Circularity Analysis Tool: Assessing circularity of biomass utilisation by valuing composition, efficiency, and functionality

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Objective

Inefficient use of bioresources threatens food security and the production of other biobased products, which causes environmental issues as greenhouse gas emissions, increased use of arable land, and loss of soil organic carbon and minerals.

To analyse the circularity of different bioconversion routes of biobased residues, a tool is developed: The Circularity Analysis Tool (CAT). The CAT assesses the circularity of biomass utilisation valuing individual components of the biomass, combined with processing efficiencies and the functionality of the applications.

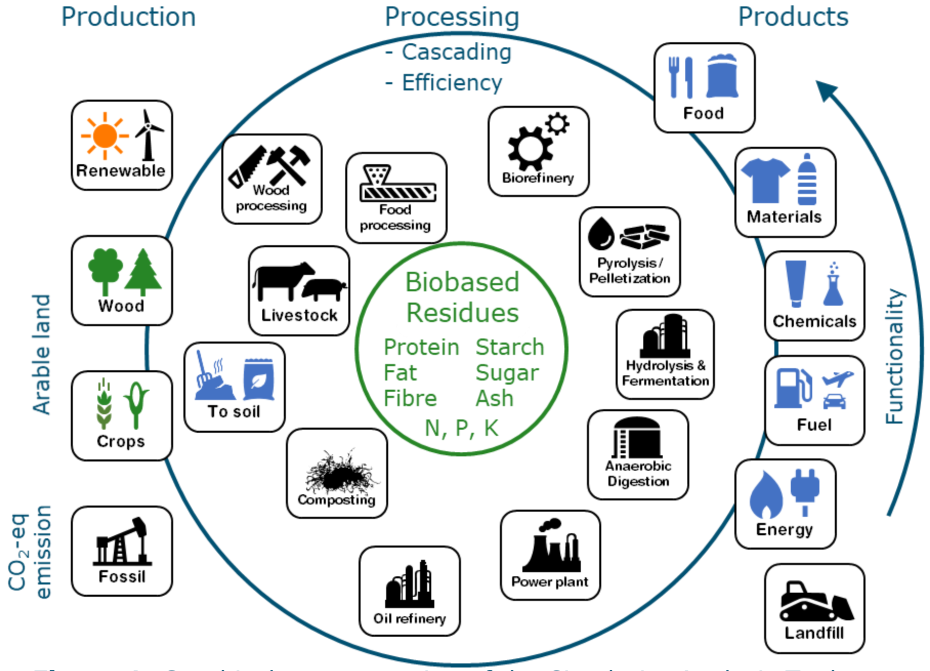

Figure 1: Graphical representation of the Circularity Analysis Tool

Method

The composition of the evaluated biomass stream is the basis of the circularity analysis. To facilitate the determination of the composition, the CAT is linked to a database containing the composition of bioresources and biobased residues.

The efficiencies of general bioconversion processes are determined on component level, resulting in a conversion matrix for each bioconversion process. In the CAT, the cascading use of biomass is included by defining default bioconversion routes with multiple processes and applications.

In the CAT, each component has an "appreciation" value, e.g. a weighing value to be able to distinguish between components in different biobased applications. Moreover, each biobased application has a "functionality" score, i.e. an indicative value to address the value of the application.

$$Circularity_{Appl.\,j} = \sum_{Comp.\,i} \begin{matrix} Content_i \\ \times\, Efficiency_{i,j} \\ \times\, Appreciation_{i,j} \\ \times\, Funtionality_{i,j} \end{matrix} \Big/ Ref.value$$

Equitation 1: The circularity of a certain biobased application j from a biobased residue is expressed as the sum-product of the content of each component i, the processing efficiency, the appreciation of the component, and the functionality of the application, divided by the reference value. The reference value is the sum-product (with a 100% efficiency) in a food or material application, i.e. the highest possible circularity score.

Results

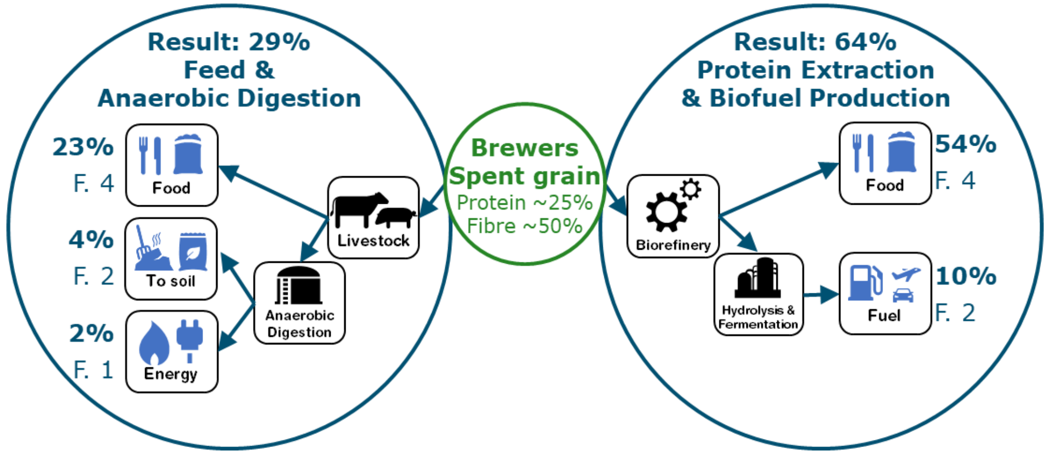

Figure 2: Comparison of the utilisation of brewers spent grain as feed & anaerobic digestion (left) and protein extraction & biofuel production (right)

Conclusion

The CAT enables the comparison of different bioconversion routes of a biobased residues, using a weighted analysis of multiple aspects including the composition of the biomass, processing efficiencies, component appreciation, and product functionality. The CAT will be used, among others, to monitor the progress of the Dutch biomass utilisation.

Acknowledgements

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