ANNEX 6 DETAILED LCA DATA AND CALCULATION RESULTS PER PLASTIC PIECE

CONTENTS

This annex is composed of six sections:

- A- System boundaries
- B- Detailed data per kg of resin for all treatment options and categories of impacts
- C- Detailed analysis per kg of resin for all treatment options and categories of impacts
- D- Sensitivity analysis about substitution rates: detailed data per kg of resin for the mechanical recycling option for the following substitution rates: 0.6, 0.65, 0.7, 0.8, 0.9, and 1
- E- Sensitivity analysis about substitution rates: graphs representing the impacts of mechanical recycling for each resin depending on the substitution rate and per impact category
- F- External costs per resin and treatment option

Data comes from two studies:

- The Fraunhofer study looks at 4 plastic parts of an ELV corresponding to the following resins: seat cushion in PUR, bumper in PP/EPDM, hubcap in PA-GF, and dashboard in 12,5 % PVC, 12,5% ABS, 25% PUR and 50% PP-TV.

  In the following, the 'total P+E+T' (where P stands for the part of the total life cycle related to production and recycling/recovery/disposal, E = Energy production (including related transport), and T = Transport (including related energy)) which represent the impacts generated by the process, the 'total avoided' which represents the avoided impacts, and the 'total' for 1000 pieces come directly from the Fraunhofer study.

  However, the 'total' impacts per kg of resin, the external costs, the impacts of the mechanical recycling due to the variation of the substitution rate are BIO IS calculations done using the data from the Fraunhofer study.

- The APME study looks at seven plastic parts of an ELV corresponding to the following resins: air duct in PP, bumper in PP, seat cushion in PUR, intake manifold in PA, wash-liquid tank and lid in PE, headlamp lens in PC, and mirror housing in ABS.

  In the following, the data comes directly from the APME study except for the impacts in terms of eutrophication which were calculated by BIO IS thanks to the LCI.

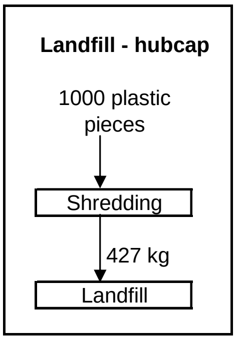
A- System boundaries in the Fraunhofer study

In this chapter are presented the system boundaries for the Fraunhofer study accompanied by some explanations as the Fraunhofer study is only available in German. For details on the system boundaries considered in the APME study, please refer the APME report and appendices.

Example of the hubcap in PA-GF (other systems are described similarly in the Fraunhofer study).

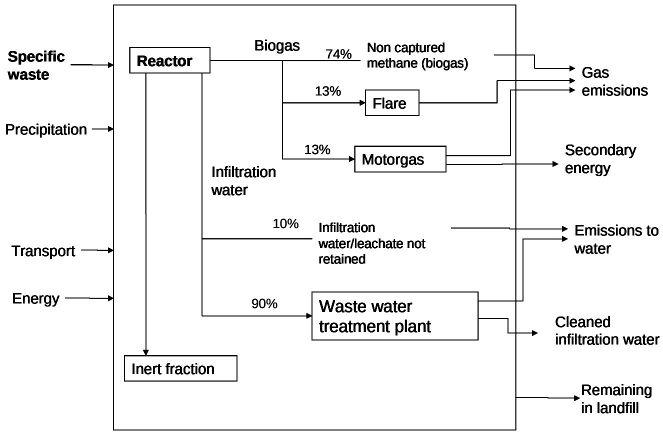
Some explanations are given for each system. More explanations can be found in the Fraunhofer study.

1.1.1 Landfill

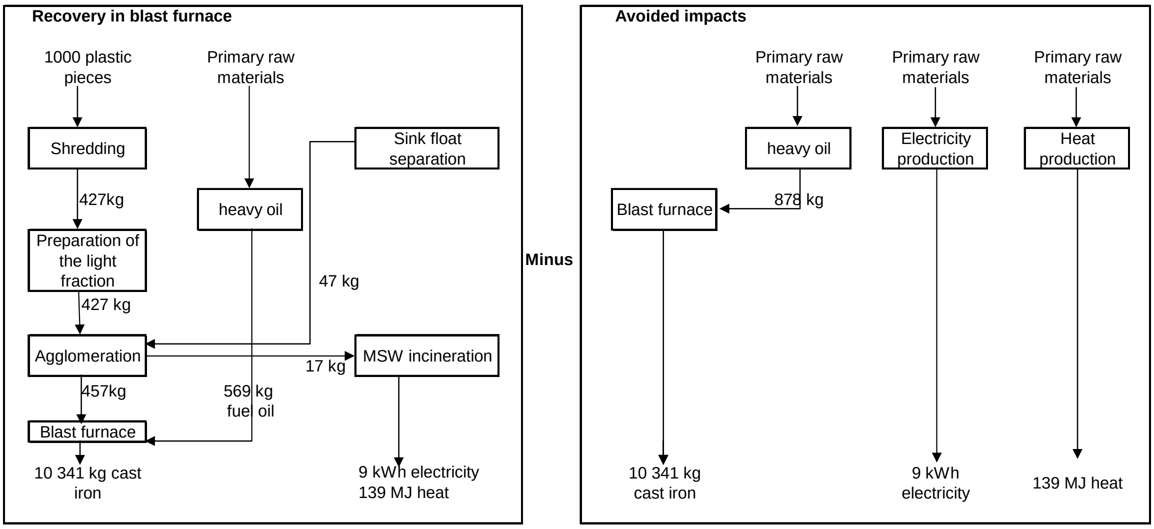


Municipal waste in landfills undergoes different microbiological processes which lead to the emissions of methane and to the spreading of leachate. Modern landfills have the technical possibility to capture part of the methane emissions, which are then cleaned and used as energy source, and to retain infiltration water and clean it.

- Time scale: Emissions take place during the decomposition of the waste which is considered to last 100 years, after which the remaining elements are considered inert.
- Allocation rule: All materials do not emit the same type of elements, depending on its composition. Thus only the emissions which can be observed considering the composition of the landfilled fraction studied are allocated to this fraction.
- Geographical representativeness: average German landfill
- System boundaries of the unit treatment of methane and leachate:

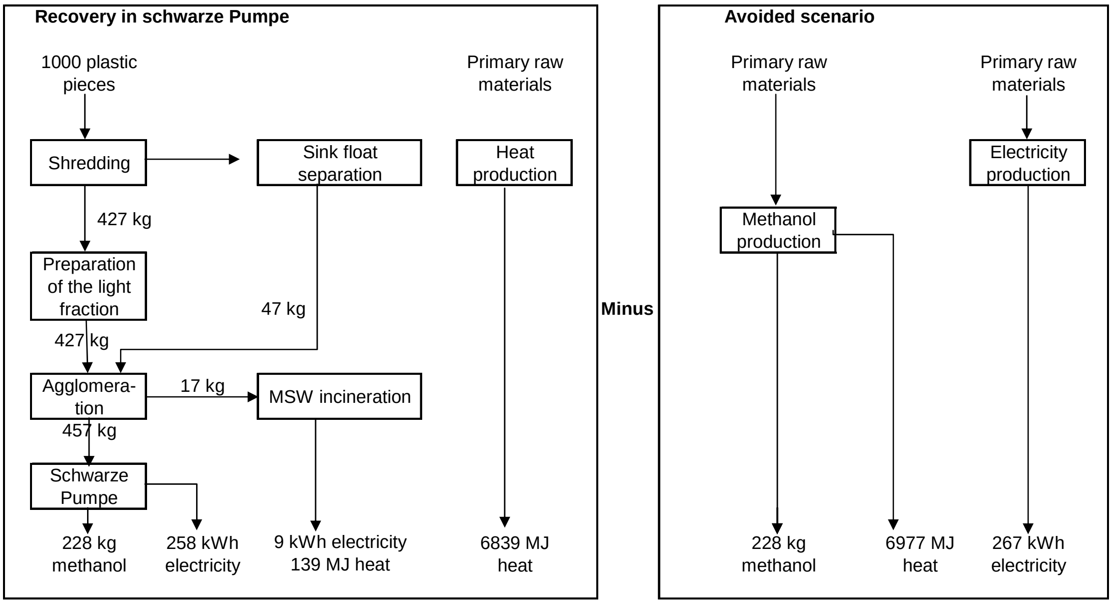


1.1.2 Blast furnace

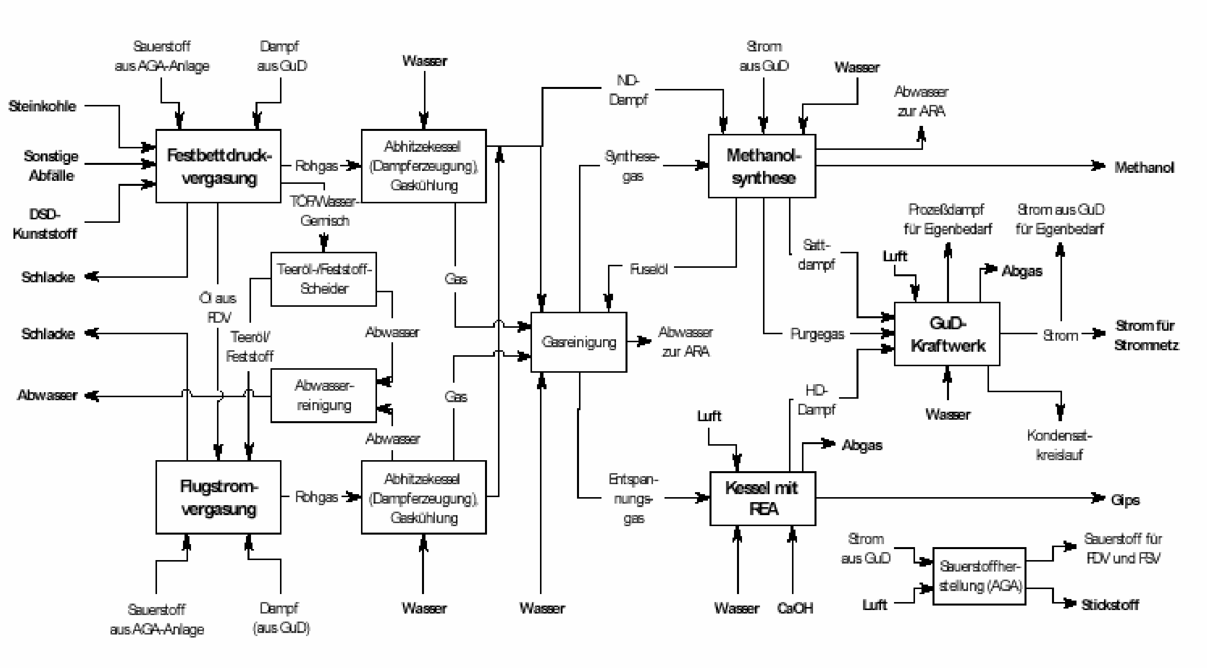


- Geographical representativeness: Germany
- Benefit: Bonus for the replacement of heavy oil (baseline scenario) or brown coal (sensitivity analysis) as reducing agent.
- Substituted:
- 1 kg of ABS/PUR/PP-TV/PVC from dashboard substitutes 0,70 kg of heavy oil
  - 1 kg of PUR substitutes 0,76 kg of heavy oil
  - 1 kg of PUR substitutes 0,76 kg of heavy oil
  - 1 kg of PA-GF substitutes 0,68 kg of heavy oil
  - 1 kg of PP/EPDM substitutes 1,08 kg of heavy oil
  - To calculate the substitution for brown coal, it was considered that 55 kg of heavy oil can be replaced by 68,7 kg of brown coal.

1.1.3 Syngas production

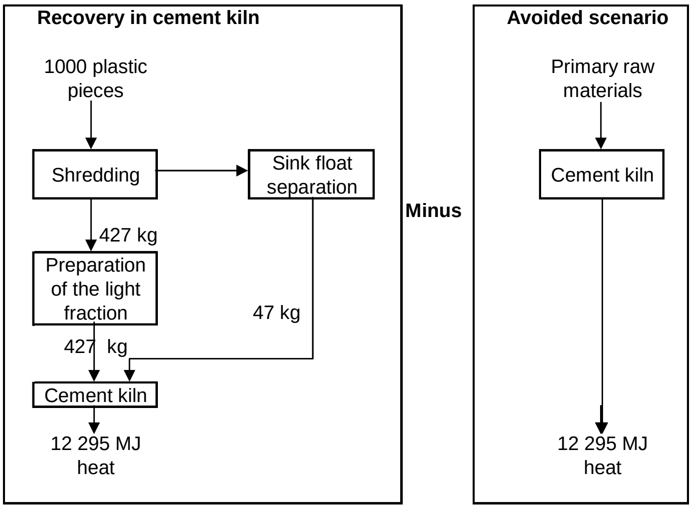


- Geographical representativeness: pilot plant
- Benefit: Bonus for the replacement of the production of methanol.
- Substituted resources: 73,4% natural gas, 22,1% waste oil, and 4,5% brown coal in the baseline; waste oil alone in a sensitivity analysis
- System boundaries (flow chart of the overall plant):

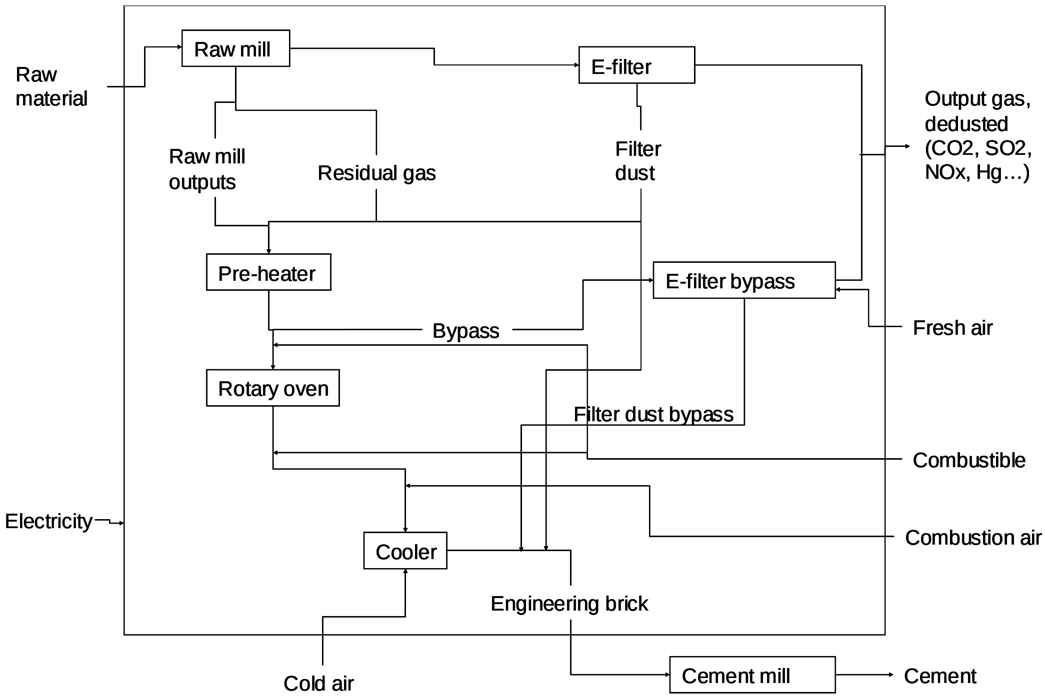


Shredder Light Fraction is introduced with other waste and coal in the syngas production system and is there gasified at a pressure of 25 bar and temperatures of 800–1,300°C. This syngas is finally transformed into methanol. This operates at temperatures between 1,350 and 1,800°C and at a pressure of 25 bar.

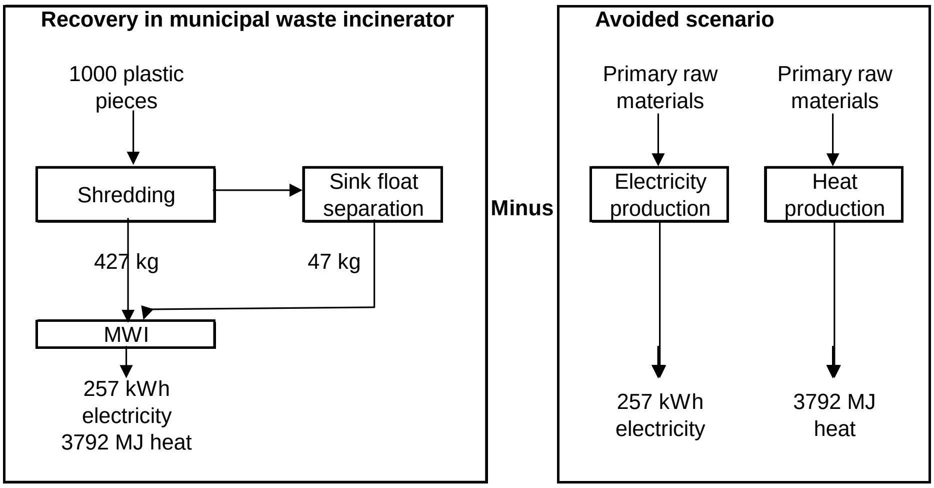
1.1.4 Cement kiln



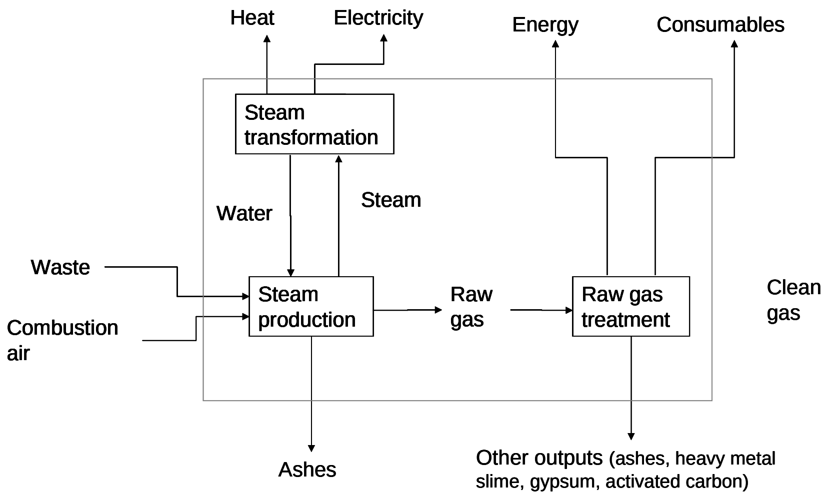
- Geographical representativeness: Germany
- Benefit: Bonus for the replacement of hard coal (baseline scenario) or brown coal (sensitivity analysis) as burning agent.
- System boundaries:



1.1.5 Municipal waste incinerator

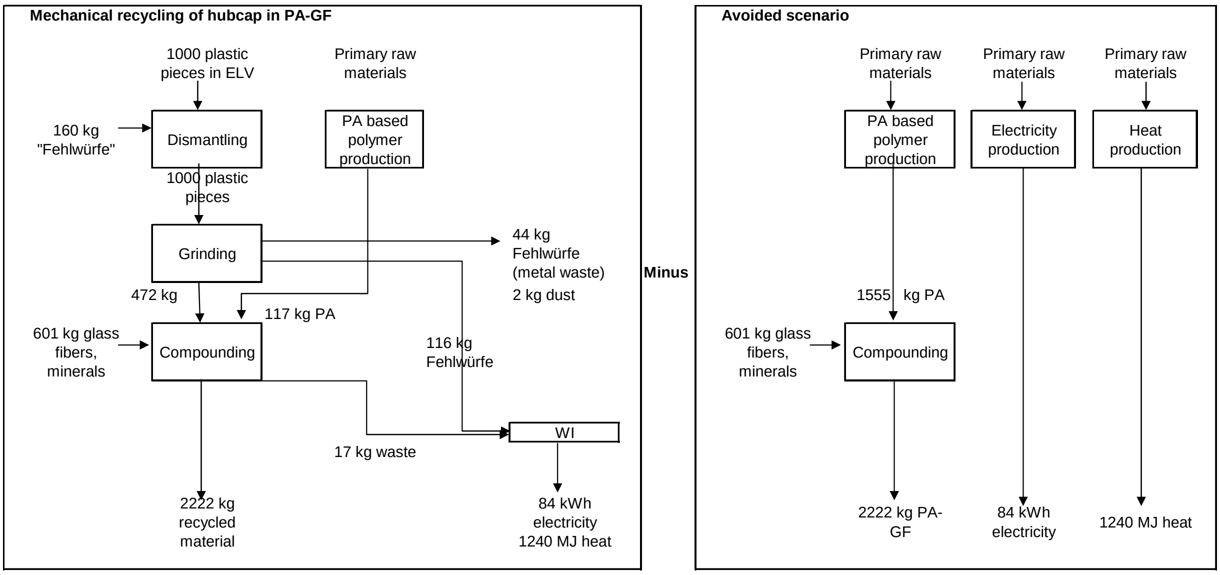


- Geographical representativeness: modern German waste incinerator
- Benefit: Bonus for the replacement of the generation of electricity and heat (baseline scenario); electricity alone; or heat alone. The percentage of the calorific value that is recovered is 39% (7,7% electricity and 31,3% steam) when a mix of electricity and steam is recovered; 14% when only electricity is recovered; and 70% when only steam is recovered. Losses are also considered (loss of energy with emitting gases (15%), energy loss due to ashes etc. (1%), loss of energy due to radiation etc. (3%)).
- Energy mix substituted (Germany 1997):
  - electricity: Nuclear 34,74%, Brown coal (lignite) 27,82%, Hard coal 25,19%, Hydroelectricity 3,86%, Natural gas 6,41%, Other gases 0,58%, Fuel oil 0,56%, Other 0,83%
  - steam: Hard coal 34,52% , Natural gas 47,98%, Brown coal (lignite) 11,35%, Fuel oil 6,15%
- System boundaries of the waste incinerator:



Residual water is not taken into account in this system because the water used to clean the gas is transformed into steam thanks to the temperature of the fumes.

1.1.6 Mechanical recycling



B- Detailed data per kg of resin for all treatment options and categories of impacts for the Fraunhofer study

Data for bumper in PP/EPDM

		Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **blast furnace (substitution=heavy oil)**			
		1000 pieces			1 kg
Flow	Units	Total (P+E+T)	Total avoided	Total	Total
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	5,35E+06	5,51E+06	-1,59E+05	-3,23E+01
Air acidification	g SO_2 eq.	1,41E+04	1,57E+04	-1,56E+03	-3,16E-01
Photochemical oxidation	g ethylene eq.	3,97E+03	5,72E+03	-1,74E+03	-3,54E-01
Eutrophication	g PO4 eq.	1,26E+03	9,65E+02	2,92E+02	5,93E-02
Water pollution	critical volume in m3	9,24E+01	1,09E+01	8,14E+01	1,65E-02
Energy consumption	MJ	4,58E+05	6,76E+05	-2,18E+05	-4,43E+01
Municipal waste	kg	4,25E-01	2,59E+00	-2,16E+00	-4,38E-04
Hazardous waste	kg	5,55E-01	7,59E-05	5,55E-01	1,13E-04

		Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**			
		1000 pieces			1 kg
Flow	Units	Total (P+E+T)	Total avoided	Total	Total
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,04E+07	4,05E+06	6,39E+06	1,30E+03
Air acidification	g SO_2 eq.	4,68E+03	-5,67E+03	1,03E+04	2,10E+00
Photochemical oxidation	g ethylene eq.	1,25E+02	-1,33E+03	1,46E+03	2,96E-01
Eutrophication	g PO4 eq.	7,74E+02	1,65E+02	6,09E+02	1,23E-01
Water pollution	critical volume in m3	8,68E+01	3,74E+02	-2,88E+02	-5,83E-02
Energy consumption	MJ	1,77E+04	2,07E+05	-1,90E+05	-3,85E+01
Municipal waste	kg	3,93E-01	-5,34E+01	5,38E+01	1,09E-02
Hazardous waste	kg	5,55E-01	2,47E-01	3,08E-01	6,24E-05

		Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Cement kiln (substitution=hard coal)**			
		1000 pieces			1 kg
Flow	Units	Total (P+E+T)	Total avoided	Total	Total
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,61E+07	2,35E+07	-7,33E+06	-1,49E+03
Air acidification	g SO_2 eq.	6,67E+04	6,76E+04	-8,79E+02	-1,78E-01
Photochemical oxidation	g ethylene eq.	1,98E+03	2,68E+03	-7,05E+02	-1,43E-01
Eutrophication	g PO4 eq.	1,98E+03	1,82E+03	1,68E+02	3,40E-02
Water pollution	critical volume in m3	2,34E+01	3,76E-01	2,30E+01	4,67E-03
Energy consumption	MJ	7,71E+03	2,23E+05	-2,15E+05	-4,36E+01
Municipal waste	kg	1,10E-01	1,16E+00	-1,05E+00	-2,13E-04
Hazardous waste	kg	1,62E-04	2,53E-06	1,60E-04	3,24E-08

		Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - MS**WI (electricity+steam)**			
		1000 pieces			1 kg
Flow	Units	Total (P+E+T)	Total avoided	Total	Total
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,59E+07	9,39E+06	6,49E+06	1,32E+03
Air acidification	g SO_2 eq.	7,58E+02	1,23E+04	-1,15E+04	-2,33E+00
Photochemical oxidation	g ethylene eq.	1,53E+02	1,18E+03	-1,03E+03	-2,09E-01
Eutrophication	g PO4 eq.	1,49E+02	9,36E+02	-7,87E+02	-1,60E-01
Water pollution	critical volume in m3	6,64E+00	3,00E+02	-2,94E+02	-5,96E-02
Energy consumption	MJ	7,54E+03	1,30E+05	-1,23E+05	-2,49E+01
Municipal waste	kg	2,53E-02	7,13E+01	-7,13E+01	-1,45E-02
Hazardous waste	kg	1,54E+01	2,09E-03	1,54E+01	3,12E-03

		Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=1**			
		1000 pieces			1 kg
Flow	Units	Total (P+E+T)	Total avoided	Total	Total
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	5,04E+06	9,93E+06	-4,89E+06	-9,92E+02
Air acidification	g SO_2 eq.	1,14E+04	9,59E+04	-8,45E+04	-1,71E+01
Photochemical oxidation	g ethylene eq.	7,98E+02	4,35E+03	-3,55E+03	-7,20E-01
Eutrophication	g PO4 eq.	1,75E+03	5,59E+03	-3,84E+03	-7,79E-01
Water pollution	critical volume in m3	2,15E+02	3,02E+02	-8,73E+01	-1,77E-02
Energy consumption	MJ	5,30E+04	3,33E+05	-2,80E+05	-5,68E+01
Municipal waste	kg	1,40E+01	1,12E+02	-9,76E+01	-1,98E-02
Hazardous waste	kg	6,92E+00	4,82E+01	-4,13E+01	-8,38E-03

		Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **blast furnace (substitution=hard coal)**			
		1000 pieces			1 kg
Flow	Units	Total (P+E+T)	Total avoided	Total	Total
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	7,72E+06	9,16E+06	-1,45E+06	-2,93E+02
Air acidification	g SO_2 eq.	7,04E+03	4,73E+03	2,31E+03	4,69E-01
Photochemical oxidation	g ethylene eq.	1,66E+03	2,14E+03	-4,85E+02	-9,83E-02
Eutrophication	g PO4 eq.	8,03E+02	2,63E+02	5,39E+02	1,09E-01
Water pollution	critical volume in m3	1,03E+02	2,76E+01	7,55E+01	1,53E-02
Energy consumption	MJ	3,89E+05	5,70E+05	-1,81E+05	-3,67E+01
Municipal waste	kg	2,37E+00	5,59E+00	-3,22E+00	-6,53E-04
Hazardous waste	kg	5,55E-01	1,92E-04	5,55E-01	1,12E-04

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from waste oil)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,04E+07	1,12E+07	-7,88E+05	-1,60E+02
Air acidification	g SO_2 eq.	4,68E+03	2,15E+04	-1,69E+04	-3,42E+00
Photochemical oxidation	g ethylene eq.	1,25E+02	8,68E+02	-7,43E+02	-1,51E-01
Eutrophication	g PO4 eq.	7,74E+02	1,90E+03	-1,13E+03	-2,29E-01
Water pollution	critical volume in m3	8,69E+01	4,65E+02	-3,78E+02	-7,68E-02
Energy consumption	MJ	1,77E+04	2,59E+05	-2,41E+05	-4,89E+01
Municipal waste	kg	3,93E-01	1,44E+02	-1,44E+02	-2,92E-02
Hazardous waste	kg	5,55E-01	1,11E+00	-5,52E-01	-1,12E-04

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Cement kiln (substitution=brown coal)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,61E+07	2,44E+07	-8,23E+06	-1,67E+03
Air acidification	g SO_2 eq.	6,67E+04	7,13E+04	-4,57E+03	-9,26E-01
Photochemical oxidation	g ethylene eq.	1,98E+03	1,98E+03	-2,00E+00	-4,06E-04
Eutrophication	g PO4 eq.	1,98E+03	2,12E+03	-1,41E+02	-2,85E-02
Water pollution	critical volume in m3	2,34E+01	5,31E+01	-2,97E+01	-6,02E-03
Energy consumption	MJ	7,71E+03	2,46E+05	-2,38E+05	-4,83E+01
Municipal waste	kg	1,10E-01	1,58E+02	-1,58E+02	-3,21E-02
Hazardous waste	kg	1,62E-04	3,65E-04	-2,03E-04	-4,12E-08

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - MS**WI - sensitivity analysis (steam)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,59E+07	1,44E+07	1,48E+06	3,01E+02
Air acidification	g SO_2 eq.	7,58E+02	2,11E+04	-2,04E+04	-4,13E+00
Photochemical oxidation	g ethylene eq.	1,53E+02	2,30E+03	-2,15E+03	-4,35E-01
Eutrophication	g PO4 eq.	1,49E+02	1,58E+03	-1,43E+03	-2,91E-01
Water pollution	critical volume in m3	6,64E+00	4,95E+01	-4,29E+01	-8,69E-03
Energy consumption	MJ	7,54E+03	1,80E+05	-1,73E+05	-3,50E+01
Municipal waste	kg	2,50E-02	1,56E+02	-1,56E+02	-3,17E-02
Hazardous waste	kg	1,54E+01	3,36E-04	1,54E+01	3,12E-03

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - MS**WI (electricity)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,59E+07	5,37E+06	1,05E+07	2,13E+03
Air acidification	g SO_2 eq.	7,58E+02	5,10E+03	-4,34E+03	-8,81E-01
Photochemical oxidation	g ethylene eq.	1,53E+02	2,82E+02	-1,29E+02	-2,61E-02
Eutrophication	g PO4 eq.	1,49E+02	4,14E+02	-2,66E+02	-5,39E-02
Water pollution	critical volume in m3	6,63E+00	5,06E+02	-4,99E+02	-1,01E-01
Energy consumption	MJ	7,54E+03	9,05E+04	-8,30E+04	-1,68E+01
Municipal waste	kg	2,50E-02	2,33E+00	-2,31E+00	-4,68E-04
Hazardous waste	kg	1,54E+01	3,51E-03	1,54E+01	3,12E-03

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Gasification (SVZ) plant (after dismantling&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,02E+07	3,25E+06	7,00E+06	1,42E+03
Air acidification	g SO_2 eq.	1,16E+04	-1,78E+03	1,34E+04	2,72E+00
Photochemical oxidation	g ethylene eq.	7,20E+02	-6,12E+02	1,33E+03	2,70E-01
Eutrophication	g PO4 eq.	1,88E+03	1,84E+02	1,70E+03	3,44E-01
Water pollution	critical volume in m3	1,44E+02	2,69E+02	-1,25E+02	-2,53E-02
Energy consumption	MJ	4,15E+04	1,27E+05	-8,56E+04	-1,74E+01
Municipal waste	kg	3,47E+01	-2,41E+01	5,88E+01	1,19E-02
Hazardous waste	kg	1,52E+01	1,32E-01	1,51E+01	3,06E-03

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Landfill**	
		1000 pieces	**1 kg**
		Landfill	**Landfill**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,79E+06	3,64E+02
Air acidification	g SO_2 eq.	6,12E+02	1,24E-01
Photochemical oxidation	g ethylene eq.	5,51E+02	1,12E-01
Eutrophication	g PO4 eq.	1,03E+02	2,08E-02
Water pollution	critical volume in m3	3,00E+00	6,09E-04
Energy consumption	MJ	1,17E+03	2,38E-01
Municipal waste	kg	4,93E+03	1,00E+00
Hazardous waste	kg	2,09E-05	4,23E-09

Data for seat cushion in PUR

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **blast furnace (substitution=heavy oil)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	2,05E+06	1,88E+06	1,70E+05	7,08E+01
Air acidification	g SO_2 eq.	5,54E+03	5,37E+03	1,79E+02	7,44E-02
Photochemical oxidation	g ethylene eq.	1,40E+03	1,96E+03	-5,54E+02	-2,31E-01
Eutrophication	g PO4 eq.	5,40E+02	3,29E+02	2,11E+02	8,77E-02
Water pollution	critical volume in m3	4,49E+01	3,33E+00	4,16E+01	1,73E-02
Energy consumption	MJ	1,60E+05	2,32E+05	-7,13E+04	-2,97E+01
Municipal waste	kg	2,07E-01	7,86E-01	-5,80E-01	-2,42E-04
Hazardous waste	kg	1,68E-01	2,31E-05	1,68E-01	6,99E-05

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	4,20E+06	1,40E+06	2,80E+06	1,17E+03
Air acidification	g SO_2 eq.	2,04E+03	-1,40E+03	3,44E+03	1,43E+00
Photochemical oxidation	g ethylene eq.	5,99E+01	-3,70E+02	4,30E+02	1,79E-01
Eutrophication	g PO4 eq.	3,28E+02	6,59E+01	2,62E+02	1,09E-01
Water pollution	critical volume in m3	4,31E+01	1,30E+02	-8,64E+01	-3,60E-02
Energy consumption	MJ	8,67E+03	6,35E+04	-5,49E+04	-2,29E+01
Municipal waste	kg	1,91E-01	-1,52E+01	1,54E+01	6,42E-03
Hazardous waste	kg	1,68E-01	7,10E-02	9,68E-02	4,03E-05

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Cement kiln (substitution=hard coal)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	5,75E+06	7,14E+06	-1,39E+06	-5,78E+02
Air acidification	g SO_2 eq.	2,05E+04	2,05E+04	-7,24E+01	-3,02E-02
Photochemical oxidation	g ethylene eq.	6,25E+02	8,15E+02	-1,90E+02	-7,91E-02
Eutrophication	g PO4 eq.	6,50E+02	5,52E+02	9,81E+01	4,09E-02
Water pollution	critical volume in m3	1,14E+01	1,14E-01	1,13E+01	4,70E-03
Energy consumption	MJ	3,75E+03	6,77E+04	-6,40E+04	-2,67E+01
Municipal waste	kg	5,35E-02	3,52E-01	-2,99E-01	-1,25E-04
Hazardous waste	kg	7,89E-05	7,68E-07	7,81E-05	3,26E-08

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **MSWI (electricity+steam)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	5,59E+06	2,84E+06	2,75E+06	1,15E+03
Air acidification	g SO_2 eq.	2,62E+03	3,71E+03	-1,09E+03	-4,54E-01
Photochemical oxidation	g ethylene eq.	5,13E+01	3,58E+02	-3,06E+02	-1,28E-01
Eutrophication	g PO4 eq.	4,84E+02	2,83E+02	2,01E+02	8,39E-02
Water pollution	critical volume in m3	2,57E+00	9,10E+01	-8,84E+01	-3,68E-02
Energy consumption	MJ	4,57E+03	3,94E+04	-3,49E+04	-1,45E+01
Municipal waste	kg	1,02E-02	2,15E+01	-2,15E+01	-8,97E-03
Hazardous waste	kg	4,65E+00	6,32E-04	4,65E+00	1,94E-03

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Recycling Substitution factor = 1**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	4,68E+06	1,34E+07	-8,73E+06	-3,64E+03
Air acidification	g SO_2 eq.	1,36E+04	7,31E+04	-5,95E+04	-2,48E+01
Photochemical oxidation	g ethylene eq.	9,28E+02	3,78E+03	-2,85E+03	-1,19E+00
Eutrophication	g PO4 eq.	2,02E+03	1,11E+04	-9,12E+03	-3,80E+00
Water pollution	critical volume in m3	3,13E+02	1,29E+03	-9,74E+02	-4,06E-01
Energy consumption	MJ	7,05E+04	2,99E+05	-2,28E+05	-9,50E+01
Municipal waste	kg	9,55E+01	7,05E+02	-6,10E+02	-2,54E-01
Hazardous waste	kg	1,08E+01	8,24E+01	-7,17E+01	-2,99E-02

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Recycling Substitution factor = 0.65**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	5,68E+07	4,73E+07	9,56E+06	3,98E+03
Air acidification	g SO_2 eq.	1,46E+05	1,38E+05	7,51E+03	3,13E+00
Photochemical oxidation	g ethylene eq.	1,24E+05	1,01E+05	2,35E+04	9,77E+00
Eutrophication	g PO4 eq.	2,47E+04	2,29E+04	1,81E+03	7,55E-01
Water pollution	critical volume in m3	4,25E+02	6,66E+02	-2,41E+02	-1,00E-01
Energy consumption	MJ	6,15E+05	5,85E+05	3,04E+04	1,27E+01
Municipal waste	kg	1,65E+02	3,51E+02	-1,86E+02	-7,74E-02
Hazardous waste	kg	2,46E+01	4,26E+01	-1,80E+01	-7,50E-03

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Landfill**	
		1000 pieces	**1 kg**
		Landfill	**Landfill**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	6,45E+05	2,69E+02
Air acidification	g SO_2 eq.	1,73E+03	7,22E-01
Photochemical oxidation	g ethylene eq.	1,98E+02	8,24E-02
Eutrophication	g PO4 eq.	9,15E+02	3,81E-01
Water pollution	critical volume in m3	1,46E+00	6,07E-04
Energy consumption	MJ	5,92E+02	2,47E-01
Municipal waste	kg	2,40E+03	1,00E+00
Hazardous waste	kg	1,01E-05	4,22E-09

Data for hubcap in PA

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - **MSWI (electricity+steam)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	9,67E+05	5,36E+05	4,31E+05	9,09E+02
Air acidification	g SO_2 eq.	4,90E+02	7,00E+02	-2,11E+02	-4,45E-01
Photochemical oxidation	g ethylene eq.	9,80E+00	6,77E+01	-5,79E+01	-1,22E-01
Eutrophication	g PO4 eq.	9,04E+01	5,34E+01	3,70E+01	7,81E-02
Water pollution	critical volume in m3	4,93E-01	1,70E+01	-1,65E+01	-3,49E-02
Energy consumption	MJ	1,39E+03	7,44E+03	-6,04E+03	-1,27E+01
Municipal waste	kg	2,50E+01	4,07E+00	2,09E+01	4,41E-02
Hazardous waste	kg	7,93E+00	1,19E-04	7,93E+00	1,67E-02

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - **Recycling substitution factor=1**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,19E+07	1,48E+07	-2,89E+06	-6,09E+03
Air acidification	g SO_2 eq.	7,86E+04	1,00E+05	-2,16E+04	-4,56E+01
Photochemical oxidation	g ethylene eq.	4,03E+03	5,16E+03	-1,13E+03	-2,39E+00
Eutrophication	g PO4 eq.	9,13E+03	1,16E+04	-2,51E+03	-5,30E+00
Water pollution	critical volume in m3	5,92E+02	7,54E+02	-1,63E+02	-3,43E-01
Energy consumption	MJ	1,86E+05	2,35E+05	-4,99E+04	-1,05E+02
Municipal waste	kg	5,04E+02	6,19E+02	-1,15E+02	-2,43E-01
Hazardous waste	kg	2,69E+01	3,33E+01	-6,44E+00	-1,36E-02

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg- **Gasification (SVZ) plant (after shredding&substitution=methanol from waste oil)**			
		1000 pieces			**1 kg**
		Total (P+E+T)	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	7,13E+05	6,06E+05	1,07E+05	2,25E+02
Air acidification	g SO_2 eq.	3,55E+02	1,16E+03	-8,06E+02	-1,70E+00
Photochemical oxidation	g ethylene eq.	1,18E+01	4,69E+01	-3,51E+01	-7,40E-02
Eutrophication	g PO4 eq.	5,63E+01	1,03E+02	-4,64E+01	-9,79E-02
Water pollution	critical volume in m3	8,37E+00	2,50E+01	-1,66E+01	-3,50E-02
Energy consumption	MJ	1,73E+03	1,39E+04	-1,22E+04	-2,58E+01
Municipal waste	kg	9,34E-01	7,81E+00	-6,88E+00	-1,45E-02
Hazardous waste	kg	2,85E-01	5,99E-02	2,25E-01	4,75E-04

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg- **Landfill**	
		1000 pieces	**1kg**
		Landfill	**Landfill**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,12E+05	2,37E+02
Air acidification	g SO_2 eq.	7,13E+02	1,50E+00
Photochemical oxidation	g ethylene eq.	3,45E+01	7,27E-02
Eutrophication	g PO4 eq.	4,03E+02	8,49E-01
Water pollution	critical volume in m3	2,88E-01	6,07E-04
Energy consumption	MJ	1,18E+02	2,50E-01
Municipal waste	kg	4,74E+02	1,00E+00
Hazardous waste	kg	2,00E-06	4,22E-09

Data for dashboard (12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV)

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **blast furnace (substitution=heavy oil)**			
		1000 pieces			**1 kg**
Flow	Units	**Total (P+E+T)**	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	4,08E+06	3,65E+06	4,31E+05	8,53E+01
Air acidification	g SO_2 eq.	1,11E+04	1,04E+04	7,17E+02	1,42E-01
Photochemical oxidation	g ethylene eq.	2,75E+03	3,80E+03	-1,05E+03	-2,08E-01
Eutrophication	g PO4 eq.	1,10E+03	6,40E+02	4,62E+02	9,15E-02
Water pollution	critical volume in m3	9,52E+01	6,90E+00	8,83E+01	1,75E-02
Energy consumption	MJ	3,13E+05	4,49E+05	-1,37E+05	-2,70E+01
Municipal waste	kg	1,36E+01	1,64E+00	1,19E+01	2,36E-03
Hazardous waste	kg	5,79E+00	4,79E-05	5,79E+00	1,15E-03

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**			
		1000 pieces			**1 kg**
Flow	Units	**Total (P+E+T)**	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	8,17E+06	2,88E+06	5,29E+06	1,05E+03
Air acidification	g SO_2 eq.	4,12E+03	-2,58E+03	6,70E+03	1,33E+00
Photochemical oxidation	g ethylene eq.	1,26E+02	-7,12E+02	8,38E+02	1,66E-01
Eutrophication	g PO4 eq.	6,53E+02	1,40E+02	5,13E+02	1,01E-01
Water pollution	critical volume in m3	8,94E+01	2,66E+02	-1,76E+02	-3,49E-02
Energy consumption	MJ	1,83E+04	1,26E+05	-1,08E+05	-2,14E+01
Municipal waste	kg	1,35E+01	-2,95E+01	4,30E+01	8,51E-03
Hazardous waste	kg	5,79E+00	1,39E-01	5,65E+00	1,12E-03

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **Cement kiln (substitution=hard coal)**			
		1000 pieces			**1 kg**
Flow	Units	**Total (P+E+T)**	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,11E+07	1,49E+07	-3,71E+06	-7,34E+02
Air acidification	g SO_2 eq.	4,30E+04	4,27E+04	2,65E+02	5,24E-02
Photochemical oxidation	g ethylene eq.	1,31E+03	1,70E+03	-3,81E+02	-7,54E-02
Eutrophication	g PO4 eq.	1,37E+03	1,15E+03	2,19E+02	4,32E-02
Water pollution	critical volume in m3	2,40E+01	2,38E-01	2,38E+01	4,70E-03
Energy consumption	MJ	7,90E+03	1,41E+05	-1,33E+05	-2,63E+01
Municipal waste	kg	1,13E-01	7,33E-01	-6,20E-01	-1,23E-04
Hazardous waste	kg	1,66E-04	1,60E-06	1,65E-04	3,26E-08

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **MSWI (electricity+steam)**			
		1000 pieces			**1 kg**
Flow	Units	**Total (P+E+T)**	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,08E+07	5,89E+06	4,91E+06	9,71E+02
Air acidification	g SO_2 eq.	6,28E+03	7,70E+03	-1,43E+03	-2,82E-01
Photochemical oxidation	g ethylene eq.	1,08E+02	7,44E+02	-6,35E+02	-1,26E-01
Eutrophication	g PO4 eq.	1,01E+03	5,88E+02	4,25E+02	8,42E-02
Water pollution	critical volume in m3	2,07E+01	1,88E+02	-1,68E+02	-3,32E-02
Energy consumption	MJ	1,01E+04	8,18E+04	-7,18E+04	-1,42E+01
Municipal waste	kg	3,65E+02	4,48E+01	3,20E+02	6,33E-02
Hazardous waste	kg	1,61E+02	1,31E-03	1,61E+02	3,18E-02

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **Recycling of the PP-beam with substitution factor = 1.**			
		1000 pieces			**1 kg**
Flow	Units	**Total (P+E+T)**	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	9,69E+06	6,68E+06	3,01E+06	5,95E+02
Air acidification	g SO_2 eq.	1,28E+04	3,66E+04	-2,39E+04	-4,72E+00
Photochemical oxidation	g ethylene eq.	7,57E+02	1,76E+03	-1,00E+03	-1,98E-01
Eutrophication	g PO4 eq.	1,97E+03	2,12E+03	-1,53E+02	-3,03E-02
Water pollution	critical volume in m3	1,86E+02	2,40E+02	-5,46E+01	-1,08E-02
Energy consumption	MJ	5,25E+04	1,52E+05	-9,92E+04	-1,96E+01
Municipal waste	kg	6,56E+01	1,42E+03	-1,36E+03	-2,68E-01
Hazardous waste	kg	7,10E+01	1,42E+01	5,68E+01	1,12E-02

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg **Recycling of PP and PVC with substitution factor = 1 - Recycling of the particles plate in a similar particle panel.**			
		1000 pieces			**1 kg**
Flow	Units	**Total (P+E+T)**	**Total avoided**	**Total**	**Total**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,06E+07	8,59E+06	2,00E+06	3,95E+02
Air acidification	g SO_2 eq.	2,31E+04	5,59E+04	-3,28E+04	-6,49E+00
Photochemical oxidation	g ethylene eq.	1,33E+03	2,49E+03	-1,16E+03	-2,30E-01
Eutrophication	g PO4 eq.	3,43E+03	3,50E+03	-6,91E+01	-1,37E-02
Water pollution	critical volume in m3	2,49E+02	3,04E+02	-5,52E+01	-1,09E-02
Energy consumption	MJ	7,76E+04	2,23E+05	-1,45E+05	-2,87E+01
Municipal waste	kg	7,78E+01	1,45E+03	-1,38E+03	-2,72E-01
Hazardous waste	kg	2,83E+01	1,98E+01	8,42E+00	1,67E-03

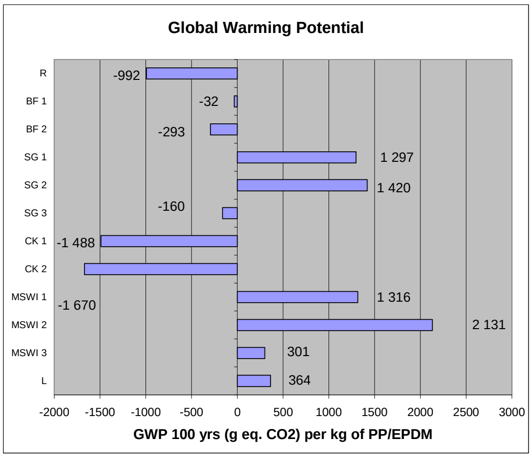
		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **Landfill**	
		1000 pieces	**1 kg**
Flow	Units	**Landfill**	**Landfill**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	1,25E+06	2,48E+02
Air acidification	g SO_2 eq.	1,92E+03	3,80E-01
Photochemical oxidation	g ethylene eq.	3,84E+02	7,59E-02
Eutrophication	g PO4 eq.	8,87E+02	1,75E-01
Water pollution	critical volume in m3	3,07E+00	6,07E-04
Energy consumption	MJ	1,26E+03	2,49E-01
Municipal waste	kg	5,06E+03	1,00E+00
Hazardous waste	kg	2,13E-05	4,22E-09

C- Detailed analysis per kg of resin for all treatment options and categories of impacts
Results obtained for PP/EPDM and discussion

PP/EPDM - **CLIMATE CHANGE**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***
- In general, the recovery of PP/EPDM does not systematically come out better than landfill in terms of greenhouse gases emissions: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of greenhouse gases emissions: mechanical recycling, blast furnace, cement kiln. For example, per kg of PP/EPDM, mechanical recycling enables to avoid the emission of approximately 1 kg eq. CO_2 when landfill generates emissions of 365 g eq. CO_2; this benefice of mechanical recycling corresponds to the difference between two contributions of big extent: the emissions generated by the process of recycling itself minus the emissions avoided due to the production of virgin plastic material.
- No recovery option comes out systematically more harmful than landfill in terms of greenhouse gases emissions.
- One recovery option comes out either equivalent or more harmful than landfill in terms of greenhouse gases emissions, depending on the assumptions considered: waste incineration. In the case where the recovered energy enables to avoid the production of heat alone (without electricity production), the assessment of the greenhouse gases emissions of the incineration of 1 kg of PP/EPDM is at 20% equivalent to the emissions generated by landfill disposal (around 365 g eq. CO_2). However, when the recovered energy enables to save either electricity alone or both heat and electricity together, the result of the incineration is much more harmful with emissions 4 to 6 times above the emissions generated by landfill disposal.[1]

[1] For a better understanding of the phenomenon at stake, it is fitting to recall here that greenhouse gases emissions due to incineration correspond to an evaluation/balance: generated emissions (energy consumption

- Certain recovery options come out either more beneficial or more harmful than landfill in terms of greenhouse gases emissions, depending on the assumptions considered: syngas production. The positioning of the syngas production option relative to landfill depends on the type of the spared resource for methanol production. In the case (SG1 et SG2) where the spared resource is mostly composed of natural gas, the syngas production option emits 3.5 to 4 times more greenhouse gases than landfill disposal; however, in the case (SG3) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of greenhouse gases emissions contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of greenhouse gases emissions (per kg of PP/EPDM, mechanical recycling permits to avoid the emission of approximately 1 kg eq CO_2).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of greenhouse gases emissions: it depends on the recovery option studied.
- In general, the mechanical recycling of PP/EPDM does not systematically come out better than all the other recovery options in terms of greenhouse gases emissions: it depends on the recovery option studied.
- Mechanical recycling comes out systematically more beneficial than some other recovery options in terms of greenhouse gases emissions: blast furnace, syngas production, waste incineration.
- Mechanical recycling comes out systematically less beneficial than another recovery option in terms of greenhouse gases emissions: cement kiln. This result is however specific to the site studied in the Fraunhofer study because it was considered that the plastics used as sources of energy in the cement kiln substituted either brown coal (CK2) or hard coal (CK1) which are resources whose combustion emits important quantities of CO_2. The conclusions would be different (and possibly to the advantage of mechanical recycling) in the case where the energy recovered by the plastic fractions substituted resources generating less CO_2 emissions than hard coal or brown coal.

- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of greenhouse gases emissions: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of greenhouse gases emissions (–30 to –300 g eq CO_2 per kg of PP/EPDM, depending on the type of spared fuel). On the contrary, the assessment of the syngas production option can be

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on site, production steps of the reactants, direct CO_2 emissions due to the combustion of PP/EPDM, that are directly related to the amount of carbon in the plastics fraction.) minus the avoided emissions (fossil resources spared thanks to the energy produced from end-of-life plastics, PP/EPDM in this case). This evaluation/balance partially depends on the nature of the incinerated materials and on the substituted fossil resources (the more the substituted resources are sources of greenhouse gases, the more beneficial the evaluation/balance). Thus, when the energy recovered by combustion of the plastics is used to produce electricity, the avoided resources are partially constituted of hydroelectricity and electricity coming from a nuclear source which do not emit greenhouse gases ; in this case, the incineration of plastics enables to avoid less greenhouse gases emissions than in the case of heat production alone.

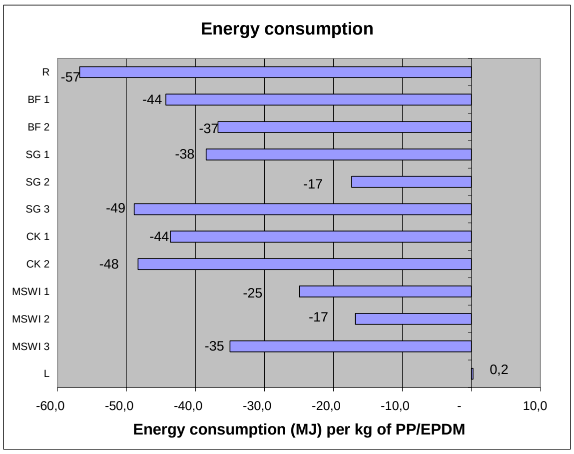
either favourable (SG3) or harmful (SG1 and SG2) depending on the nature of the energetic resource saved to produce methanol (see explications in the § Recovery vs. landfill).

- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of greenhouse gases emissions: it depends on the recovery option studied. The cement kiln option appears to be beneficial (negative value, avoided impacts) in terms of greenhouse gases emissions (approximately –1.5 kg eq CO_2 per kg of PP/EPDM). On the contrary the waste incineration option appears to be harmful (positive value, generated impacts) in terms of greenhouse gases emissions (0.3 to 2.1 kg eq CO2 emitted per kg of PP/EPDM depending on the type of energy recovery: heat alone, electricity alone, or heat and electricity together).

PP/EPDM - **ENERGY CONSUMPTION**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



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SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- The disposal of PP/EPDM consumes 0.2 MJ per kg of PP/EPDM.
- In general, the recovery options systematically come out beneficial (negative value, avoided impacts) in terms of energy consumption (-17 to -57 MJ per kg of PP/EPDM, depending on the recovery option). The recovery options appear to be favourable in terms of energy consumption because they receive a credit for the substitution of energetic resources.
- Thus, the recovery of PP/EPDM systematically comes out better than landfill in terms of energy consumption.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of energy consumption (per kg of PP/EPDM, mechanical recycling permits to avoid the consumption of approximately 57 MJ).
- In general, the other recovery options systematically come out beneficial in terms of energy consumption (-17 to -48 MJ per kg of PP/EPDM, depending on the recovery option).
- In general, the mechanical recycling of PP/EPDM systematically comes out more beneficial than all the other recovery options in terms of energy consumption.

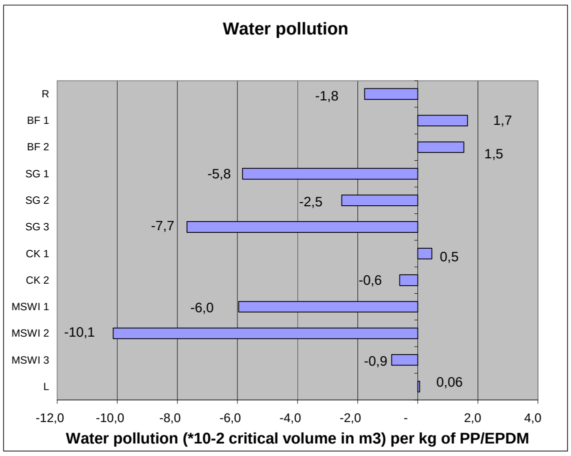
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out beneficial in terms of energy consumption.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of energy consumption.

PP/EPDM - **WATER POLLUTION**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PP/EPDM does not systematically come out better than landfill in terms of water pollution: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of water pollution: waste incineration, syngas production, mechanical recycling. For example, per kg of PP/EPDM, mechanical recycling enables to avoid the pollution of 18 dm^3 of water when landfill generates the pollution of 0.6 dm^3 of water.
- Certain recovery options come out systematically more harmful than landfill in terms of water pollution: blast furnace. The blast furnace option pollutes water 25 to 28 times more than landfill disposal, depending on the spared resource.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of water pollution, depending on the assumptions considered: cement kiln. The positioning of the cement kiln option relative to landfill depends on the type of spared energy resource for heat production. In the case (CK1) where the spared resource is hard coal, the cement kiln option pollutes water 8 times more than landfill disposal; however, in the case (CK2) where the spared resource is composed of brown coal, the cement kiln option has a favourable impact (negative value, avoided impact) in terms of water pollution contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of water pollution (per kg of PP/EPDM, mechanical recycling permits to avoid the pollution of approximately 18 dm^3 of water).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of water pollution: it depends on the recovery option studied.

- In general, the mechanical recycling of PP/EPDM does not systematically come out better than all the other recovery options in terms of water pollution: it depends on the recovery option studied.
- Mechanical recycling comes out systematically more beneficial than some other recovery options in terms of water pollution: cement kiln, blast furnace.
- Mechanical recycling comes out systematically less beneficial than another recovery option in terms of water pollution: syngas production.
- Mechanical recycling comes out either more beneficial or less beneficial than another recovery option in terms of water pollution, depending on the assumptions considered: waste incineration. The positioning of the waste incineration option relative to mechanical recycling depends on the type of spared resource for energy production. In the case where the recovered energy enables to avoid the production of heat alone (without electricity production), the assessment of the volume of polluted water avoided by 1 kg of PP/EPDM is half the volume avoiding pollution by mechanical recycling. However, when the recovered energy enables to save either electricity alone or both heat and electricity together, the assessment of incineration is much more beneficial by avoiding the pollution of a volume of water 3 to 5 times greater than the volume of polluted water avoided by mechanical recycling.

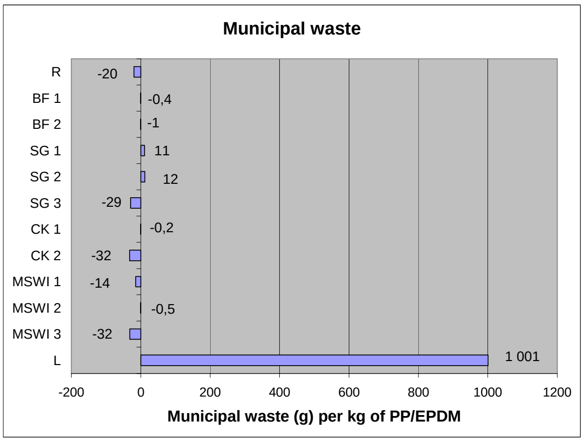
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of water pollution (approximately 15 to 17 dm^3 of water polluted per kg of PP/EPDM, depending on the spared resource). On the contrary, the assessment of the syngas production option is favourable (-25 to -77 dm^3 of water polluted per kg of PP/EPDM, depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The waste incineration option appears to be beneficial in terms of water pollution (–10 to –100 dm^3 of water polluted per kg of PP/EPDM, depending on the type of spared energetic resources). On the contrary, the assessment of the cement kiln option can be either favourable (CK2) or harmful (CK1) depending on the nature of the fuel saved.

PP/EPDM - **MUNICIPAL WASTE**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14%
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- Landfill of PP/EPDM generates 1 kg of municipal waste per kg of PP/EPDM.
- In general, the other recovery options do not systematically avoid or generate municipal waste: it depends on the recovery option studied.
- In general, landfill of PP/EPDM systematically comes out worse than all the other recovery options in terms of municipal waste. Landfill comes out approximately 100 times worse than the other recovery options generating municipal waste.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM avoids the production of 20 g of municipal waste per kg of PP/EPDM.
- In general, the other recovery options do not systematically avoid or generate municipal waste: it depends on the recovery option studied.
- In general, the mechanical recycling of PP/EPDM does not systematically come out better than all the other recovery options in terms of municipal waste: it depends on the recovery option studied.
- Mechanical recycling comes out systematically more beneficial than another recovery option in terms of municipal waste: blast furnace.
- Mechanical recycling comes out either more beneficial or less beneficial than some other recovery options in terms of municipal waste, depending on the assumptions considered: waste incineration, cement kiln, syngas production. The positioning of the waste incineration option relative to mechanical recycling depends on the type of spared resource for energy production. In the case where the recovered energy enables to avoid the production of heat alone (without electricity production), the assessment of the volume of municipal waste avoided by 1 kg of PP/EPDM is 50% higher than the volume

of municipal waste avoided by mechanical recycling. However, when the recovered energy enables to save either electricity alone or both heat and electricity together, the assessment of incineration is less beneficial by avoiding the production of a volume of municipal waste 25% to 97% lower than the volume of municipal waste avoided by mechanical recycling.

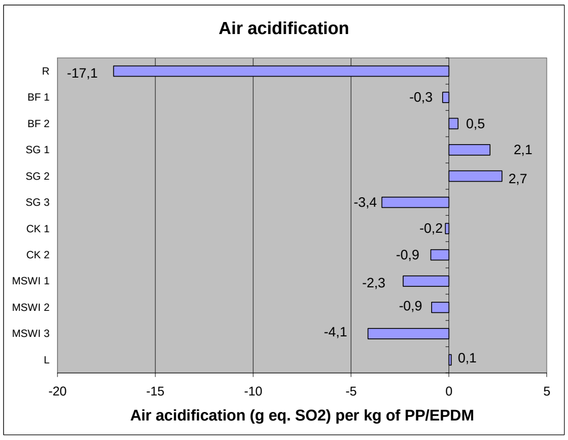
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of municipal waste: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of municipal waste (0 to 1 g of municipal waste avoided per kg of PP/EPDM, depending on the nature of the spared reducing agent). On the contrary, the assessment of the syngas production option can either avoid (SG3) or hargenerate (SG1 and SG2) municipal waste depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of municipal waste.

PP/EPDM - **AIR ACIDIFICATION**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PP/EPDM does not systematically come out better than landfill in terms of air acidification: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of air acidification: mechanical recycling, waste incineration. For example, per kg of PP/EPDM, mechanical recycling enables to avoid the emission of around 17 g eq. SO_2 when landfill generates emissions of 0.1 g eq SO_2; this benefice of mechanical recycling corresponds to the difference between two contributions of big extent: the emissions generated by the process of recycling itself minus the emissions avoided due to the production of virgin plastic material.
- No recovery option comes out systematically more harmful than landfill in terms of air acidification.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of air acidification, depending on the assumptions considered: syngas production. In the case (SG1 and SG2) where the spared resource for methanol production is in majority composed of natural gas, the syngas production option has an impact 21 to 27 times greater than landfill disposal in terms of air acidification; however, in the case (SG3) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of air acidification contrary to landfill disposal.
- Certain recovery options come out equivalent to landfill in terms of air acidification: blast furnace. In terms of air acidification, the assessment of the blast furnace option is the difference of two important values (recovery scenario minus avoided scenario). Thus a 10% change in one of the scenarios, has a great influence on the total result in terms of air acidification. Blast furnace can be therefore considered as equivalent to landfill in terms of air acidification.

- Certain recovery options come out either equivalent or more beneficial than landfill in terms of air acidification: cement kiln. In the case (CK2) where the spared resource is brown coal, the cement kiln option has a favourable impact (negative value, avoided impact) in terms of air acidification contrary to landfill disposal; however, in the case (CK1) where the spared resource is composed of hard coal, the cement kiln option can be considered as equivalent to landfill in terms of air acidification because the result is the difference of two important values (recovery scenario minus avoided scenario).

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of air acidification (per kg of PP/EPDM, mechanical recycling permits to avoid the emission of approximately 17 g eq. SO_2).
- In general, the other recovery options come out either beneficial or harmful in terms of air acidification (approximately -4 to +3 g eq. SO_2 per kg of PP/EPDM, depending on the recovery option).
- In general, the mechanical recycling of PP/EPDM systematically comes out more beneficial than all the other recovery options in terms of air acidification.

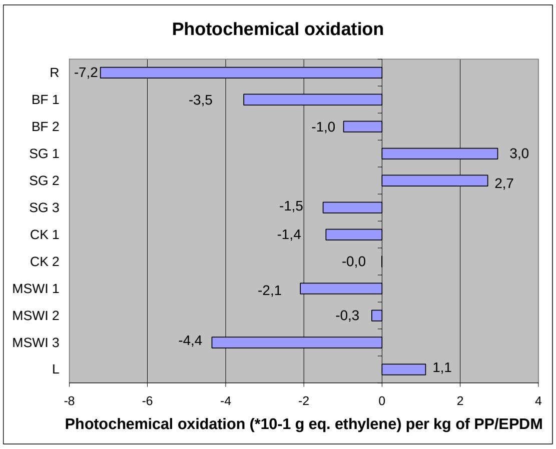
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of air acidification: it depends on the recovery option studied. The blast furnace option appears to be either favourable (BF1) or harmful (BF2) in terms of air acidification depending on the nature of the spared reducing agent. The assessment of the syngas production option can be either favourable (SG3) or harmful (SG1 and SG2) in terms of air acidification depending on the nature of energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of air acidification.

PP/EPDM - **PHOTOCHEMICAL OXIDATION**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PP/EPDM does not systematically come out better than landfill in terms of photochemical oxidation: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of photochemical oxidation: mechanical recycling, waste incineration, cement kiln, and blast furnace. For example, per kg of PP/EPDM, mechanical recycling enables to avoid the emission of approximately 0.7 g eq. ethylene when landfill generates emissions of 0.1 g eq ethylene.
- No recovery option comes out systematically more harmful than landfill in terms of photochemical oxidation.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of photochemical oxidation, depending on the assumptions considered: syngas production. For example, in the case (SG1 and SG2) where the spared resource to produce methanol is mostly composed of natural gas, the syngas production option has a harmful impact 3 times greater than landfill disposal in terms of photochemical oxidation; however, in the case (SG3) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of photochemical oxidation contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of photochemical oxidation (per kg of PP/EPDM, mechanical recycling permits to avoid the emission of approximately 0.7 g eq. ethylene).

- In general, the other recovery options come out either beneficial or harmful in terms of photochemical oxidation (approximately -0.4 to +0.3 g eq. ethylene per kg of PP/EPDM, depending on the recovery option).
- In general, the mechanical recycling of PP/EPDM systematically comes out more beneficial than all the other recovery options in terms of photochemical oxidation.

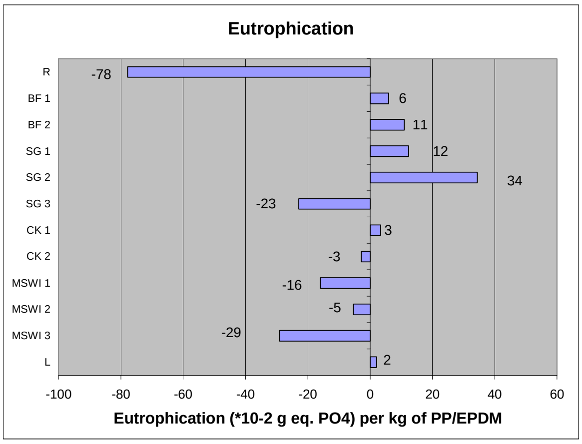
■ ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of photochemical oxidation: it depends on the recovery option studied. The blast furnace option appears to be favourable in terms of photochemical oxidation (0.1 to 0.3 g eq. ethylene avoided per kg of PP/EPDM, depending on the nature of the spared reducing agent). However the assessment of the syngas production option can be either favourable (SG3) or harmful (SG1 and SG2) in terms of photochemical oxidation depending on the nature of energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of photochemical oxidation.

PP/EPDM - **EUTROPHICATION**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PP/EPDM does not systematically come out better than landfill in terms of eutrophication: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of eutrophication: mechanical recycling, waste incineration. For example, per kg of PP/EPDM, mechanical recycling enables to avoid the emission of approximately 0.8 g eq. PO_4 when landfill generates emissions of 20 mg eq PO_4.
- Certain recovery options come out systematically more harmful than landfill in terms of eutrophication: blast furnace.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of eutrophication, depending on the assumptions considered: syngas production. For example, in the case (SG1 and SG2) where the spared resource to produce methanol is mostly composed of natural gas, the syngas production option has an impact 6 to 17 times greater than landfill disposal in terms of eutrophication; however, in the case (SG3) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of eutrophication contrary to landfill disposal.
- Certain recovery options come out either equivalent or more harmful than landfill in terms of eutrophication, depending on the assumptions considered: cement kiln. In the case (CK2) where the spared resource is brown coal, the cement kiln option has a favourable impact in terms of eutrophication contrary to landfill disposal; however, in the case (CK1) where the spared resource is composed of hard coal, the cement kiln option emits approximately 0.03 g eq. PO_4 when landfill emits approximately 0.02 g eq. PO_4. These values are not significant at a European level since the major source of eutrophication is agriculture (fertilizers).

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of eutrophication (per kg of PP/EPDM, mechanical recycling permits to avoid the emission of approximately 0.8 g eq. PO_4).
- In general, the other recovery options come out either beneficial or harmful in terms of eutrophication (approximately -0.3 to +0.3 g eq. PO_4 per kg of PP/EPDM, depending on the recovery option).
- In general, the mechanical recycling of PP/EPDM systematically comes out more beneficial than all the other recovery options in terms of eutrophication.

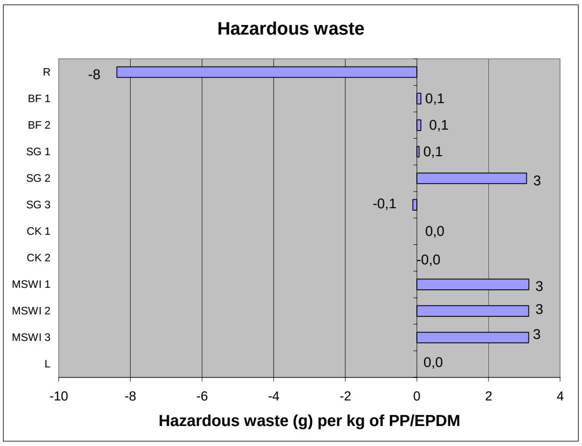
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of eutrophication: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of eutrophication (0.06 to 0.11 g eq. PO_4 generated per kg of PP/EPDM, depending on the nature of the spared reducing agent). However the assessment of the syngas production option can be either favourable (SG3) or harmful (SG1 and SG2) in terms of eutrophication depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of eutrophication. The waste incineration option appears to be favourable in terms of eutrophication (approximately 0.05 to 0.3 g eq. PO_4 avoided per kg of PP/EPDM, depending on the nature of the saved energy sources). However the assessment of the cement kiln option can be either favourable (CK2) or harmful (CK1) in terms of eutrophication depending on the nature of the spared energetic resource.

PP/EPDM - **HAZARDOUS WASTE**

Impacts due to different ELV's PP/EPDM treatment

Source: bumper in PP/EPDM, Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF 1 = blast furnace (substitution = heavy oil)
BF 2 = blast furnace (substitution = hard coal)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after dismantling & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 3 = syngas production (after shredding & substitution = methanol from waste oil)
CK 1 = cement kiln (substitution = hard coal)
CK 2 = cement kiln (substitution = brown coal)
MSWI 1 = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
MSWI 2 = waste incineration (electricity with a 14% efficiency)
MSWI 3 = waste incineration (steam with a 70% efficiency)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PP/EPDM does not systematically come out better than landfill in terms of hazardous waste: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of hazardous waste: mechanical recycling. Per kg of PP/EPDM, mechanical recycling enables to avoid the production of approximately 8 g of hazardous waste when landfill does not have a significant impact.
- Certain recovery options generate systematically more hazardous waste than landfill: waste incineration.
- Certain recovery options come out equivalent to landfill in terms of hazardous waste: cement kiln, blast furnace.
- Certain recovery options generate more hazardous waste than landfill or come out equivalent to landfill, depending on the assumptions considered: syngas production. For example, in the case (SG2) where the spared resource to produce methanol is mostly composed of natural gas and the recovery takes place after dismantling, the syngas production option appears to generate (positive value, generated impacts) hazardous waste; however, in the case (SG3 and SG1) when the recovery takes place after shredding, the syngas production option is not significant in terms of hazardous waste and thus equivalent to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PP/EPDM is favourable to the environment in terms of hazardous waste (per kg of PP/EPDM, mechanical recycling permits to avoid the production of approximately 8 g of hazardous waste).
- In general, the other recovery options avoid or generate hazardous waste (approximately -0.1 to +3 g of hazardous waste per kg of PP/EPDM, depending on the recovery option).

- In general, the mechanical recycling of PP/EPDM systematically comes out more beneficial than all the other recovery options in terms of hazardous waste.

▪ ***Comparison of the other recovery options (excluding mechanical recycling)***

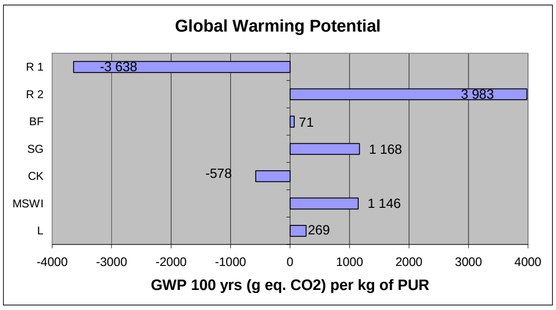
- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically avoid hazardous waste: it depends on the recovery option studied. The blast furnace option does not have a significant impact in terms of hazardous waste. However the assessment of the syngas production option shows that hazardous waste is either generated (SG2) or does not have a significant impact (SG1 and SG3) depending on the nature of energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically generate hazardous waste. The waste incineration option appears to generate hazardous waste (approximately 3 g of hazardous waste generated per kg of PP/EPDM, depending on the nature of the saved energy sources). However the assessment of the cement kiln option does not have a significant impact.

Results obtained for PUR and discussion

PUR - **CLIMATE CHANGE**

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of greenhouse gases emissions: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of greenhouse gases emissions: cement kiln, blast furnace.
- Certain recovery options come out systematically more harmful than landfill in terms of greenhouse gases emissions: waste incineration, syngas production.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of greenhouse gases emissions, depending on the assumptions considered: mechanical recycling. The positioning of the mechanical recycling option relative to landfill depends on the substitution rate. In the case (R2) where the substitution rate is 0.65, the mechanical recycling option emits approximately 15 times more greenhouse gases than landfill disposal; however, in the case (R1) where the substitution rate is 1, the mechanical recycling option has a favourable impact (negative value, avoided impact) in terms of greenhouse gases emissions contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling PUR is either favourable or harmful to the environment in terms of greenhouse gases emissions depending on the substitution rate.
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of greenhouse gases emissions: it depends on the recovery option studied.
- In general, the mechanical recycling of PUR comes out better than all the other recovery options in terms of greenhouse gases emissions when the substitution rate is 1.
- Mechanical recycling comes out systematically more harmful than all the other recovery options in terms of greenhouse gases emissions when the substitution rate is 0.65.

- The assessment of mechanical recycling in terms of greenhouse gases emissions is very sensitive to the substitution rate.

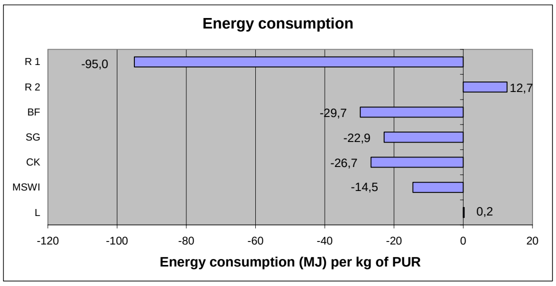
■ ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of greenhouse gases emissions.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of greenhouse gases emissions: it depends on the recovery option studied. The cement kiln option appears to be beneficial (negative value, avoided impacts) in terms of greenhouse gases emissions (approximately –0.6 kg eq CO_2 per kg of PUR). On the contrary the waste incineration option appears to be harmful (positive value, generated impacts) in terms of greenhouse gases emissions (1.1 kg eq CO2 emitted per kg of PUR).

PUR - ENERGY CONSUMPTION

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of energy consumption: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of energy consumption: cement kiln, blast furnace, waste incineration, syngas production.
- Certain recovery options come out either more beneficial in terms of energy consumption or consume more energy than landfill, depending on the assumptions considered: mechanical recycling. The positioning of the mechanical recycling option relative to landfill depends on the substitution rate. In the case (R2) where the substitution rate is 0.65, the mechanical recycling option consumes approximately 63 times more energy than landfill disposal; however, in the case (R1) where the substitution rate is 1, the mechanical recycling option has a favourable impact (negative value, avoided impact) in terms of energy consumption contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PUR either consumes energy or is beneficial to the environment in terms of energy consumption depending on the substitution rate.
- In general, the other recovery options systematically come out beneficial in terms of energy consumption (-29.7 to -14.5 MJ per kg of PUR, depending on the recovery option).
- In general, the mechanical recycling of PUR comes out better than all the other recovery options in terms of energy consumption when the substitution rate is 1.
- Mechanical recycling comes out systematically worse than all the other recovery options in terms of energy consumption when the substitution rate is 0.65.
- The assessment of mechanical recycling in terms of energy consumption is very sensitive to the substitution rate.

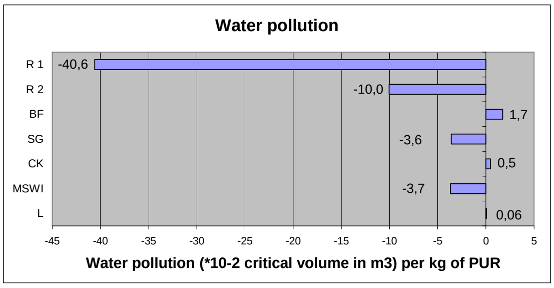
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out beneficial in terms of energy consumption.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of energy consumption.

PUR - **WATER POLLUTION**

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of water pollution: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of water pollution: waste incineration, syngas production, mechanical recycling. For example, per kg of PUR, mechanical recycling enables to avoid the pollution of approximately 0.1 to 0.4 m^3 of water depending on the substitution rate when landfill generates the pollution of 0.6 dm^3 of water.
- Certain recovery options come out systematically more harmful than landfill in terms of water pollution: blast furnace, cement kiln. The blast furnace option pollutes water 28 times more than landfill disposal. The cement kiln option pollutes water 8 times more than landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling PUR is favourable to the environment in terms of water pollution (approximately 0.1 to 0.4 m^3 of polluted water avoided depending on the substitution rate).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of water pollution: it depends on the recovery option studied.
- In general, the mechanical recycling of PUR comes out better than all the other recovery options in terms of water pollution.

- ***Comparison of the other recovery options (excluding mechanical recycling)***

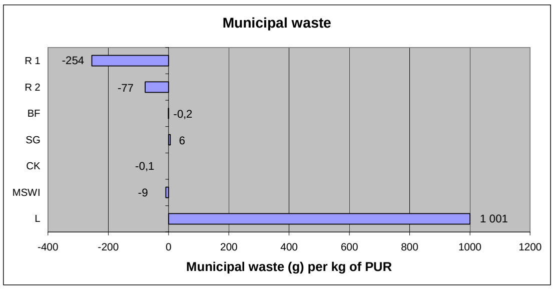
- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of water pollution (approximately 17 dm^3 of water polluted per kg of PUR). On the contrary, the assessment of the syngas production option is favourable (-36 dm^3 of water polluted per kg of PUR).

- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The waste incineration option appears to be beneficial in terms of water pollution (–37 dm^3 of water polluted per kg of PUR). On the contrary, the assessment of the cement kiln option is harmful (positive value, generated impacts).

PUR - **MUNICIPAL WASTE**

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- Landfill of PUR generates 1 kg of municipal waste per kg of PUR.
- In general, the other recovery options do not systematically avoid or generate municipal waste: it depends on the recovery option studied.
- In general, landfill of PUR systematically comes out worse than all the other recovery options in terms of municipal waste. Landfill comes out approximately 167 times worse than the other recovery options generating municipal waste.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PUR is favourable to the environment in terms of municipal waste (per kg of PP/EPDM, mechanical recycling permits to avoid the production of 77 to 254 g of waste depending on the substitution rate).
- In general, the other recovery options do not systematically avoid or generate municipal waste: it depends on the recovery option studied.
- In general, the mechanical recycling of PP/EPDM systematically comes out better than all the other recovery options in terms of municipal waste..

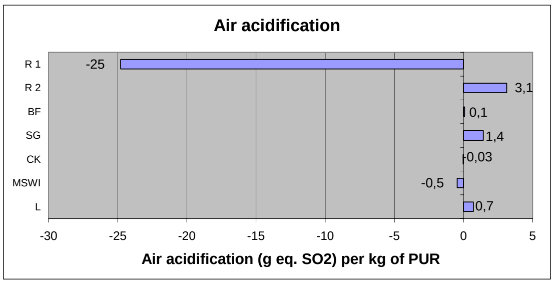
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of municipal waste: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of municipal waste (0.2 g of municipal waste avoided per kg of PUR). On the contrary, the syngas production option generates 6 g of municipal waste.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of municipal waste.

PUR - **AIR ACIDIFICATION**

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of air acidification: it depends on the recovery option studied.
- Certain recovery options come out equivalent to landfill in terms of air acidification: blast furnace, waste incineration, cement kiln. For example, in terms of air acidification, the assessment of the blast furnace option is the difference of two important values (recovery scenario minus avoided scenario). Thus a 10% change in one of the scenarios, has a great influence on the total result in terms of air acidification. Blast furnace can be therefore considered as equivalent to landfill in terms of air acidification.
- Certain recovery options come out systematically more harmful than landfill in terms of air acidification: syngas production.
- Certain recovery options come out either equivalent or more beneficial than landfill in terms of air acidification, depending on the assumptions considered: mechanical recycling. For example, in the case (R1) where the substitution rate is 1, the mechanical recycling option has a favourable impact (negative value, avoided impact) in terms of air acidification contrary to landfill disposal; however, in the case (R2) where the substitution rate is 0.65, the assessment of the mechanical recycling option is the difference of two important values (recovery scenario minus avoided scenario). Thus a 10% change in one of the scenarios, has a great influence on the total result in terms of air acidification. In the case (R2) where the substitution rate is 0.65, mechanical recycling can be therefore considered as equivalent to landfill in terms of air acidification.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling PUR is either favourable or harmful to the environment in terms of air acidification depending on the substitution rate.
- In general, the other recovery options come out either beneficial or harmful in terms of air acidification (approximately -0.5 to +1.4 g eq. SO_2 per kg of PUR, depending on the recovery option).
- In general, the mechanical recycling of PUR comes out better than all the other recovery options in terms of air acidification when the substitution rate is 1.

- Mechanical recycling comes out systematically more harmful than all the other recovery options in terms of air acidification when the substitution rate is 0.65.
- The assessment of mechanical recycling in terms of air acidification is very sensitive to the substitution rate.

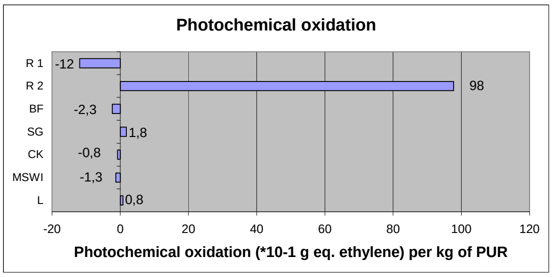
▪ ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of air acidification.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of air acidification.

PUR - **PHOTOCHEMICAL OXIDATION**

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of photochemical oxidation: it depends on the recovery option studied.
- Certain recovery options come out systematically less harmful than landfill in terms of photochemical oxidation: waste incineration, cement kiln, blast furnace.
- Certain recovery options come out systematically more harmful than landfill in terms of photochemical oxidation: syngas production.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of photochemical oxidation, depending on the assumptions considered: mechanical recycling. For example, in the case (R2) where the substitution rate is 0.65, the mechanical recycling option has a harmful impact approximately 122 times greater than landfill disposal in terms of photochemical oxidation; however, in the case (R1) where the substitution rate is 1, the mechanical recycling option has a favourable impact (negative value, avoided impact) in terms of photochemical oxidation contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling PUR is either favourable or harmful to the environment in terms of photochemical oxidation depending on the substitution rate.
- In general, the other recovery options come out either beneficial or harmful in terms of photochemical oxidation (approximately -0.23 to +0.18 g eq. ethylene per kg of PUR, depending on the recovery option).
- In general, the mechanical recycling of PUR comes out better than all the other recovery options in terms of photochemical oxidation when the substitution rate is 1.
- Mechanical recycling comes out systematically more harmful than all the other recovery options in terms of photochemical oxidation when the substitution rate is 0.65.
- The assessment of mechanical recycling in terms of photochemical oxidation is very sensitive to the substitution rate.

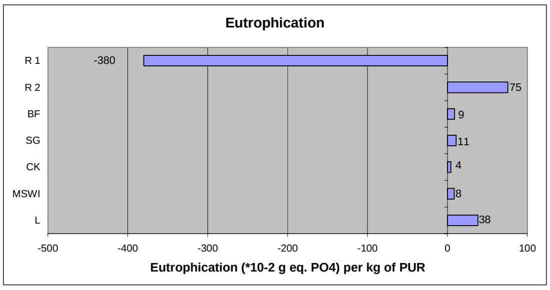
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of photochemical oxidation: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of municipal waste (-0.23 g eq. ethylene per kg of PUR). On the contrary, the syngas production option emits 0.18 g eq. ethylene.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of photochemical oxidation.

PUR	-	EUTROPHICATION

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of eutrophication: it depends on the recovery option studied.
- Certain recovery options come out systematically less harmful than landfill in terms of eutrophication: waste incineration, cement kiln, blast furnace and syngas production.
- No recovery option comes out systematically more harmful than landfill in terms of eutrophication.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of eutrophication, depending on the assumptions considered: mechanical recycling. For example, in the case (R2) where the substitution rate is 0.65, the mechanical recycling option has a harmful impact approximately 2 times greater than landfill disposal in terms of eutrophication; however, in the case (R1) where the substitution rate is 1, the mechanical recycling option has a favourable impact (negative value, avoided impact) in terms of eutrophication contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling PUR is either favourable or harmful to the environment in terms of eutrophication depending on the substitution rate.
- In general, the other recovery options come out systematically harmful in terms of eutrophication (approximately +0.04 to +0.75 g eq. PO_4 per kg of PUR, depending on the recovery option).
- In general, the mechanical recycling of PUR comes out better than all the other recovery options in terms of eutrophication when the substitution rate is 1.
- Mechanical recycling comes out systematically more harmful than all the other recovery options in terms of eutrophication when the substitution rate is 0.65.
- The assessment of mechanical recycling in terms of eutrophication is very sensitive to the substitution rate.

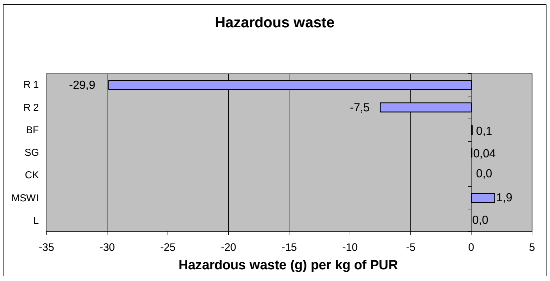
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of eutrophication.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out harmful in terms of eutrophication.

PUR - **HAZARDOUS WASTE**

Impacts due to different ELV's PUR treatment

Source: seat cushion in PUR, Fraunhofer (2002)



Legend:

R 1 = mechanical recycling (substitution rate = 1)
R 2 = mechanical recycling (substitution rate = 0,65)
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PUR does not systematically come out better than landfill in terms of hazardous waste: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of hazardous waste: mechanical recycling. For example, per kg of PUR, mechanical recycling enables to avoid the production of approximately 7.5 to 29.9 g of hazardous waste depending on the substitution rate when landfill does not have a significant impact.
- Certain recovery options generate systematically more hazardous waste than landfill: waste incineration.
- Certain recovery options come out equivalent to landfill in terms of hazardous waste: cement kiln, syngas production, and blast furnace.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PUR is favourable to the environment in terms of hazardous waste (per kg of PUR, mechanical recycling permits to avoid the production of approximately 7.5 to 29.9 g of hazardous waste).
- In general, the other recovery options generate hazardous waste or do not have a significant impact in terms of hazardous waste.
- In general, the mechanical recycling of PUR systematically comes out more beneficial than all the other recovery options in terms of hazardous waste.

- ***Comparison of the other recovery options (excluding mechanical recycling)***

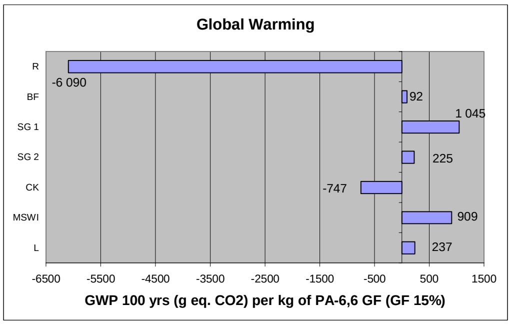
- Feedstock recycling (SG, BF): In general, feedstock recycling does not have a significant impact in terms of hazardous waste.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically generate hazardous waste. The waste incineration option appears to generate hazardous waste (approximately 2 g of hazardous waste generated per kg of PUR). However the assessment of the cement kiln option does not have a significant impact.

Results obtained for PA and discussion

PA-6,6 GF (GF 15%) - CLIMATE CHANGE

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PA-6.6 GF does not systematically come out better than landfill in terms of greenhouse gases emissions: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of greenhouse gases emissions: cement kiln, mechanical recycling, and blast furnace.
- Certain recovery options come out systematically more harmful than landfill in terms of greenhouse gases emissions: waste incineration.
- Certain recovery options come out either more harmful or equivalent than landfill in terms of greenhouse gases emissions, depending on the assumptions considered: syngas production. In the case (SG1) where the spared resource is mostly composed of natural gas, the syngas production option emits 4.4 times more greenhouse gases than landfill disposal; however, in the case (SG2) where the spared resource is composed of waste oil, the syngas production option is at 5% equivalent in terms of greenhouse gases emissions to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of greenhouse gases emissions (per kg of PA-6.6 GF, mechanical recycling permits to avoid the emission of approximately 6 kg eq CO_2).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of greenhouse gases emissions: it depends on the recovery option studied.
- In general, the mechanical recycling of PA-6.6 GF systematically comes out better than all the other recovery options in terms of greenhouse gases emissions.

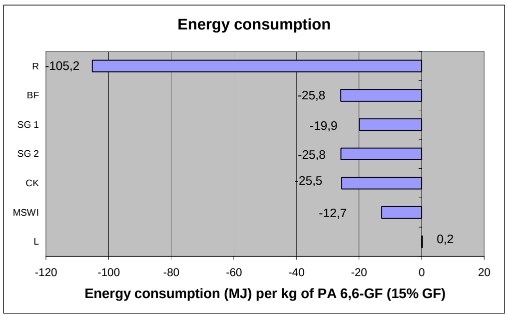
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of greenhouse gases emissions.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of greenhouse gases emissions: it depends on the recovery option studied. The cement kiln option appears to be beneficial (negative value, avoided impacts) in terms of greenhouse gases emissions (approximately –0.7 kg eq CO_2 per kg of PA-6.6 GF). On the contrary the waste incineration option appears to be harmful (positive value, generated impacts) in terms of greenhouse gases emissions (0.9 kg eq CO2 emitted per kg of PA-6.6 GF).

PA-6,6 GF (GF 15%) - **ENERGY CONSUMPTION**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- The disposal of PA-6.6 GF consumes 0.2 MJ per kg of PA-6.6 GF.
- In general, the recovery options systematically come out beneficial (negative value, avoided impacts) in terms of energy consumption (approximately -13 to -105 MJ per kg of PA-6.6 GF, depending on the recovery option). The recovery options appear to be favourable in terms of energy consumption because they receive a credit for the substitution of energetic resources.
- Thus, the recovery of PA-6.6 GF systematically comes out better than landfill in terms of energy consumption.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of energy consumption (per kg of PA-6.6 GF, mechanical recycling permits to avoid the consumption of approximately 105 MJ).
- In general, the other recovery options systematically come out beneficial in terms of energy consumption (approximately -13 to -26 MJ per kg of PA-6.6 GF, depending on the recovery option).
- In general, the mechanical recycling of PA-6.6 GF systematically comes out more beneficial than all the other recovery options in terms of energy consumption.

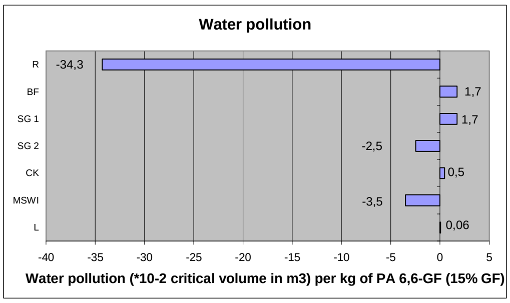
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out beneficial in terms of energy consumption.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of energy consumption.

PA-6,6 GF (GF 15%) - **WATER POLLUTION**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PA-6.6 GF does not systematically come out better than landfill in terms of water pollution: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of water pollution: waste incineration, mechanical recycling. For example, per kg of PA-6.6 GF, mechanical recycling enables to avoid the pollution of approximately 340 dm^3 of water when landfill generates the pollution of 0.6 dm^3 of water.
- Certain recovery options come out systematically more harmful than landfill in terms of water pollution: blast furnace, cement kiln. The blast furnace option pollutes water 28 times more than landfill disposal. The cement kiln option pollutes water 8 times more than landfill disposal.
- Certain recovery options come out either more harmful or more beneficial than landfill in terms of water pollution, depending on the assumptions considered: syngas production. In the case (SG1) where the spared resource is mostly composed of natural gas, the syngas production option pollutes water 28 times more than landfill disposal; however, in the case (SG2) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of water pollution contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of water pollution (per kg of PA-6.6 GF, mechanical recycling permits to avoid the pollution of 343 dm^3 of water).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of water pollution: it depends on the recovery option studied.
- In general, the mechanical recycling of PA-6.6 GF systematically comes out better than all the other recovery options in terms of water pollution.

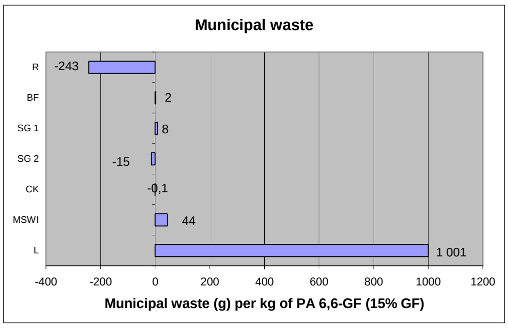
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of water pollution (approximately 17 dm^3 of water polluted per kg of PA-6.6 GF). On the contrary, the assessment of the syngas production option can be either favourable (SG2) or harmful (SG1) in terms of water pollution depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The waste incineration option appears to be beneficial in terms of water pollution (–35 dm^3 of water polluted per kg of PA-6.6 GF). On the contrary, the assessment of the cement kiln option is harmful (positive value, generated impacts) in terms of water pollution.

PA-6,6 GF (GF 15%) - **MUNICIPAL WASTE**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- Landfill of PA-6.6 GF generates 1 kg of municipal waste per kg of PA-6.6 GF.
- In general, the other recovery options do not systematically avoid or generate municipal waste: it depends on the recovery option studied.
- In general, landfill of PA-6.6 GF systematically comes out worse than all the other recovery options in terms of municipal waste. Landfill comes out approximately 23 to 500 times worse than the other recovery options generating municipal waste, depending on the recovery option studied.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of municipal waste (per kg of PA-6.6 GF, mechanical recycling permits to avoid the production of approximately 0.2 kg of waste).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of municipal waste: it depends on the recovery option studied.
- In general, the mechanical recycling of PA-6.6 GF systematically comes out better than all the other recovery options in terms of municipal waste.

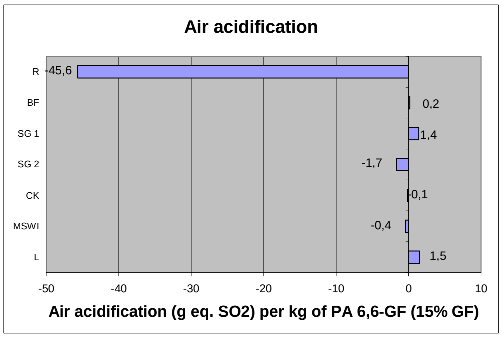
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of municipal waste: it depends on the recovery option studied. The blast furnace option appears to generate municipal waste (2 g of municipal waste generated per kg of PA-6.6 GF). On the contrary, the assessment of the syngas production option appears to either avoid (SG2) or generate (SG1) municipal waste depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of municipal waste: it depends on the recovery option studied. The waste incineration option appears to generate municipal waste (44 g of municipal waste generated per kg of PA-6.6 GF). On the contrary the cement kiln option appears to avoid the production of municipal waste (negative value, avoided impacts).

PA-6,6 GF (GF 15%) - **AIR ACIDIFICATION**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PA-6.6 GF does not systematically come out better than landfill in terms of air acidification: it depends on the recovery option studied.
- In general, the recovery options come out either beneficial or harmful in terms of air acidification, depending on the recovery option.
- Certain recovery options come out systematically more beneficial than landfill in terms of air acidification: waste incineration, mechanical recycling. For example, per kg of PA-6.6 GF, mechanical recycling enables to avoid the emissions of approximately 45.6 g eq. SO_2 when landfill generates 1.5 g eq. SO_2.
- Certain recovery options come out either equivalent or more beneficial than landfill in terms of air acidification, depending on the assumptions considered: syngas production. In the case (SG1) where the spared resource is mostly composed of natural gas, the syngas production option is at 6 % equivalent to landfill disposal; however, in the case (SG2) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of air acidification contrary to landfill disposal.
- Certain recovery options come out equivalent to landfill in terms of air acidification: blast furnace, cement kiln. For example, in terms of air acidification, the assessment of the blast furnace option is the difference of two important values (recovery scenario minus avoided scenario). Thus a 10% change in one of the scenarios, has a great influence on the total result in terms of air acidification. Blast furnace can be therefore considered as equivalent to landfill in terms of air acidification.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of air acidification (per kg of PA-6.6 GF, mechanical recycling permits to avoid the emission of approximately 45.6 g eq. SO_2).

- In general, the other recovery options come out either beneficial or harmful in terms of air acidification (approximately -1.7 to +1.4 g eq. SO_2 per kg of PA-6.6 GF, depending on the recovery option).
- In general, the mechanical recycling of PA-6.6 GF systematically comes out more beneficial than all the other recovery options in terms of air acidification.

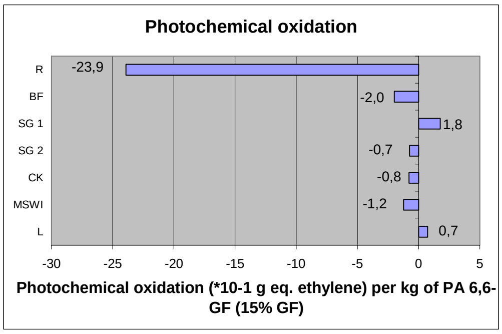
▪ ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of air acidification: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of air acidification (approximately 0.2 g eq. SO_2 emitted per kg of PA-6.6 GF). On the contrary, the assessment of the syngas production option can be either favourable (SG2) or harmful (SG1) in terms of air acidification depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of air acidification.

PA-6,6 GF (GF 15%) - **PHOTOCHEMICAL OXIDATION**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PA-6.6 GF does not systematically come out better than landfill in terms of photochemical oxidation: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of photochemical oxidation: waste incineration, cement kiln, blast furnace, and mechanical recycling.
- Certain recovery options come out either more beneficial or more harmful than landfill in terms of photochemical oxidation, depending on the assumptions considered: syngas production. In the case (SG1) where the spared resource is mostly composed of natural gas, the syngas production option has a harmful impact 2.5 times greater than landfill disposal; however, in the case (SG2) where the spared resource is composed of waste oil, the syngas production option has a favourable impact (negative value, avoided impact) in terms of air acidification contrary to landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of photochemical oxidation (per kg of PA-6.6 GF, mechanical recycling permits to avoid the emission of approximately 2.4 g eq. ethylene).
- In general, the other recovery options come out either beneficial or harmful in terms of photochemical oxidation (approximately -0.2 to +0.2 g eq. ethylene per kg of PA-6.6 GF, depending on the recovery option).
- In general, the mechanical recycling of PA-6.6 GF systematically comes out more beneficial than all the other recovery options in terms of photochemical oxidation.

- ***Comparison of the other recovery options (excluding mechanical recycling)***

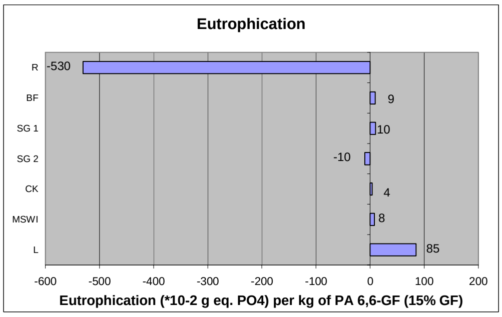
- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of photochemical oxidation: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of photochemical oxidation (-0.2 g eq. ethylene per kg of PA-6.6 GF). On the contrary, the assessment of the syngas production option can be either favourable (SG2) or harmful (SG1) in terms of photochemical oxidation depending on the nature of the energetic resource saved to produce methanol.

- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of photochemical oxidation.

PA-6,6 GF (GF 15%) - **EUTROPHICATION**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- The disposal of PA-6.6 GF is harmful to the environment in terms of eutrophication (per kg of PA-6.6 GF, landfill generates the emission of approximately 0.85 g eq. PO_4).
- In general, the other recovery options come out either beneficial or harmful in terms of eutrophication (approximately -5.3 to +0.1 g eq. PO_4 per kg of PA-6.6 GF, depending on the recovery option).
- In general, the recovery of PA-6.6 GF systematically comes out better than landfill in terms of eutrophication: it depends on the recovery option studied.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of eutrophication (per kg of PA-6.6 GF, mechanical recycling permits to avoid the emission of approximately 5.3 g eq. PO_4).
- In general, the other recovery options come out either beneficial or harmful in terms of eutrophication (approximately -0.1 to +0.1 g eq. PO_4 per kg of PA-6.6 GF, depending on the recovery option).
- In general, the mechanical recycling of PA-6.6 GF systematically comes out more beneficial than all the other recovery options in terms of eutrophication.

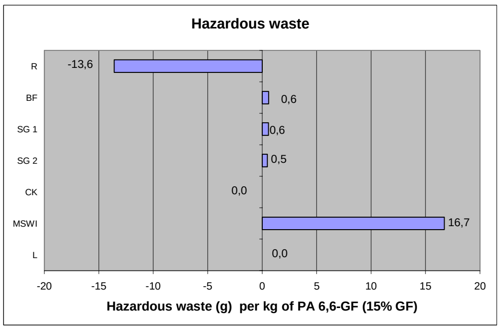
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of eutrophication: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of eutrophication (90 mg eq. ethylene per kg of PA-6.6 GF). On the contrary, the assessment of the syngas production option can be either favourable (SG2) or harmful (SG1) in terms of eutrophication depending on the nature of the energetic resource saved to produce methanol.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out harmful in terms of eutrophication.

PA-6,6 GF (GF 15%) - **HAZARDOUS WASTE**

Impacts due to different ELV's PA-6,6 GF (GF 15%) treatment

Source: hubcap in PA-6,6 GF (GF 15%) Fraunhofer (2002)



Legend:

R = mechanical recycling (substitution rate = 1)
BF = blast furnace (substitution = heavy oil)
SG 1 = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
SG 2 = syngas production (after shredding & substitution = methanol from waste oil)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of PA-6.6 GF does not systematically come out better than landfill in terms of hazardous waste: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of hazardous waste: mechanical recycling. For example, per kg of PA-6.6 GF, mechanical recycling enables to avoid the production of approximately 13.6 g of hazardous waste when landfill does not have a significant impact.
- Certain recovery options generate systematically more hazardous waste than landfill: waste incineration.
- Certain recovery options come out equivalent to landfill in terms of hazardous waste: cement kiln, blast furnace, and syngas production.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of PA-6.6 GF is favourable to the environment in terms of hazardous waste (per kg of PA-6.6 GF, mechanical recycling permits to avoid the production of approximately 13.6 g of hazardous waste).
- In general, the other recovery options generate hazardous waste or do not have a significant impact in terms of hazardous waste.
- In general, the mechanical recycling of PA-6.6 GF systematically comes out more beneficial than all the other recovery options in terms of hazardous waste.

- ***Comparison of the other recovery options (excluding mechanical recycling)***

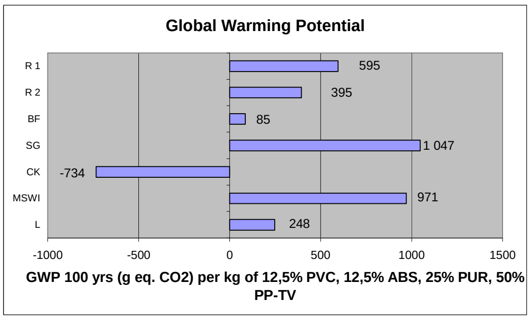
- Feedstock recycling (SG, BF): In general, feedstock recycling does not have a significant impact in terms of hazardous waste.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically generate hazardous waste. The waste incineration option appears to generate hazardous waste (approximately 17 g of hazardous waste generated per kg of PA-6.6 GF). However the assessment of the cement kiln option does not have a significant impact.

Results obtained for 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV and discussion

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV - **CLIMATE CHANGE**

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than landfill in terms of greenhouse gases emissions: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of greenhouse gases emissions: cement kiln, blast furnace.
- Certain recovery options come out systematically more harmful than landfill in terms of greenhouse gases emissions: waste incineration, syngas production, and mechanical recycling.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is harmful to the environment in terms of greenhouse gases emissions (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling generates the emission of approximately 0.4 to 0.6 kg eq CO_2 depending on the type of resin recycled).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of greenhouse gases emissions: it depends on the recovery option studied.
- In general, the mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than all the other recovery options in terms of greenhouse gases emissions: it depends on the recovery option studied.
- Mechanical recycling comes out systematically more beneficial than some other recovery options in terms of greenhouse gases emissions: syngas production, waste incineration.
- Mechanical recycling comes out systematically more harmful than some other recovery options in terms of greenhouse gases emissions: blast furnace, cement kiln.

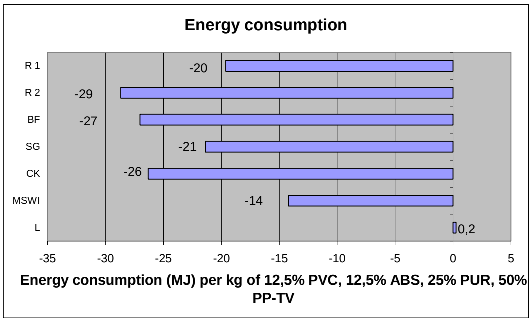
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of greenhouse gases emissions.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of greenhouse gases emissions: it depends on the recovery option studied. The cement kiln option appears to be beneficial (negative value, avoided impacts) in terms of greenhouse gases emissions (approximately –0.73 kg eq CO_2 per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). On the contrary the waste incineration option appears to be harmful (positive value, generated impacts) in terms of greenhouse gases emissions (approximately 0.9 kg eq CO2 emitted per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV).

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV - **ENERGY CONSUMPTION**

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***
- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than landfill in terms of energy consumption: it depends on the recovery option studied.
- In general, the recovery options systematically come out beneficial (negative value, avoided impacts) in terms of energy consumption (approximately -14 to -29 MJ per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, depending on the recovery option). The recovery options appear to be favourable in terms of energy consumption because they receive a credit for the substitution of energetic resources.
- Thus, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out better than landfill in terms of energy consumption.

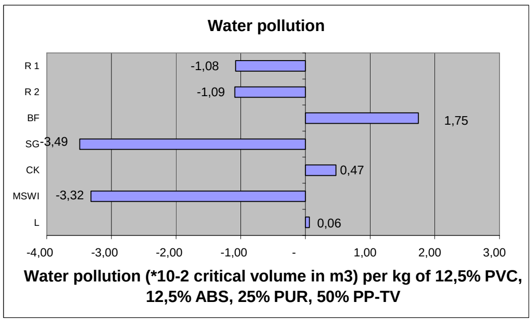
- ***Mechanical recycling vs. other recovery options***
- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is favourable to the environment in terms of energy consumption (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling permits to avoid the consumption of approximately 19.6 to 28.7 MJ depending on the type of resin recycled).
- In general, the other recovery options systematically come out beneficial in terms of energy consumption (-14 to -27 MJ per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, depending on the recovery option).
- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out better than all the other recovery options in terms of energy consumption when the substitution rate is 1.
- Certain recovery options come out systematically more beneficial than mechanical recycling when the substitution rate is 0.65 in terms of energy consumption: cement kiln, blast furnace, and syngas production.
- Certain recovery options come out systematically worse than mechanical recycling when the substitution rate is 0.65 in terms of energy consumption: waste incineration.

- ***Comparison of the other recovery options (excluding mechanical recycling)***
- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out beneficial in terms of energy consumption.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of energy consumption.

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	-	WATER POLLUTION

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than landfill in terms of water pollution: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of water pollution: waste incineration, syngas production, mechanical recycling. For example, per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling enables to avoid the pollution of approximately 11 dm^3 of water when landfill generates the pollution of 0.6 dm^3 of water.
- Certain recovery options come out systematically more harmful than landfill in terms of water pollution: blast furnace, cement kiln. The blast furnace option pollutes water 29 times more than landfill disposal. The cement kiln option pollutes water 8 times more than landfill disposal.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is favourable to the environment in terms of water pollution (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling permits to avoid the pollution of 11 dm^3 of water).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of water pollution: it depends on the recovery option studied.
- In general, the mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than all the other recovery options in terms of water pollution: it depends on the recovery option studied.
- Mechanical recycling comes out systematically more beneficial than some other recovery options in terms of water pollution: cement kiln, blast furnace.
- Mechanical recycling comes out systematically less beneficial than another recovery option in terms of water pollution: syngas production, waste incineration.

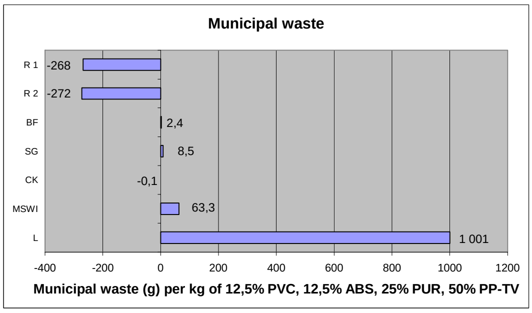
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The blast furnace option appears to be harmful in terms of water pollution (approximately 17 dm^3 of water polluted per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). On the contrary, the assessment of the syngas production option is favourable (approximately -35 dm3 of water polluted per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV).
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of water pollution: it depends on the recovery option studied. The waste incineration option appears to be beneficial in terms of water pollution (–33 dm^3 of water polluted per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). On the contrary, the assessment of the cement kiln option is harmful (positive value, generated impacts).

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	-	MUNICIPAL WASTE

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- Landfill of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV generates 1 kg of municipal waste per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV.
- In general, the other recovery options do not systematically avoid or generate municipal waste: it depends on the recovery option studied.
- In general, landfill of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out worse than all the other recovery options in terms of municipal waste. Landfill comes out approximately 16 to 500 times worse than the other recovery options generating municipal waste.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is favourable to the environment in terms of municipal waste (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling permits to avoid the production of approximately 0.3 kg of waste depending on the type of resin recycled).
- In general, the other recovery options do not systematically come out beneficial or harmful in terms of municipal waste: it depends on the recovery option studied.
- In general, the mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out better than all the other recovery options in terms of municipal waste: it depends on the recovery option studied.

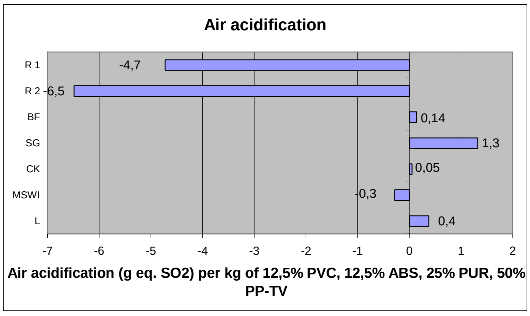
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of municipal waste: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of municipal waste (2 g of municipal waste avoided per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). On the contrary, the syngas production option generates 8.5 g of municipal waste.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of municipal waste: it depends on the recovery option studied. The cement kiln option appears to be beneficial in terms of municipal waste (0.1 g of municipal waste avoided per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). On the contrary, the waste incineration option generates 63.3 g of municipal waste.

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	-	AIR ACIDIFICATION

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than landfill in terms of air acidification: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of air acidification: blast furnace, waste incineration, and mechanical recycling. For example, per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling enables to avoid the emission of around 4.7 to 6.5 g eq. SO_2 depending on the type of resin recycled when landfill generates emissions of 0.4 g eq SO_2.
- Certain recovery options come out systematically more harmful than landfill in terms of air acidification: syngas production.
- Certain recovery options come out equivalent to landfill in terms of air acidification: cement kiln. In terms of air acidification, the assessment of the cement kiln option is the difference of two important values (recovery scenario minus avoided scenario). Thus a 10% change in one of the scenarios, has a great influence on the total result in terms of air acidification. Cement kiln can be therefore considered as equivalent to landfill in terms of air acidification.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is favourable to the environment in terms of air acidification (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling permits to avoid the emission of approximately 4.7 to 6.5 g eq. SO_2 depending on the type of resin recycled).
- In general, the other recovery options come out either beneficial or harmful in terms of air acidification (approximately -0.3 to +1.3 g eq. SO_2 per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, depending on the recovery option).
- In general, the mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out more beneficial than all the other recovery options in terms of air acidification.

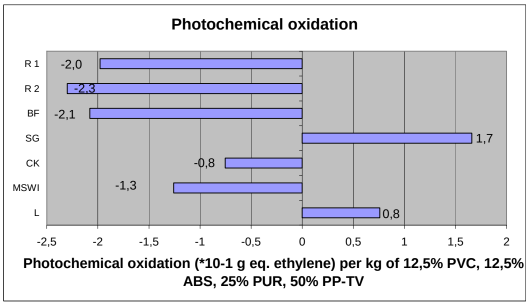
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of air acidification.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically come out beneficial in terms of air acidification: it depends on the recovery option studied. The cement kiln option does not have a significant impact in terms of air acidification. On the contrary, the waste incineration option avoids the emissions of 0.3 g eq. SO2.

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	-	PHOTOCHEMICAL OXIDATION

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than landfill in terms of photochemical oxidation: it depends on the recovery option studied.
- Certain recovery options come out systematically more beneficial than landfill in terms of photochemical oxidation: waste incineration, cement kiln, blast furnace, and mechanical recycling.
- Certain recovery options come out systematically more harmful than landfill in terms of photochemical oxidation: syngas production.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is favourable to the environment in terms of photochemical oxidation (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling permits to avoid the emission of approximately 0.2 g eq. ethylene depending on the type of resin recycled).
- Certain recovery options come out systematically more harmful than mechanical recycling in terms of photochemical oxidation: syngas production, waste incineration, cement kiln.
- Certain recovery options come out 8 to 10% equivalent to mechanical recycling in terms of photochemical oxidation, depending on the type of resin recycled: blast furnace.
-

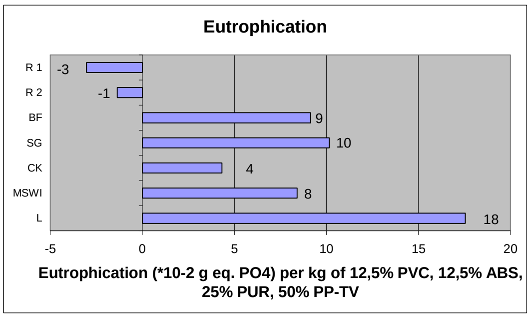
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling does not systematically come out beneficial in terms of photochemical oxidation: it depends on the recovery option studied. The blast furnace option appears to be beneficial in terms of photochemical oxidation (-0.21 g eq. ethylene per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). On the contrary, the syngas production option emits 0.17 g eq. ethylene.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out beneficial in terms of photochemical oxidation.

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	-	EUTROPHICATION

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***

- The disposal of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is harmful to the environment in terms of eutrophication (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, landfill disposal generates the emission of approximately 0.2 g eq. PO_4).
- In general, the other recovery options come out either beneficial or harmful in terms of eutrophication (approximately -30 to +100 mg eq. PO_4 per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, depending on the recovery option).
- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out better than landfill in terms of eutrophication.

- ***Mechanical recycling vs. other recovery options***

- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV is favourable to the environment in terms of eutrophication (per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, mechanical recycling permits to avoid the emission of approximately 10 to 30 mg eq. PO_4 depending on the type of resin recycled).
- In general, the other recovery options come out harmful in terms of eutrophication (approximately 40 to 100 mg eq. PO_4 per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV, depending on the recovery option).
- In general, the mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV systematically comes out more beneficial than all the other recovery options in terms of eutrophication.

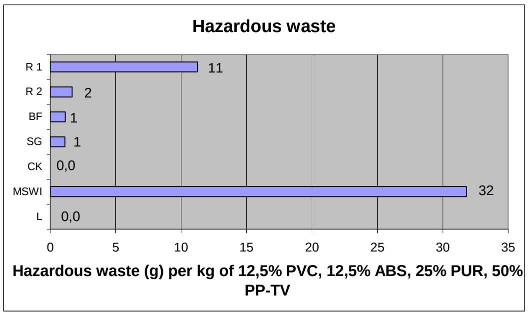
- ***Comparison of the other recovery options (excluding mechanical recycling)***

- Feedstock recycling (SG, BF): In general, feedstock recycling systematically comes out harmful in terms of eutrophication.
- Energy recovery (MSWI, CK): In general, energy recovery systematically comes out harmful in terms of eutrophication.

12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV	-	HAZARDOUS WASTE

Impacts due to different ELV's 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV treatment

Source: dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV Fraunhofer (2002)



Legend:

R 1 = mechanical recycling of the PP-beam (substitution rate = 1)
R 2 = mechanical recycling of the PP and PVC (substitution rate = 1) & recycling of the particles plate in a similar particle panel.
BF = blast furnace (substitution = heavy oil)
SG = syngas production (after shredding & substitution = methanol 73,4% from natural gas, 22,1% from waste oil, and 4,5% from brown coal)
CK = cement kiln (substitution = hard coal)
MSWI = waste incineration (mix with a 39% efficiency: electricity 7,7% and steam 31,3%)
L = landfill

- ***Recovery vs. landfill***
- In general, the recovery of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV does not systematically come out better than landfill in terms of hazardous waste: it depends on the recovery option studied.
- Certain recovery options generate systematically more hazardous waste than landfill: waste incineration.
- Certain recovery options come out equivalent or generate more hazardous waste than landfill, depending on the recovery option: mechanical recycling. In the case (R1) where PP is the recycled material, mechanical recycling generates more hazardous waste than landfill; however, in the case (R2) where the recycled material is PP and PVC, the assessment of the mechanical recycling option is the difference of two important values (recovery scenario minus avoided scenario). Thus a 10% change in one of the scenarios has a great influence on the total result in terms of hazardous waste. In the case (R2) where the recycled material is PP and PVC, mechanical recycling can be therefore considered as equivalent to landfill in terms of hazardous waste.
- Certain recovery options come out equivalent to landfill in terms of hazardous waste: cement kiln, blast furnace, syngas production.

- ***Mechanical recycling vs. other recovery options***
- The mechanical recycling of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV generates 2 to 11 g of hazardous waste.
- Certain recovery options generate systematically more hazardous waste than mechanical recycling: waste incineration.
- The other recovery options do not have a significant impact in terms of hazardous waste.

- ***Comparison of the other recovery options (excluding mechanical recycling)***
- Feedstock recycling (SG, BF): In general, feedstock recycling does not have a significant impact in terms of hazardous waste.
- Energy recovery (MSWI, CK): In general, energy recovery does not systematically generate hazardous waste. The waste incineration option appears to generate hazardous waste (approximately 32 g of hazardous waste generated per kg of 12.5% PVC, 12.5% ABS, 25% PUR, 50% PP-TV). However the assessment of the cement kiln option does not have a significant impact in terms of hazardous waste.

D- Detailed data per kg of resin for all treatment options and categories of impacts for the APME study

		Wash fluid tank and lid in PE, LCA Oeko-Institute - 0,43 kg	Wash fluid tank and lid in PE, LCA Oeko-Institute - 0,43 kg	Wash fluid tank and lid in PE, LCA Oeko-Institute - 0,43 kg	Wash fluid tank and lid in PE, LCA Oeko-Institute - 0,43 kg	Wash fluid tank and lid in PE, LCA Oeko-Institute - 0,43 kg	Wash fluid tank and lid in PE, LCA Oeko-Institute - 0,43 kg	Intake manifold in PA (filler: 30% glass fibre), LCA Oeko-Institute - 0,72 kg	Intake manifold in PA (filler: 30% glass fibre), LCA Oeko-Institute - 0,72 kg	Intake manifolc PA (fille 30% gla fibre), L Oeko- Institute 0,72 kg
		1 tank	**1 tank**	**1 tank**	**1 tank**	**1 tank**	**1 tank**	**1 intake manifold**	**1 intake manifold**	**1 intake manifol**
		landfill	**waste incin.**	**cement kiln**	**syngas**	**blast furnace**	**mech. recyc.**	**landfill**	**waste incin.**	**cement**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	14	662	-475	-70	-72	-450	24	605	
Air acidification	g SO_2 eq.	0,09	0,14	0,1	-4,91	-1,37	-6,87	0,01	-0,04	
Photochemical oxidation	g ethylene eq.	0,01	-0,05	0	-0,37	-0,11	-0,92	0,1	0,2	
Eutrophication	g PO4 eq.	7,92E-02	1,13E-01	3,88E-02	-4,37E-01	-6,00E-02	-3,93E-01	1,31E-01	1,02E-01	9,7
Water pollution	critical volume in liter	20,4	3,5	0,5	16,2	-0,3	-13,6	33,8	5	
Energy consumption	MJ	0,23	-13,62	-18,41	-25,02	-20,5	-28,95	0,38	-10,92	-
Municipal waste	kg	0,43	-0,03	-0,02	-0,04	0	0	0,72	0,16	
Hazardous waste	kg		0	0	0	0	0		0,03	

		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	Seat cushion in PUR, LCA Oeko-Institute - 1,20 kg	Seat cushion in PUR, LCA Oeko-Institute - 1,20 kg	Seat cu in PUR Oeko- Institut 1,20 kg
		1 headlamp lens	**1 headlamp lens**	**1 headlamp lens**	**1 headlamp lens**	**1 headlamp lens**	**1 headlamp lens**	**1 seat cushion**	**1 seat cushion**	**1 seat cushio**
		landfill	**waste incin.**	**cement kiln**	**syngas**	**blast furnace**	**mech. recyc.**	**landfill**	**waste incin.**	**cemen**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	10	347	1	114	33	-887	44	1539	
Air acidification	g SO_2 eq.	0,06	0,08	0,24	-1,55	-0,16	-4,81	0,3	0,3	
Photochemical oxidation	g ethylene eq.	0	-0,01	0,01	-0,12	-0,02	-0,48	0,01	-0,08	
Eutrophication	g PO4 eq.	5,50E-02	4,36E-02	4,15E-02	-1,37E-01	1,42E-02	-4,87E-01	3,05E-02	2,09E-01	1
Water pollution	critical volume in liter	14,16	2,03	0,47	5,66	0,29	-108,73	43	7	
Energy consumption	MJ	0,15	-4,35	-5,59	-8,04	-5,97	-23,33	0,74	-23,39	
Municipal waste	kg	0,3	0,07	0	-0,01	0,01	0,02	1,2	-0,05	
Hazardous waste	kg		0,01	0	0	0	0	0	0	

		Air duct in PP (20% talcum), LCA Oeko-Institute - 0,95kg	Air duct in PP (20% talcum), LCA Oeko-Institute - 0,95kg	Air duct in PP (20% talcum), LCA Oeko-Institute - 0,95kg	Air duct in PP (20% talcum), LCA Oeko-Institute - 0,95kg	Air duct in PP (20% talcum), LCA Oeko-Institute - 0,95kg	Air duct in PP (20% talcum), LCA Oeko-Institute - 0,95kg	Mirror housing in ABS, LCA Oeko-Institute - 0,27 kg	Mirror housing in ABS, LCA Oeko-Institute - 0,27 kg	Mirror housin ABS, L Oeko- Institut 0,27 k
		1 air duct	**1 air duct**	**1 air duct**	**1 air duct**	**1 air duct**	**1 air duct**	**1 mirror housing**	**1 mirror housing**	**1 mirro housin**
		landfill	**waste incin.**	**cement kiln**	**syngas**	**blast furnace**	**mech. recyc.**	**landfill**	**waste incin.**	**ceme**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	31	871	-559	-71	9	-888	9	452	
Air acidification	g SO_2 eq.	0,2	0,2	0,6	-6,3	-1,1	-11,6	0,06	0,09	
Photochemical oxidation	g ethylene eq.	0,01	-0,06	0,03	-0,49	-0,1	-0,61	0,00	-0,03	
Eutrophication	g PO4 eq.	1,74E-01	1,62E-01	1,20E-01	-5,62E-01	1,98E-03	-6,71E-01	4,94E-02	6,14E-02	2
Water pollution	critical volume in liter	44,9	8,3	1,5	22,8	0,7	-22,2	12,7	1,9	
Energy consumption	MJ	0,5	-17,7	-23,25	-32,63	-25,28	-47,83	0,14	-7,09	
Municipal waste	kg	0,95	0	0	0,01	0	0	0,27	-0,01	
Hazardous waste	kg		0,05	0	0	0,01	0		0,00	

		Bumper in PP, LCA Oeko-Institute - 3.14 kg	Bumper in PP, LCA Oeko-Institute - 3.14 kg	Bumper in PP, LCA Oeko-Institute - 3.14 kg	Bumper in PP, LCA Oeko-Institute - 3.14 kg	Bumper in PP, LCA Oeko-Institute - 3.14 kg	Bumper in PP, LCA Oeko-Institute - 3.14 kg
		1 bumper	**1 bumper**	**1 bumper**	**1 bumper**	**1 bumper**	**1 bumper**
		landfill	**waste incin.**	**cement kiln**	**syngas**	**blast furnace**	**mech. recyc.**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	103	4808	-3451	-507	-520	-3867
Air acidification	g SO_2 eq.	0,6	1	0,7	-35,6	-9,9	-48,8
Photochemical oxidation	g ethylene eq.	0,04	-0,36	-0,03	-2,71	-0,77	-2,63
Eutrophication	g PO4 eq.	5,75E-01	8,22E-01	2,82E-01	-3,18E+00	-4,36E-01	-2,86E+00
Water pollution	critical volume in liter	148,2	25,1	3,7	117,9	-2	-97,2
Energy consumption	MJ	1,64	-98,93	-133,65	-181,64	-148,82	-206,76
Municipal waste	kg	3,14	-0,23	-0,17	-0,28	-0,01	0,01
Hazardous waste	kg		0	0	0	0	0

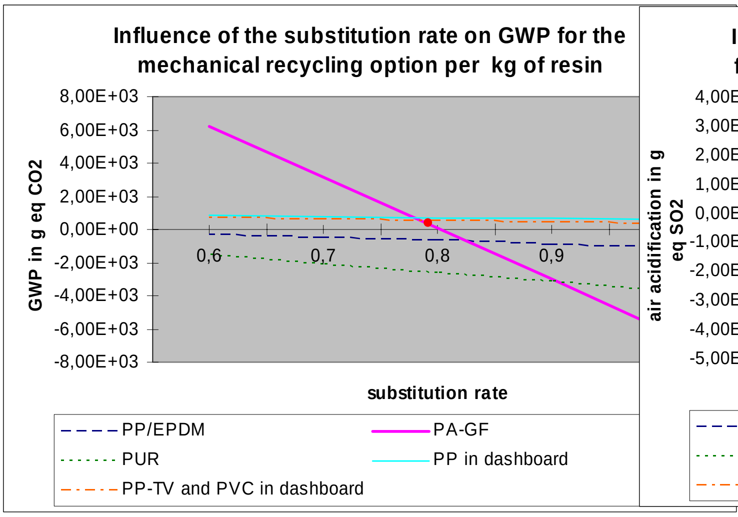
D- Detailed data per kg of resin for the mechanical recycling option with variation of the substitution rate

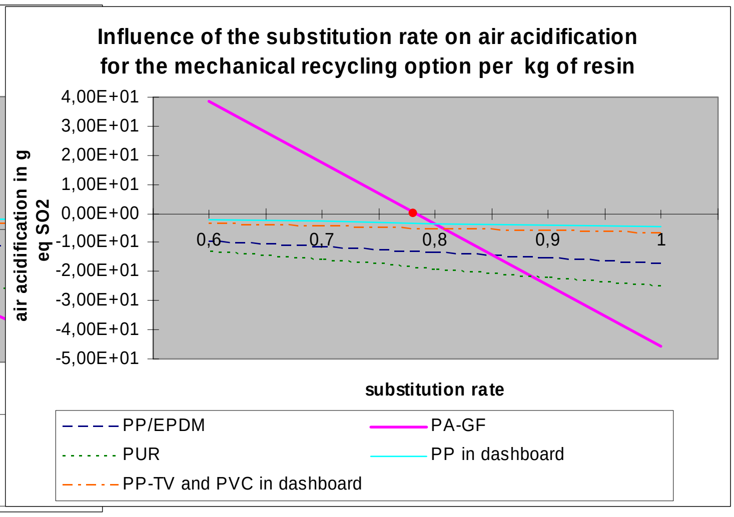
Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=1**	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=0,9**	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=0,8**	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=0,7**	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=0,65**	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=0,6**	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - Recycling substitution factor=1	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - Recycling substitution factor=0,9
		1 kg	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**
		Total	**Total (0,9)**	**Total (0,8)**	**Total (0,7)**	**Total (0,65)**	**Total (0,6)**	**Total**	**Total (0,9)**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	-9,92E+02	-8,12E+02	-6,31E+02	-4,51E+02	-3,61E+02	-2,71E+02	-6,09E+03	-3,01E+03
Air acidification	g SO_2 eq.	-1,71E+01	-1,52E+01	-1,33E+01	-1,14E+01	-1,04E+01	-9,46E+00	-4,56E+01	-2,45E+01
Photochemical oxidation	g ethylene eq.	-7,20E-01	-6,35E-01	-5,49E-01	-4,64E-01	-4,21E-01	-3,78E-01	-2,39E+00	-1,31E+00
Eutrophication	g PO4 eq.	-7,79E-01	-6,67E-01	-5,56E-01	-4,45E-01	-3,89E-01	-3,33E-01	-5,30E+00	-2,86E+00
Water pollution	critical volume in m3	-1,77E-02	-1,23E-02	-6,80E-03	-1,35E-03	1,38E-03	4,11E-03	-3,43E-01	-1,85E-01
Energy consumption	MJ	-5,68E+01	-5,03E+01	-4,39E+01	-3,74E+01	-3,42E+01	-3,09E+01	-1,05E+02	-5,61E+01
Municipal waste	kg	-1,98E-02	-1,77E-02	-1,56E-02	-1,35E-02	-1,24E-02	-1,14E-02	-2,43E-01	-1,13E-01
Hazardous waste	kg	-8,38E-03	-7,40E-03	-6,42E-03	-5,44E-03	-4,95E-03	-4,47E-03	-1,36E-02	-6,56E-03

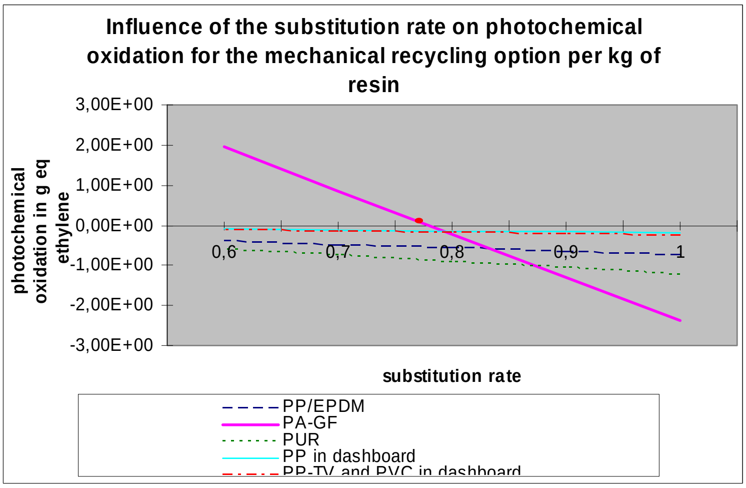
Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - Recycling Substitution factor = 1	PUR seat cushions - LCA Fraunhofer - 2.4 kg - Recycling Substitution factor = 0,9	PUR seat cushions - LCA Fraunhofer - 2.4 kg - Recycling Substitution factor = 0,8	PUR seat cushions - LCA Fraunhofer - 2.4 kg - Recycling Substitution factor = 0,7	PUR seat cushions - LCA Fraunhofer - 2.4 kg - Recycling Substitution factor = 0,65 calc	PUR seat cushions - LCA Fraunhofer - 2.4 kg - Recycling Substitution factor = 0.6	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - Recycling of the PP-beam with substitution factor = 1.	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - Recycling of the PP-beam with substitution factor = 0,9.	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - Recycling of the PP-beam with substitution factor = 0,8.
		1 kg	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**	**1 kg**
		Total	**Total (0,9)**	**Total (0,8)**	**Total (0,7)**	**Total (0,65 calc)**	**Total (0,6)**	**Total**	**Total (0,9)**	**Total (0,8)**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	-3,64E+03	-3,09E+03	-2,55E+03	-2,00E+03	-1,73E+03	-1,46E+03	5,95E+02	6,55E+02	7,15E+02
Air acidification	g SO_2 eq.	-2,48E+01	-2,18E+01	-1,87E+01	-1,57E+01	-1,42E+01	-1,27E+01	-4,72E+00	-4,09E+00	-3,46E+00
Photochemical oxidation	g ethylene eq.	-1,19E+00	-1,03E+00	-8,77E-01	-7,21E-01	-6,43E-01	-5,65E-01	-1,98E-01	-1,72E-01	-1,47E-01
Eutrophication	g PO4 eq.	-3,80E+00	-3,34E+00	-2,87E+00	-2,41E+00	-2,18E+00	-1,95E+00	-3,03E-02	4,49E-03	3,93E-02
Water pollution	critical volume in m3	-4,06E-01	-3,53E-01	-3,00E-01	-2,46E-01	-2,20E-01	-1,93E-01	-1,08E-02	-8,37E-03	-5,94E-03
Energy consumption	MJ	-9,50E+01	-8,28E+01	-7,05E+01	-5,83E+01	-5,22E+01	-4,60E+01	-1,96E+01	-1,76E+01	-1,56E+01
Municipal waste	kg	-2,54E-01	-2,25E-01	-1,95E-01	-1,66E-01	-1,52E-01	-1,37E-01	-2,68E-01	-2,41E-01	-2,13E-01
Hazardous waste	kg	-2,99E-02	-2,64E-02	-2,30E-02	-1,96E-02	-1,78E-02	-1,61E-02	1,12E-02	1,15E-02	1,18E-02

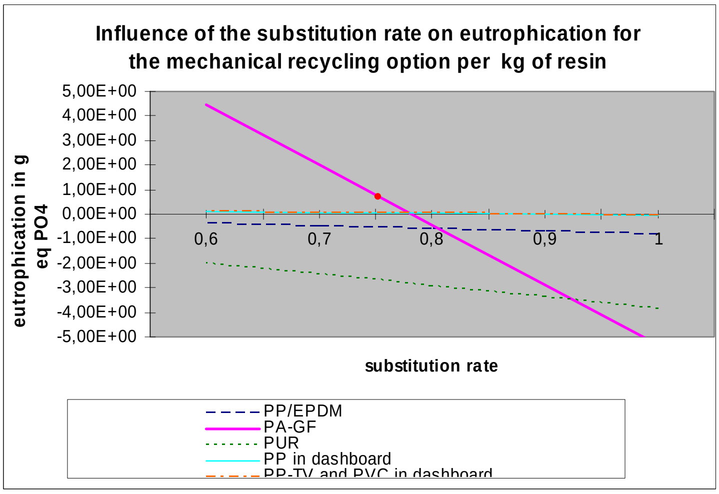
Flow	Units	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg Recycling of PP and PVC with substitution factor = 1 - Recycling of the particles plate in a similar particle panel.	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg Recycling of PP and PVC with substitution factor = 0,9 - Recycling of the particles plate in a similar particle panel.	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg Recycling of PP and PVC with substitution factor = 0,8 - Recycling of the particles plate in a similar particle panel.	Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg Recycling of PP and PVC with substitution factor = 0,7 - Recycling of the particles plate in a similar particle panel.
		1 kg	**1 kg**	**1 kg**	**1 kg**
		Total	**Total (0,9)**	**Total (0,8)**	**Total (0,7)**
Greenhouse effect (direct, 100 yrs)	g CO_2 eq.	3,95E+02	4,79E+02	5,63E+02	6,47E+02
Air acidification	g SO_2 eq.	-6,49E+00	-5,67E+00	-4,86E+00	-4,04E+00
Photochemical oxidation	g ethylene eq.	-2,30E-01	-1,95E-01	-1,60E-01	-1,26E-01
Eutrophication	g PO4 eq.	-1,37E-02	3,51E-02	8,38E-02	1,33E-01
Water pollution	critical volume in m3	-1,09E-02	-7,67E-03	-4,43E-03	-1,18E-03
Energy consumption	MJ	-2,87E+01	-2,61E+01	-2,35E+01	-2,09E+01
Municipal waste	kg	-2,72E-01	-2,44E-01	-2,16E-01	-1,87E-01
Hazardous waste	kg	1,67E-03	2,00E-03	2,34E-03	2,68E-03

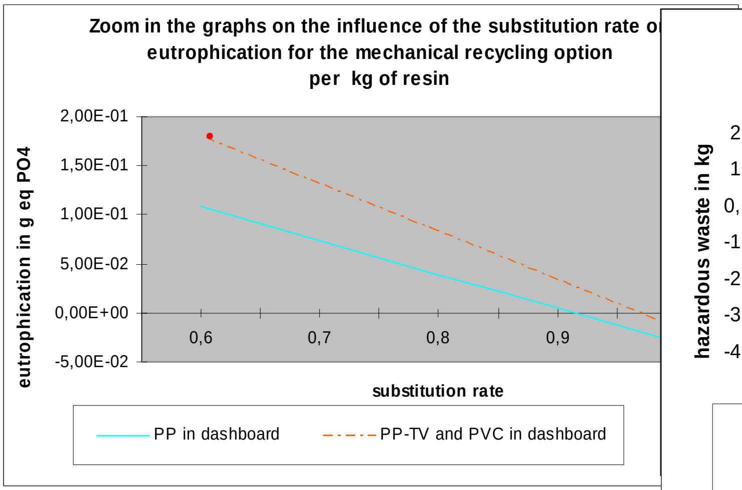
E- Graphs representing the impacts of mechanical recycling for each resin depending on the substitution rate and per impact category

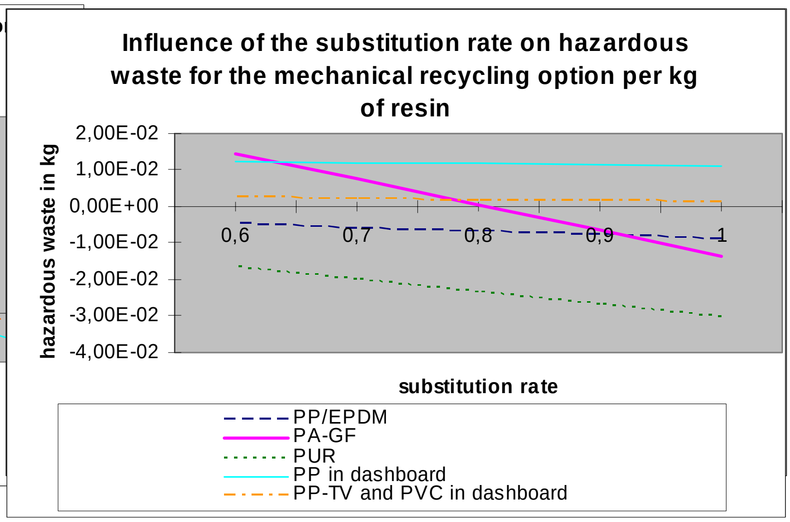


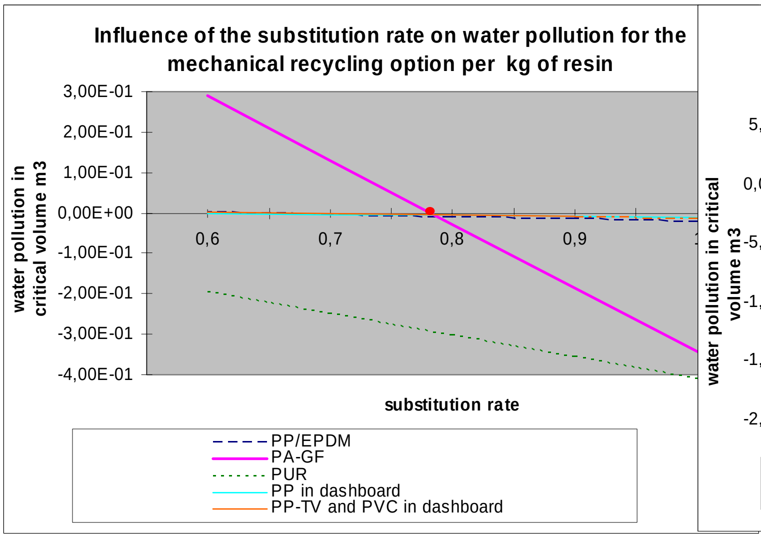


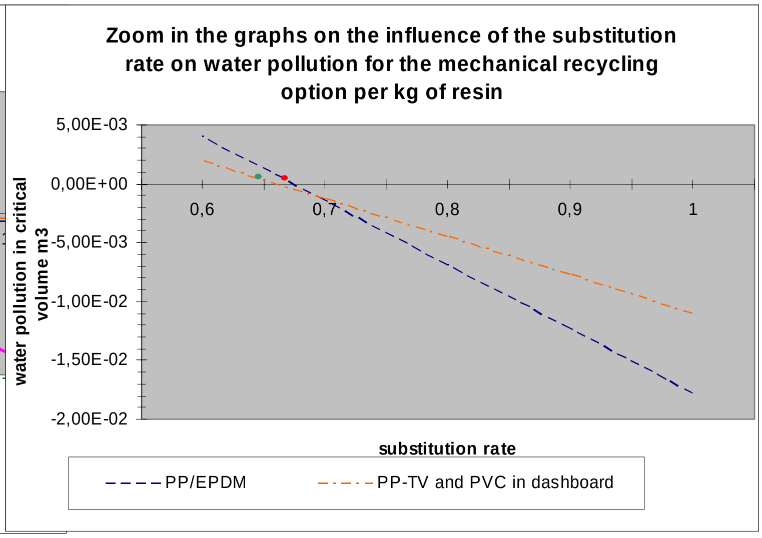


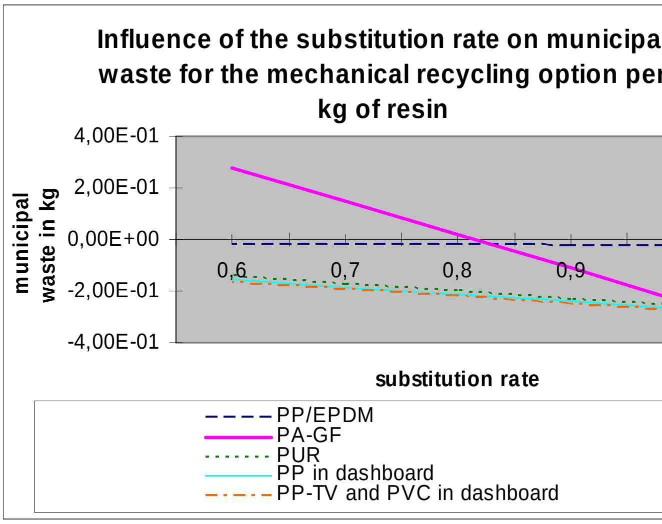


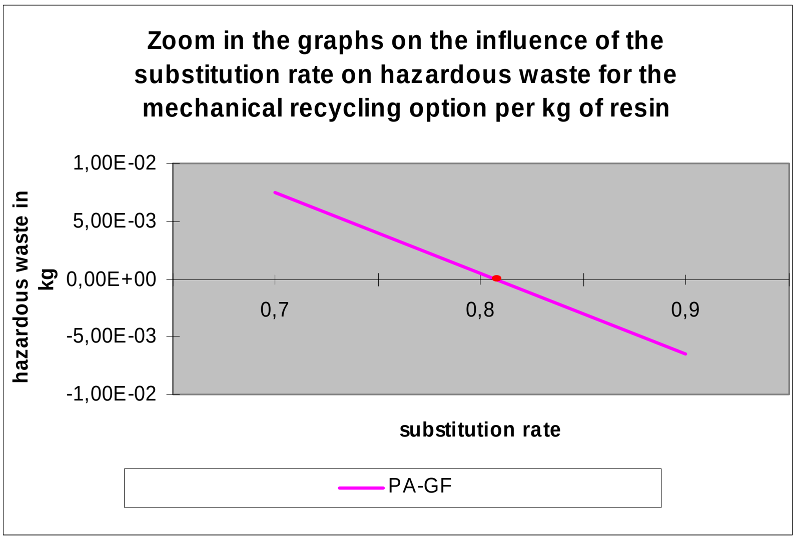

Zoom in the graphs on the influence of the substitution rate o
eutrophication for the mechanical recycling option
per kg of resin
eutrophication in g eq PO4
2,00E-01
1,50E-01
1,00E-01
5,00E-02
0,00E+00
-5,00E-02
0,6
0,7
0,8
0,9
substitution rate
PP in dashboard
PP-TV and PVC in dashboard


Influence of the substitution rate on hazardous waste for the mechanical recycling option per kg of resin
hazardous waste in kg
2,00E-02
1,00E-02
0,00E+00
-1,00E-02
-2,00E-02
-3,00E-02
-4,00E-02
0,6
0,7
0,8
0,9
1
substitution rate
PP/EPDM
PA-GF
PUR
PP in dashboard
PP-TV and PVC in dashboard


Influence of the substitution rate on water pollution for the mechanical recycling option per kg of resin
water pollution in critical volume m3
3,00E-01
2,00E-01
1,00E-01
0,00E+00
-1,00E-01
-2,00E-01
-3,00E-01
-4,00E-01
0,6
0,7
0,8
0,9
substitution rate
PP/EPDM
PA-GF
PUR
PP in dashboard
PP-TV and PVC in dashboard


Zoom in the graphs on the influence of the substitution rate on water pollution for the mechanical recycling option per kg of resin
water pollution in critical volume m3
5,00E-03
0,00E+00
-5,00E-03
-1,00E-02
-1,50E-02
-2,00E-02
0,6
0,7
0,8
0,9
1
substitution rate
PP/EPDM
PP-TV and PVC in dashboard


Influence of the substitution rate on municipa
waste for the mechanical recycling option pe
kg of resin
municipal waste in kg
4,00E-01
2,00E-01
0,00E+00
-2,00E-01
-4,00E-01
0,6
0,7
0,8
0,9
substitution rate
PP/EPDM
PA-GF
PUR
PP in dashboard
PP-TV and PVC in dashboard


Zoom in the graphs on the influence of the substitution rate on hazardous waste for the mechanical recycling option per kg of resin
hazardous waste in kg
1,00E-02
5,00E-03
0,00E+00
-5,00E-03
-1,00E-02
0,7
0,8
0,9
substitution rate
PA-GF

F- External costs per resin and per treatment option

Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - blast furnace (substitution=heavy oil)

Flow	Units	1000 pieces: Total (P+E+T) Min	Total (P+E+T) Max	Total avoided Min	Total avoided Max	Total Min	Total Max	1 kg: Total (in Euros) Min	Total (in Euros) Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	77,53 €	195,86 €	69,34 €	175,16 €	8,19 €	20,69 €	1,62E-03	4,09E-03
Air acidification	g SO_2 eq.	1,63 €	16,26 €	1,52 €	15,21 €	0,10 €	1,05 €	2,07E-05	2,07E-04
Photochemical oxidation	g ethylene eq.	2,00 €	2,55 €	2,77 €	3,53 €	-0,98 €	-0,77 €	-1,93E-04	-1,52E-04
Eutrophication	g PO4 eq.	1,70 €	1,70 €	0,99 €	0,99 €	0,71 €	0,71 €	1,41E-04	1,41E-04
Municipal waste	kg	0,05 €	0,26 €	0,01 €	0,03 €	0,05 €	0,23 €	9,44E-06	4,48E-05
Hazardous waste	kg	0,02 €	0,11 €	0,00 €	0,00 €	0,02 €	0,11 €	4,58E-06	2,18E-05
total external cost	**Euros**	**82,93 €**	**216,73 €**	**74,62 €**	**194,92 €**	**8,10 €**	**22,02 €**	**1,60E-03**	**4,36E-03**

Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)

Flow	Units	1000 pieces: Total (P+E+T) Min	Total (P+E+T) Max	Total avoided Min	Total avoided Max	Total Min	Total Max	1 kg: Total Min	Total Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	155,29 €	392,32 €	54,76 €	138,34 €	100,53 €	253,98 €	1,99E-02	5,03E-02
Air acidification	g SO_2 eq.	0,60 €	6,02 €	-3,77 €	-0,38 €	0,98 €	9,79 €	1,94E-04	1,94E-03
Photochemical oxidation	g ethylene eq.	0,09 €	0,12 €	-0,66 €	-0,52 €	0,61 €	0,78 €	1,21E-04	1,54E-04
Eutrophication	g PO4 eq.	1,01 €	1,01 €	0,22 €	0,22 €	0,79 €	0,79 €	1,56E-04	1,56E-04
Municipal waste	kg	0,05 €	0,26 €	-0,56 €	-0,12 €	0,17 €	0,82 €	3,40E-05	1,62E-04
Hazardous waste	kg	0,02 €	0,11 €	0,00 €	0,00 €	0,02 €	0,11 €	4,47E-06	2,12E-05
total external cost	**Euros**	**157,07 €**	**399,83 €**	**53,96 €**	**133,57 €**	**1,03E+02**	**2,66E+02**	**2,04E-02**	**5,27E-02**

Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - Cement kiln (substitution=hard coal)

Flow	Units	1000 pieces: Total (P+E+T) Min	Total (P+E+T) Max	Total avoided Min	Total avoided Max	Total Min	Total Max	1 kg: Total Min	Total Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	211,64 €	534,67 €	282,15 €	712,81 €	-178,14 €	-70,51 €	-3,52E-02	-1,40E-02
Air acidification	g SO_2 eq.	6,28 €	62,77 €	6,24 €	62,39 €	0,04 €	0,39 €	7,65E-06	7,65E-05
Photochemical oxidation	g ethylene eq.	0,96 €	1,22 €	1,24 €	1,58 €	-0,35 €	-0,28 €	-7,02E-05	-5,51E-05
Eutrophication	g PO4 eq.	2,10 €	2,10 €	1,77 €	1,77 €	0,34 €	0,34 €	6,66E-05	6,66E-05
Municipal waste	kg	0,00 €	0,00 €	0,00 €	0,01 €	-0,01 €	0,00 €	-2,33E-06	-4,91E-07
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1,30E-10	6,19E-10
total external cost	**Euros**	**220,98 €**	**600,77 €**	**291,40 €**	**778,55 €**	**-178,13 €**	**-70,07 €**	**-3,52E-02**	**-1,39E-02**

Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - MSWI (electricity+steam)

Flow	Units	1000 pieces: Total (P+E+T) Min	Total (P+E+T) Max	Total avoided Min	Total avoided Max	Total Min	Total Max	1 kg: Total Min	Total Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	205,20 €	518,39 €	112,00 €	282,94 €	93,20 €	235,45 €	1,84E-02	4,66E-02
Air acidification	g SO_2 eq.	0,92 €	9,16 €	1,12 €	11,24 €	-2,08 €	-0,21 €	-4,12E-04	-4,12E-05
Photochemical oxidation	g ethylene eq.	0,08 €	0,10 €	0,54 €	0,69 €	-0,59 €	-0,46 €	-1,17E-04	-9,18E-05
Eutrophication	g PO4 eq.	1,56 €	1,56 €	0,90 €	0,90 €	0,66 €	0,66 €	1,30E-04	1,30E-04
Municipal waste	kg	1,46 €	6,93 €	0,18 €	0,85 €	1,28 €	6,08 €	2,53E-04	1,20E-03
Hazardous waste	kg	0,64 €	3,06 €	0,00 €	0,00 €	0,64 €	3,06 €	1,27E-04	6,04E-04
total external cost	**Euros**	**209,85 €**	**539,19 €**	**114,75 €**	**296,63 €**	**93,10 €**	**244,56 €**	**1,84E-02**	**4,84E-02**

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **Recycling of the PP beam with substitution factor = 1.**							
		1000 pieces						1 kg	
		Total (P+E+T)		Total avoided		Total		Total	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	184,16 €	465,24 €	126,98 €	320,79 €	57,18 €	144,45 €	1,13E-02	2,86E-02
Air acidification	g SO_2 eq.	1,86 €	18,63 €	5,35 €	53,47 €	-34,85 €	-3,48 €	-6,89E-03	-6,89E-04
Photochemical oxidation	g ethylene eq.	0,55 €	0,70 €	1,28 €	1,63 €	-0,93 €	-0,73 €	-1,84E-04	-1,44E-04
Eutrophication	g PO4 eq.	3,03 €	3,03 €	3,27 €	3,27 €	-0,24 €	-0,24 €	-4,66E-05	-4,66E-05
Municipal waste	kg	0,26 €	1,25 €	5,68 €	27,00 €	-25,75 €	-5,42 €	-5,10E-03	-1,07E-03
Hazardous waste	kg	0,28 €	1,35 €	0,06 €	0,27 €	0,23 €	1,08 €	4,49E-05	2,13E-04
total external cost	**Euros**	**190,15 €**	**490,20 €**	**142,62 €**	**406,44 €**	**-4,36 €**	**135,65 €**	**-8,62E-04**	**2,68E-02**

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg **Recycling of PP and PVC with substitution factor = 1 - Recycling of the particles plate in a similar particle panel.**							
		1000 pieces						1 kg	
		Total (P+E+T)		Total avoided		Total		Total	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	201,10 €	508,04 €	163,17 €	412,23 €	37,93 €	95,81 €	7,50E-03	1,90E-02
Air acidification	g SO_2 eq.	3,38 €	33,80 €	8,17 €	81,67 €	-47,87 €	-4,79 €	-9,47E-03	-9,47E-04
Photochemical oxidation	g ethylene eq.	0,97 €	1,24 €	1,82 €	2,32 €	-1,08 €	-0,85 €	-2,14E-04	-1,68E-04
Eutrophication	g PO4 eq.	5,29 €	5,29 €	5,40 €	5,40 €	-0,11 €	-0,11 €	-2,11E-05	-2,11E-05
Municipal waste	kg	0,31 €	1,48 €	5,82 €	27,64 €	-26,16 €	-5,51 €	-5,18E-03	-1,09E-03
Hazardous waste	kg	0,11 €	0,54 €	0,08 €	0,38 €	0,03 €	0,16 €	6,66E-06	3,16E-05
total external cost	**Euros**	**211,17 €**	**550,38 €**	**184,45 €**	**529,63 €**	**-37,26 €**	**84,73 €**	**-7,37E-03**	**1,68E-02**

		Dashboard in 12,5% PVC, 12,5% ABS, 25% PUR, 50% PP-TV, LCA Fraunhofer - 5.054 kg - **Landfill**			
		1000 pieces		**1 kg**	
		Landfill		**Landfill**	
Flow	Units	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	23,78 €	60,07 €	4,70E-03	1,19E-02
Air acidification	g SO_2 eq.	0,28 €	2,80 €	5,54E-05	5,54E-04
Photochemical oxidation	g ethylene eq.	0,28 €	0,36 €	5,54E-05	7,06E-05
Eutrophication	g PO4 eq.	1,37 €	1,37 €	2,70E-04	2,70E-04
Municipal waste	kg	20,23 €	96,08 €	4,00E-03	1,90E-02
Hazardous waste	kg	0,00 €	0,00 €	1,69E-11	8,01E-11
total external cost	**Euros**	**45,93 €**	**160,68 €**	**9,09E-03**	**3,18E-02**

		PUR seat cushions - LCA Fraunhofer - 2.4 kg - **blast furnace (substitution=heavy oil)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	38,86 €	98,18 €	35,63 €	90,02 €	3,23 €	8,16 €	1,35E-03	3,40E-03
Air acidification	g SO_2 eq.	0,81 €	8,10 €	0,78 €	7,83 €	0,03 €	0,26 €	1,09E-05	1,09E-04
Photochemical oxidation	g ethylene eq.	1,03 €	1,31 €	1,43 €	1,82 €	-0,51 €	-0,40 €	-2,15E-04	-1,68E-04
Eutrophication	g PO4 eq.	0,83 €	0,83 €	0,51 €	0,51 €	0,32 €	0,32 €	1,35E-04	1,35E-04
Municipal waste	kg	0,00 €	0,00 €	0,00 €	0,01 €	-0,01 €	0,00 €	-4,59E-06	-9,66E-07
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	2,80E-07	1,33E-06
total external cost	**Euros**	**41,53 €**	**108,42 €**	**38,36 €**	**100,20 €**	**3,06 €**	**8,34 €**	**1,27E-03**	**3,48E-03**

PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	79,87 €	201,77 €	26,63 €	67,26 €	53,24 €	134,51 €	2,22E-02	5,60E-02
Air acidification	g SO_2 eq.	0,30 €	2,98 €	-2,04 €	-0,20 €	0,50 €	5,02 €	2,09E-04	2,09E-03
Photochemical oxidation	g ethylene eq.	0,04 €	0,06 €	-0,34 €	-0,27 €	0,31 €	0,40 €	1,31E-04	1,67E-04
Eutrophication	g PO4 eq.	0,51 €	0,51 €	0,10 €	0,10 €	0,40 €	0,40 €	1,68E-04	1,68E-04
Municipal waste	kg	0,00 €	0,00 €	-0,29 €	-0,06 €	0,06 €	0,29 €	2,57E-05	1,22E-04
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1,61E-07	7,66E-07
total external cost	**Euros**	**80,72 €**	**205,32 €**	**24,05 €**	**66,83 €**	**54,52 €**	**140,63 €**	**2,27E-02**	**5,86E-02**

PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Cement kiln (substitution=hard coal)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	109,25 €	276,01 €	135,63 €	342,64 €	-66,63 €	-26,37 €	-2,78E-02	-1,10E-02
Air acidification	g SO_2 eq.	2,99 €	29,88 €	3,00 €	29,99 €	-0,11 €	-0,01 €	-4,41E-05	-4,41E-06
Photochemical oxidation	g ethylene eq.	0,46 €	0,58 €	0,59 €	0,76 €	-0,18 €	-0,14 €	-7,36E-05	-5,78E-05
Eutrophication	g PO4 eq.	1,00 €	1,00 €	0,85 €	0,85 €	0,15 €	0,15 €	6,29E-05	6,29E-05
Municipal waste	kg	0,00 €	0,00 €	0,00 €	0,01 €	-0,01 €	0,00 €	-2,37E-06	-4,98E-07
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1,30E-10	6,19E-10
total external cost	**Euros**	**113,70 €**	**307,48 €**	**140,07 €**	**374,24 €**	**-66,77 €**	**-26,37 €**	**-2,78E-02**	**-1,10E-02**

PUR seat cushions - LCA Fraunhofer - 2.4 kg - **MSWI (electricity+steam)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	106,21 €	268,32 €	53,94 €	136,27 €	52,27 €	132,05 €	2,18E-02	5,50E-02
Air acidification	g SO_2 eq.	0,38 €	3,82 €	0,54 €	5,41 €	-1,59 €	-0,16 €	-6,62E-04	-6,62E-05
Photochemical oxidation	g ethylene eq.	0,04 €	0,05 €	0,26 €	0,33 €	-0,28 €	-0,22 €	-1,19E-04	-9,32E-05
Eutrophication	g PO4 eq.	0,75 €	0,75 €	0,44 €	0,44 €	0,31 €	0,31 €	1,29E-04	1,29E-04
Municipal waste	kg	0,00 €	0,00 €	0,09 €	0,41 €	-0,41 €	-0,09 €	-1,70E-04	-3,59E-05
Hazardous waste	kg	0,02 €	0,09 €	0,00 €	0,00 €	0,02 €	0,09 €	7,75E-06	3,68E-05
total external cost	**Euros**	**107,39 €**	**273,02 €**	**55,27 €**	**142,86 €**	**50,31 €**	**131,98 €**	**2,10E-02**	**5,50E-02**

PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Recycling Substitution factor = 1**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	88,92 €	224,64 €	254,81 €	643,73 €	-419,09 €	-165,89 €	-1,75E-01	-6,91E-02
Air acidification	g SO_2 eq.	1,99 €	19,86 €	10,67 €	106,72 €	-86,86 €	-8,69 €	-3,62E-02	-3,62E-03
Photochemical oxidation	g ethylene eq.	0,68 €	0,86 €	2,76 €	3,51 €	-2,65 €	-2,08 €	-1,10E-03	-8,67E-04
Eutrophication	g PO4 eq.	3,11 €	3,11 €	17,15 €	17,15 €	-14,04 €	-14,04 €	-5,85E-03	-5,85E-03
Municipal waste	kg	0,38 €	1,82 €	2,82 €	13,40 €	-11,59 €	-2,44 €	-4,83E-03	-1,02E-03
Hazardous waste	kg	0,04 €	0,20 €	0,33 €	1,57 €	-1,36 €	-0,29 €	-5,67E-04	-1,19E-04
total external cost	**Euros**	**95,11 €**	**250,49 €**	**288,54 €**	**786,08 €**	**-535,59 €**	**-193,43 €**	**-2,23E-01**	**-8,06E-02**

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Recycling Substitution factor = 0.65**							
		1000 pieces						1 kg	
		Total (P+E+T)		Total avoided		Total		Total	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	1 079,89 €	2 728,15 €	898,25 €	2 269,27 €	181,64 €	458,87 €	7,57E-02	1,91E-01
Air acidification	g SO_2 eq.	21,25 €	212,54 €	20,16 €	201,58 €	1,10 €	10,96 €	4,57E-04	4,57E-03
Photochemical oxidation	g ethylene eq.	90,71 €	115,56 €	73,59 €	93,75 €	17,12 €	21,82 €	7,14E-03	9,09E-03
Eutrophication	g PO4 eq.	38,06 €	38,06 €	35,27 €	35,27 €	2,79 €	2,79 €	1,16E-03	1,16E-03
Municipal waste	kg	0,66 €	3,13 €	1,40 €	6,66 €	-3,53 €	-0,74 €	-1,47E-03	-3,10E-04
Hazardous waste	kg	0,10 €	0,47 €	0,17 €	0,81 €	-0,34 €	-0,07 €	-1,43E-04	-3,00E-05
total external cost	**Euros**	**1 230,67 €**	**3 097,91 €**	**1 028,84 €**	**2 607,34 €**	**198,78 €**	**493,62 €**	**8,28E-02**	**2,06E-01**

Flow	Units	PUR seat cushions - LCA Fraunhofer - 2.4 kg - **Landfill**			
		1000 pieces		1 kg	
		Landfill		Landfill	
		Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	12,26 €	30,97 €	5,11E-03	1,29E-02
Air acidification	g SO_2 eq.	0,25 €	2,53 €	1,05E-04	1,05E-03
Photochemical oxidation	g ethylene eq.	0,14 €	0,18 €	6,02E-05	7,67E-05
Eutrophication	g PO4 eq.	1,41 €	1,41 €	5,87E-04	5,87E-04
Municipal waste	kg	9,61 €	45,63 €	4,00E-03	1,90E-02
Hazardous waste	kg	0,00 €	0,00 €	1,69E-11	8,02E-11
total external cost	**Euros**	**23,67 €**	**80,72 €**	**9,86E-03**	**3,36E-02**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - **blast furnace (substitution=heavy oil)**							
		1000 pieces						1 kg	
		Total (P+E+T)		Total avoided		Total		Total	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	7,09 €	17,92 €	6,27 €	15,83 €	0,83 €	2,09 €	1,74E-03	4,41E-03
Air acidification	g SO_2 eq.	0,15 €	1,49 €	0,14 €	1,37 €	0,01 €	0,11 €	2,36E-05	2,36E-04
Photochemical oxidation	g ethylene eq.	0,18 €	0,23 €	0,25 €	0,32 €	-0,09 €	-0,07 €	-1,84E-04	-1,45E-04
Eutrophication	g PO4 eq.	0,16 €	0,16 €	0,09 €	0,09 €	0,07 €	0,07 €	1,43E-04	1,43E-04
Municipal waste	kg	0,00 €	0,02 €	0,00 €	0,00 €	0,00 €	0,01 €	6,65E-06	3,16E-05
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,00 €	0,00 €	0,01 €	2,41E-06	1,14E-05
total external cost	**Euros**	**7,59 €**	**19,82 €**	**6,74 €**	**17,62 €**	**0,82 €**	**2,22 €**	**1,74E-03**	**4,69E-03**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg- **Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**							
		1000 pieces						1 kg	
		Total (P+E+T)		Total avoided		Total		Total	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	13,54 €	34,21 €	4,13 €	10,44 €	9,41 €	23,78 €	1,99E-02	5,02E-02
Air acidification	g SO_2 eq.	0,05 €	0,52 €	-0,45 €	-0,04 €	0,10 €	0,97 €	2,04E-04	2,04E-03
Photochemical oxidation	g ethylene eq.	0,01 €	0,01 €	-0,07 €	-0,05 €	0,06 €	0,08 €	1,29E-04	1,64E-04
Eutrophication	g PO4 eq.	0,09 €	0,09 €	0,01 €	0,01 €	0,07 €	0,07 €	1,54E-04	1,54E-04
Municipal waste	kg	0,00 €	0,02 €	-0,05 €	-0,01 €	0,02 €	0,07 €	3,22E-05	1,53E-04
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,00 €	0,00 €	0,01 €	2,30E-06	1,09E-05
total external cost	**Euros**	**13,69 €**	**34,85 €**	**3,58 €**	**10,34 €**	**9,66 €**	**24,97 €**	**2,04E-02**	**5,27E-02**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - **Cement kiln (substitution=hard coal)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	18,98 €	47,96 €	25,71 €	64,96 €	-17,00 €	-6,73 €	-3,59E-02	-1,42E-02
Air acidification	g SO_2 eq.	0,56 €	5,60 €	0,57 €	5,69 €	-0,09 €	-0,01 €	-1,85E-04	-1,85E-05
Photochemical oxidation	g ethylene eq.	0,09 €	0,11 €	0,11 €	0,14 €	-0,03 €	-0,03 €	-7,24E-05	-5,69E-05
Eutrophication	g PO4 eq.	0,19 €	0,19 €	0,16 €	0,16 €	0,03 €	0,03 €	5,93E-05	5,93E-05
Municipal waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	-2,25E-06	-4,74E-07
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1,30E-10	6,19E-10
total external cost	**Euros**	**19,82 €**	**53,86 €**	**26,56 €**	**70,95 €**	**-17,10 €**	**-6,74 €**	**-3,61E-02**	**-1,42E-02**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - **MSWI (electricity+steam)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	18,37 €	46,41 €	10,18 €	25,72 €	8,19 €	20,69 €	1,73E-02	4,37E-02
Air acidification	g SO_2 eq.	0,07 €	0,71 €	0,10 €	1,02 €	-0,31 €	-0,03 €	-6,49E-04	-6,49E-05
Photochemical oxidation	g ethylene eq.	0,01 €	0,01 €	0,05 €	0,06 €	-0,05 €	-0,04 €	-1,14E-04	-8,91E-05
Eutrophication	g PO4 eq.	0,14 €	0,14 €	0,08 €	0,08 €	0,06 €	0,06 €	1,20E-04	1,20E-04
Municipal waste	kg	0,10 €	0,47 €	0,02 €	0,08 €	0,08 €	0,40 €	1,76E-04	8,38E-04
Hazardous waste	kg	0,03 €	0,15 €	0,00 €	0,00 €	0,03 €	0,15 €	6,69E-05	3,18E-04
total external cost	**Euros**	**18,72 €**	**47,90 €**	**10,43 €**	**26,97 €**	**8,00 €**	**21,22 €**	**1,69E-02**	**4,48E-02**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg - **Recycling substitution factor=1**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	225,88 €	570,65 €	280,73 €	709,20 €	-138,55 €	-54,84 €	-2,92E-01	-1,16E-01
Air acidification	g SO_2 eq.	11,47 €	114,74 €	14,63 €	146,33 €	-31,59 €	-3,16 €	-6,66E-02	-6,66E-03
Photochemical oxidation	g ethylene eq.	2,94 €	3,75 €	3,77 €	4,80 €	-1,05 €	-0,83 €	-2,22E-03	-1,75E-03
Eutrophication	g PO4 eq.	14,06 €	14,06 €	17,93 €	17,93 €	-3,87 €	-3,87 €	-8,17E-03	-8,17E-03
Municipal waste	kg	2,02 €	9,58 €	2,48 €	11,77 €	-2,19 €	-0,46 €	-4,62E-03	-9,72E-04
Hazardous waste	kg	0,11 €	0,51 €	0,13 €	0,63 €	-0,12 €	-0,03 €	-2,58E-04	-5,43E-05
total external cost	**Euros**	**256,48 €**	**713,29 €**	**319,67 €**	**890,66 €**	**-177,38 €**	**-63,19 €**	**-3,74E-01**	**-1,33E-01**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg- **Gasification (SVZ) plant (after shredding&substitution=methanol from waste oil)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	13,54 €	34,21 €	11,52 €	29,09 €	2,03 €	5,12 €	4,28E-03	1,08E-02
Air acidification	g SO_2 eq.	0,05 €	0,52 €	0,17 €	1,70 €	-1,18 €	-0,12 €	-2,48E-04	-2,48E-03
Photochemical oxidation	g ethylene eq.	0,01 €	0,01 €	0,03 €	0,04 €	-0,03 €	-0,03 €	-5,40E-05	-6,88E-05
Eutrophication	g PO4 eq.	0,09 €	0,09 €	0,16 €	0,16 €	-0,07 €	-0,07 €	-1,51E-04	-1,51E-04
Municipal waste	kg	0,00 €	0,02 €	0,03 €	0,15 €	-0,13 €	-0,03 €	-5,81E-05	-2,76E-04
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,00 €	0,00 €	0,00 €	1,90E-06	9,02E-06
total external cost	**Euros**	**13,69 €**	**34,85 €**	**11,91 €**	**31,14 €**	**0,62 €**	**4,88 €**	**3,77E-03**	**7,83E-03**

Flow	Units	Hub cap in PA 6,6- GF (15% GF), LCA Fraunhofer - 0.474 kg- **Landfill**			
		1000 pieces		**1kg**	
		Landfill		**Landfill**	
		Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	2,14 €	5,40 €	4,51E-03	1,14E-02
Air acidification	g SO_2 eq.	0,10 €	1,04 €	2,19E-04	2,19E-03
Photochemical oxidation	g ethylene eq.	0,03 €	0,03 €	5,31E-05	6,76E-05
Eutrophication	g PO4 eq.	0,62 €	0,62 €	1,31E-03	1,31E-03
Municipal waste	kg	1,90 €	9,01 €	4,00E-03	1,90E-02
Hazardous waste	kg	0,00 €	0,00 €	1,69E-11	8,02E-11
total external cost	**Euros**	**4,78 €**	**16,10 €**	**1,01E-02**	**3,40E-02**

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **blast furnace (substitution=heavy oil)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	101,68 €	256,86 €	104,70 €	264,50 €	-7,64 €	-3,02 €	-1,55E-03	-6,13E-04
Air acidification	g SO_2 eq.	2,07 €	20,66 €	2,29 €	22,93 €	-2,27 €	-0,23 €	-4,61E-04	-4,61E-05
Photochemical oxidation	g ethylene eq.	2,90 €	3,70 €	4,17 €	5,32 €	-1,62 €	-1,27 €	-3,29E-04	-2,58E-04
Eutrophication	g PO4 eq.	1,94 €	1,94 €	1,49 €	1,49 €	0,45 €	0,45 €	9,13E-05	9,13E-05
Municipal waste	kg	0,00 €	0,01 €	0,01 €	0,05 €	-0,04 €	-0,01 €	-8,33E-06	-1,75E-06
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,00 €	0,00 €	0,01 €	4,50E-07	2,14E-06
total external costs	Euros	108,58 €	283,17 €	112,66 €	294,29 €	-11,12 €	-4,07 €	-2,26E-03	-8,26E-04

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	198,50 €	501,47 €	77,03 €	194,61 €	121,47 €	306,87 €	2,46E-02	6,22E-02
Air acidification	g SO_2 eq.	0,68 €	6,83 €	-8,27 €	-0,83 €	1,51 €	15,11 €	3,06E-04	3,06E-03
Photochemical oxidation	g ethylene eq.	0,09 €	0,12 €	-1,24 €	-0,97 €	1,07 €	1,36 €	2,16E-04	2,75E-04
Eutrophication	g PO4 eq.	1,19 €	1,19 €	0,25 €	0,25 €	0,94 €	0,94 €	1,90E-04	1,90E-04
Municipal waste	kg	0,00 €	0,01 €	-1,02 €	-0,21 €	0,22 €	1,02 €	4,37E-05	2,08E-04
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,00 €	0,00 €	0,01 €	2,50E-07	1,19E-06
total external costs	Euros	200,47 €	509,64 €	66,76 €	192,85 €	125,20 €	325,30 €	0,03 €	0,07 €

Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Cement kiln (substitution=hard coal)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	306,84 €	775,19 €	446,20 €	1 127,24 €	-352,05 €	-139,35 €	-7,14E-02	-2,83E-02
Air acidification	g SO_2 eq.	9,74 €	97,38 €	9,87 €	98,66 €	-1,28 €	-0,13 €	-2,60E-04	-2,60E-05
Photochemical oxidation	g ethylene eq.	1,44 €	1,84 €	1,96 €	2,49 €	-0,66 €	-0,51 €	-1,33E-04	-1,04E-04
Eutrophication	g PO4 eq.	3,05 €	3,05 €	2,80 €	2,80 €	0,26 €	0,26 €	5,23E-05	5,23E-05
Municipal waste	kg	0,00 €	0,00 €	0,00 €	0,02 €	-0,02 €	0,00 €	-4,04E-06	-8,51E-07
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	1,30E-10	6,15E-10
total external costs	Euros	321,08 €	877,46 €	460,82 €	1 231,20 €	-353,75 €	-139,74 €	-0,07 €	-0,03 €

Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - MS**WI (electricity+steam)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	301,60 €	761,94 €	178,35 €	450,57 €	123,25 €	311,38 €	2,50E-02	6,32E-02
Air acidification	g SO_2 eq.	0,11 €	1,11 €	1,79 €	17,90 €	-16,79 €	-1,68 €	-3,41E-03	-3,41E-04
Photochemical oxidation	g ethylene eq.	0,11 €	0,14 €	0,86 €	1,10 €	-0,96 €	-0,75 €	-1,94E-04	-1,53E-04
Eutrophication	g PO4 eq.	0,23 €	0,23 €	1,44 €	1,44 €	-1,21 €	-1,21 €	-2,46E-04	-2,46E-04
Municipal waste	kg	0,00 €	0,00 €	0,29 €	1,35 €	-1,35 €	-0,29 €	-2,75E-04	-5,78E-05
Hazardous waste	kg	0,06 €	0,29 €	0,00 €	0,00 €	0,06 €	0,29 €	1,25E-05	5,93E-05
total external costs	Euros	302,12 €	763,71 €	182,73 €	472,36 €	103,00 €	307,74 €	0,02 €	0,06 €

Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Recycling Substitution factor=1**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	95,72 €	241,81 €	188,67 €	476,63 €	-234,82 €	-92,95 €	-4,76E-02	-1,89E-02
Air acidification	g SO_2 eq.	1,67 €	16,70 €	14,00 €	140,01 €	-123,32 €	-12,33 €	-2,50E-02	-2,50E-03
Photochemical oxidation	g ethylene eq.	0,58 €	0,74 €	3,17 €	4,04 €	-3,30 €	-2,59 €	-6,70E-04	-5,26E-04
Eutrophication	g PO4 eq.	2,70 €	2,70 €	8,61 €	8,61 €	-5,91 €	-5,91 €	-1,20E-03	-1,20E-03
Municipal waste	kg	0,06 €	0,27 €	0,45 €	2,12 €	-1,85 €	-0,39 €	-3,76E-04	-7,92E-05
Hazardous waste	kg	0,03 €	0,13 €	0,19 €	0,92 €	-0,78 €	-0,17 €	-1,59E-04	-3,35E-05
total external costs	Euros	100,75 €	262,34 €	215,09 €	632,33 €	-369,99 €	-114,34 €	-0,08 €	-0,02 €

Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **blast furnace (substitution=hard coal)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	146,61 €	370,39 €	174,09 €	439,81 €	-69,41 €	-27,48 €	-1,41E-02	-5,57E-03
Air acidification	g SO_2 eq.	1,03 €	10,28 €	0,69 €	6,90 €	0,34 €	3,37 €	6,85E-05	6,85E-04
Photochemical oxidation	g ethylene eq.	1,21 €	1,54 €	1,57 €	1,99 €	-0,45 €	-0,35 €	-9,14E-05	-7,17E-05
Eutrophication	g PO4 eq.	1,24 €	1,24 €	0,41 €	0,41 €	0,83 €	0,83 €	1,69E-04	1,69E-04
Municipal waste	kg	0,01 €	0,04 €	0,02 €	0,11 €	-0,06 €	-0,01 €	-1,24E-05	-2,61E-06
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,00 €	0,00 €	0,01 €	4,50E-07	2,14E-06
total external costs	Euros	150,10 €	383,51 €	176,77 €	449,21 €	-68,75 €	-23,63 €	-0,01 €	0,00 €

Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Gasification (SVZ) plant (after shredding&substitution=methanol from waste oil)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	198,50 €	501,47 €	213,47 €	539,30 €	-37,82 €	-14,97 €	-7,67E-03	-3,04E-03
Air acidification	g SO_2 eq.	0,68 €	6,84 €	3,14 €	31,44 €	-24,60 €	-2,46 €	-4,99E-03	-4,99E-04
Photochemical oxidation	g ethylene eq.	0,09 €	0,12 €	0,63 €	0,81 €	-0,69 €	-0,54 €	-1,40E-04	-1,10E-04
Eutrophication	g PO4 eq.	1,19 €	1,19 €	2,93 €	2,93 €	-1,74 €	-1,74 €	-3,53E-04	-3,53E-04
Municipal waste	kg	0,00 €	0,01 €	0,58 €	2,74 €	-2,74 €	-0,58 €	-5,55E-04	-1,17E-04
Hazardous waste	kg	0,00 €	0,01 €	0,00 €	0,02 €	-0,01 €	0,00 €	-2,13E-06	-4,48E-07
total external costs	Euros	200,47 €	509,64 €	220,76 €	577,24 €	-67,61 €	-20,29 €	-0,01 €	0,00 €

Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Cement kiln (substitution=brown coal)**

		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	306,84 €	775,19 €	463,25 €	1 170,32 €	-395,13 €	-156,41 €	-8,01E-02	-3,17E-02
Air acidification	g SO_2 eq.	9,74 €	97,38 €	10,40 €	104,04 €	-6,67 €	-0,67 €	-1,35E-03	-1,35E-04
Photochemical oxidation	g ethylene eq.	1,44 €	1,84 €	1,44 €	1,84 €	0,00 €	0,00 €	-3,77E-07	-2,96E-07
Eutrophication	g PO4 eq.	3,05 €	3,05 €	3,27 €	3,27 €	-0,22 €	-0,22 €	-4,39E-05	-4,39E-05
Municipal waste	kg	0,00 €	0,00 €	0,63 €	3,01 €	-3,01 €	-0,63 €	-6,10E-04	-1,29E-04
Hazardous waste	kg	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	0,00 €	-7,83E-10	-1,65E-10
total external costs	Euros	321,08 €	877,45 €	479,00 €	1 282,48 €	-405,03 €	-157,92 €	-0,08 €	-0,03 €

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - MS**WI - sensitivity analysis (steam)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	301,60 €	761,94 €	273,39 €	690,66 €	28,21 €	71,28 €	5,72E-03	1,45E-02
Air acidification	g SO_2 eq.	0,11 €	1,11 €	3,09 €	30,87 €	-29,76 €	-2,98 €	-6,04E-03	-6,04E-04
Photochemical oxidation	g ethylene eq.	0,11 €	0,14 €	1,68 €	2,14 €	-2,00 €	-1,57 €	-4,05E-04	-3,18E-04
Eutrophication	g PO4 eq.	0,23 €	0,23 €	2,44 €	2,44 €	-2,21 €	-2,21 €	-4,48E-04	-4,48E-04
Municipal waste	kg	0,00 €	0,00 €	0,63 €	2,97 €	-2,97 €	-0,63 €	-6,03E-04	-1,27E-04
Hazardous waste	kg	0,06 €	0,29 €	0,00 €	0,00 €	0,06 €	0,29 €	1,25E-05	5,93E-05
total external costs	Euros	302,11 €	763,71 €	281,22 €	729,08 €	-8,66 €	64,19 €	0,00 €	0,01 €

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - MS**WI (electricity)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	301,60 €	761,94 €	102,01 €	257,71 €	199,59 €	504,23 €	4,05E-02	1,02E-01
Air acidification	g SO_2 eq.	0,11 €	1,11 €	0,74 €	7,45 €	-6,34 €	-0,63 €	-1,29E-03	-1,29E-04
Photochemical oxidation	g ethylene eq.	0,11 €	0,14 €	0,21 €	0,26 €	-0,12 €	-0,09 €	-2,43E-05	-1,91E-05
Eutrophication	g PO4 eq.	0,23 €	0,23 €	0,64 €	0,64 €	-0,41 €	-0,41 €	-8,30E-05	-8,30E-05
Municipal waste	kg	0,00 €	0,00 €	0,01 €	0,04 €	-0,04 €	-0,01 €	-8,88E-06	-1,87E-06
Hazardous waste	kg	0,06 €	0,29 €	0,00 €	0,00 €	0,06 €	0,29 €	1,25E-05	5,93E-05
total external costs	Euros	302,11 €	763,71 €	103,61 €	266,10 €	192,74 €	503,38 €	0,04 €	0,10 €

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Gasification (SVZ) plant (after dismantling&substitution=methanol from 73.4% from natural gas, 22.1% from waste oil, and 4.5% from brown coal)**							
		1000 pieces						**1 kg**	
		Total (P+E+T)		**Total avoided**		**Total**		**Total**	
		Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	194,74 €	491,97 €	61,70 €	155,88 €	133,04 €	336,10 €	2,70E-02	6,82E-02
Air acidification	g SO_2 eq.	1,69 €	16,95 €	-2,60 €	-0,26 €	1,96 €	19,55 €	3,97E-04	3,97E-03
Photochemical oxidation	g ethylene eq.	0,53 €	0,67 €	-0,57 €	-0,45 €	0,97 €	1,24 €	1,97E-04	2,51E-04
Eutrophication	g PO4 eq.	2,90 €	2,90 €	0,28 €	0,28 €	2,61 €	2,61 €	5,30E-04	5,30E-04
Municipal waste	kg	0,14 €	0,66 €	-0,46 €	-0,10 €	0,24 €	1,12 €	4,77E-05	2,27E-04
Hazardous waste	kg	0,06 €	0,29 €	0,00 €	0,00 €	0,06 €	0,29 €	1,22E-05	5,82E-05
total external costs	Euros	200,06 €	513,44 €	58,35 €	155,36 €	138,87 €	360,91 €	0,03 €	0,07 €

Flow	Units	Bumper in PP/EPDM, LCA Fraunhofer -4.93 kg - **Landfill**			
		1000 pieces		**1 kg**	
		Landfill		**Landfill**	
		Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	34,10 €	86,16 €	6,92E-03	1,75E-02
Air acidification	g SO_2 eq.	0,09 €	0,89 €	1,81E-05	1,81E-04
Photochemical oxidation	g ethylene eq.	0,40 €	0,51 €	8,15E-05	1,04E-04
Eutrophication	g PO4 eq.	0,16 €	0,16 €	3,20E-05	3,20E-05
Municipal waste	kg	19,74 €	93,75 €	4,00E-03	1,90E-02
Hazardous waste	kg	0,00 €	0,00 €	1,69E-11	8,04E-11
total external costs	Euros	54,49 €	181,47 €	0,01 €	0,04 €

Flow	Units	Wash fluid tank and lid in **PE**, LCA Oeko-Institute - 0,43 kg **1 kg** **landfill**		Wash fluid tank and lid in **PE**, LCA Oeko-Institute - 0,43 kg **1 kg** **waste incin.**		Wash fluid tank and lid in **PE**, LCA Oeko-Institute - 0,43 kg **1 kg** **cement kiln**		Wash fluid tank and lid in **PE**, LCA Oeko-Institute - 0,43 kg **1 kg** **syngas**		Wash fluid tank and lid in **PE**, LCA Oeko-Institute - 0,43 kg **1 kg** **blast furnace**		Wash fluid tank and lid in **PE**, LCA Oeko-Institute - 0,43 kg **1 kg** **mech. recyc.**	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,19E-04	1,56E-03	2,93E-02	7,39E-02	-5,30E-02	-2,10E-02	-7,81E-03	-3,09E-03	-8,04E-03	-3,18E-03	-5,02E-02	-1,99E-02
Air acidification	g SO_2 eq.	3,06E-05	3,06E-04	4,75E-05	4,75E-04	3,40E-05	3,40E-04	-1,67E-02	-1,67E-03	-4,65E-03	-4,65E-04	-2,33E-02	-2,33E-03
Photochemical oxidation	g ethylene eq.	1,70E-05	2,16E-05	-1,08E-04	-8,49E-05	0,00E+00	0,00E+00	-8,00E-04	-6,28E-04	-2,38E-04	-1,87E-04	-1,99E-03	-1,56E-03
Eutrophication	g PO4 eq.	2,84E-04	2,84E-04	4,05E-04	4,05E-04	1,39E-04	1,39E-04	-1,57E-03	-1,57E-03	-2,15E-04	-2,15E-04	-1,41E-03	-1,41E-03
Municipal waste	kg	4,00E-03	1,90E-02	-1,33E-03	-2,79E-04	-8,84E-04	-1,86E-04	-1,77E-03	-3,72E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Hazardous waste	kg			0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
total external cost	Euros	0,00 €	0,02 €	0,03 €	0,07 €	-0,05 €	-0,02 €	-0,03 €	-0,01 €	-0,01 €	0,00 €	-0,08 €	-0,03 €

Flow	Units	Intake manifold in **PA** (filler: 30% glass fibre), LCA Oeko Institute - 0,72 kg **1 kg** **landfill**		Intake manifold in **PA** (filler: 30% glass fibre), LCA Oeko Institute - 0,72 kg **1 kg** **waste incin.**		Intake manifold in **PA** (filler: 30% glass fibre), LCA Oeko Institute - 0,72 kg **1 kg** **cement kiln**		Intake manifold in **PA** (filler: 30% glass fibre), LCA Oeko Institute - 0,72 kg **1 kg** **syngas**		Intake manifold in **PA** (filler: 30% glass fibre), LCA Oeko Institute - 0,72 kg **1 kg** **blast furnace**		Intake manifold in **PA** (filler: 30% glass fibre), LCA Oeko Institute - 0,72 kg **1 kg** **mech. recyc.**	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,33E-04	1,60E-03	1,60E-02	4,03E-02	-1,77E-02	-7,02E-03	5,54E-04	1,40E-03	1,21E-03	3,07E-03	-2,80E-01	-1,11E-01
Air acidification	g SO_2 eq.	2,03E-06	2,03E-05	-8,11E-05	-8,11E-06	6,08E-06	6,08E-05	-6,08E-04	-6,08E-05	-1,01E-04	-1,01E-05	-3,49E-03	-3,49E-04
Photochemical oxidation	g ethylene eq.	1,01E-04	1,29E-04	2,03E-04	2,58E-04	6,08E-04	7,75E-04	-5,04E-03	-3,95E-03	-6,46E-04	-5,07E-04	-3,33E-02	-2,62E-02
Eutrophication	g PO4 eq.	2,81E-04	2,81E-04	2,18E-04	2,18E-04	2,08E-04	2,08E-04	-7,39E-04	-7,39E-04	5,90E-05	5,90E-05	-7,13E-03	-7,13E-03
Municipal waste	kg	4,00E-03	1,90E-02	8,89E-04	4,22E-03	-7,39E-03	-1,56E-03	-5,28E-04	-1,11E-04	1,11E-04	5,28E-04	-2,64E-04	-5,56E-05
Hazardous waste	kg			1,67E-04	7,92E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-2,64E-04	-5,56E-05
total external cost	Euros	0,01 €	0,02 €	0,02 €	0,05 €	-0,02 €	-0,01 €	-0,01 €	0,00 €	0,00 €	0,00 €	-0,32 €	-0,14 €

		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg		Headlamp lens in **PC**, LCA Oeko-Institute - 0,30 kg	
		1 kg		**1 kg**		**1 kg**		**1 kg**		**1 kg**		**1 kg**	
		landfill		**waste incin.**		**cement kiln**		**syngas**		**blast furnace**		**mech. recyc.**	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Flow	Units												
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,33E-04	1,60E-03	2,20E-02	5,55E-02	6,33E-05	1,60E-04	7,22E-03	1,82E-02	2,09E-03	5,28E-03	-1,42E-01	-5,62E-02
Air acidification	g SO_2 eq.	2,92E-05	2,92E-04	3,89E-05	3,89E-04	1,17E-04	1,17E-03	-7,54E-03	-7,54E-04	-7,79E-04	-7,79E-05	-2,34E-02	-2,34E-03
Photochemical oxidation	g ethylene eq.	0,00E+00	0,00E+00	-3,10E-05	-2,43E-05	2,43E-05	3,10E-05	-3,72E-04	-2,92E-04	-6,20E-05	-4,87E-05	-1,49E-03	-1,17E-03
Eutrophication	g PO4 eq.	2,82E-04	2,82E-04	2,24E-04	2,24E-04	2,13E-04	2,13E-04	-7,05E-04	-7,05E-04	7,28E-05	7,28E-05	-2,50E-03	-2,50E-03
Municipal waste	kg	4,00E-03	1,90E-02	9,33E-04	4,43E-03	0,00E+00	0,00E+00	-6,33E-04	-1,33E-04	1,33E-04	6,33E-04	2,67E-04	1,27E-03
Hazardous waste	kg			1,33E-04	6,33E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
total external cost	Euros	0,00 €	0,02 €	0,02 €	0,06 €	0,00 €	0,00 €	0,00 €	0,02 €	0,00 €	0,01 €	-0,17 €	-0,06 €

		Seat cushion in **PUR**, LCA Oeko-Institute - 1,20 kg		Seat cushion in **PUR**, LCA Oeko-Institute - 1,20 kg		Seat cushion in **PUR**, LCA Oeko-Institute - 1,20 kg		Seat cushion in **PUR**, LCA Oeko-Institute - 1,20 kg		Seat cushion in **PUR**, LCA Oeko-Institute - 1,20 kg		Seat cushion in **PUR**, LCA Oeko-Institute - 1,20 kg	
		1 kg		**1 kg**		**1 kg**		**1 kg**		**1 kg**		**1 kg**	
		landfill		**waste incin.**		**cement kiln**		**syngas**		**blast furnace**		**mech. recyc.**	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Flow	Units												
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,97E-04	1,76E-03	2,44E-02	6,16E-02	-1,49E-02	-5,89E-03	1,26E-02	3,17E-02	-4,24E-03	-1,68E-03	-9,80E-02	-3,88E-02
Air acidification	g SO_2 eq.	3,65E-05	3,65E-04	3,65E-05	3,65E-04	9,73E-05	9,73E-04	-3,65E-03	-3,65E-04	-2,80E-03	-2,80E-04	-2,31E-02	-2,31E-03
Photochemical oxidation	g ethylene eq.	6,08E-06	7,75E-06	-6,20E-05	-4,87E-05	2,43E-05	3,10E-05	-6,20E-05	-4,87E-05	-1,16E-04	-9,13E-05	-8,91E-04	-7,00E-04
Eutrophication	g PO4 eq.	3,91E-05	3,91E-05	2,68E-04	2,68E-04	1,91E-04	1,91E-04	-2,06E-04	-2,06E-04	-6,71E-05	-6,71E-05	-3,64E-03	-3,64E-03
Municipal waste	kg	4,00E-03	1,90E-02	-7,92E-04	-1,67E-04	-6,97E-03	-1,47E-03	-2,85E-03	-6,00E-04	-1,58E-04	-3,33E-05	-4,75E-04	-1,00E-04
Hazardous waste	kg	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-4,75E-04	-1,00E-04
total external cost	Euros	0,00 €	0,02 €	0,02 €	0,06 €	-0,02 €	-0,01 €	0,01 €	0,03 €	-0,01 €	0,00 €	-0,13 €	-0,05 €

		Air duct in **PP** (20% talcum), LCA Oeko-Institute - 0,95kg		Air duct in **PP** (20% talcum), LCA Oeko-Institute - 0,95kg		Air duct in **PP** (20% talcum), LCA Oeko-Institute - 0,95kg		Air duct in **PP** (20% talcum), LCA Oeko-Institute - 0,95kg		Air duct in **PP** (20% talcum), LCA Oeko-Institute - 0,95kg		Air duct in **PP** (20% talcum), LCA Oeko-Institute - 0,95kg	
		1 kg		**1 kg**		**1 kg**		**1 kg**		**1 kg**		**1 kg**	
		landfill		**waste incin.**		**cement kiln**		**syngas**		**blast furnace**		**mech. recyc.**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,20E-04	1,57E-03	1,74E-02	4,40E-02	-2,82E-02	-1,12E-02	-3,59E-03	-1,42E-03	1,80E-04	4,55E-04	-4,49E-02	-1,78E-02
Air acidification	g SO_2 eq.	3,07E-05	3,07E-04	3,07E-05	3,07E-04	9,22E-05	9,22E-04	-9,68E-03	-9,68E-04	-1,69E-03	-1,69E-04	-1,78E-02	-1,78E-03
Photochemical oxidation	g ethylene eq.	7,68E-06	9,79E-06	-5,87E-05	-4,61E-05	2,31E-05	2,94E-05	-4,80E-04	-3,77E-04	-9,79E-05	-7,68E-05	-5,97E-04	-4,69E-04
Eutrophication	g PO4 eq.	2,83E-04	2,83E-04	2,63E-04	2,63E-04	1,95E-04	1,95E-04	-9,12E-04	-9,12E-04	3,21E-06	3,21E-06	-1,09E-03	-1,09E-03
Municipal waste	kg	4,00E-03	1,90E-02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,21E-05	2,00E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Hazardous waste	kg			2,11E-04	1,00E-03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	4,21E-05	2,00E-04	0,00E+00	0,00E+00
total external cost	Euros	0,00 €	0,02 €	0,02 €	0,05 €	-0,03 €	-0,01 €	-0,01 €	0,00 €	0,00 €	0,00 €	-0,06 €	-0,02 €

		Mirror housing in **ABS**, LCA Oeko-Institute - 0,27 kg		Mirror housing in **ABS**, LCA Oeko-Institute - 0,27 kg		Mirror housing in **ABS**, LCA Oeko-Institute - 0,27 kg		Mirror housing in **ABS**, LCA Oeko-Institute - 0,27 kg		Mirror housing in **ABS**, LCA Oeko-Institute - 0,27 kg		Mirror housing in **ABS**, LCA Oeko-Institute - 0,27 kg	
		1 kg		**1 kg**		**1 kg**		**1 kg**		**1 kg**		**1 kg**	
		landfill		**waste incin.**		**cement kiln**		**syngas**		**blast furnace**		**mech. recyc.**	
Flow	Units	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,33E-04	1,60E-03	3,18E-02	8,04E-02	-2,40E-02	-9,50E-03	5,00E-03	1,26E-02	-2,67E-03	-1,06E-03	-8,36E-02	-3,31E-02
Air acidification	g SO_2 eq.	3,24E-05	3,24E-04	4,87E-05	4,87E-04	5,95E-05	5,95E-04	-1,38E-02	-1,38E-03	-3,41E-03	-3,41E-04	-1,70E-02	-1,70E-03
Photochemical oxidation	g ethylene eq.	0,00E+00	0,00E+00	-1,03E-04	-8,11E-05	0,00E+00	0,00E+00	-6,54E-04	-5,14E-04	-1,72E-04	-1,35E-04	-1,34E-03	-1,05E-03
Eutrophication	g PO4 eq.	2,82E-04	2,82E-04	3,50E-04	3,50E-04	1,61E-04	1,61E-04	-1,29E-03	-1,29E-03	-1,25E-04	-1,25E-04	-1,74E-03	-1,74E-03
Municipal waste	kg	4,00E-03	1,90E-02	-7,04E-04	-1,48E-04	-7,04E-04	-1,48E-04	-1,41E-03	-2,96E-04	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Hazardous waste	kg			0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
total external cost	Euros	0,00 €	0,02 €	0,03 €	0,08 €	-0,02 €	-0,01 €	-0,01 €	0,01 €	-0,01 €	0,00 €	-0,10 €	-0,04 €

		Bumper in **PP**, LCA Oeko-Institute - 3.14 kg		Bumper in **PP**, LCA Oeko-Institute - 3.14 kg		Bumper in **PP**, LCA Oeko-Institute - 3.14 kg		Bumper in **PP**, LCA Oeko-Institute - 3.14 kg		Bumper in **PP**, LCA Oeko-Institute - 3.14 kg		Bumper in **PP**, LCA Oeko-Institute - 3.14 kg	
		1 kg		**1 kg**		**1 kg**		**1 kg**		**1 kg**		**1 kg**	
		landfill		**waste incin.**		**cement kiln**		**syngas**		**blast furnace**		**mech. recyc.**	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Flow	Units												
Greenhouse effect (direct, 100 yr	g CO_2 eq.	6,23E-04	1,57E-03	2,91E-02	7,35E-02	-5,28E-02	-2,09E-02	-7,75E-03	-3,07E-03	-7,95E-03	-3,15E-03	-5,91E-02	-2,34E-02
Air acidification	g SO_2 eq.	2,79E-05	2,79E-04	4,65E-05	4,65E-04	3,25E-05	3,25E-04	-1,66E-02	-1,66E-03	-4,60E-03	-4,60E-04	-2,27E-02	-2,27E-03
Photochemical oxidation	g ethylene eq.	9,30E-06	1,18E-05	-1,07E-04	-8,37E-05	-8,89E-06	-6,97E-06	-8,03E-04	-6,30E-04	-2,28E-04	-1,79E-04	-7,79E-04	-6,11E-04
Eutrophication	g PO4 eq.	2,82E-04	2,82E-04	4,03E-04	4,03E-04	1,39E-04	1,39E-04	-1,56E-03	-1,56E-03	-2,14E-04	-2,14E-04	-1,40E-03	-1,40E-03
Municipal waste	kg	4,00E-03	1,90E-02	-1,39E-03	-2,93E-04	-1,03E-03	-2,17E-04	-1,69E-03	-3,57E-04	-6,05E-05	-1,27E-05	1,27E-05	6,05E-05
Hazardous waste	kg			0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
total external cost	Euros	0,00 €	0,02 €	0,03 €	0,07 €	-0,05 €	-0,02 €	-0,03 €	-0,01 €	-0,01 €	0,00 €	-0,08 €	-0,03 €