

circular logistics - BikeBox

An Analysis of CO2 Emission Reduction



Life Cycle Assessment BikeBox XL versus Cardboard Box

The impact analysis compared the CO₂ eq emissions associated with a single-use versus reusable packaging system, accounting for key variables. In single-use Cardboard Boxes, over three quarters of the carbon emissions stem from the raw material processing phase. However, with reusable packaging, a much greater proportion of the emissions stem from the transportation phase, given that the manufacturing emissions are spread over many uses.

A comparison of the single-use and reusable systems on a per cycle basis can be found below:

Life Cycle Methodology

The system boundaries for the Fast-Track LCA comparison is based on a Cradle to Cradle (upcycling) system - that is, measuring the unit processes within the material and manufacturing phase, transportation, use phase, and finally resulting in end-of-life recycling process.

The following analysis is highlighting the significant lower CO₂ Emissions when using a circular BikePackaging solution rather than a single-use cardboard box.

Comparison is made between 1 BikeBox(BBP-DF-XLarge) that is designed to be used 30 consecutive times before being recycled and 30 standard Cardboard Bike Boxes that are designed to be used once before being recycled.

The generation of microplastics or downcycling was not considered in this study for the following reasons: Since the reusable containers are made of pure monomaterial polypropylene and remain under the responsibility of circular logistics throughout the entire cycle process, we can guarantee that all packaging:

- is kept in circulation 30 times,
- is repaired when necessary,
- is 100% recycled and processed into new boxes at the end of its life,
- does not end up in landfills, thus preventing the generation of microplastics.

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Base Case

BikeBox

Reusable Packaging: 100% Polypropylene of which 60% recycled polypropylene are being added from previous generation BikeBoxes. This figure is based on input by the manufacturer of the used Polypropylene sheeting. Tests are temporarily undertaken to maximise this figure.

Our automated return system ensures a 97% return rate for all boxes through strict control mechanisms. Each box is equipped with a unique RFID, allowing for continuous tracking and rotation. Damaged boxes can be easily repaired.

Manufacturing and Recycling process in Germany to avoid transport.

Transport distance per cycle - CO2 Emissions based on average figures from the International Postal Corporation for parcel deliveries.

Number of cycles = 30

The BikeBox is being returned by postal courier (Paketdienst) each time after use and recycled after 30 uses.

BikeBox manufacturing carbon footprint is included before it's first use and it's recycling footprint is included after the 30th use.

Cardboard Bike Box

Cardboard packaging of an equal size as BikeBoxPRO

89% Recycled content.

This is in keeping with European Federation of Corrugated Board Manufacturers' (FEFCO) finding of average recycled content of corrugated cardboard as of 2017.40

Manufacturer in Europe

Disposable packaging use case is from manufacturing to recycling on each cycle.

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Packaging weight:

BikeBox PRO (BBP-DF-Extra Large) weighs 12,67kg when empty.

An equivalent sized Cardboard Box weighs 7 kg.

Weight	kg	
BikeBox (BBP-DF/XL)	12,67	Excluding extra protective packaging
Cardboard Box	7	Excluding extra protective packaging

Waste Processing

We are assuming that all materials get recycled at the end-of-life-cycle.

The emissions factor for each waste type includes waste treatment only, any emissions for processing into new materials are excluded.

For waste processing, an emission factor of 0,07kg CO2 per kg of waste is therefore used (Finnish Environment Institute).

Emission Factors

The following emission factors were used for the calculation

Item	kgCO2/kg	Source
Polypropylene	2,41	Broogard at al. (2014) for primary production
Cardboard	1,14	Broogard at al. (2014) for primary production
Return Shipping average parcel	0,21	Average parcel emits 0,21 CO2/kg if transported by road over a diistance of 1000 km with an average parcel size of 2.8kg. https://www.co2everything.com/co2e-of/freight-shipping
Return Shipping BikeBox	1,33035	Considering that the average parcel weight is 2kg, we multiplied the rate x6,335 for shipping a BikeBox
Waste treatment general	0,1	Finnish Environment Institute, SYKE

Waste Treatment (BikeBox)	1,267	1,30501	considering 3% non-return
Waste Treatmen Cardboard Box CO2/kg	0,7		

Carbon Footprint of manufacturing

Reusable BikeBox	30,5347	31,451	including 3% for non-return
Disposable Cardboard	7,98		

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	BikeBox	Cardboard		
Uses	emission kg of CO2	emission kg of CO2	saving abs. kg of CO2	saving rel %
1	31,450741	8,68	22,77	262%
2	32,781091	17,36	15,42	89%
3	34,111441	26,04	8,07	31%
4	35,441791	34,72	0,72	2%
4,236	36,772141	36,77	0,00	0%
5	36,772141	43,40	-6,63	-15%
6	38,102491	52,08	-13,98	-27%
7	39,432841	60,76	-21,33	-35%
8	40,763191	69,44	-28,68	-41%
9	42,093541	78,12	-36,03	-46%
10	43,423891	86,80	-43,38	-50%
11	44,754241	95,48	-50,73	-53%
12	46,084591	104,16	-58,08	-56%
13	47,414941	112,84	-65,43	-58%
14	48,745291	121,52	-72,77	-60%
15	50,075641	130,20	-80,12	-62%
16	51,405991	138,88	-87,47	-63%
17	52,736341	147,56	-94,82	-64%
18	54,066691	156,24	-102,17	-65%
19	55,397041	164,92	-109,52	-66%
20	56,727391	173,60	-116,87	-67%
21	58,057741	182,28	-124,22	-68%
22	59,388091	190,96	-131,57	-69%
23	60,718441	199,64	-138,92	-70%
24	62,048791	208,32	-146,27	-70%
25	63,379141	217,00	-153,62	-71%
26	64,709491	225,68	-160,97	-71%
27	66,039841	234,36	-168,32	-72%
28	67,370191	243,04	-175,67	-72%
29	68,700541	251,72	-183,02	-73%
30	71,335901	260,40	-189,06	-73%
31	71,361241	269,08	-197,72	-73%
32	72,691591	277,76	-205,07	-74%
33	74,021941	286,44	-212,42	-74%
34	75,352291	295,12	-219,77	-74%
35	76,682641	303,80	-227,12	-75%
36	78,012991	312,48	-234,47	-75%
37	79,343341	321,16	-241,82	-75%
38	80,673691	329,84	-249,17	-76%
39	82,004041	338,52	-256,52	-76%
40	83,334391	347,20	-263,87	-76%
41	84,664741	355,88	-271,22	-76%
42	85,995091	364,56	-278,56	-76%
43	87,325441	373,24	-285,91	-77%
44	88,655791	381,92	-293,26	-77%
45	89,986141	390,60	-300,61	-77%
46	91,316491	399,28	-307,96	-77%
47	92,646841	407,96	-315,31	-77%
48	93,977191	416,64	-322,66	-77%
49	95,307541	425,32	-330,01	-78%
50	97,942901	434,00	-336,06	-77%

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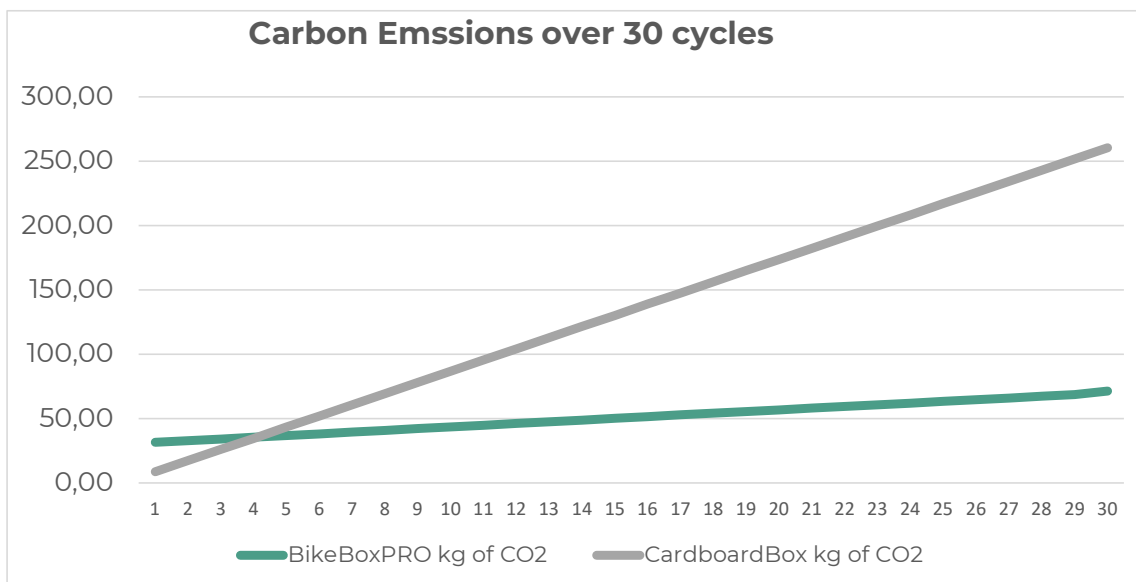
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Total Carbon Footprint for 30 uses

Reusable BikeBox Emissions CO2 in kg	71,336	kg CO2	BikeBoxPro gets returned and reused over 30 uses. Manufacturing and Recycling emissions apply only once
Disposable Cardboard	260,40	kg CO2	CardboardBox gets recycled and re-manufactured after each use.

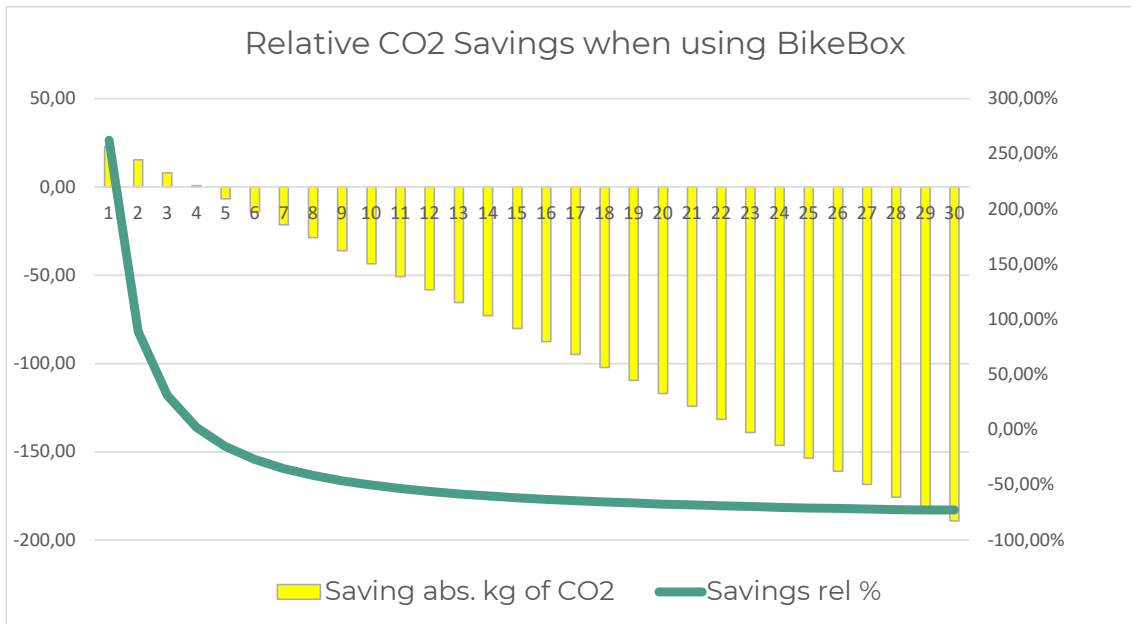
The Breakeven in carbon footprint occurs after 4,2 uses.

BikeBox produces significantly less CO2 Emissions than disposable cardboard packaging and reduces the carbon footprint by up to 76% compared to disposable packagings.



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Analysis of the total packaging weight.

Weight	weight per use	weight 30 uses	Excluding extra protective packaging
	kg	kg	
BikeBox (BBP-DF/XL)	12,67	13,06	
Cardboard Box	7	210	

While BikeBoxes turn into recyclable waste after the 30th use (assuming that only 3% get lost, the number of recyclable waste was adapted to a 97% return rate), disposable packagings cause significant recyclable waste after each single use.

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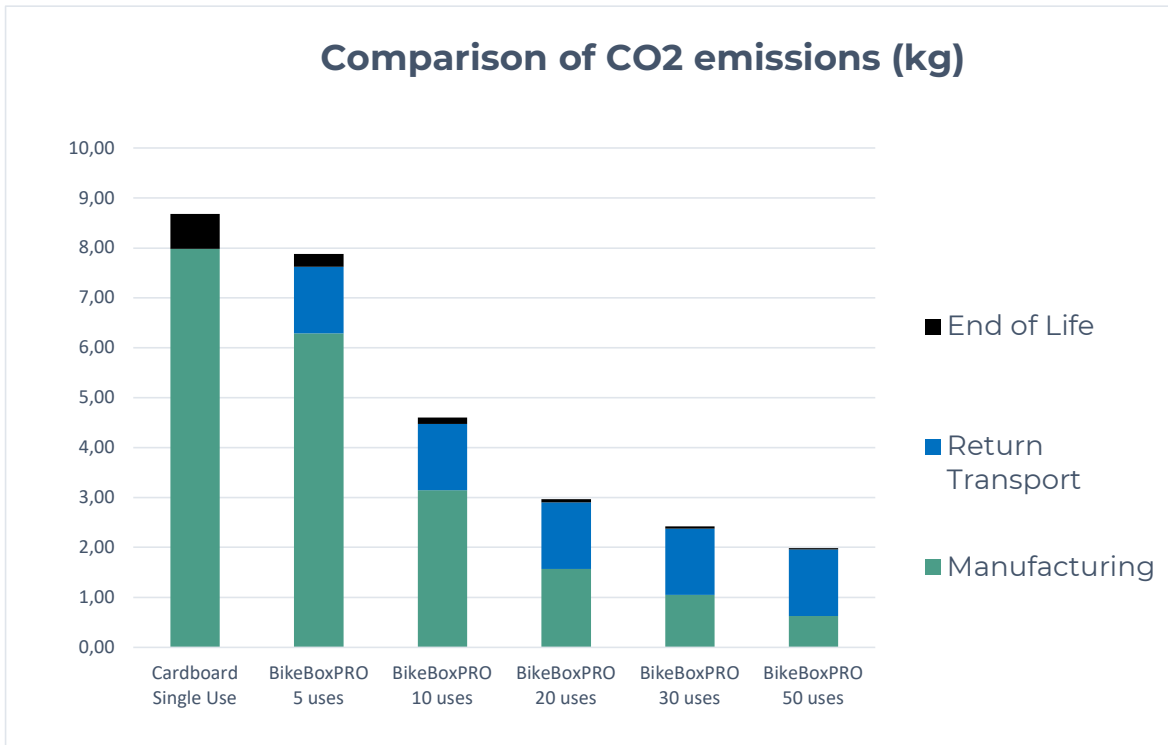
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Uses	BikeBox recyclable waste	Cardboard Box recyclabel waste	Savings abs. Kg	Savings rel. Kg
1	13,06185567	7,00	-6,06	87%
2	13,06185567	14	0,94	-7%
3	13,06185567	21,00	7,94	-38%
4	13,06185567	28,00	14,94	-53%
5	13,06185567	35,00	21,94	-63%
6	13,06185567	42,00	28,94	-69%
7	13,06185567	49,00	35,94	-73%
8	13,06185567	56,00	42,94	-77%
9	13,06185567	63,00	49,94	-79%
10	13,06185567	70,00	56,94	-81%
11	13,06185567	77,00	63,94	-83%
12	13,06185567	84,00	70,94	-84%
13	13,06185567	91,00	77,94	-86%
14	13,06185567	98,00	84,94	-87%
15	13,06185567	105,00	91,94	-88%
16	13,06185567	112,00	98,94	-88%
17	13,06185567	119,00	105,94	-89%
18	13,06185567	126,00	112,94	-90%
19	13,06185567	133,00	119,94	-90%
20	13,06185567	140,00	126,94	-91%
21	13,06185567	147,00	133,94	-91%
22	13,06185567	154,00	140,94	-92%
23	13,06185567	161,00	147,94	-92%
24	13,06185567	168,00	154,94	-92%
25	13,06185567	175,00	161,94	-93%
26	13,06185567	182,00	168,94	-93%
27	13,06185567	189,00	175,94	-93%
28	13,06185567	196,00	182,94	-93%
29	13,06185567	203,00	189,94	-94%
30	13,06185567	210,00	196,94	-94%

Above data shows that the use of a reusable BikeBox reduces the total packaging waste by 94%.

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The comparison of CO2 Emissions between single-use cardboard Boxes and reusable BikeBoxes shows a 73% reduction in CO2e Emissions at a use of 30 cycles.

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