3 regional innovation and business case studies

Opportunity scoping on agro and forestry biomass and sidestreams by carrying out a SWOT analysis, followed by a potential analysis of the research, innovation and best practice results for the most suitable techniques.

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

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Executive Summary

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 and foresters to exploit existing research results and facilitate the capture of grass root ideas for bio-industry development.

In the project, practitioners in the field of biomass side-streams are united in three Biomass Innovation Design Hubs, piloted in Spain (Andalusia), Hungary and Ireland. In each of these hubs, existing research results and good practices on valorisation of biomass side-streams from agriculture and forestry will be shared and matched with the specific needs and potentials; new grass-roots ideas collected and developed; and dedicated innovation support applied to further deploy selected topics which are dealt with by multi-actor innovation partnership groups.

Objectives

The objective of this report is the identification of opportunities for biomass sidestream valorisation for the Biomass Innovation Design hubs in Ireland, Hungray and Andalucia (ES).

Methodology

For this, the results of an opportunity scoping, carried out by a SWOT analysis, are integrated with the results of the inventory of available biomass and the needs of the farmers and foresters of each region.

Results

The SWOT analysis shows that ‘Strong networks’, ‘Knowledge level on valorization techniques’, ‘High volume of biomass sidestream availability’ and ‘Expertise and experience about biomass valorization/use’ are recognized as important Strength items of the biomass valorization sector for the three hubs. Although recognized as strength, it is important to further strengthen the connections and collaboration between research, biomass suppliers, and business valorizing biomass sidestreams. Partnerships are one way to strengthen regional or national collaboration and to stimulate ‘Ongoing developments of biomass processing facilities’.

Weakness items that are prioritized by the respondents for the three hubs are related to ‘Lack of scale and fragmented supply chain’, ‘Lack of knowledge, expertise, and experience about biomass valorization possibilities’, and ‘Uncertainty in continuity of biomass supply’.

Threats mentioned by respondents in the SWOT analysis are ‘Lack of governmental policy’, ‘Competition with fossil based products’, ‘ Competition for existing agricultural and forestry biomass resources’, and ‘Financial risks and access to finance’.

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The opportunities mentioned are e.g. to make use of the strong networks in the hubs in order to foster knowledge transfer and innovation partnerships for example to apply techniques that provide multiple products e.g. energy and (chemical) building blocks for high value applications (e.g. anaerobic digestion, pyrolysis). In general there are good examples of companies already successful in valorizing biomass sidestreams in EU which can serve as good practice examples.
Opportunities identified led to potential business cases described per hub.

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1 Introduction

AGRIFORVALOR will 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.

AGRIFORVALOR's focus on the transfer of know-how and information will enable and support farmers and foresters to exploit existing research results and facilitate the capture of grass root ideas for bio-industry development.

These networks will be managed by three Biomass Innovation Design Hubs, piloted in Spain (Andalucía), Hungary and Ireland. In each of these hubs, existing research results and good practices on valorisation of biomass side-streams from agro and forest will be shared and matched with the specific needs and potentials; new grass-roots ideas collected and developed; and dedicated innovation support applied to further deploy selected topics which are dealt with by multi-actor innovation partnership groups.

A SWOT analysis is carried out for each Biomass Innovation Design hub out to explore future potential and opportunities for agro and forestry biomass sidestream usage and to identify synergies and complementarities between the regions. The research results and best practices, as described in Del. 1.1 (Hendriks et al 2016a) and Del. 1.2 (Hendriks et al. 2016b), are integrated with the outcome of the SWOT analysis, the regional biomass availability and the identified needs of farmers and foresters in this deliverable report with the most suitable techniques for the biomass sidestreams available.

The information of this deliverable can be used in the regional innovation and business case study (e.g. WP 2 and WP 4) and will contribute to an improved flow of information and knowledge between academia and practitioners in particular on agricultural and forestry practices and innovations and to a successful deployment of the vast reservoir of existing scientific and practical knowledge.

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2.1 General objectives of AGRIFORVALOR

AGRIFORVALOR's main and long-term objective is to close the research and innovation divide through establishing cross-sectorial and multi-actor innovation partnership networks on agroforest biomass side-streams to support sustainable and economic development of forest and agriculture sectors for the benefit of rural areas, regions and communities. To do so there is need in Europe (piloted at the 3 hubs) to intensively exploit existing research results and at the same time take up innovation ideas from grass-root level. AGRIFORVALOR is offering intense knowledge transfer activities and training and education services to achieve its objective.

2.2 Objectives of this report

The objective of this deliverable is the identification of opportunities for biomass sidestream valorisation for each Biomass Innovation Design hub. For this, the results of an opportunity scoping, carried out by a SWOT analysis, are integrated with the results of the inventory of available biomass and the needs of the farmers and foresters of each region.

2.3 Foreseen impact

In this deliverable, the results of the SWOT and need analysis are described and integrated with the results on research techniques and current best practices described in the previous deliverables (D1.1: Hendriks et al 2016a and D1.2 : Hendriks et al. 2016b). Through this, the deliverable will be a useful report to inform foresters and farmers about the potential of agricultural and forestry biomass sidestream opportunities in the hubs.

By spreading the deliverable report amongst academia, business partners and practitioners connected to the hubs, the exchange of information and knowledge is stimulated, innovative ideas are nourished, and the market potential of biomass sidestreams techniques will be better exploited.

2.4 Methodology

The concept and methodology were elucidated as follows:

SWOT analysis is a method used to evaluate the strengths, weaknesses, opportunities and threats involved in a project. It involves the determination of the objective of the project and identification of the factors that are favourable and unfavourable to achieve that objective.

In AGRIFORVALOR, a SWOT analysis is carried out for the valorisation potential of agro and forest biomass sources in the 3 different hubs in Spain, Ireland and Hungary. This involves the identification of internal and external factors that are favourable and unfavourable to valorise agro and forest biomass side streams per region. Strengths and weaknesses are internal factors, and hence aspects the actors of the region can influence principally by themselves. Strengths are capabilities that provide a benefit in a given situation. Weaknesses are absent resources, qualities or things done badly. Opportunities and threats are external factors, and hence aspects which the actors of the region cannot fully control at their own. Opportunities open up possibilities, while threats negatively affect the performance and/or close off future possibilities.

2.4.1 Methodology for drafting the SWOT tables

As a first step we, University of Gent and Wageningen Environmental Research (Alterra), have drafted a document with four tables: Strengths, Weaknesses, Opportunities and Threats. The hub managers, and through them the hub partners, were asked to complete for each of these SWOT factors the issues that are important, and to provide some explanation to describe the issues. We clarified the SWOT-factors by giving some examples of possible strengths, weaknesses, opportunities and threats.

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As a second step we checked the listed issues that were sent back on the consistency and whether they were rightly classified as Strength, Weakness, Opportunity or Threat. In cases the issues were not rightly classified we discussed the meaning of the issue with the hub manager. When the meaning of the issue was clear, we classified them under the right SWOT factor.

As a third step, we clustered the issues listed. This was done because some issues mentioned by different hub partners were referring to the same issue. We kept the wording of the issue as explanation, but clustered similar issues. Also in some cases many issues were listed. By clustering them, we reduced the number of different issues to a maximum of 10 per SWOT factor. For the Hungarian hub, some additional items came forward in the hub launch meeting and were added. Comparability between the hub was maximized by clustering and reformulating the SWOT items in defined topics. As by grouping and rephrasing, some items could unintendedly have changed, the new SWOT tables were sent to the hub managers for validation.

2.4.2 Methodology for prioritization of the SWOT factors

As a fourth and last step, the validated SWOT tables with the grouped issues were sent to three experts in each biomass innovation hub, whose names were provided by the hub managers, for prioritization of the table for all the four SWOT factors. They were asked to rank the mentioned SWOT issues by importance, according to their opinion, by giving a score from 1 to 5 to the 5 most important SWOT issues for each SWOT category. The most important issue should receive 5 points, the fifth issue of importance should receive 1 point. The experts could also explain their prioritization when needed. For each hub the total prioritization was done by summing the scores for the issues of each SWOT factor. By this a top five of most important SWOT issues was created. As for the Spanish hub the prioritization was performed with the 3 experts together, there is only one score for each SWOT issue.

2.4.3 Methodology for potential analysis

Per hub, the SWOT and potential analysis is written down in 4 sections.

First, the resulting top 5 of the SWOT was described, then analysed. We looked at the prioritized items for Strength and Opportunity, whether we saw possibilities to overcome the prioritized items for Weakness and Threat.

In the second section, a summary of the needs questionnaire (Task 2.1.3) is included. The purpose of this questionnaire was to identify the specific needs and potentials of farmers, foresters and agro-industries or firms in the forestry sector, for the use of sidestreams in order to establish new business models.

Next, an overview of biomass sidestreams and their volumes are listed, based on the data given by the hub managers in Task 1.1. The list is completed with possible valorisation techniques, resulting products, good practices and research, with information from Deliverable 1.1 (Hendriks et al. 2016a) and Deliverable 1.2 (Hendriks et al. 2016b).

Finally, the results of the SWOT and need analysis are integrated with the results on research techniques and current best practices into business cases. Per hub, the last section describes the sidestream and techniques we suggest to elaborate, as we see it as an opportunity for the hub.

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3 Hub Results

3.1 Results of the SWOT analysis for the Andalusian hub

3.1.1 Description of the SWOT analysis

Three experts have prioritized the SWOT questionnaire. The prioritization was not done individually, but the three experts have given a jointly score for the priority of the SWOT items. The top 5 scores per swot item is presented in table 1 and described below.

Table 1: The 5 most important Strength, Weakness, Opportunity, Threat (SWOT) factors influencing the valorisation potential of biomass sidestreams for the Andalusian hub following the prioritization of three experts.

The number is representing the prioritized sequence with 1 being the most important factor and 5 the least important. Number in brackets show the total amount of votings received.

Strength	1. High volume of biomass sidestreams available (5) 2. Strong networks (4) 3. High level of education (3) 4. Knowledge level in valorisation techniques (2)	**Opportunity**	1. Commercialization opportunities (5) 2. Political support for a growing agricultural and forestry sector (4) 3. Contribution to the socioeconomic development (3) 4. Oil and gas independence (2) 5. Environmental sustainability (1)
Weakness	1. Government support/subsidies required (5) 2. Lack of knowledge, expertise and experience about biomass valorisation possibilities (4) 3. Lack of scale and fragmented supply chain (3) 4. Weak RTD to industry/market process (2) 5. Low demand and supply of biomass (1)	**Threat**	1. Lack of government policy (5) 2. Continuity/Security of biomass supply (fire, pests and diseases, drought and flooding) (4) 3. Competition with fossil based energy products (3) 4. Markets for high-value bio-based products still limited (2) 5. Financial risks and access to finance (1)

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Strengths

1. High volume of biomass sidestreams available

In Andalusia, the agricultural sector is of high relevance. In some regions, specific agricultural sidestreams are concentrated, and also the forest area is expanding significantly. Each year, more than 4 200 000 metric tons of vegetable waste and by-products is produced, equivalent to 56% of the total Spanish biomass sidestream volume. In 2014, biomass contributed in Andalusia to 43.4% of primary energy consumption from renewable sources.

2. Strong networks

Networks are present at the level of and between the various stakeholders. The forestry sector opportunities move through the network of environmental education centres, e.g. Forestry Training Centre Vadillo, Higher Degrees Natural Environment Management; Higher Technical School of Agricultural Engineering and Forestry, etc. The strong cooperative sector is well coordinated and permits to concentrate and foster valorisation projects for certain sidestreams, e.g. Oleicola El Tejar. Other entities are AAEF, ASAJA and Cooperativas Agro-alimentarias de Andalucía. The coordination between the regional government and the stakeholders is promoted among others by the Andalusian Forestry Committee. Next to the existing web of networks and consortia, the expansion of this web is further encouraged by initiatives like the development of the Andalusian Forest Cluster, which is in progress at this moment.

3. High level of education

The labour force in Andalusia is highly educated. People are qualified with strong technical skills and over 70% is holding at least one university degree.

4. Knowledge level in valorisation techniques

A variety of research groups, with expertise in the valorisation of agricultural and forest sidestreams, are present in Andalusia, e.g. CSIC (Instituto de la Grasa), University of Cordoba, University of Jean, University of Granada and University of Huelva.

Weaknesses

1. Government support/subsidies required

From the private sector, the financial support for research on biomass valorisation techniques is very limited. The economic feasibility of current business models is therefore highly dependent on public subsidies. The regulatory framework on sidestream valorisation is not steady and rather restrictive, e.g. in the context of electricity self-consumption.

2. Lack of knowledge, expertise and experience about biomass valorisation possibilities

The policies and plans for biomass sidestream valorisation are not well known by the stakeholders in the sector. In addition, only a limited amount of reference projects exists in which a non-energetic, high value valorisation is targeted. The current facilities for valorisation of agricultural biomass in Andalusia are:

– 9 composting plants specific for agricultural waste

– 14 plants for the valorisation of urban waste, where agricultural wastes with characteristics equivalent to urban waste are also valorised

– 11 plants for the generation of energy from olive mill solid wastes

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– 1 anaerobic digestion plant specifically designed for the valorisation of agricultural waste and by-products.

3. Lack of scale and fragmented supply chain

In general, the biomass valorisation industry consists of centralised large-scale facilities. However, sidestreams are scattered along the region and the average cost of transporting these big volumes of biomass to the valorisation plant is twice the cost of treating it in landfills.

4. Weak RTD to industry/market process

In Andalusia, a gap is present between the scientific/research sector and the business sector. Business needs are often not taken into account by researchers in the field of agricultural sidestream valorisation. Therefore, in some cases it is not possible to transfer research results to an operational industrial scale.

5. Low demand and supply of forest biomass

Despite the potential of (valorised) forest biomass, the supply and demand is limited in Andalusia.

Opportunities

1. Commercialization opportunities

The existing technologies present a lot of possibilities for new projects as the main needs in Andalusia relate to innovations in business models and not to new technology developments. Regarding the implementation of new applications, recent years have demonstrated the feasibility of innovative business models and/or value chains. In addition, opportunities exist to open new markets for the variety of products that are currently can be obtained from the valorisation of the wide availability of biomass sidestreams. Income diversification for companies in the sector can also be an incentive to explore more valorisation options. In Andalusia, only a limited number of companies producing high value compounds from agricultural sidestreams, is present.

2. Political support for a growing agricultural and forestry sector

Regional, national and European strategies and policies aim to foster bio-economy projects

3. Contributions to the socioeconomic development

Valorisation of biomass sidestreams in rural regions can lead to a resettlement of the population and to the creation of direct and indirect jobs, causing an improvement of the socioeconomic development in Andalusia.

4. Oil and gas independence

The use of biomass sidestreams as energy source reduces the dependence on foreign energy and fossil fuels.

5. Environmental sustainability

Energy production by biomass sidestream valorisation contributes to the sustainability of the environment. A reduction of CO2 emissions can be obtained, and is needed to comply with the emission targets of the Kyoto protocol.

Threats

1. Lack of government policy

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Due to the retroactive changes made in public regulations over the last years, high uncertainties exist in the biomass valorisation business. Administrative procedures are becoming time-consuming and complex tasks, causing investors lose their confidence in the sector.

2. Continuity/Security of biomass supply

The continuity of biomass supply, and therefore its valorised end product, cannot always be secured. The risk of forest fires, pests, floods and diseases is always present and endangers the raw material.

3. Competition with fossil based energy products

Fluctuations during the last years in the price of fossil fuels have generated uncertainties in investors and hindered the economic sustainability of many bio based projects That is why end users are giving priority to the use of fossil fuels in industrial and domestic applications and bioenergy is only limited used.

4. Markets for high-value bio-based products still limited

The market for high value products, resulting from biomass valorisation, is restricted and therefore the development of alternatives to bioenergy production is hindered.

5. Financial risks and access to finance

The biomass valorisation sector is relatively new and the level of uncertainty, concerning profitability and repayment, is rather high. The sector is also lacking public support schemes for reducing the risk of new projects and their payback period. As a result, a low rate of entrepreneurial activity exists in the biomass industry in Andalusia.

3.1.2 Potential of Strength and Opportunities

In this section we look at the prioritized items for Strength and Opportunity whether we see possibilities to overcome the prioritized items for Weakness and Threat.

‘Strong networks’ is mentioned as an important Strength for the Andalusian hub. Coordination between educational centres, the cooperative sector, the agro and forest industry and the regional government is existing. However, a progressive policy and financial support for implementing business models in the field of biomass valorisation is lacking. The connection between all stakeholders should be used to convince policy makers to establish a more flexible regulatory framework on sidestream valorisation and to brainstorm on the creation of new funding mechanisms for start-ups in the sector.

A discrepancy seems to be present between the availability of highly educated people and knowledge in valorisation techniques on the one hand, and the lack of expertise and experience about valorisation possibilities on the other hand. It is clear that the problem lies in the fact that the existing knowledge is not well disseminated and exploited in the industry. The networks in the region can be used to transfer knowledge in an efficient way and to encourage companies to hire the educated and qualified people to develop and improve the sidestream valorisation industry.

As sidestreams are scattered across the region and transportation costs are high, a biomass valorisation industry consisting of centralized large-scale facilities, as currently is the case, is not favourable. The solution is to focus on low-scale or medium-scale facilities at a local scale in which a higher valorisation can be obtained. By using the existing strong networks, partnership between small actors can be promoted. A strategic plan needs to be established to place the receiving biomass plants near the production areas, allowing the transportation costs to be reduced, the delivery in optimal conditions to be ensured and the supply chain to be optimised. A cost-benefit analysis, in which the transportation distances of the biomass sidestreams are mapped will reveal the feasibility of cost-efficient valorisation at local scale.

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To improve the transfer of promising research results into good working techniques for the business sector, the strong networks can be used as well, especially to disseminate the available knowledge of the stakeholders by organizing workshops. As many opportunities exist to open new markets for the variety of products that can be obtained from biomass valorisation, and because the feasibility of innovative business models is already demonstrated, optimization of the commercialization process is of great importance.

The coordination between the stakeholders can also help to overcome the lack of government policy. The existing network can ease the complex administrative procedures, imposed by the government, by offering centralized support. Further, by collecting data of best practices and performing cost-benefit analyses, the network can distribute information to the government, in order to influence their policy making. As the continuity of biomass supply is nature dependent and therefore cannot be secured, risk management is needed for small actors in a local-scale industry. The existence of a strong network can serve this purpose, but to further reduce the financial risks for the business sector, the government should act as safety net. The government can also promote the valorisation of biomass by including emission targets and foreign energy dependence reduction.

3.1.3 Results of the need questionnaire

Concerning the Andalusian needs questionnaire, 14 surveys were carried out in the agro-food sector and 21 surveys in the forest sector. For the agro-food sector, both the producing sector and the agro-industry, mainly workers in an olive grove, were interviewed. The most important needs from farmers and foresters that came forward, are summarized below.

In Andalusia, the use of biomass waste in agro-food industries is mainly related to energy applications, either by the industries themselves, or by power generation plants. Also, more and more stoves, dryers, ovens, boilers in homes, hotels and public bodies are manufactured and installed, all potential consumers of biomass.

The respondents mentioned a variety of difficulties in the valorisation of biomass. The main disadvantages encountered for the use of biomass are the lack of stability in the energy regulatory framework and the absence of logistic strategies that are feasible in the field of biomass valorisation from the current technical and economical point of view. New projects and business models are needed, that give an alternative to the production of bioenergy and that give a solution to the environmental problems on the farms as well as in the industrial processes.

Further, the seasonality in the generation of waste is mentioned as a disadvantage, as it makes the supply of biomass and its processing discontinuous. In some cases, it is difficult to obtain value of agricultural biomass, as moisture content or diseases can lead to increasing transport and handling costs, sidestreams are then burned in the field. In addition, the elimination of waste by the farmer involves costs. However, sidestreams can be used directly on the farm as feed for livestock or fertilization purposes (compost, nutrients, organic matter).

Farms are linked to and concentrated around the agroindustry, so there is a short distance, literally and figuratively, from the farms to the cooperatives. Therefore the agricultural cooperatives or agribusiness can be considered as a logistics centre for biomass treatment.

In general, the opinion on public support linked to biomass investments for energy use is positive. Further, the respondents are open to new business models around biomass that generate new products, and at the same time, reduce operating costs and environmental impact.

From the forestry sector, more data was achieved. The main sources of biomass are the residues of forestry and silviculture treatments, e.g. bark, sawdust and wood chips. The amount of biomass produced is strongly depending on the working area and the period of time considered. As a result, companies with an output ranging from 3000 tonnes each year to over 65 000 tonnes each year have

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been identified in Andalusia. A variety of challenges exist in the forestry industry. The distribution of ownership of the forest biomass is fundamentally divided into public administrations, foresters and forestry companies. This biomass is scarcely used, mainly due to ignorance, high extraction costs, lack of public support and a fragmented logistic chain. All interviewees highlighted the distance between the available resources, the processing industry and the final consumers.

Almost all companies agree on their availability to valorise forest biomass, mainly to generate energy, but for this, important barriers need to be overcome. First of all, the forest industry needs more stability in the regulatory framework and greater public support. Due to the existing regulations regarding work in the natural environment, summer months are unproductive in the forestry sector. In addition, the lack of business opportunities is mentioned. R&D projects and transfer possibilities are scarce, technologies are not available and business plans are missing. More favourable conditions for innovation would stimulate biomass valorisation e.g. by upscaling and a decrease in operation costs.

3.1.4 Analysis of available biomass and possible related techniques and good practices

In Task 1 of WP 1, for each hub an overview of biomass sidestreams and their volumes was given by the hub managers with the support of the hub network (D1.1: Hendriks et al. 2016a). The important sidestreams (volumes) mentioned in that overview are listed in table 2.

Based on the results of Task 1 (Techniques for biomass valorisation Hendriks et al. 2016a) and of Task 2 (Good practices for biomass valorisation Hendriks et al. 2016b) possible valorisation techniques and resulting products are added to table 2. Also examples of good practices and research were added based on earlier results of Task 1 and Task 2 of WP1. The known examples are completed with new specific examples when available.

Table 2: Biomass sidestreams in Andalusia, annual production, possible processing techniques, possible valorisation products, and examples of processing facilities

Biomass sidestream	Production (kton or k m^3 per year)	Technique	Products	Examples
Olive pruning	2524	Hydrolysis Fermentation	Ethanol Antioxidants Oligosaccharides Lignin-derived chemicals	Universidad de Jaén, Spain http://www.agriforvalor.eu/sidestreams/Olive-biomass-as-an-energy-source-and-chemicals-60
Olive leaves	345	Extraction Hot water treatment	Tanning agents for leather (fine chemical)	Wet green, Germany http://www.agriforvalor.eu/sidestreams/wet-green-161
Olive pits	552	Extraction	Polyphenols, bioactive compounds, nutraceuticals Animal nutrition Electricity	Natac and Oleícola El Tejar, Spain http://www.agriforvalor.eu/sidestreams/INNOVAOLEO-S-L-152

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Moist spent olives	3011	Anaerobic digestion Extraction Purification Combustion	Biogas	Campillos Biogas Plant, Spain
Two-phase olive mill waste	3544	Anaerobic digestion Extraction Purification Combustion	Biogas	Campillos Biogas Plant, Spain
Straw	1901	Fermentation Combustion Pyrolysis	Biochemicals (lactic acid, succinic acid, laccase, cellulase, vanillin, ethanol, biohydrogen) Biofuels (ethanol, pyrolysis oil), heat Compost	Cereal Biorefinery: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774676/ Pilze Nagy, Hungary http://www.agriforvalor.eu/article/A-good-practice-on-energy-recovery-techniques-by-Pilze-Nagy-Hungary-a-project-partner-of-AGRIFORVALOR-15 BTG, Netherlands http://www.btgworld.com/nl/rtd/test-facilities/fast-pyrolysis Biogas: http://www.biogas-info.co.uk/about/feedstocks/#agricultural IEA, Austria: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/6/e/b/82465f23-60cc-48dd-87be-ba8d2e5cf183_prmpbf16211%20LIF%20IEA%20Biorefining%20Fa

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				ctsheet%203%20Platform%20v2 %20w.pdf
Slaughterhouses and meat	100	Incineration Pyrolysis	Fertilizer (P, N) Fertilizer (Biochar)	University of Hohenheim, Germany https://improve-p.uni-hohenheim.de/uploads/media/moeller2015-factsheet-Meat-and-bone-meal.pdf Terra Humana ltd, Hungary http://www.3ragrocarbon.com/
Pig slurry	1477	Anaerobic Digestion	Biogas Minerals (P, N, K) Organic compost	H2020 project Systemic, Netherlands http://www.wur.nl/nl/nieuws/Grootschalige-demonstratieprojecten-voor-terugwinning-van-nutrienten-uit-mest-en-slib.htm Campillos biogas plant, Spain http://www.agriforvalor.eu/article/Success-case-on-innovative-business-model-for-waste-valorisation-The-Campillos-biogas-plant-17 McDonnell Farms Biogas Limited, Shanagolden, Co. Limerick, Ireland http://www.seai.ie/Publications/Renewables_Publications_/Bioenergy/Anaerobic_Digestion-Shanagolden_Case_Study_2010.pdf Azucarera Española, Spain http://www.agriforvalor.eu/sidestreams/Anaerobic-digestion-of-residues-from-beet-and-co-digestion-with-livestock-manure-in-different-temperature-ranges-

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				Energy-assessment-72
Cow dung	1371	Anaerobic Digestion	Biogas Minerals (P, N, K) Organic compost	See previous examples pig slurry
Hen droppings	350	fluidized bed combustion Anaerobic Digestion	Heat Electricity Minerals (P, N, K)	**BHSL, Ireland** http://www.bhsl.com/ Campanillos biogas plant, Spain http://www.agriforvalor.eu/article/Success-case-on-innovative-business-model-for-waste-valorisation-The-Campillos-biogas-plant-17

Table 2 shows that for biomass sidestreams, olive oil production waste has high volumes, and to a lesser extent also straw, pig and cattle slurry. Given their volumes, these sidestreams look interesting for scaling up. In the next paragraph, these valorisation opportunities are discussed.

3.1.5 Business model on olive sidestream valorisation in Andalusia

Techniques and good practices

Olive waste can be valorised into a variety of products, depending on the olive biomass sidestream and the technique applied. Milling residues from the olive oil industry can be used as feedstock for the production of biogas. By anaerobic digestion (fermentation), biogas (fuel) is generated and then sold for heating purposes to end consumers. Important in this technique is that olive waste serves as co-substrates. As olive mill waste is rich in phenolic compounds, microbial growth and activity is inhibited. A good practice of this technique exist in Spain, the Campillos Biogas Plant (Del. 1.2: Hendriks et al 2016b). Olive waste is used in this plant as one of the co-substrates of pig slurry and the results are promising.

In addition to fermentation of milling residues, valuable alternatives exist to further valorise olive waste.

- The solid digestate, a sidestream of the fermentation, is processed into compost (fertilizer).
- As mentioned above, also straw, manure and urine can (and have to) be converted together with the olive waste in the same biogas production facility.
- Olive mill waste can be valorised by extracting and purifying polyphenols and other bioactive compounds, for food, cosmetics and pharmaceutical purposes (food/functional material), out of the olive pomace. The same applies for olive stones. After extraction of the high value compounds, the

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secondary biomass is combusted or fermented for the generation of electricity (fuel). In Spain, a good example of this technique can be found in the biotech company Natac is. In Italy, the EU project Bioactive net, with important research on this topic, is in a TRL9 phase.

- Olive waste has a sidestream of olive leaves, obtained during olive harvest and pruning. By adding boiling water to the leaves, an ecological leather tanning agent (functional material) can be recovered. Wet-green, a German leather innovation centre, is performing this application on industrial scale.

- Further, more research is done in Andalusia on olive sidestream valorisation, e.g. to develop bioplastics from olive pruning, and to obtain inks and resins, not only from olive waste but from rice husks and nutshells as well.

The potential is further reinforced by the widely available knowledge and expertise in valorisation techniques (S) in Andalusia, in addition to people qualified with strong technical skills (S). Both aspects are seen as important strengths and open opportunities for extending the olive waste valorisation industry. The current operational facilities, inside and outside the region, and promising research results in this field, can act as starting point to further explore the potential of these techniques.

Value chain and security of biomass supply

Andalusia is the world's largest olive oil producing region. In Spain 70% of the olive oil production is produced in Andalusia (Del. 1.2: Hendriks et al 2016b). Hence, a large amount of olive biomass sidestreams is available in this region (S), which is mentioned as a key strength. However, sidestreams are scattered across Andalusia and transportation costs are high (W).

To address this, the operational Campillos Biogas Plant for example has shown that potential exists when working at local scale. This plant treats the biomass waste generated in a number of farms in its immediate surroundings, as all the suppliers of the waste are located within a radius of 4 km from the plant (Del. 1.2: Hendriks et al 2016b). Transportation costs can thus be minimalized, and because of the relative small scale of a common biogas installation, fragmentation of biomass supply is not considered to create a problem. However, in case there is not enough supply of olive waste (T), biogas can be produced without this sidestream as well, e.g. only from manure. Valorisation of biomass sidestreams at local scale can also contribute to the socioeconomic development of rural regions (O).

Provided that enough olive mill waste is available throughout the year, this valorisation approach can be applied. In Andalusia, milling residues account for more than 6 500 000 m^3 and manure for more than 2 100 000 m^3. As the Campillos plant converts 65 000 m3 of waste each year, and only a few facilities are currently valorising this sidestream, a lot of opportunities may exist to further extend this sector. Thereby, regional availability of biomass sidestreams can be an important factor for regional specialisation.

As only a limited amount of reference projects exists in which a non-energetic (W), high value valorisation is targeted, the alternatives for biogas production from olive waste should also be considered. More than 2 500 000 m^3 olive pruning, 345 000 m^3 olive leaves and 550 000 m^3 olive stones are available.

Environmental issues

Sidestream management is very important in the olive oil supply chain, as the high phytotoxicity associated with olive oil mill waste has a great impact on the environment, both land and water. By valorising it through food, fuel, fertilizer and functional materials, contamination of the environment can be reduced.

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Through the production of heat (biogas) from biomass, the combustion of non-renewable fuels can be reduced, leading to lower emission of CO2 and other greenhouse gases (O). Also the alternatives to valorise olive waste are considered to be environmentally friendly. For example, the combustion of biomass to generate electricity contributes to a reduced CO2 emission as well. In addition, The obtainment of natural high value compounds from olive biomass sidestreams has a positive impact on the environment because the techniques applied are not as polluting as the chemical processes to produce these compounds. Similarly, by producing a natural leather tanning agent, the use of tanning chemicals, which can harm our health and environment, can be avoided.

Policy support

Biomass based production of renewable energy is supported by Europe. By using energy more efficiently, the reliance on external suppliers of oil and gas (O) can be reduced and the environment can be protected. Spain needs to comply with the European legislation on climate and energy. To reach a 20% cut in greenhouse gas emissions (from 1990 levels) and 20% of its energy from renewable resources by 2020, the regional, national and European government have set out a strategic approach to foster bio-economy projects (O). Biogas production through anaerobic digestion of olive waste can contribute to these policies as heat, electricity and biofuels are generated with the biogas produced.

Financial risk and access to finance

The current regulatory framework on biomass valorisation creates uncertainties in the sector (T), e.g. by imposing complex administrative tasks. As the economic feasibility of current business models is highly dependent on public subsidies, investors lose confidence and government subsidies are required (W). More changes have to be made to the current approach to construct a stimulating environment for biomass valorisation.

The use of the strong existing networks (S) can be a first step to achieve this. A better connection between the stakeholders might lead to the creation of private funding mechanisms for start-ups in the sector. Starting a biogas production business will be more feasible when partnerships exist between the (small) producers of olive waste. The current cooperatives can serve as starting point. The techniques are innovative, so small-scale actors cannot finance this on their own as the payback period and the profitability will be highly uncertain (T). A cost-benefit is needed to succeed, as well as a thorough risk analysis (and risk management schemes). Founding a partnership can help to manage the risk of biomass loss from one of the partners. Risks can further be covered by extending the valorisation to only straw and manure as well. However, the government could also act as a safety net, as the strong network cannot account for everything. If a company is successful, it can extend and extract high value compounds prior to fermentation. A cascading valorisation of olive mill waste shows a lot of potential.

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3.2 Results of the SWOT analysis for the Hungarian hub

3.2.1 Description of the SWOT analysis

Three experts have prioritized the SWOT questionnaire. The top 5 scores per swot item is presented in table 3 and described below.

Table 3: The 5 most important Strength, Weakness, Opportunity, Threat (SWOT) factors influencing the valorisation potential of biomass sidestreams for the Hungarian hub following the prioritization of three experts.

The number is representing the prioritized sequence with 1 being the most important factor and 5 the least important. Number in brackets show the total amount of voting received.

Strength	1. Strong networks (13) 2. High volume of biomass sidestreams available (12) 3. Expertise and experience about biomass valorisation possibilities (10) 4. Knowledge level in valorisation techniques (9)	**Opportunity**	1. Large area potentially suitable for agriculture/forestry (15) 2. National and EU support for a growing Forestry and Agro sector (12) 3. (Government) support/subsidies required (crowdfunding) (8) 3. High demand of valorised biomass (8)
Weakness	1. Lack of knowledge, expertise and experience about biomass valorisation possibilities (14) 2. Lack of scale and fragmented supply chain (11) 3. Weak RTD to industry/market process (10) 3. Continuity/Security of biomass supply (10)	**Threat**	1. Government support/subsidies required (no start-up subsidies) (13) 2. Lack of government policy (11) 3. Financial risks and access to finance (10) 4. Low level of education/Lack of skilled people working in the sector (9) 5. Lack of awareness/promotion of biomass valorisation (5)

Strengths

1. Strong networks

The Hungarian hub manager is working for Bay Zoltán Nonprofit ltd, an applied research institute, unique in Hungary. Her expertise can be used to increase awareness on the topic of biomass sidestream valorisation and to provide a bridge between research and industry so the scale-up of RTD results to the market becomes easier. The importance of clusters also appears from B2B meetings in which rapid information change is possible.

2. High volume of biomass sidestreams available

Hungary has a good biomass production potential. The annual production amounts:

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– 54 million tonnes of dry matter of primary biomass (46 million tonnes from agriculture and 8 million tonnes from forestry);

– about 13 million m3 of wood from the million hectares of forests (of this, 10.5 million m3 can be lumbered in a sustainable way);

– about 700 000 m3 of wood by-products (waste wood, wood chips) from the wood processing plants, but because these are often contaminated with chemical substances, only about 50 per cent of the resulting quantity (mostly sawdust and bark) can be used for energy production;

– 4-4.5 million tonnes of straw from the production of cereals (of this, about 2.4-2.8 million tonnes could be used for energy production in a sustainable way);

– 8-10 million tonnes of maize stover (of this, about 2.5-3.0 million tonnes could be utilized as biomass for energy production);

– a significant amount of sunflower stems and oilseed rape straw, about 150-200 thousand tonnes of vineyard biomass and 400-500 thousand tonnes of orchard biomass.

3. Expertise and experience about biomass valorisation possibilities

Several technologies already exist and for the forestry sector, a variety of best practices is available on the market. AGRIFORVALOR helped in the identification of these practices.

4. Knowledge level in valorisation techniques

Strong research and development activity and skills exist in the field of biomass valorisation. The production of bioenergy, as well as novel uses of biomass, like the production of high added value substrates, are tackled in various RTD projects in the region. Bay Zoltán Nonprofit ltd is one of the at least 9 RTD institutes or universities with projects on biomass use.

Weaknesses

1. Lack of knowledge, expertise and experience about biomass valorisation possibilities

In Hungary, the share of energy from renewable sources is low compared to the neighbouring countries and the European Union. An explanation can be found in the less efficient use of nature's potential. Existing technologies are not known by the farmers and foresters, and therefore, they lack experience in how to use them. Even on governmental level, there is not enough information about real best practices. It's not easy for end users to access information and coordination between them is missing. In addition, current technologies are not adapted to the needs of their users and are not planned and prepared appropriately.

2. Lack of scale and fragmented supply chain

Most of the woody biomass is processed in large power plants. There are no opportunities to sell and process biomass near its production site so transportation of woodchips for over 100 km is not unusual. Logistical collaboration between farmers, governments and industry is absent. In addition, more emphasis should be put on the economies of scale because they strongly influence the relevance of a technology. Lack of scale can increase the return on investment, which can hinder the innovation motivation.

3. Continuity/Security of biomass supply

Very little information on the available quantities of the different types of biomass and their energy potential exists. Data on the amount of biomass present are scattered throughout literature and cannot

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be used to estimate its potential. Uncertainty regarding the available biomass leads to uncertainty for the biomass valorisation industry.

4. *Weak RTD to industry/market process*

The effectiveness of the technology transfer activities is low. There are no established pathways in the upscaling of research projects to the market and the connection between R&D and business is weak. Researchers lack skills and competencies in this process and don't include lifecycle assessment and sustainably calculations and concepts. Therefore, only a few RTD results get closer to the market than TRL 5.

Opportunities

1. *Large area potentially suitable for agriculture/forestry*

The biggest part of Hungary is flat area, from which 6 179 300 ha is used for agricultural production, and 1 762 900 ha consists of forest area. Favourable agro-ecological conditions lead to the presence of agricultural and forestry sidestreams in both fields. Hungarian agriculture is capable of sustainably producing biomass in excess of food and feed demand. Therefore, the theoretical potential of bioenergy production could exceed as much as 20% of the energy demand estimated for 2020 and the electricity production can be planned and controlled.

2. *National and EU support for a growing forestry and agro sector.*

The energy plans of the EU and Hungary for 2020 provide a solid basis for the development of biomass valorisation. The European Commission is developing clean technologies to make the European economy more climate-friendly and less energy-consuming in a cost-efficient way. Both EU and national targets are established for the minimum share of energy from renewable sources that has to be achieved by 2020. In addition, for the financing of biomass valorisation, several EU funds are accessible. Horizon 2020, EU Biofuels Platform, NER 300 and LIFE are some examples.

3. *(Government) support/subsidies required*

Crowd funding for start-ups and other investments is possible, as well as funding of innovative ideas by for-profit companies. With the cooperation of institutes, this can act as a bridge between research and practice, and a full operating value chain from TRL 1 to TRL 10 can be created.

4. *High demand of valorised biomass*

On the market, a demand for RTD results and innovative product exist. Biomass is prioritized in the following order: fodder, substitution of soil's nutrient content, industrial raw material and energy production. So RTD projects with objectives different from bioenergy production show potential as well.

Threats

1. *Government support/subsidies required*

There is no financial support from the government, so funding for planting new energy installations is not available. Therefore, without financial support, farmers have no intent to establish new short-rotation coppices.

2. *Lack of government policy*

The share of energy from renewable sources in Hungary is low compared to the neighbouring countries and the rest of EU-28, probably partly due to the less effective legislation. The government is not a good manager of biomass resources. The existing regulations regarding sidestream valorisation use a top-down approach and some recyclable biomass is considered municipal solid waste or even

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hazardous waste. Therefore, these sidestreams cannot be recycled but need to be dumped at a cost. As a result, the unfavourable governmental background make it difficult or even impossible (for local initiatives) to gather and valorise biomass.

3. Financial risks and access to finance

Regarding the economic payback, a variety of uncertainties is present. Current biogas production plants in the region are not profitable despite extensive knowledge of the technique. The purchase price for the electricity produced is not fixed, and cannot be guaranteed as changes in market conditions are unforeseen. In addition, because the farms are small, not much opportunities for investment exist.

4. Low level of education/Lack of skilled people working in the sector

The lack of relevant competence in the region hinders the biomass valorisation industry. For SMEs, it is hard to implement innovation activities because there is no background in human resources.

5. Lack of awareness/promotion

Due to the few best practices in the region, the awareness level in the public and professional sector is low.

3.2.2 Potential of Strength and Opportunities

In this section we look at the prioritized items for Strength and Opportunity whether we see possibilities to overcome the prioritized items for Weakness and Threat.

In Hungary, the existing biomass valorisation technologies are little known by farmers and foresters, and therefore they lack experience in how to use them. However, in the research sector, strong activity and skills are present for the development of new biomass valorisation techniques. So, it seems the problem is related to the transfer and the use of knowledge, more than to the availability of knowledge. Setting up courses and training programs can help to increase the knowledge level and expertise. Making use of existing expertise and good practices can be of help for the education, e.g. the expertise of Bay Zoltán Nonprofit ltd, and the network surrounding it, can be used to disseminate knowledge and increase awareness on the topic of biomass valorisation, for the stakeholders as well as for the public. By teaching courses and organizing workshops for practitioners and advisors in the field, farmers and foresters can learn about their possibilities.

However, it is also of high importance that researchers are informed about the needs of farmers, foresters and end users, so biomass valorisation research can be performed in an efficient way. BZN can provide a bridge between research and industry to facilitate the scale-up of RTD results to the business sector in the first place, and to the market in the second place. As the demand for valorised biomass is high, coordination between all stakeholders of the value chain is thus needed and can be accomplished when strong networks exist.

Data on the amount of biomass and biomass sidestreams is scattered throughout literature and cannot be used to estimate its potential. Uncertainty regarding the available biomass leads to uncertainty for the biomass valorisation industry, and is seen as an important Weakness. Strong networks can provide a solution, by working together and collecting data. Then, databases should be created and submitted to the government, in order to direct them into evidence-based decision-making in the field of biomass valorisation support on the base of which a roadmap for the bio-economy can be drafted.

To further support the government policy on this topic, not only data on the available sidestreams should be collected, but also on the results of best practices. In this case, a strong network is the perfect candidate to distribute the collected information to the policy makers to raise awareness on the importance of biomass sidestream valorisation for the economy and environment. By showing them

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promising results from the valorisation industry, they might draft new policies to stimulate the bio-economy. A bottom-up approach can maybe establish more favourable conditions to gather and valorise biomass. The government should also stimulate programs to reduce the financial risk for the business sector by acting as safety net, as too much uncertainties regarding economic payback hinder expansion of the sector.

Woodchips are often transported over more than 100 km as woody biomass is valorised in several large power plants across Hungary. Opportunities to sell biomass near its production site are missing. To optimize the supply chain, the centralized large-scale valorisation sector should be extended with a local small-scale biomass industry, in which transportation costs are negligible and selling biomass is more profitable. Business plans are needed to place receiving biomass plants near the production areas and to obtain end products with more diversity and higher value.

3.2.3 Results of the need questionnaire

Regarding the Hungarian needs questionnaire, a total of 24 farmers and foresters participated in the survey. For 85% of the respondents, animal livestock production and/or cultivation of arable crops (grains, corn, rape, etc.) or fruits or vegetables, is the main activity. Most respondents are SMEs and the Southern Great Plain NUTS2 statistical region of Hungary is the most common working area. 75% of the interviewees have the availability of electricity and water supply on the site where the sidestreams are produced.

The main sources of the utilizable biomass produced under own activity are coming from agricultural activity, more specific from herbaceous plant cultivation (cereal straw, rape straw, maize stalks, sunflower straw etc.) and animal livestock production. A minority of the interviewed farmers produces biomass sidestreams out of woody agricultural activities and forestry. 71% of respondents know the amount of biomass sidestreams they produce.

Farmers are the owners of their sidestreams and in most cases, also the user of these biomass resources for internal production processes, e.g. animal feed and soil fertilization. Almost half of the respondents sells the biomass sidestreams produced (or a part of it), and around half of the respondents utilizes biomass sidestreams produced by other producers, obtained within a distance of 35 km. Not much is known about supply chains that may or may not exist to deliver biomass sidestreams to the agro and forest related industry.

At present, 79% of respondents do not apply any innovative technology to utilize biomass sidestreams (for energy production or other purposes). The majority of technologies applied by the remaining part of the respondents (permaculture, deep mulching, heat production, straw burning in heat generator) serve energy production purposes.

Two thirds of the respondents mentioned the lack of logistics chains and/or lack of knowledge about utilization technologies as the key barrier(s) in utilizing agricultural and forestry sidestreams. 85% of the interviewees has a general knowledge about the utilization of biomass sidestreams for energy production and/or as feed and/or as fertilizer, but maximum 5% of them knows other possibilities. The majority of the respondents thinks that biomass is transported not more than 35 km to supply these technologies.

When evaluating the possible barriers that can hinder or slow down the operations in sectors of the economy linked utilization of sidestreams, the respondents rated the following options equally important:

– lack of public support,
– lack of encouraging national laws,

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- lack of awareness/knowledge/training of investors,
- lack of business opportunities or networks,
- lack of logistic chains,
- lack of knowledge about technologies
- lack of RDI projects or transfer results.

Only one third of the respondents has an idea about a technology appropriate to valorise the biomass sidestreams produced under own activity. Half of the respondents have already heard of such technologies but do not have enough knowledge to decide whether these technologies can be fitted into their activity in order to valorise biomass sidestreams.

Assuming favourable conditions and economic payback supported by a business plan, 58% of the respondents expect that the implementation of a new technology can result in a decrease in operational costs. At the same time, the same proportion of respondents considers it important that by introducing a new technology, a decrease of the environmental effects of their activity (and so the effects of the local agricultural/forestry production) and environmental awareness can be achieved as a good production practice.

3.2.4 Analysis of available biomass and possible related techniques and good practices

In Task 1 of WP 1, for each hub an overview of biomass sidestreams and their volumes was given by the hub managers with the support of the hub network (D1.1: Hendriks et al. 2016a). The important sidestreams (volumes) mentioned in that overview are listed in table 4.

Based on the results of Task 1 (Techniques for biomass valorisation Hendriks et al. 2016a) and of Task 2 (Good practices for biomass valorisation Hendriks et al. 2016b) possible valorisation techniques and resulting products are added to table 4. Also examples of good practices and research were added based on earlier results of Task 1 and Task 2 of WP1. The known examples are completed with new specific examples when available.

Table 4: Biomass sidestreams in Hungary, annual production, possible processing techniques, possible valorisation products, and examples of processing facilities

Biomass sidestream	Production (kton or k m^3 per year)	Technique	Products	Examples
Straw (wheat)	4000-7000	Fermentation Combustion Pyrolysis	Biochemicals (lactic acid, succinic acid, laccase, cellulase, vanillin, ethanol, biohydrogen) Biofuels (ethanol, pyrolysis oil), heat Compost	Cereal Biorefinery: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774676/ Veolia, Pécs, Hungary Pilze Nagy, Hungary http://www.agriforvalor.eu/article/A-good-practice-on-energy-recovery-techniques-by-Pilze-Nagy-Hungary-a-project-partner-of-AGRIFORVALOR-15

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				BTG, Netherlands http://www.btgworld.com/nl/rtd/test-facilities/fast-pyrolysis Biogas: http://www.biogas-info.co.uk/about/feedstocks/#agricultural IEA, Austria: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/6/e/b/82465f23-60cc-48dd-87be-ba8d2e5cf183_prmpbf16211%20LIF%20IEA%20Biorefining%20Factsheet%203%20Platform%20v2%20w.pdf
Corn residues (rachis, stem and leaf)	5000-14000	Fermentation Combustion Pyrolysis	Fuel Fertilizer Fine chemical	Budapest University of Technology and Economics (BME), Hungary http://www.agriforvalor.eu/sidestreams/Value-added-utilisation-of-corn-fibre-58
Sunflower stem	400-1000	Extraction	Cosmetics (skin cream)	Helia D, Hungary http://www.agriforvalor.eu/sidestreams/Cosmetics-from-sunflower-stems-155
Pruning residues (fruit tree, vine)	1000-2000	Extraction Purification Combustion	Pharmaceuticals Food additives Animal nutrition Electricity	Spirajoule pyrolyzer: Biogreen, France http://www.biogreen-energy.com/biogreen/spirajoule/
Wood waste of forestry (logs, wood chips, wood cuttings, sawdust, branches, bark, etc.)	1000-1500	Chipping Combustion Pyrolysis Biorefinery	Filter material for bio-filters Mulching	Compost: Terracottem, Spain http://www.terracottem.com/ Bio-filters: Foba kft, Hungary http://www.fobakft.hu/ Spirajoule pyrolyzer: Biogreen, France http://www.biogreen-

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		Supercritical extraction	Heat/power Bio-char Bio-oil Tall oil (glue, paint, ink, biofuels) Research in progress on: Adhesives (Tannin) Foams (Tannin) Lignin applications' Wooden (bark) panels	energy.com/biogreen/spirajoule/ Bioproduct mill: http://bioproductmill.com/bioproducts Research: http://dx.doi.org/10.1016/j.rser.2013.06.024 http://dx.doi.org/10.1016/j.supflu.2016.07.001 https://aaltodoc.aalto.fi/bitstream/handle/123456789/15348/isbn9789513882150.pdf?sequence=1 http://virtual.vtt.fi/virtual/probark/Probark_Project%20Presentation_WW%20Annual%20Seminar%202009.pdf IEA, Austria: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/8/8/d/e2daab7a-68e3-4695-8e66-43ef0c86bdd8_prmpbf16210%20LIF%20IEA%20Biorefining%20Factsheet%202%20Platform%20v2%20w.pdf http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/0/7/4/b3392f8a-b84a-486b-8d17-515a707391aa_prmpbf16212%20LIF%20IEA%20Biorefining%20Factsheet%205%20Platform%20C6%26C5%20A4%20v2.pdf
Apple pomace	Unknown	Digestion Extraction	Methane Ethanol Food additives (pectins, anti-oxidants) Food (apple syrup jam)	Research on lactic acid from apple pomace, Spain http://www.tandfonline.com/doi/pdf/10.1080/11358120902906990
Dairy by-	30000-60000	Hydrolysis	Nutritional	Carbery, Ireland

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products (e.g. whey)		Fermentation Anaerobic digestion	additions (proteins) Bio-ethanol Bio-gas Fertilizer (N,P)	http://carbery.com/nutrition/our-products/ wheypack production of PHB Biopolymers from whey residues http://www.ainia.es/en/food-news/releases/first-bioplastic-made-from-surplus-whey-cheese-industry/ http://www.wheypack.eu/eng/index.html https://www.rd.usda.gov/files/RR214.pdf Demetra, Ireland: Small-Scale AD Bag Solutions :http://www.demetra.ie/ Monte Ziego, Germany
By-products of sugar beet industry	33000	Fermentation Combustion Pyrolysis Composting Acidification and gasification	Fuel (biogas) Fertilizer	Azucarera Española, Spain http://www.agriforvalor.eu/sidestreams/Anaerobic-digestion-of-residues-from-beet-and-co-digestion-with-livestock-manure-in-different-temperature-ranges-Energy-assessment-72

Table 4 shows that for biomass sidestreams, straw and dairy waste have high volumes, and to a lesser extent also maize stover, and wood waste. Given their volumes, these sidestreams look interesting for scaling up. In the next paragraph, these valorisation opportunities are discussed.

3.2.5 Business models on straw and dairy waste valorisation in Hungary

Techniques and good practices

Straw, a sidestream of wheat production, can be valorised into various types of bioenergy. First option is the cogeneration of electricity and heat in a biomass-fuelled plant. The straw-burning biomass cogeneration provides for heating and electricity purposes in the region surrounding the power plant. Good practices of this technique exist in Pécs, Hungary (Veolia, http://www.veolia.com/en/heating-network-cogeneration-biomass). A second option is the thermochemical conversion (pyrolysis) of biomass sidestreams such as straw into bio-oil, biogas and biochar. Biogreen (Del. 1.2: Hendriks et al 2016b) is the commonly applied technique for this process. Both techniques can be extended with other biomass sidestreams as feedstock. Corn stover can be used as alternative in the cogeneration plant, and the Biogreen installation can be used for the pyrolysis wood waste as well.

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Whey, a sidestream of cheese production, can be valorised into various types of bioenergy. The first option is the fermentation of filtrated whey, containing lactose, into ethanol. Depending on the production process applied, the ethanol produced can be used for food/pharma or fuel applications. In Ireland, a good example of this technique can be found in the company Carbery Milk Products (Del. 1.2: Hendriks et al 2016b). Second option is the production of biogas, also through fermentation of whey. The biogas can then be burned in a cogeneration plant, if production of electricity and heat is targeted. Monte Ziego (Del. 1.2: Hendriks et al 2016b) is a valuable example of this technique, as this company aims to be the first zero-energy dairy in Germany.

In addition to the current operational facilities (S), the potential of the aforementioned sidestreams are further reinforced by the widely available knowledge in valorisation techniques (S) in Hungary. Both aspects are seen as important strengths and open opportunities for extending the biomass waste valorisation industry.

Value chain and security of biomass supply

Hungary has a large area potentially suitable for producing agricultural and forest biomass (O), as the ecological conditions are favourable and the surface is flat. As a result, a high volume of biomass sidestreams is already available in Hungary (S), exceeding food and feed demand, and therefore, a lot of potential for bioenergy production exists. However, the biomass supply chain is fragmented and collaboration to get the biomass from the production to the processing location, is lacking (W).

To address this, the operational Veolia plant in Pécs has shown its potential when working at local scale. This plant treats straw from around twenty farms in the region, and ensures the energy of the city of Pécs. Transportation costs can thus be minimalized, and because of the relative small scale of such a biomass-fuelled plant, fragmentation of biomass supply is not considered to create a problem. However, reliable data on the amount of biomass and biomass sidestreams is scattered throughout literature (W), making it difficult to estimate its value. In case there is not enough supply of olive waste, the cogeneration can be done with maize stover as feedstock. The same is true for the Biogreen technique (which can be applied at the company's site and could produce up to several tons per hour) that is capable to valorise wood waste in addition to straw. In the case of whey valorisation, the energy production facility is installed on the production site of the cheese factory. Transportation costs are negligible and the energy produced can be used to (try to) reach an energy neutral dairy company.

Provided that enough biomass waste (straw/whey) is available, the suggested valorisation techniques can be applied, given that Hungary has, each year, more than

- 4000 000 m³ of straw,
- 5 000 000 m³ of maize stover,
- 1 000 000 m³ of wood waste,
- 30 000 000 m³ of dairy by-products.

A good case in point is the Veolia plant in Pécs, which can valorise 180 000 m³ of straw/maize stover each year. As expertise and experience in the field of biomass valorisation is limited (W), opportunities exist to further extend the centralized large-scale sector with a local small-scale industry to valorise straw and whey more locally.

Environmental issues

By valorising straw in a cogeneration plant or by pyrolysis into bioenergy, the emission of CO2 can be significantly reduced. Further, biochar, produced by pyrolysis, can be used for soil amendment as well, and reduces soil emissions of greenhouse gases. By valorising whey through fermentation into biogas

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or bioethanol, reduction of CO2 emissions is possible. In addition, the residues of the biogas plant can be used as fertilizer.

Policy support

Biomass based production of renewable energy is supported by Europe. By using energy more efficiently, the reliance on external suppliers of oil and gas can be reduced and the environment can be protected. Hungary needs to comply with the European legislation on climate and energy, and reach a 20% cut in greenhouse gas emissions (from 1990 levels) and 13% of its energy from renewable resources by 2020. Therefore, the national and European government have set out a strategic approach to make foster bio-economy projects (O). Valorisation of straw and whey can contribute to these policies as heat, electricity and biofuels are generated with the energy produced.

Financial risk and access to finance

The current regulatory framework on biomass valorisation creates uncertainties in the sector (T), e.g. by imposing a top-down approach. For the moment, the economic feasibility of current business models is partly depending on private subsidies and crowd funding (O), as government subsidies are lacking (T). More changes have to be made to the current approach to construct a stimulating and financially feasible environment for biomass valorisation.

The use of the strong existing networks (S) can be a first step to achieve this. A better connection between the stakeholders may lead to the creation of better private funding mechanisms for start-ups in the sector. Starting a bioenergy business will be more feasible when partnerships exist between the (small) producers of straw from wheat, or whey from milk. The techniques are innovative, so small-scale actors cannot finance this on their own as the payback period and the profitability will be highly uncertain (T). Cost-benefit analyses as well as a thorough risk analysis (and risk management schemes) are needed to justify the implementation of these techniques. Founding a partnership can help to manage the risk of biomass loss by one of the partners. Risks can further be managed by extending the valorisation of straw to maize stover and wood waste as well. However, the government could also act as a safety net, as the strong network cannot account for all risks.

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3.3 Results of the SWOT analysis for the Irish hub

3.3.1 Description of the SWOT analysis

Four experts have prioritized the SWOT questionnaire. The top 5 scores per swot item is presented in table 5.

Table 5: The 5 most important Strength, Weakness, Opportunity, Threat (SWOT) factors influencing the valorisation potential of biomass sidestreams for the Irish hub following the prioritization of four experts.

The number is representing the prioritized sequence with 1 being the most important factor and 5 the least important. Number in brackets show the total amount of voting received.

Strength	1. Participation of Irish companies in EU Level strategic programs for the development of the bio-economy (13) 2. Strong Networks (11) 2. Expertise in energy crop management and biomass use (11) 3. Knowledge level in valorisation techniques (9) 4. Ongoing developments of biomass processing facilities (8)	**Opportunities**	1. Commercialization opportunities (17) 2. Growing need for materials which can be produced from underutilized resources (15) 3. Government commitment to bio-economy (14) 4. National and EU support for a growing forestry and agricultural sector (5) 5. Regulation of air quality and emissions targets (4) 5. Oil and gas independence – fluctuating prices (4)
Weakness	1. Lack of scale and fragmented supply chain (18) 2. Lack of expertise and experience about biomass valorisation possibilities (11) 3. Lack of development of bio-refinery facilities in Ireland (9) 3. Lack of test bed and piloting facilities (9) 4. Continuity/Security of biomass supply (7)	**Threats**	1. Financial risks and access to finance (16) 2. Competition for existing agricultural and forestry biomass resources (10) 2. Competition with advanced or advantaged competitors (10) 3. Low External costs of alternative materials - competition with fossil based energy products (8) 4. Previous market failures (7)

Strengths

Table 3.4.1 shows that of the factor Strength, the four highest prioritized items are related to network aspects ('**participation of Irish companies in EU Level strategic programs for the development of the bio-economy'**, '**strong networks'**), knowledge aspects ('**expertise in energy crop management and biomass use'** and '**knowledge level in valorisation techniques'**), and innovation aspects ('**ongoing developments of biomass processing facilities'**). The first three items are prioritized with about an equal number of points (12 and 11). Number four and five of the list have 9 and 8 points

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respectively. Hence, not really large differences in the awarded number of points are shown between the prioritized top 5 items for Strength.

The number one of the list of Strength items ‘**participation of Irish companies in EU strategic level programs’ shows** that participation in strategic programs is found to be very important. The importance probably refers to the exchange of knowledge and experience on technical aspects of developments in the bio-economy, economic aspects such as funding opportunities and strategic aspects such as EU and national policy making. Examples mentioned are the BBI JU Call, BioBase4SME network, Horizon2020 AGRIFORVALOR. So overall, for the Irish hub this is found to be the most dominant Strength. The need for and strength on collaboration is further underlined by ‘Strong networks’ being prioritized as second item of importance. This item is referring to the national network of companies, knowledge centres, umbrella organisations of business, farmers and foresters and so on.

“**Expertise and knowledge”** (**expertise in energy crop management and biomass use’** and ‘**knowledge level in valorisation techniques’)** are prioritized also in the top 5 items. Respondents find the ‘expertise in energy crop management and biomass use’ and the knowledge level in valorisation techniques’ very important. First item is mostly related to the supply side, e.g. biomass cultivation and biomass use for energy applications for which courses, websites and harvesting techniques are developed to disseminate the knowledge. Second item, is intermediate the supply and demand side, developing techniques for bio-refinery (fine chemicals, functional materials, food applications etc.) and energy purposes (bio-methane).

‘**Ongoing developments of biomass processing facilities’** is prioritized as fifth item of importance of Strength. So apparently, the level of expertise and knowledge present in the Irish hub is sufficient to initiate first start-ups and to scale up good practices. The fact that ‘ongoing development of biomass processing facilities’ is prioritized in the top 5 of the Strength, means that currently there are some developments of processing facilities, but also that further development is needed.

Weaknesses

For the prioritized Weaknesses, ‘**lack of scale and fragmented supply chain’** by far has the most points of all items (18). All respondents prioritized this item as most or second most important Weakness for the Irish hub. The difference in prioritization of the other items is less pronounced, with a range of 11 to 7 points given in total. The items mentioned are covering a wide field of obstacles, related to **lack of expertice and experience about biomass valorisation possibilities, little progress in development of test beds, piloting facilities and bio-refinery facilities.** The continuity of the **future biomass supply** is also mentioned as one of the top five weakness items.

For the item ‘**Lack of scale and fragmented supply chain’** it was mentioned that the fragmented supply chain create logistical problems to reach an economically interesting scale for bio-refineries. Also some have doubt whether Ireland has the necessary scale to support large scale bio-refineries with the required amount of feedstock. A social aspect mentioned is that it is not in the tradition of farmers, with exception of the dairy farmers, working collectively, which is seen as a necessity to overcome the fragmented supply chain.

Opportunities

Opportunities prioritized are related to financial aspects (‘**commercialization opportunities’**), efficiency aspects (‘**growing need for materials which can be produced from underutilized resources’**), the need for certainties (‘**government commitment to bio-economy’**, ‘**national and EU support’ and ‘governmental regulations of air quality and emission targets’**) and replacement of fossil fuel based products (‘**Oil and gas independence – fluctuating prices’**). The top 3 of the Opportunities mentioned are close to each other as regard to the number of points with 17, 15 and 14

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points respectively. In addition, the top 3 has been prioritized by a much higher number of points than the issues prioritized from the items rated as 4 to 6 which have 5, 4, and 4 points respectively.

The '**commercialization opportunities'** refer to the opportunity to take valorisation technologies developed in international and Irish Research Centres into an industrial setting. The fact that this is the number one of the Opportunities and that all four respondents have prioritized this within their top 3 of Opportunities, makes clear that the respondents are rather convinced that there are real opportunities. However, no examples were mentioned about possible opportunities. Possibly the opinion for this item is related to the other items prioritized in the top 5 of opportunities. So the growing need for resources which urge for more efficient use of resources and therefore also increase the use of biomass sidestreams. And just as important, is the support of the European Commission and the Irish government, resulting in commitments on the bio-economy and regulations such as that for air quality and emission targets.

Threats

The top 5 of the Threats prioritized are related to financial aspects ('**financials risks and access to finance'**), competition aspects ('**competition for existing agricultural and forestry biomass resources, and competition with advanced or advantaged competitors'**, '**competition with low cost alternative materials**'), and uncertainties ('**previous market failures'**).

The financial aspects are prioritized by far with the most points (16), the competition aspects ('**competition for existing agricultural and forestry biomass' and 'competition with advanced or advantaged competitors'**) have scored 10 points, while the number 4 and 5 in priority ('**low cost external materials'** and '**previous market failures'**) have scored 8 and 7 points respectively.

Some explanations given on the item prioritized as most important Threat (**'financial risks and access to finance')** are that Irish banks have limited experience dealing with biomass valorisation projects. Also is mentioned that the level of resources required for new business start-ups as well as potential business and investment risks, is a possible deterrent for financial institutions to become involved. Another point raised is that there is quite some uncertainty in the time needed to get return on investment. Industry and banks are reluctant to invest without seeing pilot deployment. Also uncertainties over Brexit and exchange rate fluctuations are mentioned, since Great Brittan is an important trade partner for Ireland.

When comparing the items of Strength and Weakness, it strikes that at first sight, some of the items for strength and weakness seem to be similar items, namely the Strength 'expertise in energy crop management and biomass use' and 'knowledge level in valorisation techniques' versus the Weakness 'lack of expertise and experience about biomass valorisation possibilities'. When looking more into detail, it is mentioned that as weakness is considered that farming and forestry advisors are currently expected to provide knowledge and expertise in this area without training, many of whom have no prior expertise in this area. The successful implementation of a biorefinery industry in Ireland requires skilled workers in steady supply. Also the need for a national bio-energy and biorefinery information centre and web portal, which would promote activities in the region and provide wide information and support is mentioned.

Other items that seem connected are the Strength '**ongoing developments of biomass processing facilities**' and the Weakness '**lack of test bed and piloting facilities'** and '**lack of development of bio-refinery facilities**'. In this case, the '**ongoing developments of biomass processing facilities'** largely refer to bioenergy production in view of higher valorisation processes through bio-refinery. The difference can be due to a different interpretation on the speed of development of the number of pilot facilities. But also it can be caused due to experiences in getting connected or access to such facilities or to experiences of not finding valorisation possibilities or customers for biomass sidestreams.

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Comparing Opportunities and Threats, it strikes that '**commercialization opportunities'** is prioritized as number one Opportunity item and at the same time, '**financial risks and access to finance'** is prioritized as the number one Threat. Obviously there is the conviction that there are commercialization opportunities but at the same time there are experiences or doubts about the financial feasibility as confirmed by the number five Threat '**previous market failure'**. Also it is recognized that investments in biobased and bioenergy products can largely be influenced by policy initiatives, quota's, access to market and subsidies etc. which is reflected in Threats ' **Financial risks and access to finance**' and ' **competition with advanced or advantaged competitors'**.

It is also remarkable that '**government commitment to the bio-economy'** is seen as Opportunity but that any future change in policy on this field is not seen as a threat. This might be interpret that there might be a rather strong faith that policy in the field of bio-based economy, renewable energy, green economy etc. is really promising to the future and will stand over a long period of time.

3.3.2 Potential of Strength and Opportunities

In this section we look at the prioritized items for Strength and Opportunity whether we see possibilities to overcome the prioritized items for Weakness and Threat.

'**Strong networks'** and '**participation in EU strategic programmes'** is mentioned as important Strength. So apparently there is an extensive network of experts, practitioners, business, policy makers in the field of biomass production, processing and innovation.

Regular organizing of biomass vaporization events, where key-players with influence in the sector meet and discuss possibilities to get the supply chain functioning at a higher level can be a good thing to do. As 'competition with advanced or advantaged competitors' is seen as an important Threat, these competitors can be invited to make part of the existing network and to look for joint interests to strengthen the network.

'**Lack of scale'** is probably hard to change, especially in the short term. But taken this for granted, one can also think of a spatial distribution of areas that differ in scale and therefore differ in possibilities for valorisation techniques to be used best. With increasing scale aspects, the focus can be more on producing biomass for bulk products such as energy and bulk chemicals (e.g. ethanol) . In small scale areas, the focus can be on possibilities for techniques with higher valorisation potentials like food and pharma applications from biomass or at techniques for small scale applications e.g. anaerobic digesters, mobile pyrolysis installations and small scale bio-refineries (e.g. mobile grass refinery unit Grass from the Netherlands). This might compensate for the additional costs of the lack of scale. These small scale areas then have to produce high quality biomass, perfectly matching the needs for the high valorisation applications. Such a high quality can only be reached with relative high management expertise and intensity, which is not feasible when producing biomass for bulk applications. Biomass analysing techniques that define the quality of the biomass (e.g. near infrared analysis by Celignis) can be of use for these high valorisation applications.

There seem to be some mismatch between expertise and knowledge available and the impact of the knowledge. '**Expertise in energy crop management and biomass use' and 'knowledge level in valorisation techniques**' is mentioned as Strength. On the other hand '**lack of expertise and experience about biomass valorisation'** is mentioned as Weakness. It seems that there is not a lack of expertise and knowledge but possibly a lack of knowledge transfer and dissemination. Education and development and teaching of specific courses and training programmes on different aspects of biomass valorisation for practitioners and advisors in the field can improve the knowledge transfer. This holds both for the supply and the demand side. The latter can also be an action target at the improving the development of bio-refinery facilities, test bed and piloting facilities, and take away the negative atmosphere of previous market failures which is mentioned as Threat. Raising awareness by knowledge transfer, publicity of pilot projects, organizing round tables to get commitment on future developments are important. On these actions, the strong network can play an important supporting role.

Regarding the financial risks, the strong network can be used to make connections to the financial/investment sector to elaborate new innovative funding mechanisms. Connecting reliable hub partners as ambassadors to financial institutions can possibly take away (partly) the doubts on economic profitability. Besides the traditional investment sector, also use can be made of new innovative business partners who have already acquired a position with their company in the biomass valorisation sector to get investors aboard. Or try to unite social engaged entrepreneurs to raise joint funds for bio-based innovations. There are some examples of this abroad (e.g. Germany). See the example of the good practice Monte Ziego in deliverable D1.2 (Hendriks et al 2016b).

Also the competition aspect is mentioned as a threat. For this item it depends from what perspective you look at it. From the demand side it can be a threat because indeed in the future competition can be expected for biomass resources. From the supply side perspective this however, can be opportunity because through competition prices will increase. Of course, at this moment, prices have to compete with fossil oil prices, which currently are very low, and therefore it is hard to have quick returns on investments in many cases. There is however an interest of both the supply side and demand side to regulate the supply and demand of biomass. Therefore market mechanisms balancing supply and demand have to be developed. In agriculture, contract tillage for crops is common practice. Such practice can also be developed for biomass and biomass sidestreams. This will ensure both farmers, foresters and biomass processing industries of sales channels and certainty of feedstock supply. Also collaboration throughout the whole chain – from producers, transporters and processors to manufacturers and resellers – can contribute to the valorisation of biomass sidestreams. There are examples for instance in the energy sector where consumers of biomass-generated energy pay just for the use of energy (on a kWh base) and not for the biomass or technical installation. This requires collaboration of actors throughout the valorisation chain producing adequate amounts of biomass (wood), transport and processing (chipping and storage), installation and maintenance of installations (boilers and energy networks) etc. It is worthwhile to explore these kind of total solutions for other biomass fed chains.

Another aspect of competition can be the search for solutions of multiple biomass use. For instance, bark sidestreams in sawmills is in many case already used to produce process-heat and power in the sawmills. Using this stream for other purposes will enlarge competition for biomass. A good practice can be that of using this stream in a way that some compounds are extracted (e.g. tannin, resin, lignin) and that remaining parts still can be used for energy production. Another example is that of biogas production through anaerobic digestion which is possible with production at the same time of nutrient (bio-fertilizers) and low-nutrient compost (soil conditioner).

3.3.3 Result of the needs questionnaire and hub launch workshop

According to the Irish needs questionnaire results, the main types activities of participants in the forestry and agricultural sectors were timber supply and processing with a smaller numbers citing beef production, dairy and tillage production. Biomass produced ranged from the small (4 tonnes) to the very large (50,000 tonnes), with the surveyed timber respondents generally producing a larger amount of biomass in general than the farmers. The types of available agro biomass included herbaceous biomass like straw as well as manure, a small amount of woody biomass (e.g. fruit trees) was available with the majority of available biomass (64%) indicated as forestry biomass. The respondents indicated that primarily forestry biomass is available to them within a 60km radius, with a smaller number indicating straw, and manure. These sidestreams are mostly available within a 35-50km radius with around 32% being available within 10km. During a workshop at the Irish Biomass Innovation Hub Launch on November 23rd 2016, a discussion also took place around availability of feedstock in

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Ireland where it has been suggested that grass and whey are also available and hold strong potential for valorisation. It is notable that these feedstocks were not included as options in the questionnaire.

Forestry biomass appears to be more in year-round supply, whereas straw and manure are more seasonal. Over half of respondents indicated that existing supply chains could supply an agro or forest-related industry with this sidestream material, with prices of around €30 per ton suggested for straw and €35 per tonnes suggested for forestry biomass. Around a quarter of participants have stated that they currently have a technology for adding value to the sidestream and of those who valorise the sidestream the majority produce energy with a smaller amount producing fertilizer and feed.

Over half of respondents indicated lack of logistics chain as the main reason for not valorising sidestreams, with smaller amounts indication lack of knowledge, lack of public support and lack of business opportunities. Respondents indicated a number of outlets using biomass sidestreams in their areas including – intensive energy demanding industries, public buildings/district heating, biogas plants, farms/agri industry, forestry companies/foresters and households. Applications of sidestreams usage in the area are largely cited as being for energy with a smaller amount being used as functional material, fertilizer and feed. Nearly half of respondents estimate that sidestreams travel between 35-50km to reach the user/facility for application/processing. Most respondents indicate that the highest demand for sidestreams occurs in winter, perhaps highlighting use for energy purposes.

Lack of public support, regulatory framework, knowledge of investors, business opportunities and network, availability of technologies are all seen as moderate barriers to effective sidestream utilization. Over 80% agreed that with favourable conditions and economic payback supported by an appropriate business plan, it would be possible to introduce a new technology to add value to sidestreams.

3.3.4 Analysis of available biomass and possible related techniques and good practices

In Task 1 of WP 1, for each hub an overview of biomass sidestreams and their volumes was given by the hub managers with the support of the hub network (D1.1: Hendriks et al. 2016a). The sidestreams mentioned in that overview are listed in table 6. For cattle and pig slurry, volumes are taken from Foged et al. (2011), for poultry from SEI (2004). Available volumes for grass (in excess of the feedstock requirements) were taken from McEniry et al. (2013). Forestry volumes are taken from information of Coford Connect (Knaggs and O'Driscoll 2016). Other volumes were taken from the overview provided by the hub.

Based on the results of Task 1 (Techniques for biomass valorisation Hendriks et al. 2016a) and of Task 2 (Good practices for biomass valorisation Hendriks et al. 2016b) possible valorisation techniques and resulting products are added to table 6. Also examples of good practices and research were added based on earlier results of Task 1 and Task 2 of WP1. The known examples are completed with new specific examples when available.

Table 6: Biomass sidestreams in Ireland, annual production, possible processing techniques, possible valorisation products, and examples of processing facilities

Biomass sidestream	Production (kton or k m^3 per year)	Technique	Products	Examples
Pig Slurry	1,423	Anaerobic Digestion	Biogas Minerals (P, N, K)	H2020 project Systemic, Netherlands http://www.wur.nl/nl/nieuws/Groots

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			Organic compost	chalige-demonstratieprojecten-voor-terugwinning-van-nutrienten-uit-mest-en-slib.htm Campillos biogas plant, Spain http://www.agriforvalor.eu/article/Success-case-on-innovative-business-model-for-waste-valorisation-The-Campillos-biogas-plant-17 **McDonnell Farms Biogas** **Limited, Shanagolden, Co. Limerick, Ireland** http://www.seai.ie/Publications/Renewables_Publications_/Bioenergy/Anaerobic_Digestion-Shanagolden_Case_Study_2010.pdf
Cattle Slurry	33,983	Anaerobic Digestion	Biogas Minerals (P, N, K) Organic compost	See previous examples pig slurry Teagasc Grass Silage and Cattle Slurry to Biogas Demonstration Unit at Grange, Co. Meath Ireland https://www.teagasc.ie/media/website/animals/beef/ATBEST.pdf Demtra, Ireland. Small-Scale AD Bag Solutions. http://www.demetra.ie/
Poultry litter	140	Fluidised bed combustion Anaerobic Digestion	Heat Electricity Minerals (P, N, K)	**BHSL, Ireland** http://www.bhsl.com/ Campanillos biogas plant, Spain http://www.agriforvalor.eu/article/Success-case-on-innovative-business-model-for-waste-

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				valorisation-The-Campillos-biogas-plant-17
Spent Mushroom Compost	240	Anaerobic Digestion	Biogas Heat Fertilizer (compost)	Pilze Nagy, Hungary http://www.agriforvalor.eu/article/A-good-practice-on-energy-recovery-techniques-by-Pilze-Nagy-Hungary-a-project-partner-of-AGRIFORVALOR-15
Grass	1,700	Anaerobic Digestion Filtration Extraction Osmosis Mechanical separation	Food additives (flavour) Ingredients for cosmetics Bio-plastics Biomaterials (e.g. Insulation, paper) Organic fertilizer Feed Bio-gas	Biowert, Germany/Switzerland http://www.biowert.de/ Teagasc Grass Silage and Cattle Slurry to Biogas Demonstration Unit at Grange, Co. Meath Ireland https://www.teagasc.ie/media/website/animals/beef/ATBEST.pdf http://agriforvalor.eu/sidestreams/Biogas-from-grass-108 Grassa, Netherlands http://www.grassa.nl http://agriforvalor.eu/sidestreams/Fresh-Grass-to-feed-and-biobased-products-174 IEA, Austria: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/f/a/9/ab5211d7-9c90-457b-b18f-748c68d0043e_prmpbf16213%20LIF%20IEA%20Biorefining%20Factsheet%204%20Platform%20v2%20w.pdf
Meat waste, bone meal, tallow	214	Incineration Pyrolysis	Fertilizer (P, N) Fertilizer (Biochar) Bio-oil Syngas	University of Hohenheim, Germany https://improve-p.uni-hohenheim.de/uploads/media/moeller2015-factsheet-Meat-and-bone-meal.pdf

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				Terra Humana ltd, Hungary http://www.3ragrocarbon.com/
Dairy Whey	200	Hydrolysis Fermentation Anaerobic digestion	Nutritional additions (proteins) Bio-ethanol Biogas Fertilizer (N,P)	**Carbery, Ireland** http://carbery.com/nutrition/our-products/ wheypack production of PHB Biopolymers from whey residues http://www.ainia.es/en/food-news/releases/first-bioplastic-made-from-surplus-whey-cheese-industry/ http://www.wheypack.eu/eng/index.html https://www.rd.usda.gov/files/RR214.pdf Demetra, Ireland: Small-Scale AD Bag Solutions :http://www.demetra.ie/
Paunch waste	100	Anaerobic Digestion	Methane Fertilizer (N,P)	Pilot installation, Australia https://espace.library.uq.edu.au/view/UQ:349671/UQ349671_OA.pdf **Research, Ireland:** http://dx.doi.org/10.1016/j.renene.2016.05.068
Apple pomace	5	Anaerobic Digestion Extraction	Methane Ethanol Food additives (pectin, anti-oxidants) Food (apple syrup jam)	Research: DOI: 10.1007/s00253-016-7665-7 http://www.ifr.ac.uk/totalfood2014/Total%20Food%202014%20Uyttebroek.pdf
Straw	421	Fermentation Combustion	Biochemicals (lactic acid, succinic acid, levulinic acid, laccase, cellulase, vanillin, ethanol,	Cereal Biorefinery: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3774676/

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		Pyrolysis	biohydrogen) Biofuels (ethanol, pyrolysis oil), heat Compost	Pilze Nagy, Hungary: http://www.agriforvalor.eu/article/A-good-practice-on-energy-recovery-techniques-by-Pilze-Nagy-Hungary-a-project-partner-of-AGRIFORVALOR-15 BTG, Netherlands: http://www.btgworld.com/nl/rtd/test-facilities/fast-pyrolysis GFBiochemicals, Italy: production of Levulinic Acid from lignocellulose material including straw http://www.gfbiochemicals.com/technology/ Beta renewables, Italy: production of ethanol from straw :http://www.betarenewables.com/en/proesa/what-is-it Biogas: http://www.biogas-info.co.uk/about/feedstocks/#agricultural IEA, Austria: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/6/e/b/82465f23-60cc-48dd-87be-ba8d2e5cf183_prmpbf16211%20LIF%20IEA%20Biorefining%20Factsheet%203%20Platform%20v2%20w.pdf
Wood based panel residues	114 (k m^3)	Combustion Pyrolysis	Fuel/Heat/Power Pyrolysis oil Syngas Bio-char	**Wood pellets, Laois saw mill, Ireland** http://www.laoissawmills.com/wood-pellets/ Low smoke fuels: CPL, Ireland http://www.cplfuels.ie/products/ecoal50-smokeless-coal CHP-plant: Astellas, Ireland: http://www.coillte.ie

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				Spirajoule pyrolyzer: Biogreen, France http://www.biogreen-energy.com/biogreen/spirajoule/ Insight Renewables Torrefaction System - http://insightrenewables.com/ http://agriforvalor.eu/sidestreams/Agro-forestry-to-Biocoal-175
Post-consumer recovered wood	300 (k m^3)	Chipping Combustion Pyrolysis Reuse/recycling	Fuel/Heat/Power Pyrolysis oil Syngas Bio-char Wood products from recycled wood	See previous examples of wood based panel residues) **Reuse of wood products:** Reuse of pallets: http://www.connaughttimber.com/wood-recycling-pallet-recycling.html http://www.cjs.ie/wood_waste.php http://www.rocrecycling.com/materials-recycled-wood.aspx **paper and wood waste recycling services, Ireland:** http://ie.kompass.com/a/paper-and-wood-waste-collection-and-recycling-services/72430/
Sawmill residues (Bark)	138 (k m^3)	Chipping Combustion Pyrolysis Biorefinery Supercritical extraction	Filter material for bio-filters Mulching Heat/power Bio-char Syngas Bio-oil Tall oil (glue, paint, ink, biofuels)	Wood K Plus, producing wood polymer composites : http://agriforvalor.eu/sidestreams/Natural-fibre-reinforced-composites-173 Compost: Terracottem, Spain http://www.terracottem.com/ Bio-filters: Foba kft, Hungary http://www.fobakft.hu/ Spirajoule pyrolyzer: Biogreen, France http://www.biogreen-energy.com/biogreen/spirajoule/ http://www.biofuelstp.eu/factsheets/

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			Research in progress on: Adhesives (Tannin) Foams (Tannin) Lignin applications' Wooden (bark) panels	EIBI-4-torrefaction%20and%20pyrolysis.pdf Bioproduct mill: http://bioproductmill.com/bioproducts Research: http://dx.doi.org/10.1016/j.rser.2013.06.024 http://dx.doi.org/10.1016/j.supflu.2016.07.001 https://aaltodoc.aalto.fi/bitstream/handle/123456789/15348/isbn9789513882150.pdf?sequence=1 http://virtual.vtt.fi/virtual/probark/Probark_Project%20Presentation_WW%20Annual%20Seminar%202009.pdf Insight Renewables Torrefaction System - http://insightrenewables.com/ http://agriforvalor.eu/sidestreams/Agro-forestry-to-Biocoal-175
Sawmill residues (Sawdust)	209 (k m^3)	Pelletizing Combustion Pyrolysis Supercritical extraction	Heat/power Bio-oil (fuel) Syngas Bio-char (fuel, fertilizer) Tall oil (glue, paint, ink, biofuels)	See previous examples of sawmill residues (bark) Insight Renewables Torrefaction System - http://insightrenewables.com/ http://agriforvalor.eu/sidestreams/Agro-forestry-to-Biocoal-175 Wood K Plus, producing wood polymer composites http://agriforvalor.eu/sidestreams/Natural-fibre-reinforced-composites-173
Sawmill residues (Woodchips)	606 (k m^3)	Combustion Pelletizing Pyrolysis	Heat/power Bio-oil Syngas	See previous examples of wood based panel residues Empyro, operational pyrolysis oil plant, Netherlands

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			Biochar	http://www.empyroproject.eu/index.php https://www.btg-btl.com/media/cms_block/leafletempyro.pdf http://www.biogreen-energy.com/biogreen/spirajoule/ http://www.biofuelstp.eu/factsheets/EIBI-4-torrefaction%20and%20pyrolysis.pdf http://www.upmbiofuels.com/biofuel production/biorefinery/Pages/Default.aspx Insight Renewables Torrefaction System - http://insightrenewables.com/ http://agriforvalor.eu/sidestreams/Agro-forestry-to-Biocoal-175 Wood K Plus, producing wood polymer composites http://agriforvalor.eu/sidestreams/Natural-fibre-reinforced-composites-173 IEA, Austria: http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/8/8/d/e2daab7a-68e3-4695-8e66-43ef0c86bdd8_prmpbf16210%20LIF%20IEA%20Biorefining%20Factsheet%202%20Platform%20v2%20w.pdf http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/0/7/4/b3392f8a-b84a-486b-8d17-515a707391aa_prmpbf16212%20LIF%20IEA%20Biorefining%20Factsheet%205%20Platform%20C6%26C5%20A4%20v2.pdf
Pulp wood	165 (k m^3)	Chipping	Heat/Power	See previous examples of wood

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(excl. panel board use)		Combustion Pyrolysis	Bio-oil Syngas Bio-char	based panel residues
Forest harvest residues (Lop and Top wood)	284 (k tonnes) (60 k m3 used currently)	Brash harvesting Chipping Combustion	Heat/power	See previous examples of wood based panel residues

Table 6 shows that for agricultural biomass sidestreams, pig and cattle slurry and grass have high volumes and to a lesser extent also straw from cereals have large volumes. From forestry, sawmill residues (bark, woodchips, sawdust) have high volumes. So given the volumes, these are interesting sidestreams for scaling up.

Pig and cattle slurry and poultry litter are available in large quantities and with a good continuity of supply. The available processing technique anaerobic digestion (AD) is well developed. The main output is bio-methane and digestate which can be used as fertilizer and soil conditioner. There is however ongoing research on extraction of solid fertilizers from the digestate. This can enlarge the potential of the application because it creates an extra revenue. Pilot installations are already operational. Advantage of AD-installations is that they can be built near the production location which reduces logistic costs. Research on further processing biogas (e.g. methane) to higher value products (e.g. methanol) is ongoing but techniques are not market ready yet. So circumstances for AD seem to be quite favourable also with respect to future developments.

Grass, in excess of livestock requirements, is available in large quantities with an annual production of 1,700 kton. Techniques are quite well developed and good practices of grass biorefineries exist (e.g. Biowert, see Hendriks et al. 2016b). Techniques producing 3 or more products are the most promising in economic viability. The biorefinery of grass can produce amino acids, lactic acid, biogas, fibres (which can be used for feed, fertilizer or functional material such as insulation, paper and composites.

3.3.5 Business models for valorizing cattle and pig slurry for the Irish hub

Technique and good practices

Animal slurry and manure (pigs, cows, sheep, poultry) can be valorised through anaerobic digestion for fuel applications (methane production). Traditionally, the technique is focussed on bio-gas production. New advanced anaerobic digestion techniques can produce multiple products. Besides the bio-gas (methane) also bio-fertilizer (replacing chemical or fossil N, P and K fertilizers) and nutrient poor (but carbon rich) soil conditioners (digestate/organic matter) are produced. Some good practice examples exist in Ireland (e.g. http://www.seai.ie/Publications/Renewables_Publications_/Bioenergy/Anaerobic_Digestion-Shanagolden_Case_Study_2010.pdf) , The Netherlands (http://www.wur.nl/nl/nieuws/Grootschalige-demonstratieprojecten-voor-terugwinning-van-nutrienten-uit-mest-en-slib.htm) and Spain (http://www.agriforvalor.eu/article/Success-case-on-innovative-business-model-for-waste-valorisation-The-Campillos-biogas-plant-17).

Knowledge and expertise is widely available in Ireland. Several plants are operational in a commercial environment. So, also expertise on the technical installation is available, which is seen as Strength by respondents.

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Value chain and security of biomass supply

Advantage of such installations is that they can be build close to the slurry/manure production locations. So transport costs are minimal and because of the relative small scale of a common installation, fragmentation of biomass supply (Weakness) does not have to be a problem. Condition is that enough slurry is available throughout the year (for the Irish good practice example mentioned above the annual input feedstock was 5.800 ton cattle slurry and 900 ton chicken litter). Besides the manure also other biomass sidestreams are required to stimulate the digesting process such as food waste or crop waste. When the digester is built on a farm location, there might be biomass sidestreams available on the farm for the digesting process such as green/silage grass, straw, food waste, straw, etc. When the additional sidestreams are not available on the own farm/location (Weakness), it is important that the supply of this feedstock is guaranteed by external companies or other farms. This can be done by contracting or by partnership.

Production of biogas may differ, depending on the mixture of different slurry and manure types and additional biomass sidestreams. The biogas yield also depends on the composition of the substrates used and on the ambient conditions in the digester (e.g. temperature, retention time).

Environmental issues

An important contribution of biogas technology to environmental protection is that it avoids additional carbon dioxide emissions compared with fossil energy sources. Research shows that through anaerobic digestion of slurries and manure in Ireland greenhouse (GHG) emission reduction by 2030 can be achieved to 32% of total national GHG emissions (Pazera and Stambasky 2016).

Manure is an important fertilizer in the agricultural crop production process. However, in case of high manure production volumes, farmers may have problems when manure storages are filled or the manure quantities produced exceed the requirements for healthy soil conditions when applied in the field. Processing of manure through anaerobic digestion may contribute to solve manure surpluses by producing natural fertilizers in concentrated form which can substitute chemical fertilizers). Storage and transport of these natural dry fertilizers is more efficient and also the application can be more efficient, avoiding nutrient surpluses in soil and ground water. Also the natural fertilizer can be sold for application elsewhere by which additional benefits can be obtained and excessive nutrient application to the soil can be omitted.

Policy support

Biomass based production of renewable energy is clearly supported by Irish policy. Policy support is mentioned as important Opportunity by the respondents. The Government's 2007 White Paper "Delivering a Sustainable Energy Future for Ireland" sets out a roadmap that will steer Ireland to a new and sustainable energy future. The White Paper includes ambitious and challenging bioenergy targets to 2020, setting a clear path for meeting the Government's goals of ensuring safe, secure, affordable energy. The 2020 targets include:

- 33% electricity consumption from renewables (since revised to 40%)
- 12% renewable heat including 10% from bioenergy
- 10% biofuels penetration in transport
- 800 MW from Combined Heat and Power (CHP) with an emphasis on Biomass-CHP
- 30% co-firing with biomass at the three State owned peat power generation stations to be achieved progressively by 2015 beginning with immediate development by Bord na Móna of its pilot project at Edenderry Power Station.

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In 2010 the National Renewable Energy Action Plan for Ireland (NREAP 2010) was published. It sets out the Government's strategic approach and concrete measures to deliver on Ireland's 16% target under Directive 2009/28/EC. In the NREAP submitted to the European Commission bioenergy is estimated to contribute approximately:

- 7% to the renewable electricity goal,
- 82% to the renewable heat goal, and
- More than 90% to the renewable transport goal.

Although policy support is clear, this does not apply for the current financial support. Two new renewables support schemes are under development - a Renewable Heat Incentive (RHI) aimed at increasing renewables in the heat sector, and, a Renewable Electricity Support Scheme aimed at providing support for renewable electricity (RESS).

Biogas production through anaerobic digestion can contribute in several ways to these policies. With the biogas produced, electricity, heat, and biofuels for the transport sector can be produced. Electricity and heat can be produced in CHP installations by burning the produced biogas.

Financial risk and access to finance

In case external finance is needed, the reliability of the installation, output volumes and profitability are important aspects for investors. Since anaerobic digesting is a proven technique and such installations are becoming more common, the economic risk of the technique as such is quite low. Technical problems however, may rise, as for every technical installation, influencing the reliability of the output (biogas/electricity/heat). To reduce such risks, partnerships can be entered with other owners of digesting installations. Clusters of about 5 installations have shown to be a good cluster size for reducing risks and production volumes (Informa Economics 2014). In such cases, the partnership can be the contracting entity with the customers, e.g. power companies.

Availability of labour can also be a risk. In case labour needed to operate the installation is not available (sufficiently) on the own farm/business or felt burdensome, a third-party ownership can be considered.

Availability, continuity and price level of required feedstocks can also be seen as risk for investors. In case not all required feedstocks are available, or not available in the required amounts, partnership with biomass suppliers can be considered. This can be through contracting, but also through development of net-metering or wheeling arrangements.

3.3.6 Business model for valorising grass for the Irish hub

Technique and good practices

In a grass biorefinery, fresh grass or silage grass is used as feedstock. Grass juice and press cake (containing raw grass fibres) are available as raw product following primary refining (mechanical fractionation - pressing). A green biorefinery is typically coupled with biogas production for which a part of one or both fractions (grass juice and grass fibre) is utilised as a co-substrate. The grass juice either goes directly into the biogas plant, or its ingredients (e.g. lactic acid, acetic acid, proteins, amino acids) are separated. Lactic acids can be used for production of bio-plastics. The acetic acid, amino acids and proteins can be used for food and feed and cosmetic applications. The grass fibre can be processed into animal feed, or can be used as functional material, e.g. for insulation products, paper or fibre-reinforced synthetics. Grass biorefineries are not very common yet, but operational, commercial and demonstration plants already exist, e.g. Biowert in Germany (http://www.biowert.de/), Grassa in the Netherlands (www.grassa.nl) and Green Biorefinery in Austria (http://www.iea-bioenergy.task42-biorefineries.com/).

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Value chain and security of biomass supply

Research (O'Keeffe et al. 2012) shows that for Ireland the optimum scale for grass bio-refinery is about 700-800 ha. Larger scale plants will require longer transport distances which negatively influences the economic viability. An added benefit of a decentralised bio-refinery facility processing approximately 0.8t of dry matter per hour, is that it allows for ease of operation and better knowledge of the source and quality of the grass being supplied. Most viable green biorefinery was the one producing biogas, fibres (e.g. for insulation materials). Addition production of proteinaceous products (for animal feed or cosmetics) did not affect the viability substantially.

To secure biomass supply, contracting of biomass suppliers is required. Alternative, partnerships can be entered with farmers having in total the required grassland area (700-800 ha).

Green biorefineries can be an alternative business model for the dairy and beef sector, since this sector is undergoing large uncertainty due to fluctuating commodity prices and anticipated consequences of Brexit. Products of grass biorefinery could slightly mitigate the competition with the traditional agricultural commodities (Threat).

Green biorefinery can result in output of biogas, lactic acid, amino acids, fibre, fertilizer (P, N, organic compost) and feed. The biogas can be sold directly or used to generate electrical power/heat for own use, or it can be sold to the grid. Lactic acid, amino acids and fibres can be sold to chemical, food or manufacturing industries for further refinery and high value products (e.g. insulation material from grass fibres). Fertilizers can be applied at the own farm or sold external.

For grass bio-refinery, green as well as silage grass can be used or a combination of both. The use of silage grass ensures the continuity of the feedstock during the whole year.

Environmental issues

To produce biogas, the grass is mainly mixed with animal slurry/manure and then digested. As explained in the previous example of anaerobic digestion, the production of biogas reduces CO2 emissions substantially.

From lactic acid, bio-plastics can be made, reducing the use of fossil fuels for the plastics, and through that reduce greenhouse gas emissions, and reducing waste because bio-plastics can be recycled, some are biodegradable or can be used for green energy generation. From the digestate, fertilizers can be produced, reducing fossil phosphorus requirements. From the fibres and amino acids feed can be produced, reducing imports of protein concentrates. Another use of the fibres is that of use as insulation materials, paper and polymer composites

Policy support

In the government policy statement on growth and employment in the green economy 'Delivering our green potential' the Irish government expresses its support for the green economy. The government provides support to the various sectors making up the Green Economy, and has published a number of strategies to support the further development of those sectors (e.g. Strategy for Renewable Energy, Sustainable Development Framework, National Energy Efficiency Action Plan, A Resource Opportunity – the new national waste policy).

The Policy Statement on the Green Economy draws on these existing strategies and identifies the economic and employment opportunities that are available for businesses in different sectors that make up the Green Economy. In addition, the Government has established a Consultative Committee on the Green Economy to identify emerging opportunities for Ireland in the Green Economy.

At the moment, however, there is no overarching policy on the Green Economy yet. Incentives to promote biobased products are required for the development of new markets. Assistance is needed

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with the development of viable long term market outlets and integration with development of the supply chain for bio-chemicals and bio-materials through e.g. specification and standardisation of bio-products, sustainability criteria for chemicals and materials, public procurement criteria etc.

Policy support for production of renewable energy is described in the previous example of anaerobic digestion of animal slurry/manure. Although policy support is clear, this does not apply for the current financial support. Two new renewables support schemes are under development - a Renewable Heat Incentive (RHI) aimed at increasing renewables in the heat sector, and, a Renewable Electricity Support Scheme aimed at providing support for renewable electricity (RESS).

Financial risk and access to finance

Small scale biorefineries require less investments than large scale installation, which can be influencing the risk assessment of investors. Investments for a small scale bio-refinery (700-800 ha supply area, feedstock volume ca. 7100 tonne per year) is expected to approximate €7 million (O'Keeffe et al. 2012). The study shows that biorefineries using silage grass as feedstock and that produce only fibres and biogas (with possible additional proteinaceous product) are the most viable. Biorefineries producing also lactic acid, require higher investments, making them not viable on the small scale.

On the basis of experimental results in Germany, calculations on the economics and ecology of a large plant assume a system capacity of 2t of dry matter per hour of green waste and silage (ca. 91,000 tonne per year) for which circa 2,300 hectares of grass-land is needed for raw material supply. These type of biorefineries, can produce lactic acids (another chemical e.g. acetic acid and amino acids) on an economical scale but require larger investments than small scale biorefineries do. An investment of approximately €15 million is expected for the implementation of this large scale type of bio-refinery (FNR 2012).

The security of the feedstock supply is influencing the risk for investors. Having own feedstocks available will substantially reduce that risk. When no or not sufficient feedstock is available, alternative partnerships with other biomass suppliers (other farms having waste grass available) can be considered. This can be trough contracting or development of net-metering or wheeling arrangements.

3.3.7 Business model for valorising sawmill residues for the Irish hub

Technique and good practice

A third possible business case is that of the valorisation of sawmill residues. For Ireland, these resources are available in large quantities, In 2015 a total of 953,000 m3 sawmill residues were available, existing of woodchips (606,000 m3), sawdust (256,000 m3) and bark (138,000 m3). Future quantities of sawmill residues are expected to increase due to an increase in harvesting volumes resulting from an expanding forest area and the fact that the current forest is getting older.

Sawmill sidestreams can be valorised in several ways resulting in different types of fuel or bioproducts. Although promising, most wood related techniques for bioproducts have to be further developed before they are marketable. A well-developed valorisation technique possibilities is pyrolysis, a technique by which lignocellulosic biomass can be converted to biofuels (e.g. syngas, bio-oil, methanol, torrefied wood), biochar (e.g. bio-char, fertilizer, activated carbon), and bio-chemicals (e.g. phenols, organic acids, furfural, HMF and levoglucosan). The bio-oil and chemicals can be applied in a wide spectrum of fossil fuel replacing products with applications as pharmaceutical, food additives, chemical resins). The high value applications however, are not fully developed yet, but offer a high potential in the near future.

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Pyrolysis itself is a proven technique and several commercial operational plants exists throughout the world. In 2015 the Empyro plant was started in the Netherlands (https://www.btg-btl.com/media/cms_block/leafletempyro.pdf). The basis for creating high value compounds is the cost-effective fractionation of the pyrolysis oil. Fractionation will result in various qualities of oil needed for further upgrading into fine chemicals, petrochemicals, automotive fuels and energy. However the technique is proven, the upscaling is just starting, and mainly focussed on production of bio-oil. Production of fine chemicals in most cases is in the phase of research, of which some close to the commercialization phase.

Value chain and security of biomass

In principle, many kinds of biomass can be used for the pyrolysis process. The type of biomass used influences the amount and quality of the output produced (pyrolysis oil, bio-gas and biochar). Saw mill residues such as sawdust and woodchips can perfectly be used as feedstock. It can also be mixed with other biomass resources, such as straw, or crop residues. Pyrolysis refineries can be set up locally by sawmills, valorizing their own sidestreams. Big advantage then is the direct connection of the sidestream production and processing, without transport of the biomass over long distances, which has a positive impact on the viability. The quantity and type of sidestreams available on the sawmill determines the quantity and quality of the output. In case of smaller quantities, mobile pyrolysis installations can be used for processing the sidestreams. Alternative partnerships with other sawmills can be set up, to enlarge the total volume of sidestreams which can enable optimizing the scale of the pyrolysis refinery.

A big advantage of a pyrolysis biorefinery is the possibility of decentralized production of the pyrolysis oil in regions where abundant biomass is readily available creating the possibility of cost-effective transport of the resulting liquids. Another advantage of small scale decentralized processing is the opportunity for each installation to produce for different markets. The pyrolysis process can be regulated in such a way that more or less output is yielded for each of the process components (syngas, bio-oil and biochar). With different (blends of) input feedstocks the quality and composition of the pyrolysis products can be regulated. By regulating the environmental conditions of the pyrolysis process (mainly temperature) different amounts of bio-oil, syngas and biochar can be produced. Slow pyrolysis which occurs in lower temperatures produces higher amounts of char, whereas fast pyrolysis produces more bio-oil.

Environmental issues

Compared to the use of fossil fuels for transport and energy generation, production and use of pyrolysis oil can reduce greenhouse gas emissions substantially, even up to 80% over the total value chain from extracting natural resources to the use for energy generation or transport. (IEA Energy factsheet http://www.iea-bioenergy.task42-biorefineries.com/Factsheet)

Application of biochar as soil conditioner has positive effects on carbon sequestration in the soil, since the torrefied wood is very slow degradable. . Biochar also may increase crop yield, especially on nutrient poor soils in the tropics, it reduces leaching of nutrients and it may decrease N2O emissions from soils.

Torrefied wood can also be mixed with fossil coal, by which low smoke fuels can be produced and greenhouse gas emissions of coal-fires stoves and boilers can be substantially reduced (low smoke fuels – Hendriks et al. 2106b).

Policy support

Biomass based generation of renewable energy is clearly supported by Irish policy. Policy support is mentioned as important Opportunity by the respondents. The Government's 2007 White Paper "Delivering a Sustainable Energy Future for Ireland" sets out a roadmap that will steer Ireland to a new

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and sustainable energy future. The White Paper includes ambitious and challenging bioenergy targets to 2020, setting a clear path for meeting the Government's goals of ensuring safe, secure, affordable energy. The 2020 targets include:

o 33% electricity consumption from renewables (since revised to 40%)

o 12% renewable heat including 10% from bioenergy

o 10% biofuels penetration in transport

o 800 MW from Combined Heat and Power (CHP) with an emphasis on Biomass-CHP

o 30% co-firing with biomass at the three State owned peat power generation stations to be achieved progressively by 2015 beginning with immediate development by Bord na Móna of its pilot project at Edenderry Power Station.

In 2010 the National Renewable Energy Action Plan for Ireland (NREAP 2010) was published. It sets out the Government's strategic approach and concrete measures to deliver on Ireland's 16% target under Directive 2009/28/EC. In the NREAP submitted to the European Commission bioenergy is estimated to contribute approximately:

o 7% to the renewable electricity goal,

o 82% to the renewable heat goal, and

o More than 90% to the renewable transport goal.

Production of pyrolysis oil contributes in several ways to these policies. With the bio-oil produced, electricity, heat, and biofuels for the transport sector can be produced. Electricity and heat can be generated in small CHP installations or through co-firing in large power plants or by mixing torrefied wood and fossil coal to produce low smoke fuels.

At the moment, however, there is no overarching policy on the Green Economy yet. Incentives to promote biobased products are required for the development of new markets. Assistance is needed with the development of viable long term market outlets and integration with development of the supply chain for bio-chemicals and bio-materials through e.g. specification and standardisation of bio-products, sustainability criteria for chemicals and materials, public procurement criteria etc.

Policy support for production of renewable energy is described in the previous example of anaerobic digestion of animal slurry/manure. Although policy support is clear, this does not apply for the current financial support. Two new renewables support schemes are under development - a Renewable Heat Incentive (RHI) aimed at increasing renewables in the heat sector, and, a Renewable Electricity Support Scheme aimed at providing support for renewable electricity (RESS).

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4 Conclusions

4.1 SWOT Analysis comparison

When we look for recurring items in the top 5 of the SWOT for the different hubs, we can identify 17 issues that are mentioned two or three times. **An overview of shared SWOT items is presented in table 7.** Due to differences in interpretation, it can be possible that one item is classified both intern or extern. For example, biomass supply continuity can be insecure as information on the amount of the sidestreams is missing (intern, weakness) or as pests, floods and fire endanger the raw material (extern, threat).

From table 7, the importance of knowledge sharing between the different hubs can be clearly seen. As the hubs face the same threat or opportunity, they can work together on a solution to defeat or seize these. Furthermore, even when a specific item is an opportunity for one hub and a threat for another hub, knowledge sharing is needed, as the hubs can learn from each other.

Table 7: Shared SWOT items among the 3 Hubs

SWOT item	Andalusia	Hungary	Ireland
High volume of biomass sidestreams available	S	S	
Strong networks	S	S	S
Level of education	S	T	
Knowledge level in valorisation techniques	S	S	S
Government support/subsidies	W	O/T	
Expertise and experience about biomass valorisation possibilities	W	S/W	S/W
Lack of scale and fragmented supply chain	W	W	W
RTD to industry/market process	W	W	
Commercialization opportunities	O		O
National and EU support for a growing forestry and agro sector	O	O	O
Oil and gas independence	O		O
Environmental sustainability	O		O
Continuity/Security of biomass supply	T	W	W
Government policy	T	T	O
Financial risks and access to finance	T	T	T
Demand of valorised biomass	T	O	O
Competition with fossil based energy products	T		T

The SWOT analysis shows that ‘Strong networks’, ‘Knowledge level on valorization techniques’, ‘High volume of biomass sidestream availability’ and ‘Expertise and experience about biomass valorization/use’ are recognized as important Strength items of the biomass valorization sector for the three hubs. Although recognized as strength, it is important to further strengthen the connections and

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collaboration between research, biomass suppliers, and business valorizing biomass sidestreams. Partnerships are one way to strengthen regional or national collaboration and to stimulate 'Ongoing developments of biomass processing facilities'. 'Participation of companies in EU Level strategic programs for the development of the bio-economy' as recognized strength for the Irish hub is a way to connect to and to collaborate with the international network.

'National and EU support for a growing forestry and agricultural sector', 'Oil and gas independence' and 'Commercialization opportunities' are seen as important opportunities for the biomass valorization sector. There is currently important support from the national and EU government. To guarantee further development of the biobased economy, it is important to feed policymakers with the needs of this sector and to develop action plans. The 'strong networks' have to include also policymakers by which innovative ideas an pathways can be explored and elaborated to connect commercialization opportunities with policy objectives.

Weakness items that are prioritized by the respondents for the three hubs are related to 'Lack of scale and fragmented supply chain', 'Lack of knowledge, expertise, and experience about biomass valorization possibilities', and 'Uncertainty in continuity of biomass supply'. Some of these weaknesses may be alleviated or solved by making use of the strong network. Supply of biomass is distributed all over the rural areas of countries. So it must be extracted, collected and transported over long distances before it can be further processed. Raw biomass however is very voluminous whereby transport is very costly. Therefore techniques with which valuable ingredients of biomass side streams can be extracted and concentrated can economically be very attractive. Transport of these semi-products is much less expensive than transport of raw biomass. By entering partnerships the scale issue and the issue of the continuity of the biomass supply can be secured. Also the knowledge/expertise issue can partly be covered by partnerships when exchange of experience and knowledge is part of the collaboration, e.g. by mutual training, courses, communication of pilot projects.

Important Threats mentioned by respondents in the SWOT analysis are 'Lack of governmental policy', 'Competition with fossil based products', ' Competition for existing agricultural and forestry biomass resources', and 'Financial risks and access to finance'. Policy support is very important for further development of the biobased economy. By making use of the strong network, a joint vision of the biobased sector on their needs and future developments can help to clarify what support is needed from policymakers and other stakeholders. In many cases biomass sidestreams are used to generate energy (heat or electricity). When using the sidestreams for other purposes, this might compete with the energy demand. Therefore, techniques that provide multiple products e.g. energy and (chemical) building blocks for high value applications, are very promising (e.g. anaerobic digestion, pyrolysis). The issue of 'Financial risks and access to finance' requires creative solutions such as partnerships by which risks of supply to processing industries can be reduced. Partnerships can include partners that contribute with regard to biomass supply, technical issues, transport, processing etc. It can also include partners that in one way or another contribute to funding issues. There are some good examples of companies already successful in valorizing biomass sidestreams setting up investment funds for new start-ups in the biobased sector.

4.1.1 Conclusion on SWOT items identified for Andalucia

For the Andalusian hub, we can conclude the following:

Strong networks are mentioned as an important Strength for the Andalusian hub. Coordination between educational centres, the cooperative sector, the agro and forest industry and the regional government is existing. These strong networks can be used to tackle a large number of problems that exist in the field of biomass valorisation in Andalusia.

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First, as progressive policy and financial support for implementing business models is lacking, the existing networks should be used to force policy makers in creating a more flexible regulatory framework on sidestream valorisation, e.g. by providing risk management, and to brainstorm on the creation of new funding mechanisms for start-ups in the sector. Second, as the availability of highly educated people and knowledge in valorisation techniques do not result in expertise and experience about valorisation possibilities, it seems that the existing knowledge is not well disseminated and exploited in the industry. The existing networks can be used to transfer knowledge in an efficient way and to encourage companies to hire the right people. Third, as sidestreams are scattered across the region and transportation costs are high, a biomass valorisation industry consisting of centralised large-scale facilities, as currently is the case, is not favourable. By using the existing strong networks, partnership between small actors can be promoted and low-scale or medium-scale facilities at a local scale can be set up.

4.1.2 Conclusion on SWOT items identified for Hungary

For the Hungarian hub, we can make a similar conclusion:

Bay Zoltán Non-profit ltd, and the network surrounding it, can help to change and improve the biomass sidestream valorisation industry in Hungary.

First, as farmers and foresters know little of the existing biomass valorisation technologies, and how to use them, although strong activity and skills are present in the research sector, it seems a problem exists when it comes to knowledge transfer and use. Strong networks can be used to disseminate knowledge and expertise, e.g. by setting up courses and training programs. Second, as data on the amount of biomass (sidestreams) is scattered throughout literature, uncertainty regarding the available biomass exists, and leads to uncertainty for the biomass valorisation industry. Strong networks can provide a solution, as they can work together to collect data on available sidestreams and best practices. The databases created can be submitted to the government, to raise awareness on the importance of biomass sidestream valorisation for the economy and environment, and to direct them into evidence-based decision-making. The government should reduce the financial risks for the business sector by providing funding and risk management. Third, as opportunities to sell biomass near its production site are missing, the centralized large-scale valorisation sector should be extended with a local small-scale biomass industry. Strong networks can help to optimize the supply chain, as they promote partnerships between small actors, capable of starting a business.

4.1.3 Conclusion on SWOT items identified for Ireland

For the Irish hub, we can conclude the following:

Strong networks and Participation in EU strategic programmes are mentioned as important “Strength”. There seem to be some mismatch between expertise and knowledge available and the impact of the knowledge. It seems that there is not a lack of expertise and knowledge but possibly a lack of knowledge transfer and dissemination. Education and development and teaching of specific courses and training programmes on different aspects of biomass valorisation for practitioners and advisors in the field can improve the knowledge transfer. The strong network can help in disseminating knowledge and expertise and incorporation of knowledge and expertise from abroad. Making more use of existing expertise may also improve the successful development of bio-refinery facilities, test bed and piloting facilities, and take away the negative atmosphere of previous market failures which is mentioned as Threat. Raising awareness by knowledge transfer, publicity of pilot projects, organizing round tables to get commitment on future developments are important for public and governmental support. The weakness “Lack of scale” is probably hard to change, especially in the short term. In fragmented small scale areas, the focus can be on techniques that can be applied on the small scale such as. anaerobic digesters, mobile pyrolysis installations and small scale bio-refineries (e.g. mobile grass refinery units). Also the competition aspect is mentioned as a threat. In this the government can play an important role

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by setting standards and criteria for sustainable production and taxation structures. With respect to competition issues the multiple use of biomass can be an important solution, e.g. the production of biogas production through anaerobic digestion in combination with production of fertilizers and soil conditioners. Regarding the financial risks, setting up partnerships can offer (partial) solutions. Also the founding of investment funds for start-ups by engaged entrepreneurs in the biobased sector (Hendriks et al 2016b) can contribute to funding opportunities beside the traditional funds from banks and private investors.

4.2 Conclusion on Business opportunities identified for Andalucia, Hungary and Ireland

4.2.1 Business case opportunities for the Andalusian hub

In the Andalusian hub olive mill waste, due to the large volume, environmental challenges and chemical compound, comprises a promising business case for the Andalusian hub. Due to the very large volume, more than one valorization technique can be of interest. Extraction of valuable compounds from the olive mill waste (e.g. polyphenols, anti-oxidants) can be used to produce ingredients for food cosmetics and pharmaceutical purposes (e.g. biotech company Natac: Hendriks et al. 2016b). After extraction of valuable compounds, anaerobic co-digestion of olive mill waste (mixed with pig or cow slurry and other crop residues e.g. straw) can be applied to produce biogas. The biogas can be sold for heating purposes (transport through piping) or can be used to generate electricity which can be sold to the grid (e.g. Biogas plant Campillos: Hendriks et al. 2016b). Techniques using fermentation of olive mile waste to produce biopolymers, enzymes and biofuels are promising but have to be further developed before economic application becomes viable. Processing olive mill wastes to usable products, has large environmental benefits due to reduction of the large environmental impact of current waste streams (toxic compound in waste water and solid wastes) and reduction of emissions from incineration. Partnerships of small olive mills may increase funding opportunities for investments in technical facilities. Large olive oil producing companies may invest private funding in research and techniques as this reduces the environmental impact of their operations.

4.2.2 Business case opportunities for the Hungarian hub

In Hungary there are large volumes of biomass sidestreams of straw and whey, offering opportunities for valorization. Currently 180.000 m3 straw and 400,000 m3 wood are used in a 100% biomass cogeneration heat network to heat dwelling houses. This large scale application can be applied on other locations on the condition enough feedstock is available in the surroundings of the power plant. Another valorization option for straw is to produce bio-oil through pyrolysis. The bio-oil can be used for the automotive sector or for heating purposes. In the pyrolysis process also heat, syngas and biochar are produced. The energy (heat and syngas) can be used for the required process heat, and the surplus can be sold, eventual as electricity to the grid. The pyrolysis technique can be applied both on the large as well on the small scale. A few large scale plants already exist in Europe. In many cases however, small-scale solutions (e.g. mobile pyrolysis facilities) will be more viable given the regional infrastructure and local availability of straw and wood. Small scale applications require much less investments than large scale installations. Investment costs for the facilities can be funded with multiple partners when a partnership is raised. In addition alternative methods (besides burning) for producing fertilizer from straw for improving the quality of the soil would also provide innovative business opportunities. A second option is the valorization of whey, which is also available in large volumes in Hungary. Through fermentation whey can be valorized to bio-ethanol which can be used as bio-fuel or as chemical building block to process other products such as food, pharmaceuticals or functional materials. A good practice of such a whey processing company exists in Ireland (e.g. Carbery: Hendriks et al. 2016b). Both the production of bio-oil and ethanol are supported by policy, which is

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targeting at an increasing use of renewable energy for both energy production as for the automotive sector. However incentives for further support have to be put in place.

4.2.3 Business case opportunities for the Irish hub

In Ireland large volumes of grass, sawmill residues and animal slurries are available. Anaerobic digestion (AD) of animal slurry/manure and food waste or crop residues can be used to produce bio-gas, fertilizer and soil conditioner. Bio-gas can be used for heating purposes or generation of electricity. Installations can be built on farm scale, minimalizing transport costs. A second business case is that of farm scale grass biorefinery producing biogas, fibres, feed, proteinaceous products and eventually also lactic acids. The latter is very promising, however also more complex and requiring larger investments. So, starting-up new green-biorefineries at farm scale, production of biogas, fibres and feed seem most viable. Next generation biorefineries, or with adequate funding resources also lactic acid (or other organic acids) producing refineries are optional. A third business case comprises valorization of sawmill residues through pyrolysis, producing bio-oil, biogas and biochar. The bio-oil can be used as bio-fuel in the automotive sector (and marine sector), or for the production of biochemical. The syngas can be used for heating purposes or generation of electricity through CHP. Pyrolysis refineries can be built on large or medium industrial scale, requiring large volumes of feedstock to be transported over long distances, and requiring large investment for the plant. In case of fragmented supply, small scale installations (e.g. mobile pyrolysis installation) are viable options processing feedstocks at the mill. Bio-oil can be used for own purposes or sold externally. Transport of bio-oil is much more efficient than transport of the raw material. In future also valuable compounds of the bio-oil can be further valorized. For all the small scale techniques it applies that by setting up partnerships, total investments in installations, technique and maintenance can be reduced, output supply can be better secured resulting in reduced risks for customers, what then may result in easier access to funding opportunities at more favourable conditions. Although there is a clear policy support for production of renewable energy and biobased materials, clear incentives have to be put in place to stimulate a long term viable market for a green economy.

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