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Accelerating circular bio-based solutions
integration in European rural areas

Structure of biomass streams in agriculture and food

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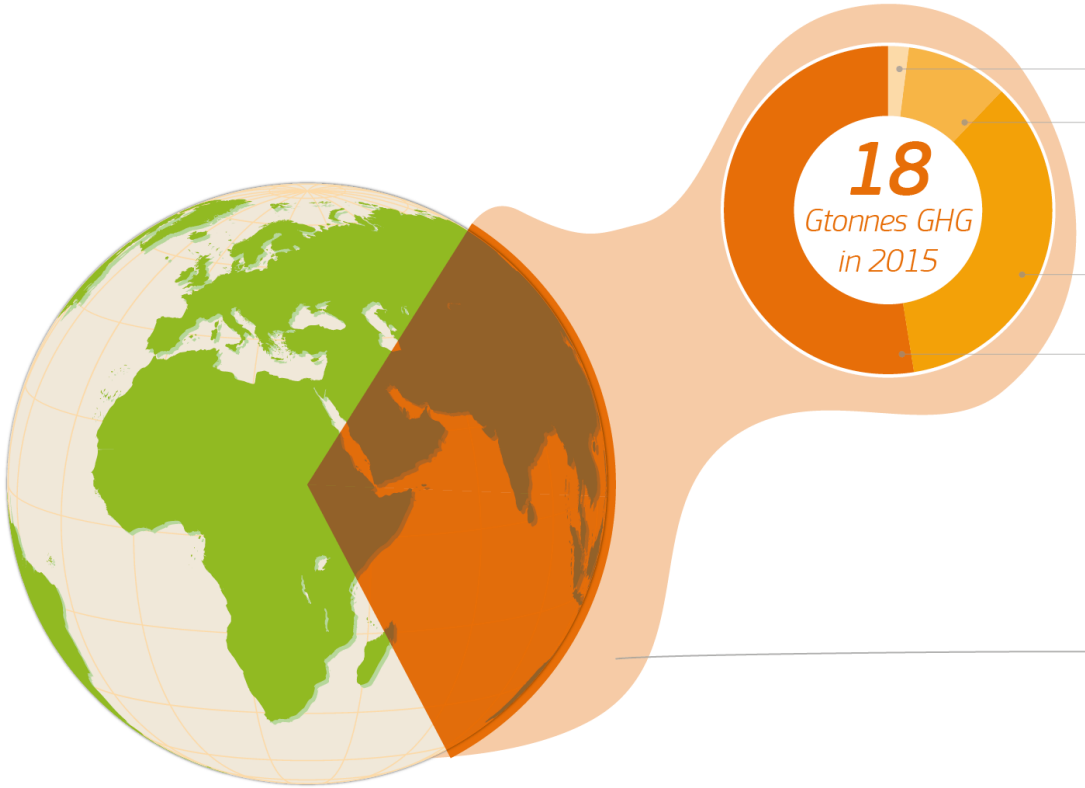
NATIONAL INSTITUTE OF CHEMISTRY

The role of food in global emissions of Greenhouse Gases



2 % F-gases (fluorinated gases)

11 % N2O (nitrous oxide)

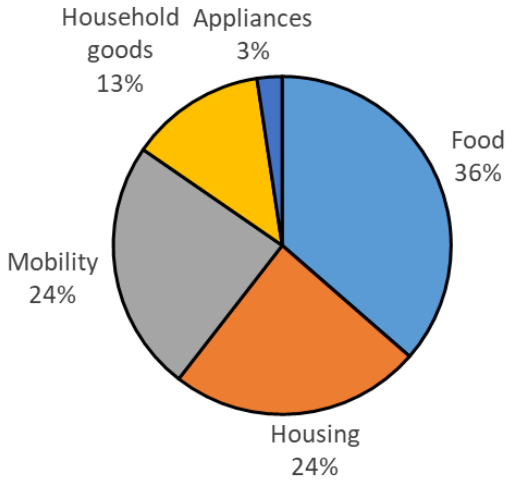
35 % CH_4 (methane)

52 % CO_2 (carbon dioxide)

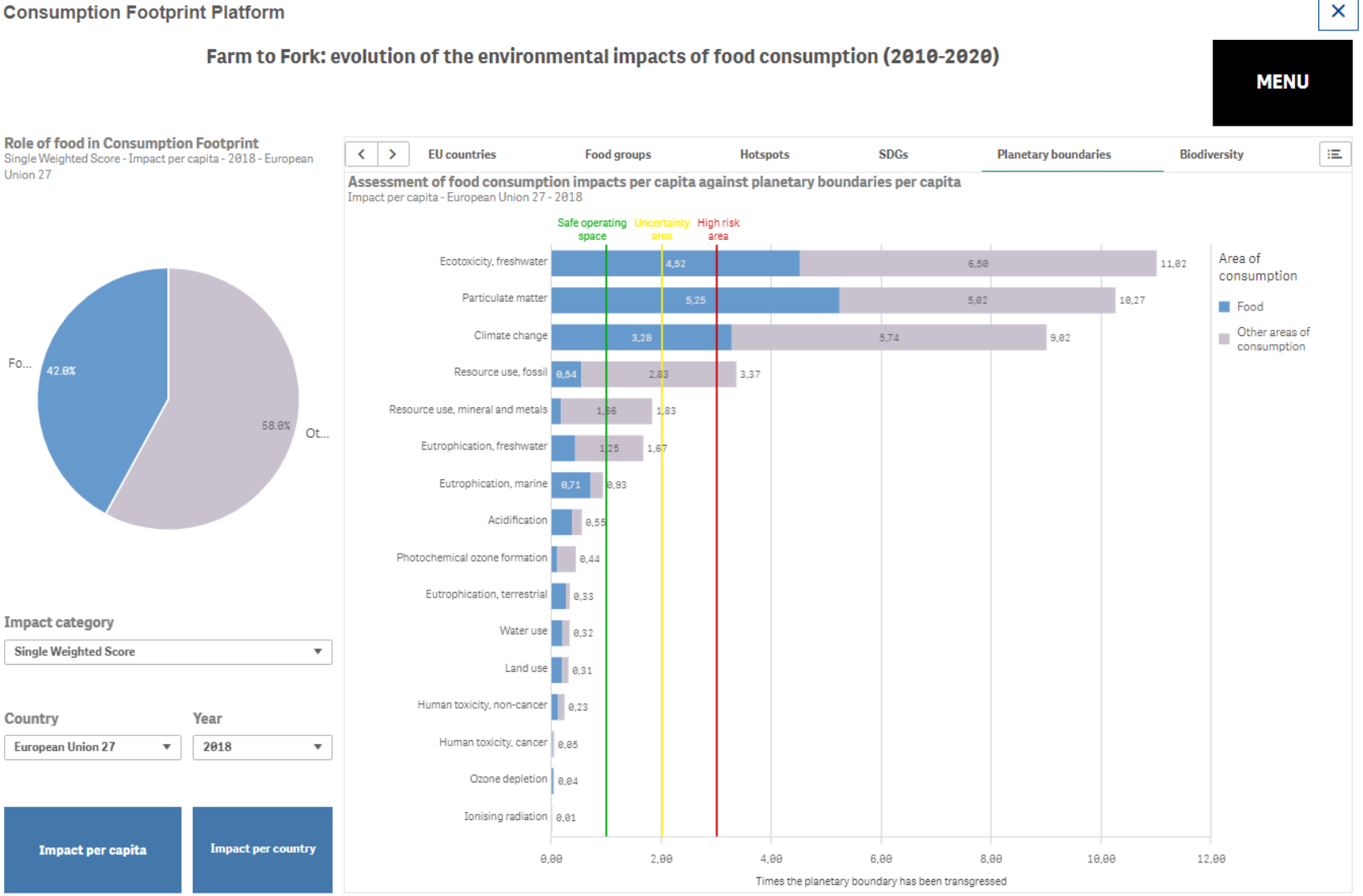
1/3 *of global GHG emissions come from the food system*

https://edgar.jrc.ec.europa.eu/edgar_food

Climate change impacts of EU food system are **3.6 times the Planetary Boundary**



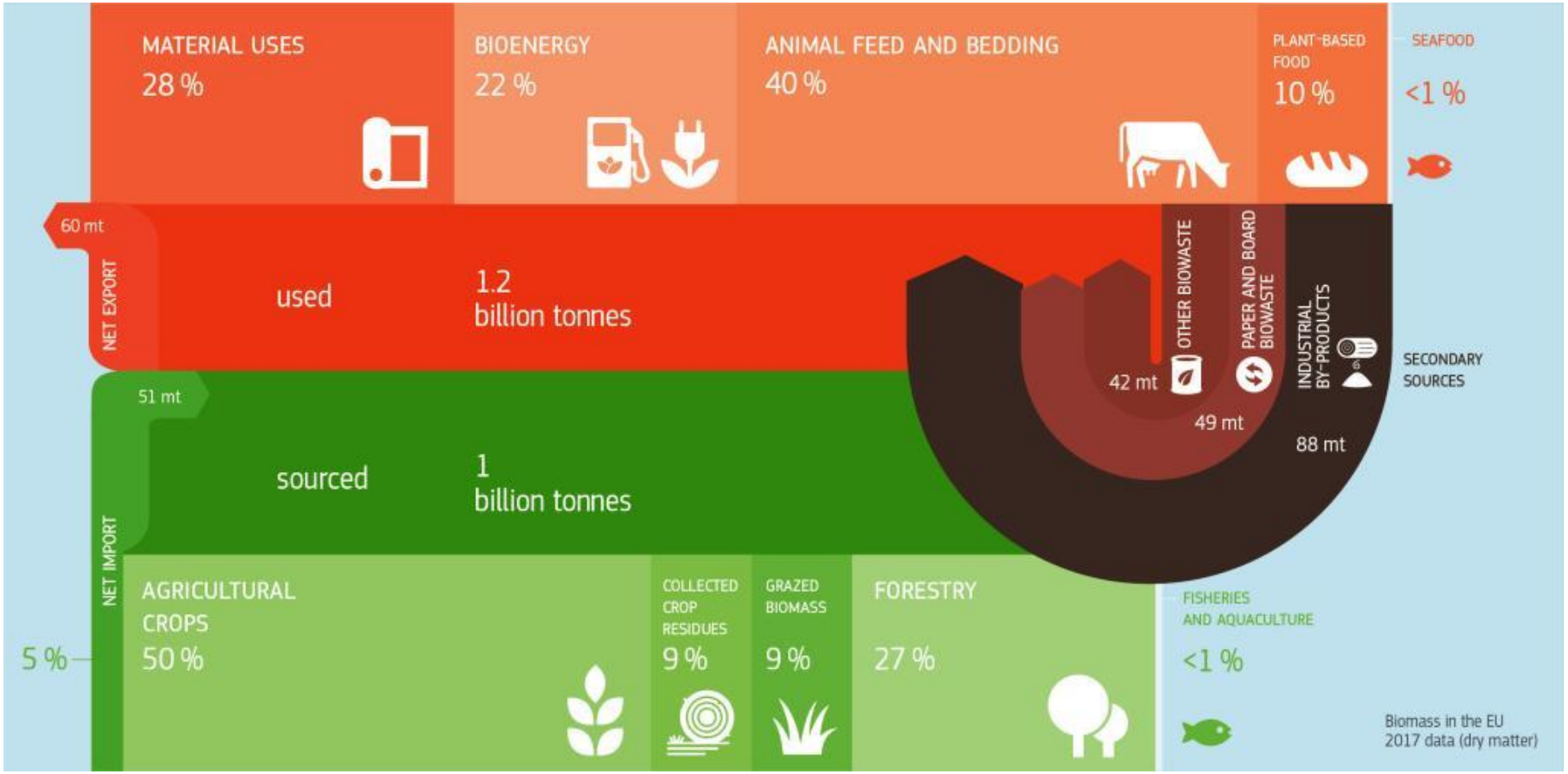
EU food consumption represents **36% of the overall climate change** of EU Consumption (2018)



Biomass in agriculture

Sources of agricultural biomass in EU-27, 2017

1 billion tonnes sourced in EU-27 from primary sources:
50 % agricultural crops
9 % grazed residues



https://knowledge4policy.ec.europa.eu/publication/infographics-biomass-sources-uses-eu-27-2017-data_en

Current agricultural production and use of biomass in the EU

8 % of agricultural production is available for **materials and energy** use.

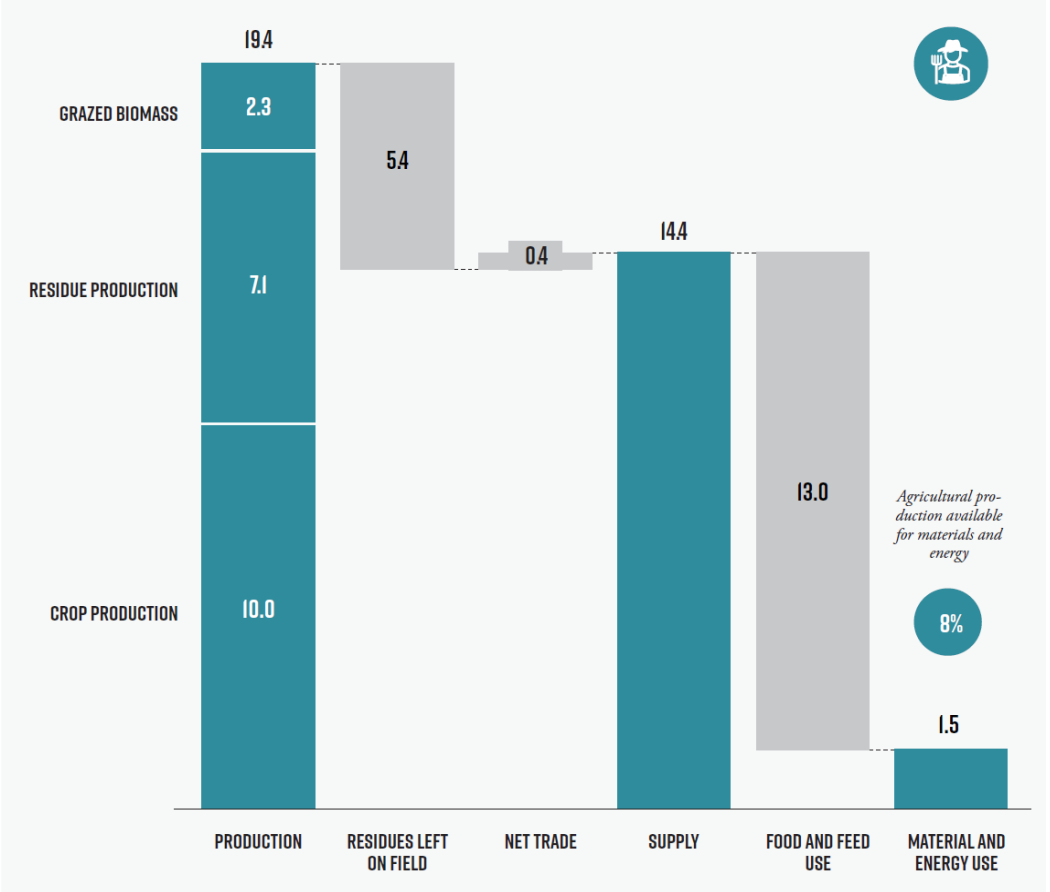
Across EU, 167 million hectares (39 % of al land) is used for agriculture.

Collectively, agriculture produces 19.4 EJ per year.

***Crop production** leads to large amount of **residues** (7.1 EJ), from which only a quarter is extracted for:*
- bedding for animals (1 EJ)
- energy production (0.7 EJ)

***Dedicated energy crops** are grown on 3.2 % of EU cropland, generating 0.8 EJ.*

***Non-food energy crops** amount for less tna 0.1 EJ.*

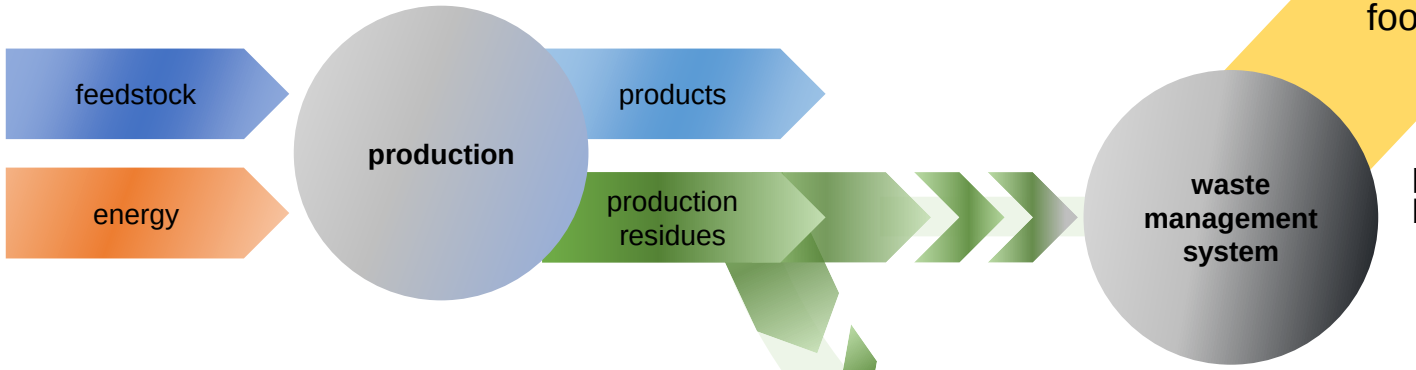


EJ per year – primary energy equivalents

https://www.climate-kic.org/wp-content/uploads/2021/06/MATERIAL-ECONOMICS-EU-BIOMASS-USE-IN-A-NET-ZERO-ECONOMY-ONLINE-VERSION.pdf

Biomass production residues in food processing

Production residues



Production residues are all substances that are formed during a production process, where the main purpose is not the production of these substances. Depending on further use, the same residues may become a by-product or waste.

21 350 000 tonnes
agriculture, forestry and fishing

33 900 000 tonnes
food, beverages and tobacco
(EUROSTAT, 2023)

production residues become ***wastes***

production residues become ***by-products***

major amounts
no official data at MS's and EU level
e.g. EU annal estimates
32 000 000 tonnes oil cake and meal
3 400 000 tonnes spent brewery grain
50 000 000 m^3 whey

https://foodwasteexplorer.eu/
https://doi.org/10.3390/su13084428

VALORISATION OF AGRIFOOD RESIDUES

EXAMPLES OF RECENTLY PUBLISHED STUDIES

Hop shoots, stems and leaves

Olive leaves, branches and pomace

Pomegranate peels

Onion cuttings and peels

Research performed in the scope of national research programme ‚Biochemical characterisation of natural compounds' (ARRS, P4-0121)

Contents lists available at ScienceDirect

Industrial Crops and Products

journal homepage: www.elsevier.com/locate/indcrop

A comparison of antioxidant and antimicrobial activity between hop leaves and hop cones

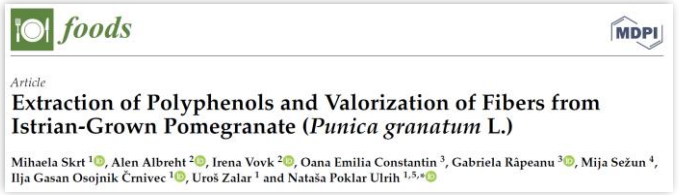
Veronika Abram [a], Barbara Čeh [b], Mateja Vidmar [a], Mario Hercezi [a], Neda Lazič [a], Valentina Bucik [a], Sonja Smole Možina [a], Iztok J. Košir [b], Milica Kač [a], Lea Demšar [a], Nataša Poklar Ulrih [a,*]

ORIGINAL RESEARCH

WILEY

Enhanced yield of oleuropein from olive leaves using ultrasound-assisted extraction

Domenico Cifa [1] Mihaela Skrt [2] | Paola Pittia [1] | Carla Di Mattia [1] | Nataša Poklar Ulrih [2,3]



foods

MDPI

Article

Extraction of Polyphenols and Valorization of Fibers from Istrian-Grown Pomegranate (*Punica granatum* L.)

Mihaela Skrt [1], Alen Albreht [2], Irena Vovk [2], Oana Emilia Constantin [3], Gabriela Râpeanu [3], Mija Sežun [4], Ilja Gasan Osojnik Črnivec [1], Uroš Zalar [1] and Nataša Poklar Ulrih [1,5,*]

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Waste streams in onion production: Bioactive compounds, quercetin and use of antimicrobial and antioxidative properties

Ilja Gasan Osojnik Črnivec [a,1], Mihaela Skrt [a,1], Danijela Šeremet [b], Meta Sterniša [a], David Farčnik [a], Erna Štrumbelj [a], Aleš Poljanšek [c], Nika Cebin [c], Lea Pogačnik [a], Sonja Smole Možina [a], Miha Humar [d], Draženka Komes [b], Nataša Poklar Ulrih [a,e,*]

Inedible food parts as an ingredient or functional food additive

ingredient in bakery products

stable storage

extract addition to EV olive oil

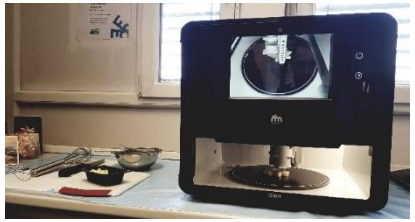
Ethanol extract of *the inedible (waste) fraction*

antioxidant capacity ~ two fold higher than water extracts

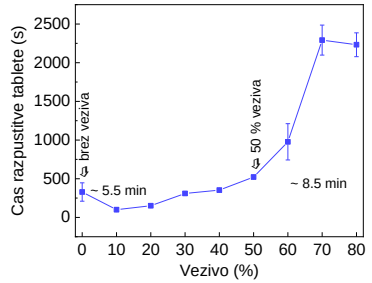
most suitable for quercetin recovery

/ kg DM produce:

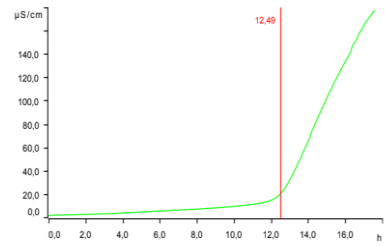
- ***Red onion: 300 mg***
- ***Yellow onion: 200 mg***
- ***Red onion 400 mg***



Maintained sensory and textural properties.

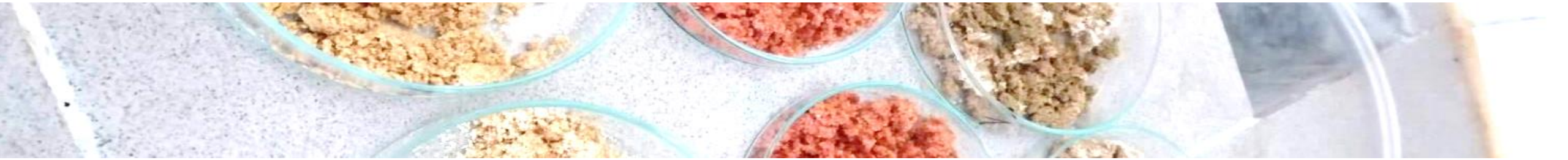


Stabile form for simple dosing during individual food supplementation.



Prolonged shelf-life (~30 % or + 1-5 months), good sensory properties.

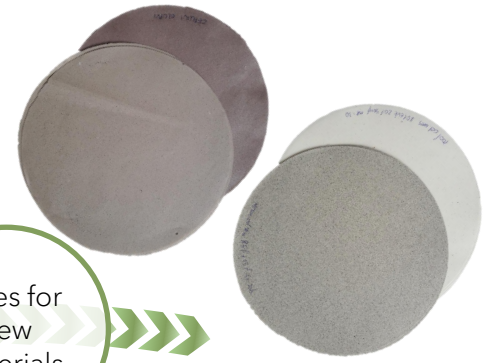
Lignocellulosic residues of bioactives extraction



		Bioactives p.a.	**Cellulose** % DM	**Hemicellulose** % DM	**Lignin** % DM
Onion peels		Quercetin 10 mg/g DM	36,4	33,1	3,5
Olive leaves and branches		Oleuropein 37 mg/g DM	14,4	37,1	19,6
Pomegranate peals		Autocyanins 0.2 mg/g DM	11,0	11,6	12,2

high yield extracts → functional additives for food or other products

fibres for new materials → special papers, packaging for special products



I.G. Osojnik Črnivec, M. Skrt, D. Šeremet, M. Sterniša, … D. Komes, N. Poklar Ulrih, Waste mamagement 126 (2021) 476-486
M. Skrt, N. Poklar Ulrih, Stabilizacija ekstraktov oljčnih listov, CRP V4-1621 Ostanki proizvodnje v oljkarstvu, 2019
I.G. Osojnik Črnivec, M. Sežun, M. Skrt, T. Kapun, N. Poklar Ulrih, 2nd circular packaging conference (september), Papir (november), 2021

Papermaking

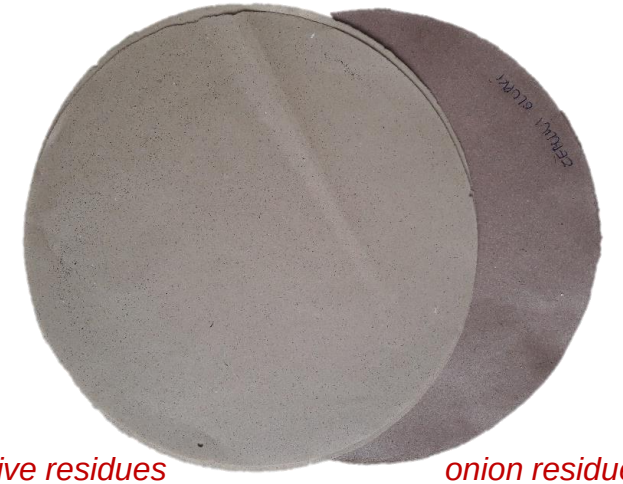
Optical and mechanical properties of paper.

Cellulose composition (80% eucalyptus, 20% conifers, ground to 30 SR)

Parameter	Samples			
	Onion skins (100%)	Olive leaves (100%)	Pomegranate peels/ cellulose (15/ 85%)	Cellulose (100%)
Grammage (g/m^2)	67.9	37.4	63.6	65.0
Thickness (µm)	115	144	161	116
Tensile index (Nm/g)	39.3	9.9	41.4	53.3
Breaking length (km)	4.010	1.009	4.222	5.334
Bendtsen roughness (ml/min)	518	1991	1677	342
ISO whiteness (%)	14.5	18.6	41.4	77.0
Opacity (%)	99.7	94.4	96.8	86.6
Tear index (mNm^2/g)	2.09	2.80	7.35	7.85
Burst index (kNm^2/g)	1.75	1.02	2.65	3.48

Apperance of test papers

manufactured from



olive residues *onion residues*

pomegranate additive *papermaking celluose*

Food waste prevention and the utilization of surplus and former food

Food Waste

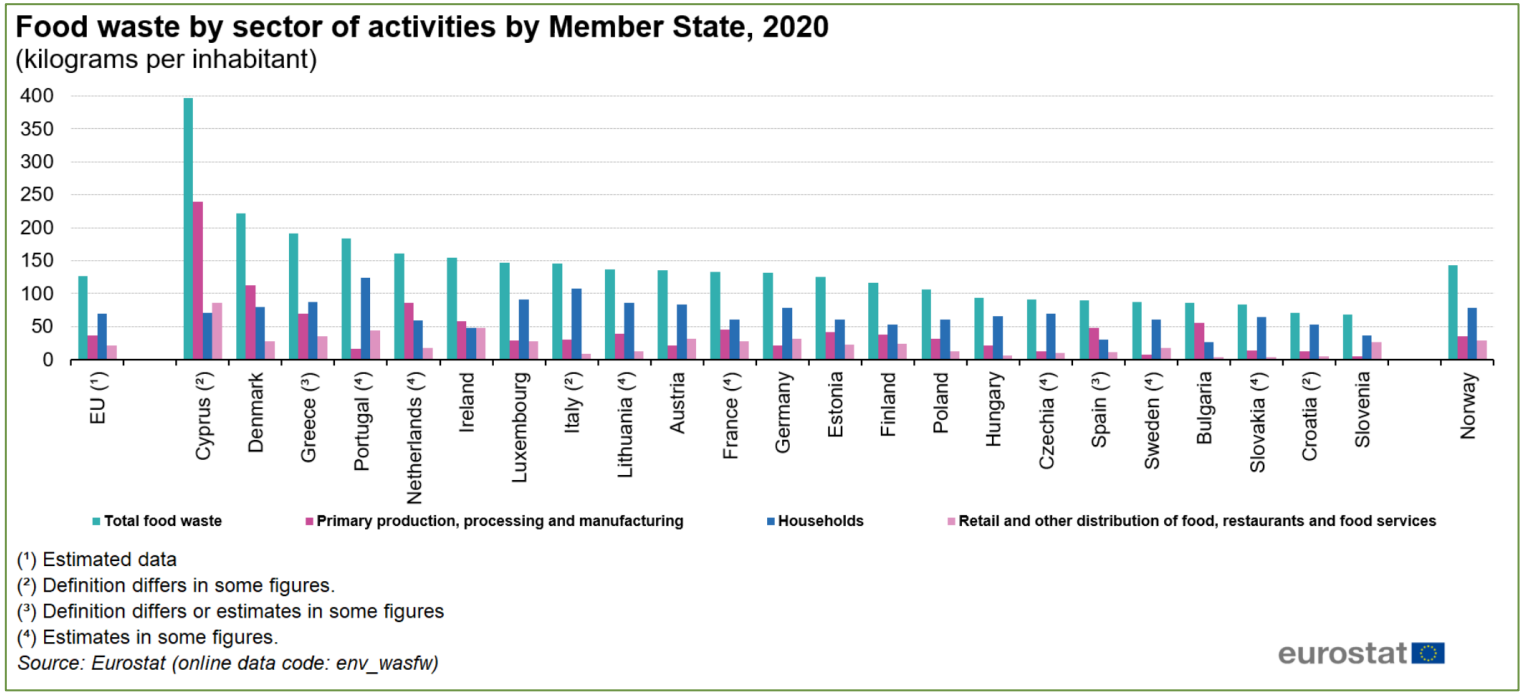
Globally, a **sixth of all the food** is estimated to be wasted by UNEP (2021).

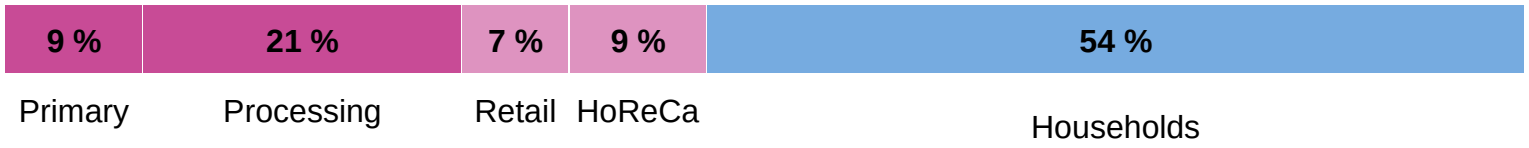
Based on first harmonized estimate in 2023, **58 million tonne/year** of food was wasted in the EU,

corresponding to **70-400 (130) kg/capita** (EUROSTAT, 2020).

This quantities have an estimated market value of **132 billion euros**.

Simultaneously, **10 %** of EU citizens are malnourished.

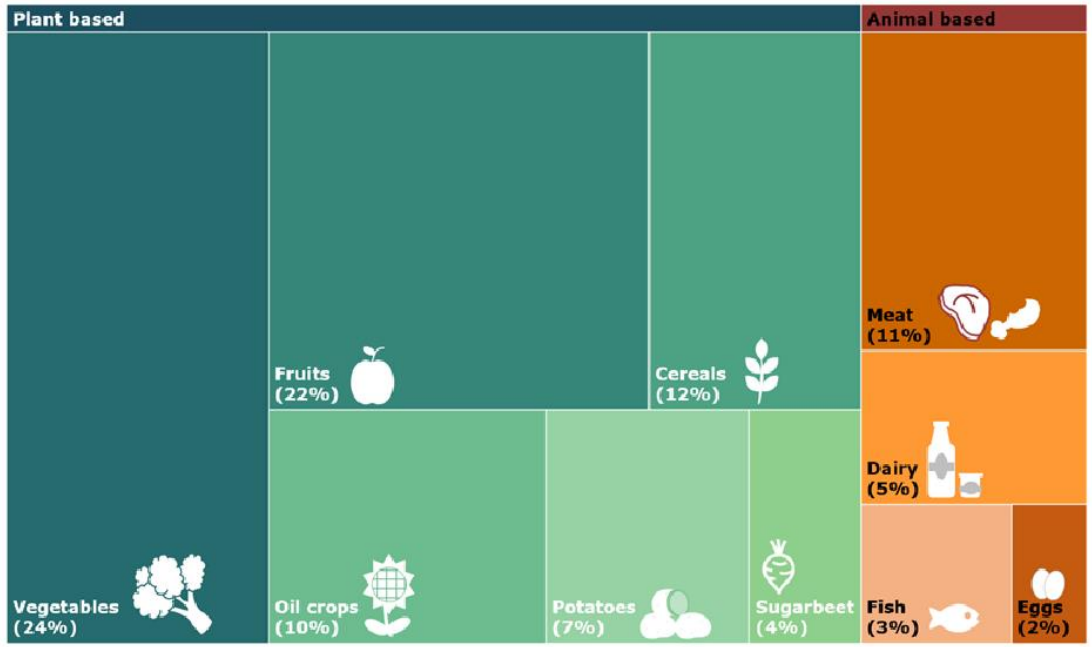




Food Waste Structure

prominent fraction of **plant based** sources

Food waste quantification EU 28, 2011



Food waste in EU-28:
129 Mt fm

Sanchez Lopez, J., Caldeira, C., De Laurentiis, V. and Sala, S., Brief on food waste in the European Union, Avraamides, M. editor(s), European Commission, 2020, JRC121196.

European Commission

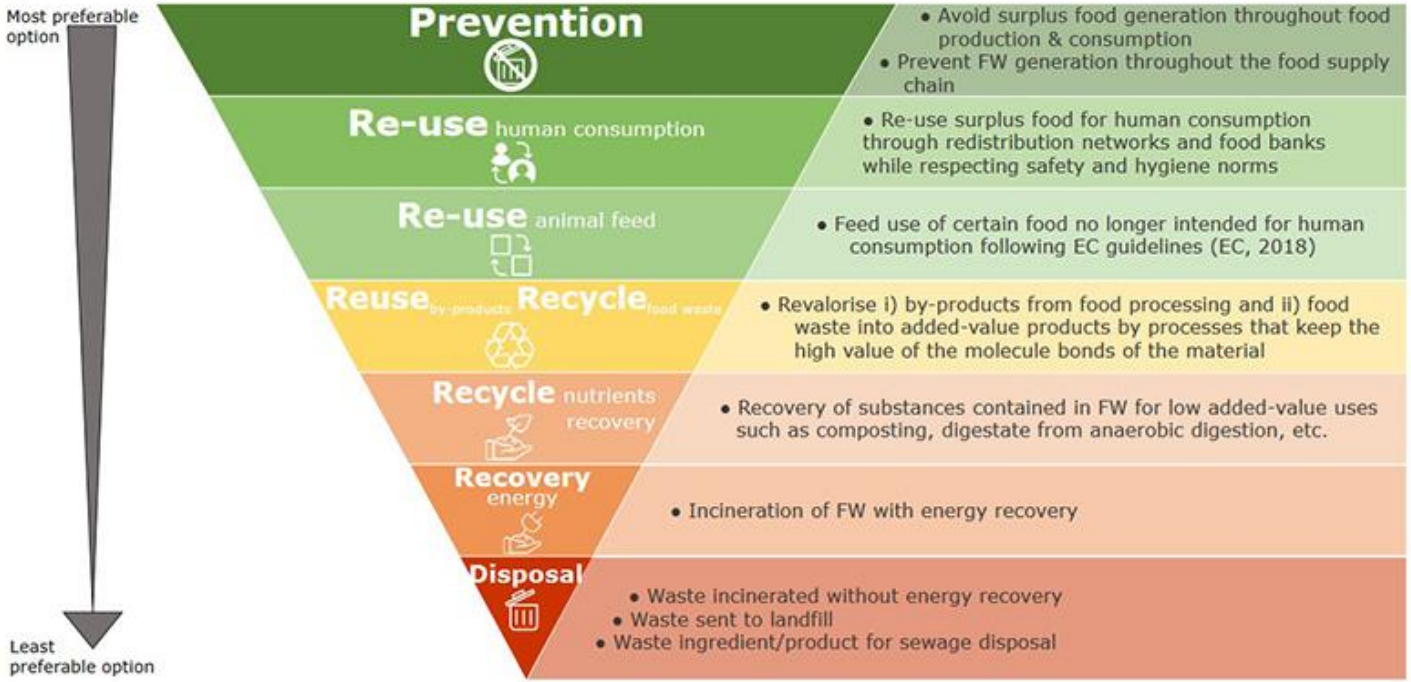
https://food.ec.europa.eu/system/files/2020-11/fw_eu-platform_20201125_fwm-webinar_pres-3.pdf

Prevention and utilization of food related streams

Farm to Fork Strategy at the heart of European Green Deal.

Directive (EU) 2018/851 changed the definition of food waste, as all food that has become waste, and food being defined with all of its counterparts, including edible and inedible parts.

*The directive introduces the **waste hierarchy** concept, that is also logically applicable for waste food prevention.*



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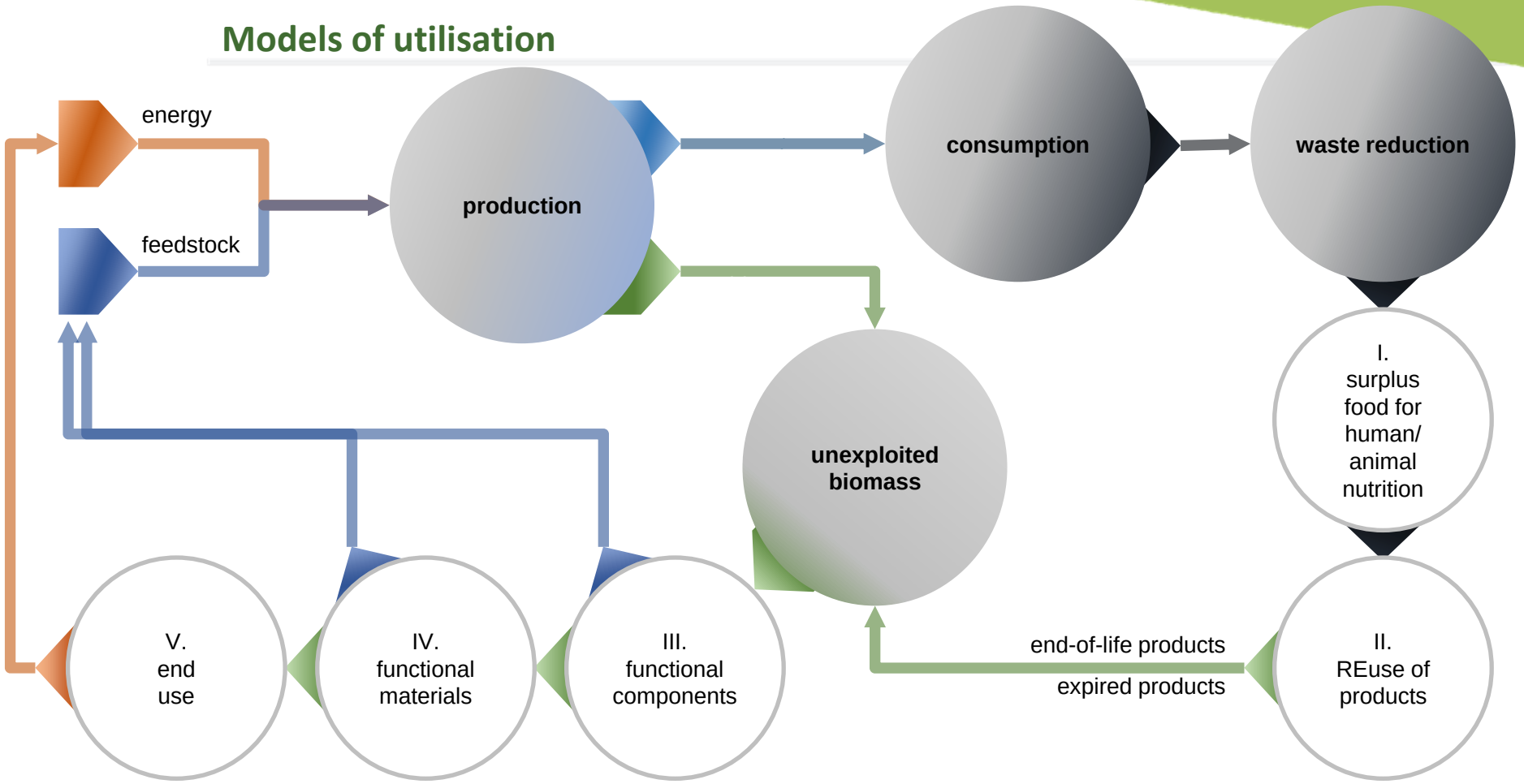
Models of utilisation



Agrifood biomass

1. Edible food waste needs to be prevented and reduced. Upon withdrawal of the product from the food supply chain (CN (2018/C 133/02)), former food needs to be considered first for animal feed (EU (2008/98/EC)).
2. **Agricultural biomass**, **food processing by-products** and **inedible food parts** have promising applications in new foods, bioactives, nutrient recovery, chemicals, polymer and material production.
3. Energy production from wasted materials is siutable for end-of-line materials, lower quality and more heterogeneous biomass streams.

Small scale applications

surplus food for human/ animal nutrition

Novel foods
- plant/food ingredients as natural food colors and aromas
- blending protein and OH by-products, mildly fermented foods
- new preparation technologies (freeze drying – new structure, vacuum drying – alcohol removal …)

Former foods for feed (including insect bioconversion)

functional components

Novel small unit extraction procedures
- ultrasound extraction
- disruptive/cavitation based extraction

IV. functional materials

Fibrous and/or lignin fraction
- papermaking from own residual feedstocks for special papers
- active packaging (antioxidant/antimicrobial/light protection)

V. end use

Biochar
Nutrient recovery
Biogas

NextGeneration Green Transition

- **renewable energy** transformation and **heat cycling**
- solar farming and biomethane for **H_2 production**
- electrolysis for **wastewater processing** and H_2 generation.
- **carbon farming** and **biogenic CO_2** production

Thank You!

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