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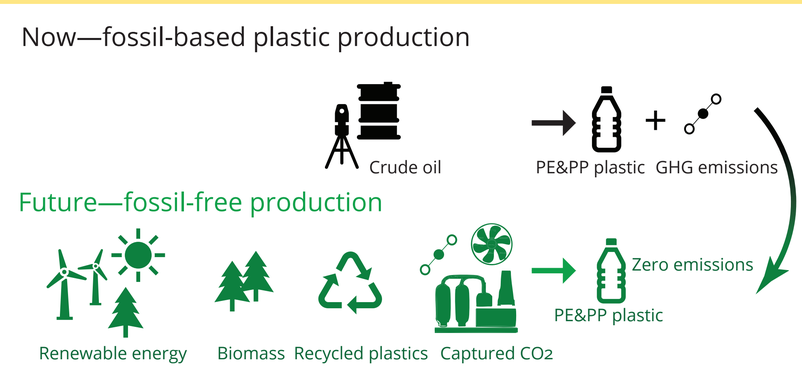
CBIQ

Integrated pathways for fossil-free polyethylene and polypropylene production

Shiyu Ding[a, *], Gert Jan Kramer[a], André Faaij[a, b], Matteo Gazzani[a]
[a]Utrecht University, Princetonlaan 8a, 3584 CB Utrecht, The Netherlands
[b]TNO, Radarweg 60, 1043 NT Amsterdam, the Netherlands
*s.ding@uu.nl

Introduction



Carbon mining from air (aka DAC), **biomass (BIO)**, and **plastic gasification (PWG)** are the key net-zero pathways of fossil-free **polyethylene and polypropylene (PE&PP)** production.

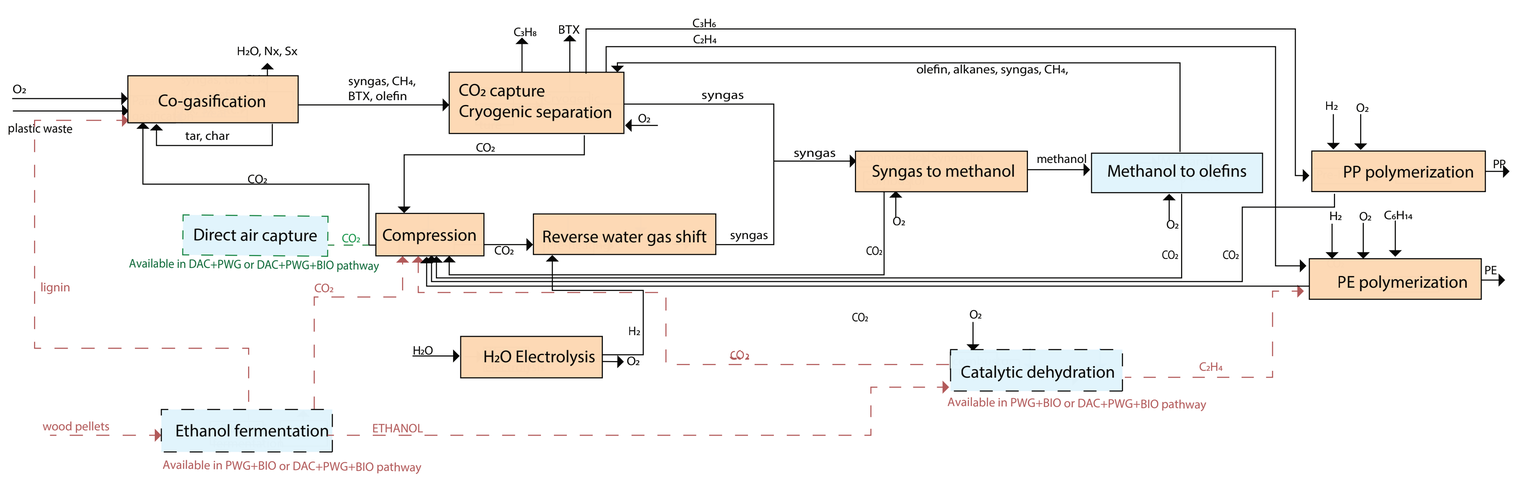
Challenges: accessing a large amount of single feedstock for the scale of the current industrial plants, and the high cost of fossil-free production.

Proposed solution: mixing feedstocks from DAC, BIO and PWG pathways

Method: process simulation and techno-economic assessment (TEA)

Research questions:
What are the process integration opportunities for DAC, BIO and PWG pathways?
How do they perform compared to the relevant separate pathways?

Process flowsheet diagram of integrated pathways



• The boxes indicate the modeled processes: the **orange boxes** indicate that the process model is built in ASPEN Plus and the **blue boxes** indicate the process model is built in MATLAB.

Integration opportunities

• Recycling heat from residual fuel gas combustion (waste from other processes)

• Recycling CO_2 from residual fuel gas combustion to reverse water gas shift process

• Recycling O_2 from H_2 production for fuel gas combustion

• Integrating cryogenic separation from methanol to olefin process and gasification process

• Integrating syngas from gasification process and reverse water gas shift process

• Co-gasifying recycled plastic waste and lignin waste from bioethanol fermentation

• Other exchange integration network is possible and can be identified by pinch analysis

Case studies

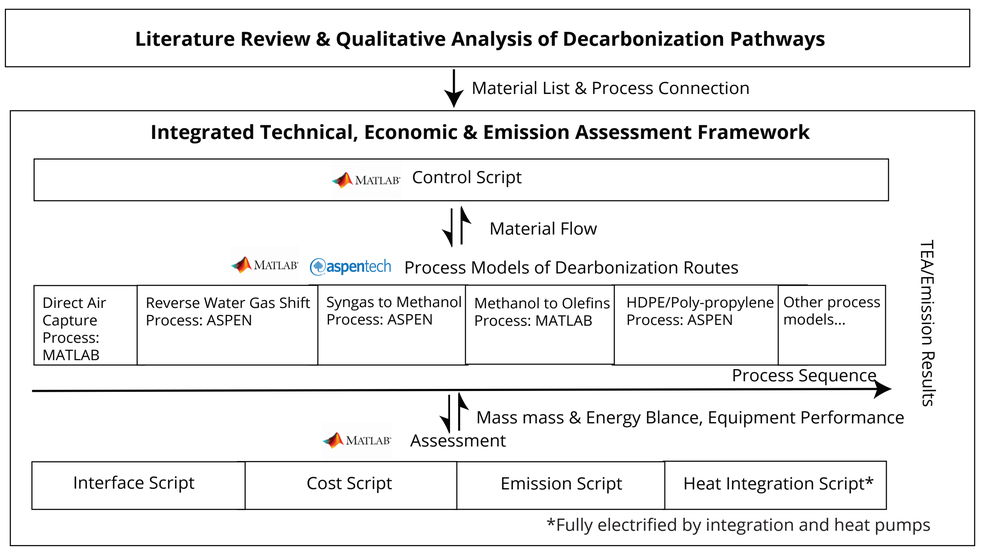
• **Case 1: PWG + BIO**
The carbon content of feedstock: plastic waste:wood pellets=0.5:0.5

• **Case 2: DAC + PWG**
The carbon content of feedstock: plastic waste:CO_2 from air=0.5:0.5

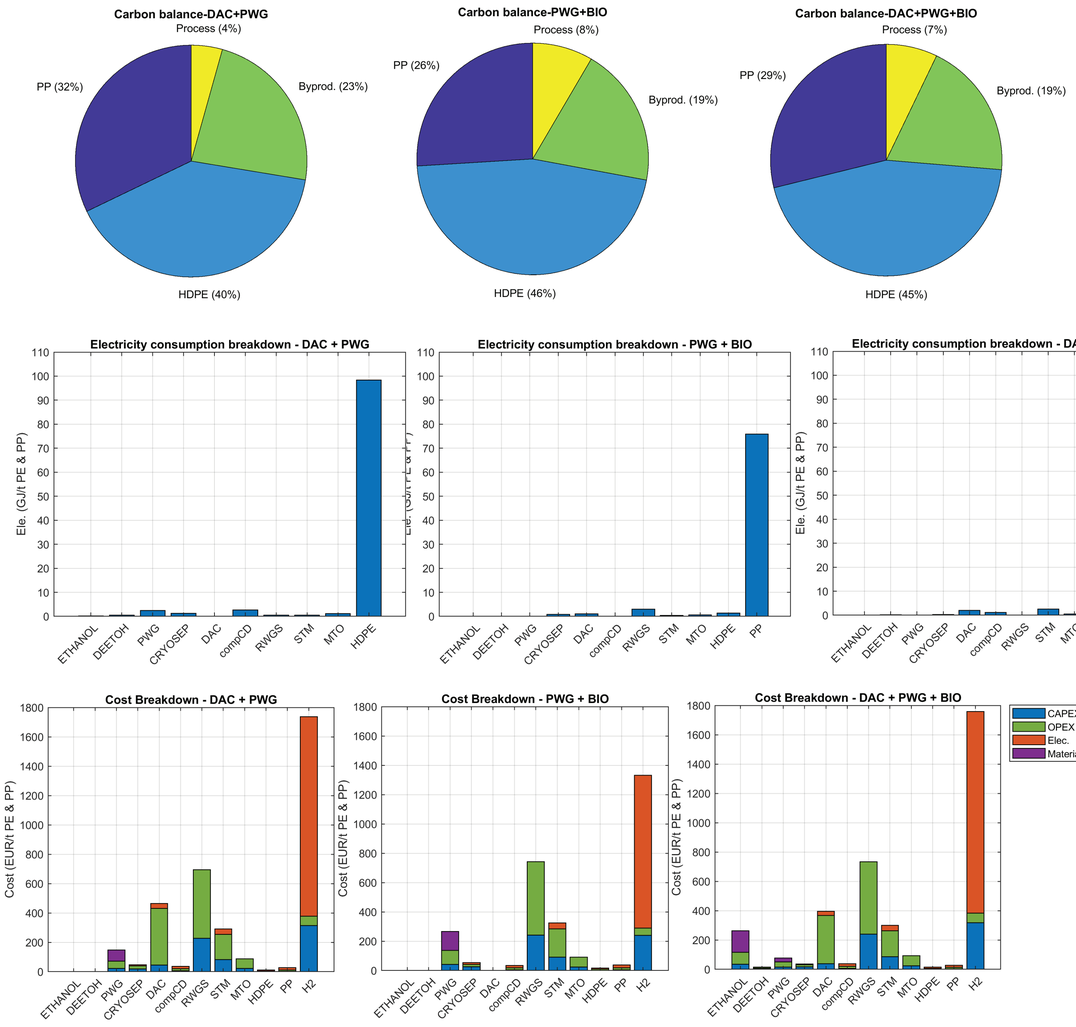
• **Case 3: DAC + PWG + BIO**
The carbon content of feedstock: plastic waste:biomass:CO_2 from air = 0.17:0.41:0.42
The scale of biomass fermentation plant is 460 KTA and plastic gasification plant is 120 KTA (the largest plant known so far), and the captured CO_2 from air supplements the carbon feedstock to ensure the PE plant at the current scale (250 KTA)

Product capacity
250 KTA PE and possible PP

Modeling methodology



Results



Results

	PL	DAC	BIO	PWG	DAC+PWG	PWG+BIO	DAC+PWG+BIO
Cost (€/t_{PP+PE})	3,986	6,183	2,077	1,324	3,546	2,898	3,749
Electricity consumption (GJ/t_{PP+PE})	5.07	27.59	0.96	13.4	8.94	7.17	8.19
Feedstock (t/t_{PP+PE})	-	-	7.61 BM*	2.30 PW*	0.91 PW	0.9 PW + 1.36 BM	0.29 PW+1.13 BM
H_2 consumption (t/t_{PP+PE})	0.67	0.67			0.52	0.40	0.51
Energy efficiency	32%	27%	32%	38%	29%	27%	31%
Carbon efficiency	64%	64%	25%	59%	72%	75%	74%

* BM: biomass.
* PW: plastic waste.

Conclusion & Future work

• Integrated pathways show higher carbon efficiency than the separate pathways; the effiiency is limited to 74% no mater of mixing ratios; 4% carbon loss is unavoidable in the process conversion.

• The electricity consumption of H_2 production is dominating in energy consumption; cross-process heat integration is crucial in balancing the high-temperature heat demand.

• The integrated pathways are more expensive than biomass and plastic gasification pathways but cheaper than direct air capture pathway; H_2 production is the most expensive sub-process; the cost contribution from reverse water gas shift is also significant, which plays an important role in reducing the recycled CO_2 from other processes and from air.

• Recycling CO_2 demands extra H_2 and increases the cost, while increasing the production and scaling up the sub-process, and the future analysis will focus on the this rade-off.

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