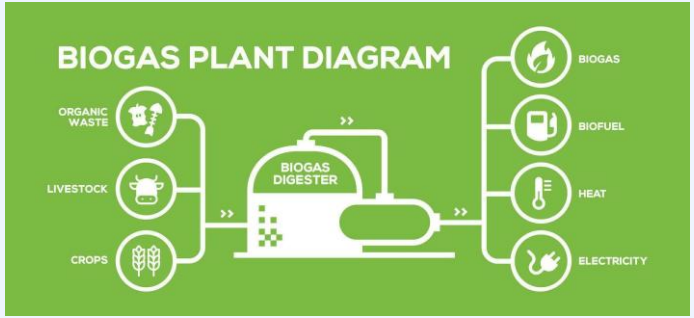
94th Swiss Discussion Forum LCA · 06.11.2026
Turning waste into value: LCA of side-stream valorization and food waste reduction

Expired food: a proven source of energy

Turning packaged expired food from shelves and food companies into a homogeneous End-of-Waste biogas feedstock: an industrial case study





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Who we are: UMWELT srl

Since

2002

Padova, Italy

Active in Industrial and Environmental Process Engineering
From permitting to detailed design, technical consulting and due diligence

Biogas and biomethane

Renewable energy & bioenergy

Waste and End-of-Waste

Waste management & waste treatment

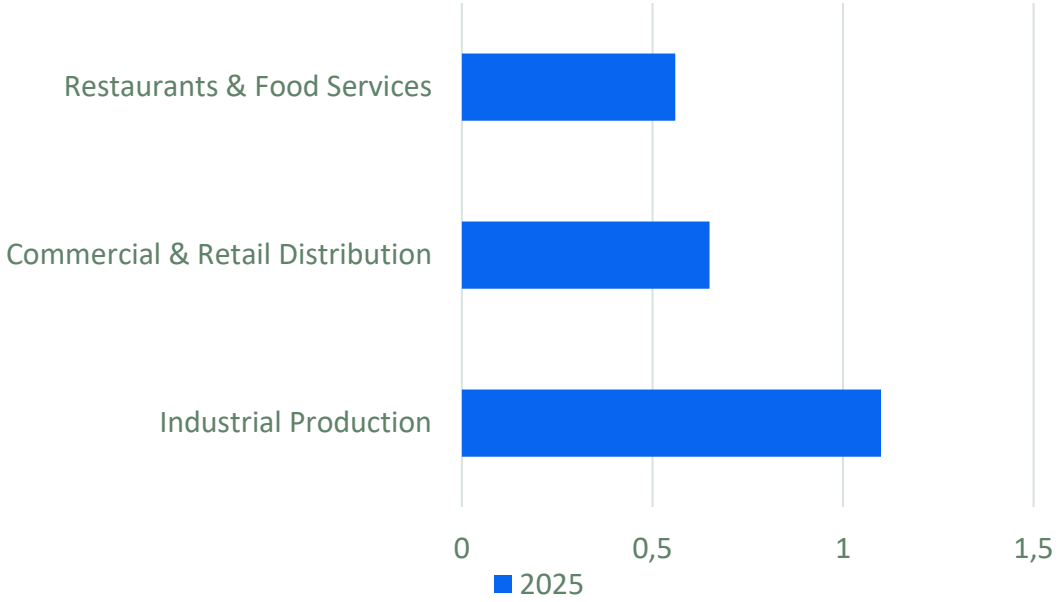
Carbon footprint and LCA

Environmental impact assessment

Our role in this case study: carbon footprint of the depackaging plant and its End-of-Waste product

Food waste in Italy

Food waste by sector, Italy, million tonnes



2,34 Mt

in 2026 from these three sectors

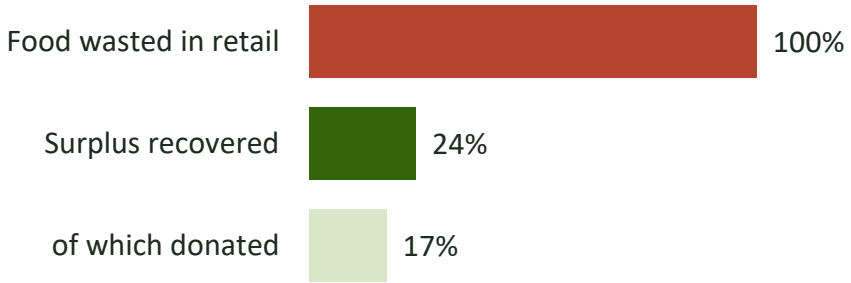
29%	Industrial Production
47%	**Retail and distribution**
24%	Restaurants and food services

Not municipal organic waste: we look at food distribution chains, where expired food is mostly packaged

Source: Eurostat, env_wasfw (2026). European Commission. Consumerismo.it.

On the shelf: packaged food that expires

Italian retail, % of food wasted (565 kt/y = 100%)



1 : 4 ≈ 1t recovered for every 4t wasted

91% of Federdistribuzione chains discount products nearing expiry

41% of retail companies run promotions on products close to expiry

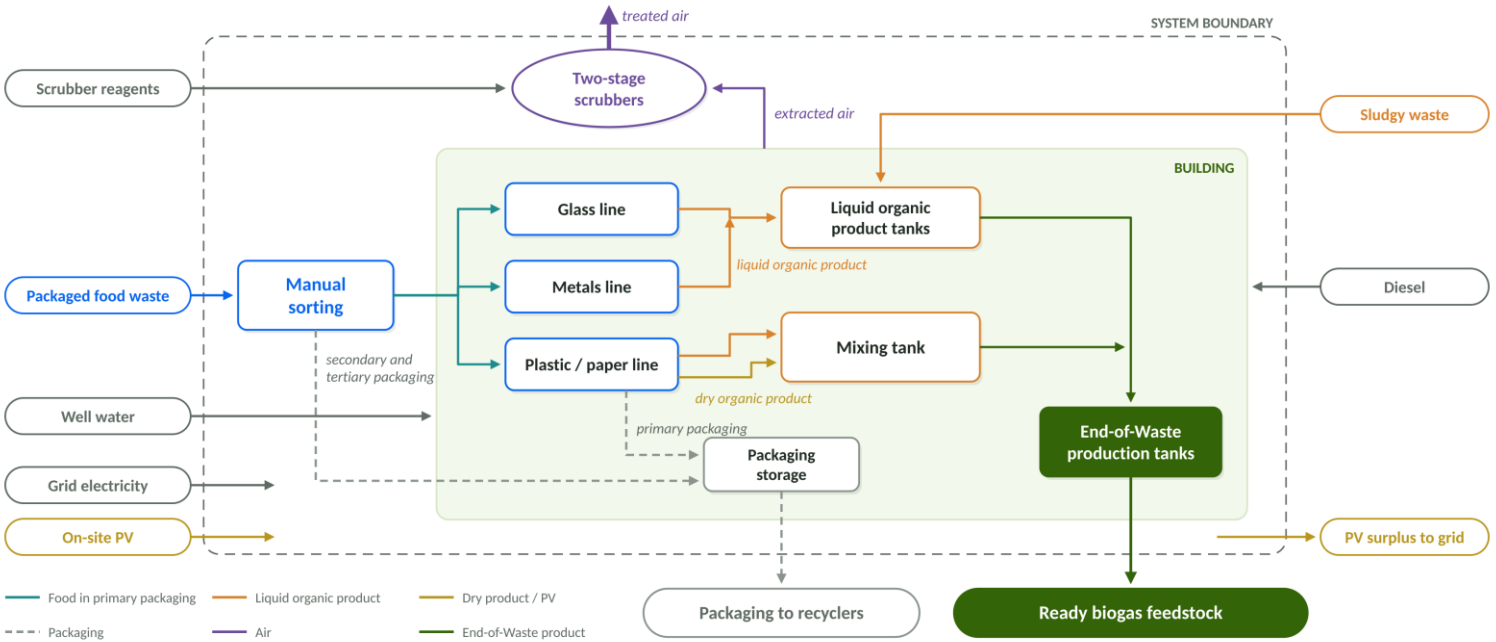
14% of supermarket food waste is fresh dairy and packaged cured meats

What expires on the shelf leaves in its packaging: food and packaging must be separated

PoliMi, Osservatorio Food Sustainability (17.06.2026); Federdistribuzione (2021); Cicatiello et al., REDUCE (2019).

How the plant works

Manual sorting › Depackaging lines › Storage and mixing › EoW production › **Ready biogas feedstock** › Air scrubbing



UMWELT emissions assessment report. Capacity 30,000 t/y; 2024 production ≈ 21,000 t/y.

The LCA: carbon footprint

Goal and scope

Goal: GHG emissions of the EoW biogas feedstock, for RED II certification

FU: kg of CO_2eq per unit of EoW product

Boundary: transportation in & out, sorting, treatment, processing, odor treatment

Methodological choices

Method: UNI/TS 11567 App. C, D.Lgs. 199/2021 Annex VI, Directive 2008/98/EC

Waste: enters burden-free (zero emissions up to collection)

Allocation

None: all burdens on the EoW product, incl. transport of the packaging waste

Packaging: cut-off, no recycling credit

PV: self-use at zero; exports not credited

Data quality

Primary: 2024 plant records (waste, grid power, diesel, chemicals)

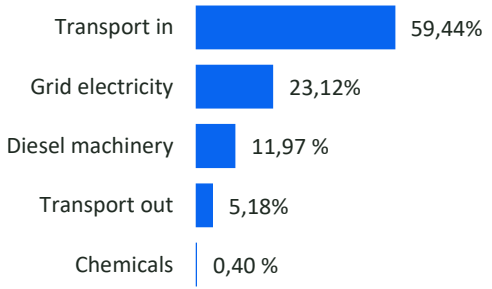
Secondary: Ecoinvent 3.9, BioGrace-II, Reg. (EU) 2022/996, IPCC 2006

Estimated: transport km and fuel use

10.06 g CO_2eq /kg

2.2 g/MJeq

CO_2eq contribution by each sector per year



In the food system: 65% is logistics; unsaleable food becomes energy at ≈ 10.06 g CO_2eq /kg

UMWELT emissions assessment report ; plant data 2024: 215.15 t CO_2eq/y, ≈ 21,000 t/y produced (capacity 30,000 t/y), 125 Nm^3/t.

The End-of-Waste product

No longer waste

End-of-Waste under art. 184-ter D.Lgs. 152/2006 (AD PD/695/2017), Directive 2008/98/EC

Homogeneous

Liquid and dry fractions blended into one product

Stable, pH ≈ 4

Prevents fermentation in the storage, monitored by probes

Analysed

Full analysis every 1,000 t, incl. methane potential

Packaging-free

Glass, metals, plastic and paper removed and recycled

Traceable

Every incoming load tracked by barcode

Energy-rich

125 Nm^3 CH_4/t:
1,12 times more than corn silage

Low footprint

10.06 g CO_2eq/kg
2.2 g CO_2eq/MJ

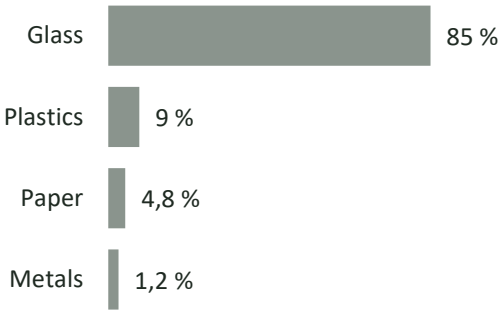
From a variable waste to one consistent feedstock for biogas and biomethane plants

AD PD/695 of 08.05.2017; plant data 2024; UMWELT emissions assessment. Corn silage: Pilarski et al., Energies 19 (2026) 1105.

Packaging: recycling or incineration?

From our separation lines

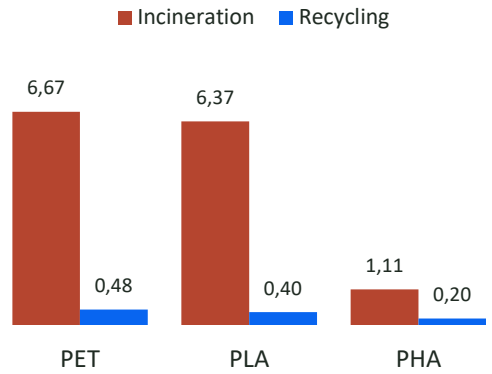
Packaging out, 2024, tonnes



4,000t sent to recyclers

Borda et al. 2026

GWP, g CO_2eq per g of polymer



82–94% lower GWP if recycled

Ferreira et al. 2014

Packaging system, Portugal

Climate: incineration has the highest impact; burning plastics releases fossil CO_2 (≈ 0.94 t CO_2/t burned)

Energy: recycling system saves ≈ 100 GWh of primary energy

By material: recycling best for plastics, glass and metals; paper/cardboard is the exception

Clean, separated packaging can be recycled: lower GWP than incineration

Plant data 2024. Borda et al., Int. J. Adv. Manuf. Technol. 142 (2026), Table 4, per bottle, converted per g (properly managed). Ferreira et al., Waste Manag. 34 (2014).

Energy recovered, powered by the sun

Energy in the EoW product

125 Nm^3 CH_4 / t — 111 Nm^3/t BMP of silage

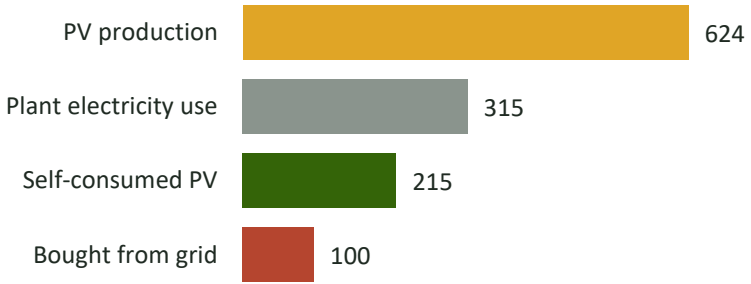
≈ 24,000 t corn silage eq / y — Using 21.000 t/yr of EoW

27 GWh / yr — Of primary energy from methane gas

11.7 + 12.0 GWh (el + heat)/ y — CHP: 42% el, 43% heat

On-site photovoltaic plant, 2024

MWh per year



68%
of plant electricity from PV

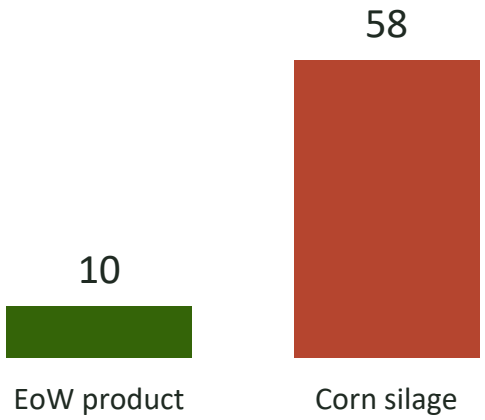
107 t
CO_2eq/y avoided vs grid

Plant electricity ≈ 1% of the energy in the product, mostly from its own PV

Plant data 2024; BMP: plant value. Corn silage: Pilarski et al. (2026). CHP: Clarke Energy (2013). Grid: Reg. (EU) 2022/996.

EoW plant vs corn silage

kg CO_2eq per tonne of feedstock at the digester



	EoW plant	Corn silage
Methane	125 Nm^3 CH_4/t	111 Nm^3 CH_4/t
Footprint	10 kg CO_2eq/t	≈ 58 kg CO_2eq/t
Per MJ	2.2 g CO_2eq/ MJ	≈ 13 g CO_2eq/ MJ
Main source	transport (65%)	crop N_2O, fertiliser
Farmland	none (waste)	≈ 63 t/ha

Same methane per year: 21,000 t EoW product → 211 t CO_2eq vs ≈ 24,000 t corn silage ≈ 1,400 t CO_2eq

≈ 5× lower footprint than corn silage

Corn silage: derived from Valli et al., Biofuels Bioprod. Bioref. (2017), MAIZE case (crop production + transport, 121.8 g CO_2eq/kWh). EoW: plant data 2024.

Conclusions: from waste to value

1 **Reduce the waste on the shelf**

Packaged expired food from shelves and food companies is a growing side stream: retail +59% in 2020–2024, only ≈ 1 t recovered for every 4t wasted.

2 **Turn it into value**

Depackaging makes a homogeneous End-of-Waste feedstock: ≈ 21,000 t/y (capacity 30,000 t/y) carrying ≈ 27 GWh/y, equal to roughly 24,000 t/y of corn silage; 4,000 t of packaging go to recycling.

3 **At a low footprint**

58 g CO_2eq/kg vs 10.06 g CO_2eq/kg . Logistics are 65% of it; 68% of the plant electricity comes from its own PV.

Next steps

- Check plastic residues in product and digestate
- Add the economic and social side: towards LCSA
- Scale up: a regional network of depackaging plants

Expired food: a proven source of energy — food and packaging both recovered

Thank you

Questions and discussion

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