Biobased Building Materials

Opportunities to increase the use of local crops and side streams

Arjen van Kampen, Wageningen Food & Biobased Research

June 8-9, Barcelona

WAGENINGEN
UNIVERSITY & RESEARCH

Wageningen Food & Biobased Research

Applied research for sustainable biobased innovations

- In-depth knowledge of the entire agri-food chain
- Market oriented R&D approach
- Multi-disciplinary applied R&D project teams; 270 employees
- Up-scaling: from lab to pilot
- Connection with the University of Wageningen

Sustainable and Healthy Food Chains

Biobased Products

WAGENINGEN
UNIVERSITY & RESEARCH

Biobased Products Innovation Plant

FOOD & BIOBASED RESEARCH
WAGENINGEN UR

The opportunity of biobased building materials

- We are facing multiple environmental crises (climate, biodiversity, soil quality). Our land use is key to integrally tackle these challenges.
- Besides agriculture for food, also new crops and growing methods are needed for non-food biobased applications.
- Housing is a basic need. Biobased materials offer the opportunity to construct buildings using natural, renewable and locally available feedstocks.
- They can make a significant contribution to achieving climate goals by 'storing' biogenic carbon for a long period in houses and buildings. For example, wood skeleton buildings could already result in a CO_2-reduction of 60% by mitigating the use of resource-intensive materials, like concrete, steel and others.
- However, so far biobased materials represent only a minor fractions of the materials used in construction. For example, in The Netherlands, only 2% of construction materials consists of wood and 0.1% of other biobased materials.

A range of biobased building solutions is already available

WAGENINGEN
UNIVERSITY & RESEARCH

Biobased building material applications

- Wood can replace concrete, cement and steel in piles, bearing walls, flooring and ceiling.
- Wooden chip boards and alternative fibre boards for internal walls
- Biobased composites (e.g. facade cover)
- Insulation boards based on wood or alternative fibres
- Moulded parts based on wood or alternative fibres

The potential of (ligno)cellulose for biobased building materials

- Lignocellulosic crops are often perennial and have potential to contribute to soil quality and biodiversity.
- Cellulose fibres have abundant applications as insulation material, in composites and board material, whereas lignin is a natural binder and can be used as such in various applications.
- Our ability to make local lignocellulose feedstock available and exploitable, is of great importance to ensure access to sustainable building materials (and many other applications)
- This presentation shows an overview of how WUR/WFBR works along the value chain in order to make more lignocellulose available for building applications. It will address:
    - Cultivation of alternative lignocellulose crops (not wood)
    - Processing of (ligno)cellulose rich crops
    - Application of lignin and cellulose in building materials

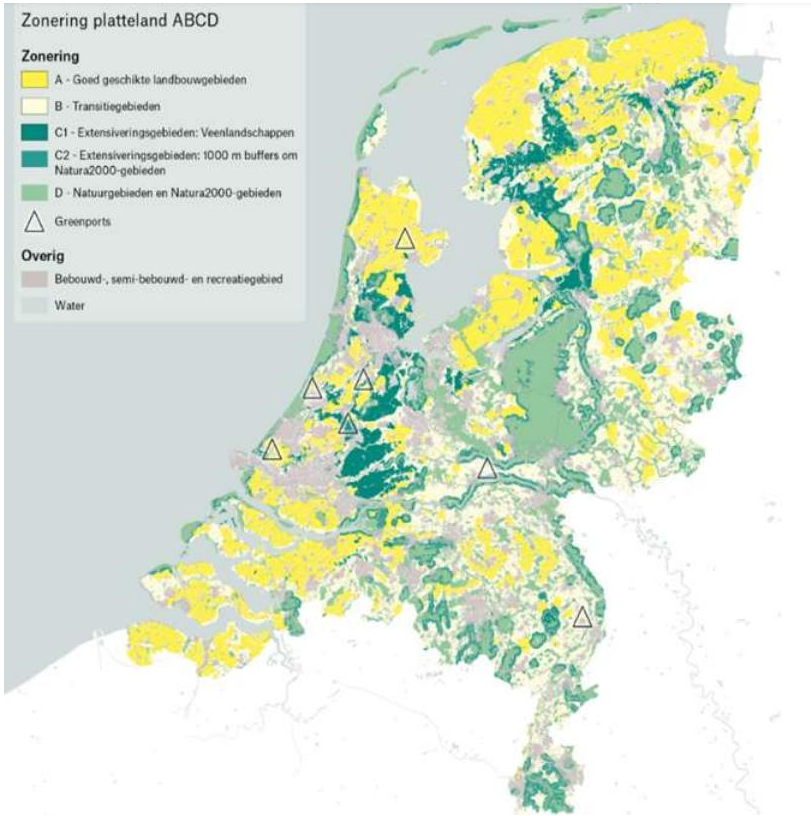
Cultivation of lignocellulose crops

- A framework for non-food crop cultivation in landscape planning
- Options for the cultivation of fibrous crops

A framework for non-food crop cultivation in landscape planning

Four zones:

- Zone A: Very fertile agricultural areas with main purpose Sustainable Agriculture.
- Zone B: Transition areas with restrictions for agriculture (e.g. marginal lands, spatial restrictions) and should be integrated with other functions, like nature, recreation, housing)
- Zone C: Areas with restrictions for agriculture because of specific environmental or natural preservation objectives (reduction of nitrogen, soil subsidence).
- Zone D: Nature preservation and Natura 2000 areas.



Perspectieven voor landbouw in een gebiedsgerichte benadering, Essay requested by ministry of LNV, Martin Scholten, Martha Bakker & Roel Jongeneel, 15 oktober 2021

Zone B (white) and C (dark green) could potentially be of interest to grow fibrous crops for building materials. Equivalent of 1 Mha.

WAGENINGEN UNIVERSITY & RESEARCH

Options for the cultivation of fibrous crops for building materials

Monocultures

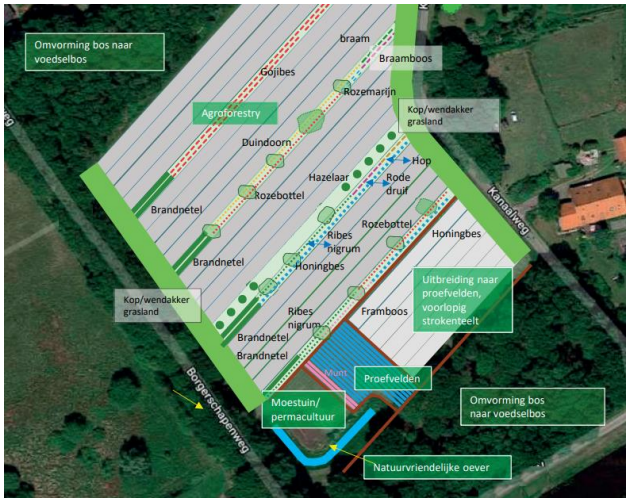
Hemp

Miscanthus

Cattail

Grass

Polycultures (agro-forestry)



One out of 6 agro-forestry designs of WUR-study on agro-forestry pioneers and the evaluation of their design in terms biodiversity, soil quality, yield and financial performance.

Source: Agroforestry in Agriculture, Entrepreneurs in their search for the right design, WUR Open Cultivation, 2020)

Agricultural or food processing residues

Tomato stems

Brewers spent grain

Cocoa shells

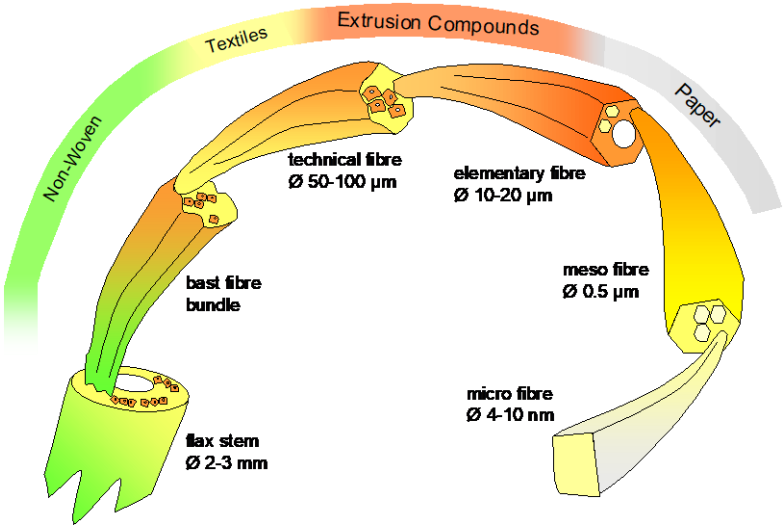
The business case for cultivation of non-food crops will improve (e.g. through carbon farming.

By setting up local value chains towards biobased buildings, also other environmental benefits (e.g. biodiversity, soil quality) could be monetized.

WAGENINGEN UNIVERSITY & RESEARCH

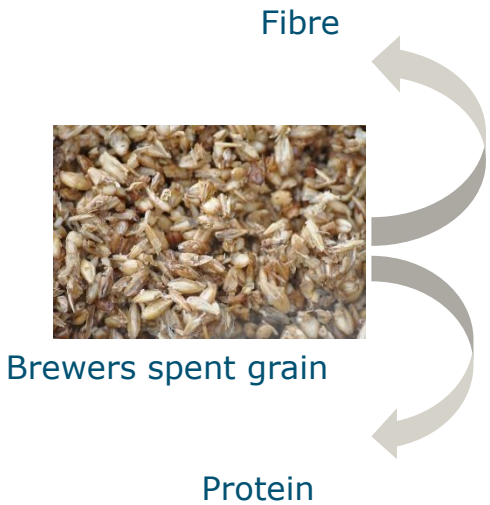
Biorefinery approaches to obtain high quality cellulose, lignin or both

- Fibres from protein-rich biomass
  - Protein fibre separation
  - Fibre – Wet nutrient separation
- Mild biorefinery of lignocellulose biomass

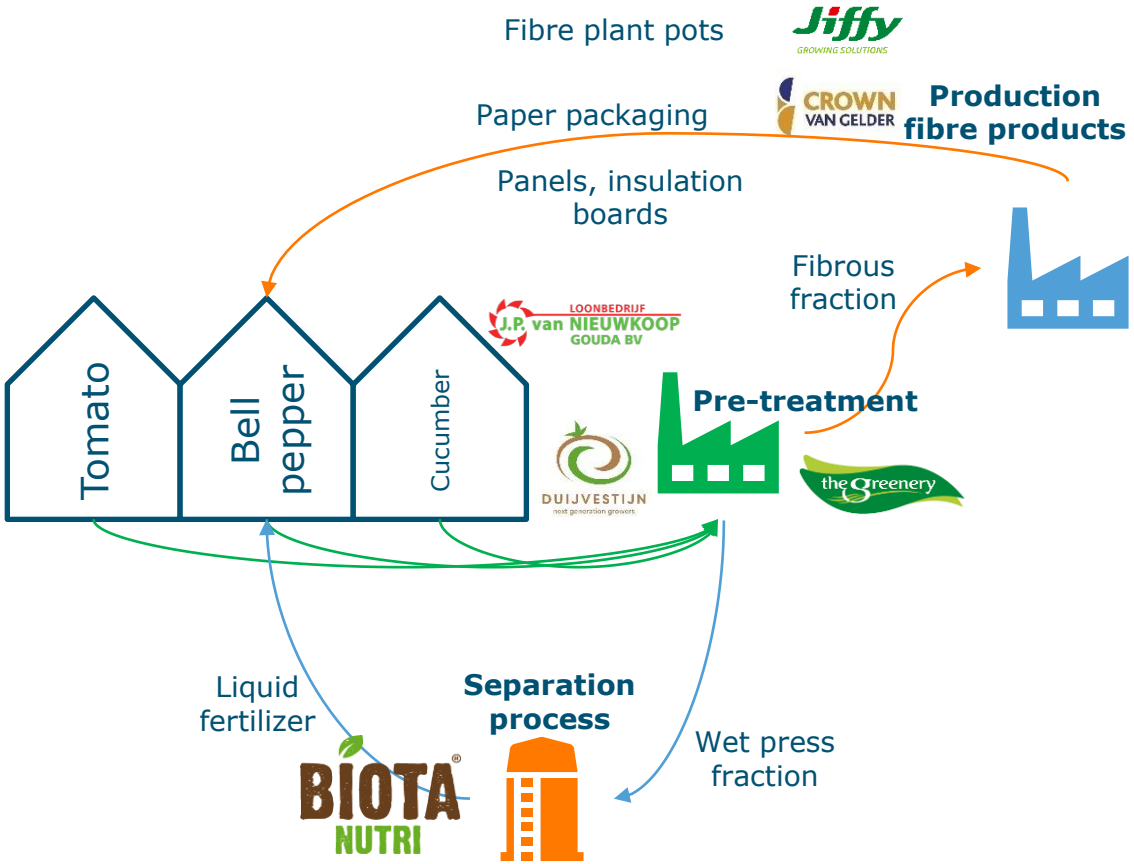


Fibres from protein rich biomass

Separation of protein and use residual fibre

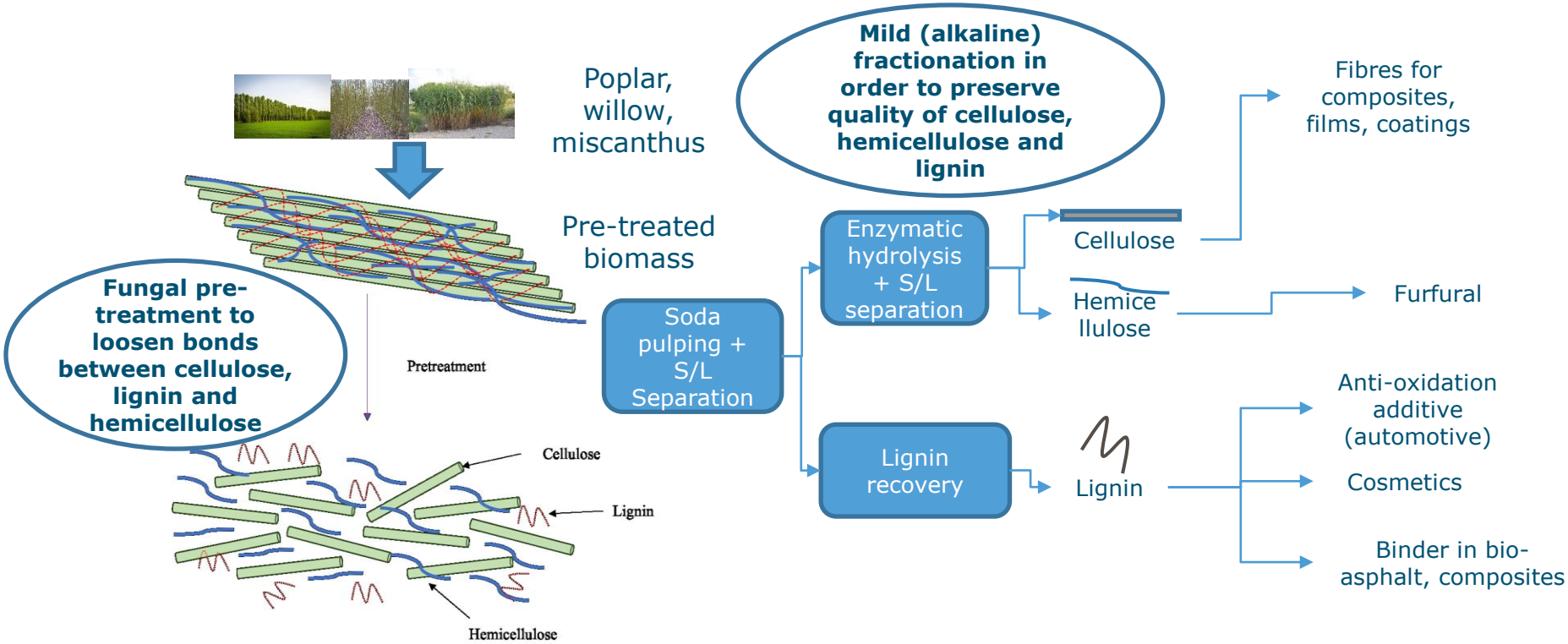


Fibre production and re-use of wet press fraction as fertilizer



WAGENINGEN UNIVERSITY & RESEARCH

A mild lignocellulose biorefinery for high quality cellulose AND lignin



WAGENINGEN
UNIVERSITY & RESEARCH

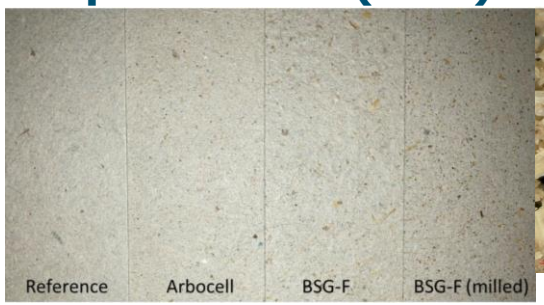
Examples of applications of lignin, cellulose or both

- Cellulose fibres in biobased building products
- Lignin as a binder: asphalt binder and trespa panels
- Binderless board technology
- Future outlook: 3D printing?

Fiber boards using partially biobased resins

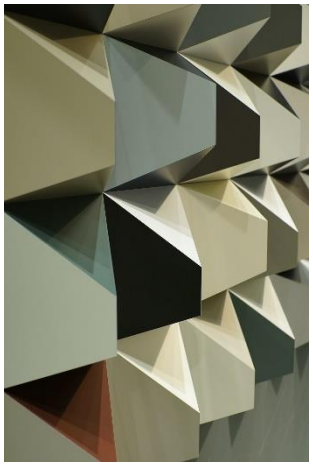
- **Reed fiber boards** based on reed from nature management areas
- Formaldehyde- and monomeric isocyanate-free resins
- Collaboration with DSM and Natuurmonumenten (Dutch Society for Nature Conservation)
    - Multi annual reed meeting P4 performance level
    - Annual reed meeting P6 performance level (using pMDI)

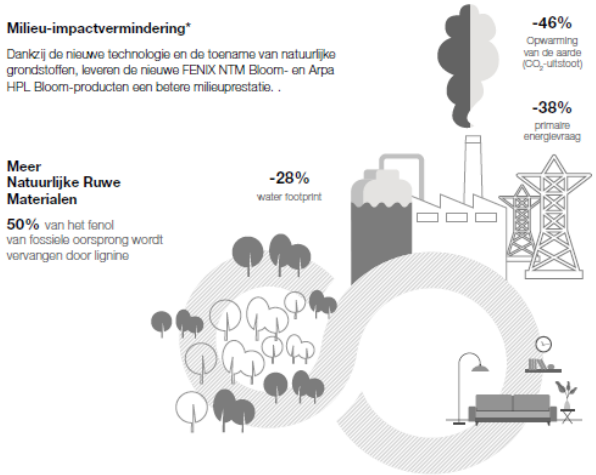
- **Fiber board based on Brewer's Spent Grain (BSG)**
- Residue from protein extraction

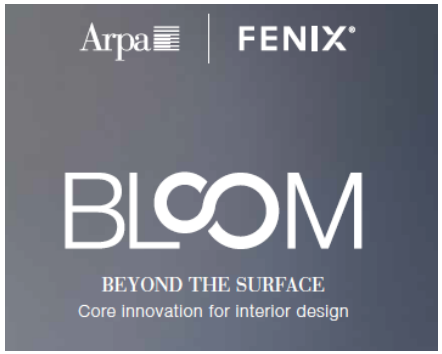


Lignin applied in thermoset resins

- 8 years collaboration with Nemho/Trespa/Arpa (NL/IT)
  - Resulted in a commercial interior HPL glued with a resin in which 50% phenol is substituted by lignin
  - Fenix Bloom product with 46% CO_2 emission reduction



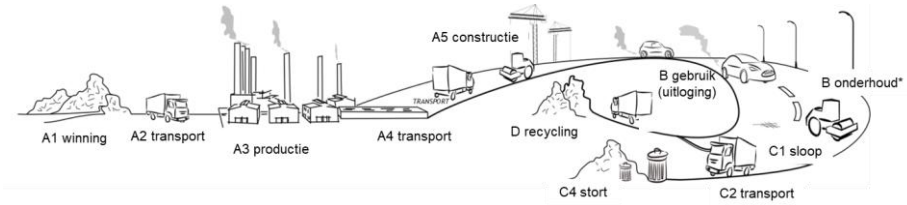




- In TKI AF project "Reactive lignin" we further develop this technology to get a 100% biobased resin (Production and modification to get a more reactive lignin)

Lignin based asphalt binder

- Two technologies which enable up to 50% replacement of bitumen by lignin, derived from wood and miscanthus:
  - Mixing @ asphalt mill (WFBR/AKC): 25 demonstration roads in NL
  - Blending lignin/bitumen binder (TNO/WFBR)



- Current application in roads where local authorities demand more sustainable biobased materials (even at higher price)
- Fairly low price of bitumen (300 – 500 € / ton), but lignin can act as direct drop-in for biobitumen as soon as price approximates bitumen price
- Biobased content with lower CO_2-footprint (50-70%) is of added value to many municipalities, regions and national authorities responsible for road construction and maintenance
- Our final goal: development of a bitumen-free asphalt binder

WAGENINGEN
UNIVERSITY & RESEARCH

Gosselink, R.J.A., P. Landa, Lignin-based bio-asphalt, WO2019/092278
Slaghek, T., D. van Vliet et al., Bitumen composition, EP2 918 640 (2014)

Binderless technology

Type of feedstocks a.o.:

- Cocoa shells
- Grass
- Prunings

Product characteristics:

- Good mechanical properties
- Good resistance to moisture, water and oil
- Non-toxic and environmentally friendly - 100% bio-based
- Competitive pricing (for specific product examples)
- Products manufactured from lignocellulosic side streams
- Lignin as in-situ binder – no additional binders/chemicals

WAGENINGEN
UNIVERSITY & RESEARCH

Outlook: Biofibre based 3D-printed products

- Material preparation based on extrusion compounding experience
- Fibre structure-polymer flow-product performance relationships

Erlenmeyer flask art (demo)

WAGENINGEN
UNIVERSITY & RESEARCH

Conclusions

- There are ample application opportunities for lignocellulosic biobased materials in construction. This offers good opportunities for more sustainable value chains based on local feedstocks and with a significantly lower carbon footprint.
- Nevertheless, a real transition towards biobased materials (beyond wood) requires a vision on the cultivation of crops: which areas and which cultivation concepts.
- In making value chains commercially viable, the cascading use of the whole biomass is essential. Besides this, local in-situ conversion of the biomass (e.g. binderless or 3D-printing) could provide additional opportunities.
- Local value chains towards biobased building materials increase the chance that the environmental benefits (GHG, biodiversity, soil quality) can actually be valued and monetized. Increasing attention should be paid to the additional value lignocellulosic crops (e.g. in agroforestry) could provide for biodiversity, soil quality and recreation.

Thank you for your attention

Arjen.vankampen@wur.nl

WAGENINGEN
UNIVERSITY & RESEARCH