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INDUSTRIAL RESINS & MATERIALS

Comparative Life Cycle Assessment

KLIMA-PUR:

Novel bio-Polyurethane framing material for sustainable highly energy eficient windows.

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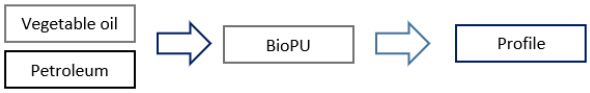
INTRODUCTION

Goal and scope of LCA

The aim of that pre-assessment is to get a first estimation of potential environmental impacts of the production of KLIMA-PUR. This first LCA draft is focused on the carbon footprint of the BioPU production, in order to make a comparison with other materials commonly used for windows frame, such as aluminum, PVC and wood. That estimation aims only to show the relevance of using BioPU as substitute to higher carbon intensity materials for the needed of this proposal.

1.1. System boundaries

The LCA focus on the transformation to chemical products to the production of KLIMAPUR profile, as the graph below shows. So, it is a Cradle-to-Gate assessment.



1.2. Functional unit

The function of the system is to produce KLIMAPUR out of BioPU. In order to make a faire comparison with other material, we decide to use one meter long standard profile (700mm thick).

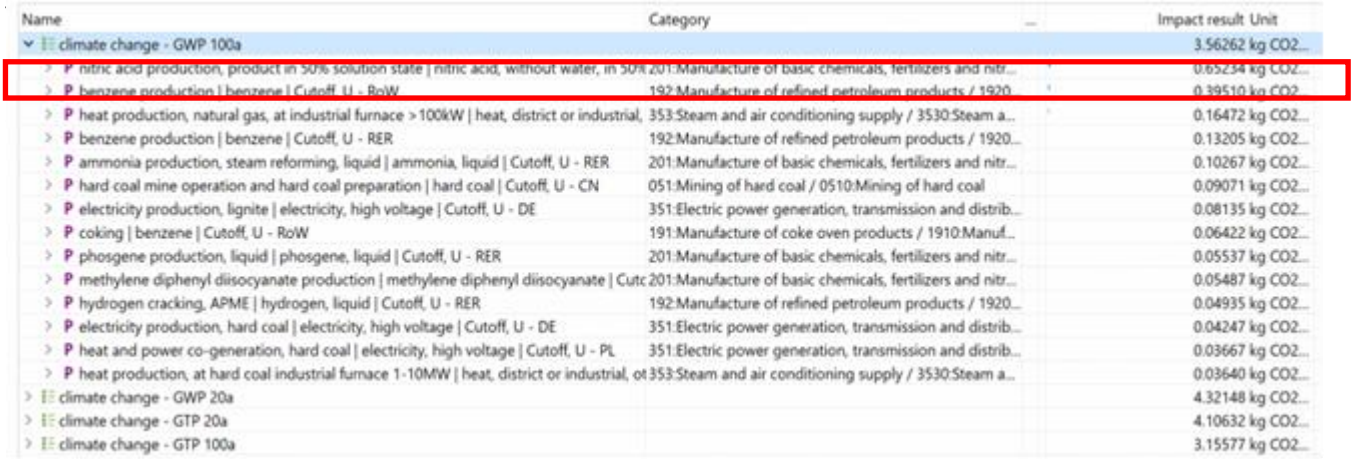
2. Life-Cycle Inventory Assessment of KLIMA-PUR Frames

1.1. Inputs

The inventory is based on the bioPUR formulation at a lab scale where biopolyols are not available in any data base. Therefore, an approximation has been modeled with vegetable oil methyl ester as it is also produced from a transesterification process. The electricity consumption of the plant for production process was calculated in ***Annex 3E***. In order to make a realistic model we adapted it on the "polyurethane production, rigid foam, RER U" available in the 3.6 version of the ecoinvent database. Regarding the outputs we removed the PU waste since all production residues will be reused as raw material after being grinded.

Inputs	Unit	Amount
chemical factory, organics	Item(s)	4E-10
electricity, low voltage, label-certified	kWh	0.246
glycerine	kg	0.056
methylene diphenyl diisocyanate	kg	0.52
vegetable oil methyl ester	kg	0.212
vegetable oil methyl ester	kg	0.212
Pentane	kg	0.003
polyurethane, rigid foam	kg	1

1.2. Results obtained



Name	Category	Impact result	Unit
climate change - GWP 100a		3.56262	kg CO2...
nitric acid production, product in 50% solution state | nitric acid, without water, in 50%	201:Manufacture of basic chemicals, fertilizers and nitr...	0.65234	kg CO2...
benzene production | benzene | Cutoff, U - RoW	192:Manufacture of refined petroleum products / 1920...	0.39510	kg CO2...
heat production, natural gas, at industrial furnace >100kW | heat, district or industrial,	353:Steam and air conditioning supply / 3530:Steam a...	0.16472	kg CO2...
benzene production | benzene | Cutoff, U - RER	192:Manufacture of refined petroleum products / 1920...	0.13205	kg CO2...
ammonia production, steam reforming, liquid | ammonia, liquid | Cutoff, U - RER	201:Manufacture of basic chemicals, fertilizers and nitr...	0.10267	kg CO2...
hard coal mine operation and hard coal preparation | hard coal | Cutoff, U - CN	051:Mining of hard coal / 0510:Mining of hard coal	0.09071	kg CO2...
electricity production, lignite | electricity, high voltage | Cutoff, U - DE	351:Electric power generation, transmission and distrib...	0.08135	kg CO2...
coking | benzene | Cutoff, U - RoW	191:Manufacture of coke oven products / 1910:Manuf...	0.06422	kg CO2...
phosgene production, liquid | phosgene, liquid | Cutoff, U - RER	201:Manufacture of basic chemicals, fertilizers and nitr...	0.05537	kg CO2...
methylene diphenyl diisocyanate production | methylene diphenyl diisocyanate | Cutc	201:Manufacture of basic chemicals, fertilizers and nitr...	0.05487	kg CO2...
hydrogen cracking, APME | hydrogen, liquid | Cutoff, U - RER	192:Manufacture of refined petroleum products / 1920...	0.04935	kg CO2...
electricity production, hard coal | electricity, high voltage | Cutoff, U - DE	351:Electric power generation, transmission and distrib...	0.04247	kg CO2...
heat and power co-generation, hard coal | electricity, high voltage | Cutoff, U - PL	351:Electric power generation, transmission and distrib...	0.03667	kg CO2...
heat production, at hard coal industrial furnace 1-10MW | heat, district or industrial, ot	353:Steam and air conditioning supply / 3530:Steam a...	0.03640	kg CO2...
climate change - GWP 20a		4.32148	kg CO2...
climate change - GTP 20a		4.10632	kg CO2...
climate change - GTP 100a		3.15577	kg CO2...

1.3. Comparison of LCA results of KLIMA-PUR frames to competitor materials

Finally, in order to produce 1 meter of KLIMAPUR profile, 1.58 kg of BioPUR are requested, thus showing a potential impact of **5.63 kgCO2e/m for bioPUR.** This result is compared in to competitors

FRAME TYPE	70 mm width	Profile (1 m)	Emission factor		Embodied energy			
	Material	kg/m or m3/m	kgCO2/kg or m3	kgCO2e/m	MJ/kg	MJ/m	kWh/kg	kWh/m
KLIMA-PUR	*bioPUR*	1,58	3,56	**5,63**	32,56	51,44	8,99	**14,21**
Aluminium	*Alu*	3,00	3,10	**9,29**	108,60	325,80	30,00	**90,00**
PVC	*PVC* *Steel*	1,81 1,22	2,00 1,71	**5,72**	67,50 20,00	146,77	24,17	**40,54**
Wood	*Wood*	0,00	104,27	**0,30**	7,40	11,68	2,04	**3,23**

3. Life-Cycle Inventory Assessment of KLIMA-PUR Windows

3.1. Inputs & result obtained

We based our study on the Sinha and Kutnar 2012 comparative report for most common materials used for windows frame, such as aluminum, wood and PVC. Since authors provide a full inventory for the production of 1m^2 window, where 8m of frames are usually required, we estimated 10m of KLIMAPUR frames (including a typical waste of 2m).

1m2 of KLIMAPUR windows	CO2e	Quantity	unit	factor
Acetone, liquid, at plant/RER U	0.039	0.017	kg	2.23
Alkyd paint, white, 60% in H2O, at plant/RER U	15	5.49	kg	2.73
Alkyd resin, long oil, 70% in white spirit, at plant/RER U	0.087	0.024	kg	3.56
Aluminium, production mix, at plant/RER U	26.1	3.06	kg	8.53
Aluminium, production mix, cast alloy, at plant/RER U	0.048	0.016	kg	3.1
Anodising, aluminium sheet/RER U	3.29	0.81	m2	4.06
Benzimidazole-compounds, at regional storehouse/RER U	0.052	0.004	kg	13.21
Butanol, 1-, at plant/RER U	0.036	0.02	kg	1.83
Copper, at regional storage/RER U	0.012	0.006	kg	1.88
Disposal, paint, 0% water, to municipal incineration/CH U	0.681	0.286	kg	2.38
Electricity, medium voltage, production UCTE, at grid	30.4	57.7	kWh	0.53
Isopropanol, at plant/RER U	0.001	0	kg	1.84
Melamine formaldehyde resin, at plant/RER U	0.337	0.073	kg	4.6
Metal working factory/RER/I U	3.73	3.67 × 10-8	p	1.02E+08
Methyl ethyl ketone, at plant/RER U	0	0	kg	1.76
Nylon 66, glass-filled, at plant/RER U	2.46	0.349	kg	7.05
Pellets, mixed, burned in furnace 50 kW/CH U	0.634	54	MJ	0.01
Polyethylene, LDPE, granulate, at plant/RER U	0.049	0.023	kg	2.1
Polypropylene, granulate, at plant/RER	0.046	0.023	kg	1.97
Polyvinylchloride, at regional storage/RER	0.271	0.136	kg	1.99
Propylene glycol, liquid, at plant/RER	0.001	0	kg	4.06
BioPUR (KLIMA-PUR formulation)	***56.2954***	***15.8***	***kg***	***3.563***
Section bar extrusion, Aluminium/RER U	3.15	3.06	kg	1.03
Section bar rolling, steel/RER U	1.03	5.18	kg	0.2
Steel, low-alloyed, at plant/RER U	8.88	5.18	kg	1.71
Synthetic rubber, at plant/RER U	3.01	1.14	kg	2.64
Titanium dioxide, production mix, at plant/RER	0.003	0.01	kg	4.55
Toluene, liquid, at plant/RER U	0.047	0.031	kg	1.5
Transport, lorry > 16 t, fleet average/RER U	4.78	38.2	tkm	0.13
Transport, lorry 20–28 t, fleet average/CH U	0.2	1.05	tkm	0.19
Water, completely softened, at plant/RER U	0	0.377	kg	0
White spirit, at plant/RER U	0.007	0.007	kg	0.93
Wood pellets, u = 10%, at storehouse/RER U	-0.458	-0.004	m3	103.15
Zinc coating, pieces/RER U	3.05	0.493	m2	6.19
Zinc, primary, at regional storage/RER U	0.977	0.29	kg	3.37
Total -	164.2454			

As can be seen in the table above, a **KLIMA-PUR window results in a C-Footprint of 164.25kgCO2e/m^2** being compared to competitors in the following table taking mentioned Sinha and Kutnar 2012 report as reference.

Windows (1m2)	KgCO2e/m2	% difference
Aluminum frame window	486	**-66%**
PVC frame window	258	**-36%**
Wood frame window	130	**26%**
KLIMAPUR	**164.25**	