Öko-Institut e.V.
Institut für angewandte Ökologie
Institute for Applied Ecology

Climate impact of pyrolysis of waste plastic packaging in comparison with reuse and mechanical recycling

Study commissioned by ZWE and RPa

27 September 2022

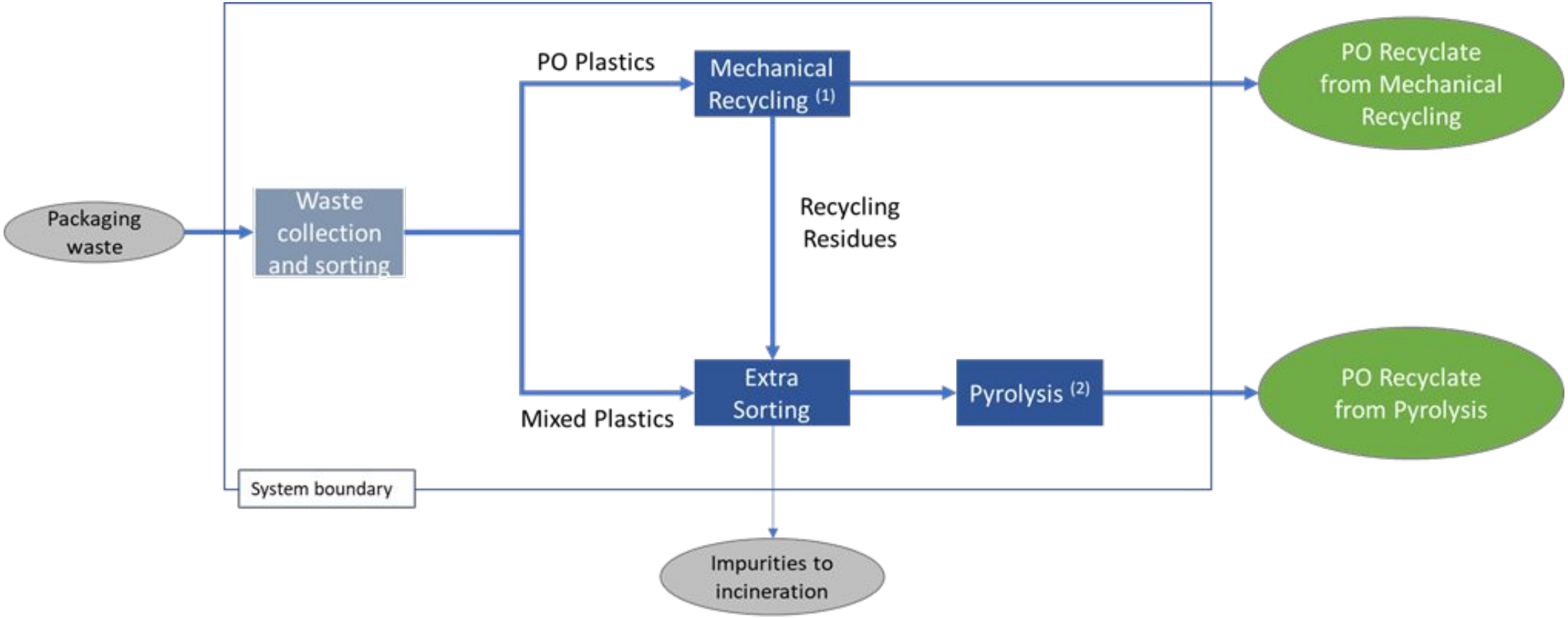
Motivation for the Study

- Following the *European Green Deal* and the new *Circular Economy Action Plan*, the European Commission is putting forward proposals to make the transition to a circular economy.

 Pyrolysis is proposed by Eunomia, the consultancy in charge of the impact assessment on behalf of the European Commission, as a general solution to the problems with (non-recyclable) plastic waste and for contact-sensitive material

- Objective:
  - Assessing the climate impact of shifting towards pyrolysis as the main way to tackle packaging waste
  - Demonstrating the impact of **reducing plastic consumption** and **improving mechanical recycling** compared to focusing on pyrolysis

Scenarios - Basic Scheme



(1) Recycling includes: Washing, further sorting, regranulation. (2) Pyrolysis includes: Pyrolysis, purification of pyrolysis oil, cracking and polymerisation.

Scenarios - Data Basis Mass Flows

- Basis: figures from Eunomia
- Based on the estimated future recycled content targets in plastic packaging, Eunomia estimated **output** capacity requirements for 2030

	Chemical recycling (primarily pyrolysis) in kilo tonnes (kt)		Mechanical recycling plus dissolution in kilo tonnes (kt)	
	medium	ambitious	medium	ambitious
Polyolefin recyclate	649	1,487	868	1,330

Scenarios - Overview

- “Chemical recycling scenario” (numbers as proposed by Eunomia)
- “Reduction scenario” (reduction of the total volume of plastic packaging)
- “Mechanical recycling scenario” (shift to more mechanical recycling)
- “Mixed scenario” (reduction plus shift to more mechanical recycling)

Scenarios – Measures until 2030

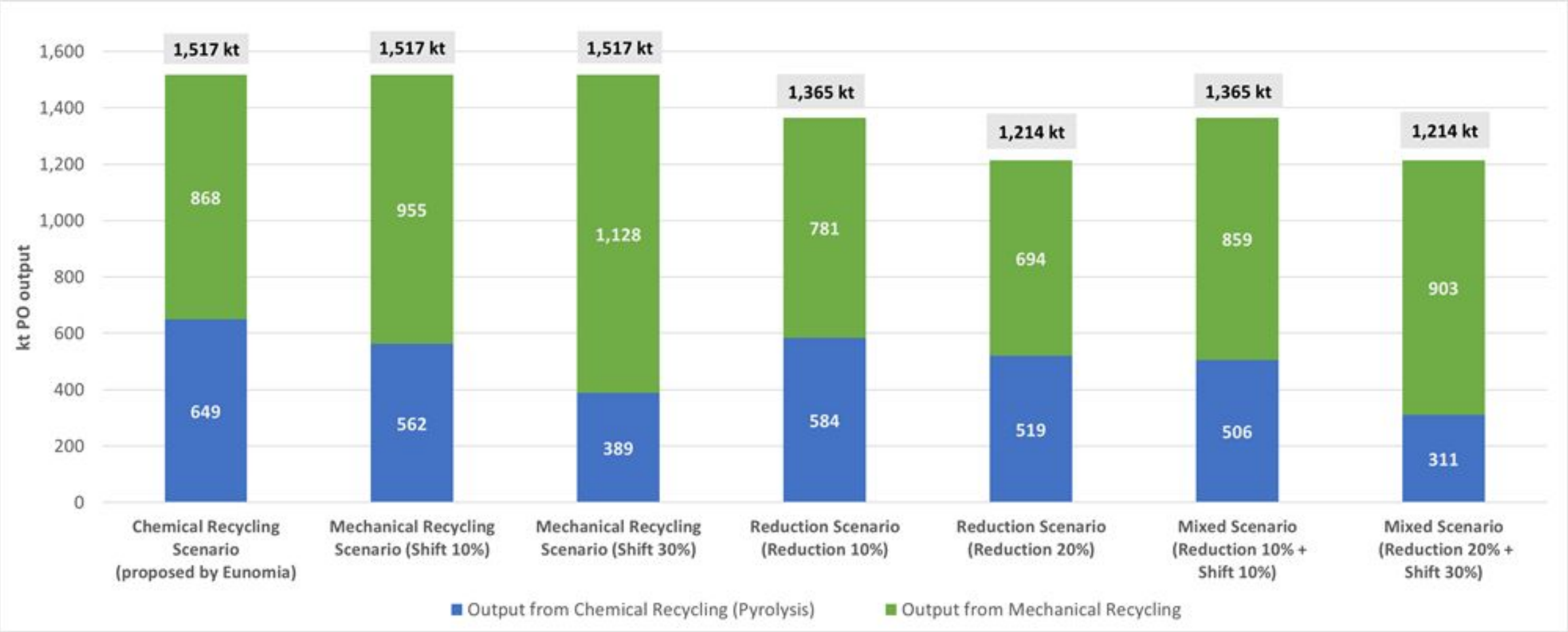
Reduction Scenario

- Avoiding unnecessary packaging
- Reducing the volume and sizes
- Introducing reusable packaging systems
  - 10% reduction (European Plastic Pact)
  - 20% reduction (more ambitious)

Mechanical Recycling Scenario

- Design for Recycling
- New collection systems
- Innovations, e.g., layering systems
  - 10% shift
  - 30% shift

Scenarios - Output Quantities



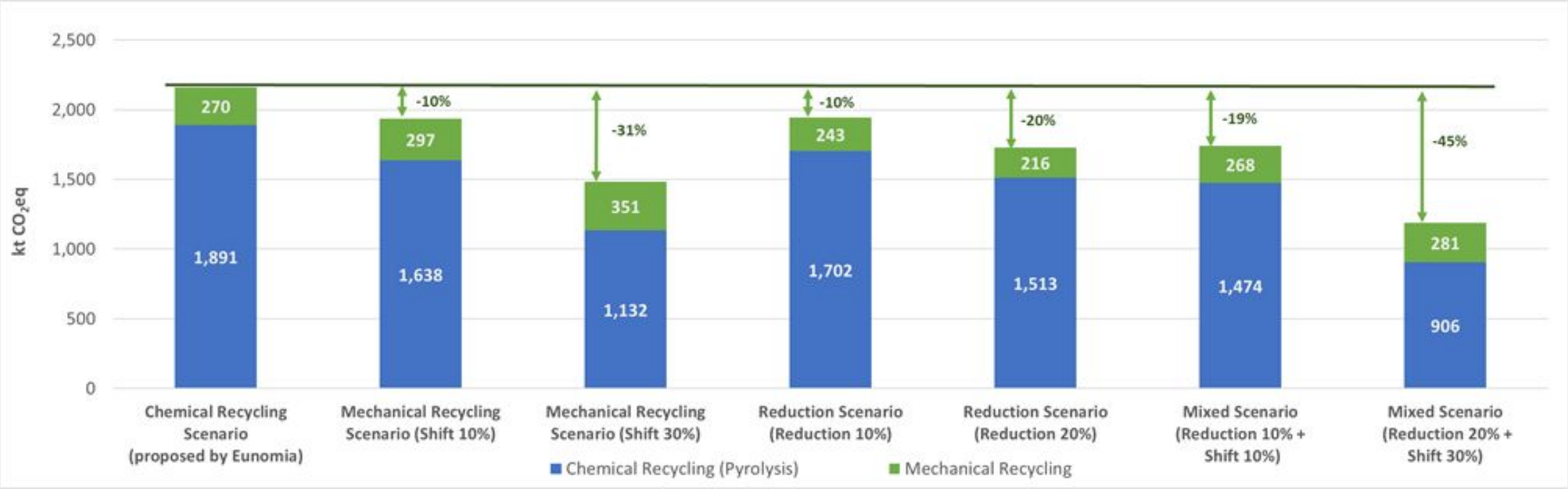
Data Basis THG-Emissions - Pyrolysis

Source	Financed/ Commissioned	Geographic scope	Input	Output	Results in kg CO_2eq/kg recyclate output
Sphera 2022	The Consumer Goods Forum	Europe	Mixed plastic waste	PE/PP mix	2.48
Sphera 2020	BASF	Germany	Mixed plastic waste	LDPE (2)	3.35

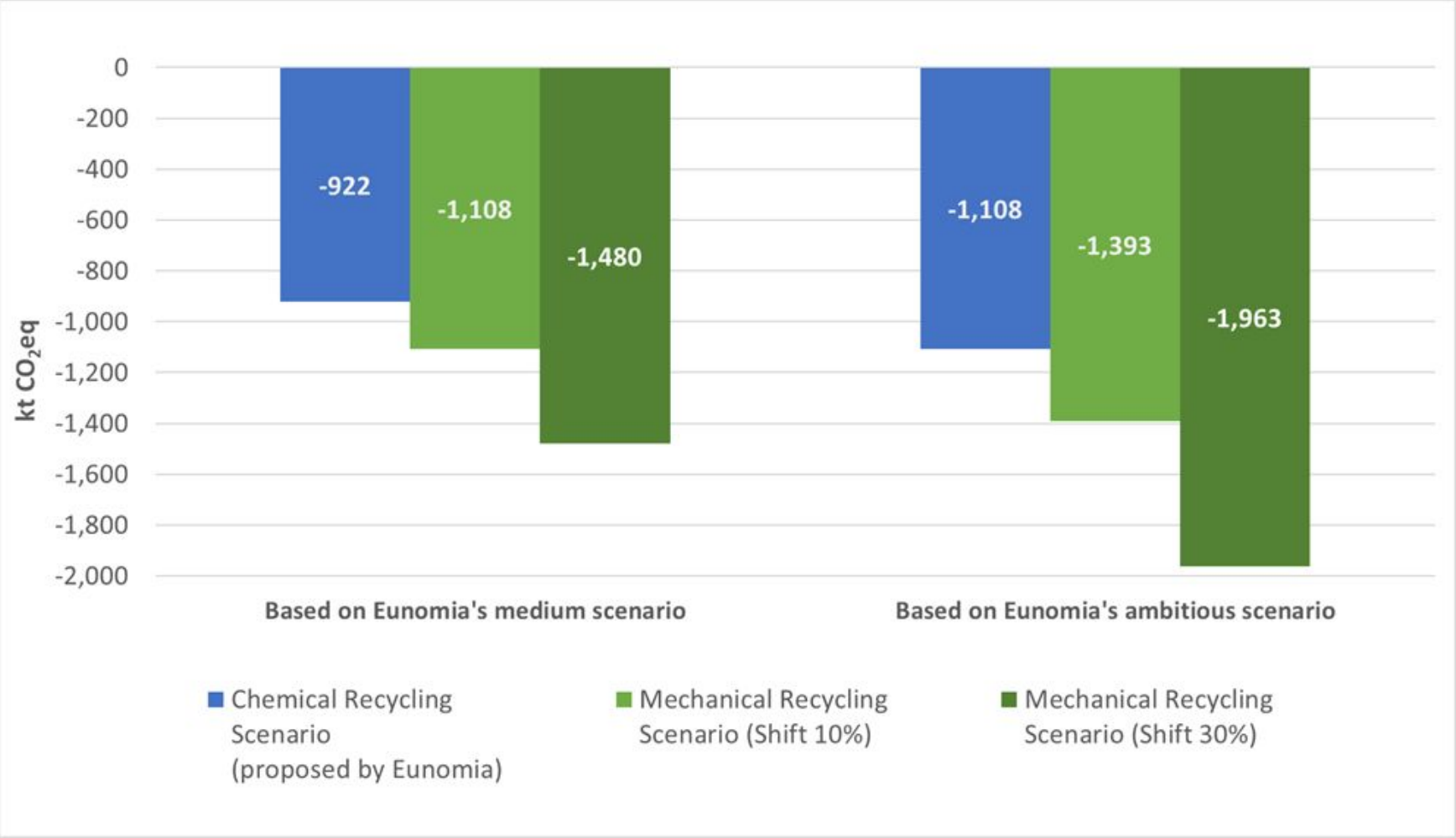
Data Basis THG-Emissions - Mechanical Recycling

Source	Financed/ Commissioned	Geographic scope	Input	Output	Results in kg CO_2eq/kg recyclate output
Oeko-Institut 2022	Dual Systems in Germany	Germany	Sorted Polyolefines	PE/PP mix	0.311

Results Climate Impact



Results Climate Impact - Sensitivity



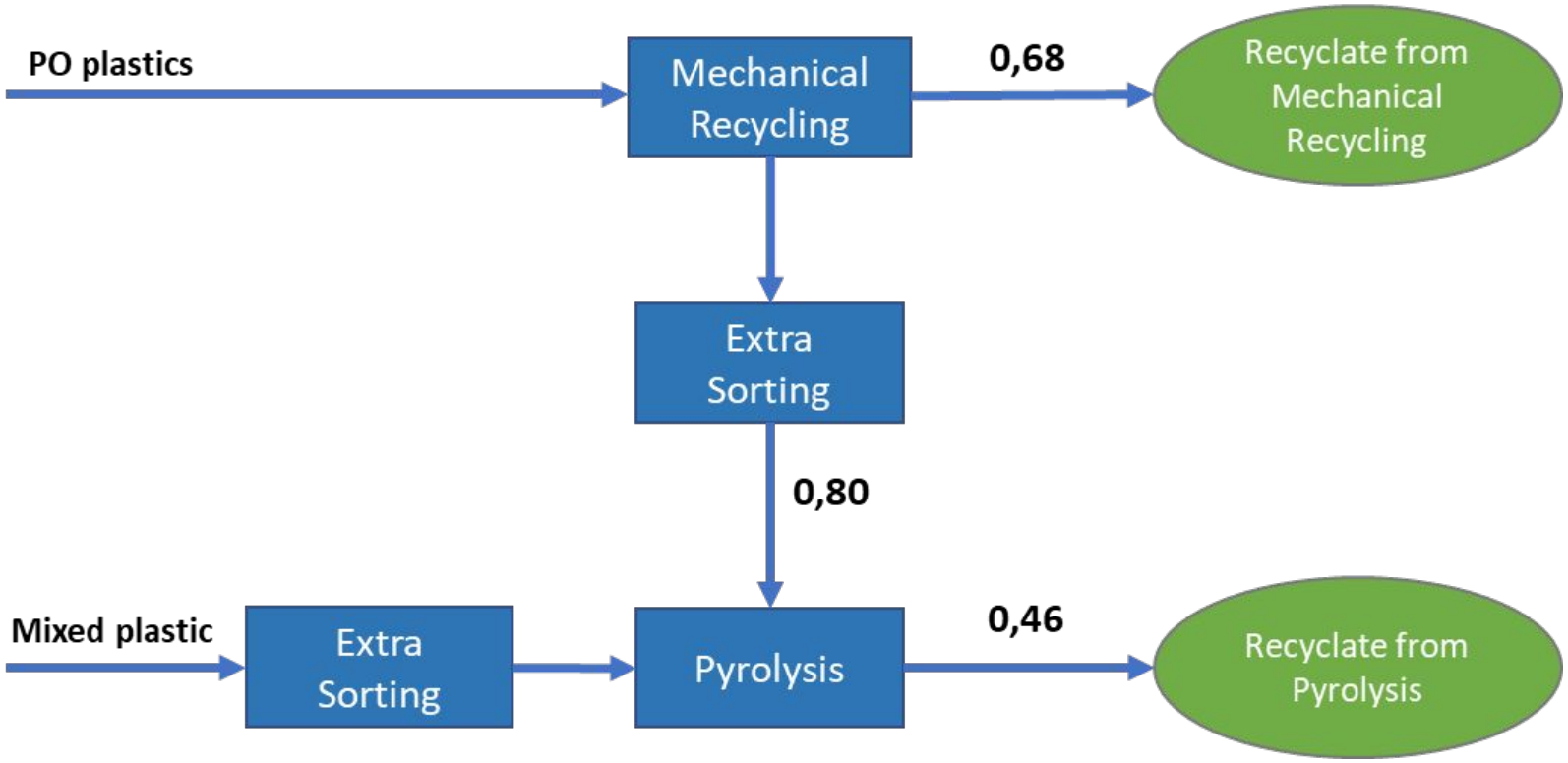
- Credit for replacing primary plastic
- A discount of 20% was added to the credit for recyclate from mechanical recycling (due to current qualitative differences)

Results Climate Impact - Conclusion

- Over 75% of the total GHG emissions are attributable to chemical recycling
- Combining “Reduction” and “Shift to mechanical recycling” results in the highest GHG reductions compared to the “Chemical recycling scenario”, up to 45% in the most ambitious scenario
- The chemical recycling scenario causes 2.4 Mt CO_2eq per year, while saving 0.9 Mt CO_2eq per year compared to new plastic production,
  - Shift to mechanical recycling by 30% saves 1.5 Mt CO_2eq compare to new plastic production (61% more)
  - This is despite a major discount for the lower recyclate quality for mechanical recycling of 20%
- The emissions for pyrolysis come mainly from the burning of the pyrolysis gas to power the process
- Zero emissions and circular economy:
  - relatively easy for mechanical recycling by replacing energy from fossil fuels
  - difficult for pyrolysis, as disposal of pyrolysis gas and other residuals are a big challenge.

  A combination of efforts to reduce plastic consumption and improve the recyclability of packaging leads to the highest possible reduction of GHG emissions

Carbon Efficiency – Recycling technologies



Efficiency for:

- Pyrolysis based on Sphera 2020 and 2022
- Mechanical recycling based on Oeko-Institut 2022
- Extra sorting recycling residues based on own assumption

Carbon Efficiency - Scenarios

Scenario	Efficiency
Chemical Recycling	**65%**
Mechanical Recycling (Shift 10%)	**68%**
Mechanical Recycling (Shift 30%)	**74%**

- Shifting plastic packaging waste away from chemical recycling towards mechanical recycling increases carbon efficiency

 The more waste is treated through mechanical recycling, the less carbon is lost and, correspondingly, less primary carbon must be used to compensate

Results Carbon Efficiency - Conclusions

- The “chemical recycling scenario” ends up with a total carbon efficiency of 65%. By shifting to mechanical recycling of about 30%, a total efficiency of 74% can be achieved.
- One way to reduce carbon loss is the shift from chemical to mechanical recycling
- If a chemical recycling industry is established, the industry will use the most easily material available to treat in pyrolysis (feedstock that can be actually recycled through mechanical recycling)
- Without regulations, efforts to strengthen mechanical recycling will be severely hampered

Final Conclusion

- A zero-emission economy based on chemical recycling seems to be impossible
- Mechanical recycling must be prioritised over pyrolysis wherever possible
- Measures such as Design for Recycling and other innovations must be incentivised
- Legal equality of chemical and mechanical recycling for packaging waste must be prevented
- The climate impact of different recycling technologies should be considered when setting targets for recycled content
- It is important to reduce the overall amount of packaging to lower the GHG emissions in this sector - it is not possible to achieve a zero-emission economy by recycling alone

Do you have further questions?

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