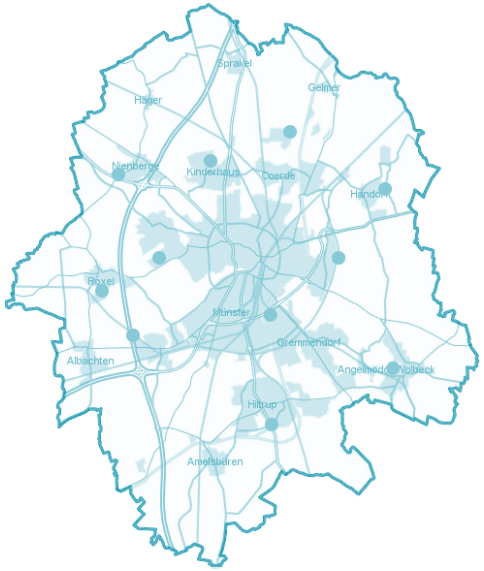
From Waste to Resource:
Exploring the Transformation of Organic Residues into Biochar through Pyrolysis

Dr. Christoph Baumann

07.05.2024

The HOOP project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°101000836

City of Münster



Capital of Westphalia

- Residential population over 320.000

Sustainability at the municipal level

- *Bicycle Capital* of Germany (2023)
- Winner of the "*National Sustainability Award*" (2019)
- Finalist in the election for the "*European Green Capital*" (2017)
- Multiple awards as "*Federal Capital in Climate Protection*"
- Accepted into the "*100 Climate-Neutral and Smart Cities by 2030*" by the EU

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- **Municipal waste management company** of Münster
- **ISO-certified** for quality, **environment** and work safety
- **450 employees** responsible for city cleaning, winter services, waste collection & transport, recycling and waste treatment

- **Vision 2030:** *“Münster - A capital of waste prevention”*

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Logistics in Münster

Door-to-door collection:

- Weekly:
  - Biowaste
- Bi-weekly:
  - Residual waste
  - Paper & cardboard
  - Packaging & household recyclables
- Monthly:
  - Garden and green waste
  - Bulky household waste

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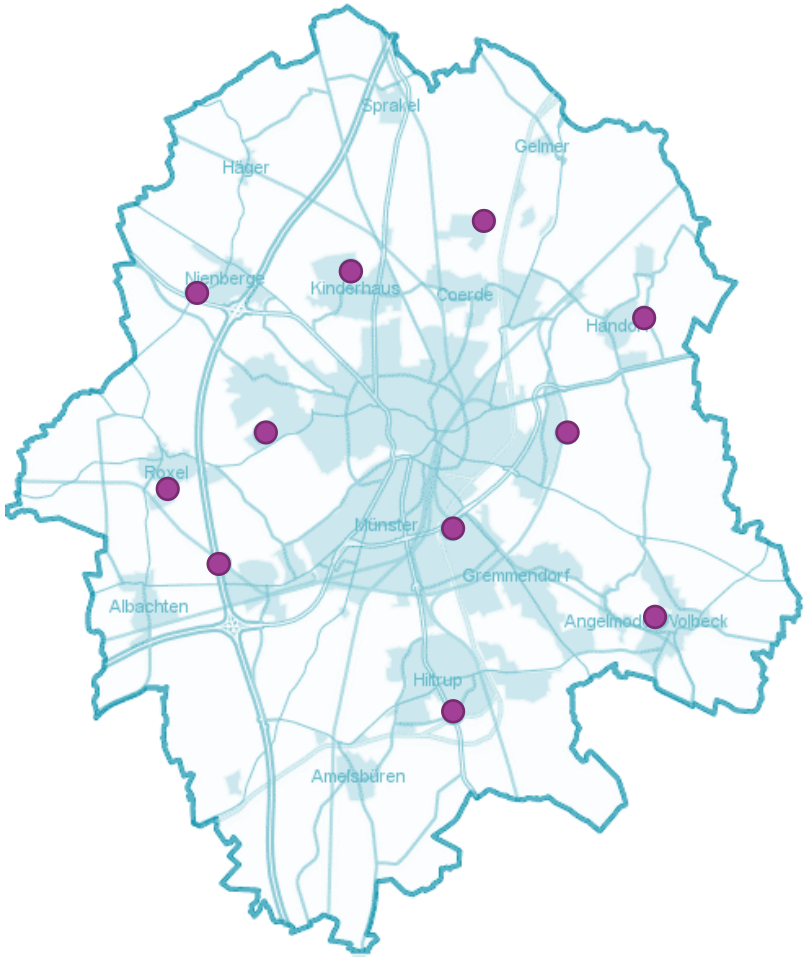

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11 Decentralized Recycling Stations (max. 3km distance)

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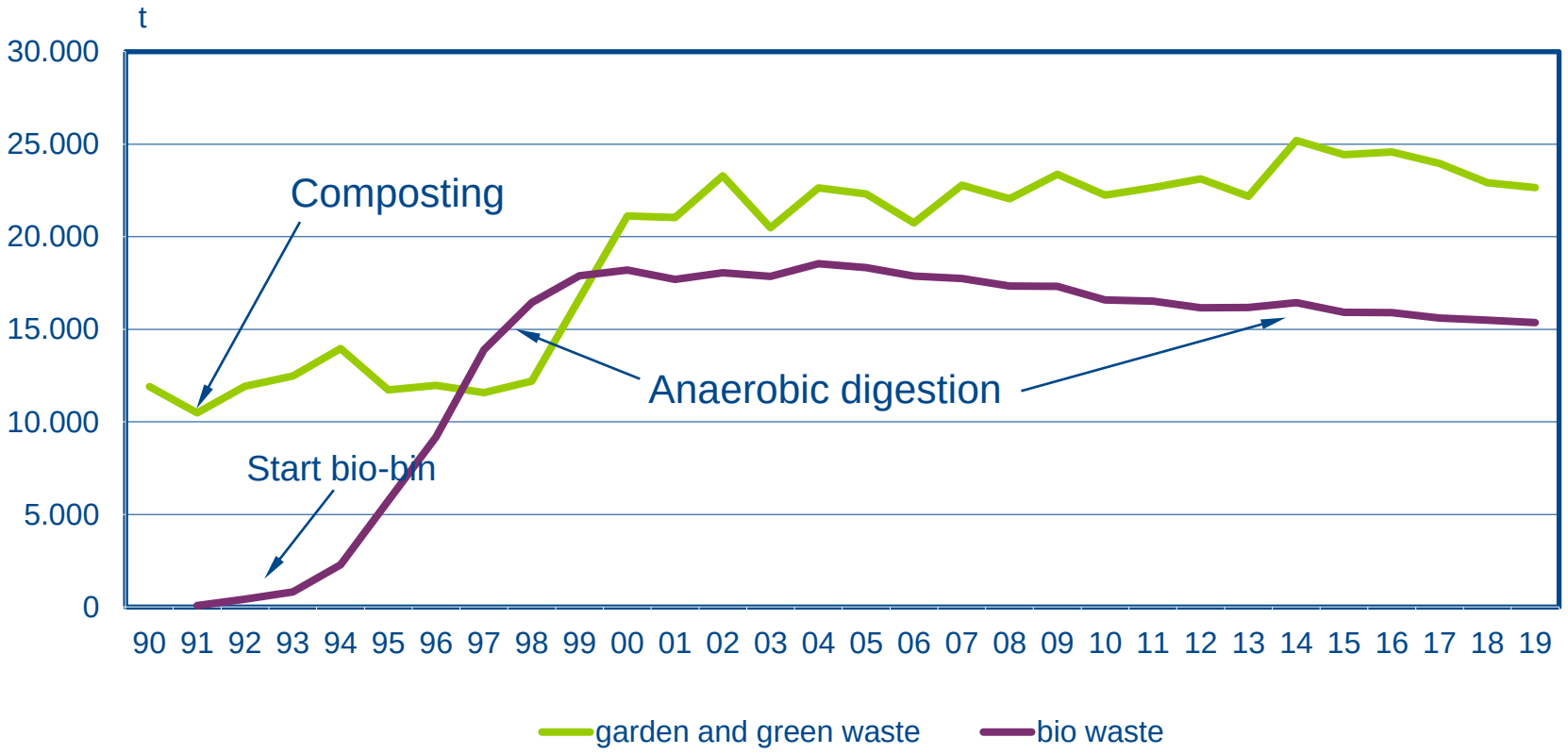
Development of Organic Waste Recycling



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Campaign „Aktion Biotonne Münster“

Our goal - achieving sustainable behavior change:

Increasing the **quality** and **quantity** of biowaste

Starting point (2017):

Estimated **3.5 % impurities** in biowaste

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Campaign started in 2017 :

Phase I: Education and Information
Phase II: Motivation
Phase III: Reminder
Phase IV: Controls of the biowaste bins (ongoing)

Intermediate result:
Impurities decreased to **1.9%** with strong decrease for plastics.

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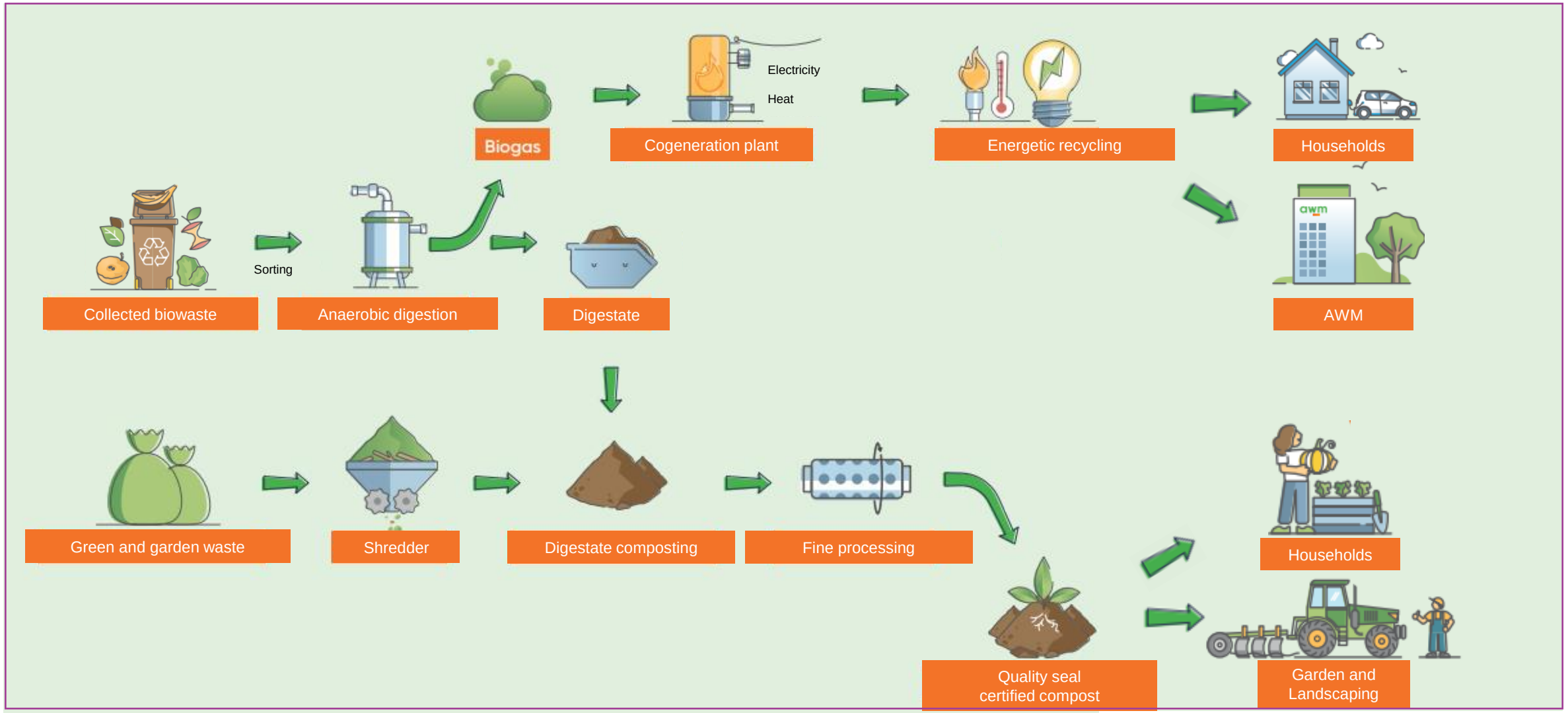
Status Quo: Biowaste & Green and Garden Waste Recycling



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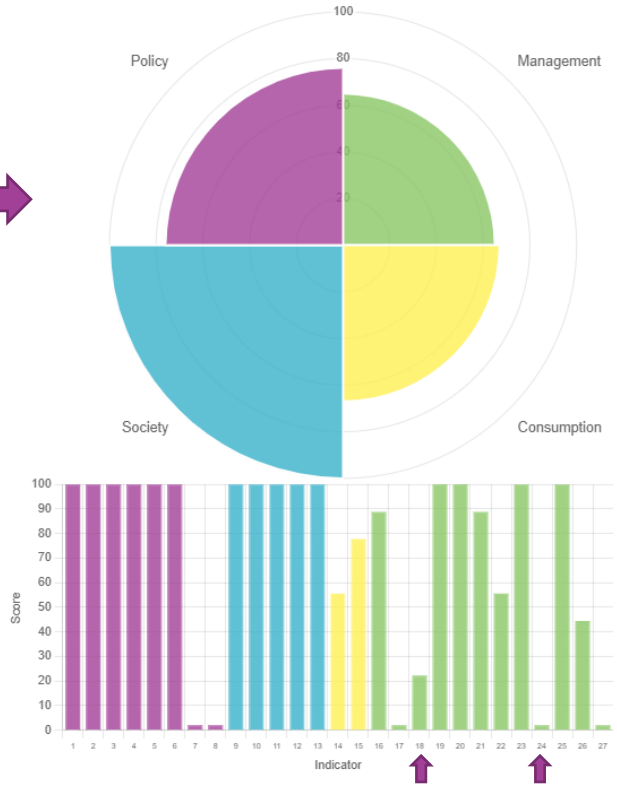
Circularity-Label: Identifying potential for improvement



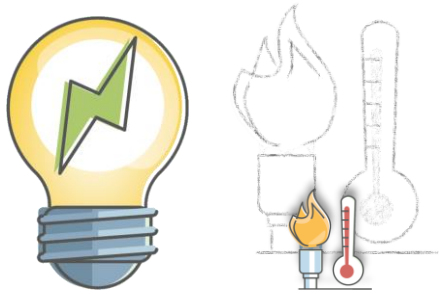
Münster

Circularity Level 8

(Total Score: 72 / 100)

<u>Identified areas for improvement</u>

Share of renewable energies



Number of innovative bio products

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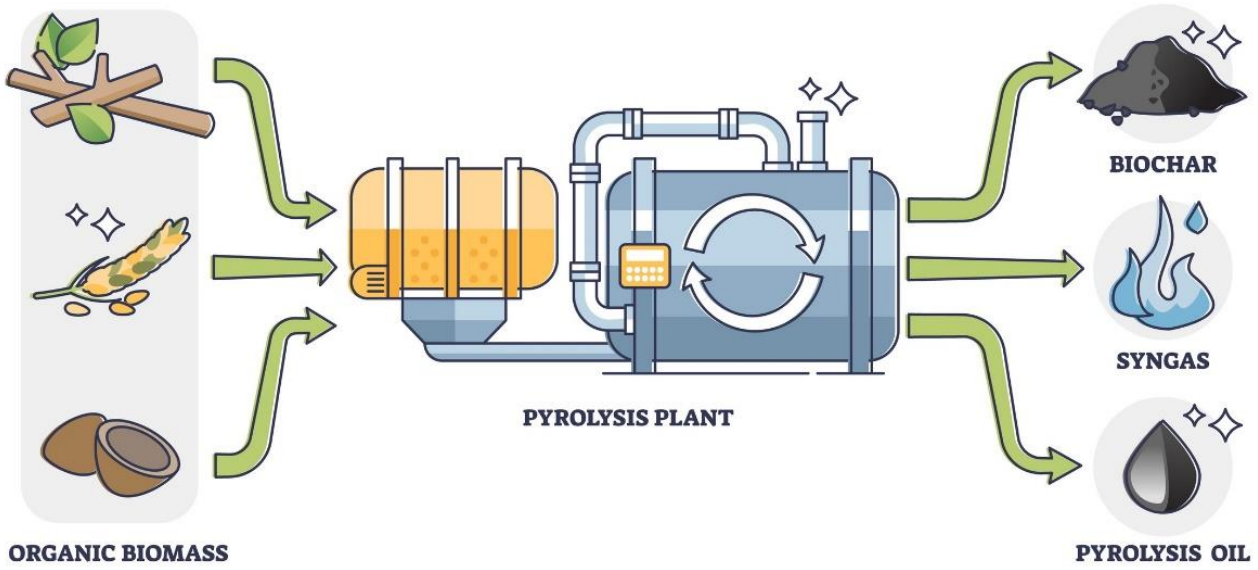
Pyrolysis – a Negativ Emission Technology (NET)



- Production of a carbonisate (**biochar**) from diverse organic substances → **NEW innovative bio product**
- **Exothermic** process (with optimized process parameters and suitable input material) → **MORE renewable energy**
- **Biochar** used in soil applications allows for **long-term CO_2 Sequestration** → **Climate protection**

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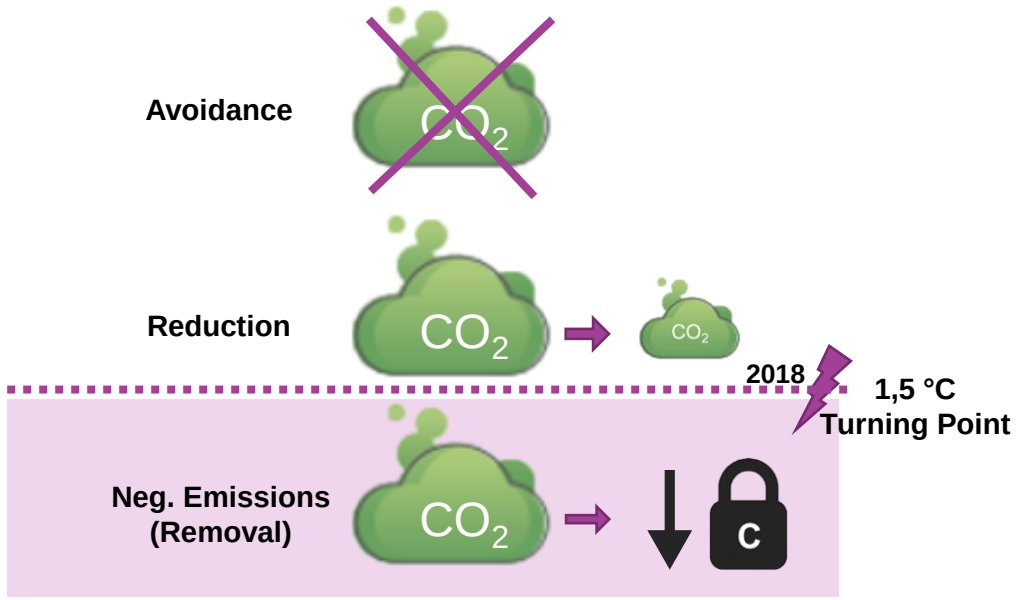
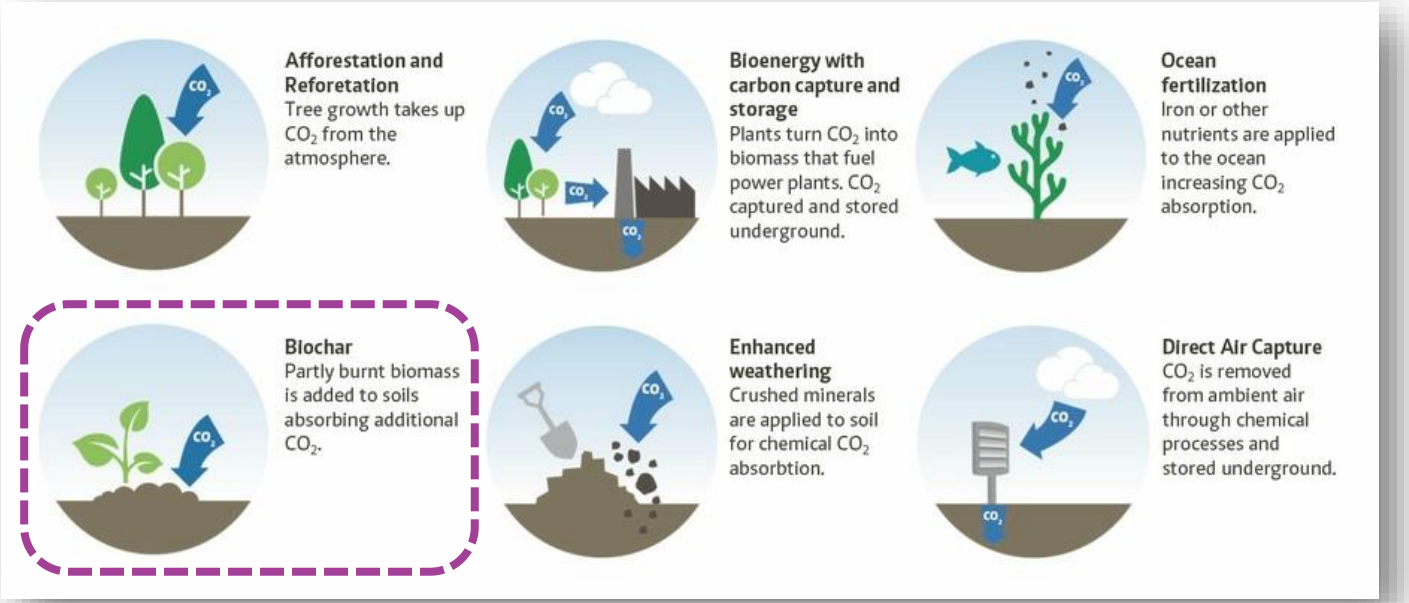
Carbon Sinks - an important Tool for Climate Protection

Courses of action



Six promising options for creating **carbon sinks:**



- Some technologies are better suited for specific areas

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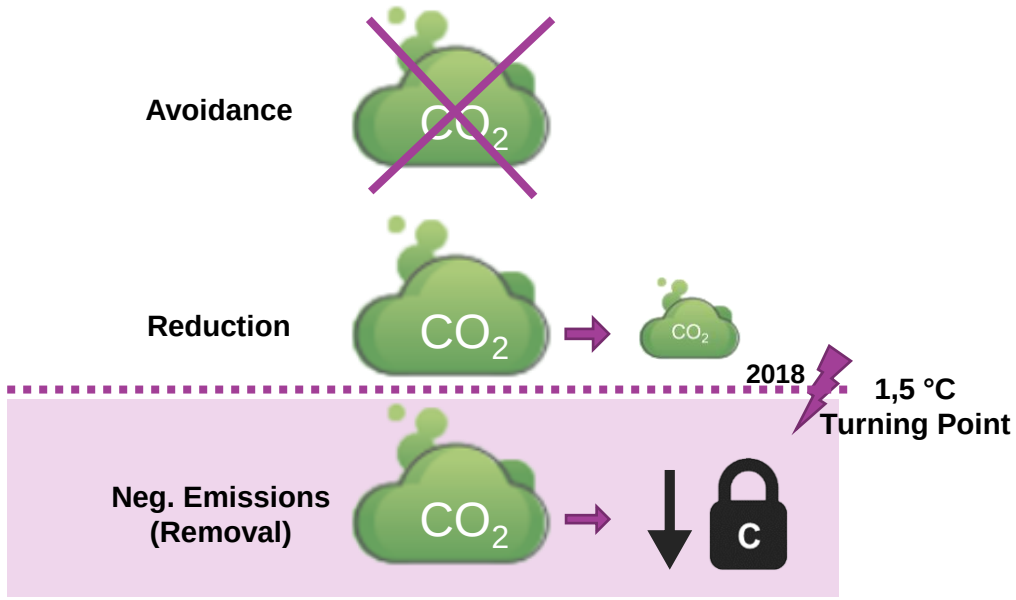
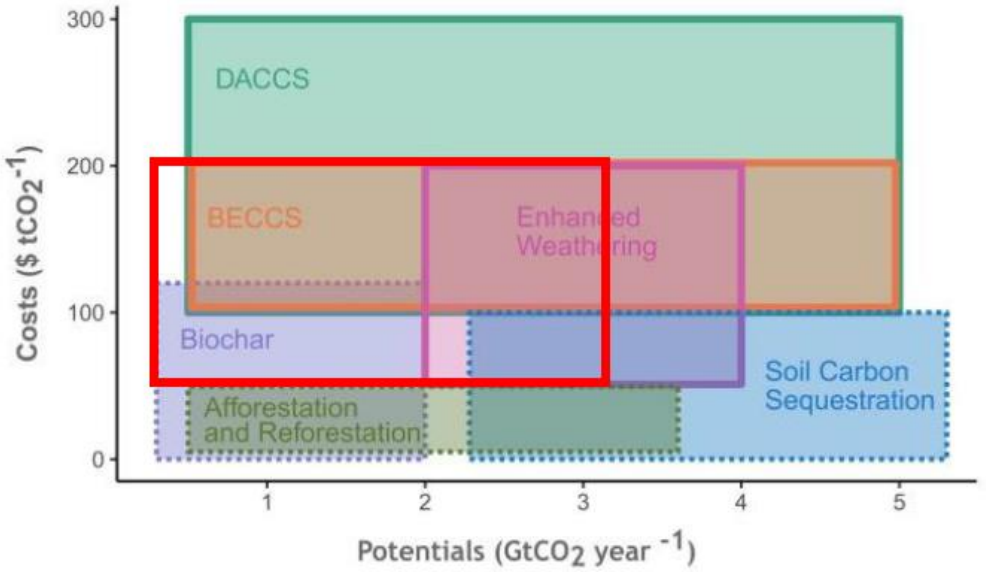


Biochar Carbon Removal (BCR) – Cheapest permanent carbon removal



IPCC, 2018: Summary for Policymakers. In:Global Warmingof 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty

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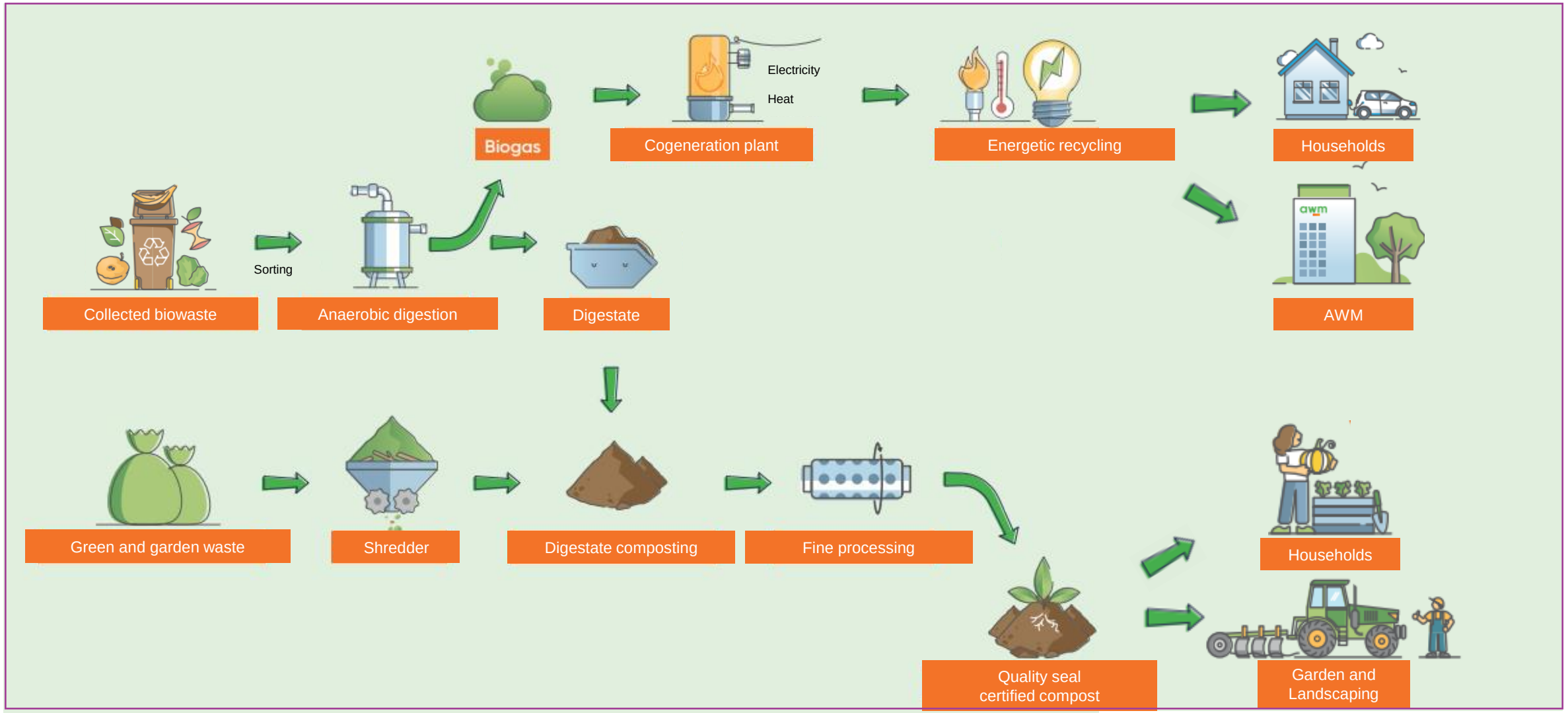

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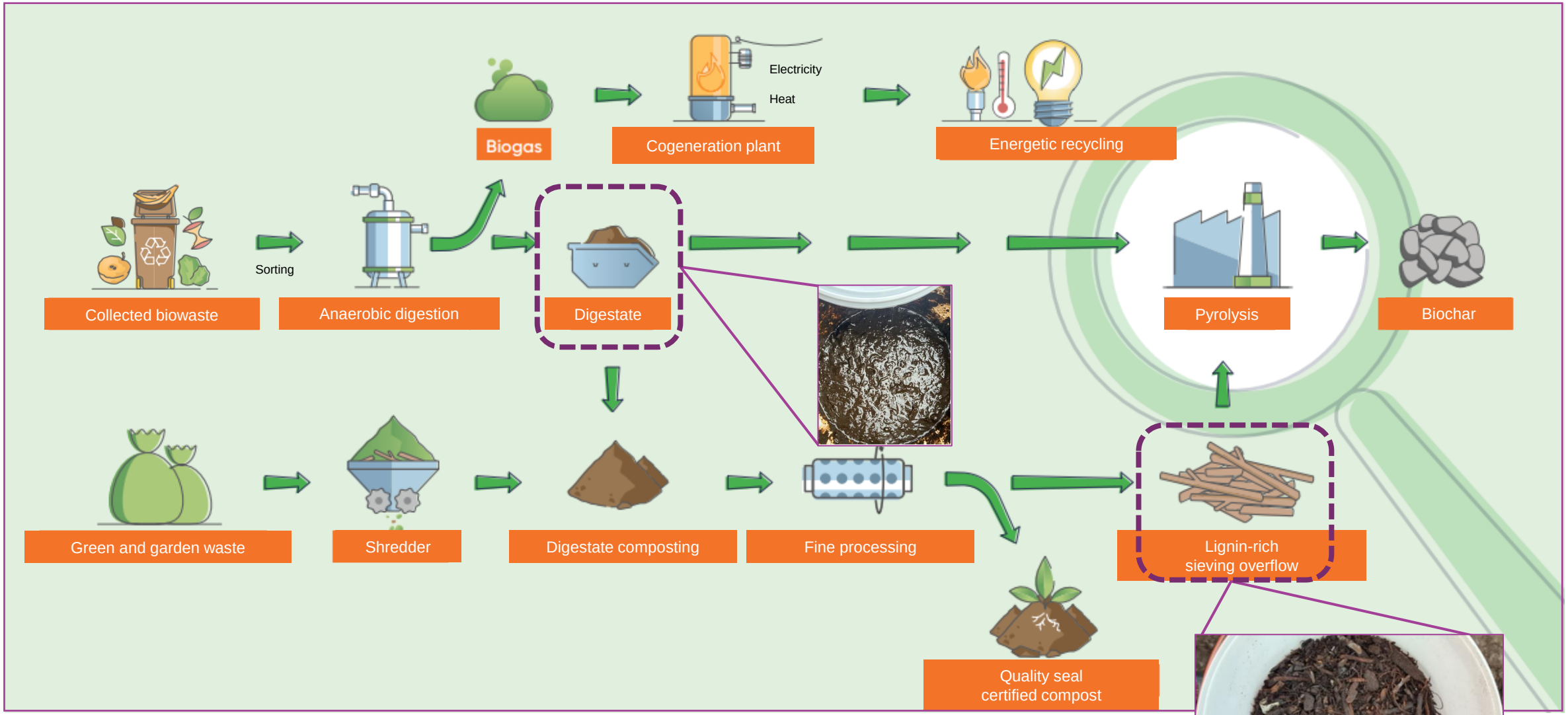
Exploring Pyrolysis for Biowaste Management



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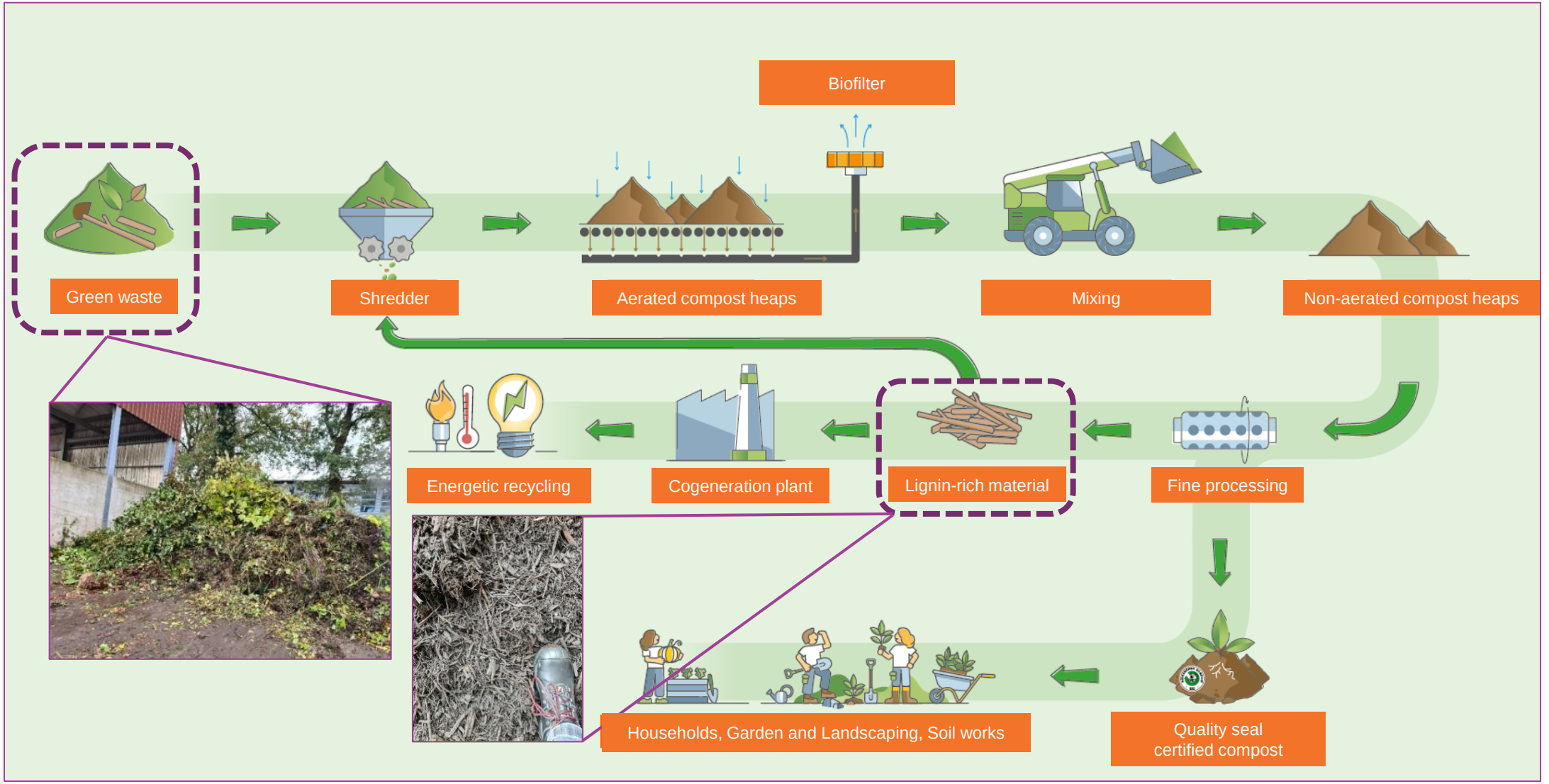
Optional Input Materials



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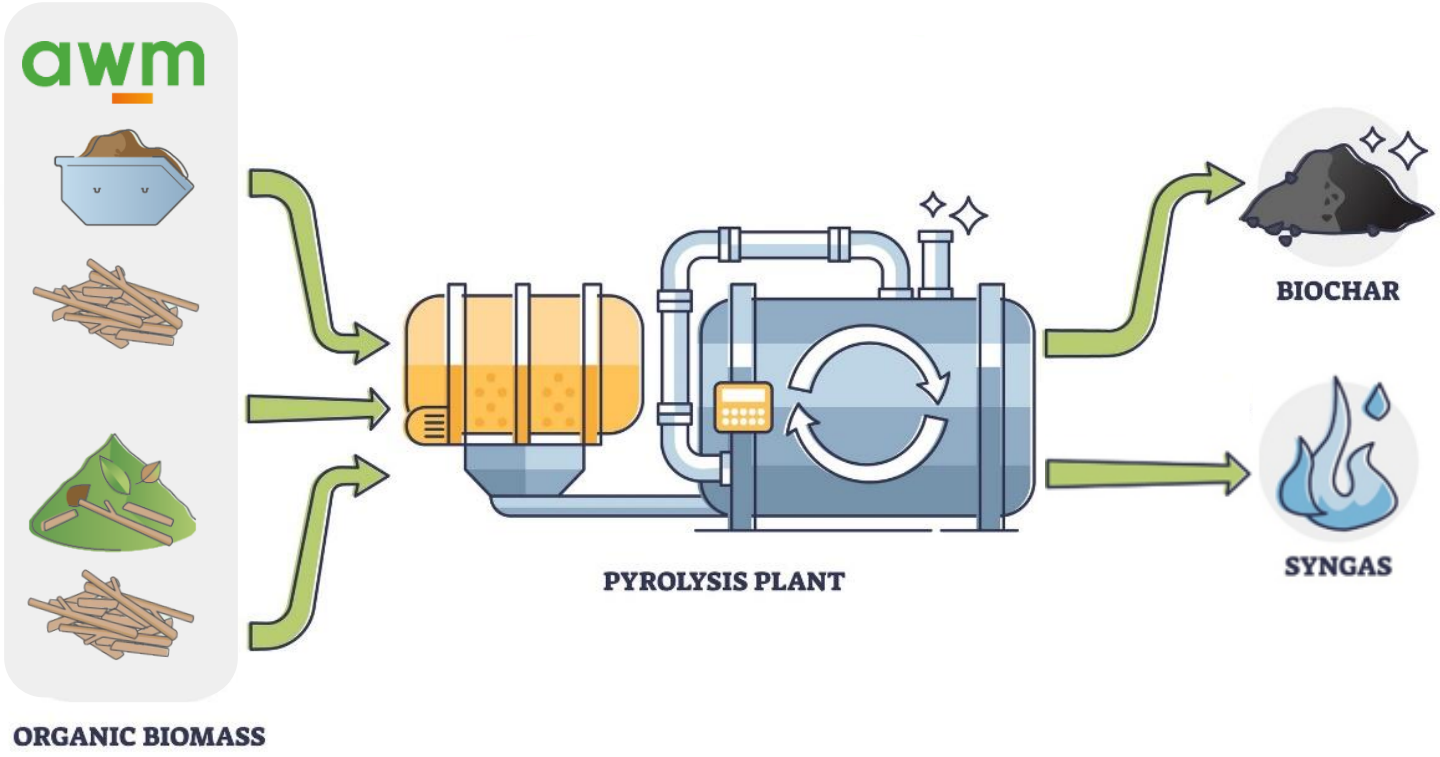
Pyrolysis - Synergies with Münster waste management

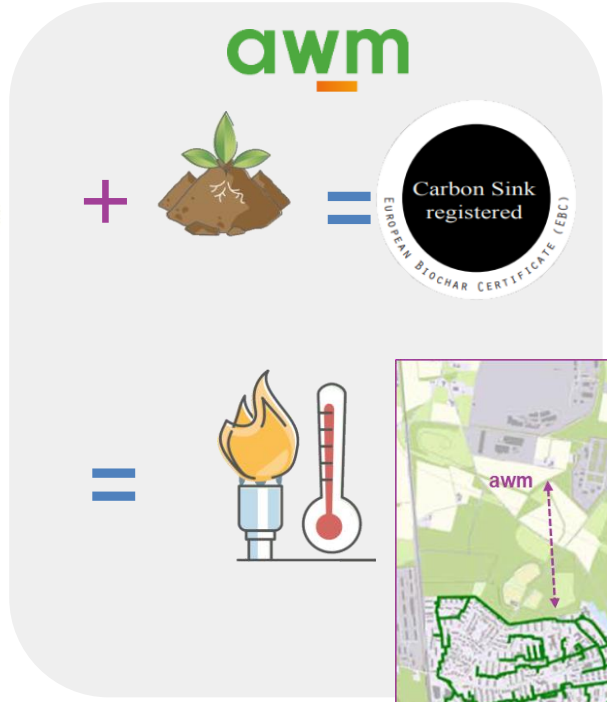
Digestate

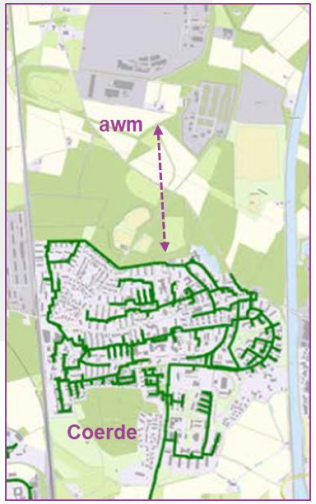
Sieving Overflow
(digestate comp.)

Green Waste

Sieving Overflow
(Composting)







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Feasibility Studies

Analyzed by ithaka institute

Digestate

- High moisture content (>70%)
- low abundance of woody material
- 0,5 – 2 % plastic content
- **Sufficient availability (~10.000 T/a)**

Sieving Overflow (digestate comp.)

Green Waste

Sieving Overflow (Composting)

Digestate Biochar

- High drying effort required (**no** excess heat available)
- Low carbon (< 30 %) & high ash content

- EBC-Limits for Nickel, Chromiom and Cadmium significantly exceeded (~~EBC-Agro~~, ~~EBC-Urban~~)

➢ **Possible field of application**:
  - Material applications (EBC-BasicMaterials)

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Feasibility Studies

Digestate

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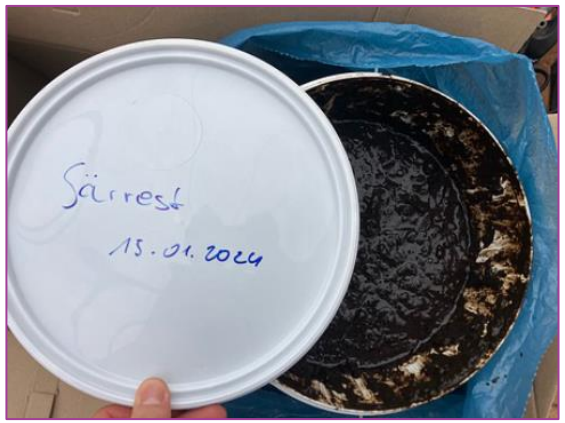
(digestate comp.)

Green Waste

Sieving Overflow
(Composting)

EBC-BasicMaterials: Biochar for material application



Digestate
(10.000 T/a)

Co-Pyrolysis

20 % **+** **80 %**

Waste Wood (A1-A3)
(3.000 - 5.000 T/a)

Usecase Examples:

Climate positive Asphalt (Enschede, NL)**:**

"The combination of **Ecofalt** and **biochar** makes a sidewalk construction CO2-negative."

CO_2-neutral concrete

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Feasibility Studies

Analyzed by PYREG NET ZERO TECHNOLOGY

- High fines content (>40 %)
- Many impurities
- **Limited availability (~1.000 T/a)**

Pre-treatment (Shredding & fine processing)

ca.19 MJ / kg
Calorific value

Biochar from sieving overflow

Digestate

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Biochar from sieving overflow

Calorific value: ca.19 MJ / kg

High Value Biochar

- Carbon content: > 50 %
- Specific surface area: 189 m_2/g
- Water holding capacity: 177 %

But: 2 EBC limits exceeded (Nickel/Chromium)

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Feasibility Studies

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Pre-treatment (Shredding & fine processing)

Biochar from sieving overflow

Calorific value: ca.19 MJ / kg

For EBC-Agro or EBC-Urban applications:

- More effective fine processing
- Check internal processes for avoidable inputs of Chromium and Nickel

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Feasibility Studies

Digestate

Sieving Overflow
(digestate comp.)

Green Waste

Sieving Overflow
(Composting)

Not suitable for pyrolysis

- **No analysis planned**

- High availability (15,000 - 19,000 t/a)
- Low proportion of wood (max. 20 %), high proportion of green cuttings → high pre-treatment costs
- Wood parts are an important structural material in composting → biomass competition

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Proof of Concept / Feasibility Studies

Digestate

Sieving Overflow
(digestate comp.)

Green Waste

Sieving Overflow
(Composting)

Analyzed by

PYREG

NET ZERO TECHNOLOGY

- Hardly any contamination (only green waste)
- Less suitable as structural material for composting (less competition for biomass)
- Limited **availability (~1,000 t/a)**

Test pyrolysis **in progress**

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Currently considered Applications for Biochar in Münster

Diverse Opportunities for Biochar Utilization

Local Agricultural Sector:

- Cascading use or single use to enhance soil fertility and crop productivity

Urban Applications:

- Utilization in city tree plantings or regeneration projects
- Improves urban green spaces and stormwater management

Production of Higher-Value Substrates:

- Collaboration with soil works
- Enhances plant growth and sustainability (gardening)

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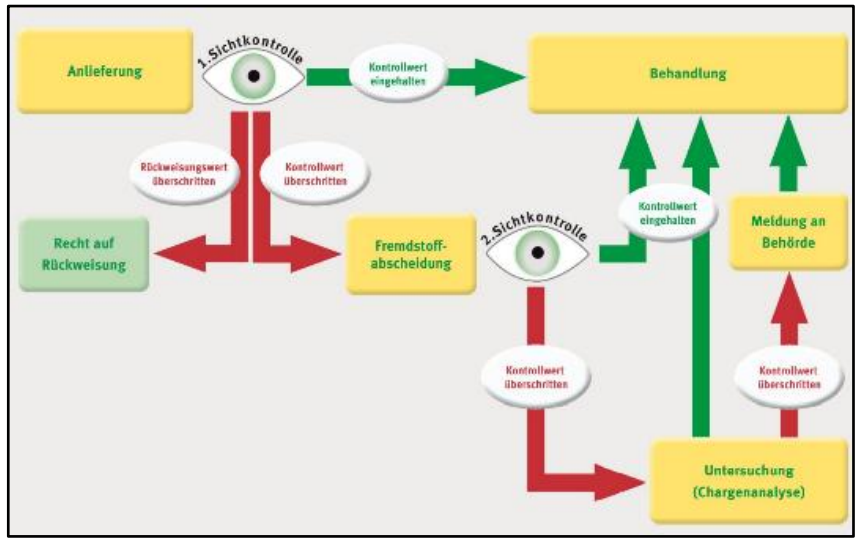
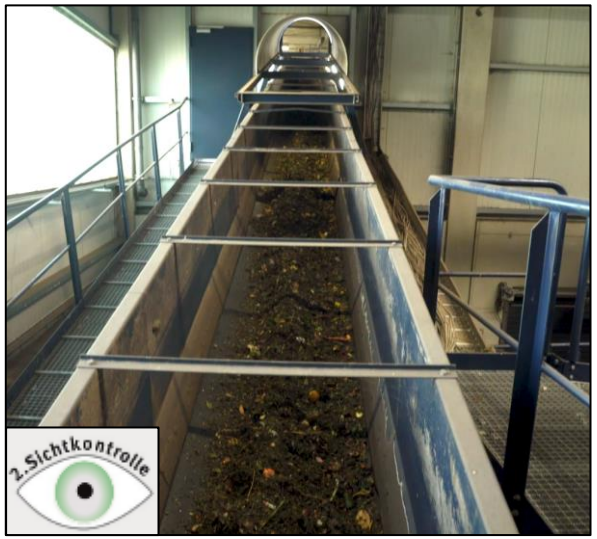
Recent amendment to the Bio-Waste Ordinance in Germany





- Percentage of **plastics** in biowaste must be **less than 1 %** (**2 visual inspections** before and after treatment)
- Amendment comes into force in **2025**

➢ **Repeated control value violation:** Acceptance of biowaste into our processes can be prohibited by local authorities

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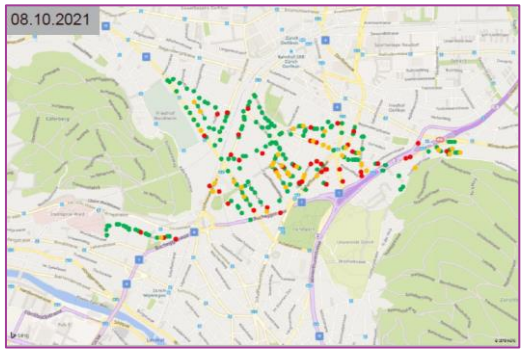
A look forward: Enhancing Biowaste Inspection through Automation

- **Implementation of Automated Detection Systems:**
  - Supplement manual inspections (Aktion Biotonne)
  - Automated impurity detection systems deployed on biowaste collection vehicles
  - **AI-Based Image Recognition Technology** to identify impurities in biowaste

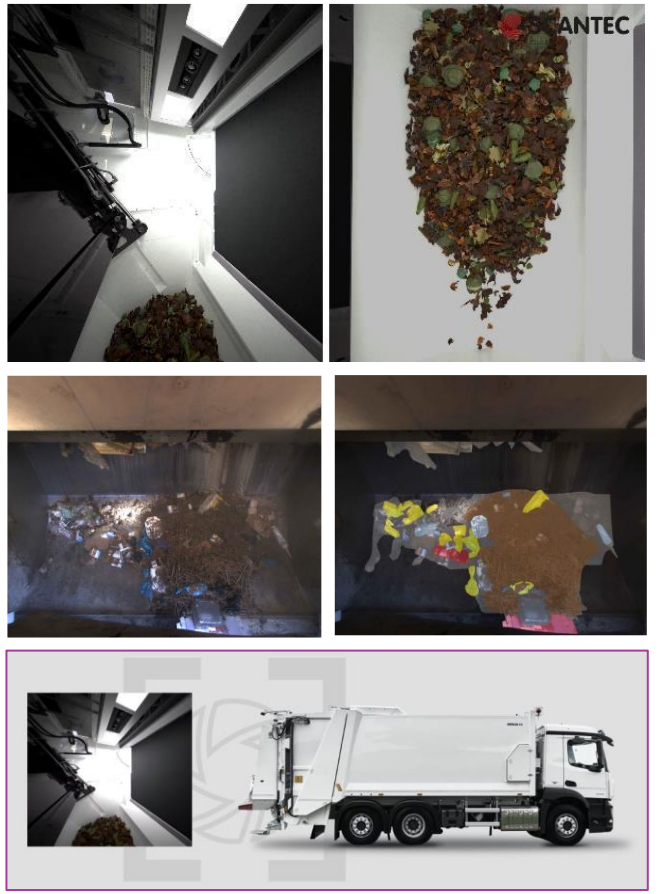


➢ **To increase coverage of biowaste inspections**

➢ **To promote targeted educational initiatives**

SMART SCAN

SCANTEC ZOELLER GROUP



***Sample Technology Provider**

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Questions?
Let’s discuss!

Dr. Christoph Baumann

Join the HOOP Network in 2 minutes

Scan me!

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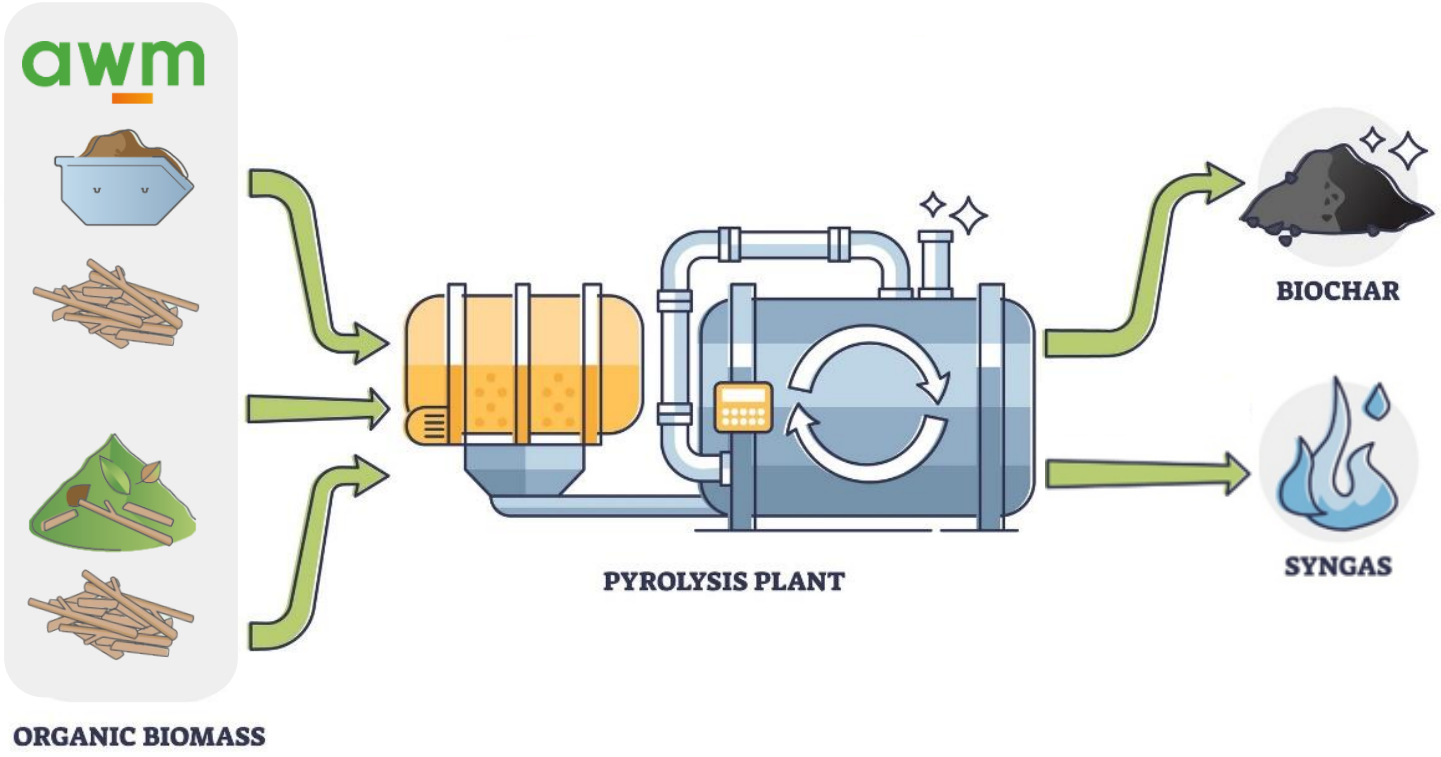

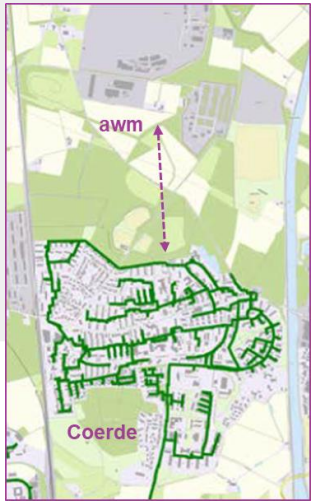

Example: PYREG PX 1500

Annual throughput 3.300 t Input material
Annual production 900 t Biochar
C-removal potential **2.100 t CO_2 per year**

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Regulatory Assessment

Renewable Energies Act (EEG)

- regulates compensation of electricity from biogas
- §43 (2) might prevent other material use for digestate (like pyrolysis) except composting

Missing Harmonization between European Fertilizer Regulation & German Fertilizer Regulation

- Untreated wood as only recognized input material
- Other input materials require CE-Certification and a declaration of conformity to EU law
- Federal Ministry of Food and Agriculture signaled a revision:
  - inclusion of more input material provided appropriate standards are developed (EBC)

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