

“Quo Vadis polymer cost”:

An impartial monetary
comparison for true cost of most
used oil-based and bio-based
polymers

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Innograaf B.V assisting companies to make a transition to sustainable materials.

Board member of the Dutch plastics and Rubber Federation NRK (portfolio Construction and Bio-Based)

Consultancy for value chain cooperation and application of sustainable processes and materials.

Packaging is only part of the recycling dossier

Tabel 1 - Plastic op de Nederlandse markt (2017)

Gebruikscategorie	Kiloton plastic op de markt in 2017	% van totaal op de markt	Levensduur
Auto's	~ 48 kton	3%	17,9 (CBS, 2016)
Elektrische en elektronische apparaten	~ 53 kton	3%	1-20 jaar
Verpakkingen	~ 530 kton	28%	< 6 maanden
Kleding en textiel	~ 208 kton	11%	- 5 jaar
Bouwmateriaal	~ 290 kton	15%	- 50 jaar
Kleine en grote gebruiksvoorwerpen, overig	~ 747 kton	40%	1-50 jaar
Totaal	~ 1.876 kton		






Cost drivers for true cost

- ▶ **1. Packaging Removal tax (Verwijderingsbijdrage)**
 - ▶ Significant differences per country
- ▶ **2. CO2 tax <-> LCA**
 - ▶ EU driven
 - ▶ Benefit for biobased
- ▶ **3. Penalty on non recycle content (Brexit tax)**
 - ▶ 800 €/t announced
- ▶ **4. Litter tax**
 - ▶ 800 €/t announced
- ▶ **5. Polymer price<-> inherent energy**

Developments are multifold

Cost drivers for true cost

- ▶ 1. Packaging Removal tax (Verwijderingsbijdrage)
 - ▶ Significant differences per material and per country

		Frost plus	CITEO	Afvalfonds	Ecoembes	Gune punkt	
Material 2022	5 country average recycling fee (eur/kg)	 Belgium	 France	 NL	 Spain	 Germany	NL bedrijfs verpakkers
aluminium	€ 0,11	€ 0,041	€ 0,126	€ 0,160	€ 0,102	€ 0,130	€ 0,036
cork	€ 0,43	€ 1,730	€ 0,365	€ 0,020	€ 0,020	€ 0,020	€ 0,011
glass	€ 0,03	€ 0,049	€ 0,013	€ 0,048	€ 0,020	€ 0,010	€ 0,016
paper	€ 0,08	€ 0,101	€ 0,164	€ 0,022	€ 0,080	€ 0,030	€ 0,011
hard plastic PE	€ 0,43	€ 0,430	€ 0,468	€ 0,700	€ 0,402	€ 0,170	€ 0,130
foils PE	€ 0,67	€ 1,159	€ 0,468	€ 0,700	€ 0,856	€ 0,170	€ 0,130
bio- PE	€ 0,69	€ 1,251	€ 0,468	€ 0,700	€ 0,856	€ 0,170	€ 0,130
bio-degradable PLA PHA etc	€ 0,84	€ 1,738	€ 0,711	€ 0,700	€ 0,856	€ 0,170	€ 0,130
wood	€ 0,43	€ 1,730	€ 0,365	€ 0,020	€ 0,020	€ 0,020	€ 0,011
low tariff plastic	€ 0,37	€ 0,417	€ 0,320	€ 0,440	€ 0,490	€ 0,170	nvt
drink bricks	€ 0,73	€ 1,730	na	€ 0,640	€ 0,424	€ 0,130	nvt
other metals	€ 0,13	€ 0,188	€ 0,047	€ 0,230	€ 0,110	€ 0,050	€ 0,048
EPS/ Styrofoam	€ 0,79	€ 1,738	€ 0,468	€ 0,700	€ 0,856	€ 0,170	

France 50% penalty

/PRO-Europe-Participation-Costs-Overview-2021.pdf

<https://naturaldevelopment.fr/citeo-contribution-emballages-2022-evolutions-des-tarifs/>

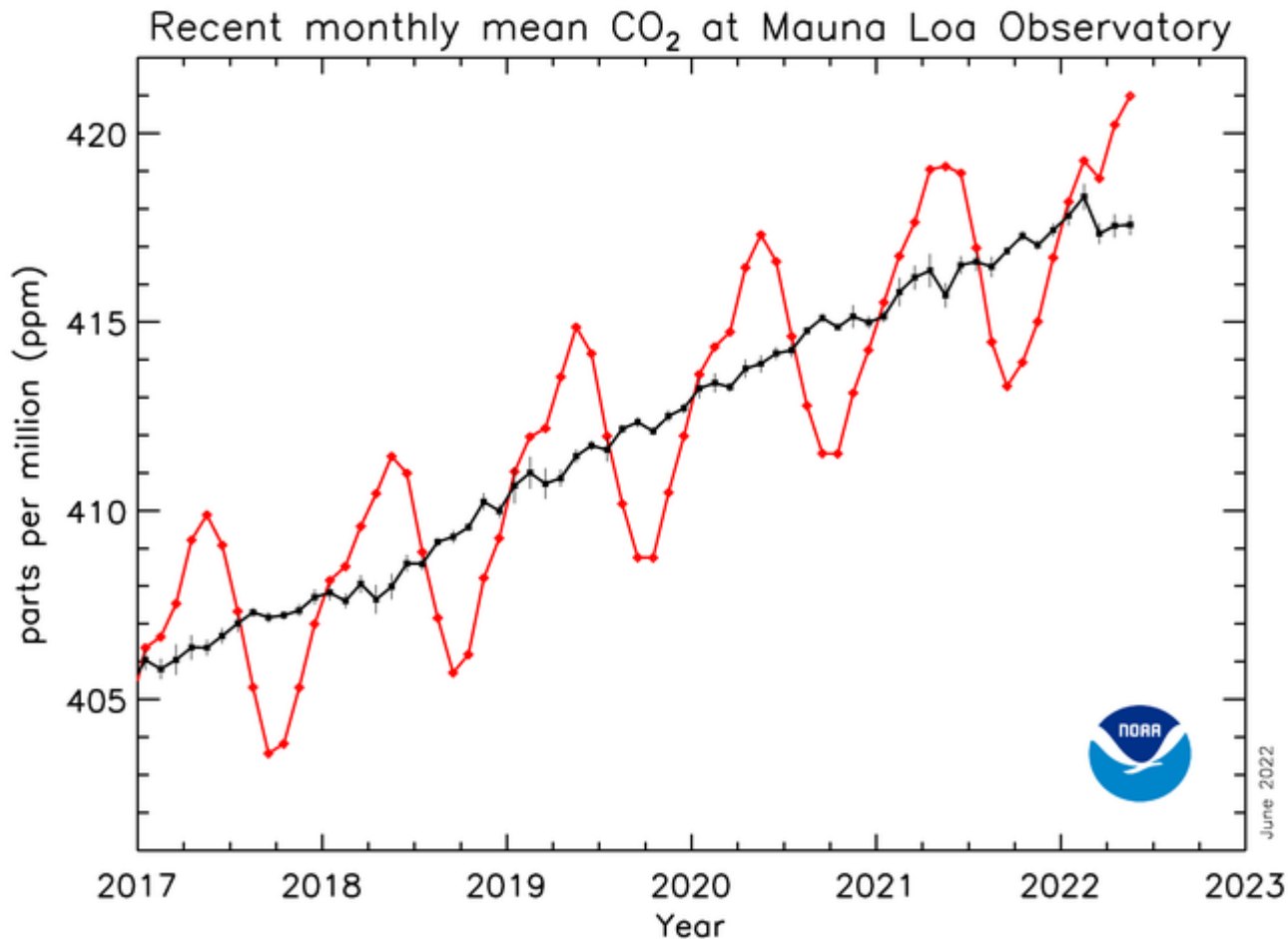
<http://docplayer.nl/215835286-De-groene-punt-tarieven-2022.html>

<https://afvalfondsverpakkingen.nl/verpakkingen/alle-tarieven>

<https://www.fostplus.be/nl/leden/de-groene-punt-tarieven>

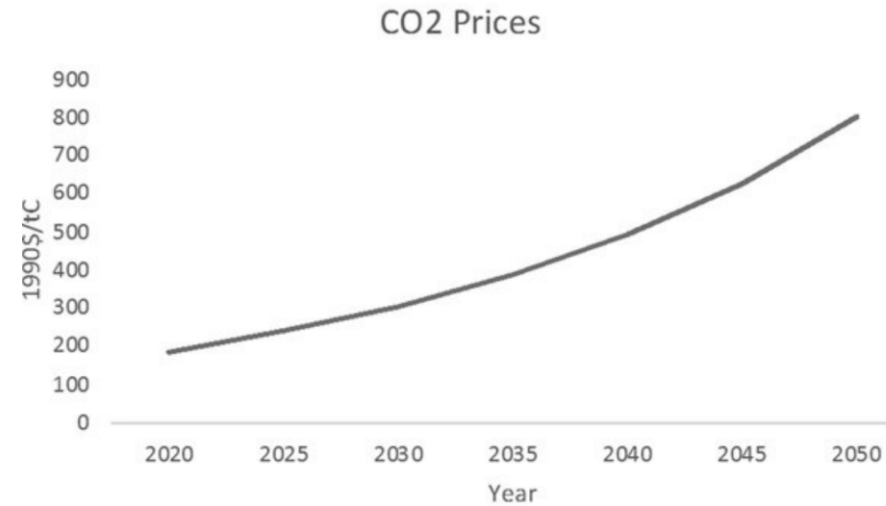
CO2 levels continue to rise.

The New 400ppm World: CO2 Measurements at Mauna Loa Continues to Climb ,now peaked at 422 PPM



What does CO₂ cost?

From 20 to 1 to 90€/kg to 1000€/t



https://www.researchgate.net/publication/335393070_Global_Change_Assessment_Model_GCAM_considerations_of_the_primary_sources_energy_mix_for_an_energetic_scenario_that_could_meet_Paris_agreement/figure/s?lo=1

Cost drivers for true cost

- ▶ 2. CO2 tax <-> scenario: LCA 100€/t CO2 -> by 2050: 1000€/t
 - ▶ EU driven , Benefit for biobased
 - ▶ LCA battle will emerge, whoever reports the best LCA will win

material	CO2 tax		source
	€/ton		
	100	1000	
	CO2 levy €/kg	LCA kgCo2/kg material	
aluminium	€ 1,15	11,50	https://datawrapper.dwcdn.net/fX2LY/10/
cork	€ 0,20	2,00	https://www.corkqc.com/pages/carbon-footprint
glass	€ 0,10	0,97	http://www.greenrationbook.org.uk/resources/footprints-glass/
paper	€ 0,11	1,05	http://www.greenrationbook.org.uk/resources/footprints-glass/
hard plastic PE	€ 0,18	1,80	plastics europe
foils PE	€ 0,18	1,80	plastics europe
bio- PE	€ -0,22	-2,20	http://www.braskem.com.br/...-enviro-assessment-summary-report-final.r
bio-degradable PLA	€ 0,06	0,60	https://www.natureworksllc.com/What-is-Ingeo/Why-it-Matters/Eco-Profile
rPE	€ 0,12	1,20	https://plasticsrecycling.org/images/library/2018-APR-LCI-report.pdf
bio-degradable PHA	€ -0,20	-2,00	https://hrcak.srce.hr/file/209412
wood	€ -0,50	-5,00	https://www.fpl.fs.fed.us/documnts/pdf2014/fpl_2014_bergman007.pdf
low tariff plastic	€ 0,20	2,00	plastics europe
drink bricks	€ 0,10	1,05	paper with 5% PE
steel	€ 0,18	1,80	https://datawrapper.dwcdn.net/fX2LY/10/
EPS/ Styrofoam	€ 0,24	2,40	plastics europe
PET	€ 0,22	2,20	plastics europe
rPET (100%)	€ 0,10	1,00	https://plasticsrecycling.org/images/library/2018-APR-LCI-report.pdf

Cost drivers for true cost

▶ 3. Penalty on non recycle content (Brexit tax)

- ▶ EU : 800 €/t announced
- ▶ Italy 450€/t (again postponed now until 2023)
- ▶ Spain 450€/t (again postponed now until 2023)
- ▶ Czech plastic 25€/t , coated paper 238€/t
- ▶ UK 200 GBP/t per April 2022
- ▶ Other countries to follow

- ▶ Message : Political development
- ▶ In model use 450€/t

▶ 4. Litter tax

Litter tax announced at 800€/t, assumed at 450€/t

Feedstock/energy vs polymer price

Increase in polymer price vs feed stock price

Source PIE Europe

Type €/t	Crude	HDPE inj	GPPS	PP copo	PET pack
increase jan 20- may22	473,0	822,5	1.330,0	1.305,0	830,0

<https://plasticseurope.org/sustainability/circularity/life-cycle-thinking/eco-profiles-set/>

Conclusion : Increase far more than feedstock cost

Inherent energy cost | source LCA Plastics Europe

	fuel energy MJ/ton	feed stock MJ/ton	total MJ/ton
PE	33	47	80
PET	35	34	69
PS	41	43	84

from MJ/t to €/t

Fuel Energy mix for petochemicals gas /electricity gas 80/20

1MJ gas = 0,277 kWh

	2020	2022	maybe 2050
1 Kwh gas kost	€ 0,06	€ 0,20	€ 0,30
1 kwh electra cost	€ 0,25	€ 0,85	€ 4,00
80/20	per Kwh	€ 0,10	€ 0,33
	per MJ	€ 0,35	€ 1,19
	p/ton	€ 12	€ 39

<https://convertlive.com/nl/u/converteren/megajoule/s/naar/kilowattuur>

**Conclusion : feedstock and energy cost do not at all explain higher polymer price.
Supply/demand /panic**

€/kg Price evolution

5. Polymer cost itself

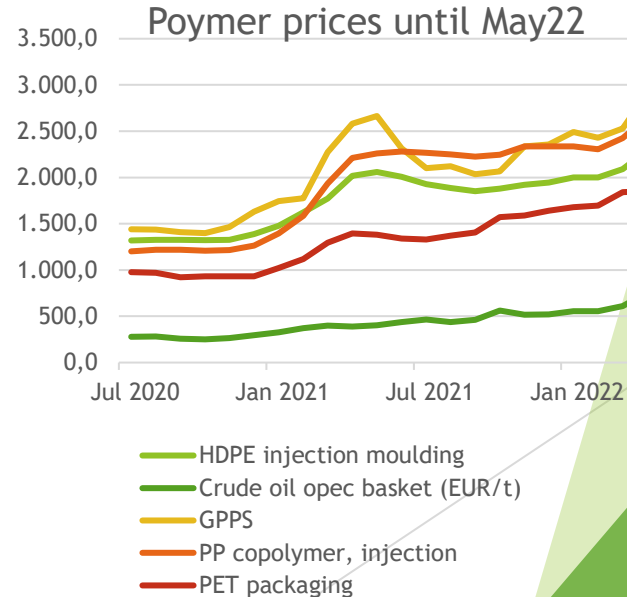
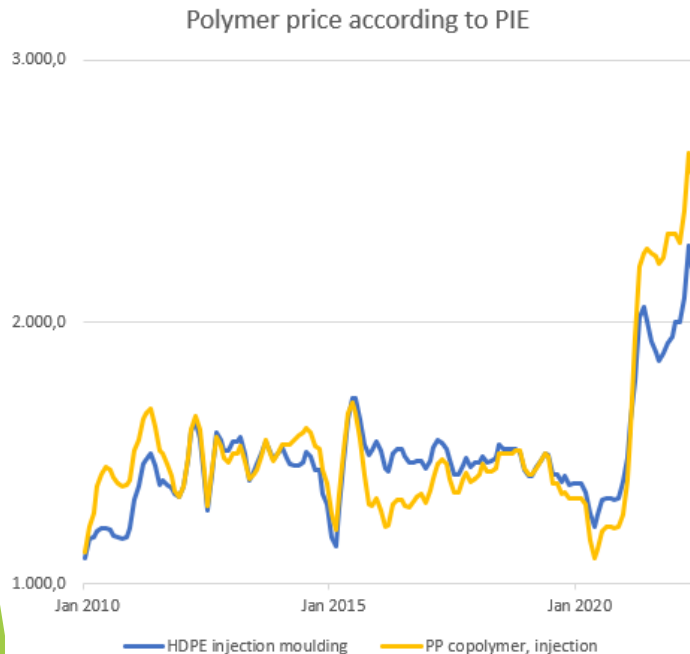
Historical 2010-2021 in hindsight stable

Begin 2021 Economic up turn, scarcity in supply

End 2021 Energy price increased sharply

2022 Energy went up even more due to Ukraine war

Feedstock/ Energy cost 30% of polymer cost only



True cost of all materials

Price evolution → 2050.

effective Kg cost	2050 scenario									2050 winner /loser /equal
	5 country average recycling fee (eur/kg)	CO2 levy	Possible EU plastic levy on non recycled plastic (eur/kg)	litter removal taks 0,45€/kg	total removal cost €/kg	kg price april 22 €/kg	total cost €/kg	cost % over kg cost	CO2 levy	
		100 €/ton							1000 €/ton	
Material 2022	CO2 levy €/kg	CO2 levy €/kg							total cost €/kg	
aluminium	€ 0,11	€ 1,15		€ 0,45	€ 1,71	€ 3,00	€ 4,71	157%	€ 15,06	320%
cork	€ 0,43	€ 0,20		€ 0,45	€ 1,08	€ 4,00	€ 5,08	127%	€ 6,88	135%
glass	€ 0,03	€ 0,10			€ 0,12	€ 0,80	€ 0,92	116%	€ 1,79	194%
paper	€ 0,08	€ 0,11			€ 0,18	€ 1,00	€ 1,18	118%	€ 2,13	180%
hard plastic PE	€ 0,43	€ 0,18	€ 0,45	€ 0,45	€ 1,51	€ 2,00	€ 3,51	176%	€ 5,13	146%
foils PE	€ 0,67	€ 0,18	€ 0,45	€ 0,45	€ 1,75	€ 2,00	€ 3,75	188%	€ 5,37	143%
bio- PE	€ 0,69	€ -0,22	€ 0,45	€ 0,45	€ 1,37	€ 3,20	€ 4,57	143%	€ 2,59	57%
rPE	€ 0,69	€ 0,12	€ -	€ 0,45	€ 1,26	€ 3,20	€ 4,46	139%	€ 5,54	124%
bio-degradable PLA	€ 0,84	€ 0,06	€ 0,45	€ 0,45	€ 1,80	€ 5,00	€ 6,80	136%	€ 7,34	108%
bio-afbreekbaar PHA	€ 0,84	€ -0,20	€ 0,45	€ 0,45	€ 1,54	€ 9,00	€ 10,54	117%	€ 8,74	83%
wood	€ 0,43	€ -0,50			€ -0,07	€ 0,20	€ 0,13	66%	€ (4,37)	-3334%
low tariff plastic	€ 0,37	€ 0,20	€ 0,45	€ 0,45	€ 1,47	€ 2,00	€ 3,47	173%	€ 5,27	152%
drink bricks	€ 0,73	€ 0,10	€ 0,45	€ 0,45	€ 1,74	€ 1,00	€ 2,74	274%	€ 3,68	134%
steel	€ 0,13	€ 0,18			€ 0,31	€ 0,50	€ 0,81	161%	€ 2,43	301%
EPS/ Styrofoam	€ 0,79	€ 0,24	€ 0,45	€ 0,45	€ 1,93	€ 3,00	€ 4,93	164%	€ 7,09	144%
PET	€ 0,37	€ 0,22	€ 0,45	€ 0,45	€ 1,49	€ 3,00	€ 4,49	150%	€ 6,47	144%
rPET (100%)	€ 0,37	€ 0,19	€ -	€ 0,45	€ 1,01	€ 3,45	€ 4,46	129%	€ 6,17	138%

big winner winner equal loser big loser

- Winners : bio-PE, PHA, wood
- Undefined : recycled content
- Losers : Aluminium, steel , prime polymer

Example 1 Lids



			CO2 100€/t	CO2 1000€/t		
material	gr/lid	gr/1000 lids	€/1000		moisture resistant	SUP
PS lid	3,23	3230	€ 15,91	€ 22,89	yes	yes
Pulp lid	3,27	3270	€ 3,87	€ 6,96	no	no
Paper lid 5% PE	5,45	5450	€ 6,13	€ 12,46	yes	yes
PHA lid solid	4,00	4000	€ 42,14	€ 34,94	yes	yes
PLA lid solid	4,00	4000	€ 27,18	€ 29,34	yes	yes
Paper lid 5% PLA	5,45	5450	€ 25,51	€ 15,78	yes	yes

Winner paper plus coating (paper compatible /degradable)

Example 2 cups



			100€/t CO2		1000€/t CO2	
			true prices		true prices	
			1000 pieces		1000 pieces	
16 oz			16 oz		16 oz	
gr /per cup			€ per 1000 pieces		€ per 1000 pieces	
base	coating	base cup material	cold	hot	cold	hot
29,5		Aluminium	€ 139,00		€ 444,32	
4,0		EPS		€ 19,71		€ 28,35
12,5	0,75	single wall paper /PE7%	€ 17,62		€ 30,65	
12,5	0,75	single Paper PLA 7%	€ 19,90		€ 32,12	
20	0,75	double wall Paper /7% PE		€ 26,50		€ 48,09
8,0		PET	€ 35,90		€ 51,74	
8,0		rPET	€ 32,06		€ 45,74	
5,5		PHA foam development		€ 57,94		€ 48,04

Cold drinks -paper with liner

No way forward for aluminium

rPET more expensive than paper

Paper Liner development is key
To ensure recyclability

Hot drinks EPS cheapest with recycling

Paper with PE <-> recycle issue

Home compostable PHA foam dark horse

Example 3 Bottle closures Cork, PE vs Aluminium



		Alu liner	CO2 100€/t	CO2 1000€/t
material	g/piece	gr/piece	€/1000	€/1000
Alu closure	4,47	4,47	€ 21,06	€ 67,31
Cork closure	3,40	1,14	€ 22,62	€ 40,49
Green PE cork closure	4,68	1,14	€ 26,73	€ 29,21
Prime PE polymer cork	4,68	1,14	€ 21,79	€ 41,12

the ultimate stopper :

Recycle bio Green PE	4,68	1,14	€ 24,62	€ 27,11
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Winner: Green PE stoppers

Loser : Aluminium

So: Cost drivers for true cost

- ▶ **1. Packaging Removal tax (Verwijderingsbijdrage)**
 - ▶ Significant differences per country
- ▶ **2. CO2 tax <-> LCA**
 - ▶ EU driven, clear benefit for biobased <-> capacity limitation
 - ▶ future for other type of coatings?
 - ▶ Example : PLA world wide 300kt , EU polymer production 54,000kt +
- ▶ **3. Penalty on non recycle content (Brexit tax)**
 - ▶ 800 €/t announced, not implemented , tends to 450€/t
- ▶ **4. Litter tax**
 - ▶ 800 €/t announced, not implemented; when it will be implemented it is less
- ▶ **5. Polymer price<-> mismatch in inherent energy**

Multiple Developments

Take away: Recycling, Biobased will become cheaper due to economy of scale, but capacity is never large enough to make an impact in the next 10 years

Biodegradable fits a niche, if it does not filter back into normal recycling

Conclusion: Recycling remains key

Opportunities everywhere

Challenges

- ▶ Recycled aluminium, lowered CO2 ?
- ▶ Weight reduction
- ▶ Food approval

Opportunities

- ▶ Biobased content <-> only for CO2
 - ▶ Will stay a niche
- ▶ Paper compatible coatings
- ▶ Home compostable compositions
- ▶ Recycling
- ▶ Chemical recycling

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