



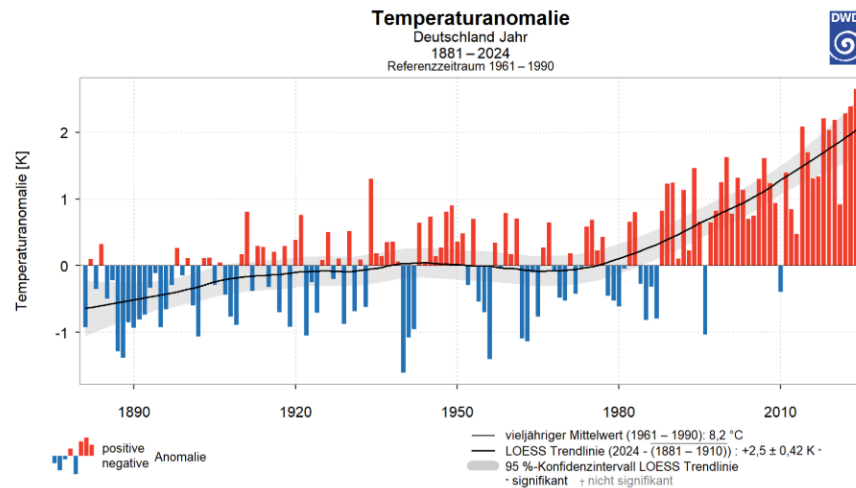
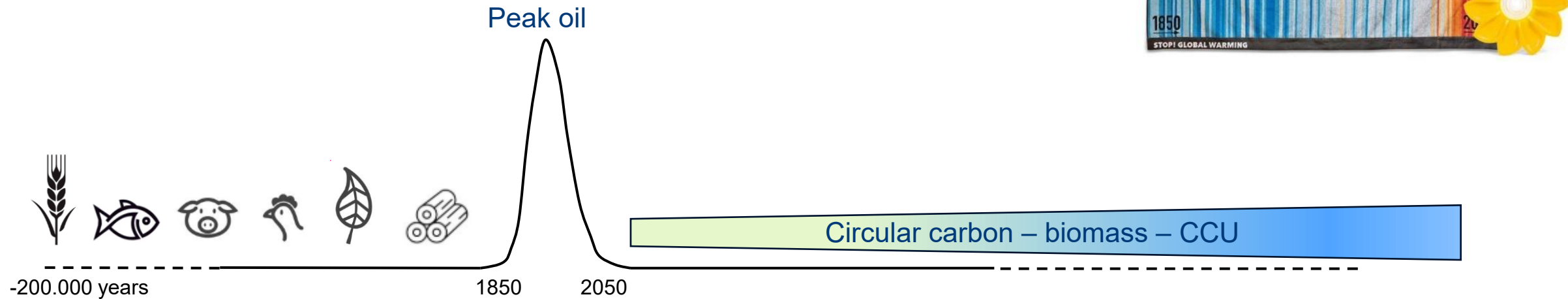
Ostfalia
Hochschule für angewandte
Wissenschaften

Too good to burn – Upcycling Paper Towel Waste into Bio-Based Products

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Versorgungstechnik

The overall Motivation



- Rising world population
- Rising demand
- Loss of arable land
- Technical progress

The special goal

70.000 t/a in Germany

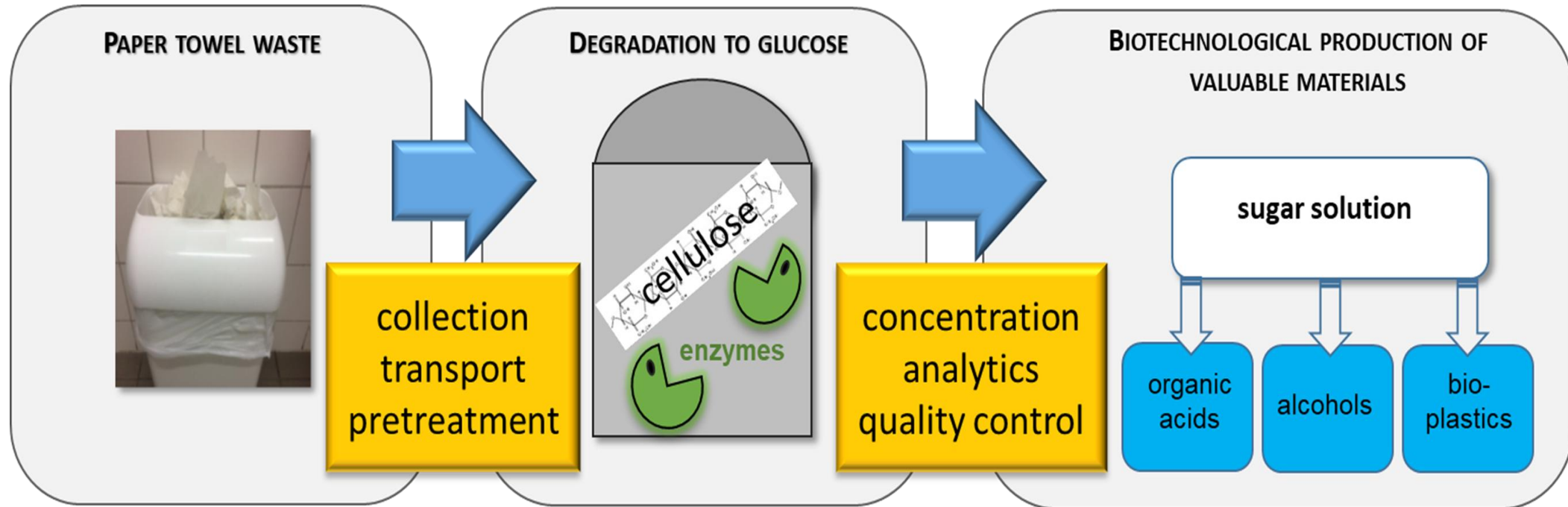


Source: Institut für Bio- und Geowissenschaften

- Biotechnological reuse of existing and valuable carbon skeleton glucose instead of combustion and mineralisation to CO₂
- Contribution to climate protection
- Contribution to bioeconomy
- Contribution to social awareness and acceptance

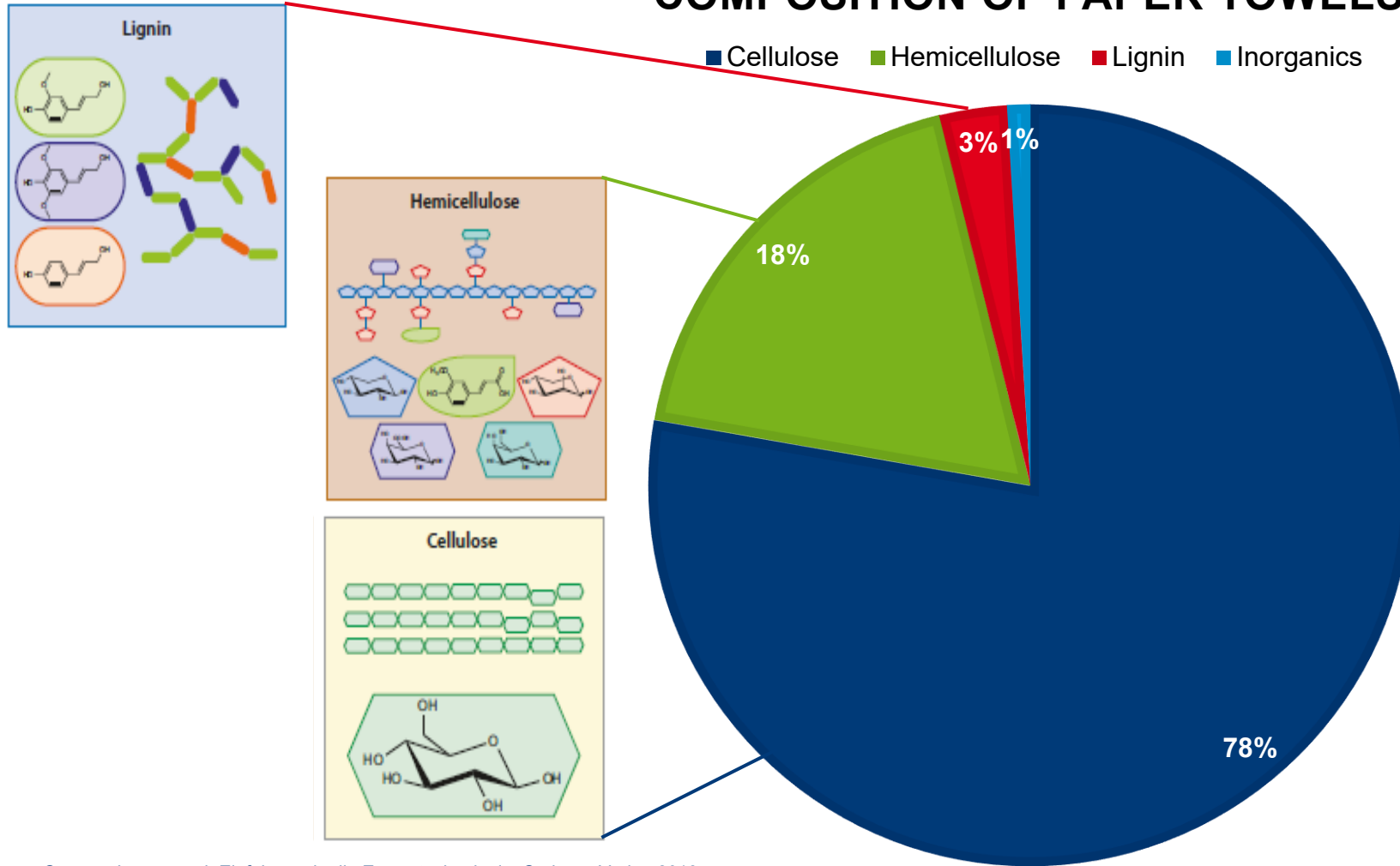
Paper towel waste – too good to burn

Project Cell2Cell – from cellulose to cells and cellular products



Paper towel waste – too good to burn

COMPOSITION OF PAPER TOWELS



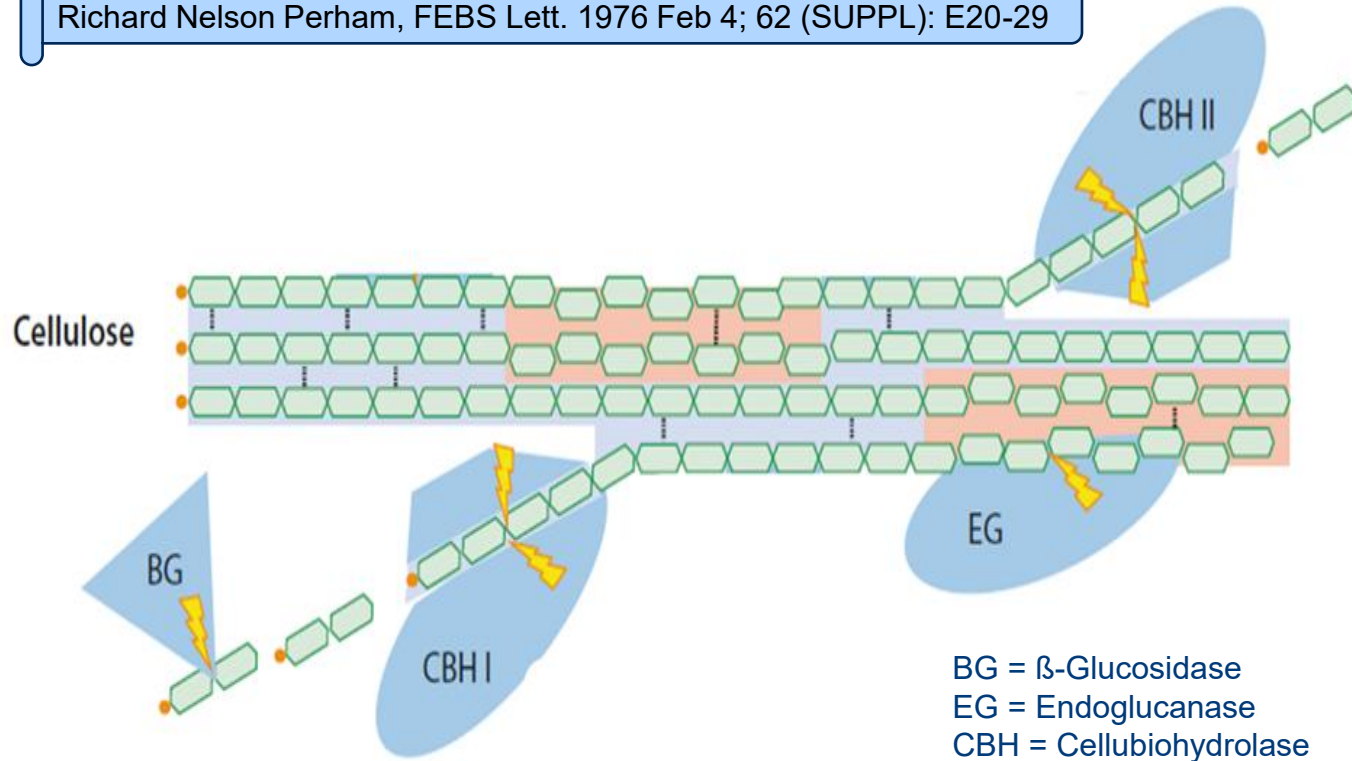
- Paper towels are mainly cellulose
- Cellulose is regularly built up
- Polymer from glucose monomers

Source: Jaeger et al. Einführung in die Enzymtechnologie, Springer-Verlag 2018

Saccharification of paper towels

„Enzymes are proteins, things of beauty and a joy forever.“

Richard Nelson Perham, FEBS Lett. 1976 Feb 4; 62 (SUPPL): E20-29

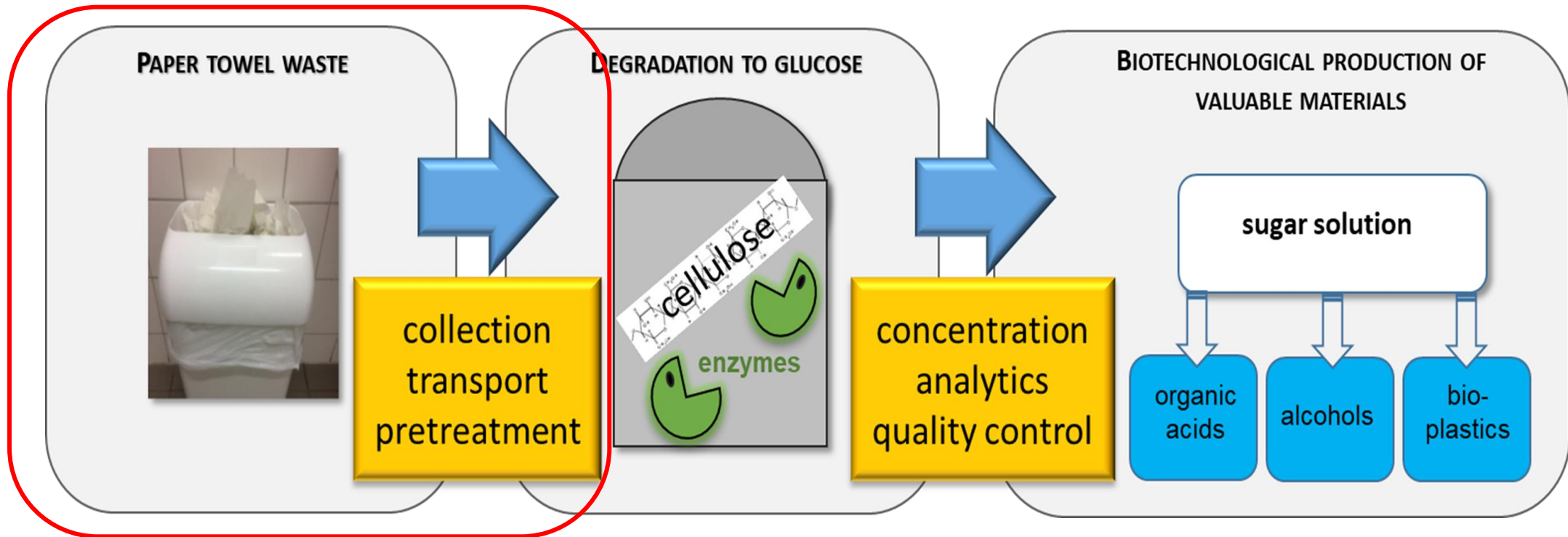


- Cellulases
 - monomerise cellulose to glucose
 - are commercially available
- Glucose is a universal energy and growth substrate for microorganisms

Source: Jaeger et al. *Einführung in die Enzymtechnologie*, Springer Verlag 2018.

<https://cms.zdv.uni-mainz.de/studium/wp-content/uploads/sites/12/2023/02/Molekulare-Biotechnologie-BSc.jpg>

Phase 1 - Collective logistics



Phase 1 - Collective logistics at Ostfalia



1st collection:
Ø 2,22 mass% impurities

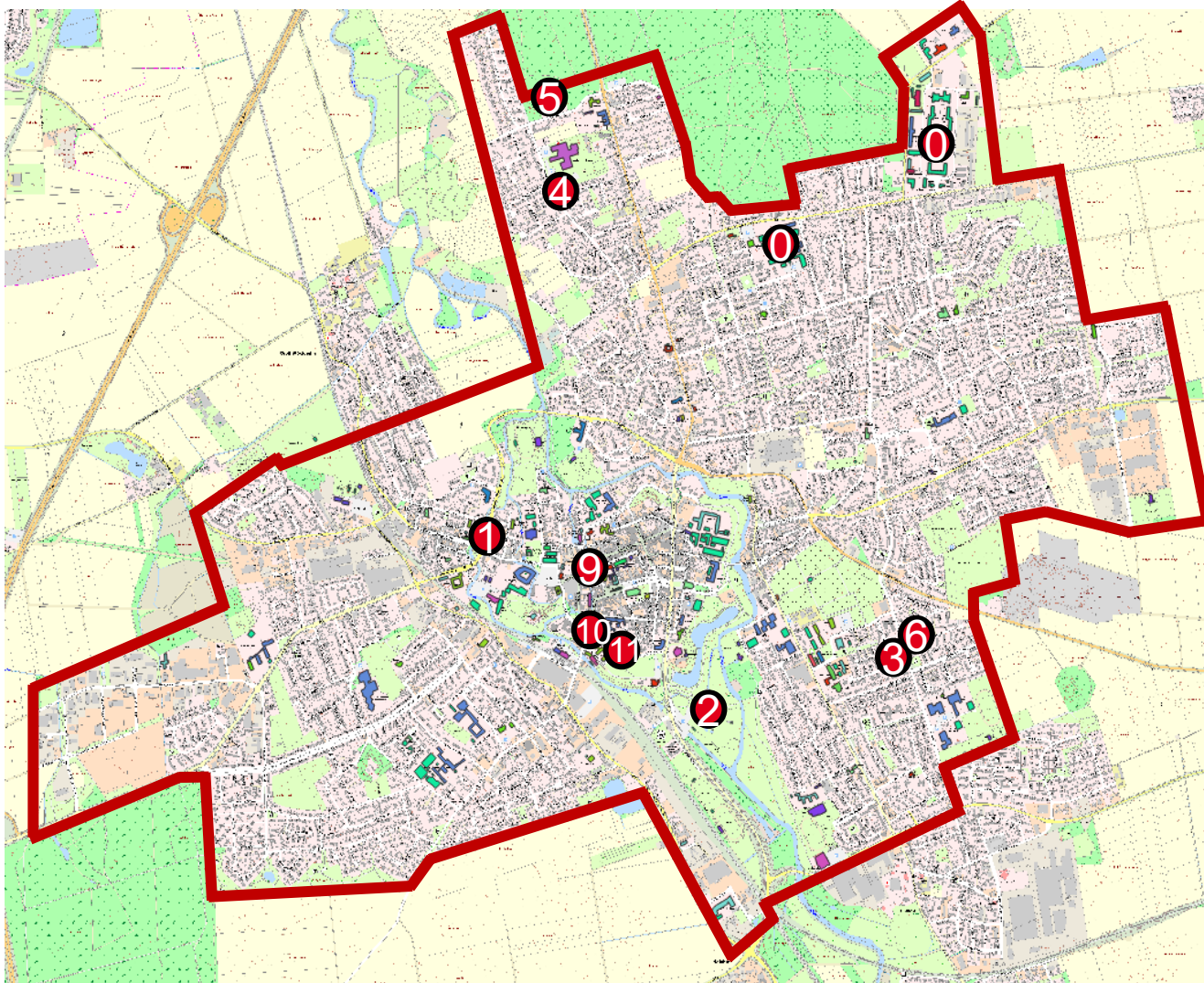


2nd collection:
Ø 0,56 mass%

- Information reduces impurities

Phase 1 - Collective logistics in Wolfenbüttel

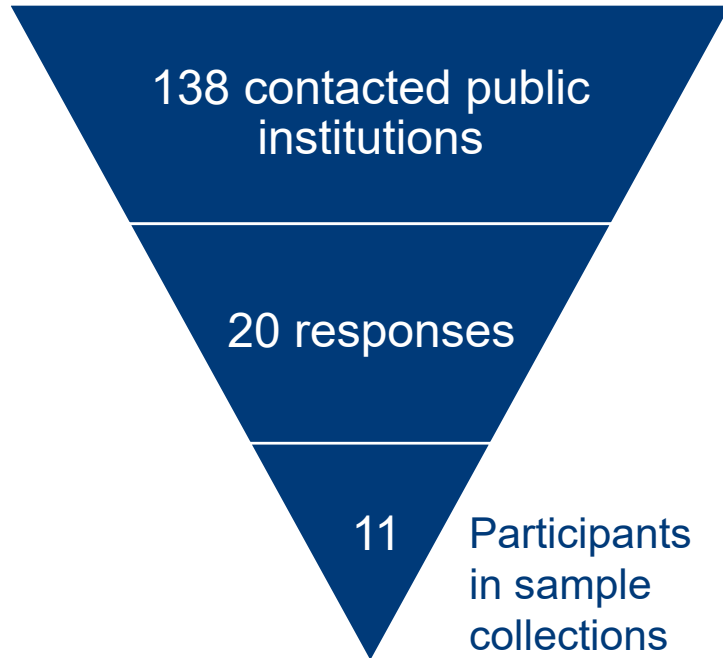
7
Vöhrum



8
Berlin

- Survey on paper towel use, quantity and type
- Predominant use of folded paper towels
- Different qualities&suppliers

Phase 1 - Collective logistics in Wolfenbüttel



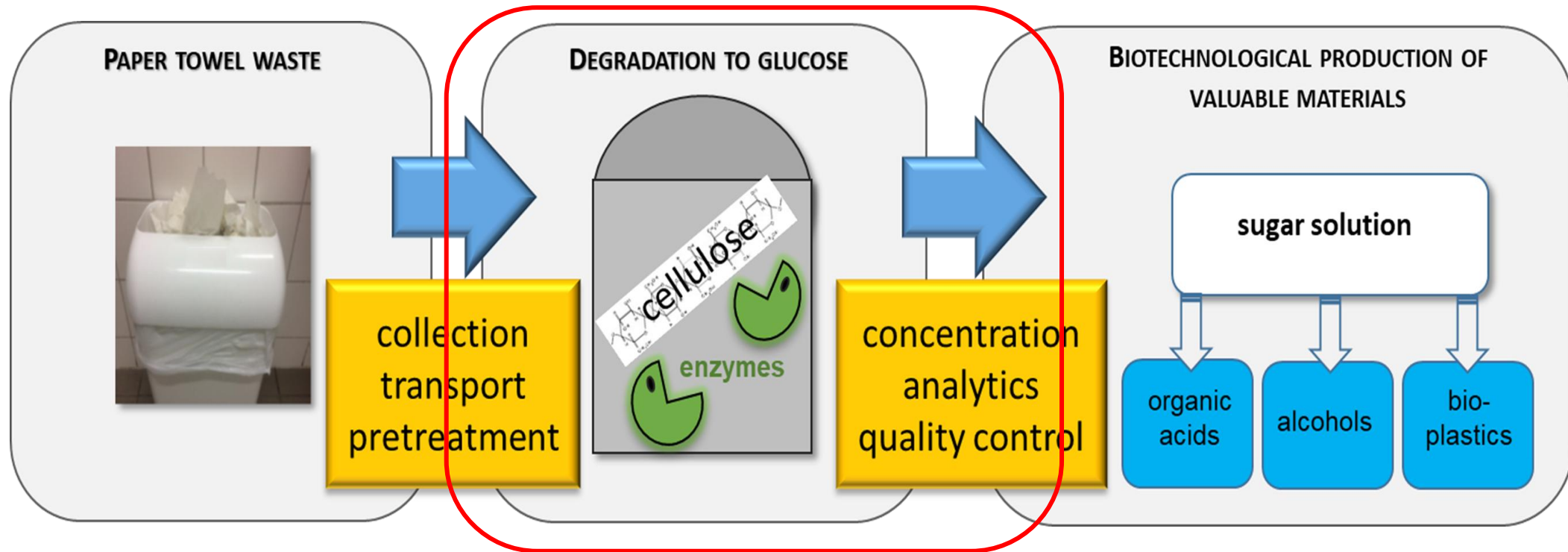
- 150 kg manually sorted
- Ø 9% impurities
- Machine sorting required

Phase 1 – Automated test sorting

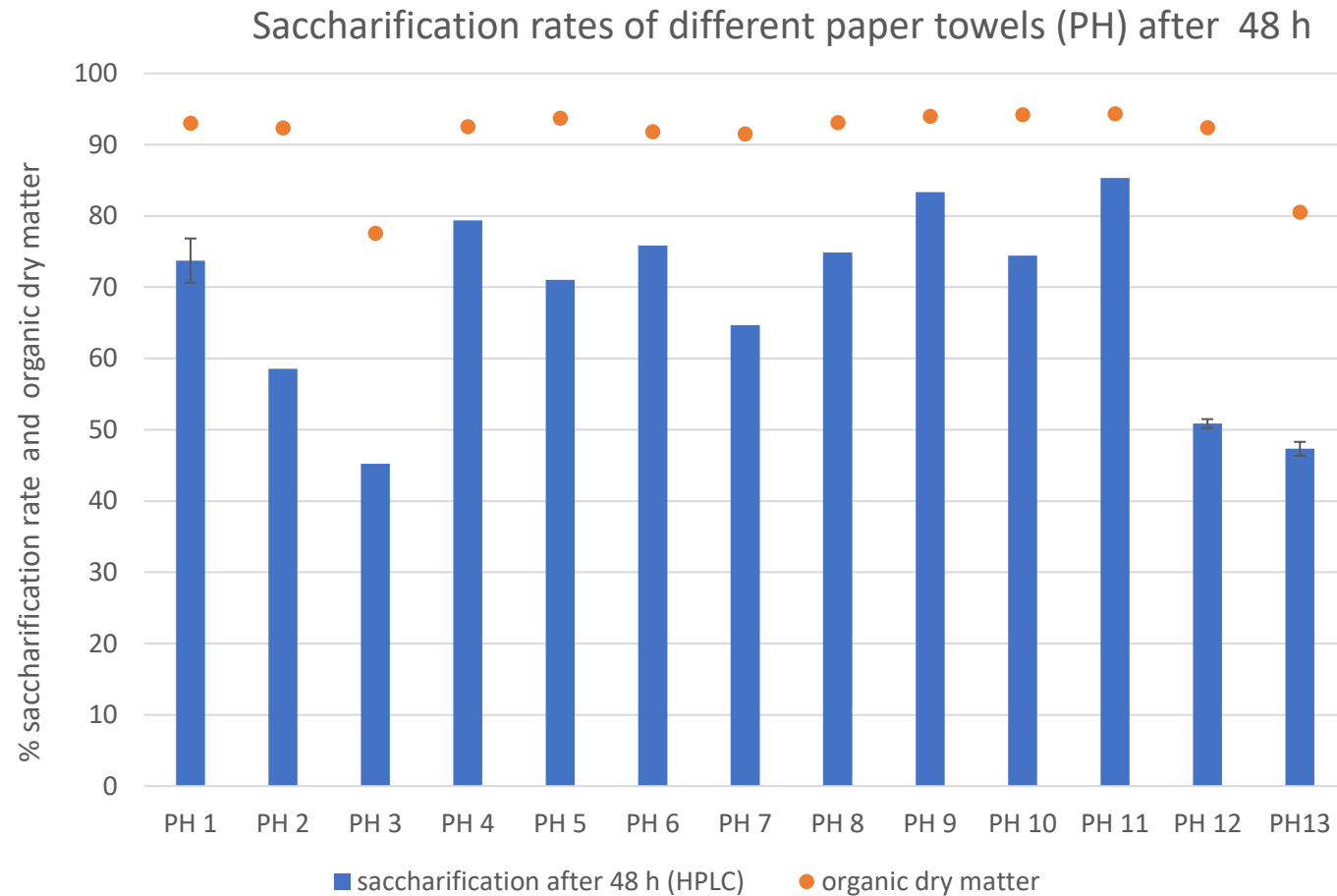
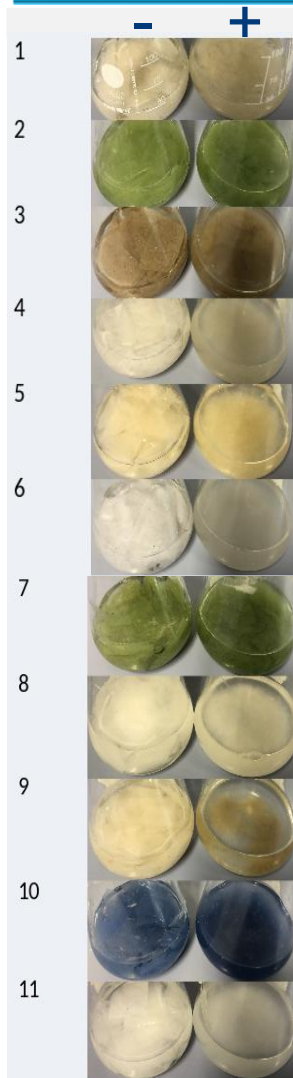


- 99,6% purity
- 4% loss of paper towels
- Sieving and two-step NIR

Phase 2 – Enzymatic saccharification



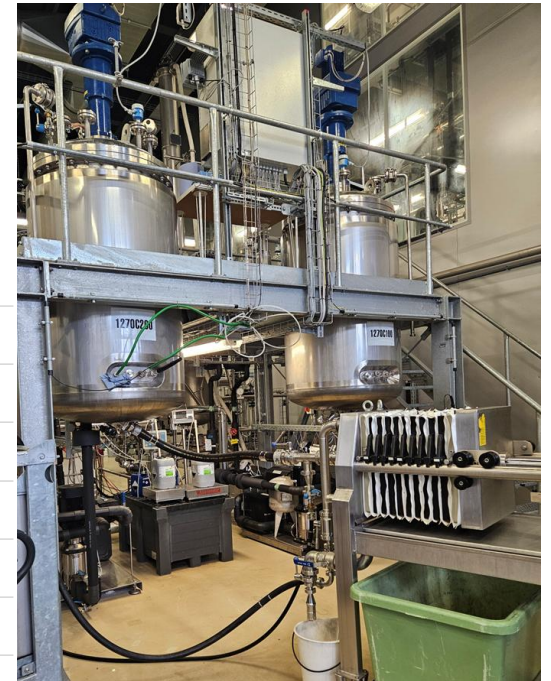
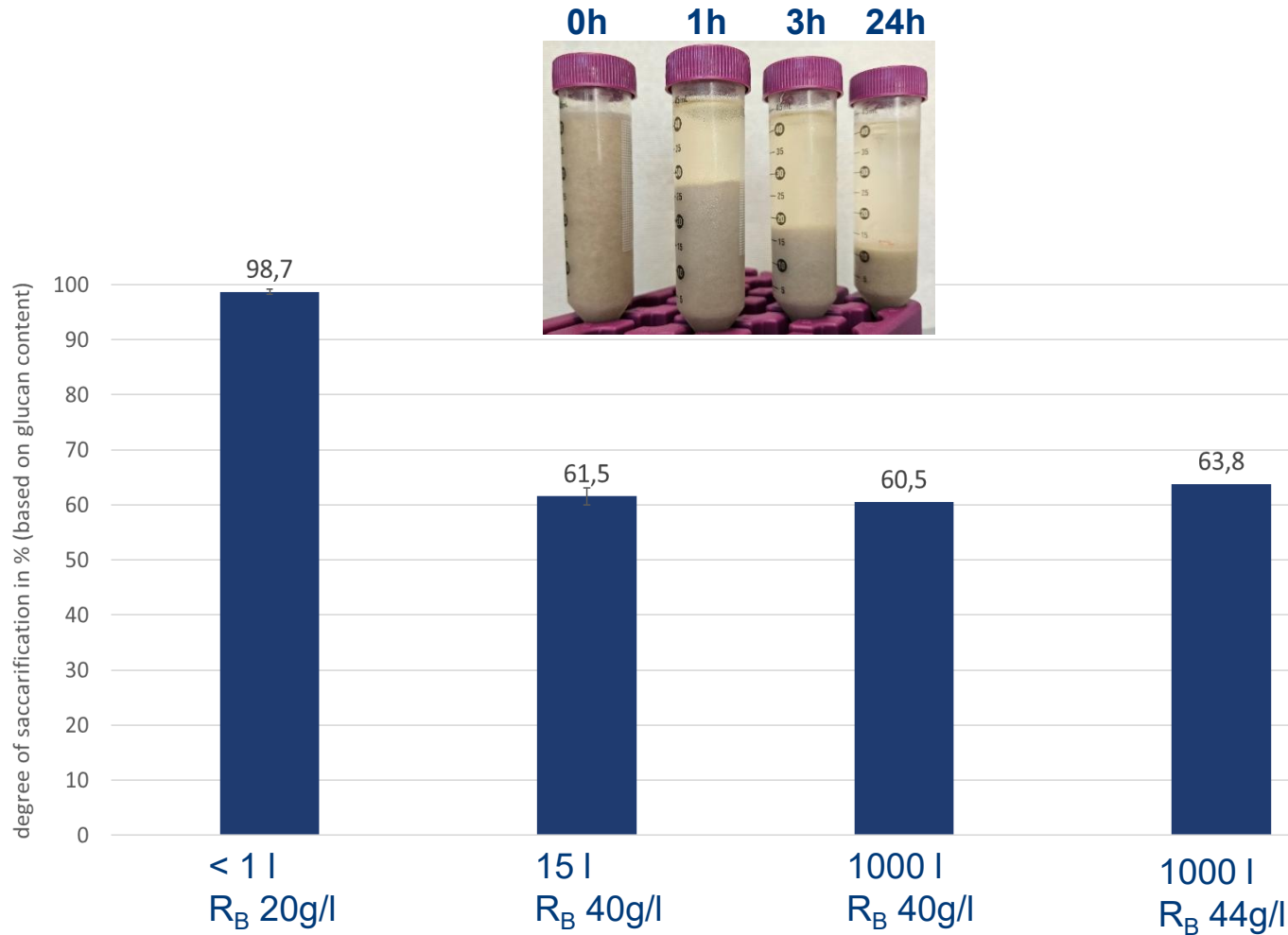
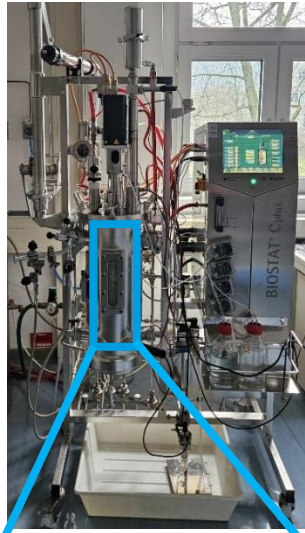
Phase 2 – Enzymatic saccharification on lab scale



Cellulases

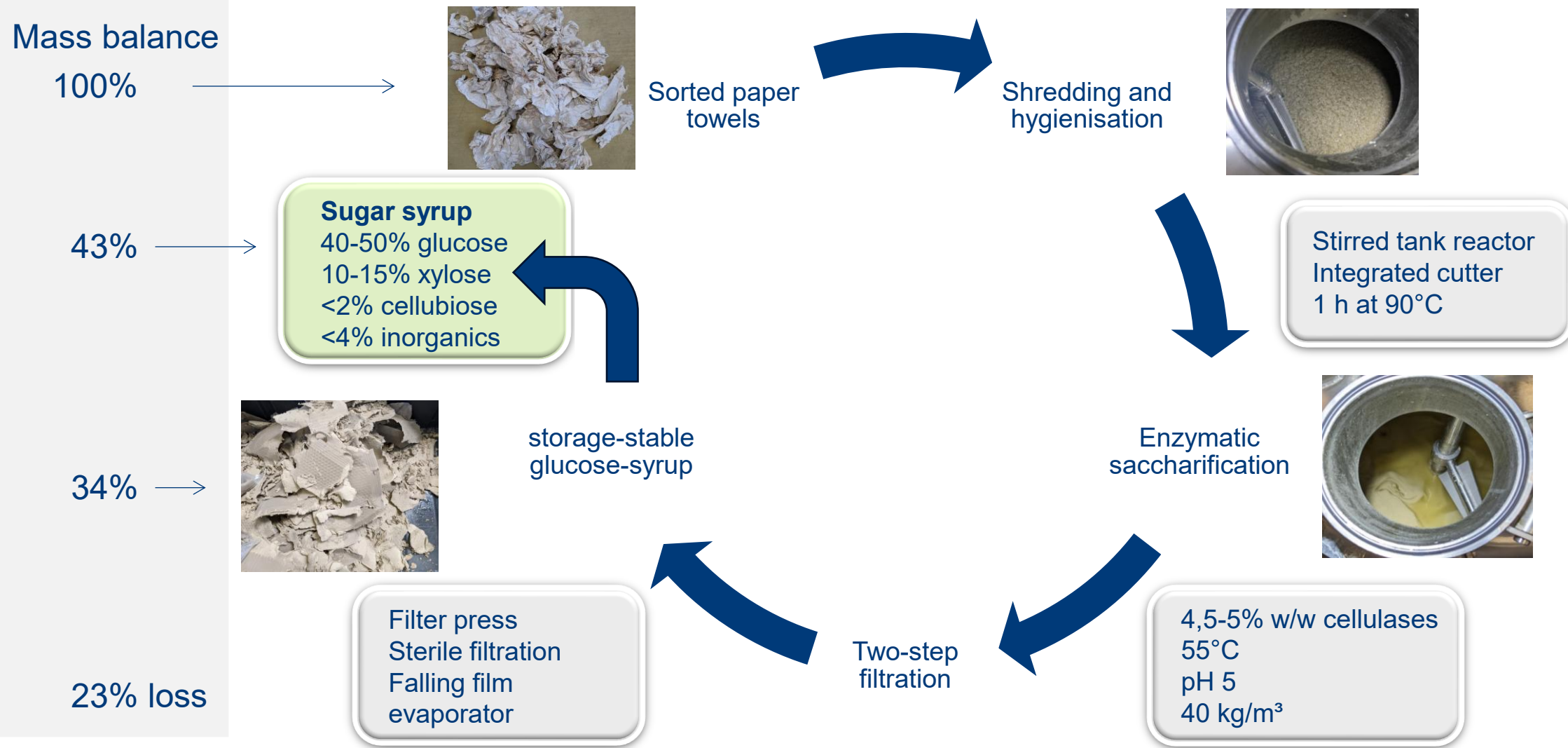
- All tested paper towels could be saccharified
- 46-86% saccharification rates

Phase 2 – Upscaling of enzymatic saccharification

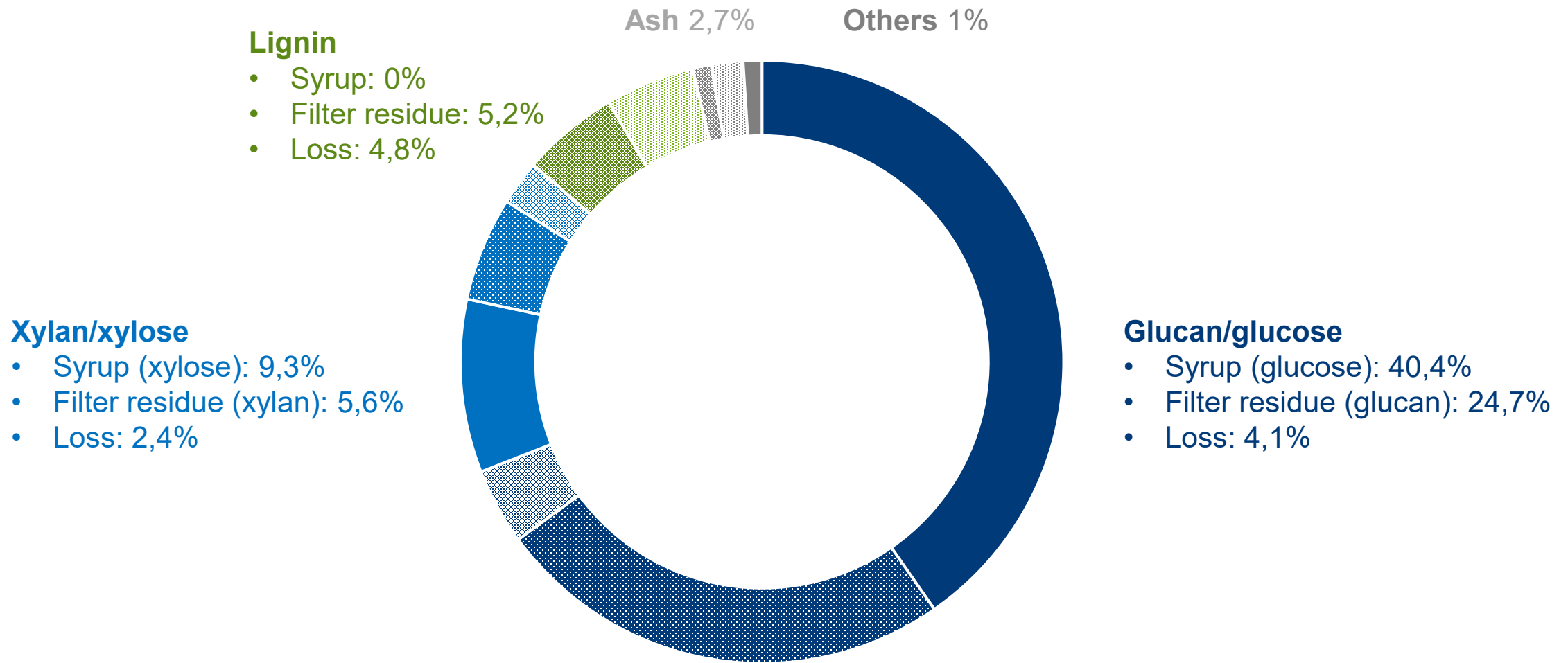


- ~60% saccharification rates
- no upscaling effect

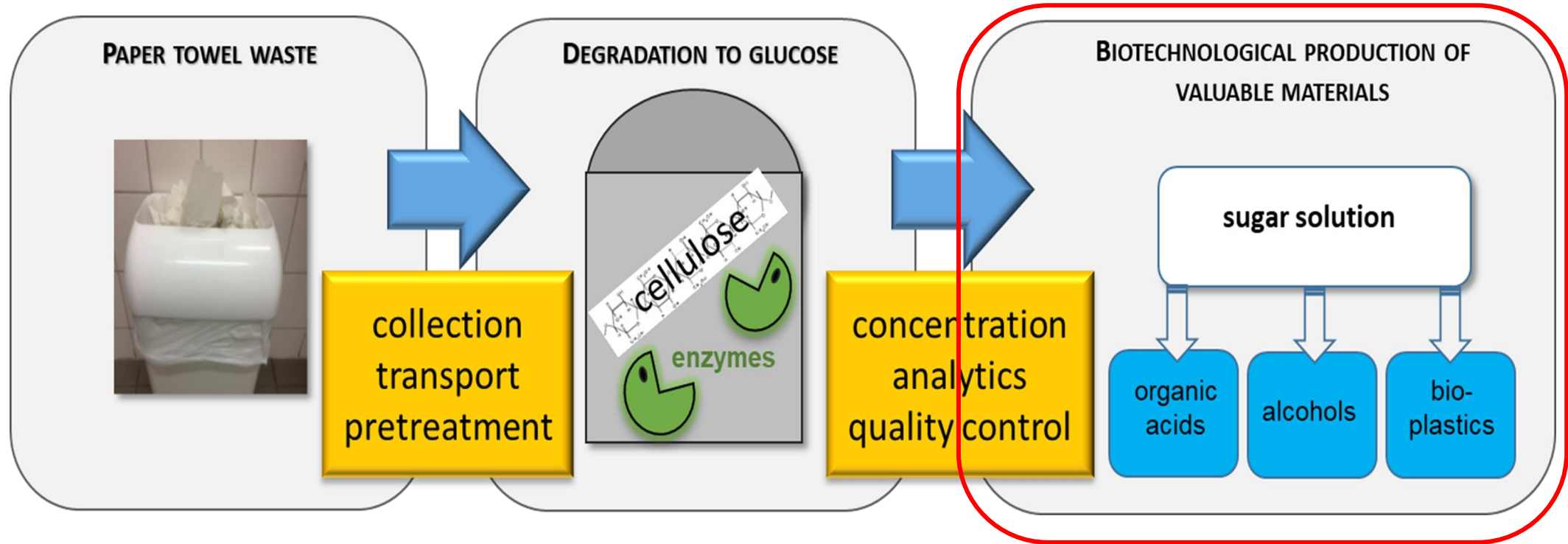
Phase 2 – Process from paper towels to sugar



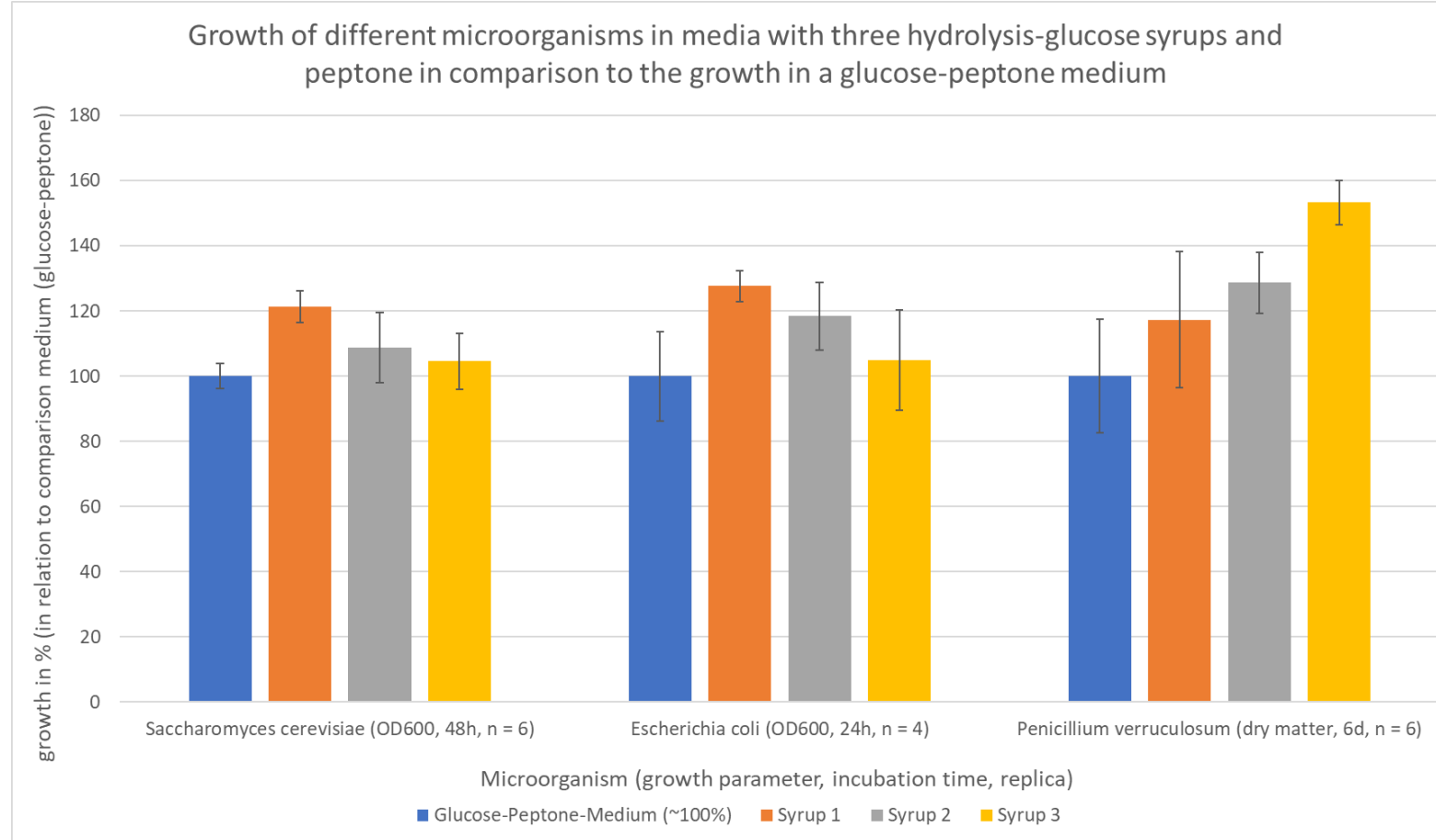
Mass balances – recovery rates on pilot scale (n = 3)



Phase 3 – Biotechnological conversion

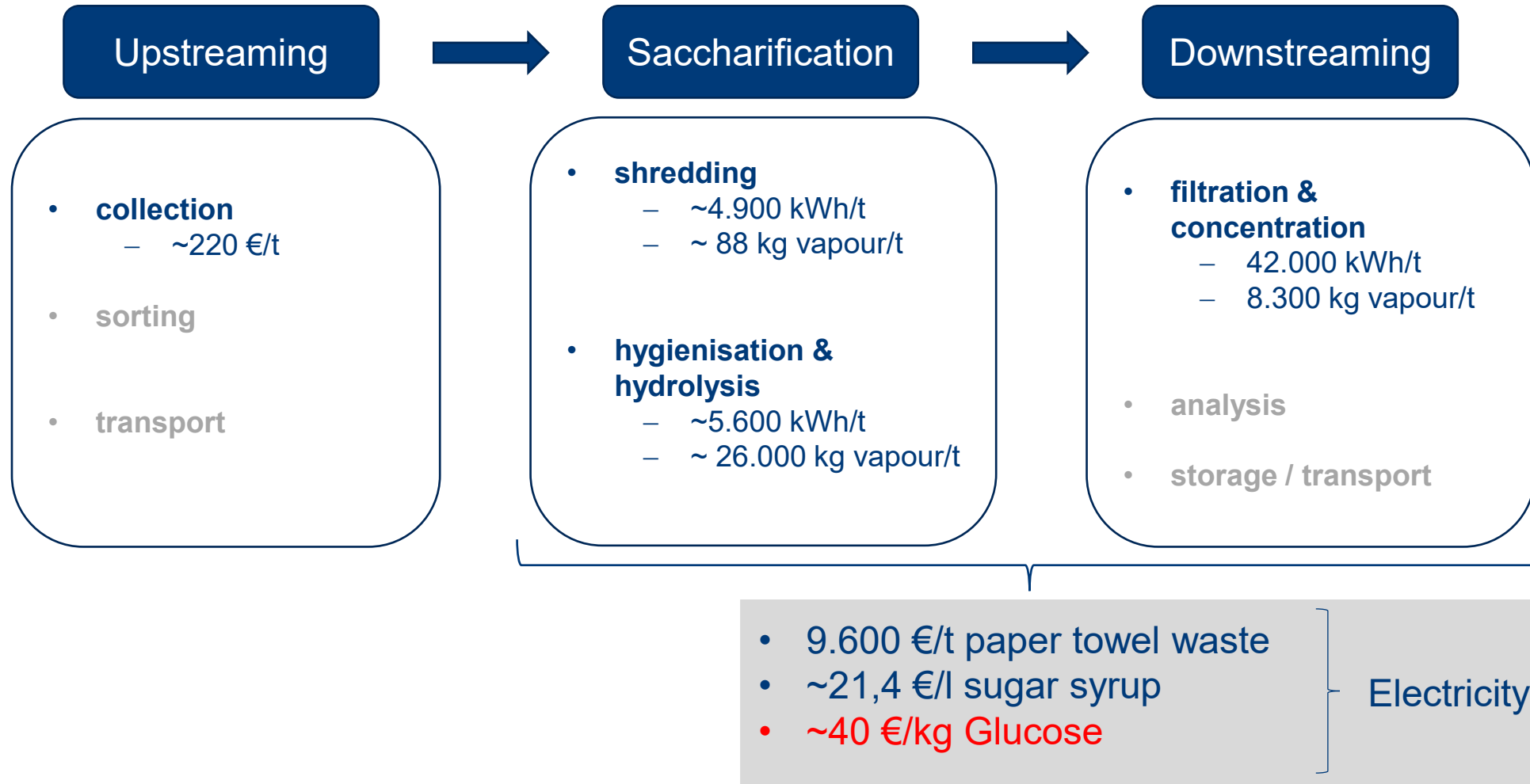


Phase 3 – Suitability of the syrup for biotechnology



- No inhibitory effects
- Suitable media component

Last not least – Economic efficiency



Summary

Used paper towels: valuable material, not waste

Price

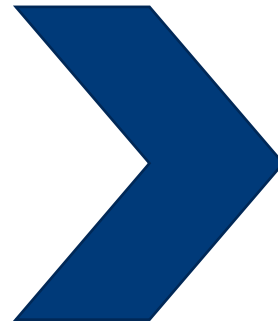
Enzymatic saccharification is obvious

Quantity

Process without technical or social limits

Economic viability requires quota regulations, political guidelines or shortage of fossil raw materials

Thank you for your attention!



Thanks to the team!

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Dr.-Ing. Katja Patzsch



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