Life cycle assessment of biological and mechanical processes of valorization of absorbent hygiene products

Ing. Francesca Demichelis
Ing. Carola Martina
Prof. Tonia Tommasi
Prof. Debora Fino

Politecnico di Torino
1859

Absorbent hygiene products AHPs

In Italy are produced, consumed and disposed **1.2 Mt/y**

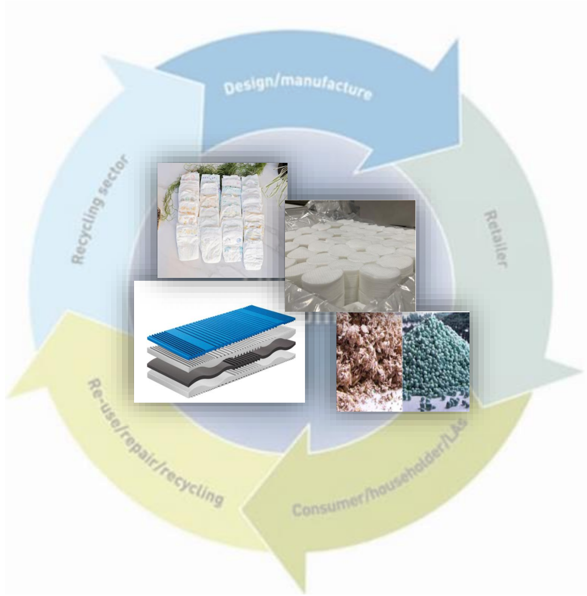
Landfill or **Incineration**

- GHGs emission;
- Space consumption;
- Economic issues.

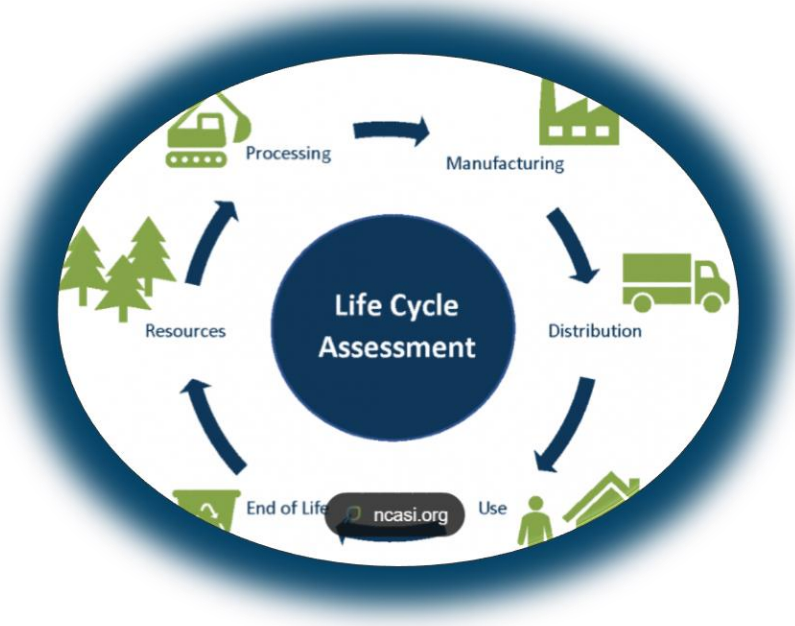
AHP are made of **valuable material**

From problem to resource

AHP are made up of **valuable materials** that can be recovered according to Circular Economy principles applying the concept of urban mining.



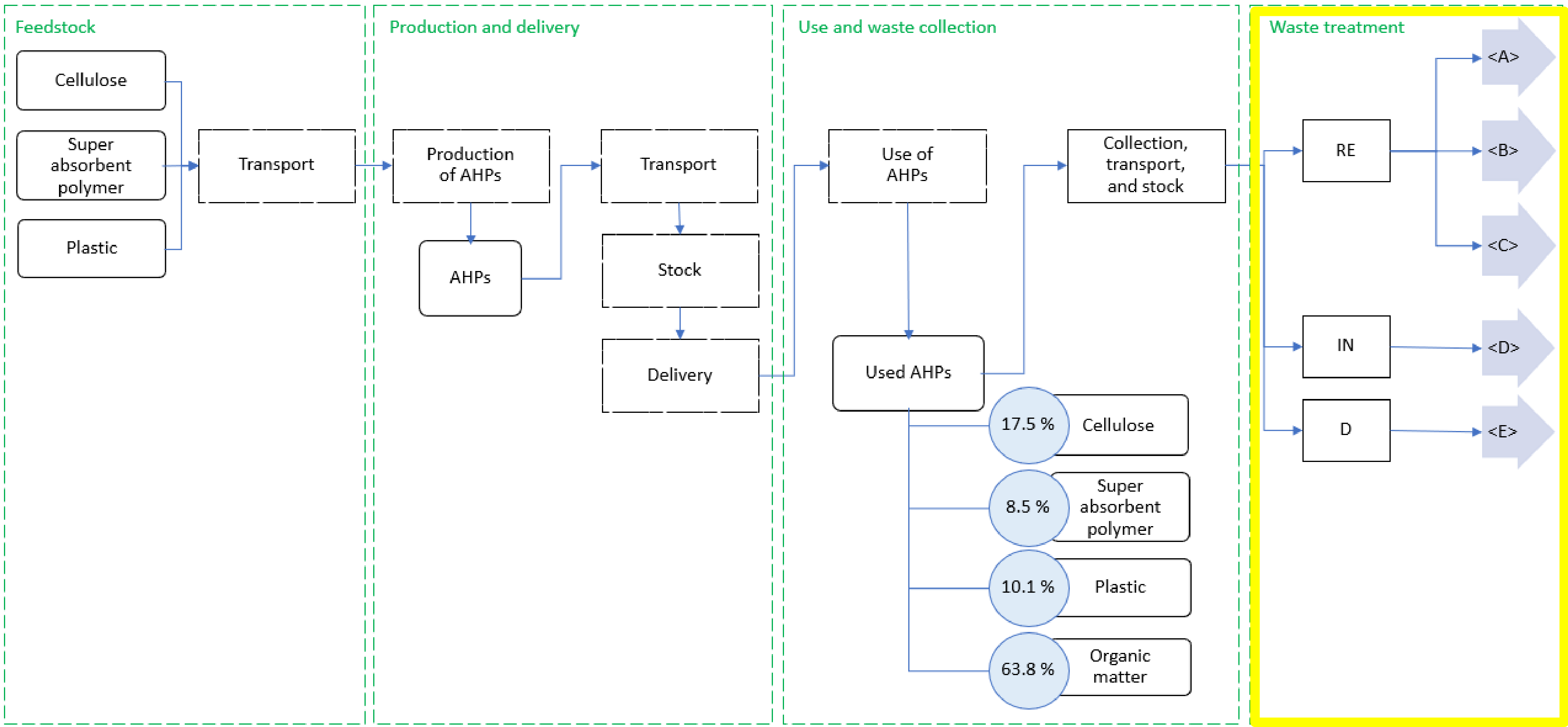
The **sustainability** of these action is evaluated through **Life Cycle Assessment.**



The **aim** of this study is the evaluation of the **life cycle assessment of AHP products from cradle to grave with particular focus on five different waste to value management scenarios.**

Life Cycle Assessment of Absorbent Hygiene Products

FU = 1 t of AHP



Biological treatment;

OMPECO technology

Fater technology

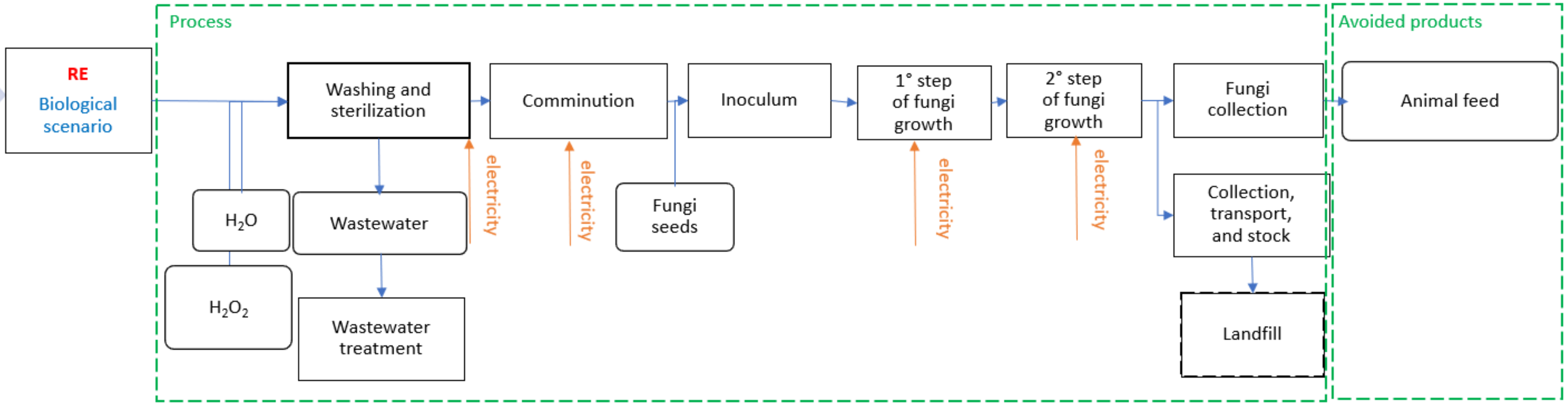
Incineration with energy

Fater technology

Life Cycle Inventory Assessment of AHPs

Biological treatment:
The treatment was carried out with the fungus ***Pleurotus Ostreatus***, which can *bio-degrade cellulosic matter*.
The data of collection and transport are based on primary data, whereas the data about the treatment are based on the study of (M.Liza et al. 2019).

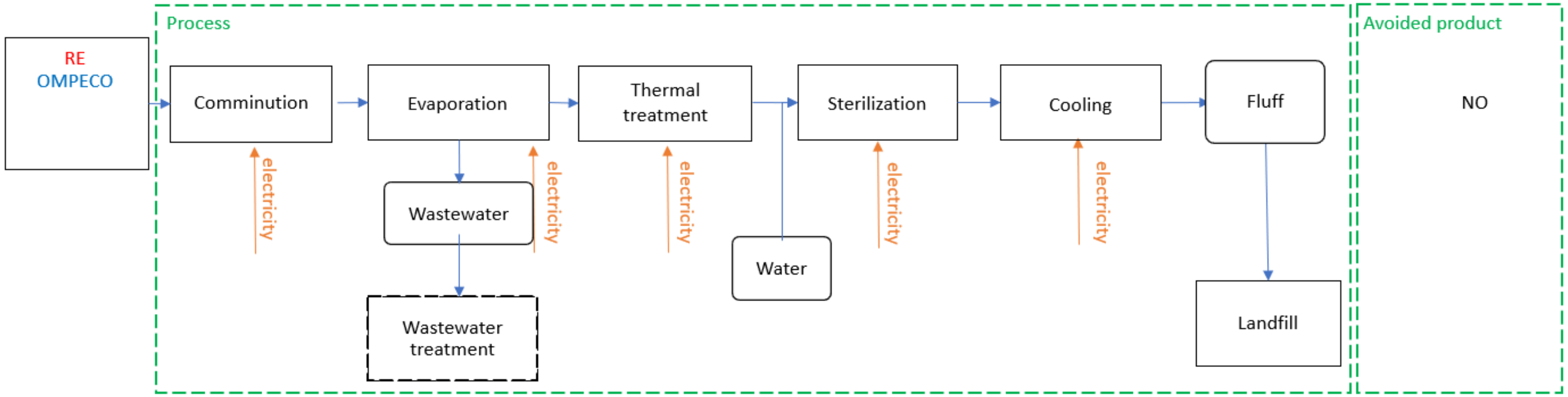
Data for Life Cycle Inventory		
Collection	Transport (km) Euro 5	47
Washing and sterilization	Pump (kWh)	2.5
	H_2O (t)	0.8
	H_2O_2 (t)	0.1
Comminution	Energy (kW/t)	5.14
Inoculum	Seed of fungi (g)	533
1° step of fungi growth	time (d)	21
	temperature (°C)	25-29
	humidity (%)	70- 80
	Growth condition	darkness
Aspiration	electricity (kW/t)	0.35
2° step of fungi growth	time (d)	47
	temperature (°C)	22-25
	humidity (%)	70 - 80
	Growth condition	light
Aspiration	electricity (kW/t)	0.35
Fungus	(kg)	225
Waste	disposal	landfill
	Amount (t)	0.28
	transport (km)	0



M. m. Liza, "Use of oyster mushroom (pleurotus ostreatus) to degrade used diapers and sanitary pads in selected esatates in thika, kiambu county, kenya a thesis submitted in partial fulfilment of the requirements for the award of the degree of master of science (microbiology) in the school of pure and applied sciences of kenyatta university," 2019.

Life Cycle Inventory Assessment of AHPs

OMPECO technology:
Ompeco S.r.l (Turin, Italy) patented the **Converter technology**, which is based on the *principle of mechanical to thermal energy transformation*, hence the machines can reach an optimal sterilization temperature of 150°C, without high pressure, and with low water consumption.

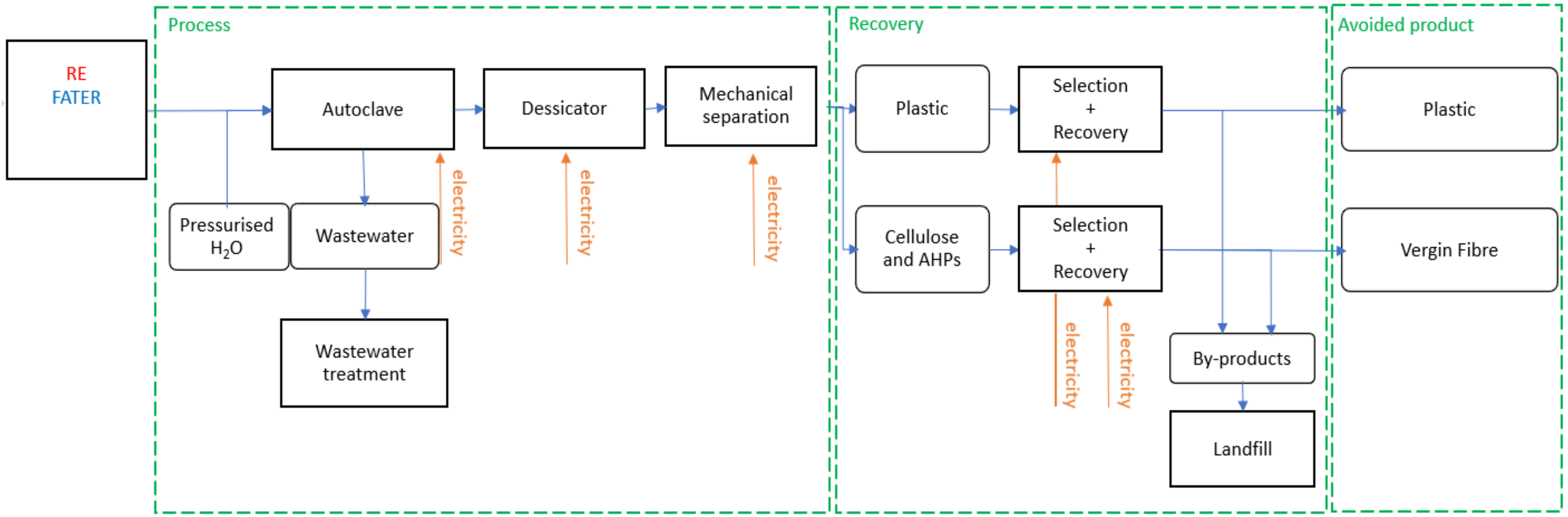


Data for Life Cycle Inventory		
Collection	Transport (km) Euro 5	47
Converter	H_2O (kg)	5
	electricity (kWh/kg)	0.5
Waste	fluff (kg)	370
	disposal	Landfill

Ompeco, Available: https://www.ompeco.com/

Life Cycle Inventory Assessment of AHPs

Fater technology:
Fater S.p.A technology was developed by FaterSMART (**Sustainable Materials and Recycling Technologies**), and Contarina S.p.A and it consists of *stabilization and elimination of the organic matter and possible pathogenic compounds* of AHPs waste through the autoclave exploiting the pressure steam.



Fater, Available: https://www.fatergroup.com/it/news/progetto-riciclo /

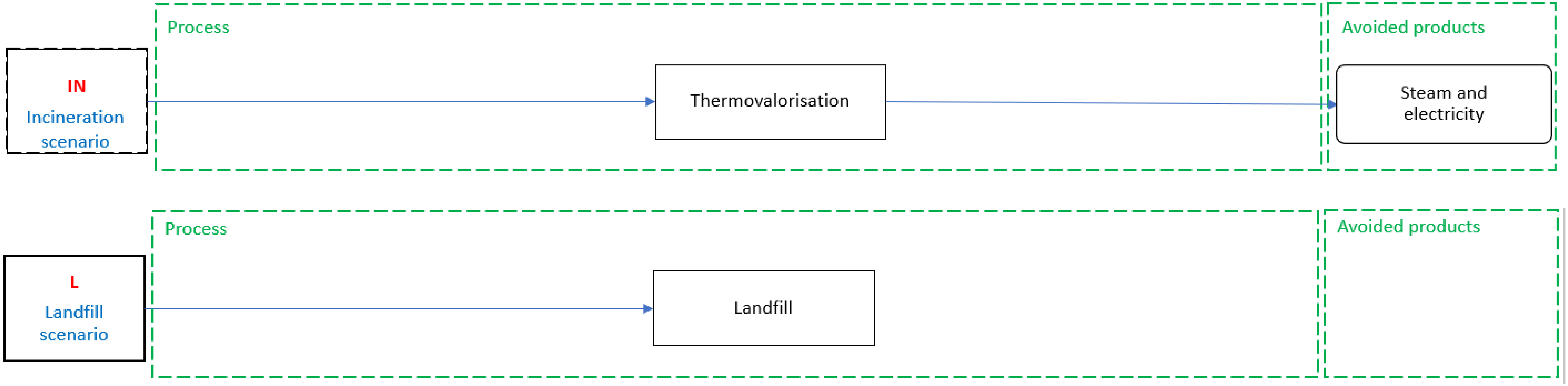
Data for Life Cycle Inventory		
Collection	Transport (km) Euro 5	47
Sterilization + desiccator + mechanical separation	H_2O (kg)	500
	Primary energy (MJ/ton)	1870
	sludge (kg)	2,1
	Recovered cellulose (kg)	354
	Recovered plastic (kg)	146
Transport of plastic matter	Euro 5 (20t) (km)	2.7
Recovery of plastic matter	Plastic (kg)	146
	Primary energy (MJ/t)	6500
	Avoided plastic (kg)	110
	Efficiency (%)	75
	waste (kg)	36
Transport of cellulosic matter	Euro 5 (20t) (km)	9,2
Recovery of cellulose	Cellulose (kg)	354
	Primary energy (MJ/t)	9919
	Avoided virgin fibers (kg)	283
	Efficiency (%)	80
	waste(kg)	71
Waste disposal	Waste from the recycling of plastic (kg)	36
	Waste from the recycling of cellulose (kg)	71
	Total waste (kg)	107
	Disposal	Landfill

Life Cycle Inventory Assessment of AHPs

Current mangement of AHPs waste:

The distances of landfill and incineration from the collection center are respectively stated according to the waste management centers in the Nord-West part of Piedmont.

Data for Life Cycle Inventory		
Collection	Transport (km) with Euro 5	47
Incineration with energy recovery	LHV of AHPs (MJ/ton)	10360
	Efficiency (%)	23
	Produced energy (MJ/ton)	2383
	Produced heat (MJ/ton)	1072
	Produced electricity (kW/h)	834
Landfill	Transport with Euro 5 (20 t) km	16.2



Life Cycle Impact Assessment of AHPs

SimaPro 9.2

Database Ecoinvent 3.3

ReCiPe Midpoint (H) method 20216

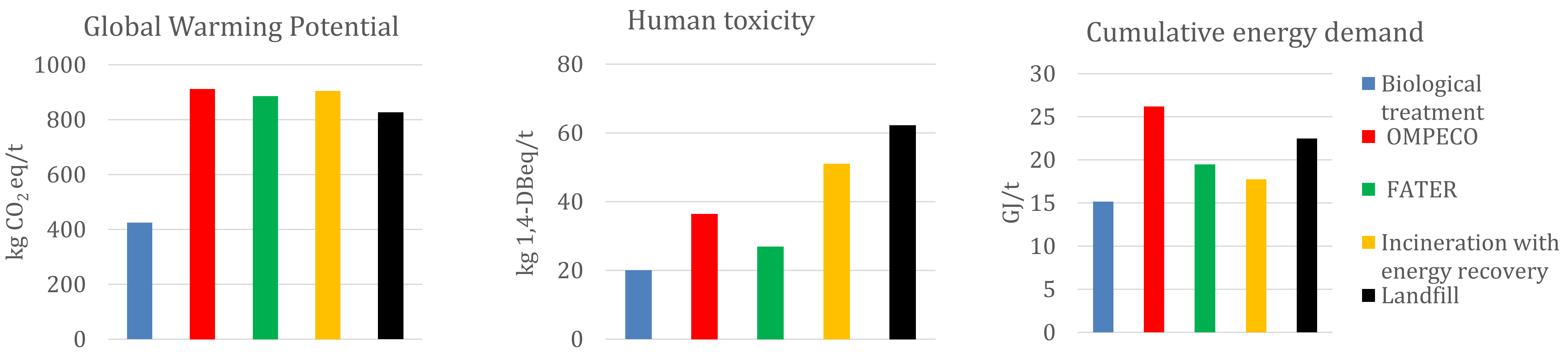
- Global Warming Potential (kg CO_2 eq);
- Human Toxicity (kg 1,4-DBeq),

Because the attention was focused both on the environmental quality and human health.

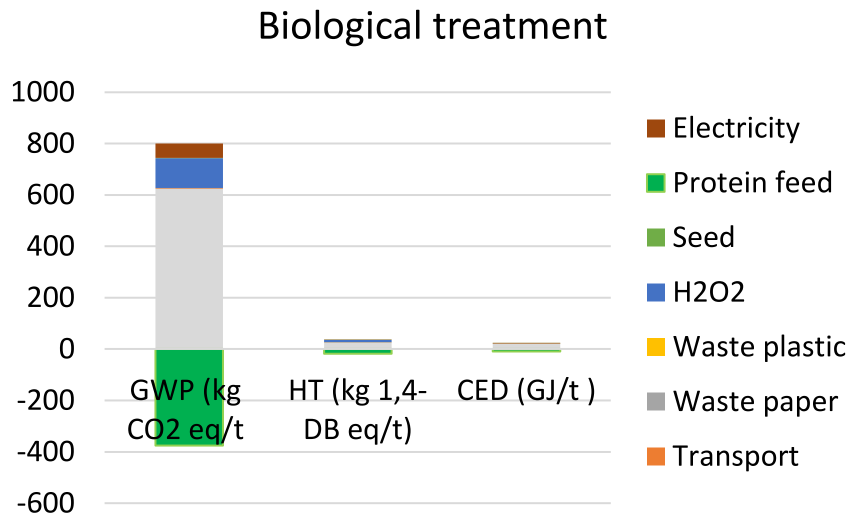
Cumulative Energy Demand (CED).

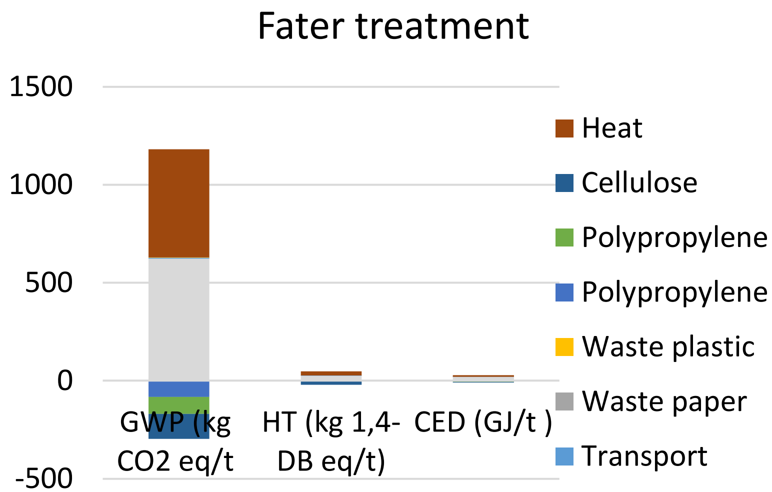
The CED method was employed to evaluate the energy impact of the proposed AHPs valorization treatments considering the total energy required and saved in the whole process especially for the evaluation of mechanical processes.

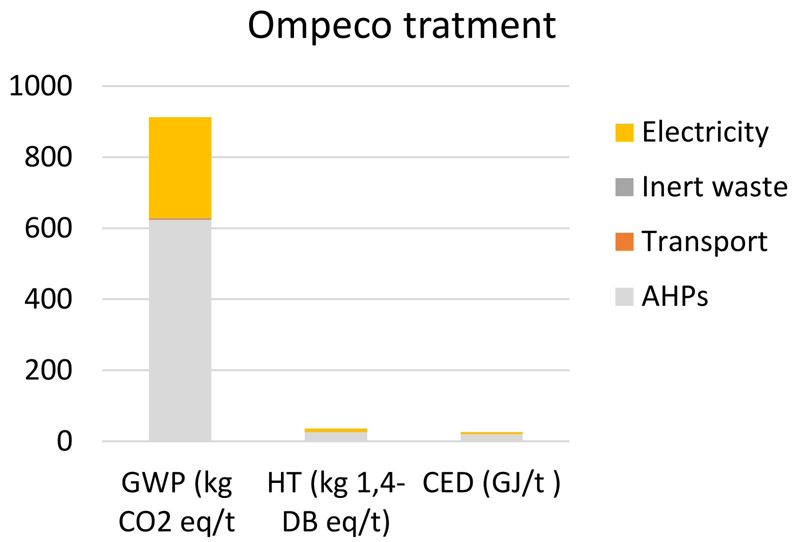
Life Cycle Assessment of AHPs: results



Life Cycle Assessment of AHPs: results

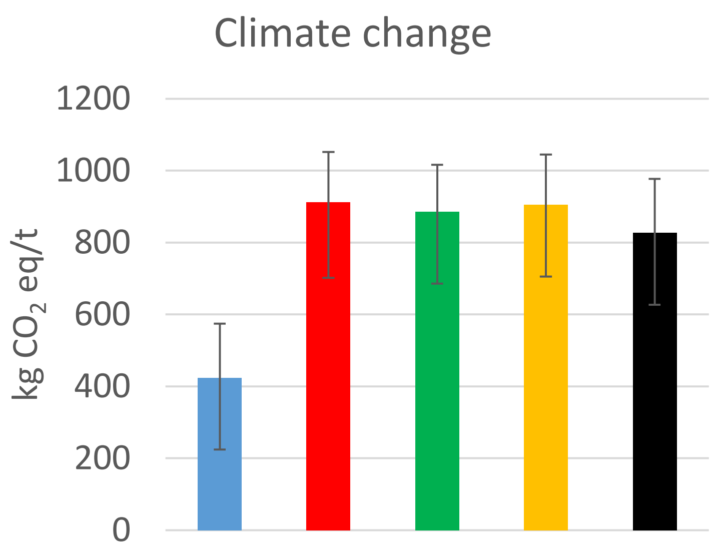


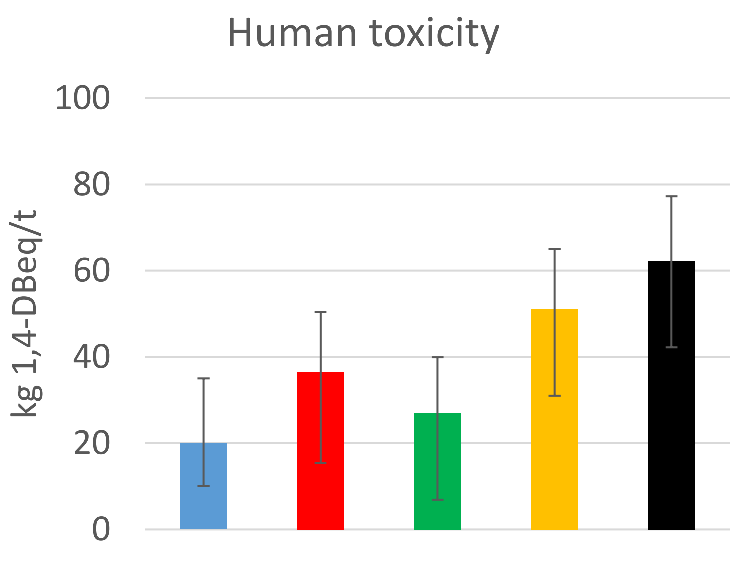


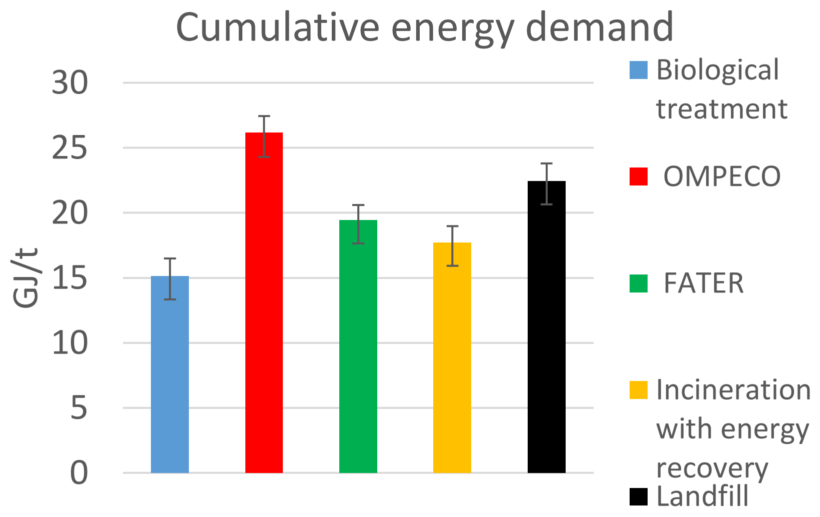


Life Cycle Assessment of AHPs: results sensitivity analysis I

The first sensitive analysis was performed varying **kilometers of collection, transport, and disposal of AHPs waste in a range ± 10 km** since recent that biomass yield density (t/hay) varied with biomass supply distance (km) from refinery plant location. In detail, the study according to (R. Golecha and J. Gan, 2016).



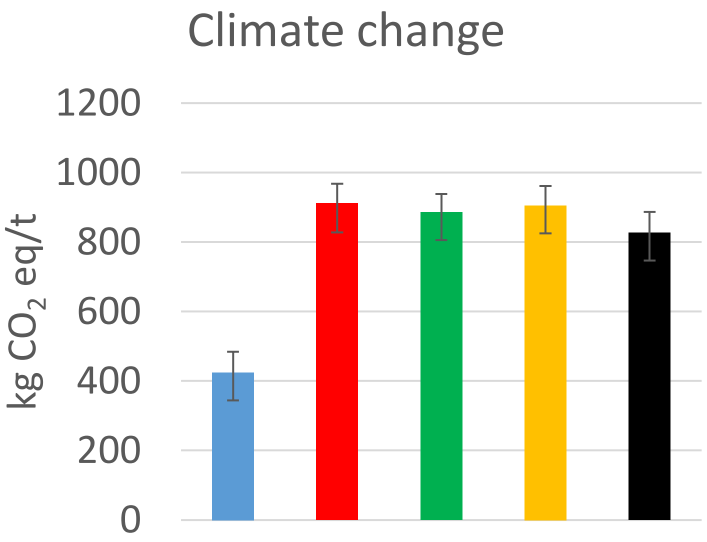


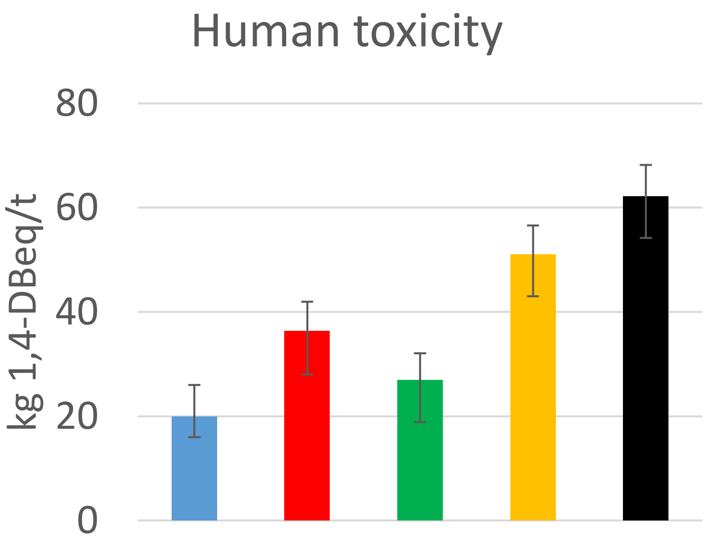


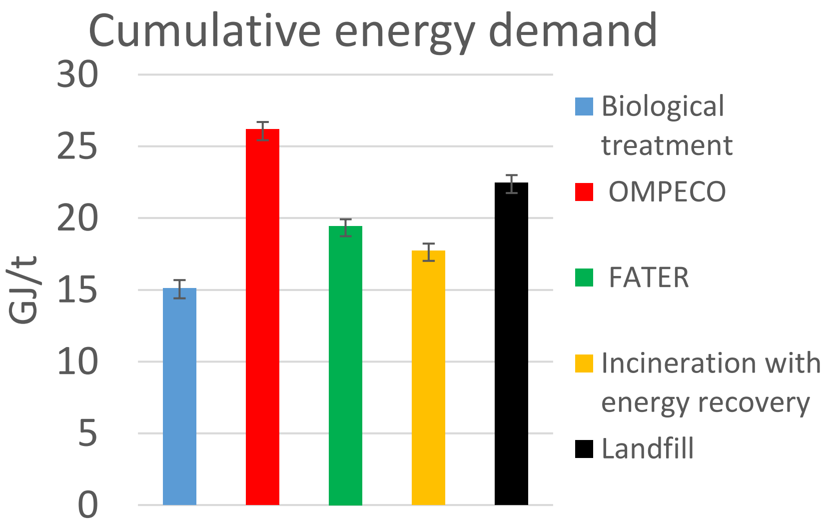
R. Golecha and J. Gan, "Biomass transport cost from field to conversion facility when biomass yield density and road network vary with transport radius," *Appl. Energy*, vol. 164, pp. 321–331, 2016, doi: 10.1016/j.apenergy.2015.11.070.

Life Cycle Assessment of AHPs: results sensitivity analysis II

The second sensitivity analysis for the LCA section was applied to change the efficiency of the proposed technologies in a range of ± 5 % according to (M. J. Somers, et al.2021).







M. J. Somers, J. F. Alfaro, and G. M. Lewis, “Feasibility of superabsorbent polymer recycling and reuse in disposable absorbent hygiene products,” *J. Clean. Prod.*, vol. 313, Sep. 2021, doi: 10.1016/j.jclepro.2021.127686

Conclusion and future perspectives

- The study evaluated the environmental impacts of Absorbent Hygiene Products (AHPs), through Life Cycle Assessment (LCA) from cradle to grave, with particular focus on the end-of-life scenarios.
- The five the end-of-life scenarios included three innovative treatments: one biological and two mechanical processes and two baseline scenarios the incineration with energy recovery and the landfill.
- AHPs composition represented the highest environmental impact contribution equal to 50-65 % of the total impact due to the consumption of raw material.
- The high environmental impact of the mechanical treatments was due to the absence of avoided products and high energy requirement and due to the low recovery rate of the product.
- By combining the results achieved for GWP, HT, and CED, the rank is:
  - Biological process;
  - Fater process;
  - Ompeco process;
  - Incineration with energy recovery;
  - Landfill.

Thank you for the attention

Politecnico
di Torino
1859

francesca.demichelis@polito.it