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Study on availability of herbaceous resources for production of solid biomass fuels in Latvia

A. Beloborodko*, K. Klavina, F. Romagnoli, K. Kenga, M. Rosa and D. Blumberga

Riga Technical University, Institute of Energy Systems and Environment, Kronvalda blvd. 1, LV-1010 Riga, Latvia;
*Correspondence: anna.beloborodko@rtu.lv

Abstract. Latvia has set a target to increase the gross final consumption of energy from renewable energy sources up to 40% by 2020. To reach this ambitious objective an increase of the amount of energy produced from locally available biomass is a priority. In Latvia, as in the European Union, consumption of wood and wood waste has increased during the last decade. At the same time, the export of pellets and briquettes produced in Latvia is a growing trend, therefore production amounts depend greatly upon export market demand. In the light of a foreseeable increase in the global market for solid biofuels the same trend would be reproduced in Latvia. Consequently and in the light of an increase in energy consumption this would result in shortages of the substrate biomass for the production of compressed biomass. To cover the growing biomass demand for both domestic consumption and export, potential biomass sources from agricultural and industrial sectors have to be investigated.
The main objective of this paper is to determine the availability of potential herbaceous biomass sources for production of compressed biofuels in Latvia. In order to reach this target the available amounts of herbaceous agricultural and industrial by-products in Latvia have been evaluated and their energy potential has been calculated. In addition, the current use of these materials is described and sustainability aspects of various applications of such materials are discussed.
This study intends to provide the necessary background information to select the most suitable and convenient sources (in terms of availability and energy value) for the production of compressed mixed biomass fuels at laboratory conditions and the consecutive determination of quality and physical, mechanical, thermo-chemical and combustion properties of such fuels.

Key words: biomass resources, renewable energy, by-product use, industrial synergies, mixed biomass.

INTRODUCTION

Nowadays the European Union (EU) is moving towards its target of obtaining 20% of the required energy demand from renewable energy sources (RES) by 2020. Since 2005, when this goal was set, the share of RES in gross final consumption of energy in Latvia already was 32.6%, Latvia set the target to increase the use of all RES up to 40% by 2020 (EU 2009/28/EC). Increasing the amount of energy produced from locally available RES such as hydropower, wind and biomass is a priority of this ambitious objective (Ministry of Economics of the Republic of Latvia, 2011).

During the last decade the production of wood-based fuels (e.g. pellets, briquettes, logs) in Latvia has received an important boost (EUROSTAT, 2013, Central Statistical Bureau of Latvia, 2013[a]) due to the increasing demand from internal (see Fig. 1.) and EU Member's markets. In order to make the market requests favourable and at the same time to satisfy the internal demand for solid biofuels at the base of the RES Directive the need to test non-woody biomass as raw material for solid biofuel preparation appears evident.

In 2011 the share of 92% and 76% of produced pellets and briquettes, respectively, were exported (Central Statistical Bureau of Latvia, 2013[a]). This indicates that pellet and briquette production amounts in Latvia mainly depend upon the export market demand.

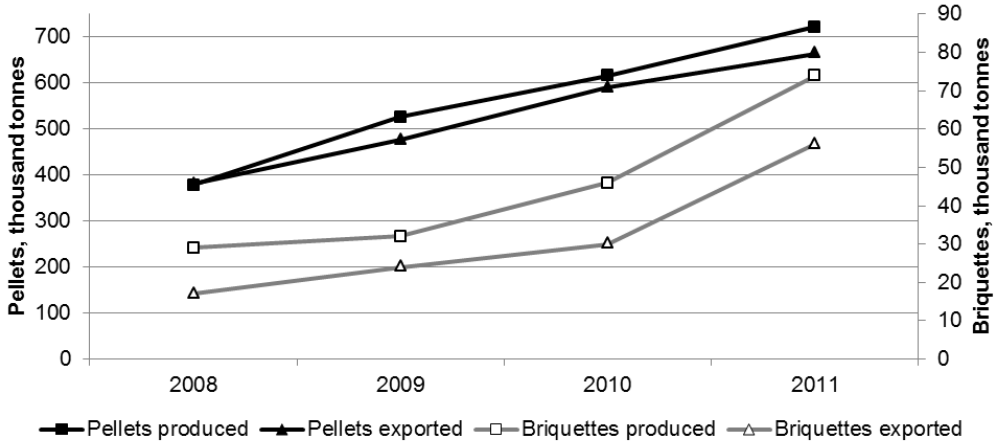

Figure 1. Production and export of wood pellets and briquettes in Latvia (Central Statistical Bureau of Latvia, 2013[a]).

Production of compressed wood fuels (e.g. wood pellets and briquettes, from sawdust and shavings) is a sustainable way of managing wood processing by-products. This kind of application decreases the amounts of generated waste and allows by-products to be used as an energy source bringing evident environmental benefits.

Due to a large demand, compressed solid biofuels are also produced by using round wood as raw material in addition to wood wastes. In this direction, and in order to meet the growing demand in export markets, testing the substitution of part of the woody substrate for pellets with other leftover biomass has been done in Latvia (Communication with LatGran Ltd.). Within the scientific arena increased interest in RES has also led to new researches on the use of such herbaceous sources as common reed and hogweed for energy production (Kronbergs, 2011; RTU ITTC, 2012). Nevertheless, there is still the lack of a complete evaluation of the possibility to produce compressed biomass fuels without being dependent on the availability of wood-based substrates. The potential of herbaceous by-products from manufacturing industries that could be used for energy purposes instead of being landfilled is still a matter for debate.

In the light of a foreseeable increase in the global market for solid biofuels the same trend would be evident in Latvia. Consequently and in the light of an increase in energy consumption this would result in shortages of the substrate biomass for the production of compressed biomass for energy production. Therefore the investigation of different potential biomass sources from agricultural and industrial sectors is needed to cover the growing biomass demand for both domestic consumption and export.

The main objective of this paper is to determine the availability of potential herbaceous biomass sources for production of compressed biofuels in Latvia to decrease the strong dependency on the use of wood-based wastes. In order to reach this target the available amounts of herbaceous agricultural and industrial by-products in Latvia have been evaluated and their energy potential has been calculated. In addition, the current use of these materials is described and sustainability aspects of various applications of such materials are discussed.

MATERIALS AND METHODS

A common European biofuel classification is presented in the standard 'Solid biofuels – Fuel specifications and classes – Part 1: General requirements' (EN14961-1:2010). According to this standard various biofuels are classified by their origin and source. Within this classification system biofuels are divided into four groups:

1. Woody biomass (i.e. biomass from trees, bushes, shrubs);
2. Herbaceous biomass (i.e. biomass from plants that have a non-woody stem and which die back at the end of growing season, including grains and their by-products such as cereals);
3. Fruit biomass (i.e. biomass from parts of plant which are from or hold seeds);
4. Blends and mixtures (i.e. biomass of various origin, blends include intentionally mixed biofuels, mixtures are unintentionally mixed biofuels).

The current study focuses mainly on the available herbaceous biomass sources in Latvia. Additionally, the potential of fruit biomass is assessed for some types of food processing industry by-products.

The available amounts of various herbaceous biomasses were determined from literature research, analysing statistical data and company pollution permits as well as personal communication with representatives of production companies. The representatives from eight of the largest grain processing companies, three large rape processing companies (from which one is a cooperative of 664 farms) and one farm processing buckwheat were interviewed.

Potential herbaceous and fruit biomass resources in Latvia

In this chapter the study in regard to the available biomass for non-woody biomass namely herbaceous biomass and fruit biomass will be proposed.

Herbaceous biomass resources in Latvia

Potential sources of herbaceous biomass in Latvia are related to the well-developed agricultural sector and food processing industry. Common herbaceous locally available biomass materials include: straw, grains not matching food industry

requirements, various grain husks and shells, leftovers from oil seed crop production and spent grain. The most notable resource already in use as a solid biofuel is straw, although it comprises only 0.02% of total solid biofuels used in Latvia (Central Statistical Bureau of Latvia, 2013[a]). The use of straw biomass for energy generation purposes in Latvia began in 1999 when four straw fired water boilers were installed in Saulkalne (Jankevica et al., 1999). In recent years production of straw pellets has increased, even though there is no recent data about the real available amount of straw.

Nowadays the number of companies that are trying to maximise their resource efficiency by utilising herbaceous by-products as solid biofuel has increased. Even untypical fruit biomass (for local conditions) such as cocoa shells from the confectionery industry are being used for heating applications in Latvia (Communication with JS Laima, 2013).

Other promising biomass resources in Latvia are some wild or invasive plant species like common reed and giant hogweed. As it is generally for countries with a temperate climate and a vast hydrologic system there are large areas of reed plantations which could be harvested and used, among other purposes, for energy production. The large expansion of hogweed is identified as an important problem in Latvia. Basically there are two important aspects of hogweed expansion: the first is related to the decrease in biodiversity of the local habitat (no other plant species are able to grow together with hogweed) and the second is related to human health problems – hogweed contains phototoxic juice, which can cause serious skin burns. Specifically this second aspect complicates and limits the research on this particular plant and the application of hogweed as a fuel. Therefore the use of hogweed for solid biofuel production could reduce the expansion of this species while being beneficial compared to bare control methods.

Another type of herbaceous source is potato pulp. Potato pulp is a residue of potato starch production. The largest Baltic potato pulp production company is located in Latvia and generates important amounts of potato pulp residue. Research proposed by Obidziński (2011) shows good results for using potato pulp as solid biofuel. S. Obidziński in his study notes that potato pulp is especially attractive as an additive in pellet production with different biomass types (e.g. sawdust, straw, buckwheat husks) because of its ability to improve the physical properties of the pelletising process and the low content of chlorine in potato pulp.

Fruit biomass resources in Latvia

In some European countries fruit stones and other residues from processing are recognised as a potential biomass fuel source. The largest fruit processing companies in Latvia manufacture their products from imported pre-processed raw materials avoiding the possibility to have sizable sources of this kind of biomass.

In Latvia, on a smaller production scale, there are processing companies devoted to the preparation of candied fruits, syrups and juices, berry seed oils, etc. These companies are not required to state the amounts of generated waste; hence the exact overall amount of fruit biomass available for production of biofuel is unknown. However it can be assumed that the amount is negligible, because most companies are striving towards a waste free production. For example, the processing of sea buckthorn involves pressing juice from the berries and oil from the seeds, thus maximising the output product from the initial biomass source. In this case, the reduction of the waste

can also be achieved by using production left-overs as animal feed (i.e. pomace or marc). Case studies on feeding horses with buckthorn by-products have been analysed by the Latvian University of Agriculture and have shown good results (Bula & Ositis, 2008).

Available amounts of herbaceous resources in Latvia

Straw

One of the main herbaceous biomass sources from agriculture is straw. It is traditionally used as stable bedding in animal farms, as animal feed and for some technical purposes as producing paper, construction materials, etc. Nevertheless, grain production in Latvia is high and approximately 30% of total generated straw is not consumed for the previously mentioned purposes, and about one third of this amount or 10% of total generated straw is considered to be technically available for use as biomass fuel (Adamovičs et. al., 2009). In 2011 this resulted in approximately 107 thousand tons of available straw.

Common reed

Though it is not specially cultivated, common reed is widespread in Latvia. Typically reed grows near waterbeds, seashores, wetlands, swamps, meadows and ponds. Each year reed stalks wither and degrade releasing methane (CH_4) emissions into the atmosphere and the stems oxygenate the sediments and prevents phosphor from being released. (Komulainen et. al., 2008).

Traditionally in Latvia reed is used for roofing, but the share of reed that can match the quality requirements of being used in roofing takes up only a small portion of all available reed plantations. When uncultivated reed groves are mowed only about one sixth of the obtained biomass can be used for roofing (Communication with Nature conservation agency). Recently the interest in using reed for other purposes, such as biofuel, has increased. Several researches have been made in order to determine total energetic potential and biofuel quality parameters of common reed biomass in Latvia and other European countries (Kronbergs et. al., 2011). Research about availability of reed biomass in 132 Latvian lakes (Cubars, n.d.) defines the total potential of reed (winter mowed) is approximately 97,000 tons per year. However, the technically feasible annual amount of biomass that can be harvested is about 46,500 tonnes (Cubars, 2012).

Unfortunately there is a drawback in the use of common reed in fuel production; it has been found that reed plantations have a tendency to absorb heavy metals like Cd, Co, Cr, Cu, Fe, Mn, Ni and Pb from the waterbeds (Cubars, 2012). Caution should be exercised to avoid secondary pollution and comprehensive studies have to be carried out on the emissions from common reed incineration. With correct handling the annual reed harvesting for fuel production might become a tool for cleaning the waterbeds from heavy metals as well as organic matter, phosphor and nitrogen (Komulainen et. al., 2008).

Crops

Both the agricultural sector and grain processing industry in Latvia are well-developed. The most common cultivated grain crops are wheat, barley, oat and rye (see Table 1). Though production of crops is annually varying, the total sown areas of cereals have been stable during the last decade. Only the share of rape in the total sown area of cereals during the last decade has increased from 1% in 2001 to 11.2% in 2011 (Central Statistical Bureau of Latvia, 2013[a]). This is connected to the well-established rapeseed processing industry, since rape is widely used for oil extraction and biodiesel production.

Table 1. Total crop production in Latvia in 2010 and 2011 (Central Statistical Bureau of Latvia, 2012, Central Statistical Bureau of Latvia, 2013[b])

Crops	Total production, thousand tonnes	Percentage from total cereal production, %	Total production, thousand tonnes	Percentage from total cereal production, %
	2010	2010	2011	2011
Cereals	1,435.5		1,412.0	
Winter cereals	931.6	64.9	713.7	50.5
of which				
wheat	790.5	55.1	618.8	43.8
rye	70.2	4.9	64.0	4.5
triticale	26.4	1.8	21.4	1.5
Spring cereals	503.9	35.1	698.3	49.5
of which				
wheat	198.8	13.8	320.7	22.7
barley	184	12.8	227.2	16.1
oats	100.6	7.0	120.9	8.6
buckwheat	5.5	0.4	9.6	0.7
Rape	226.3		219.1	

According to statistical data there are 26 grain processing companies in Latvia (Central Statistical Bureau of Latvia, 2013[a]). Grain processing includes grain cleaning, peeling, milling and screening to produce flour and other products. Therefore the grain processing industry is a large source of grain husks and chaff. To determine the current use of such by-products representatives of eight grain processing companies were interviewed and statistical data for these and another of the three largest companies was obtained.

In total three companies are reusing generated by-products onsite for animal feed production, energy generation or other purposes. Three companies are selling grain processing by-products (approximately 1,600 tons per year) to be used as animal fodder in local farms or substrate at biogas production plants. This is a sustainable way of managing grain processing by-products; in fact the output of either process will still be a valuable substrate that could be used as fertiliser for agricultural lands. One of the interviewed companies is providing grain husks to a pellet production company, to be mixed with wood-based pellets (approximately 200 tons per year). In this case both companies are located close by and therefore efficient industrial synergy is ensured.

Still in 2011 in four of the examined companies in total 556 tons of grain processing by-products were landfilled. At current rates of production more than 500 tons per year of grain processing by-products that are now being landfilled could be used as solid biofuel.

Rapeseed

Rapeseed processing involves cleaning, peeling, drying, storing and processing into non refined oil. The main by-products of rapeseed processing are rapeseed cake and grain pre-treatment dust. At the moment the rapeseed cake produced in the rapeseed oil production is consumed in the domestic and export animal feed market due to its high nutrient value, consequently there are no available leftovers. The typical price of rapeseed cake is approximately 300–320 € per tonne (Communication with Agricultural co-operative LATRAPS and Bioventa Ltd.), which is at least twice-fold the price of wood pellets (Forest and Wood Products Research and Development Institute, 2011), therefore using rapeseed cake as a fuel would not be economically feasible at this time.

The pre-treatment dust though appears to have a possibility to be used as a solid biofuel. One rapeseed oil production company in Latvia is selling the rapeseed dust to fuel production companies. However another rapeseed oil production company is using the rapeseed dust in their internal production processes. According to Table 1 in 2010 the total production of rapeseed in Latvia was 226.3 thousand tonnes. The pre-treatment dust share usually forms 1 to 3% of the initial mass but can vary significantly reaching even 20%. (Communication with Iecavnieks Ltd., Agricultural co-operative LATRAPS, Bioventa Ltd.)

Buckwheat

Buckwheat is a minor agronomy culture in Latvia but nonetheless it has its place in Latvian culture and traditions. It is used as a source of honey in beekeeping and for production of buckwheat grain. Buckwheat processing involves buckwheat dehulling. High quality hulls are used for pillow and mattress fillings, which are high added value products. However around 90% of the hulls produced during the dehulling process are below the necessary quality for fillings and turn into waste (Communication with farm *Mētras*).

At this moment the buckwheat processing industry in Latvia has attenuated. Unprocessed buckwheat is exported to neighbouring countries and the treated product is imported for domestic consumption. This mainly depends on the decisions of the largest Latvian grain processing corporations, which have chosen to buy the most profitable product, which at the time is the imported processed buckwheat (Būmane, 2011). The use of low quality hulls for the production of biomass fuel could become a side business for small processing companies, lift their economic situation and add competitive advantages to the Latvian buckwheat processing industry.

According to Table 1 in 2011 the buckwheat yield was 9.6 thousand tonnes (Central Statistical Bureau of Latvia, 2012). One tonne of buckwheat yields 0.17 to 0.26 tonnes of hulls (Oplinger, 1989; Bonafaccia et. al., 2003) thus in 2011 there were approximately 1,500 to 2,300 tonnes of hulls that could have been used for fuel production in Latvia taking into account the share used for pillow and mattress fillings.

Spent grain

Spent grain is fermented grain e.g. from beer brewing. Spent grain usually contains high amounts of protein and therefore is very suitable to be used as animal feed. There were 16 beer breweries in Latvia in 2011 that generate up to 26.7 thousand tonnes of spent grain per year (Central Statistical Bureau of Latvia, 2013[a], Environment State Bureau, 2013). Almost all of them are selling or providing spent grain to various farms to be used as fodder. Due to its preparation technique spent grain usually has a high moisture content. Production of compressed solid biomass from spent grain would require intensive drying of the material and would result in high energy consumption per tonne of solid biomass produced. Therefore at this time spent grain is not considered as a high potential biofuel resource.

However there could be some potential for grain cleaning leftovers such as dust and broken grains, which are generated during grain pre-treatment stages at beer-breweries. Currently such materials are being given to forestry concerns, to be used as wild animal food, or landfilled. Annually approximately 83 tons of grain dusts are generated and could be used for energy recovery (Environment State Bureau, 2013).

Potato pulp

According to the potato starch manufacturing company's polluting activity permit 2,660 tonnes of potato pulp are produced annually and because it does not have a large-scale application it is handed to a waste management company (Environment State Bureau, 2013). The raw material has moisture content exceeding 88% meaning that it is possible to annually obtain around 319 tonnes of potato pulp dry mass for solid fuel production. The gross calorific value of such material is 15.465 MJ kg^{-1} (Obidziński, 2011).

Hogweed

Hogweed was originally imported into Latvia as a crop for fodder and nectar, but currently it has spread throughout a large area of unmanaged land and ditches. At the moment a study on the use of hogweed for production of biobutanol is carried out by the Riga Technical University in collaboration with the Institute for Environmental Solutions. The results of this study show that currently biobutanol production from hogweed is not economically feasible but might become relevant with increasing fossil fuel costs (RTU ITTC, 2012). In the middle of 2012 in total over 10 thousand hectares of land were covered with hogweed groves in Latvia with potentially available 45 to 80 t ha^{-1} of biomass (State Plant Protection Service, 2012, RTU ITTC 2012).

As no profound researches have been done before, the methods for collection, processing and handling of hogweed as well as the emissions from incineration of this type of biomass has to be carefully studied to avoid health or environmental risks.

RESULTS AND DISCUSSION

To calculate the potential amount of energy that could be recovered from such sources several samples of herbaceous biomass were gathered to determine their total moisture (according to standard method LVS EN 14774-2:2010) and calorific value (according to standard method LVS EN 14918:2010). Grain husks, rapeseed dust,

buckwheat husks and straw were gathered from industries, reed and hogweed were gathered in-situ (winter mowed) (see Fig. 2.).

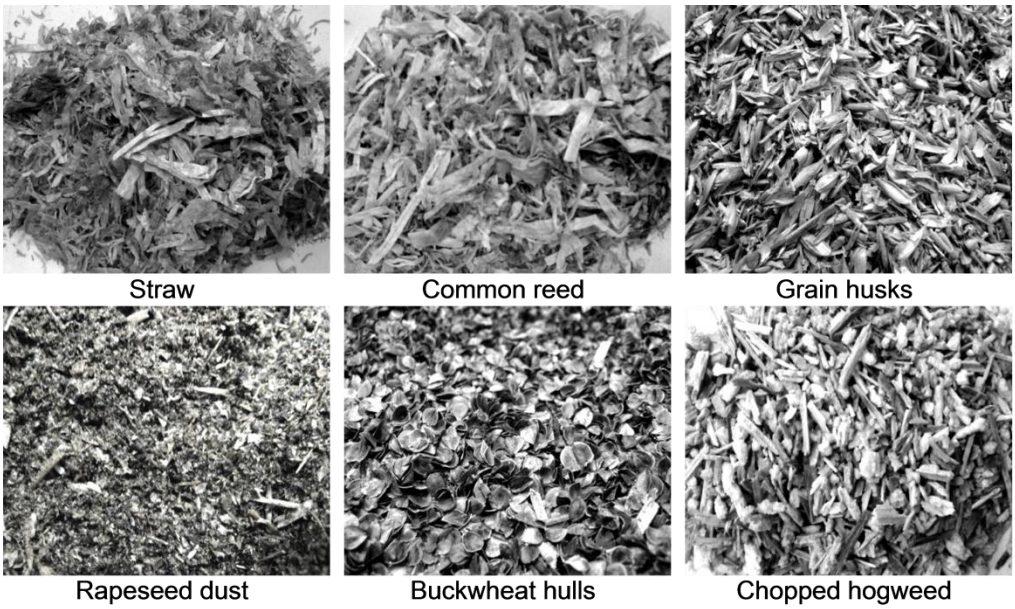

Figure 2. Gathered herbaceous biomass samples.

The properties of grain dusts are assumed to be the same as that of grain husks. A moisture content of 90% was assumed for hogweed (mature living plants usually 80% to 90% (Taiz & Zeiger, 1998)). Summary of the amounts of indicated herbaceous biomass sources and their energy potential is presented in Table 2.

Table 2. Availability and energy potential of herbaceous biomass in Latvia

Biomass type	Amount, fresh weight (t year^{-1})	Moisture content (% fresh weight)	Gross calorific value per dry weight (MJ kg^{-1})	Amount, dry weight (t year^{-1})	Total amount of energy per dry weight (TJ)
Straw	107,000	8.5	18.78	97,905	1,839
Common reed	46,500	8.2	18.88	42,687	806
Grain husks	500	10.1	19.20	450	9
Rapeseed dust	4,526	8.4	22.11	4,146	92
Buckwheat hulls	1,500	14.4	19.64	1,284	25
Grain dusts	83	10.1	19.20	75	1
Potato pulp	2,661	88	15.47	319	5
Hogweed	625,000	90	19.25	62,500	1,203
TOTAL	787,770			459,366	4,810

Main available herbaceous biomass sources are straw, reed and hogweed. As reed and hogweed are involuntarily grown species in Latvia, their harvesting would provide

both an energy resource and pose additional benefits due to landscape and waterbed improvements. Though the processing industry provides smaller amounts of herbaceous biomass sources the potential is evident, especially, if it would be used on-site or at close facilities thus reducing potential impact from fuel transportation.

Though this article focuses mainly on a theoretically available amount of herbaceous biomass in Latvia, other environmental and economic aspects have to be considered when planning real energy production facilities. To ensure that energy obtained from any kind of biomass would be sustainable, the choice of harvesting techniques, energy production appliances and emission control systems and even placement of the facility is essential.

CONCLUSIONS

Though in Latvia herbaceous agricultural and processing industry by-products are used for various purposes, including animal feed, stable bedding, biogas substrate and wood pellet additives, still a part of it is being landfilled. This part as well as herbaceous biomass from local involuntary grown species (e.g. common reed, giant hogweed) can be used to obtain approximately 4,800 TJ of energy.

Though herbaceous biomass typically has lower energy content per mass unit than woody biomass, the total potential of such biomass is great enough to consider it as a valuable local renewable resource in Latvia.

By using herbaceous agricultural and processing industry by-products as biomass fuels, landscape improvements and reduction of the amount of landfilled organic waste provides additional environmental benefits. In the case of common reed and giant hogweed application land management issues are also addressed.

Nevertheless, more in depth research about combustion properties and the technical feasibility of herbaceous materials has to be carried out due to the different growing conditions and thus more complex chemical composition of herbaceous biomass in contrast to wood biomass.

One of the factors that can influence the sustainability of processing by-product use is the transportation distance from the origin of such materials to their end use. As with the woody biomass, herbaceous biomass still has to be transported to the place of application. If possible a geographically close located supplier-end user systems, e.g. industrial symbiosis network, should be implemented, to ensure that transportation of biomass does not generate a large impact on the environment. The indicated example of grain processing by-product use as biogas substrate or pellet production additive is a good example of such an arrangement.

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