

Life Cycle Management in bioplastics production

Francesco Degli Innocenti¹, Francesco Razza¹,
Maurizio Fieschi², Catia Bastioli¹

¹ Novamont S.p.A. Italy

² Studio Fieschi, Italy

Why bioplastics?

- Waste production is increasing at a fast rate
- Use of renewable resources is encouraged, whenever possible (global warming)
- Bio-based and biodegradable polymers are considered a promising solution

Biodegradable products already exist...



Traditional vs biodegradable & biobased products?

- Not necessarily. The advantage of one class or the other depends very much on the framework
- When are biopolymers and bio-products of benefit?

LCA is applied to compare products

- The question generally asked is:

are the biodegradable and biobased products better than the traditional ones from an environmental viewpoint?

An example

- Catering meals with disposable cutlery: is biodegradability and compostability of cutlery an advantage?



Introduction

- We have carried out a preliminary study on disposable cutlery used in fast food restaurants, canteens and town festivals.
- Disposable tableware is more and more distributed for reasons of simplification
- As a consequence there is the generation of huge amount of waste

Scope of the study

- The main scope was to evaluate the environmental consequences of using different disposable cutlery in fast food restaurants, town festivals etc.
- Different cutlery allows different waste treatment systems



Current scenario

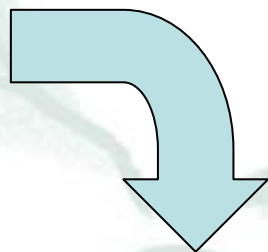
Food scraps

Plastic foam

Plastic or coated paper mug



Plastic cutlery



- the at source separate waste collection is a very difficult option in fast food restaurants and town festivals



Li



Life.



An heterogeneous waste is generated.

- **Plastic waste:** plastic cutlery, dishes, plastic or laminated paper cups, foam polystyrene containers, etc.
- +
- **Food waste:** kitchen and guests leftovers expired food, etc.

The *heterogeneous* waste cannot be recycled

- the food waste is biodegradable and compostable
- the plastic tableware is not biodegradable and compostable
- the mixed heterogeneous waste is eventually landfilled and/or incinerated.



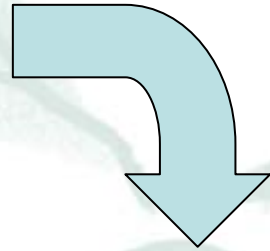
Alternative scenario

- A very interesting alternative is to only use tableware that is biodegradable and compostable (B&C), similarly to the food scraps.

Food scraps

B&C foam

B&C mug



B&C cutlery



An homogeneous waste is generated

- **B&C plastic waste**
- **Food waste**

Both fractions are compostable and can be collected as a whole *homogeneous* fraction

The homogeneous waste can be recycled

- by means of organic recovery, i.e. composting or anaerobic digestion followed by composting. Compost is a valuable soil improver.



The Study

Functional Unit

- serving 1000 meals, which generates 150 kg organic waste (on average 0,150 kg/meal) with the use of 1000 sets of disposable cutlery

Functional Unit

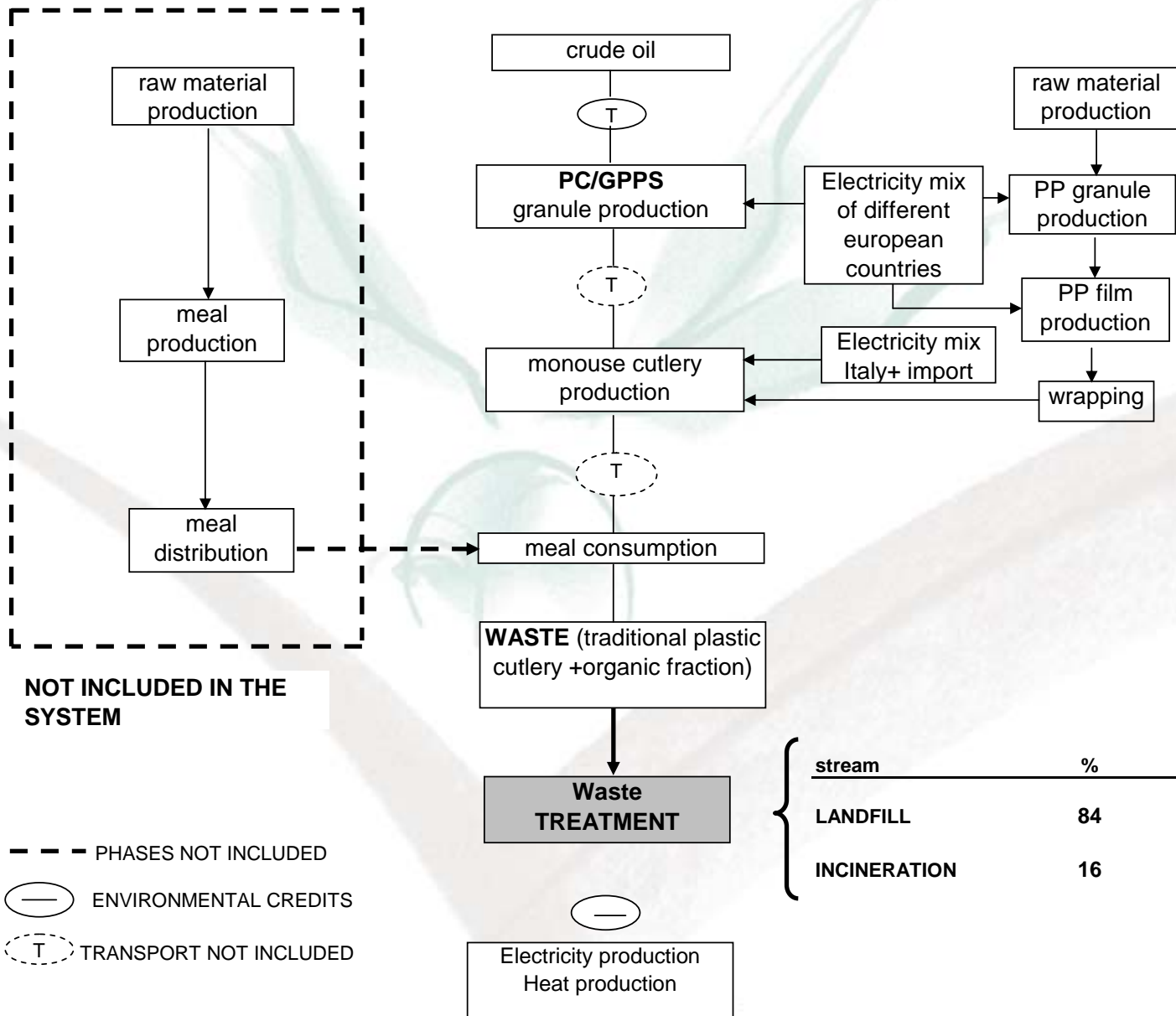
Material	mass (kg)		
	fork +knife	packaging ^a	Organic waste
Mater-Bi (YI)	15,70	1,4	150
Polycarbonate (PC)	13,68	1,2	150
General Purpose Polystyrene (GPPS)	11,78	1,2	150

a Mater-Bi cutlery packaging is made with a biodegradable Mater-Bi NF type film; in all the other cases the packaging is made with polypropylene.

CURRENT SCENARIO

- serving 1000 meals using traditional plastic cutlery
- collecting the total waste in a single heterogeneous stream
- disposing the waste by means of landfilling and incineration with energy recovery

MEAL PRODUCTION



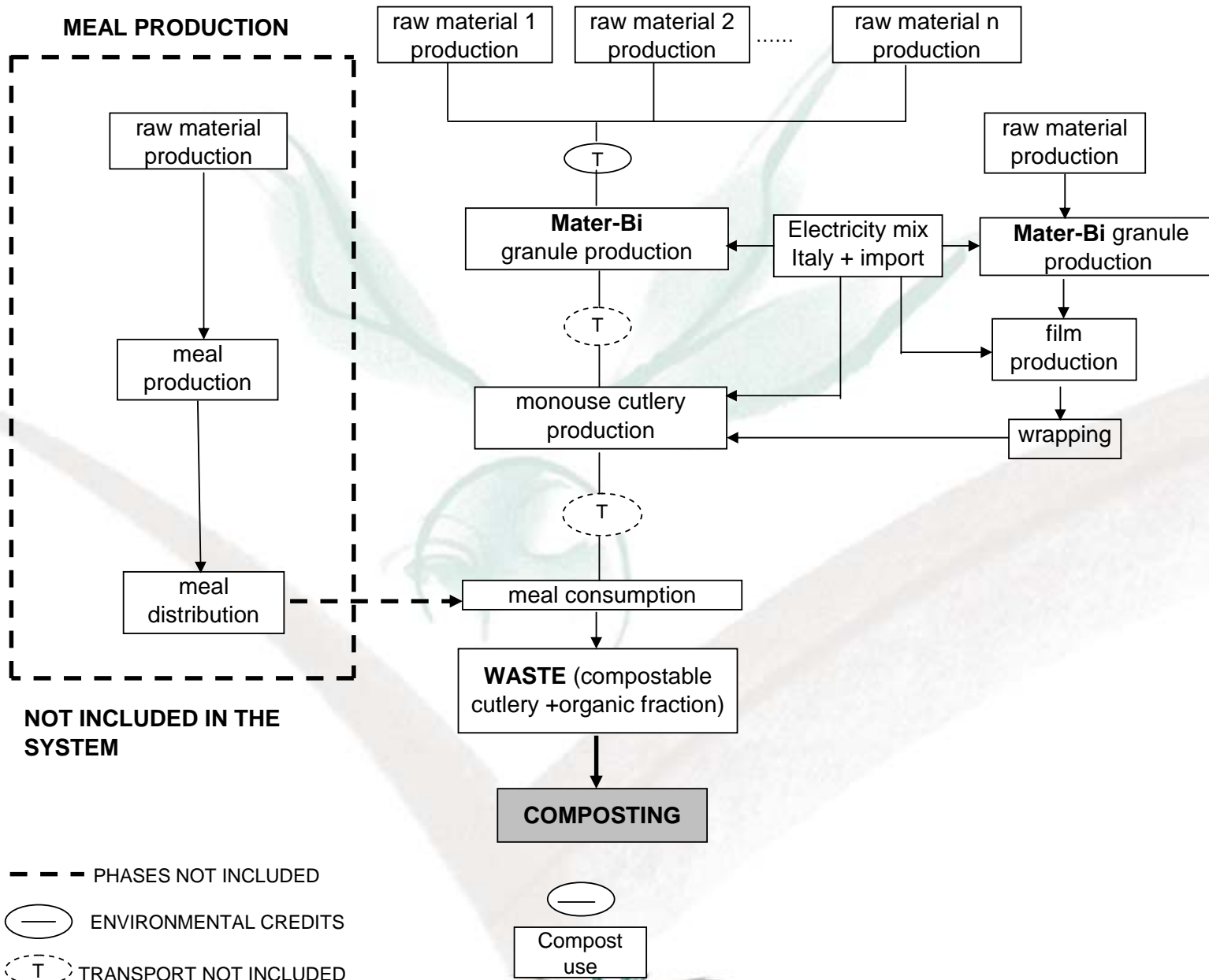
NOT INCLUDED IN THE SYSTEM

- - - PHASES NOT INCLUDED
- (—) ENVIRONMENTAL CREDITS
- (T) TRANSPORT NOT INCLUDED

stream	%
LANDFILL	84
INCINERATION	16

ALTERNATIVE SCENARIO

- serving 1000 meals using compostable disposable cutlery (Mater-Bi Y, a material containing a cellulose-based constituent and starch)
- collecting the total waste in a single homogeneous stream
- composting





Results

Life Cycle Impact Assessment (LCIA) data referring to the treatment of 150 kg organic waste.

Two different fates are compared:

1. Landfill after stabilisation and incineration in an 84:16 ratio (corresponding to the current situation in Italy).
2. Composting

LCIA results of different organic waste treatment options (food leftovers produced by serving 1000 meals)

Impact category	Unit	Composting with compost credits*	Landfill** (84%) and incineration*** (16%)
Acidifying compounds	molH ⁺ /g,max eq.	-1,97	1,28
Eutrophication comp.	g O ₂ /g,max eq.	-831	2790
Greenhouse gases	kg CO ₂ eq.	-26,5	11,1
Ozone depleting gases	kg CFC-11 eq.	-9E-07	4,8E-07
Photochemical ozone	kg C ₂ H ₄ eq	-0,00018	0,000191
Solid waste	kg	-	9,26
Resources en non ren	MJ	-912	60,8

*: Carbon sequestration, savings of N,P and K (as fertilizers), increasing water holding capacity; ** Biogas capturing = 55%; *** Energy recovery (net yield=16% of the calorific value of the feedstock material);

“Cradle to grave” LCIA results of two scenarios

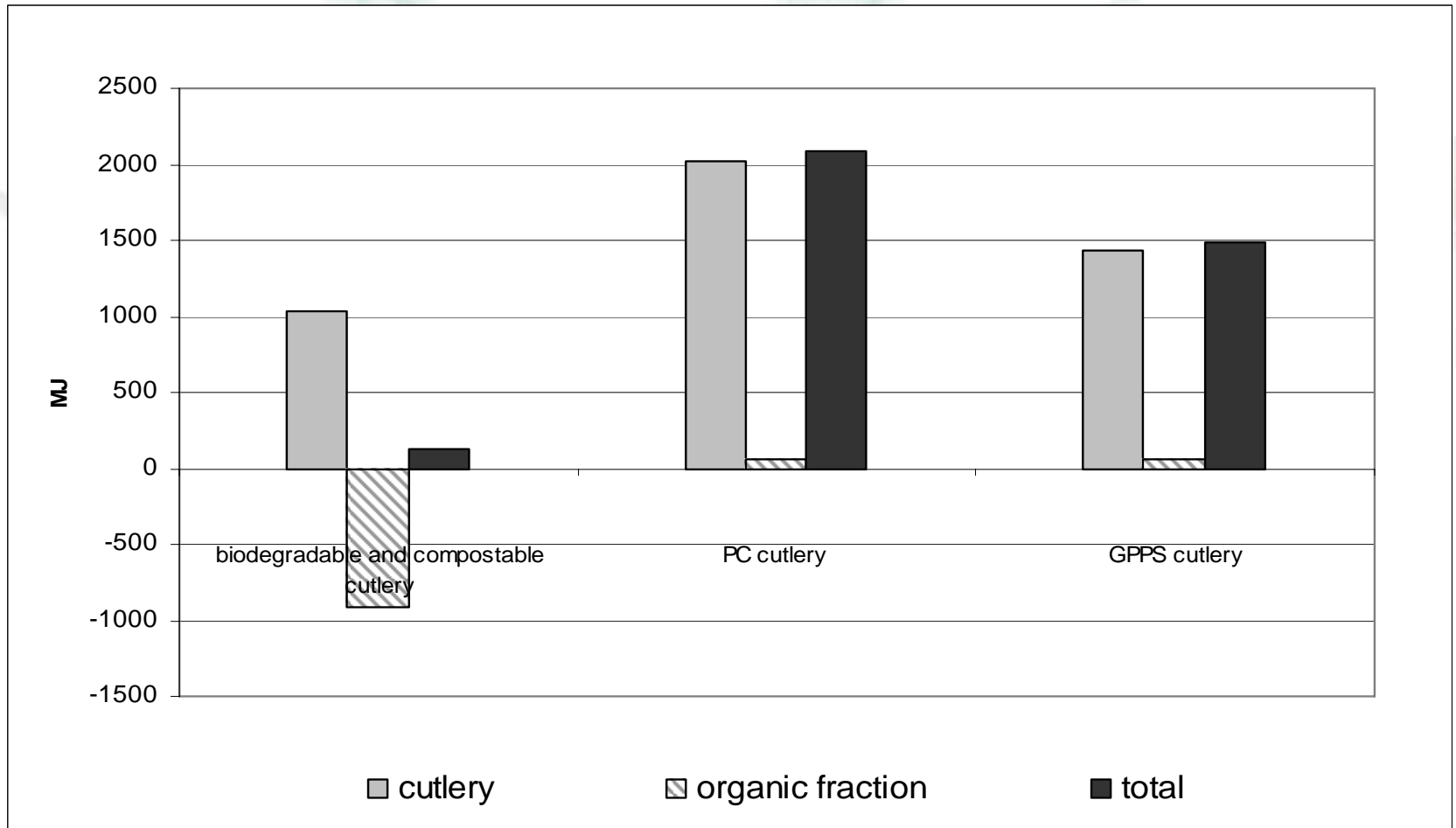
- B&C cutlery is composted together with the organic waste.
- The cutlery made with traditional plastics is disposed of with the organic waste according to the Italian scenario (landfill 84%, incineration with energy recovery 16%).

Total impact

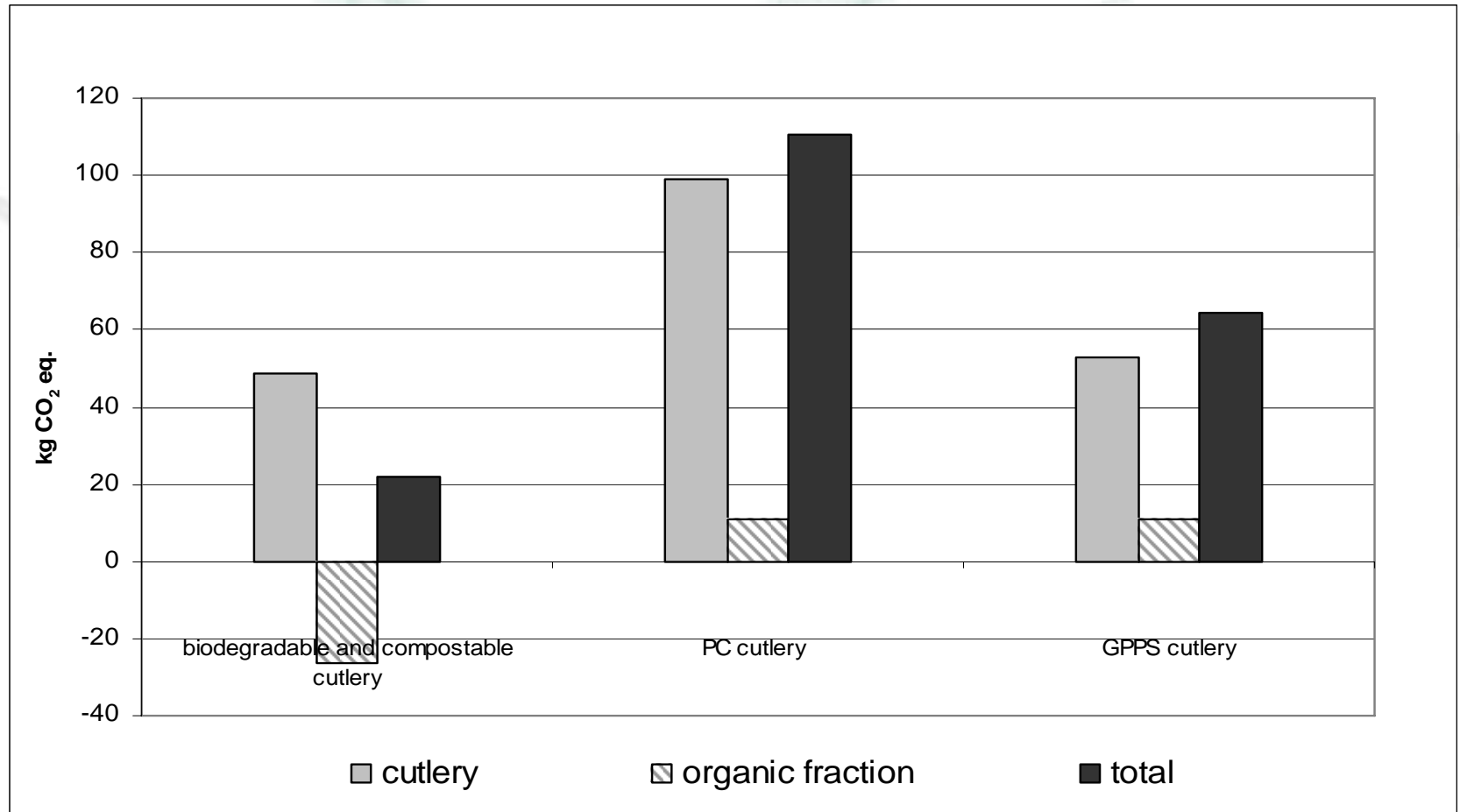
Impact category	Unit	Cutlery type Waste treatment		
		Mater-Bi composting	PC Landfill & incineration	GPPS Landfill & incineration
Acidifying compounds	molH ⁺ /g,max eq.	5,85	16,38	11,25
Eutrophicating compounds	g O ₂ /g,max eq.	789	4945	4207
Greenhouse gases	kg CO ₂ eq.	22,1	110,3	64,2
Ozone depleting gases	kg CFC-11 eq	0,00000765	0,0000025	0,0000021
Photochemical creation ozone	kg C ₂ H ₄ eq.	0,0057	0,0275	0,0022
Solid waste	Kg	0,25	24,5	21,3
Resources_en_non ren_MJ	MJ	128	2081	1491

PC=polycarbonate; GPPS=general Purpose Polystyrene

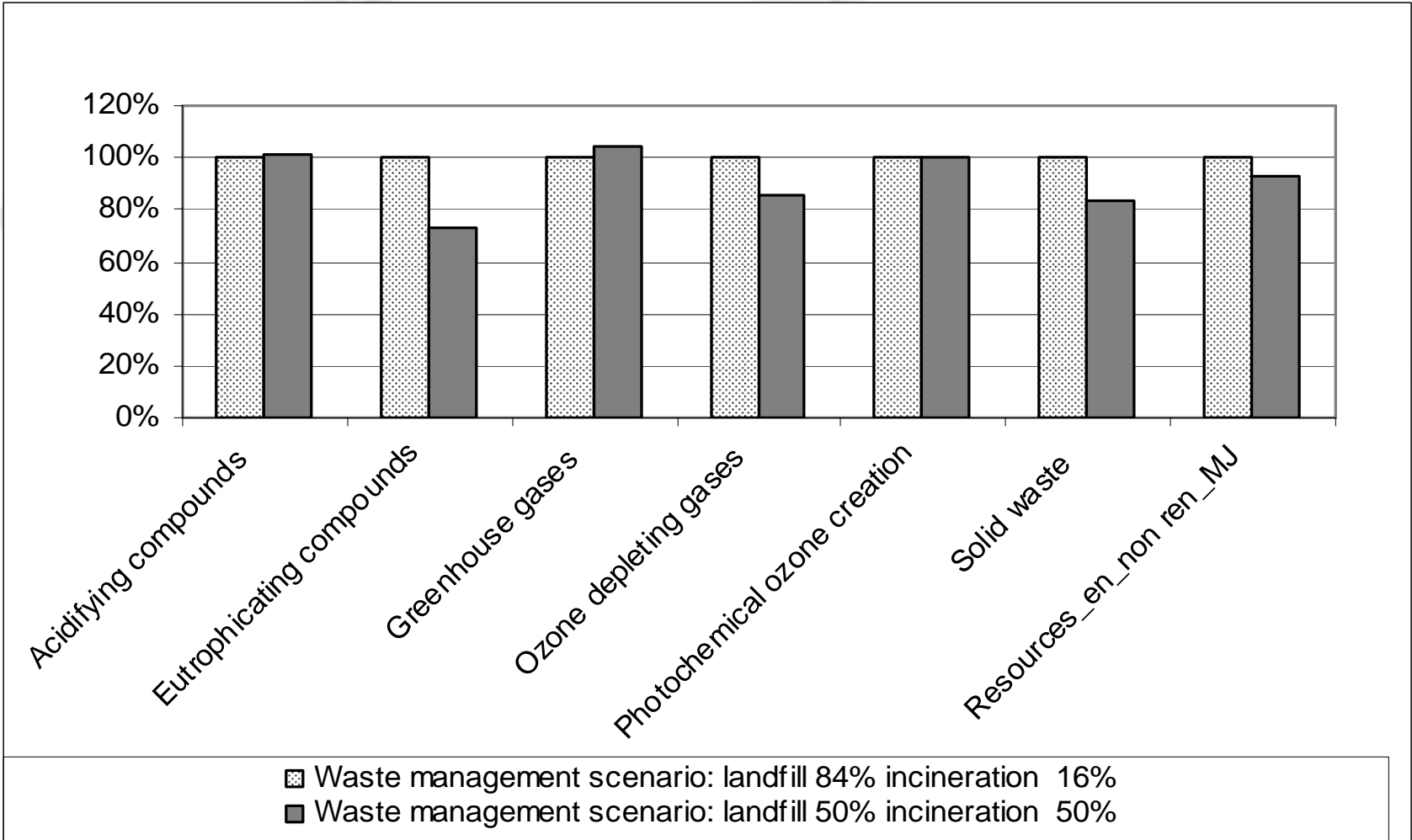
Non renewable energy (MJ) produced by serving 1000 meals either with B&C or with traditional plastic cutlery



Greenhouse gases produced by serving 1000 meals either with B&C or with traditional plastic cutlery.



Sensitivity analysis to verify the effect of a higher incidence of incineration with energy recovery. (scenario: 50% landfill and 50% incineration)





Conclusions

Composting is the favourite treatment of organic waste.

- Organic waste is rather wet (“humid fraction”). The high water content reduces the net calorific value. Landfilling of organic fraction is conducive of biogas formation
- On the other hand, composting is a real form of recycling of the organic fraction with the creation of a product whose use is particularly beneficial for the environment .

The study shows that:

- The B&C cutlery has a good environmental profile

The environmental performance of the B&C cutlery can be further on improved on condition that:

1. the mass per item (fork, knife, and spoon) is decreased, thanks to an improved design;
2. the renewable fraction is increased
3. the environmental impact of the cellulose processing phase is decreased thanks to improved green chemistry technologies.

The substantial environmental effect:

- the use of compostable cutlery makes it possible to collect the mixed waste as a *whole, homogeneous fraction*, which can be recycled through composting or anaerobic digestion followed by aerobic stabilisation.

- Two fractions which otherwise cannot be recycled can be effectively recycled and this is *the substantial environmental advantage* which the present study has quantified.

Comparison between products

The risk is to put under the microscope the single product, forgetting the interactions with the system and how the product would fit in an improved future scenario.



Many thanks for your attention!