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Environmental footprint of bio-refineries feeding with olive biomass residues and wastes

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Introduction

Biorefineries producing bioproducts and bioenergy together contribute to the more efficient use of biomass resources and increase the sustainability of the processes.

The aim of the study is to analyse the environmental impacts of two biorefineries and compare to those produced by conventional systems obtaining the same co-products, verifying the emission savings generated by the introduction of the circular economy and bioeconomy concepts. The first biorefinery approach is based in the use of biomass residues from olive tree pruning (OTP), and the other is going to use extracted olive pomace (EOP) from secondary extraction factories (olive pomace mills).

Materials & Methods

The environmental sustainability of two schemes of biorefineries is assessed applying the LCA approach By means of the Environmental Footprint (EF, ILCD impact categories [1]). The functional unit has been defined as the total amount of feedstock feeding the refinery (OTP and EOP respectively). The performance of the processes has been simulated by Aspen-Plus model on the basis on bench-scale experimental data and complementary literature data.

Land use management changes using OTP in biorefinery instead of leaving on field as inert soil coverage have been taking into account [2-3]. OTP distance transport is 15 km. EOP is considered free of previous environmental burdens. The total energy consumed in the plants are provided by the own feedstocks.

Reference systems has been defined considering the commercial existing products available in the market, which are going to be substituted by output produced in biorefineries. The counterparts are: gasoline - bioethanol, hydroquinone - antioxidants, sugarcane molasses - biorefinery sugars, soy based polyol - xylitol and electricity from Spanish mix-bioelectricity.

Life Cycle Inventory (LCI) is described in tables 1 and 2.

Inputs	Kt	Outputs	Kt
EOP	127,00	Emissions to the air	
H2SO4	7,68	N2	689,38
Ethyl acetate	0,77	Antioxidants	0,00
Ca(OH)2	4,69	H2O	691,28
Ethanol	0,04	CO2	161,10
Yeast	0,08	O2	84,80
Water	778,45	NO2	2,73
Air	898,74	SO2	0,32
		Emissions to the water	146,88
Co-products	Kt		
Xylitol	2,33	Solids to landfill	21,55
Antioxidants	10,56		
Electricity kWh	86,69		

Table 1. OTP LCI.

Inputs	Kt	Outputs	Kt
OTP	43	Emissions to the air	
Enzyme	1,89	H2O	37,65
Yeast	0,11	EtOH	0,000115
H3PO4	0,89	O2	5,70
H2SO4	0,00023	N2	98,19
Ca(OH)2	0,80	NO2	1,11
Ethyl acetate	0,14	SO2	0,04
Water	198,71		
Air	128,96		
Co-products	Kt		
Bioethanol	5,04	Emissions to the water	19,37
Antioxidants	1,70	Solids to landfill	3,39
Sugars	5,97		
Electricity kWh	16,59		

Table 2. EOP LCI.

Results & Discussion

The environmental profile of both facilities exhibits better behaviour in most of the impact categories (Figure 1). Climate change shows significant emission savings: 51% in case of OTP and 95% in EOP. Most of the impact of OTP comes from the avoided carbon sequestration as consequence of not leaving the pruning as cover crops. Emissions savings by impact categories are shown in Figure 2. OTP saves 95% of non renewable energy, while EOP reaches 98% of reduction (Figure 3).

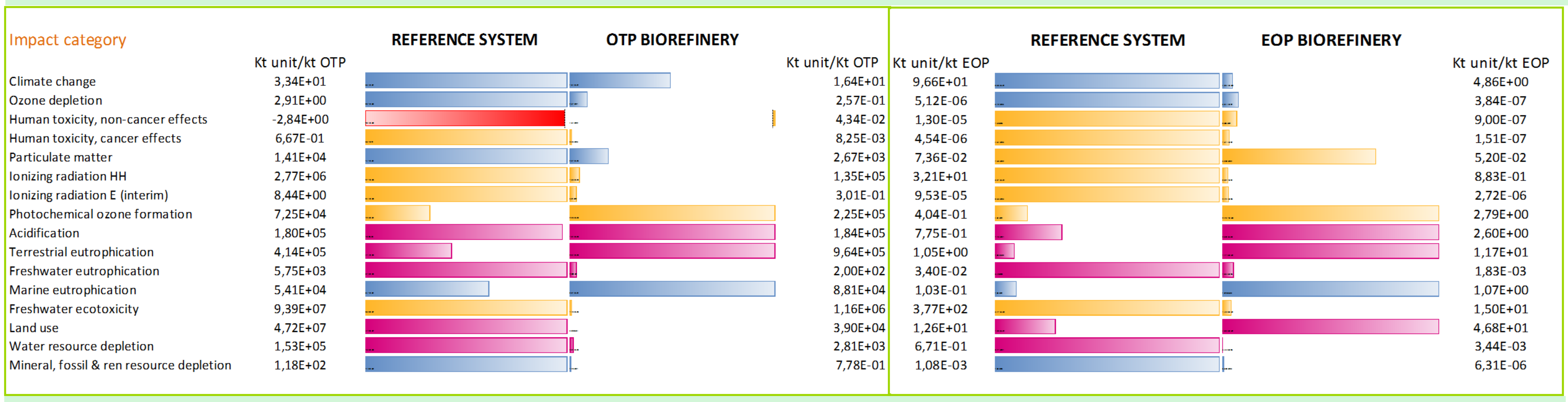

Figure 1. Comparative EF results of OTP biorefinery (left) and EOP biorefinery (right) versus corresponding reference systems.

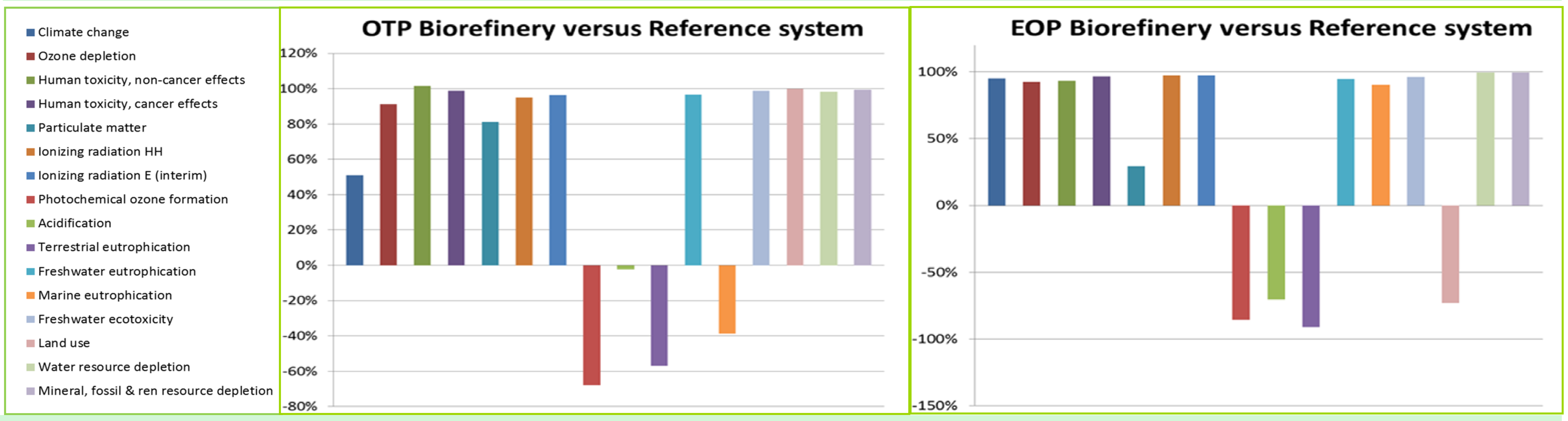

Figure 2. Emissions savings by impact categories: OTP (left) and EOP (right) biorefineries.

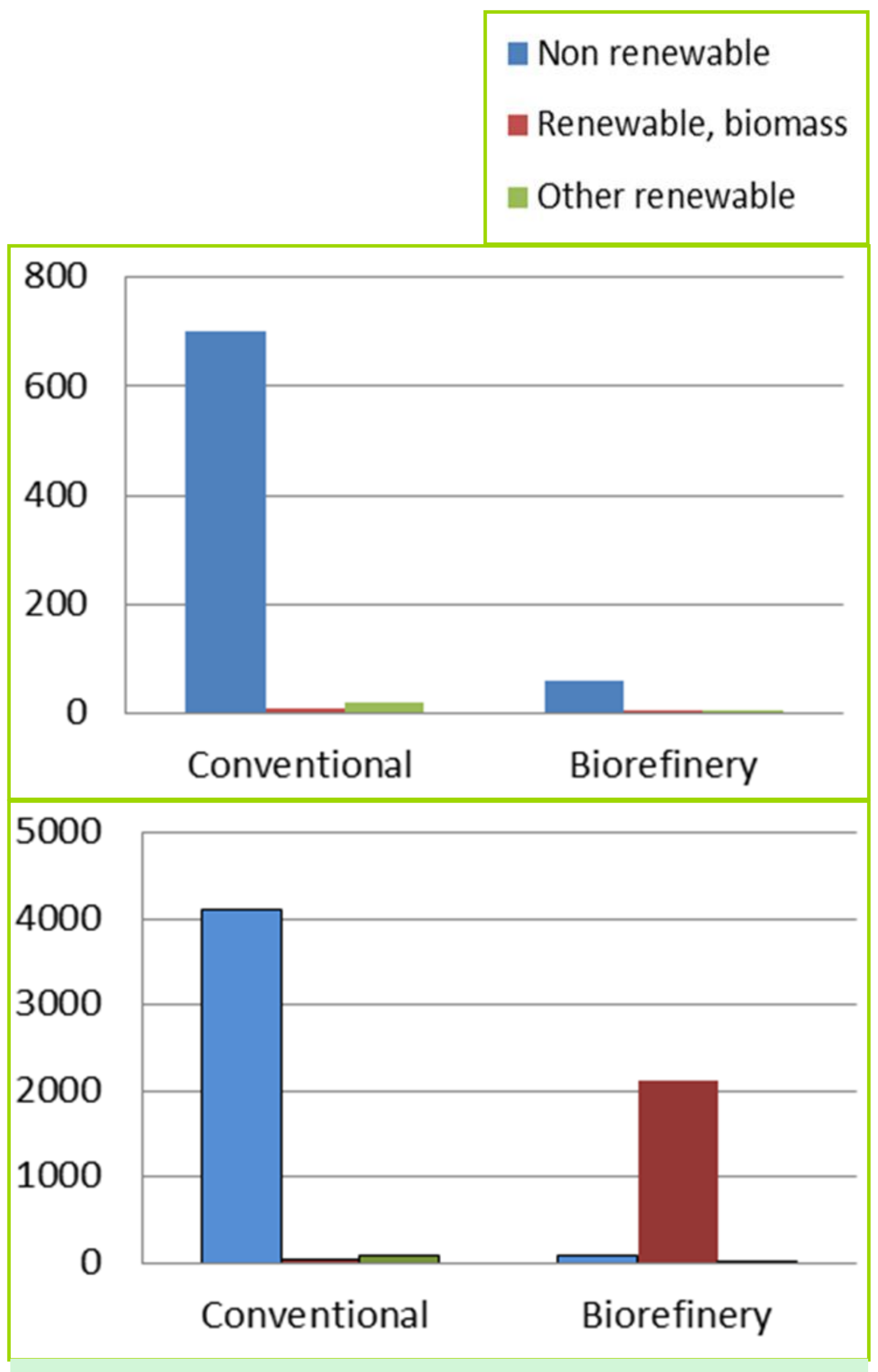

Figure 3. Cumulative energy demand (CED) results (TJ / year) of OPT (up) and EOP (down) biorefineries versus conventional reference system.

Conclusions

Biorefineries using biological biomass residues present environmental advantages in comparison to reference systems in most of the impact categories. Climate change mitigation is one of the main reasons to promote biorefineries implementation in rural areas taking advantage of both, biomass residues and wastes from agro-food industries. The transition to a low carbon economy in rural areas can be made through biorefineries deployment, among other possible pathways.

At the same time, biorefineries development can contribute to reduce country energy dependence, increasing energy security, as their energy needs are supplied with renewable energy and allow fossil energy consumption savings of around 95% compared to reference systems.

References

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