



**Cristina Cabeza, James Gaffey, Nora Hatvani,
Kees Hendriks, Evelien Lambrecht, Hartmut Welck**

Potential of biomass sidestreams for a sustainable biobased economy

**Bringing added value to agriculture and
forest sectors by closing the research
and innovation divide**



*Cristina Cabeza, James Gaffey, Nora Hatvani,
Kees Hendriks, Evelien Lambrecht, Hartmut Welck*
Potential of biomass sidestreams for a sustainable biobased economy

This document was prepared in the framework of the AGRIFORVALOR project. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 696394.

Authors

Cristina Cabeza, Agencia Andaluza del Conocimiento

James Gaffey, Institute of Technology Tralee

Nora Hatvani, Bay Zoltán Nonprofit Ltd. for Applied Research

Kees Hendriks, Wageningen University and Research

Evelien Lambrecht, University of Gent

Hartmut Welck, Steinbeis 2i GmbH

Further contributing partners

Manuel Beltrán Miralles, Gabinete de Iniciativas Europeas, S.A.

Attila Benkea, National Agricultural Research and Innovation Centre

Mariano Castro Lobera, Gabinete de Iniciativas Europeas, S.A.

Noel Gavigan, Irish Business and Enterprise Confederation

Xavier Gellynck, University of Gent

Katalin Kurucz, Bay Zoltan Nonprofit Ltd. for Applied Research

Helena McMahon, Institute of Technology Tralee

Gert-Jan Nabuurs, Wageningen University and Research

Heidi Vandenhoute, University of Gent

**Cristina Cabeza, James Gaffey, Nora Hatvani,
Kees Hendriks, Evelien Lambrecht, Hartmut Welck**

Potential of biomass sidestreams for a sustainable biobased economy

**Bringing added value to agriculture and
forest sectors by closing the research
and innovation divide**



Imprint

© 2019 Steinbeis-Edition

All rights reserved. No part of this book may be reprinted, reproduced, or utilised in any form by any electronic, mechanical, or other means now known or hereafter invented, including photocopying, microfilming, and recording or in any information storage or retrieval system without written permission from the publisher.

Cristina Cabeza, James Gaffey, Kees Hendriks, Nora Hatvani, Evelien Lambrecht, Hartmut Welck
Potential of biomass sidestreams for a sustainable biobased economy
Bringing added value to agriculture and forest sectors by closing the research and innovation divide

1st edition, 2019 | Steinbeis-Edition, Stuttgart
ISBN 978-3-95663-217-4

Layout: Steinbeis-Edition

Cover picture: Chinnapong/shutterstock.com | Book envelope printed on grass paper.
This book is also available as printed version. ISBN 978-3-95663-211-2

The platform provided by Steinbeis makes us a reliable partner for company startups and projects. We provide support to people and organizations, not only in science and academia, but also in business. Our aim is to leverage the know-how derived from research, development, consulting, and training projects and to transfer this knowledge into application – with a clear focus on entrepreneurial practice. Over 2,000 business enterprises have already been founded on the back of the Steinbeis platform. The outcome? A network spanning over 6,000 experts in approximately 1,100 business enterprises – working on projects with more than 10,000 clients every year. Our network provides professional support to enterprises and employees in acquiring competence, thus securing success in the face of competition. Steinbeis-Edition publishes selected works mirroring the scope of the Steinbeis Network expertise.

208907-2019-07 | www.steinbeis-edition.de

Preface

Modern society is dependent upon fossil-based resources that are cheap, abundant and available. Products of the fossil economy are of high quality and support nearly all aspects of society including transport fuel, energy production (e. g. solid fuel), food production (fertiliser), materials (plastic packaging, textiles), and chemicals (paints, glues, solvents, pharmaceuticals). However, fossil resources are finite and while one can argue about the length of time that fossil-based resources will continue to serve society they are not renewable. Furthermore, the use of fossil resources contributes to greenhouse gas emissions which contribute to climate change.

While a relatively new term in the world's lexicon, the bioeconomy, is ancient and has provided us with biobased products such as food, feed, biomaterials, chemicals, and energy for millennia. Extensive improvements in supply chains, extraction and separation efficiencies, conversion technologies, and product applications mean that many biobased value chains have been replaced by fossil value chains. The need to switch back to the use of renewable biobased resources is a great opportunity to apply modern thinking and technology to our natural resources and transition society towards sustainability. That switch is also intertwined with other sustainability challenges such as mitigating climate change, resource efficiency, food security, social fairness and others which are skillfully captured in the United Nations 17 sustainability goals. This adds additional layers of complexity to the switch from a fossil to a biobased economy.

The bioeconomy faces challenges that the fossil economy addresses daily e. g. resource heterogeneity, resource distribution, supply chains, resource efficiency and the production of high-quality and high value products. Which biobased value chains does one choose? "There is no one bioeconomy but multiple bioeconomies" (John Bell European Commission Head of Bioeconomy unit, Directorate General Research and innovation). Nations and regions will choose biobased value chains that play to regional strengths, but this smart specialization must be supported by high quality research data not only of

the region but also best practices and knowledge in other regions. Regional co-operation is a valuable way to enable this knowledge transfer in the bio-economy that can create new jobs, contribute to rural regeneration and jobs close to the biomass.

The first iteration of the new emerging bioeconomy focused on bioenergy and liquid bio-fuels but thinking has evolved towards the production of higher value products such as chemicals and materials. However, society needs energy and so the cascading of biomass to first produce chemicals or materials followed by bioenergy production is needed. The need for large scale biorefineries was recognized over a decade ago (“Lead Market Initiative” (LMI) of the European Commission for biobased products taking biobased from promise to market 2008, doi 10.2769/34881) as being key to demonstrate the impact of biobased value chains. More of these are needed so that industry, policy makers and society at large can support the development of the bioeconomy for the benefit of their communities.

Farmers are central to the bioeconomy and yet there is a real risk that they will not be winners in the new bioeconomy value chains. Farmers need to re-organise so that they can maximise the value of their resource, not by bargaining for a better price for their feedstock, but by owning a share in the higher value biorefinery companies and products so they and their rural communities can greatly benefit from the bioeconomy. This will take some time to come about and will require co-ordinated education and policy measures to stimulate and reward innovation in agriculture, forestry and the marine. Smaller on-farm-biorefineries can enable farmers to engage early in the new bioeconomy. Farmers could convert their resource into higher value products (e. g. protein) on the farm, reduce transport costs, generate bioenergy (after cascading) for farm use, return nutrients to the soil (biobased fertilizer) as a result of small scale biorefinery side stream use, increasing resource efficiency and reducing dependency on fossil energy and fossil-based fertilizer. Larger ventures can occur in parallel or after the small scale biorefineries demonstrate their benefits. Inherent in these biorefineries is resource efficiency and circularity where side streams are used and waste minimized or avoided.

The bioeconomy is not just about harvesting and transforming our natural resources. It is also about inspirational natural capital that provides humans with a valuable recreational outlet that is also capturing carbon, improving air quality, and providing business opportunities for ecosystem services. The bioeconomy is full of biodiversity but also dependent upon biodiversity for resilience. Biodiversity can make the bioeconomy resilient by reducing our need for inputs such as water, fertilizer, pesticides, herbicides but also improve biomass productivity and soil quality.

The sustainable circular bioeconomy is a major challenge and opportunity that requires not only technological and ecosystem solutions but also strategic investment and policies that reward stakeholder innovation (including social entrepreneurship and ecosystem services). Co-operation between farmers, industry, technology developers, social scientists, business developers, policy makers, and wider society is critical to developing a holistic approach to developing a sustainable bioeconomy.

Dublin, February 2019

Professor Kevin O'Connor

Director BEACON SFI Bioeconomy Research Centre, Ireland

Chairperson Scientific Committee Biobased industries Joint Undertaking (BBIJU)

Editorial

Integrating farmers in bio-based value chains for a fair share of added value

The role of farmers, forest owners and their cooperatives is crucial for a successful transition to a European bioeconomy that contributes to rural development, circular economy and to tackling climate change.

It is always good to address future perspectives, but it is also important not to forget that the agriculture and forestry sectors have already carried out quite astonishing pragmatic initiatives to support and contribute to the uptake of bioeconomy, both in bioenergy and bio-based material production. Still, more could be done to better use the existing resources and increase the circularity of residues and by-products. This would require farmers and cooperatives to develop a kind of “natural instinct” by rethinking and internalising the concept of circularity. They need to propose proactive and concrete solutions together with upstream operators.

Better integration of farmers into bio-based value chains should also mean that farmers delivering raw materials receive a greater share of the added value. We need to continue to invest in agriculture and forestry, because a sustainable bio-based economy is not possible without sustainable farming practices. In this regard, paying attention to sustainability downstream is just as important as the work being done upstream. This is why the primary sector needs to get a fair share of the value added by bioeconomy. All local initiatives that have managed to scale up have one thing in common: a greater involvement of primary producers in the project and a fair income for their contribution.

As Copa and Cogeca, we also know that local willingness should be accompanied by strong policy support, at national and European level. Numerous initiatives promoting cooperation and a multi-actor approach have been implemented with national and EU support from the CAP (including EIP Agri), Horizon 2020 and the European Fund for Strategic Investments.

However, we still need a more strategic approach to bioeconomy if Europe wants to remain the front runner in line with the ambition expressed by Commission President Jean-Claude Juncker. This renewed vision should address the challenges that primary producers are facing – challenges such as the availability of and access to infrastructures, technologies and the logistics to increase biomass mobilisation and the availability of instruments to enhance their sustainability and competitiveness. The implementation of the EU Bioeconomy Strategy should reflect this by increasing the consistency between all EU policies and ensuring funding, Advisory services, knowledge exchange, investments, digitalisation, etc. should also be addressed as part of the implementation of the strategy.

Finally, we should also not forget that end consumers – in the food market, for example – will have a fundamental role to play by opting for bio-based products rather than non-renewable alternatives. Once again, the bioeconomy sector should rely on farmers to ensure the promotion of those alternatives. History shows that farmers and cooperatives across the EU can be trusted ambassadors and creative marketers.

Bioeconomy should be circular in all its dimensions, be it production methods, the share in added value or communication. Strong alliances between all relevant actors including consumers are necessary for a joint approach which addresses the sectors' needs for continued investment in sustainable bio-based solutions and in order to jointly promote the benefits that bioeconomy provides for the whole of society.

Brussels, June 2019
Oana Neagu, Director General Affairs
COPA and COGECA

Abstract

A sustainable and circular biobased economy is seen by many as a future base for a sustainable society and economy. In this sense bioeconomy and circular economy concepts must be systemically integrated.

The bio-economy is the key means to replace fossil fuels while ensuring a sustainable food production in order to cope with the global challenge of needing 50 % more food, 45 % more energy and 30 % more water in 2030 than today all at a time, when environmental boundaries are throwing up new limits to supply (United Nations secretary-General's high-level panel on Global sustainability 2012). The basic concept of a circular economy is a closed-loop system in which the final disposal of waste and by-products is minimised by promoting their reuse and valorisation (Corrado, Sala 2018).

New innovative techniques, partnerships, businesses and policies are being developed, replacing fossil based fuels and materials with renewable materials. Biomass, as renewable and abundant resource, has many direct and indirect applications for food, feed, fuels, fertilizers, chemicals and materials.

AGRIFORVALOR aims to close the research and innovation divide by connecting practitioners from agriculture and forestry to research and academia as well as with associations and clusters, bio-industry, policy makers, business support organisations, innovation agencies and technology transfer intermediaries in multi-actor innovation partnership networks. The focus of the project is on the transfer of know-how and information to enable and support farmers and foresters to exploit existing research results and facilitate the capture of grass root ideas for bio-industry development.

Practitioners addressed by the project are united in three Biomass Innovation Design hubs, piloted in Spain (Andalucía), Hungary and Ireland. In each of these hubs, existing research results and good practice cases on valorisation of biomass sidestreams from agriculture and forestry are shared and matched with the specific needs and potentials; new grass-roots ideas collected and devel-

oped; and dedicated innovation support applied to further deploy selected topics which are dealt with by multi-actor innovation partnership groups.

In the AGRIFORVALOR project an overview is drafted of valorisation techniques and good practice cases based on biomass sidestreams. Also, a web-based tool is developed, making this information easily available for stakeholders such as foresters, farmers, the biomass processing industries and the bioenergy sector.

Table of Content

Table of Figures	15
List of Tables	16
1 Biomass sidestreams for a sustainable biobased economy	17
1.1 The AGRIFORVALOR project.....	17
1.2 Andalusian Biomass Innovation Design Hub	20
1.3 Hungarian Biomass Innovation Design Hub	21
1.4 Irish Biomass Innovation Design Hub	23
1.5 Outline of the article.....	24
2 Available biomass sidestreams and valorising techniques	25
2.1 Good practice cases of biomass sidestream valorisation	31
2.1.1 Bio-oil from forest based sidestreams	32
2.1.2 Mushrooms and biogas from agricultural crop residues	33
2.1.3 Olive biomass sidestream in functional foods, food supplements and active pharmaceutical ingredients.....	34
2.1.4 Wood pellets from sawmill by-products.....	35
2.1.5 Bioplastic, fine chemicals and natural fertilizer from grass	36
3 The Sidestream Value Tool	38
4 Business cases for Andalusia, Ireland and Hungary	40
4.1 Valorisation of olive biomass sidestreams in Andalusia, Spain.....	40
4.2 Valorisation of grass sidestreams in Ireland	45
4.3 Valorisation of whey and straw in Hungary	48
5 Recommendations at hub level	52
5.1 Recommendations for the Andalusian Hub.....	52
5.1.1 Recommendations related to the exploitation of valorisation technologies	52
5.1.2 Recommendations related to business model developments from the market point of view	53

5.1.3	Regional impact expected by implementation of recommendations related to exploitation of existing technologies and to business model development	54
5.2	Recommendations for the Hungarian hub	54
5.2.1	Recommendations related to the exploitation of valorisation technologies.....	55
5.2.2	Recommendations related to business model development from the market point of view.....	57
5.2.3	Regional impact expected by implementation of recommendations related to exploitation of existing technologies and to business model development	59
5.3	Recommendations for Irish Hub.....	60
5.3.1	Recommendations related to the exploitation of valorisation technologies	60
5.3.2	Recommendations related to business model development from the market point of view.....	63
5.3.3	Regional impact expected by implementation of recommendations related to exploitation of existing technologies and to business model development	66
5.4	Recommendations at EU level.....	67
6	Lignocellulose sidestream potential to close resource cycles to achieve a sustainable circular Bioeconomy	70
6.1	Biocomposite as vehicle to achieve closed resource cycles	71
7	Conclusions	74
	Literature.....	76

Table of Figures

Figure 1: Available agricultural and forestry biomass in Europe.....	25
Figure 2: Pyrolysis installation for bio-oil.....	32
Figure 3: Anaerobic digester converting spent mushroom substrate into biogas, heat and fertilizer.....	33
Figure 4: Production location for oyster mushroom substrate.....	34
Figure 5: ALLOLIVE® Full plant profile: extract based on simultaneous concentration of compounds.....	35
Figure 6: Wood pellets from sawmill by-products.....	36
Figure 7: The Biowert Factory and products from grass: hangers, terrace profiles, cups, insulation material.....	37
Figure 8: Interface of the sidestream value tool.....	39
Figure 9: Olive grove and olive residues (mill waste, leaves and olives).....	41
Figure 10: Natac manufacturing facilities, Spain.....	42
Figure 11: Anti-oxidant and anti-aging.....	42
Figure 12: Irish Grassland.....	45
Figure 13: Grass fibres.....	46
Figure 14: Straw – a sidestream from wheat production.....	49
Figure 15: Whey – a sidestream from dairy production.....	49
Figure 16: The Carbery Plant, Ireland, can be a guiding example for Hungary.....	50
Figure 17: Circular economy model demonstrated with lignocellulose sidestreams.....	71
Figure 18: Closing resource cycles based on fibres from primary, secondary and tertiary sidestreams.....	73

List of Tables

Table 1: List of project partners and main contact persons	20
Table 2: Rough estimation of agricultural and forest based biomass sidestreams (kton) available within the AGRIFORVALOR Innovation Design Hubs.	26
Table 3: Overview of valorisation techniques and resulting output per sidestream.....	31

1 Biomass sidestreams for a sustainable biobased economy

The biobased economy is seen by many as a future base for a sustainable society and economy. New innovative techniques, partnerships, businesses and policies are being developed to support the biobased economy aiming to replace fossil based fuels and materials with renewable biobased materials. Biomass, as renewable and abundant resource, has many direct and indirect applications for food, feed, fuels, fertilizers, chemicals and materials. The type of biomass strongly differs per region. In the Mediterranean region a lot of olive and vine biomass is available, in Scandinavia it is mainly forest related biomass while in many other regions there is a lot of agricultural biomass production. However, biomass used for the biobased economy should not compete with food production. Therefore, especially biomass sidestreams are of interest for the biobased economy. Agricultural and forestry biomass sidestreams take the form of residual stalks, straw, leaves, roots, desk, nut or seed shells, animal husbandry waste, forest harvest residues, saw mill residues, etc. It is widely available, renewable, and cost-effective. Its use is carbon neutral, can displace fossil fuels, helps to reduce GHG emissions while closing the carbon cycle and it can be converted into a wide range of bioenergy and biomaterial products. When developing new routes for valorisation of biomass, it is important to take dimensions and criteria into account in terms of “people, planet and profit” in order to make the transition towards a sustainable future.

1.1 The AGRIFORVALOR project

AGRIFORVALOR aims to close the research and innovation divide by connecting practitioners from agriculture and forestry to research and academia as well as with associations and clusters, bio-industry, policy makers, business support organisations, innovation agencies and technology transfer intermediaries in multi-actor innovation partnership networks. The focus of the project is on the transfer of know-how and information to enable and support farmers