



photo by Martin Dotzauer, DBFZ

## **Impact of promotion mechanisms for advanced and low-iLUC biofuels on markets**

**Straw for bioenergy**

**IEA Bioenergy**

**Task 40: Sustainable  
International Bioenergy Trade**

## Authors

Marek Gawor  
Stefan Majer  
DBFZ

Daniela Thrän  
UFZ & DBFZ

[www.dbfz.de](http://www.dbfz.de)



## Project coordinator

Luc Pelkmans  
VITO  
<https://www.vito.be>



**Study accomplished under the authority of IEA Bioenergy Task 40**

**Published in August 2014**

### Conditions of Use and Citation

All materials and content contained in this publication are the intellectual property of IEA Bioenergy Task 40 and may not be copied, reproduced, distributed or displayed beyond personal, educational, and research purposes without IEA Bioenergy Task 40's express written permission. Citation of this publication must appear in all copies or derivative works. In no event shall anyone commercialize contents or information from this publication without prior written consent from IEA Bioenergy Task 40. Please cite as:

*Gawor et al. 2014. Impact of promotion mechanisms for advanced and low-iLUC biofuels on biomass markets: Straw for bioenergy. IEA Bioenergy Task 40. August 2014.*

### Disclaimer

This report was written for IEA Bioenergy Task 40 "Sustainable Bioenergy Trade". While the utmost care has been taken when compiling the report, the authors disclaim any legal liability or responsibility for the accuracy, completeness, or usefulness of any information contained herein, or any consequences resulting from actions taken based on information contained in this report.

# **Impact of promotion mechanisms for advanced and low-iLUC biofuels on markets: Straw for bioenergy**

**August 2014**

**Authors:**

**Marek Gawor (DBFZ)**

**Stefan Majer (DBFZ)**

**Daniela Thrän (UFZ)**

**Project coordinator:**

**Luc Pelkmans (VITO)**

## Table of Contents

<b>1. Introduction</b>	<b>5</b>	
1.1. Background		5
1.2. Scope of the overall study		5
1.3. Scope of this report		6
<b>2. Promotion mechanisms for the use of straw for bioenergy in Germany, Denmark and Poland</b>	<b>7</b>	
2.1 Germany		7
2.2 Denmark		9
2.3 Poland		13
<b>3. Volumes and prices of straw used for energy</b>	<b>16</b>	
<b>4. Critical issues and risks</b>	<b>19</b>	
<b>5. Impact of promotion mechanisms on straw markets</b>	<b>20</b>	
5.1 Impact in the past years		20
5.2 Anticipated trends in the future		20
5.3 Lessons for policy makers		21

# 1. Introduction

## 1.1. Background

With current discussions on indirect effects of biofuels (the ‘indirect land use change or iLUC debate’), and the aim to broaden feedstocks to non-food biomass, policies are trying to put focus on biofuels from waste, residues and lignocellulose materials, so called ‘advanced’ biofuels with low iLUC impact. Next to the general biofuel incentives, these biofuels are getting extra support through specific promotion mechanisms. Examples are the double-counting mechanism for advanced biofuels in the EU, and the specific targets for advanced biofuels in the US.

While technologically challenging lignocellulosic (‘2<sup>nd</sup> generation’) biofuels are developing slower than expected, markets so far seem to have focused on cheaper options, using waste and residues or cheap feedstocks in more conventional biofuel technologies to take advantage of these extra incentives. Typical examples are used cooking oil or animal fats which are used for biodiesel production in the EU, or sugarcane ethanol to fulfil advanced biofuels targets in the US.

However well these policy measures intended to be, some of these may create unintended effects. These promotion mechanisms induce market movements and also trading of specific biomass and biofuel types. Other applications relying on these (residue) materials - traditionally very cheap feedstocks – may be impacted by this, both in terms of available volumes, and in terms of feedstock prices.

## 1.2. Scope of the overall study

In this study, some typical cases are presented where promotion mechanisms for advanced biofuels have had an impact on markets and trade, or may be anticipated to impact markets and trade in the future.

The study focuses on some concrete cases. The selected cases are:

1. **Used cooking oils and animal fats for biodiesel:** impact of the double-counting mechanism for advanced biofuels in the European Renewable Energy Directive on market prices and trade flows, analysed for the Netherlands and Italy.
2. **Sugarcane ethanol:** impact of the subtargets for specific advanced biofuels in the US Renewable Fuels Standard (RFS2), where sugarcane ethanol is classified as ‘advanced biofuel’. This has had a clear impact on prices and trade patterns between Brazil and the US.

The other two are more prospective cases, where we can learn from a stimulated demand for straw or woody biomass in the past (for stationary bioenergy). With the introduction of advanced biofuel technologies (based on lignocellulosic feedstocks), these feedstocks may experience an additional demand for biofuels production (also stimulated by specific promotion mechanisms such as double counting):

3. **Crop residues (straw) for bioenergy:** straw may play an important role for advanced biofuels in the future. In countries such as Germany, Denmark or Poland, this is an

emerging feedstock for energy and biofuels. There are already some experiences we can take into account from the promotion of straw for stationary energy, e.g. in Denmark.

4. **International trade of US wood pellets for bioenergy in the EU:** Renewable Energy promotion in certain EU Member States is causing considerable trade flows from the US to the EU. There is clear that there are interactions with existing wood markets and forestry practises. In the future there may be additional effects when demand for cellulose-based biofuels enters these markets.

For each case, the specific relevant promotion mechanisms in place, volume and price evolutions of the specific feedstocks, emerging trade patterns and impact on other applications/markets are discussed. Impacts can be increased competition or additional pressure to ecosystems; however, it may also induce new possibilities and synergies for certain markets. Potential future impacts are also anticipated, e.g. on straw or woody biomass when advanced biofuel technologies get more mature. The case studies themselves are available as separate reports. All reports are available at:

<http://bioenergytrade.org/publications.html#lowiluc>

### 1.3. Scope of this report

The use of organic residues like straw for the production of bioenergy is considered to be an environmentally beneficial and socially acceptable option for bioenergy provision. Agricultural residues like straw seem to have the advantage of low competition with other land uses and thus comparably low corresponding land use change effects. Currently, legislations on European and national level are developed towards an improved framework for the energy-related utilization of these raw materials. At European level, the 'double counting mechanism' in the Renewable Energy Directive<sup>1</sup> promotes their application for biofuel production. On a national level, support schemes for renewable energy production are increasingly promoting the use of agricultural residues (e.g. the Renewable Energy Sources Act<sup>2</sup> in Germany). Nevertheless, there are a number of uncertainties with regard to the actual potential of agricultural residues like straw that could be used for the production of bioenergy in a sustainable manner.

The purpose of this chapter is therefore twofold: 1) to describe the status of the current use of straw for bioenergy production in three European countries and 2) to discuss the potentials and opportunities to increase the share of straw for bioenergy on a mid-term level. The special focus will be the production of advanced biofuels and the possible shape of the potential market in the future.

---

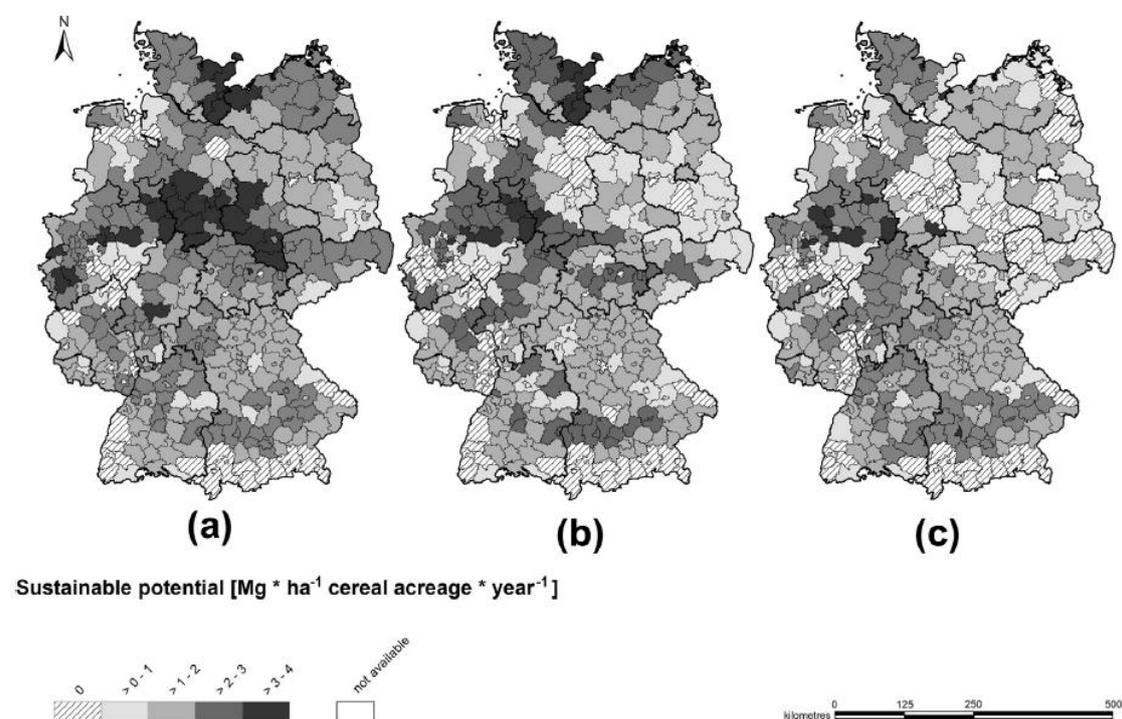
<sup>1</sup> European Commission (EC), Directive 2009/28/EC; 2009.

<sup>2</sup> Act on granting priority to renewable energy sources; 2012. Available at: [http://www.erneuerbare-energi.de/fileadmin/ee-import/files/english/pdf/application/pdf/eeg\\_2012\\_en\\_bf.pdf](http://www.erneuerbare-energi.de/fileadmin/ee-import/files/english/pdf/application/pdf/eeg_2012_en_bf.pdf), last accessed 06.05.2014. [German]

## 2. Promotion mechanisms for the use of straw for bioenergy in Germany, Denmark and Poland

### 2.1 Germany

According to Weiser et al.<sup>3</sup> approximately 29.8 million tonnes of straw (fresh matter) are produced annually in Germany (1999–2007). Between 8 and 13 million tonnes of this theoretical potential could be used sustainably for energy or fuel production. Highest straw potential (4 tonnes per ha) can be found in parts of Schleswig-Holstein, Mecklenburg-West Pomerania, North Rhine-Westphalia and Lower Saxony. But there are also regions that show a net deficit (see Figure 1).



**Figure 1.** Quantity of annually sustainable available straw relative to the cereal cultivation area ( $\text{Ton ha}^{-1} \text{yr}^{-1}$ )

Note: considering three different methodologies for the humus balance (VDLUFA lower (a) and upper (b) values method and the Dynamic Humus Unit method (c)) according to Weiser et al. 2013<sup>4</sup>

This highlights the potential contribution of straw to renewable sources of energy. However, even though straw is one of the most important agricultural residues in Germany, it is not yet used for energy purposes extensively. Current practices in agricultural management suggest that cereal straw is either chopped after threshing the grain and spread onto the field with a combined harvester, or it is harvested, baled and utilized for animal husbandry. Nevertheless, the transition from straw based livestock housing to housing types with slotted floors decreased the demand for cereal straw as litter significantly.

<sup>3</sup>Weiser et al. Integrated assessment of sustainable cereal straw potential and different straw-based energy applications in Germany, Applied Energy, DOI: 10.1016/j.apenergy.2013.07.016.

<sup>4</sup>Ibidem.

Driven by the intense public debate about the sustainability of a large scale use of energy crops, the interest in straw as a potentially sustainable feedstock for bioenergy is currently increasing significantly in Germany.

Most important instrument for the promotion of electricity from renewable energies in Germany is the Renewable Energy Sources Act. The purpose of this Act is to facilitate a sustainable development of energy supply and to promote the further development of technologies for the generation of electricity from renewable energy sources. To achieve this purpose the Act aims to increase the share of renewable energy sources in electricity supply in Germany to at least:

- 35 percent by no later than 2020;
- 50 percent by no later than 2030;
- 65 percent by no later than 2040; and
- 80 percent by no later than 2050;

and to integrate these quantities of electricity in the electricity supply system.

The 2012 amendment of the Renewable Energy Sources Act included a specific instrument to promote the use of straw for the production of electricity. According to this amendment, electricity producers receive an additional bonus payment per kWh of electricity for the use of straw.

Other instruments to promote the use of straw for bioenergy in Germany are the Renewable Heating Act<sup>5</sup> and, for the promotion of advanced biofuels from agricultural residues, the national biofuel quota<sup>6</sup> and the German Energy Tax Act<sup>7</sup>. The Energy Tax Act includes a paragraph under which a number of specifically defined biofuels can be exempt from the energy tax. The definition of these advanced biofuels includes biofuels from straw (e.g. ethanol from lignocellulosic biomass).

However, one of the main differences with regards to the ratio of straw utilised for energy production between Germany and countries like Denmark are the strong thresholds for direct emissions from straw combustion in Germany. These thresholds lead to a significantly higher technical effort and thus investment costs for straw combustion plants compared to Denmark.

Due to these technical and economic restrictions the current number of installed straw combustion units in Germany is estimated at approximately 130 plants<sup>8</sup>.

---

<sup>5</sup> Act on the Promotion of Renewable Energies in the Heat Sector, available at:

<http://www.erneuerbare-energien.de/en/unser-service/mediathek/downloads/detailview/artikel/act-on-the-promotion-of-renewable-energies-in-the-heat-sector-heat-act-eewaermeg/>, last accessed 06.05.2014.

<sup>6</sup> Sechsendreißigste Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes (Verordnung zur Durchführung der Regelungen der Biokraftstoffquote); 2012. Available at [http://www.gesetze-im-internet.de/bimschv\\_36/BJNR006010007.html](http://www.gesetze-im-internet.de/bimschv_36/BJNR006010007.html), last accessed on 28.04.2014. [German]

<sup>7</sup> German Energy Tax Act, available at: <http://www.gesetze-im-internet.de/energiestg/> last accessed on 28.04.2014. [German]

<sup>8</sup> Hering, Thomas: Energetische Halmgutnutzung in Deutschland, 2. Internationale Fachtagung Strohennergie, conference proceedings, 2012. [German]

Beside these small scale combustion units a number of activities regarding the use of straw in large scale CHP units and the production of advanced biofuels have started recently. In 2013, the currently biggest facility for the production of heat and power, with an overall capacity of 50 MW was built in Emlichheim<sup>9</sup> (Germany). Since autumn 2012, Clariant and the TFZ Straubing are operating a demonstration plant with an annual capacity of 1000 tonnes (bioethanol output) for the production of ethanol from straw<sup>10</sup>.

Furthermore, the production of biomethane from straw is seen as a promising future option. One of the biggest German producers of biomethane has started the (co-) fermentation of straw in biomethane production facilities in Zörbig and Schwedt (Germany).

## 2.2 Denmark

The introduction of support mechanisms for bioenergy in Denmark can be traced back to the year 1980. According to Jørgensen<sup>11</sup>, the development of the Danish biomass energy market was possible thanks to the introduction of so-called Danish Biomass Action Plan, which drove Danish power plants to use biomass for production of power and heat. The fastest development of the market occurred with the help of the action plan implemented in 1993, which aimed at the use of 1.0 million tonnes of straw and 0.2 million tonnes of wood chips by 2000. In 2007, these amounts were exceeded significantly (1.4 million tonnes of straw and 2.3 million tonnes of wood, respectively<sup>12</sup>). According to the new energy plan biomass shall be further supported to achieve a share of 30% renewable energy in the energy sector by 2025 and 10% in transportation sector by 2020. Additionally, dedicated development and demonstration plants are in place to support the development of e.g. 2<sup>nd</sup> generation biofuels.<sup>13</sup>

As a result of these consequent and long-lasting political actions, the straw market in Denmark belongs to most developed in entire Europe. It is strongly dominated by the farm scale boilers, which represent approximately 30% of the total straw consumption in the home market. The combustion systems are mostly designed for big bales feeding. In recent years, the combustion efficiency has improved. However, there is a need for continuous improvements for minimization of the emissions. Currently, approximately 7000 units are installed in Denmark (compare Table 1)<sup>14</sup>. Due to less favourable policies in the recent times, the use of straw is declining since 2009 (compare Figure 2).

**Table 1.** Overview of straw fired units in operation<sup>15</sup>

Market	Number of units (approx.)
Farm scale boilers	7,000

<sup>9</sup> See also: <http://www.bioenergie-emslund.de>. [German]

<sup>10</sup> See also: <http://www.bmbf.de/de/17786.php>. [German]

<sup>11</sup> Jørgensen, H. (2007): Current status on biorefineries in Denmark. Available at [http://www.biorefinery.nl/fileadmin/biorefinery/docs/publications/presentations-kickoff/4\\_Country\\_status\\_Denmark\\_IE42\\_150307.pdf](http://www.biorefinery.nl/fileadmin/biorefinery/docs/publications/presentations-kickoff/4_Country_status_Denmark_IE42_150307.pdf), last accessed 06.05.2014.

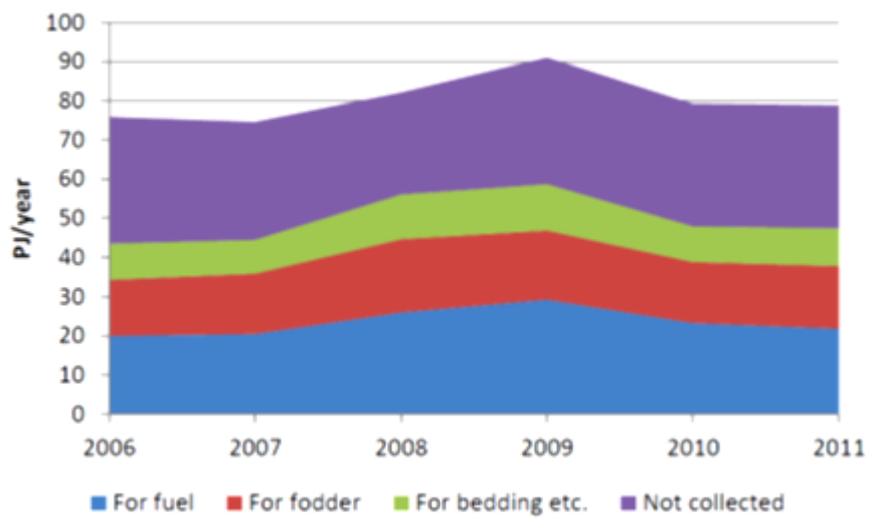
<sup>12</sup> Ibidem.

<sup>13</sup> Ibidem.

<sup>14</sup> FNR Tagungsband 2012: Gülzower Fachgespräche. 2 Internationale Fachtagung Strohenergie. 29./30. März 2012, Berlin. Band 38. Anders Ewald: Länderbericht: Denmark. [German]

<sup>15</sup> Ibidem.

District heating boilers	50
Combined heat and power - CHP plants	7
Co-firing	1
Dedicated PF power plants	1



**Figure 2.** Annual straw production in million ton and the use of straw for different purposes in Denmark. Source: <sup>16</sup>.

The district heating area of the market can be characterized by a constant number of installations (approximately 50), with simultaneously increasing levels of consumers receiving district heating. Currently, approximately 60,000 consumers are using heat from this source of renewable energy, and 20% of the straw resources are used. The average size of the installation is 3.8 MW, with the range between 0.4 MW to 11 MW thermal output <sup>17</sup>.

Other pathways of straw use in Denmark are limited: only few CHP plants are using straw, one power plant is co-firing straw pellets, and there is one dedicated power plant running on straw<sup>18</sup>. The development in this sector focuses on the increase of efficiency (through e.g. increasing steam temperature). Additionally, gasification solutions are being tested. It has been estimated that straw has the potential to substitute 7% of coal in the energy generation sector. Moreover, straw pellets which have the largest potential to substitute fossil fuels, may be produced in Denmark, thus reducing the transportation distances.

The straw potential originates mainly from wheat and barley cultivation. The total amount of agricultural residues is 8.3 million tonnes per year, corresponding to an energy resource of approximately 33 TWh <sup>19</sup> (Table 2):

<sup>16</sup> Bang, C. et al (2013): Analysis of biomass prices. Future Danish prices for straw, wood chips, and wood pellets. Available at [http://www.ens.dk/sites/ens.dk/files/undergrund-forsyning/vedvarende-energi/bioenergi/analyse-bioenergi-danmark/analysis\\_of\\_biomass\\_prices\\_2013.06.18\\_-\\_final\\_report.pdf](http://www.ens.dk/sites/ens.dk/files/undergrund-forsyning/vedvarende-energi/bioenergi/analyse-bioenergi-danmark/analysis_of_biomass_prices_2013.06.18_-_final_report.pdf) (last accessed 10.06.2014).

<sup>17</sup> Ibidem.

<sup>18</sup> Ibidem.

<sup>19</sup> Pellet atlas: Development and promotion of a transparent European Pellets Market. Creation of a European real-time Pellets Atlas. Pellet market country report: Denmark.

**Table 2.** Agricultural residues potential, Denmark, 2000, in thousand tonnes.  
Adopted from<sup>20</sup>

Type of plant	Residues potentials in 1000 tonnes
Wheat	3796
Rye	486
Barley	3821
Oats and mixed cereals	251
<b>Total</b>	<b>8354</b>

An interesting option for the increase of renewable energy generation is the use of pellets (especially made from wood and agricultural residues) in industrial installations providing heat and electricity to a larger number of consumers. In Denmark, small producers focus on substrates other than straw. The Vattenfall company, on the other hand, produces and utilizes approximately 80-100 thousand tonnes of straw pellets annually. The feedstock is obtained locally, mainly from farmers in Sealand<sup>21</sup>. The potential technical problems related to the use of straw or mixed pellets may not be omitted, however:

- Slag generation
- Malfunction of the incineration system
- Corrosion and fouling
- Higher costs and worse properties that in case of wood pellets<sup>22</sup>.

Figure 3 to Figure 4 give an insight into the development of the Danish straw energy market with respect to volume of the production, generation of renewable electricity or fuel prices according to the statistical data (compare<sup>23</sup>).

As the figures reveal, there are no spectacular changes of the market within the past decades. The use of straw for energy from 2006 to 2009 has been slightly increasing from 1 to 1.5 million tonnes, with diminishing use of straw for bedding and forage and also a diminishing share of the not-used straw potential. However, after 2009, a decrease may be noticed.

From the mid-1980s up to the year 2000 straw generates a rather constant amount of renewable energy between 10 and 13 PJ, slightly increasing to 15-20 PJ in the past 10 years (Figure 3).

The price level of straw (paid by district heating facilities) is quite constant up to 2007 at about 100 DKK/MWh (54€ per tonne for straw as delivered, with average humidity of 11-14%, recently increasing to around 130 DKK/MWh (70€/tonne) (Figure 4).

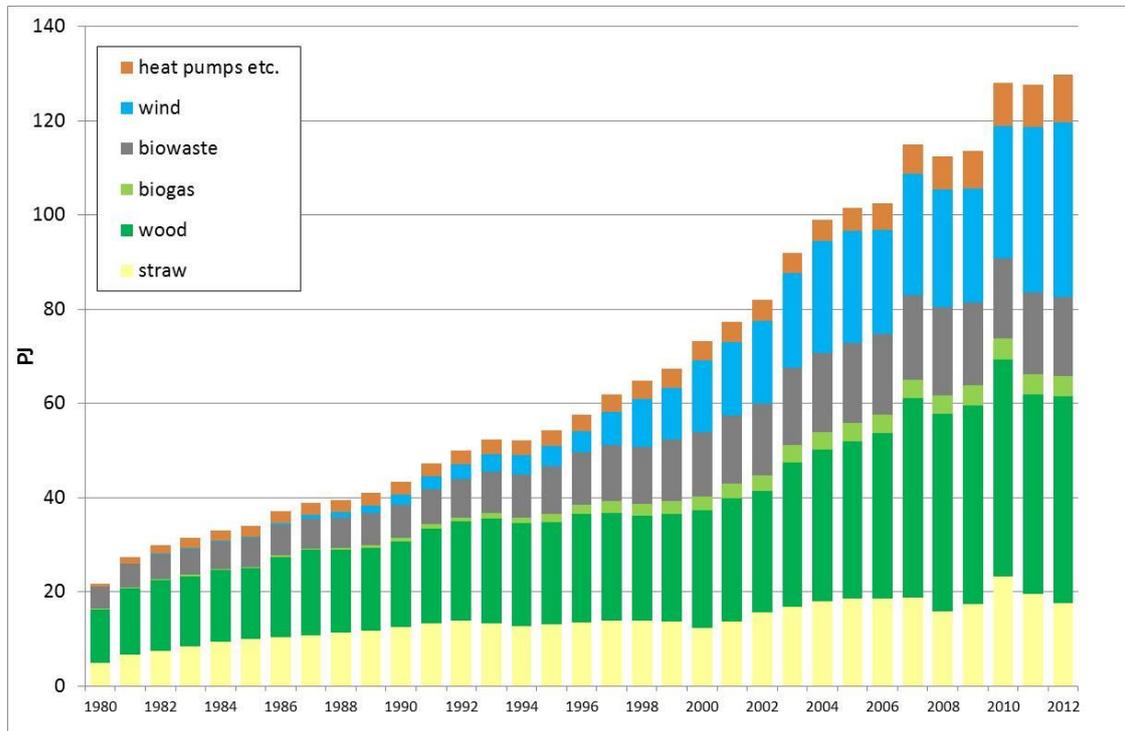
---

<sup>20</sup> Ibidem.

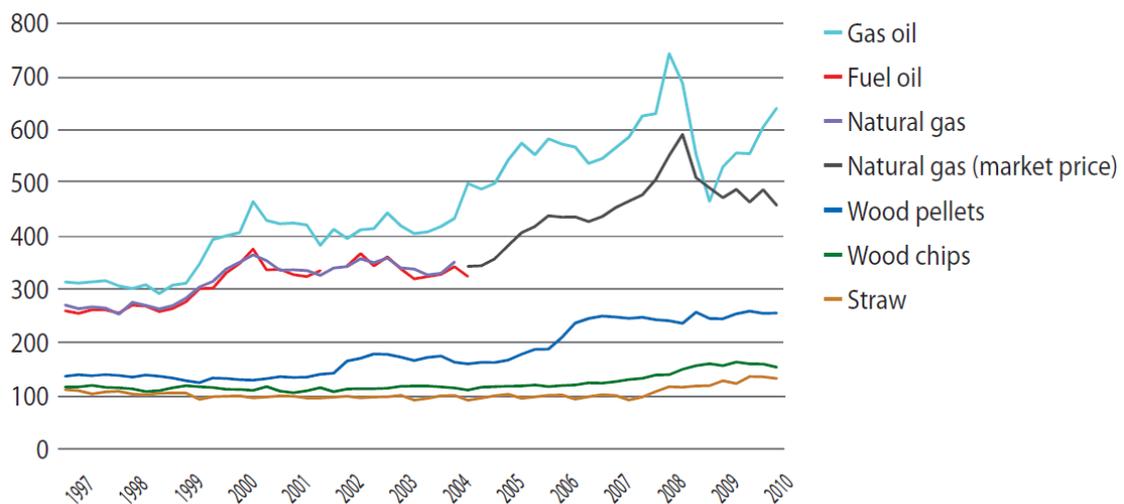
<sup>21</sup> Ibidem.

<sup>22</sup> Ibidem.

<sup>23</sup> Straw to Energy. Status, Technologies and Innovation in Denmark 2011. Statistic Denmark, after Danish Energy Agency.



**Figure 3.** Production of renewable energy in Denmark.<sup>24</sup>



**Figure 4.** Fuel prices in DKK/MWh of the various types of fuels for the district heating purposes.<sup>25</sup>

(100 DKK = 13.4 €; 1 tonne straw ~ 4 MWh)

It might be concluded, that with a great probability, the situation on the market and the role of straw will not be dramatically changed. Certainly, energy-related use of straw will play a role and may even increase further if cellulose biofuels start off.

<sup>24</sup> Danish Energy Agency: Annual Energy Statistics <http://www.ens.dk/en/info/facts-figures/energy-statistics-indicators-energy-efficiency/annual-energy-statistics> (accessed May 2014) .

<sup>25</sup> Straw to Energy. Status, Technologies and Innovation in Denmark 2011. Danish District Heating Association, after Danish Energy Agency.

## 2.3 Poland

Renewable energy installations (e.g. small hydropower plants) have been present in Poland in smaller scale since many decades. However, the most vivid development of the renewable energy market took place after the introduction of the support schemes connected to the EU 2020 goals. In Poland, the support takes the form of a quota system based on a system of various certificates, depending on the type of the renewable energy generated, type/size of the installation or details of applied technology (e.g. efficiency of the installation).

For renewable electricity, green certificates and penalty fees for not fulfilling the required quota play the most important role in the system. Electricity produced from straw might play an important role in the future. However, the development of the entire market is not predictable.

The increase of prices for green certificates during the first years after the establishment of the system allowed installation owners to make viable business plans for future installations. However, around the year 2012, the dramatic fall of the prices for green certificates made the planning of new installations uncertain. In many cases, the electricity producing companies have stopped buying the contracted amounts of biomass. Therefore, no drastic changes of the renewable energy market structure in Poland shall be expected in the coming years, and this applies also for the energy-related use of straw<sup>26</sup>. Even though the prices for green certificates have meanwhile partially recovered, the uncertainty of the investors remained. The full consequences of these negative developments will be visible first in few years. The government will, however, be forced at least to support renewable energy sources in order to achieve the planned share of 15.5% renewable energy by 2020 (19.3 for electrical energy).

The development of the straw market in the last decade indicates that straw may play a significant role in the entire process. As for the estimated resources available, the numbers vary according to the source:

- According to the FNR land report: the surpluses of straw in Poland amounts to 9-12 million ton, while 30 million tonnes of straw are produced yearly, from which 19 million tonnes are used for agricultural purposes<sup>27</sup>;
- Brzóška and Węglarzy (2006) estimate the production of straw at 12-15 million tonnes annually, with straw surplus estimated at 7-8 million tonnes<sup>28</sup>;
- In 2009, according to the Main Statistical Office, 29 million tonnes of straw has been obtained (basic grains without rapeseed). A constant increase of the straw production can be observed<sup>29</sup>;
- Kozłowski and Cygan (2011) estimate the average straw yield at around 3.5 tonnes of straw per hectare with the total annual Polish surplus of straw in the period of

---

<sup>26</sup> Raport o rynku biomasy w Polsce. Available at <http://www.polska-biomasa.pl/o-nas/16-raport-o-rynku-biomasy-w-polsce-2>, last accessed on 10.01.2014. Association "Polska Biomasa". [Polish]

<sup>27</sup> FNR Tagungsband 2012: Gülzower Fachgespräche. 2 Internationale Fachtagung Strohennergie. 29./30. März 2012, Berlin. Band 38. Länderbericht: Polen. [German]

<sup>28</sup> Wiadomości Zootechniczne, R. XLIV (2006), 3: 3-14: Odnawialne źródła energii pochodzenia rolniczego. Wykorzystanie słomy dla celów energetycznych. Franciszek Brzóška, Karol Węglarzy. [Polish]

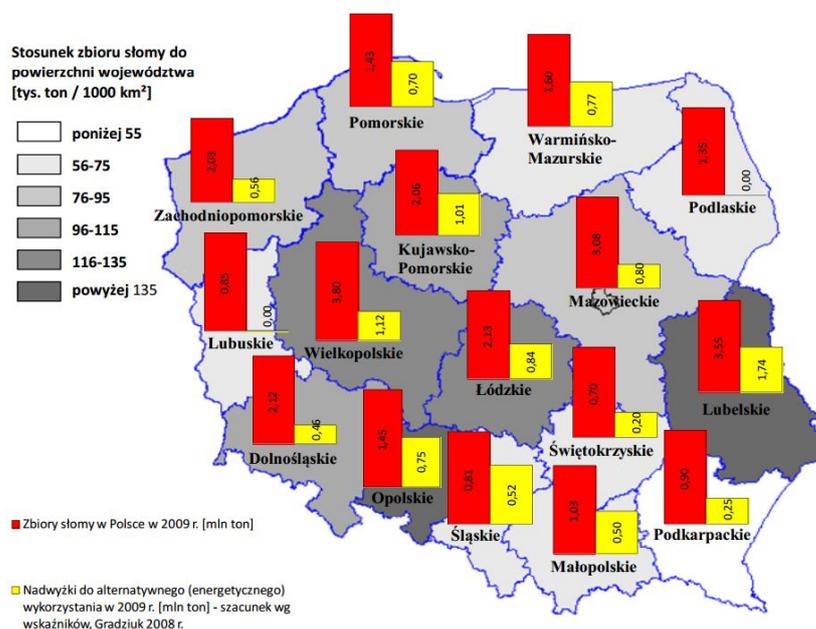
<sup>29</sup> Main Statistical Office (GUS) after Kozłowski, Cygan. [Polish]

1999-2008 at 7.6 million tonnes, increasing in year 2009 even 10.2 million tonnes<sup>30</sup> (see Table 3).

**Table 3.** Production of straw from basic grains in Poland in million tonnes. Agricultural area remained constant.<sup>31</sup>

	2000	2002	2005	2007	2008	2009
<b>Straw production [million tonnes]</b>	18.4	21.0	22.4	19.7	23.1	25.4
<b>Agricultural area, basic grains [thousand ha]</b>	7336	6929	6892	6848	7155	7243

Potentials of straw for energy-related use are also estimated at the regional levels (compare Figure 5 and Figure 6 for two different studies). Both studies estimate high potentials for the following regions: Wielkopolskie, Opolskie, Kujawsko-Pomorskie or Pomorskie.

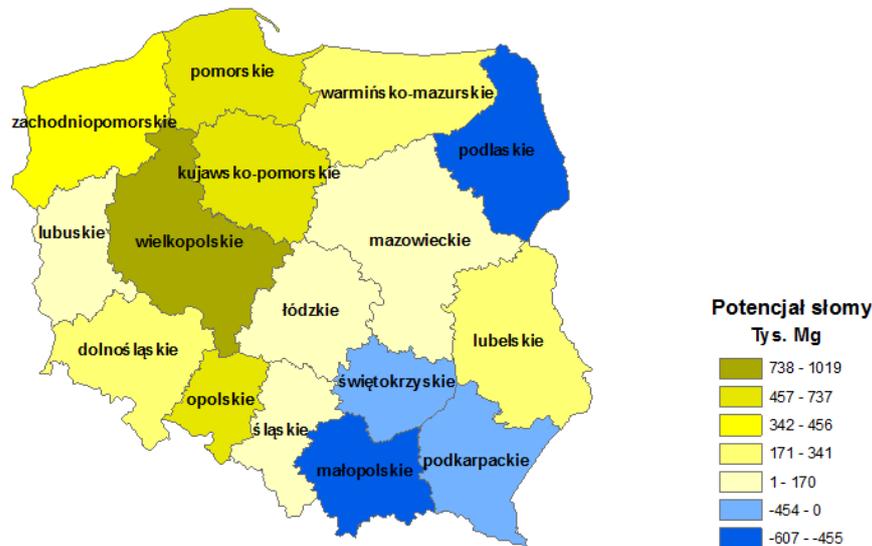


**Figure 5.** Average straw yields in Poland in 2009 in million tonnes per region. Red colour: Straw yield, yellow colour: estimated surplus for the energy-related purposes.<sup>32</sup>

<sup>30</sup> Wiktor Kozłowski, Krzysztof Cygan: Współspalanie słomy z węglem w dużym kotle energetycznym (2011). [Polish]

<sup>31</sup> Ibidem.

<sup>32</sup> Ibidem.



**Figure 6.** Straw potential in Poland in thousand tons. <sup>33</sup>

The original goals of the renewable energy generation (i.e. creation of local added value, renewable energy generation in modern, highly efficient installations) have not been, however, achieved in Poland. According to Association “Polska Biomasa”, co-firing in existing (large scale) installations remains the simplest method to achieve the required quotas set up by the authorities. In 2012, dedicated installations for biomass combustion used only 1.5 million tonnes of biomass, in comparison to 6 million tonnes of co-fired biomass<sup>34</sup>. The already mentioned problems with the straw combustion (e.g. slag formation) are slowing down the development of the market. However, several local companies which provide e.g. heat and warm water use already straw-fired boilers (e.g. in Lubań – the installation has a total power output of 8 MW<sup>35</sup>). However, there is no data available showing the overall amount of straw-fired installations in Poland.

<sup>33</sup> Renata Jaworska: Rynek Biomasy w Polsce – mocne i słabe strony. Uniwersytet Łódzki, Wydział Ekonomiczno-Socjologiczny. [Polish]

<sup>34</sup> Raport o rynku biomasy w Polsce. [www.polska-biomasa.pl/o-nas/16-raport-o-rynku-biomasy-w-polsce-2](http://www.polska-biomasa.pl/o-nas/16-raport-o-rynku-biomasy-w-polsce-2), last accessed on 10.01.2014. Association “Polska Biomasa” [Polish]

<sup>35</sup> Paweł Wójcik: W Lubaniu grzeją słomą. Available at [http://www.ekos.org.pl/hid\\_mc\\_gfx/luban.rtf](http://www.ekos.org.pl/hid_mc_gfx/luban.rtf), last accessed on 02.05.2014. [Polish]

### 3. Volumes and prices of straw used for energy

To discuss the potential future share of energy from straw on the entire European market, the technical potential of straw has to be considered as a crucial factor. Unfortunately, only very few scientific studies are available to evaluate this potential. Furthermore, as already visible in the previously discussed case studies, the existing approaches clearly differ in terms of the used methodology and obtained results. Considering the existing publications, the technical straw potential in the EU-27 varies between 820 and 1800 PJ annually<sup>36, 37, 38</sup>. Within the EU-27, France and Germany show the highest technical straw potentials. Altogether, approximately one third of the overall European straw potential is located in both countries. However, the exploitable part of this technical potential is influenced by a number of regional factors, such as competing uses, carbon and nutrient balances, the technical restrictions and the spatial distribution of the technical potentials.

In general, the future potential of energy from straw and other agricultural residues is promising. Straw, especially as a complement to the use of other biomass feedstocks, can make a significant contribution to the targets for energy from biomass in Europe. Despite various problems with regards to the technical combustion properties of straw, a significant number of initiatives for the further development of straw conversion technologies have been established in the recent years (see for example section 2.1).

The following table shows exemplary results for straw potentials in different European member states as well as the possible development of this potential under different scenarios.

The definition of prices for straw seems to be a rather difficult task. Because of its low energy density straw is currently not comparable to other biomass commodities like wood chips. Prices for straw differ significantly between countries and regions and are influenced by a number of local, technical and economic parameters. Brosowski (2013)<sup>39</sup> indicated a number of parameters influencing final straw prices:

- Types of logistical processes including loading/unloading, round trips, operation speed/time,
- Personnel costs,
- Machinery costs (fixed and running costs),
- Diesel fuel (including refunds for agricultural machines),
- Storage capacities and costs,
- Storage losses,
- Fertilizer costs.

---

<sup>36</sup> Joint Research Centre of the EU (JRC): Cereal Straw Resources for bioenergy in the European Union. Proceedings of an Expert Consultation; Pamplona, Oktober 2006.

<sup>37</sup> Zeller et al.: Basisinformationen für eine nachhaltige Nutzung landwirtschaftlicher Reststoffe zur Bioenergiebereitstellung; 2011, Bd. 2, Schriftenreihe des BMU-Förderprogramms „Energetische Biomassenutzung“, (ISBN: 2192-1806). [German]

<sup>38</sup> Thrän et al.: Regionale und globale räumliche Verteilung von Biomassepotenzialen. Status Quo und Möglichkeit der Präzisierung; Deutsches Biomasseforschungszentrum gGmbH, Leipzig, Germany, 2009. [German]

<sup>39</sup> Brosowski, A.: Biomass supply costs for cereal straw and preference regions for an ethanol plant in Germany. EU BC&E 2013 21st European Biomass Conference and Exhibition, Copenhagen, 03.06.2013.

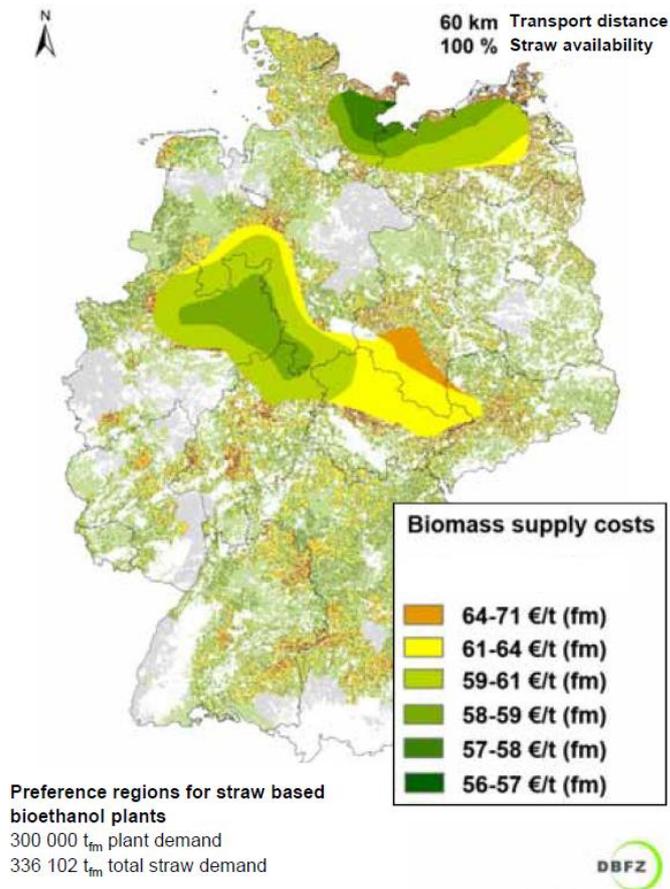
**Table 4.** Straw potential (kTOE) per country in 2004, 2020 and 2030<sup>40</sup>.

kTOE	2004	2020	2030
Austria	600	677	615
Bulgaria	1295	1396	1820
Belgium/Luxembourg	171	334	450
Cyprus	0	0	1
Czech Republic	1235	1448	1478
Germany	5125	8883	7496
Denmark	575	1300	1200
Estonia	63	285	211
Greece	341	439	572
Spain	1672	2153	2850
Finland	421	576	635
France	3479	11000	10848
Hungary	1214	3182	3247
Ireland	0	55	0
Italy	2028	3205	2764
Lithuania	182	576	588
Latvia	68	275	372
Malta	0	0	0
Netherlands	39	195	111
Poland	1884	6142	4447
Portugal	109	190	32
Romania	1351	3312	3601
Sweden	311	596	586
Slovenia	38	127	88
Slovakia	306	827	761
UK	430	2114	2722
<b>EU-27</b>	<b>22936</b>	<b>49285</b>	<b>47493</b>

Hence, unlike other biogenic fuels (e.g. wood chips), local straw prices are strongly cost driven. Furthermore, they correlate strongly with the type of planned installation, chosen location, estimated availability or the local straw demand (compare Figure 7).

---

<sup>40</sup> Panoutsou et al.: The role of straw for heat & electricity in EU27 member states in 2020 and in 2030 with respect to costs and sustainability criteria, available at: [http://veranstaltungen.fnr.de/fileadmin/allgemein/pdf/veranstaltungen/Strohenergie2012/Abstract\\_Panoutsou.pdf](http://veranstaltungen.fnr.de/fileadmin/allgemein/pdf/veranstaltungen/Strohenergie2012/Abstract_Panoutsou.pdf), last accessed on 15.04.2014.



**Figure 7.** Preference regions and straw supply costs for bioethanol plants. <sup>41</sup>

<sup>41</sup> Brosowski, A.: Biomass supply costs for cereal straw and preference regions for an ethanol plant in Germany. EU BC&E 2013 21st European Biomass Conference and Exhibition, Copenhagen, 03.06.2013.

## 4. Critical issues and risks

The use of residues from agriculture for the production of energy can play a role in the transition towards a more renewable energy supply. However, sustainability issues have to be considered along the entire provision chain as they affect the resource and energy potential, as well as the achievable contribution to climate mitigation. It must be taken into consideration that cereal straw plays an important role in the humus balance of soils. For this reason not the complete technical straw potential is available. Some of the straw must be left scattered on the agricultural land to prevent nutrients from being permanently extracted from the soil.

One of the risks related to the sustainable use for straw may also be related to the country-specific support mechanisms relating to the renewable energy. Trends show that renewable energy e.g. in Poland is produced by the biggest players (power plants and energy companies), which invest in large installations (such as GDF Suez with an installation demanding 1.2 to 1.5 million tonnes of biomass, Dalkia Łódź and Dalkia Poznań approximately 400 thousand tonnes, ZE PAK 1.3 million tonnes of biomass per year, etc.<sup>42</sup>). Thus, it could happen that the question of e.g. maintaining the minimum levels of soil fertility in the vicinity of the installations will have a lower priority for the farmers and companies than obtaining the necessary substrate for the fulfilment of the EU and governmental targets of the green energy production. Currently, the main responsibility on maintenance of the soil fertility is put on the farmers and mandatory legal requirements are defined on European and national levels. Issuing the legal frameworks and determining the maximum amounts of the straw and residue removal on the political level will be difficult, because the methods of the determination of the humus balance for various soil types are still under determination.

However, quite interesting is also another phenomenon, which unexpectedly endangered the entire renewable energy branch in Poland, namely the drastic fall of green certificate prices and the subsequent decrease of demand for agricultural substrates from the large players. As the result, at the beginning of 2013 the price of one tonne of straw in Poland decreased from approximately 125 Euros to 25 Euros. The companies that invested in e.g. straw pelletizing installations lost their customers, but also at the same time the small, heat producing installations could obtain the substrate at lower prices<sup>43</sup>. In any case, the instability of the market and price levels will have a long-term negative influence on the entire market, since the potential investors may delay or abandon their projects.

---

<sup>42</sup> Dariusz Bliniak, Parkiet Biomasy/Polish biomass exchange. Towarowa Gielda Energii SA. [Polish].

<sup>43</sup> Jadwiga Jarzębowicz, TVP: Słoma tania jak barszcz (2013). Available at: [www.tvp.pl/wroclaw/aktualnosci/rolne/sloma-tania-jak-barszcz/10600856](http://www.tvp.pl/wroclaw/aktualnosci/rolne/sloma-tania-jak-barszcz/10600856), last accessed on 10.01.2014. [Polish].

## 5. Impact of promotion mechanisms on straw markets

### 5.1 Impact in the past years

As already mentioned, the straw markets for energy depend strongly on the political situation and the stability of the regulation and promotion mechanism for green energy. In Denmark, where straw is widely used for heat and electricity generation, the price of straw is rather constant and there are no visible drastic changes on the market. In Poland, on the contrary, since 5-7 years a drastic increase of the prices of not only straw, but also other substrates (e.g. wood) could be observed. Straw has become a valuable material as the number of straw using installations increased. However, after a drop in the prices of green certificates, the price of straw has decreased as well. It seems that the stabilization of the market will be one of the most important tasks for future years in order to create a basis of trust for the development of straw-using technologies.

### 5.2 Anticipated trends in the future

So far, it is difficult to estimate the future role of straw for energy provision in different countries and different sectors. Because of the comparable expensive provision and conversion technologies the energetic use of straw will depend on incentives and support schemes.

It is not clear whether the EU 2030 targets for the transportation sector will be continued in the form known currently in the 20-20-20 objectives. However, the facilities for the production of the advanced biofuels typically have to be realised on large scale to profit from economies of scale and achieve low production costs. This criterion however limits the possible locations for those plants. As straw potentials are often scattered, it seems more promising to focus on the installation of smaller straw conversion units – for heat, combined heat and power and for material use, than for the advanced biofuels. Another possibility is to use a variety of lignocellulosic biofuels in one single plant in order to overcome above mentioned restrictions.

The second open question is how the feedstock priorities for bioenergy will develop. Today there is a clear preference of using residues and wastes for the provision of biofuels, established in the so called “double counting” of biofuels from residues<sup>44</sup>. An increased bioenergy provision from straw under the current support scheme can lead to the following discussion:

- Maintaining the humus balance: The availability of straw in many European regions has been investigated in different studies (compare <sup>45</sup>, <sup>46</sup>, <sup>47</sup>, <sup>48</sup>, <sup>49</sup>). Nevertheless, the

---

<sup>44</sup> Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

<sup>45</sup> Rettenmaier, N. u. a.: Status of Biomass Resource Assessments; Version 1, Institut für Energie und Umweltforschung Heidelberg GmbH, Heidelberg, Dezember 2008. Available at: <http://www.eubee.com/>, last accessed 13.05.2014.

<sup>46</sup> Globale und regionale räumliche Verteilung von Biomassepotenzialen - Status Quo und Möglichkeit der Präzisierung; Endbericht, November 2010, BMVBS-Online-Publikation. Available at: <http://www.bbsr.bund.de/BBSR/DE/Veroeffentlichungen/BMVBS/Online/2010/ON272010.html>, last accessed 13.05.2014. [German]

collection and use of straw may influence the soil organic carbon, the humus balance of the soil and can cause environmental problems like erosion, effects of the water household etc. Regional information is necessary to avoid those complications. First investigation for Germany showed that there are preferable regions for straw utilisation. A comparable information base for Europe is still missing but necessary especially if larger conversion facilities are planned.

- Indirect effects of increased straw utilisation: Is the residue an “unused residue” or does the increased use of straw lead to shift of material flows, for example in animal feeding; this discussion might even be more difficult if straw based biofuels are imported from outside Europe and especially if they are produced in developing countries (compare<sup>50, 51</sup>).
- Greenhouse gas reduction potential and environmental effects: It is necessary to define clearly the calculation procedures (e.g. energetic or exergetic allocation shall be applied?) as well as to identify other effects from the agricultural production (e.g. biodiversity risks through intensive production).
- Straw has a market price which may vary depending on the supply and demand situation. Current prices are in the range of 50-100€ per tonne, but higher and lower spikes are possible. Also for advanced biofuels this feedstock cost creates a risk for business development.

Given stable political frame conditions, a moderate increase of bioenergy provision from the domestic potential is expected.

### 5.3 Lessons for policy makers

- There is a high potential of energy from straw in the EU-27 that could contribute to the future targets for renewable energy in Europe. However, the spatial distribution of this potential is very heterogeneous and can therefore, amongst others, lead to big differences in regional prices for straw.
- Since a specific amount of straw is needed to preserve soil and humus functions the mechanisms and political incentives for the exploitation of the available sustainable straw potential should be developed carefully. Proposals like a quadruple<sup>52</sup> counting

---

<sup>47</sup> Edwards, R.A.H. u. a.: GIS-Based Assessment of Cereal Straw Energy Resource in the European Union; Proceedings of the 14th European Biomass Conference & Exhibition. Biomass for Energy, Industry and Climate Protection, Florenz, München, 2005, (ISBN: 88-89407-07-7).

<sup>48</sup> Ericsson, K.; Nilsson, L.J.: Assessment of the potential biomass supply in Europe using a resource-focused approach; Biomass and Bioenergy, Bd. 30 (2006), Nr. 1, S. 1–15, (doi:10.1016/j.biombioe.2005.09.001).

<sup>49</sup> Scarlat, N.; Martinov, M.; Dallemand, J.-F.: Assessment of the availability of agricultural crop residues in the European Union: Potential and limitations for bioenergy use; Waste Management, Bd. 30 (2010), Nr. 10, S. 1889–1897, (doi:10.1016/j.wasman.2010.04.016).

<sup>50</sup> Majer, S.; Oehmichen, K.: Influence of the re-evaluation of residual and waste materials on the GHG balance of first generation biofuels; October 2013, Report prepared for UFOP. Available at: [http://www.ufop.de/files/3513/9176/9353/Report\\_DBFZ\\_GHG\\_waste\\_080114.pdf](http://www.ufop.de/files/3513/9176/9353/Report_DBFZ_GHG_waste_080114.pdf), last accessed 14.07.2014.

<sup>51</sup> Batidzirai, B.: Design of Sustainable Biomass Value Chains: Optimising the supply logistics and use of biomass over time; November 2013, (ISBN: 9789086720569).

<sup>52</sup> In October 2012 the European Commission has published a proposal for the adaptation of the EU RED and FQD. This proposal included a quadruple counting of biofuels from straw towards the 10% target for 2020.

of fuels from straw might create strong incentives to overuse the sustainable share of available straw.

- The choice of the inefficient policy mechanisms or unexpected market changes as it was e.g. the case in Poland may, however, cause severe turbulences of the entire market (not only of the straw market). Therefore, correction mechanisms should be implemented by policy makers shortly after the negative trends become visible.
- The development of advanced bioenergy technologies based on straw has to be based on stable political frame conditions. Especially for the European biofuel sector, specific targets for the time frame beyond 2020 have to be defined by EU policy makers.
- Straw availability in developing and especially tropical countries is much more limited than in temperate zones. Import of products provided from straw need a clear framing by dedicated sustainability criteria.