



Innograaf BV

The case of bio-based polymers versus the alternatives.

Examples in cases for infill and packaging

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INNOGRAAF BV

11th April 2024

Nordic Bioplastic Conference 2024 Copenhagen

About Innograaf BV

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

25 years polymer processing experience (E)PS,PLA,PP,PE and a focus on biodegradability

EU representation Polyphen International PTY LTD. Australia

Board membership of the Dutch Plastics and Rubber Federation NRK (portfolio Construction and Bio-Based)

2022: Assisted Kirbi-Lego in TDD for investment participation in APK- PE solvent recycling

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



February 09, 2023 01:52 PM

LyondellBasell, Lego family holding KIRKBI invest in APK

APK AG embarks on strategic partnership with the 2 new investors

Presentation Contents

▶ **INFILL**

- ▶ Biodegradability
 - ▶ Industrial
 - ▶ home composting
 - ▶ ECHA Microplastic legislation
- ▶ OECD microplastic free certification
- ▶ Indirect benefits

▶ **PACKAGING**

- ▶ Packaging Removal tax
- ▶ CO2 tax <-> LCA
- ▶ Penalty on non recycle content (Brexit tax)
- ▶ Litter tax
- ▶ Polymer price

Types of infill

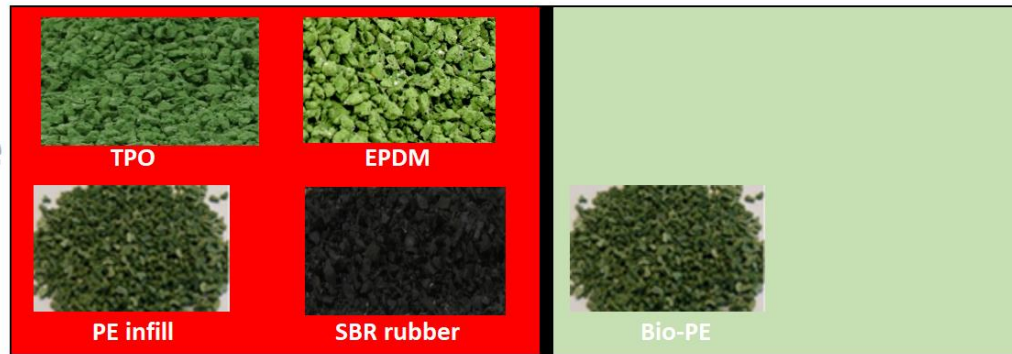
Fossil vs. bio-based, degradable vs. not-degradable

Infill types fossil vs bio-based

Fossil based

Bio-based

Non-degradable




Degradable



Characteristics of infill

Take back and
recoating
of BioFlex by Unisport

Types of Infill	SYNTHETIC INFILLS				
	SBR	TPO	EPDM	PBAT	PE
Fossil- based					
Microplastic kg /m2	7,5	7	10	3	7
Non-microplastic polymer kg / m2					
Types of Infill	ORGANIC INFILLS			SUSTAINABLE INFILLS	
	Olive Pits	Wood	Cork	BioFill	BioFlex ECO
Bio-based					
Microplastic kg /m2				2,5	
Non-microplastic polymer kg / m2	n.a	n.a	n.a		0,1

Degradation legislation and standards

- ▶ Industrial composting
- ▶ Home composting
- ▶ Degradation OECD norms
- ▶ Microplastics

What Is the OECD?
(Organization for Economic Cooperation and Development)

- It is an association of 38 nations in Europe, the Americas, and the Pacific
- It helps member countries formulate economic and social policies
- Members and key partners represent 80% of world trade
- It aids developing countries outside membership and promotes reform

the balance

Degradation standard EN13432

Industrial composting

- ▶ Testing for certification according to EN 13432 / EN 14995 encompasses:



- ▶ Chemical test: Disclosure of all constituents, threshold values for heavy metals are to be adhered to.
- ▶ Biodegradability in controlled composting conditions (oxygen consumption and production of CO₂): Proof must be made that at least **90 percent of the organic material is converted into CO₂ within 6 months.**
- ▶ Disintegration: After 3 months' composting and subsequent sifting through a 2 mm sieve, no more than 10 percent residue may remain, as compared to the original mass.
- ▶ Ecotoxicity test: Examination of the effect of resultant compost on plant growth (agronomic test)

Degradation standard

Home composting

- ▶ Home composting
- ▶ The certifier TÜV AUSTRIA BELGIUM, offers home compostability certification scheme
- ▶ DIN CERTCO offers a certification to the **Australian standard AS 5810**.
- ▶ Italy has a national standard for composting at ambient temperature, **UNI 11183:2006**.
- ▶ **The French Standard NF T 51-800 Plastics** – Specifications for plastics suitable for home composting was introduced. This standard is covered in the DIN CERTCO scheme.
- ▶ **Room temperature testing , testing may take up to two years**



Non-microplastic certification completed

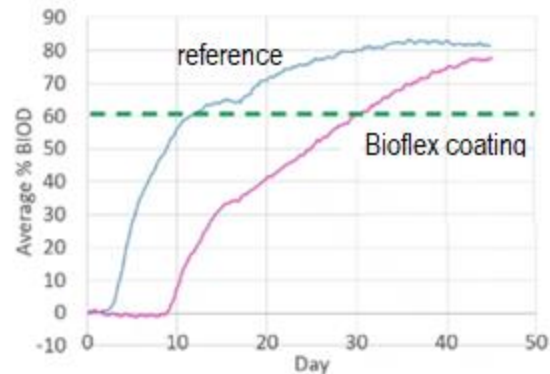
- ▶ Infill ready degradability testing with 60 days OECD-301F standard
- ▶ Formal certification being finalised



INN-3228
Digital Photos
November 6, 2023



Tested under OECD 301F, in accordance to the microplastics regulation
City Sludge; inoculum not pre-adapted



Pure polymer result

Tests are conducted by laboratory accredited to ISO 17025 and is GLP certified

Bioflex cellulose polymer coating sand composition degradation.

- ▶ Industrial composting



Testing certification according to EN 13432

No soil toxicity

- ▶ Home composting



- ▶ No-microplastics testing OECD 301 F



Pure polymer coating material

Degradation is well understood

10+ years of experience

Why long life in field and faster degradation outside

▶ In the field

- ▶ Drainage of field/rather dry
- ▶ Presence of salt slows degradation
- ▶ Rather in-active microclimate

▶ **SLOW** degradation

- ▶ Guarantees a prolonged player usage
- ▶ Continuous evaluation of the maintenance program to control degradability

▶ Outside the field

- ▶ Continuous moisture
- ▶ Presence of fungus
- ▶ Active microclimate

▶ **FAST** degradation

Coated sand



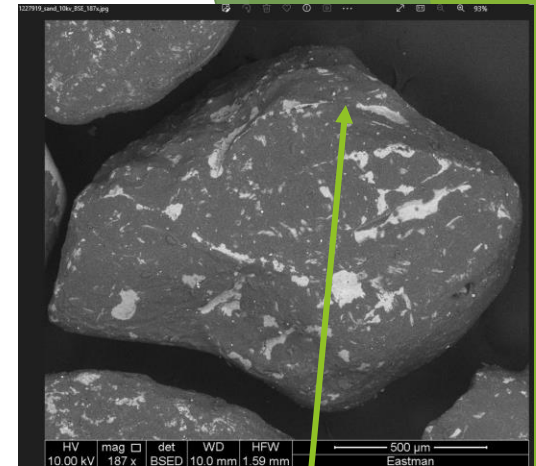
Coating applied by



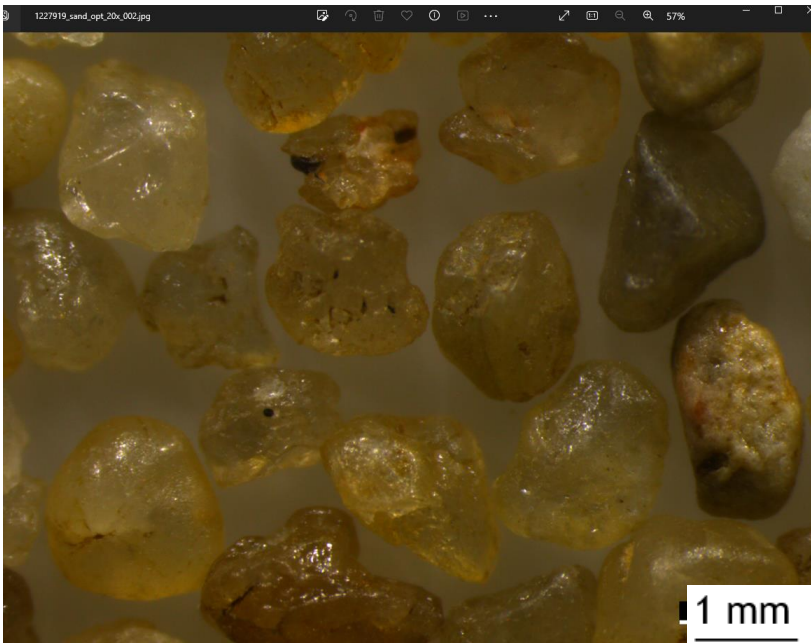
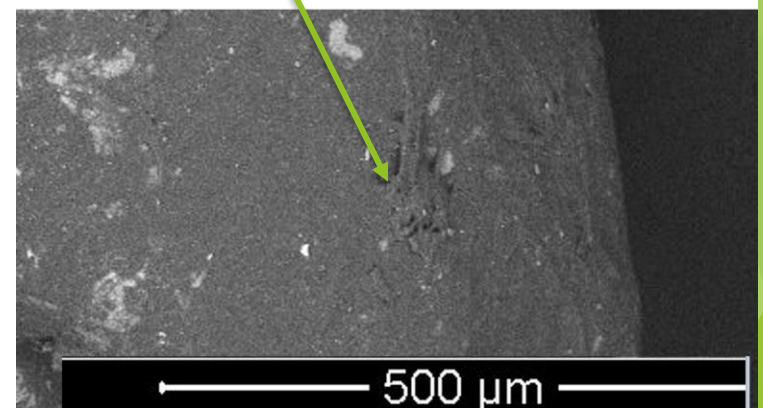
COVIA EUROPE ApS

SEM pictures

- white: original sand surface
- black: cellulose polymer coating



Nett coating: only covers sharp edges and fills unevenness



Coated sand



Indirect microplastic generation significantly less wear after 20.000 Lisport cycles

► BioFlex coating



► Normal sand



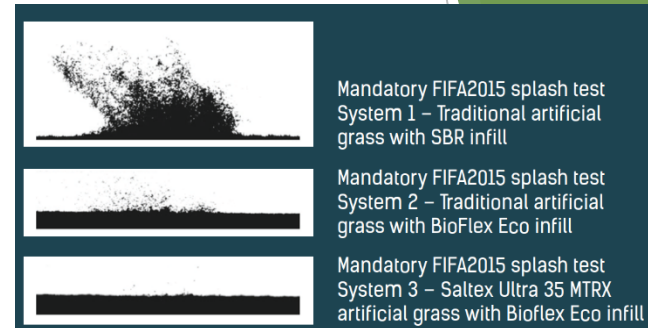
ERCAT

CENTRE FOR TEXTILE SCIENCE AND ENGINEERING
DEPARTMENT OF MATERIALS, TEXTILES AND CHEMICAL ENGINEERING

POINTS TO TAKE AWAY

BioFlex Eco™ is:

- ▶ Non- spreading infill
- ▶ Circular <-> take back scheme
- ▶ Based on a renewable feedstock
- ▶ Biodegradable
- ▶ Contains <1% Microplastic free coating
- ▶ Commercially available in large quantities
- ▶ FSC Chain of Custody certification
- ▶ Used in turf systems that meet FIFA standards
 - ▶ Field References are available



Packaging



Cost drivers for true cost

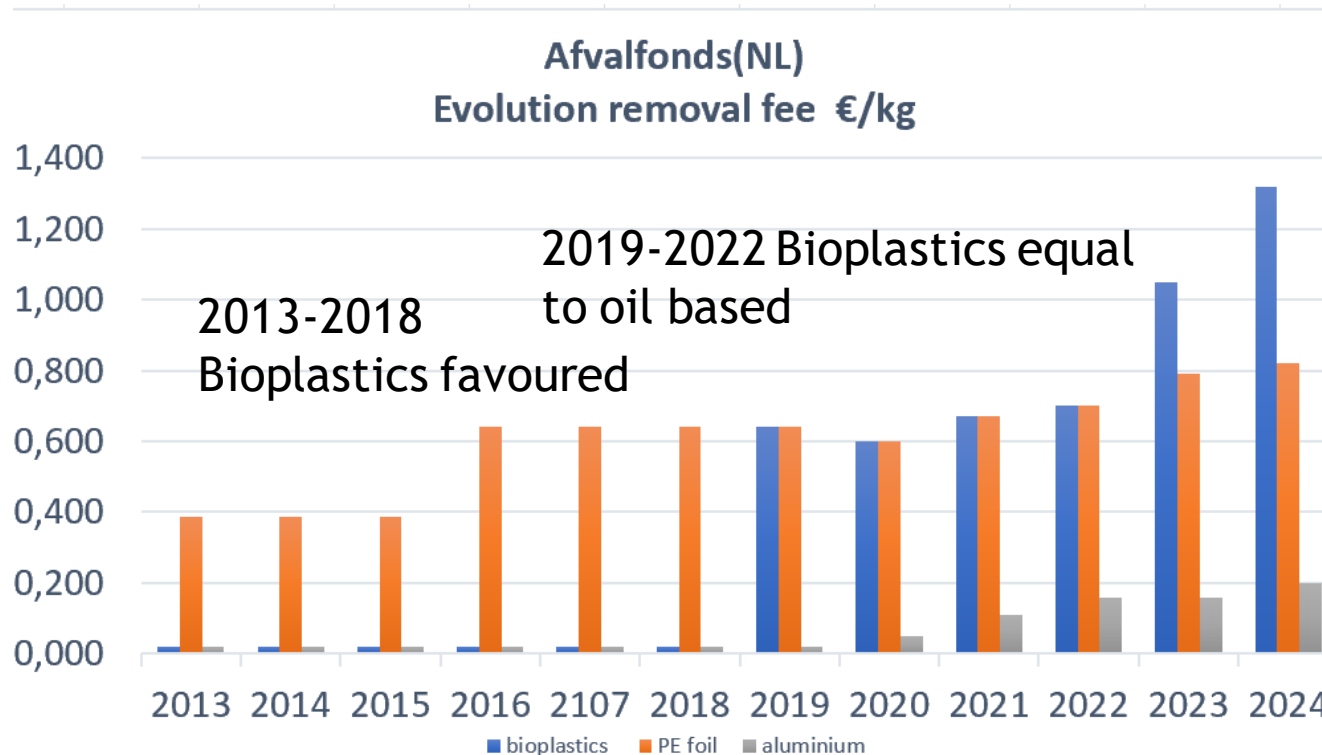
- ▶ **1. Packaging Removal tax (Verwijderingsbijdrage)**
 - ▶ Significant differences per country
- ▶ **2. CO2 tax <-> LCA**
 - ▶ EU driven
 - ▶ Benefit for biobased
- ▶ **3. Penalty on non recycle content (Brexit tax)**
 - ▶ 800 €/t announced beacem 450€/t
- ▶ **4. Litter tax /SUP**

- ▶ **5. Polymer price<-> inherent energy**

Developments are multifold

Removal fees NL 2013-2024

Biobased - PE foil - Aluminium




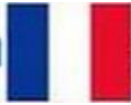



As off 2023 Bioplastics not-favoured
2024: Benefit for recycle 0,50€/t

Cost drivers for true cost

► 1. Packaging Removal tax (Verwijderingsbijdrage)

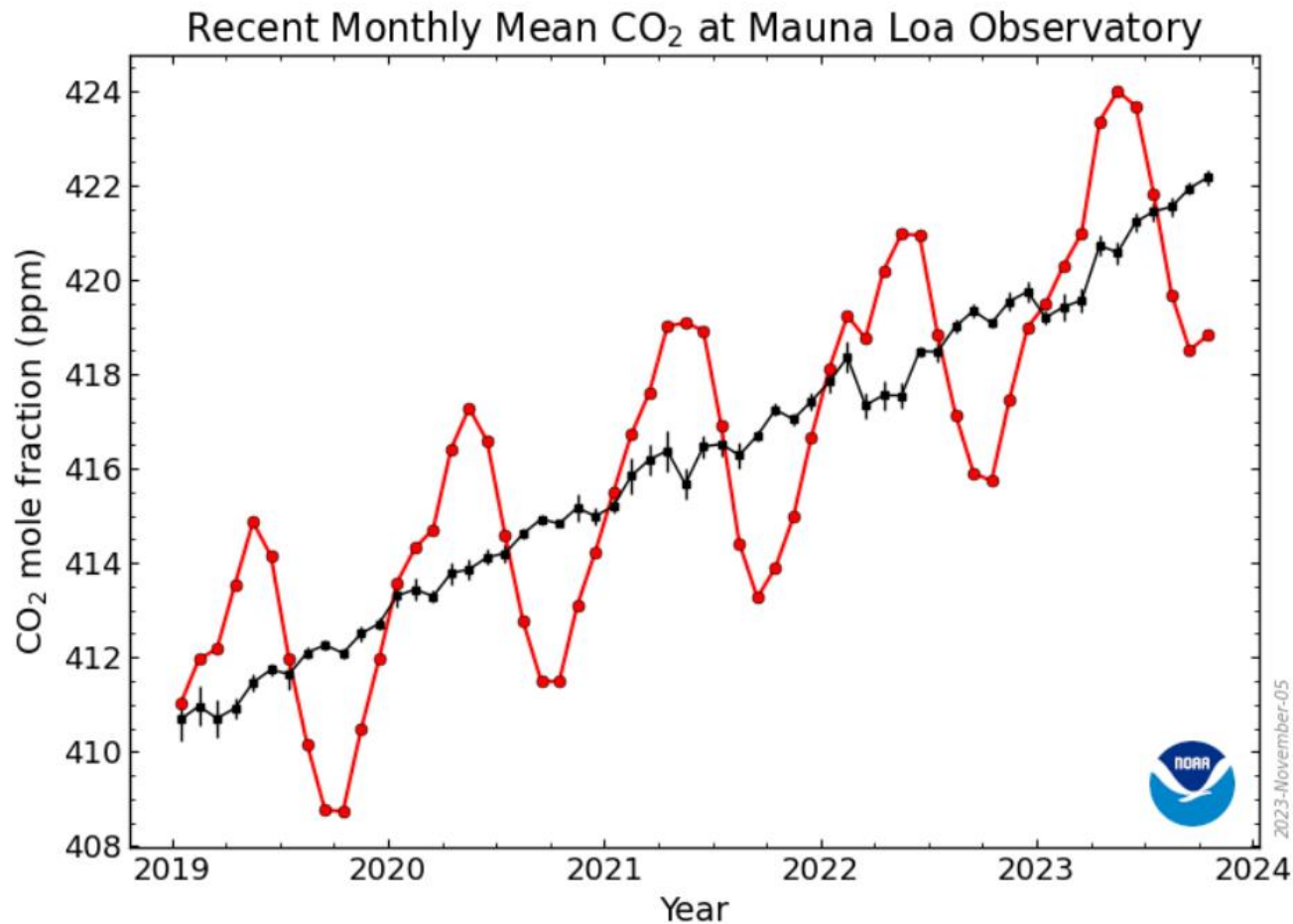
► Significant differences per material and per country

source:
 <https://www.ecoembes.com/es/empresas/tarifas-del-punto-verde>
 <https://www.verpackgo.com/de/license-calculator/>
 https://cdn.citeo.com/mkt/CITEO_SERVICES/Guide%20du%20tarif_2024.pdf
 <https://www.afvalfondsverpakkingen.nl/nl/tarieven>
 <https://www.fostplus.be/nl/media/1004/download>

		Fost plus 	CITEO 	Afvalfonds 	Ecoembes 	Gune punkt 
Material 2024	5 country average recycling fee (eur/kg)	Belgium	France	NL 2024	Spain	Germany
aluminium	€ 0,11	€ 0,022	€ 0,153	€ 0,200	€ 0,062	€ 0,097
cork	€ 0,21	€ 0,760	€ 0,209	€ 0,015	€ 0,007	€ 0,082
glass	€ 0,06	€ 0,069	€ 0,015	€ 0,100	€ 0,030	€ 0,070
paper	€ 0,14	€ 0,121	€ 0,202	€ 0,017	€ 0,135	€ 0,240
hard plastic PE	€ 0,69	€ 0,470	€ 0,419	€ 1,220	€ 0,450	€ 0,910
foils PE	€ 1,05	€ 1,380	€ 0,540	€ 1,320	€ 1,080	€ 0,910
bio- PE	€ 1,05	€ 1,380	€ 0,540	€ 1,320	€ 1,080	€ 0,910
bio-degradable PLA PHA etc	€ 1,49	€ 4,033	€ 0,649	€ 1,320	€ 0,544	€ 0,910
wood	€ 0,87	€ 4,033	€ 0,209	€ 0,015	€ 0,007	€ 0,082
drink bricks	€ 0,66	€ 0,630	€ 0,304	€ 0,840	€ 0,550	€ 0,990
other metals	€ 0,15	€ 0,060	€ 0,057	€ 0,330	€ 0,196	€ 0,090
EPS/ Styrofoam	€ 0,94	€ 0,760	€ 0,649	€ 1,320	€ 1,080	€ 0,910
PET	€ 0,79	€ 0,704	€ 0,508	€ 1,220	€ 0,600	€ 0,910
r PET 100%	€ 0,23	€ 0,006	€ 0,458			
r PE 100%	€ 0,06		€ 0,060			

CO2 levels continue to rise.

The New 400ppm World: CO2 Measurements at Mauna Loa Continues to Climb ,now peaked at 424 PPM



What does cost?

From 20 to 1 to 100 €/kg



What does CO₂ cost?

From 20 to 1 to 100 €/kg to 1000€/t



Provincie Utrecht gebruikt als eerste overheid in Nederland een eerlijke CO₂-prijs

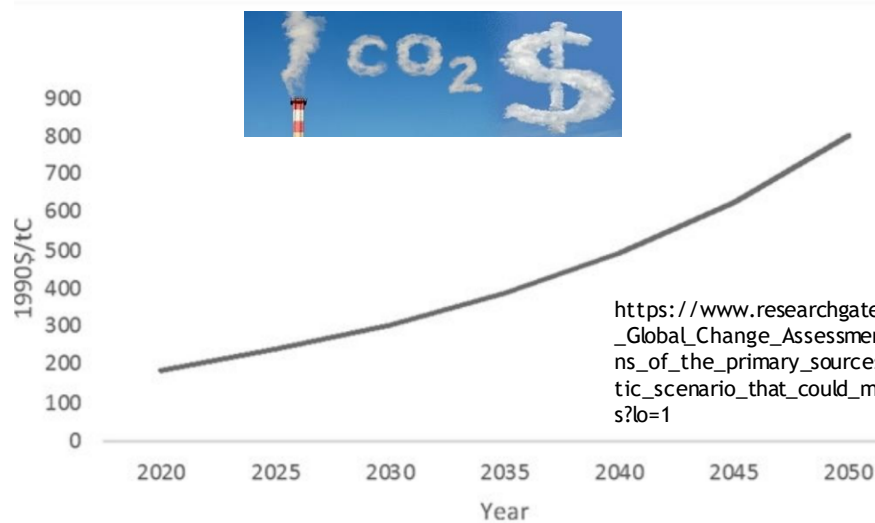
18 januari 2023 - in [Energie en klimaat](#), Huib van Essen

De provincie Utrecht gaat als eerste overheid in Nederland wereldwijde maatschappelijke kosten van klimaatverandering meewegen in haar beleidsafwegingen en -keuzes. Onderdeel van deze afwegingen is ook de toekomstige schade van klimaatverandering. Dit hebben Gedeputeerde Staten besloten. Met een interne rekenprijs van **minimaal 875 euro per ton CO₂** legt de provincie de lat hoog en daagt ze medeoverheden en marktpartijen uit haar voorbeeld te volgen.

 **Green Office van Gemeente Amsterdam** [+ Follow](#) ...
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Amsterdam neemt als eerste gemeente het initiatief voor true pricing


Het college van Amsterdam gaat onderzoeken of we binnen de gemeente true pricing kunnen gebruiken. Een eerste stap daarin is het gebruik van CO₂-beprijzing. Het gemeenteraad heeft namelijk onlangs ingestemd met een aanpassing van de zogenaamde Toepassingsregel Duurzame Investerings. Hiermee kunnen we bij elke grote investering berekenen wat de CO₂-uitstoot is, en wat de maatschappelijke kosten zijn van die uitstoot. Per ton CO₂-emissies hangt de gemeente nu een **prijkaartje van €418 (in 2023)**. We zijn de eerste gemeente in Nederland die deze prijs hanteert. Dankzij deze vernieuwde regel kan er een betere afweging worden gemaakt tussen investeringen.



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

CO2 tax effects on material price		YEAR 2023 100€/ton	Year 2050 1000€/ton
	GWP from published LCA in ton CO2 /ton material	CO2 levy on material €/kg	CO2 levy on material €/kg
material			
aluminium	11,50	€ 1,15	11,50
cork	2,00	€ 0,20	2,00
glass	0,97	€ 0,10	0,97
paper	1,05	€ 0,11	1,05
hard plastic PE	1,80	€ 0,18	1,80
foils PE	1,80	€ 0,18	1,80
bio- PE	-2,20	€ -0,22	-2,20
bio-degradable PLA	0,60	€ 0,06	0,60
bio-degradable PHA	-2,00	€ -0,20	-2,00
wood	-5,00	€ -0,50	-5,00
drink bricks	2,50	€ 0,25	2,50
other metals/steel	1,80	€ 0,18	1,80
EPS/ Styrofoam	2,40	€ 0,24	2,40
PET	2,20	€ 0,22	2,20
rPET (100%)	1,00	€ 0,10	1,00
rPE	1,20	€ 0,12	1,20

EU driven

Benefit for biobased and recycle

material	GWP data : source
aluminium	https://datawrapper.dwcdn.net/fX2LY/10/
cork	https://www.corkqc.com/pages/carbon-footprint
glass	http://www.greenrationbook.org.uk/resources/footprints-glass/
paper	http://www.greenrationbook.org.uk/resources/footprints-glass/
hard plastic PE	plastics europe
foils PE	plastics europe
bio- PE	http://www.braskem.com.br/...-enviro-assessment-summatry-report-final.pdf
bio-degradable PLA	https://www.natureworksllc.com/What-is-Ingeo/Why-it-Matters/Eco-Profile
bio-degradable PHA	https://hrcak.srce.hr/file/209412
wood	https://www.fpl.fs.fed.us/documnts/pdf2014/fpl_2014_bergman007.pdf
drink bricks	* https://www.beveragecarton.eu/wp-content/uploads/2021/01/ACE-Circular_Analytics_ACE_report.pdf
other metals/steel	https://datawrapper.dwcdn.net/fX2LY/10/
EPS/ Styrofoam	plastics europe
PET	plastics europe
rPET (100%)	https://plasticsrecycling.org/images/library/2018-APR-LCI-report.pdf
rPE	https://plasticsrecycling.org/images/library/2018-APR-LCI-report.pdf

* 83 gr CO2 /liter pack ,29-36 gr brick per pack, median 32. , 2500 kg/ton

Cost drivers for true cost

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

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

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

Cost drivers for true cost

▶ 4. Litter tax

- ▶ NL 2,30 /100 pieces

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

True cost of all materials

Price evolution → 2050.

effective Kg cost	2023 current	CO2 levy					CO2 levy
		100 €/ton					100 €/ton
Material 2024	5 country average recycling fee (eur/kg)	CO2 levy €/kg	EU plastic levy on non recycled plastic (eur/kg)	SUP removal taks 0,45€/kg	total removal cost €/kg	kg price nov 23 €/kg	2023 total cost €/kg
aluminium	€ 0,11	€ 1,15			€ 1,26	€ 2,05	€ 3,31
cork	€ 0,21	€ 0,20			€ 0,41	€ 3,00	€ 3,41
glass	€ 0,06	€ 0,10			€ 0,15	€ 3,00	€ 3,15
paper	€ 0,14	€ 0,11		€ 0,45	€ 0,70	€ 1,20	€ 1,90
hard plastic PE	€ 0,69	€ 0,18	€ 0,45	€ 0,45	€ 1,77	€ 1,80	€ 3,57
foils PE	€ 1,05	€ 0,18	€ 0,45	€ 0,45	€ 2,13	€ 1,80	€ 3,93
bio- PE	€ 1,05	€ -0,22	€ 0,45	€ 0,45	€ 1,73	€ 2,00	€ 3,73
bio-degradable PLA	€ 1,49	€ 0,06		€ 0,45	€ 2,00	€ 2,40	€ 4,40
bio-degradable PHA	€ 1,49	€ -0,20		€ 0,45	€ 1,74	€ 8,00	€ 9,74
wood	€ 0,87	€ -0,50	€ 0,45	€ 0,45	€ 1,27	€ 0,80	€ 2,40
drink bricks	€ 0,66	€ 0,25	€ 0,45	€ 0,45	€ 1,81	€ 6,00	€ 7,81
other metals	€ 0,15	€ 0,18			€ 0,33	€ 0,08	€ 0,41
EPS/ Styrofoam	€ 0,94	€ 0,24	€ 0,45	€ 0,45	€ 2,08	€ 1,60	€ 3,68
PET	€ 0,79	€ 0,22	€ -	€ 0,45	€ 1,46	€ 1,20	€ 2,66
r PET 100%	€ 0,23	€ 0,10	€ 0,45	€ 0,45	€ 1,23	€ 1,40	€ 2,63
rPE 100%	€ 0,06	€ 0,12	€ -	€ 0,45	€ 0,63	€ 1,30	€ 1,93

Undefined : recycled content

Losers : Aluminium, steel , prime polymer

True cost of all materials

Tekengebiet	2023 current	CO2 levy			2023 current	CO2 levy			2023 current	CO2 levy	2050 winner/loser/equal
		100	1000	1000		100	1000	1000			
effective Kg cost		€ /ton			€ /ton		€ /ton		€ /ton		
Material 2024	5 country average recycling fee (eur/kg)	CO2 levy €/kg	EU plastic levy on non recycled plastic (eur/kg)	SUP removal taks 0,45€/kg	total removal cost €/kg	kg price nov 23 €/kg	2023 total cost €/kg	cost % over kg cost	2050 total cost €/kg		
aluminium	€ 0,11	€ 1,15			€ 1,26	€ 2,05	€ 3,31	161%	€ 13,66	413%	
cork	€ 0,21	€ 0,20			€ 0,41	€ 3,00	€ 3,41	114%	€ 5,21	153%	
glass	€ 0,06	€ 0,10			€ 0,15	€ 3,00	€ 3,15	105%	€ 4,02	128%	
paper	€ 0,14	€ 0,11		€ 0,45	€ 0,70	€ 1,20	€ 1,90	158%	€ 2,84	150%	
hard plastic PE	€ 0,69	€ 0,18	€ 0,45	€ 0,45	€ 1,77	€ 1,80	€ 3,57	199%	€ 5,19	145%	
foils PE	€ 1,05	€ 0,18	€ 0,45	€ 0,45	€ 2,13	€ 1,80	€ 3,93	218%	€ 5,55	141%	
bio- PE	€ 1,05	€ -0,22	€ 0,45	€ 0,45	€ 1,73	€ 2,00	€ 3,73	186%	€ 1,75	47%	
bio-degradable PLA	€ 1,49	€ 0,06		€ 0,45	€ 2,00	€ 2,40	€ 4,40	183%	€ 4,94	112%	
bio-degradable PHA	€ 1,49	€ -0,20		€ 0,45	€ 1,74	€ 8,00	€ 9,74	122%	€ 7,94	82%	
wood	€ 0,87	€ -0,50	€ 0,45	€ 0,45	€ 1,27	€ 0,80	€ 2,40	300%	€ (2,10)	-88%	
drink bricks	€ 0,66	€ 0,25	€ 0,45	€ 0,45	€ 1,81	€ 6,00	€ 7,81	130%	€ 10,06	129%	
other metals	€ 0,15	€ 0,18			€ 0,33	€ 0,08	€ 0,41	508%	€ 2,03	498%	
EPS/ Styrofoam	€ 0,94	€ 0,24	€ 0,45	€ 0,45	€ 2,08	€ 1,60	€ 3,68	230%	€ 5,84	159%	
PET	€ 0,79	€ 0,22	€ -	€ 0,45	€ 1,46	€ 1,20	€ 2,66	222%	€ 4,64	174%	
r PET 100%	€ 0,23	€ 0,10	€ 0,45	€ 0,45	€ 1,23	€ 1,40	€ 2,63	188%	€ 3,53	134%	
rPE 100%	€ 0,06	€ 0,12	€ -	€ 0,45	€ 0,63	€ 1,30	€ 1,93	148%	€ 3,01	156%	

big winner

<50%

winner

<100%

equal

100-150%

loser

150%-200%

big loser

< 200%

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

Example Bottle closures

Cork, PE vs Aluminium vs glass



		Alu liner	CO2 100€/t	CO2 1000€/t
material	g/piece	gr/piece	€/1000	€/1000
Alu closure +PE liner	4,47	4,47	€ 14,92	€ 59,22
Cork closure	3,40	1,14	€ 15,36	€ 33,23
Green PE cork closure	4,68	1,14	€ 21,19	€ 23,67
Prime PE polymer cork	4,68	1,14	€ 21,19	€ 28,81
Glass stopper (not optimised)	19,73	0,72	€ 65,04	€ 89,18

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/SUP**
 - ▶ 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



Questions?

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