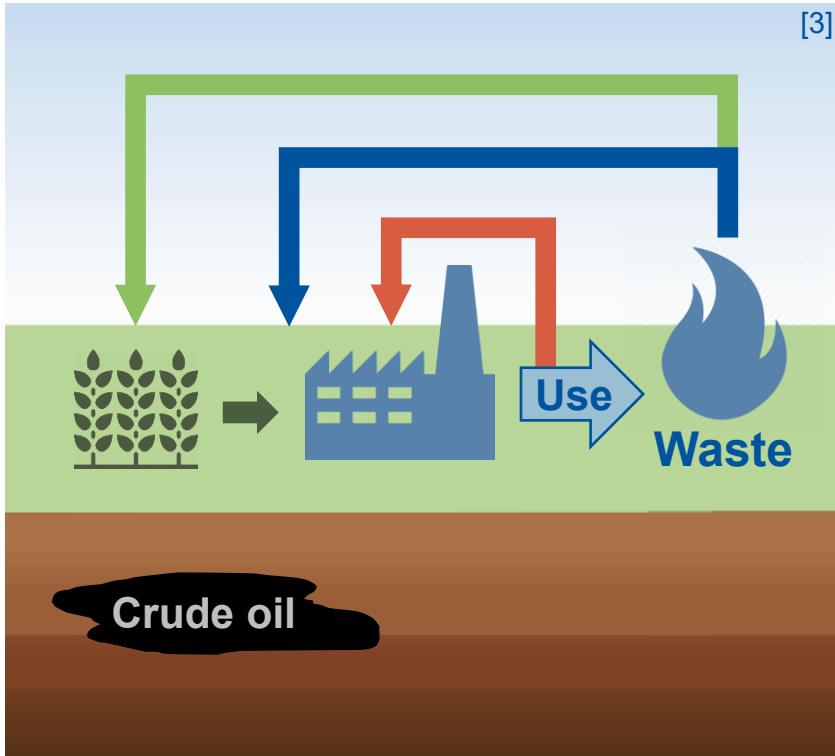


GHG emissions of plastics in 2050:  
**4.7 Gt CO<sub>2</sub>-eq**

[3]

3 [3] Meys et al. (2021) - Achieving net-zero greenhouse gas emission plastics by a circular carbon economy, *Science*

# Circular production pathways



## Circular carbon technologies:

- **Recycling**
- **CO<sub>2</sub>** via carbon capture and utilization (CCU)
- **Biomass** utilization

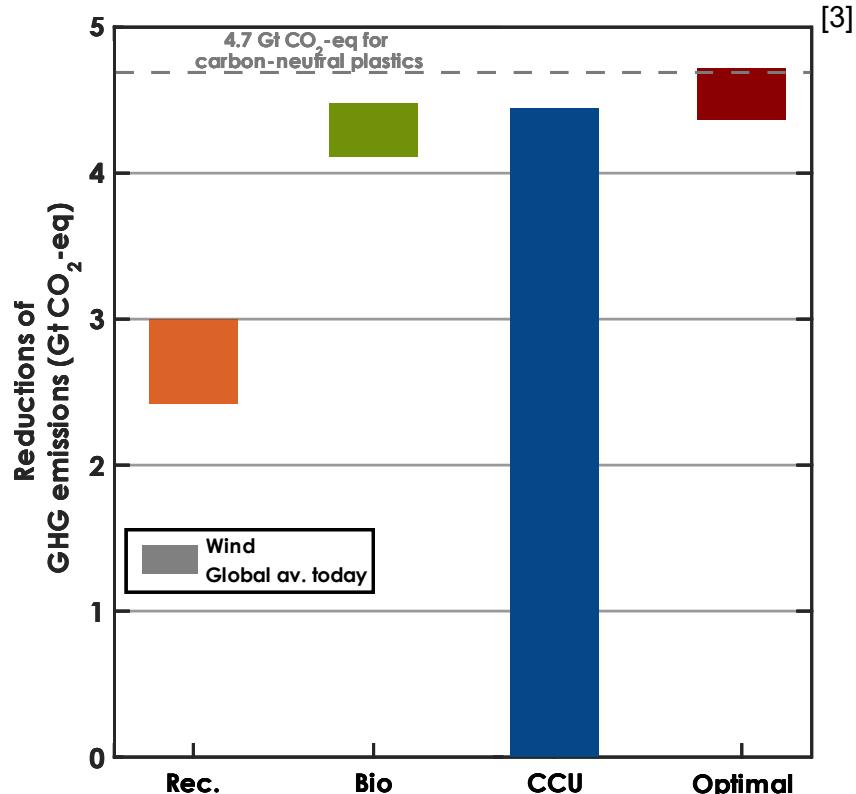
1.

Can we achieve net-zero GHG emission plastics by circular carbon technologies?

2.

Can we achieve absolute environmentally sustainable plastics?

# Achieving net-zero GHG plastics by a circular economy

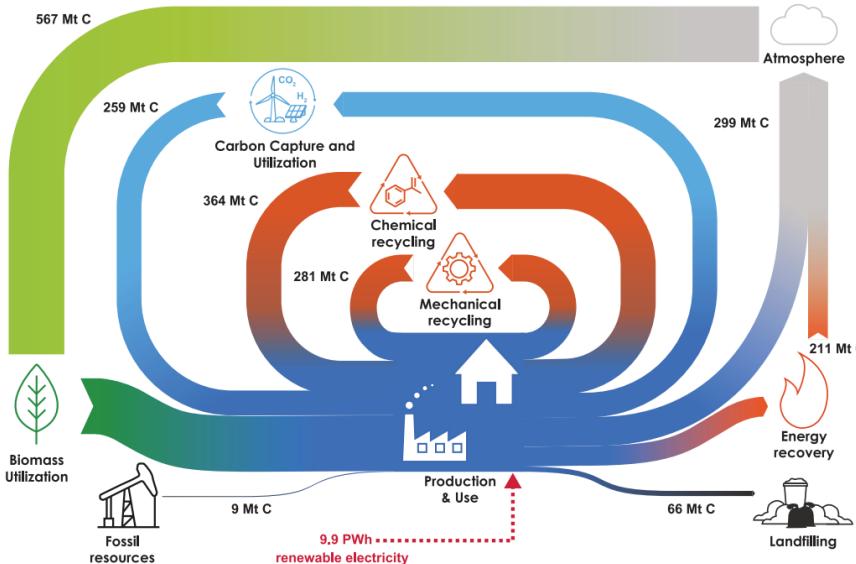


In 2050, a **fossil** industry would emit 4.7 Gt CO<sub>2</sub>-eq

Reductions from circular carbon technologies:

- ✓ **Recycling**: 3.0 Gt CO<sub>2</sub>-eq
- ✓ **Biomass**: 4.5 Gt CO<sub>2</sub>-eq
- ✓ **CCU**: 4.4 Gt CO<sub>2</sub>-eq
- ✓ CO<sub>2</sub> requires very clean electricity
- ✓ **Combining circular technologies** achieves net-zero plastics

# Achieving net-zero GHG plastics by a circular economy

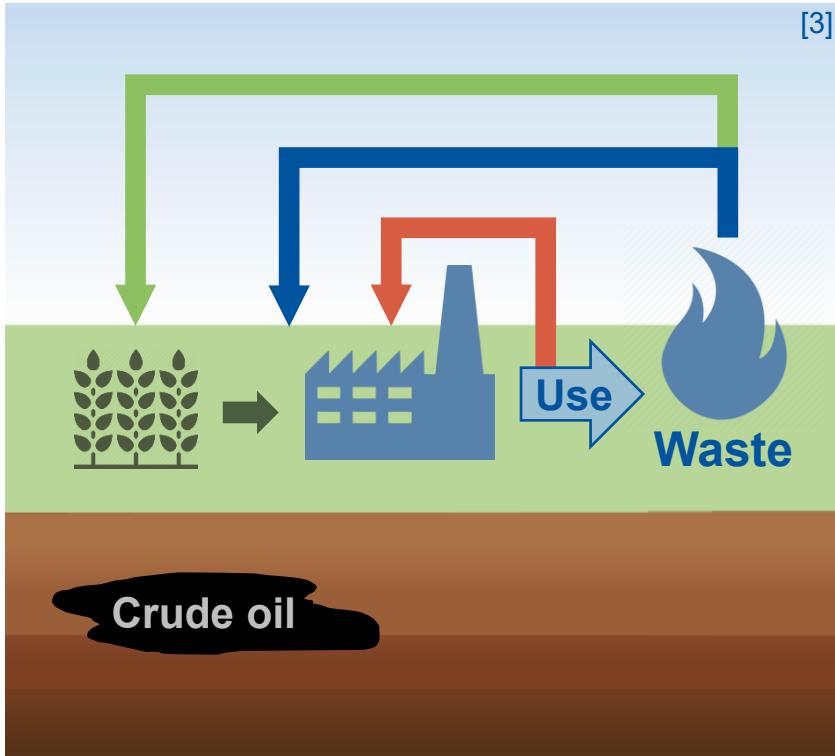


## Combining circular technologies

- ✓ Optimal combination includes all three circular technologies
- ✓ **Recycling**: minimizes GHG emissions from biomass cultivation and electricity supply
- ✓ **Biomass / CCU**: supply remaining renewable feedstock for polymers

**Recycling is a key to net-zero GHG emissions**

# Circular production pathways



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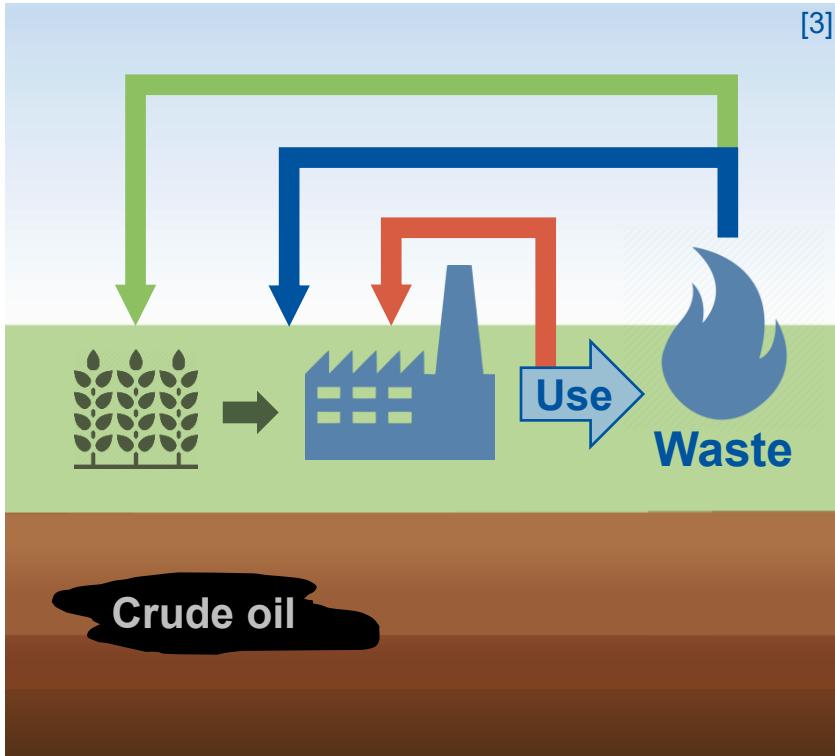
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# Circular production pathways



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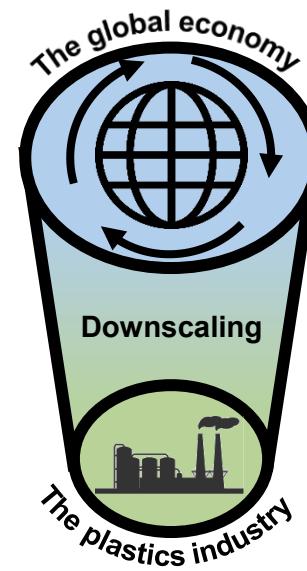
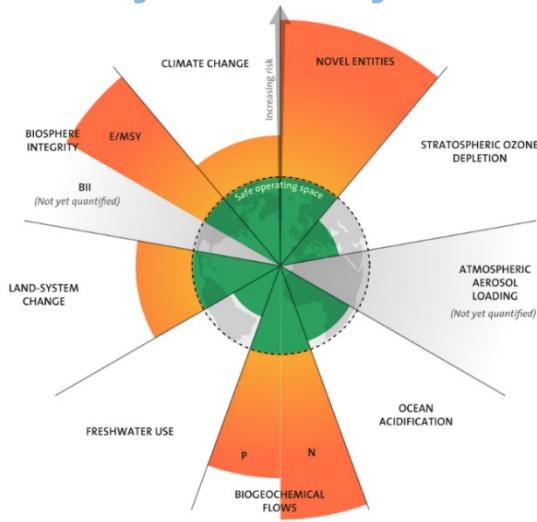
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# Towards absolute environmentally sustainable plastics

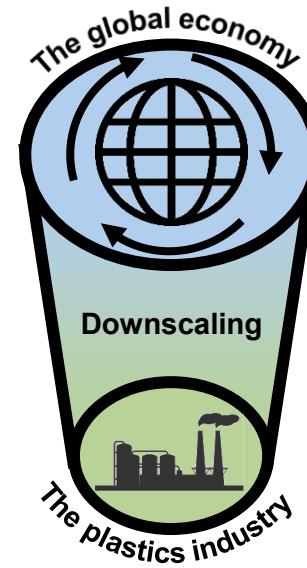
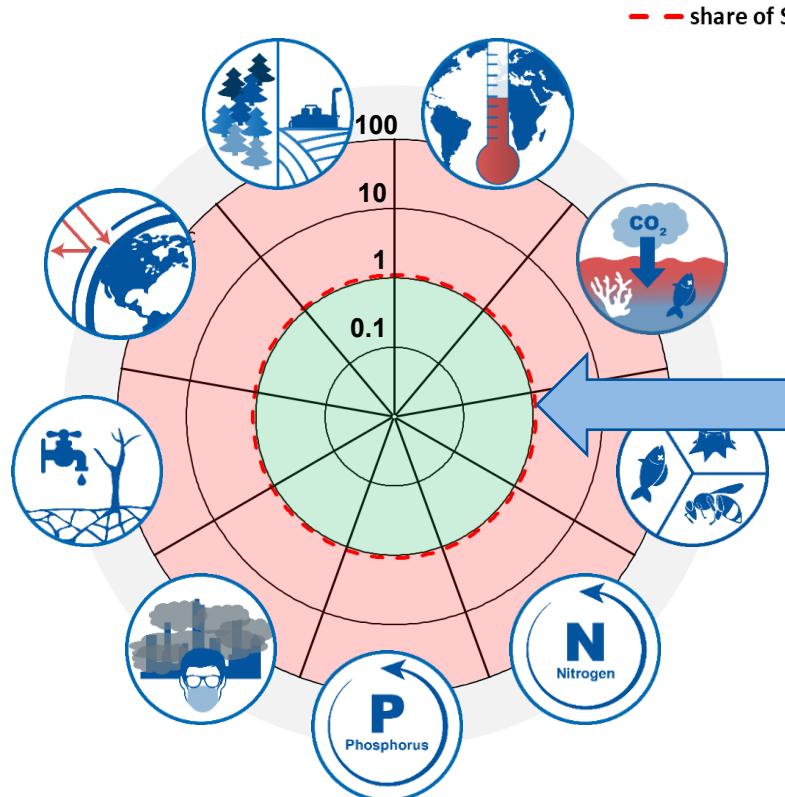
## Planetary Boundary Framework



→ Environmental thresholds:  
„safe operating space“ (SOS)

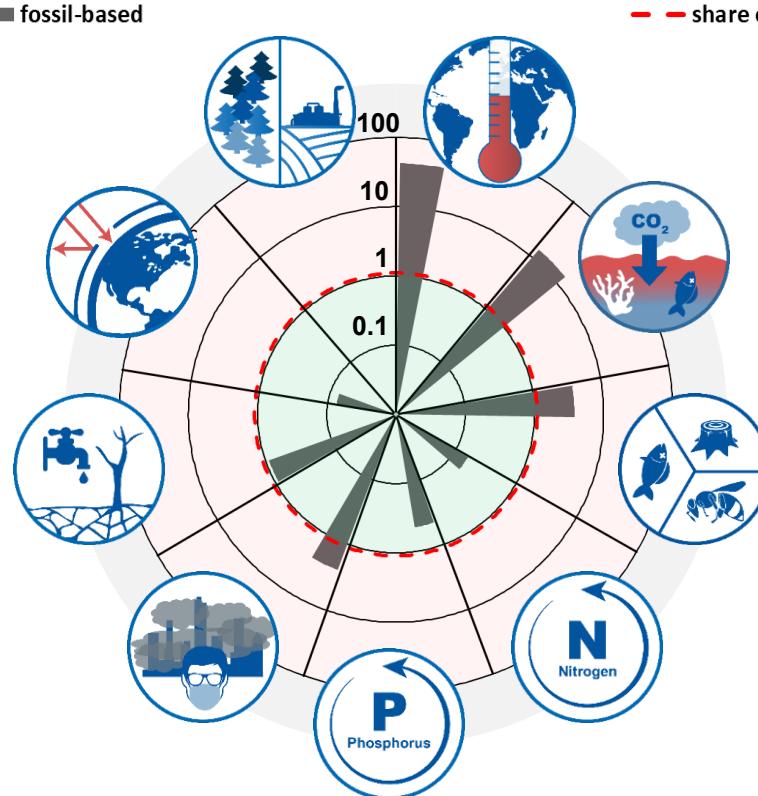
→ allocation to maximize welfare  
[consumption expenditure]  
→ 1.1 % of global SOS

# Downscaling to thresholds on industry level



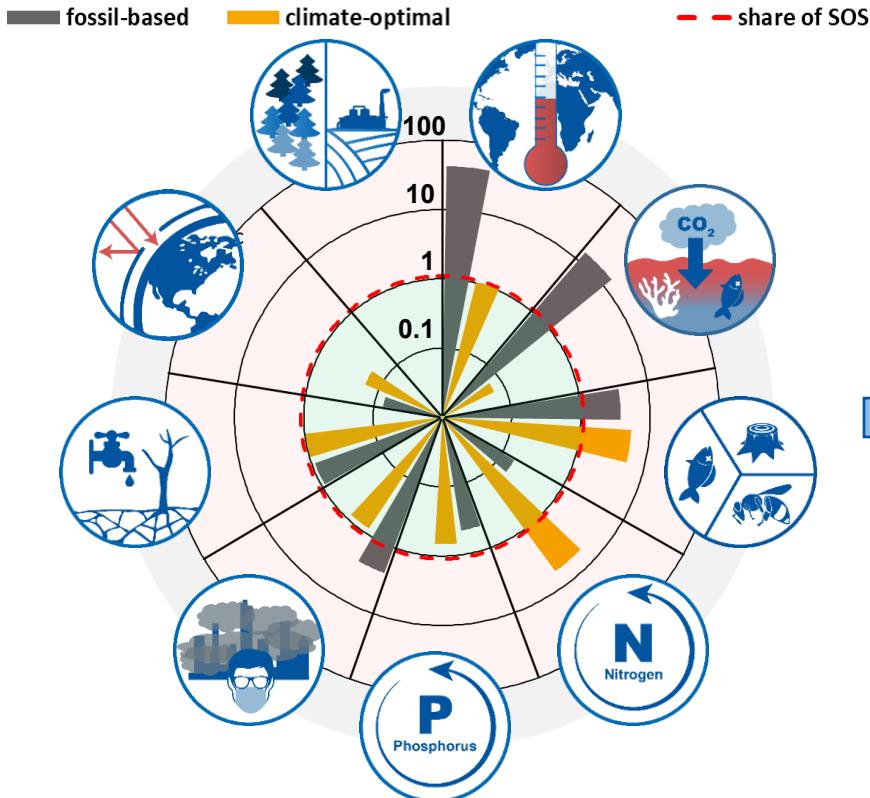
**1.1%**  
of global SOS

# The planetary footprints of global plastic production



## Fossil-based plastics exceed share of safe operating space.

# The planetary footprints of global plastic production

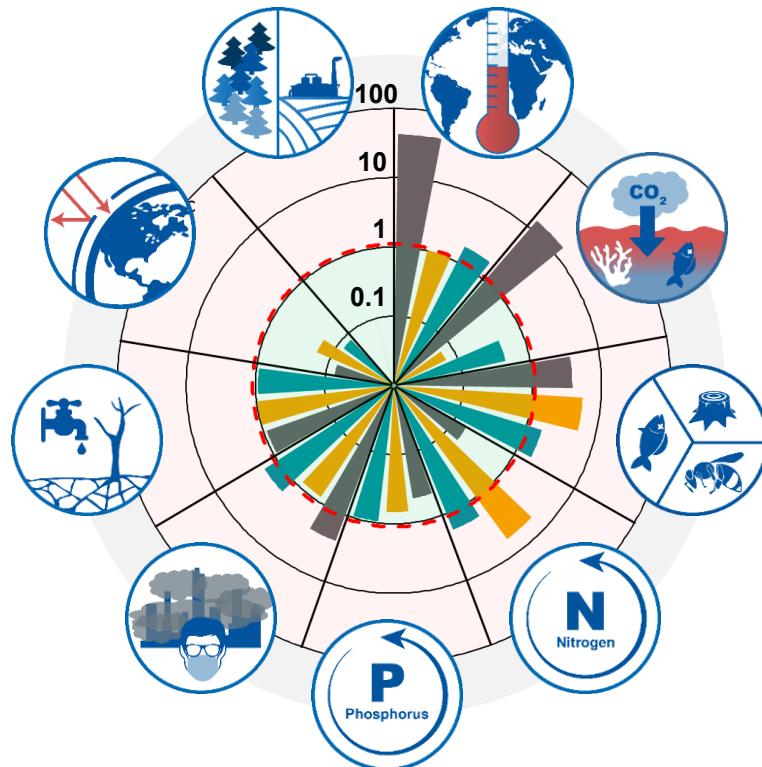


- Goal: Minimum transgression of all planetary boundaries

Climate-optimal plastics exceed share of safe operating space.

# The planetary footprints of global plastic production

— fossil-based    ■ climate-optimal    ■ balanced    - - - share of SOS



- Goal: Minimum transgression of all planetary boundaries

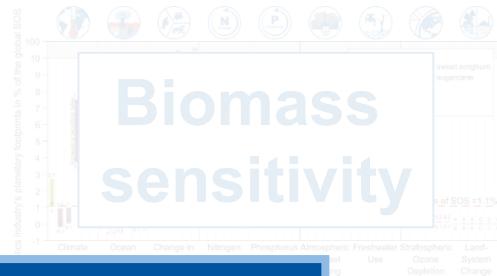
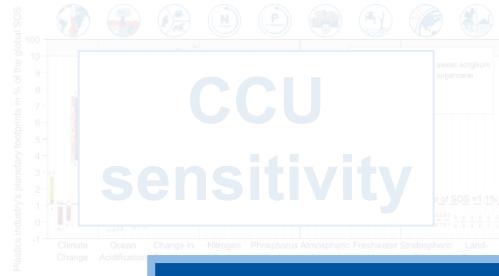
With mature technologies  
plastics exceed share of safe  
operating space.

# Improvements towards absolute sustainability



Improve recycling efficiency

High efficiency chemical monomer recycling



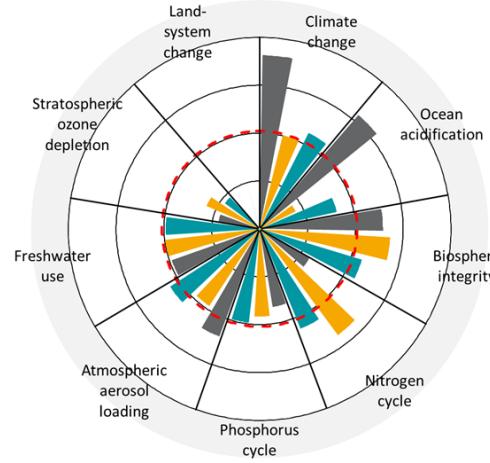
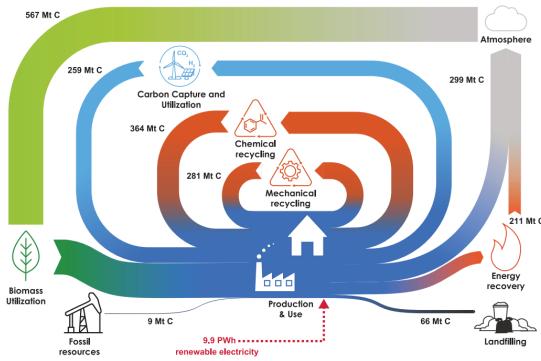
## Keys towards sustainable plastics

- Improve recycling efficiencies
- Realize high recycling rates
- Mechanical & chemical recycling

Wind power

Energy crops

# Conclusion



We need **ALL** circular technologies  
+  
Recycling is a key to net-zero

There are **MORE** impacts than climate change  
+  
Enhance recycling efficiencies

Consider plastic waste as a **VALUABLE** resource  
+  
Recycling tackles the plastic crisis at all levels

# Thank you for your attention!

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**Life cycle optimization towards economically and environmentally sustainable chemicals**  
Christian Zibunas, Institute of Technical Thermodynamics, RWTH Aachen University

**1) Linear vs. circular production of chemicals**

**Today - Linear Chemicals**  
4.7 Gt<sup>13</sup> Does GHG mitigation also achieve sustainable chemicals and plastics?  
economically:

- foresight vs. myopia
- environmentally
- socially

**Tomorrow - Circular Chemicals**

**2) Cost-optimal transition pathways**

**Perfect foresight** vs. **Myopic** decision making of the chemical industry. The myopic approach to derive innovation pathways. Myopia can be modeled by a Rolling horizon and the perfect foresight approach by a long-term extension in the chemical industry by 2050

**3) The planetary boundaries**

**Nine Planetary Boundaries** define a safe operating space for humanity that does not compromise the Earth system.

**4) Results**

**5) Methods**

**6) You can also ask me about ...**