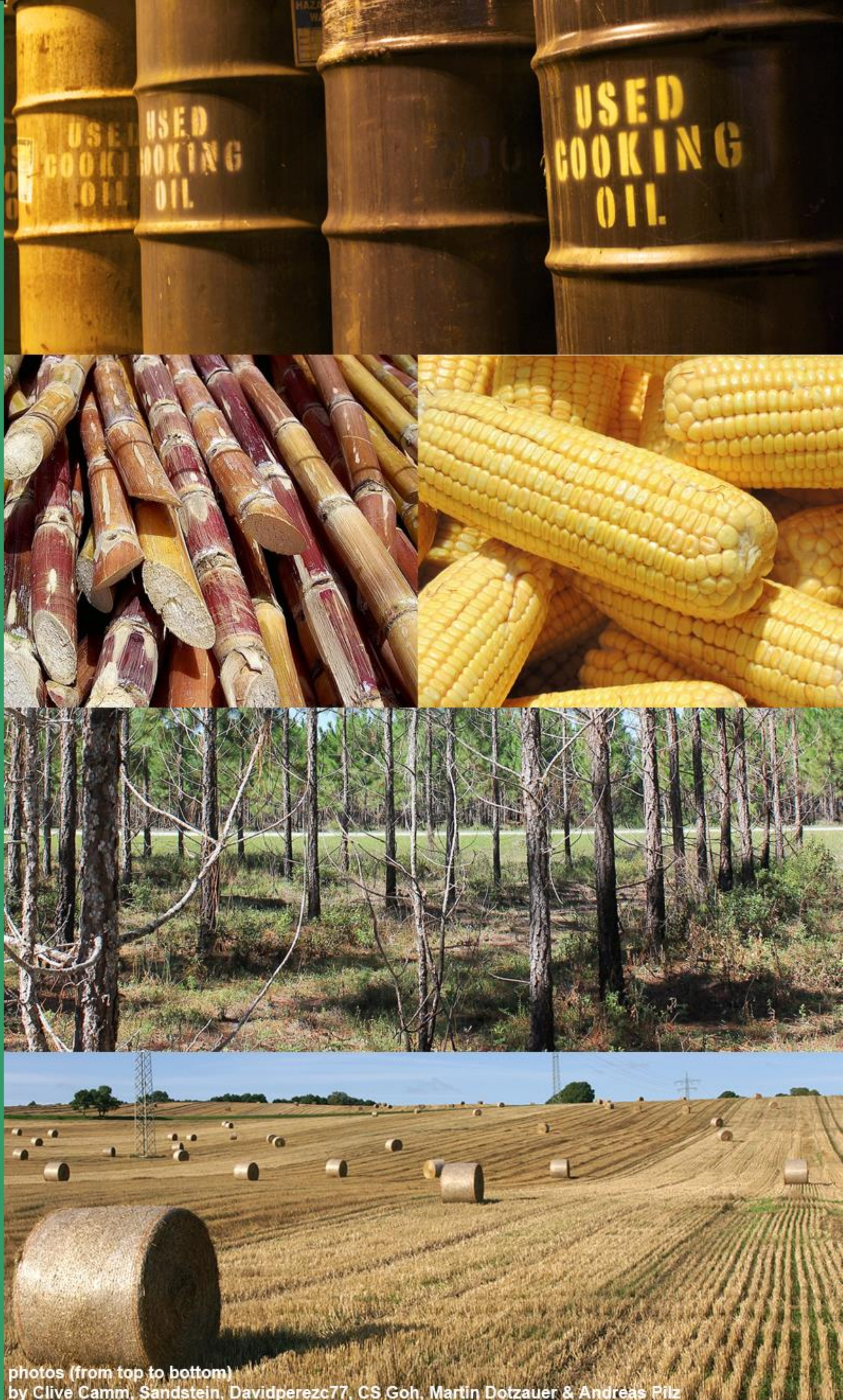

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Impact of promotion mechanisms for advanced and low-iLUC biofuels on markets

Summary report

IEA Bioenergy

Task 40: Sustainable International Bioenergy Trade

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Table of Contents

Table of Contents 5
1. Introduction 6
1.1. Background 6
1.2. Scope of the study 6
2. Used cooking oils and animal fats for biodiesel 8
2.1 Double counting advanced biofuels in the EU 8
2.1.1. Renewable Energy Directive 8
2.1.2. Implementation of double counting biofuels in the EU 8
2.2 Used cooking oils and animal fats for biodiesel in the Netherlands, Italy and the UK 10
2.2.1. Trade of UCO, AF and double counted biofuels 10
2.2.2. Impacts on traditional end-uses 11
2.3 Critical issues and risks 12
2.4 Conclusions 13
3. Sugarcane ethanol from Brazil to the US 14
3.1. Renewable Fuel Standard in the US 14
3.1.1. Biofuel mandates 14
3.1.2. Adjustments to the biofuel mandates 15
3.2. Brazilian Biofuel Policy 15
3.3. Ethanol trade between Brazil and the US 15
3.4. Critical issues and risks 17
3.5. Conclusions 18
4. Straw for bioenergy 19
4.1. Straw potential and use for energy 19
4.2. Straw prices 20
4.3. Critical issues and risks 22
4.4. Conclusions 23
5. Wood pellets from the US to the EU 24
5.1. Introduction 24
5.2. Impact in the past years 26
5.3. Anticipated trends in the future 26
5.4. Conclusions and recommendations 27
6. Conclusions from the case studies 29

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 USA.

While technologically challenging lignocellulosic ('2nd 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 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 (see chapter 2).

2. **Sugarcane ethanol**: impact of the subtargets for specific advanced biofuels in the US Renewable Fuels Standard (RFS2), where sugar cane ethanol is classified as 'advanced biofuel'. This has had a clear impact on prices and trade patterns between Brazil and the US. (see chapter 3)

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. (see chapter 4)

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. (see chapter 5)

This report contains the summary of the case studies. The case studies themselves are available as separate reports. All reports are available at:
http://bioenergytrade.org/publications.html#lowiluc

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.

2. Used cooking oils and animal fats for biodiesel

2.1 Double counting advanced biofuels in the EU

2.1.1. Renewable Energy Directive

According to the Renewable Energy Directive[1] (RED) the share of renewable energy in the transport sector must rise to a minimum of 10% in every European Member State in 2020. While electric vehicles can contribute to this target, the main share is expected to be covered by biofuels.
The Directive aims to promote only biofuels which fulfil certain sustainability criteria, i.e. they need to generate substantial greenhouse gas (GHG) savings if compared to fossil fuels' emissions, and they should not cause negative impacts on land use in terms of biodiversity and carbon stock.

The use of **waste, residues, non-food cellulosic material and lignocellulosic material** for the production of biofuels is supported as a favourable alternative to traditional agricultural commodities-based feedstocks. In order to stimulate the use of such feedstocks, the RED foresees that biofuels from these feedstock types can be counted double towards the renewable energy in transport target (RED, Art.21). In practice countries can fulfil their target with half the amount of biofuels, and when applied to fuel distributors, they can be allowed to blend only half of the biofuel into fossil fuel in order to reach their blending obligations if the respective biofuel was produced from waste, residues or lignocellulose. This incentive is widely known as ***double counting***.

2.1.2. Implementation of double counting biofuels in the EU

The Renewable Energy Directive allows double counting in biofuels support mechanisms, but there is no uniform measure provided by the European Commission to implement the double counting mechanism on Member State level. Member States have implemented different measures in the market and applied different definitions to determine which feedstocks are eligible for double counting.

The main support policies implemented in EU Member States are:

- ***Substitution obligations***, requiring fuel distributors to put a certain amount of biofuels (% share of transport fuel) to the market.
    - Art.21 biofuels can be counted double towards this target (not always implemented by Member States)
    - Different Member States have coupled this with certificates to demonstrate compliance. These certificates can be tradable, i.e. the obligated party pays another party for certificates showing he has put a certain volume of biofuels on the market.
    - In practice there should be a penalty for non-compliance.
- ***Tax reduction*** for biofuels compared to fossil fuels
    - Some countries still apply tax reduction for biofuels. In some cases there is a differentiated tax for Art.21 biofuels.

The main biofuels applied under the double-counting mechanism are:

- biodiesel (methyl ester) from used cooking oils (UCO) and animal fats (AF),

[1] Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources

- HVO (hydrotreated vegetable oil) from used cooking oils and animal fats,
- biomethane from digestion of organic waste, manure or sludge

Some advanced technologies are emerging; most of them are still in demonstration or pre-commercial production; so far their contribution to the transport biofuel targets is marginal:

- bio-ethanol from lignocellulose material, such as straw or woody biomass (in demo, IT)
- bio-methanol from crude glycerine (NL)
- bio-DME from black liquor (SE)
- Fischer-Tropsch diesel (BTL) from gasified woody biomass

When looking at the reported volumes of double counting biofuels in the EU Member States, the Member States can be divided in three groups:

- 9 countries with substantial markets, also relying on trade,
- 6 countries with a (small) domestic market,
- 13 countries where no double counting biofuels have been reported.

Overall more than 90% of double counting biofuels in the EU are based on used cooking oils and animal fats. This market is dominated by a few countries, namely the UK, Germany (from 2012), Italy and the Netherlands.

This case study has focused on the markets in the Netherlands and Italy, and included results of a study done by Ecofys in 2013 for the UK market[2].

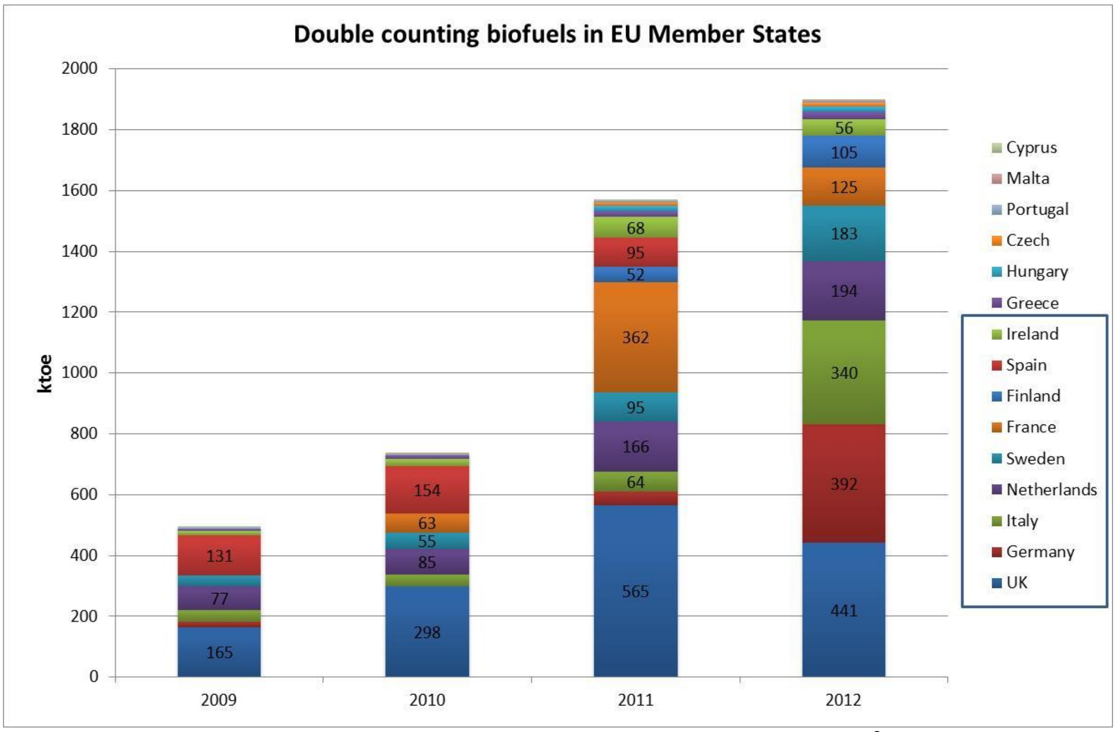

Figure 1. Overview of double counting biofuels in the EU Member States [3]

[2] Ecofys (2013) G. Toop et al. Trends in the UCO market. Study commissioned by the UK Department for Transport. November 2013

[3] Based on 2013 Renewable Energy Progress Reports of the EU Member States

2.2 Used cooking oils and animal fats for biodiesel in the Netherlands, Italy and the UK

Table 1 shows the overview of the implementation of double counting mechanism in the Netherlands, Italy and the UK. The Netherlands and the UK have been heavily relying on double counted biofuels in meeting the blending obligation in the past few years. The demand for double counted biofuels in Italy also shows an increasing trend. However, domestic availability of UCO and AF in these countries is insufficient to reach this demand, so they have been importing from other Member States or even oversea. While Italy and UK are net importer of double counted biofuels, the Netherlands has actually been producing excessive stock of UCO biodiesel for export, largely based on imported UCO and AF.

Table 1. Overview of the implementation of double counting mechanism in the Netherlands, Italy and UK[4]

Feedstock			
Used Cooking Oil	x	x	x
Animal fat cat. I	x	x	x
Animal fat cat. II	x	-	?
Animal fat cat. IIII	-	-	-
Biofuel blend *(ktoe)*			
Total biofuel blended	319	1362	888
Of which double counted	194	340	441
Principle biofuels for double counting	Mostly UCO & AF biodiesel and HVO; fractions of bio-methanol (from glycerine) and bio-methane	Mostly UCO & AF biodiesel	Mostly UCO & AF biodiesel
Situation in relation to trade	Large importer of UCO & AF; exporter of biodiesel of these feedstocks	Large import dependency	Large import dependency
Form of non-physical trade	Bio-tickets	Biofuel Immission Certificates (CICs)	Renewable Transport Fuel Certificates (RTFCs)

2.2.1. Trade of UCO, AF and double counted biofuels

The Netherlands: Germany has been the largest trade partner of the Netherlands in terms of UCO volumes. The Dutch UCO & AF market is closely linked to the German market. The prices in both markets determine the supply and flow of UCO & AF. However, in terms of net import, Belgium, UK and US are among the biggest suppliers. Interestingly, the import of oils and fats mixture from North America as well as Asia has grown remarkably from 2010 - 2012[5]. In 2009, the volume of these trade flows was negligible. Compared to 2010, a

[4] Based on 2013 Renewable Energy Progress Reports & ePURE (2003). Double counting, half measures: Study on the effectiveness of double counting as a support for advanced biofuels. March 2013

[5] MVO (2013) Statistics Year Book 2012.

relatively large amount of UCO & AF have been processed to biofuels in 2012, however only a small percentage was being consumed domestically and the rest were exported to other Member States.

Italy: Different from the Netherlands, Italy mainly imported double counted biofuels instead of the feedstock. In 2012, about 98 % of UCO biofuels consumed in Italy were imported. The largest trade partners are Spain and the Netherlands, together supplying more than 70% of the total consumption. Double counting was restricted to EU sourced feedstocks. Interestingly, Italy has also imported biofuels made from UCO collected in Italy but processed outside Italy (about 3%). However, local production of UCO biofuels has increased substantially from 2 ktons in 2012 to 14 ktons in 2013 using domestic source of UCO, while total consumption of double counting biofuels has plummeted from 380 ktons in 2012 to 129 ktons in 2013[6]. This was related to the special limitations to double counting biofuels from 2013 in Italy and more accurate controls on the correctness of the information gathered. Similarly for AF biofuels, Italy has also turned to a producer in 2013 rather than relying heavily on import. AF was collected from domestic source, and also imported from neighbouring countries like Austria, Germany and other Member States. These AF mainly come from category I fats.

UK: The consumption of domestic produced UCO biofuels in UK has remained stable in the range of 100 – 150 million litres. However, the import has been fluctuating in the past 5 years. The total consumption peaked at about 760 million litres in 2011/12, but fell sharply in 2012/13, when the import from the Netherlands, Germany and US has plummeted[7]. The decrease may simply be because the volume of UCO from that source has decreased or it may be indicative of biodiesel being traded through the Netherlands and therefore potentially misreported as being of Dutch origin (i.e. mistakenly reporting the origin of the biodiesel or the place of purchase of the biodiesel, rather than the origin of the UCO feedstock itself). In 2013, the share of non-European sources is clearly growing, but also shifting from US to over 50 other countries worldwide.

2.2.2. Impacts on traditional end-uses

There are multiple end-uses of UCO and AF:

- *Oleo-chemistry*: According to APAG, the European association of the oleochemical industry, the relation between UCO and animal fat used in the industry is 1:9. The relatively low UCO share is explained by its variable quality, due to the variety of sources from different entities using different vegetable oils. About 10% of collected UCO is used by the oleochemical industry.
- *Animal feed ingredients*: Before the year 2003 UCO was mainly used as an animal feed ingredient. However in 2003 the EU Animal Byproduct Regulation banned the use of UCO in animal feed due to health reasons. Animal fats are also broadly used as ingredients in feed for livestock animal and pets, in the petrochemical industry (as lubricants, insulators, emulsifiers, etc…) and also in the manufacturing of health care products like soap, perfumes and cosmetics.
- *Power generation*: UCO can be burned in bioliquids power plants.
- *Food*: Edible animal fats (as category 3) are largely used in the food industry, such as in the meat manufacturing and for frying or directly in cooking. Various acids and triglycerides of refined and fractionated fats are used as emulsifiers in the food

[6] GSE database, 2014

[7] UK Department for Transport RTFO Biofuel Statistics

production. AF from category 3 are however not considered for double counting in all three countries.

The Netherlands: The consumption volume of UCO and AF for animal consumption has decreased significantly in 2011 and 2012. UCO and AF were also used for other purposes, but not burnt in power plants. Since 2011 the volume of UCO and AF consumed for biofuel production has become larger than the total volume of UCO and AF consumed for other uses.

Italy: Around 5.8 ktons of UCO and 17 ktons of AF were burned in power plants in Italy in 2013. The amount of UCO used for other purposes is unclear. For AF, less than 10% of AF were used for biofuel production. There is no clear picture from the statistics how the use of UCO and AF for biofuels has impacted the other uses.

UK: Before the use of UCO for biofuel production, UCO was most commonly put into the local drainage system or sent to landfill, despite these disposal options being prohibited under UK law. The price which is now received from UCO collectors is a clear incentive for customers (e.g. restaurants, pubs) to have its UCO collected.

2.3 Critical issues and risks

Biofuels from UCO or AF can be counted double towards companies' obligations, so there is a clear incentive to use these instead of virgin oils in countries where the double counting principle is clearly implemented in national legislation (targets can be reached with only half the amount of biofuel). Nevertheless available amounts of UCO and AF are limited, so there may be different issues arising:

- *Lower efforts towards advanced '2nd generation' biofuels*: While the double counting mechanism was intended to support technology innovation (towards more technologically advanced '2nd generation' biofuels), it has actually pushed UCO and AF biodiesel, which were relatively mature and inexpensive in relation to other advanced biofuels. So it has only little contributed to technology innovation, while the potential of UCO and AF remains limited (in the order of 1% of transport fuel consumption).

- *Reduced physical volumes of biofuels on the markets*: For some countries relying heavily on UCO and AF biofuels, we notice a decrease of the physical amount of biofuels on their markets - although administratively the obligated target is still achieved - because of their shift to double counting biofuels. This also implies that less fossil fuel is displaced when using the double counted UCO biofuel, contributing less to energy security.

- *Inefficient trade and market distortion due to differences in policies between Member States*: Promotion mechanisms in countries like the UK, the Netherlands, Italy, Finland and Ireland have attracted UCO and AF from other countries (which have less favourable policies). Uncertainties and differences in policies such as the definition of waste, the eligibility of feedstock for double counting and mechanisms to verify the sources have caused confusion in the market.

- *Impacts on traditional markets relying on these feedstocks*: Prices for UCO & AF have increased steadily in the past years, from near zero in the 1990s to a little below virgin oil prices. These price increases may impact other applications of UCO and AF, mainly in the oleochemical industry, which uses around 10% of UCO resources. Nevertheless it does provide an interesting alternative for unsustainable disposal (drainage, landfill) and unhealthy practices (extended use in cooking).

- *Risk for unlawfully claiming double counting for certain batches of vegetable oil biofuels*: It is important to distinguish, trace and verify UCO and AF to reduce the risk of fraud. There have been various inconsistencies in the markets in previous years. Tracing of UCO and AF is more difficult than virgin oils and there is lack of uniform mechanisms across Member States. Verification of UCO from outside the EU is very challenging.

- *Long-distance trade of UCO?* Export regions in America and Asia also implement their own support policies for biodiesel (from UCO), so we should watch out that European incentives are not competing against domestic policies in these regions. This may induce displacement effects and create trade inefficiencies. Moreover, shipping this material to the other side of the world also brings along additional greenhouse gas emissions – it is probably more beneficial to improve domestic waste management and processing of UCO in these regions.

2.4 Conclusions

Producing biofuels from used cooking oil or animal fats provides an interesting outlet for these products, with high greenhouse gas advantage, on condition that these feedstocks are really waste. Nevertheless we should take into account that potentials of UCO and AF are limited and to achieve higher fossil fuel replacement, other biofuel types will still be needed. The double counting mechanism, which was intended to promote advanced biofuels, has merely incentivised the use of UCO and AF biodiesel, a relatively mature and inexpensive biofuel in relation to other biofuels. For market parties this was a very cost-effective way to reach their obligations, but it hardly contributed to technological advances. More specific promotion mechanisms will be needed to achieve that.

The current promotion mechanism has boosted demand for UCO and AF in certain countries, which are now importing UCO from all over the world. It should be analysed if this has led to displacement effects in the sourcing regions and trade inefficiencies. Moreover, prices of UCO and AF have increased to a little below the level of virgin oils. This clearly has an impact on other markets using UCO and AF, such as the oleochemical industry.

Finally, double counting biofuels from these materials gives an extra economic incentive over other (more expensive) biofuels. This induces risks of fraud (unlawful claiming of double counting). A good tracing and verification system becomes very important, but is not evident, specifically for materials imported from all over the world.

More detailed analysis can be found in the case study report.

3. Sugarcane ethanol from Brazil to the US

Brazil and the USA are the most important producers, consumers and traders of ethanol. Brazilian ethanol is produced primarily from sugarcane, while the US produces ethanol primarily from maize. Until 2010, ethanol trade between the two countries was one direction only (from Brazil to the US). In recent years, there have been significant volumes of bilateral trade of (physically identical) ethanol between the US and Brazil driven by their different biofuel policies[8]. Part of it is related to the way 'advanced biofuels' are promoted in the US.

3.1. Renewable Fuel Standard in the US

The main promotion system for biofuels in the US is the Renewable Fuel Standard (RFS).The RFS is a requirement that a certain percentage of petroleum transportation fuels needs to be displaced by renewable fuels. RFS1 started with the Energy Policy Act of 2005. This was amended by the Energy Independence and Security Act (EISA) of 2007, the new renewable fuel standard being known as RFS2. The RFS2 further segmented biofuels in four classes (renewable fuels, advanced fuels, biobased diesel, cellulosic biofuel), each with their own mandated volume[9].

3.1.1. Biofuel mandates

The cellulosic biofuel (S) and bio-based diesel (B) mandates set minimum quantities of these two types of fuels to be consumed. The overarching advanced fuel (A) mandate is greater than the sum of the cellulosic and bio-based diesel mandates, which creates an undefined advanced gap for other advanced fuels used to meet the larger advanced fuel mandate. The 'other advanced fuels' explicitly include ethanol made from sugarcane and explicitly exclude maize starch ethanol. This advanced mandate is nested in a larger over-arching renewable fuels mandate (T). This mechanism creates a hierarchy among the fuels.

In the actual RFS targets two aspects catch the eye:

- ***Cap on non-advanced biofuels*** (i.e. corn ethanol). There is an implicit cap on non-advanced biofuels of 15 billion gallons from 2015. Mind that ethanol consumption in 2010 almost reached 13 billion gallons, so the growth margin for corn-based ethanol is very limited. On the other hand US gasoline consumption is around 130-140 billion gallons per year, so about 9-10% of fuel sold as motor gasoline is ethanol, which is close to the E10 blend wall. This implies that growth margin for ethanol overall (including advanced ethanol) is limited, unless E15 or E85 are introduced on large scale.
- ***High expectation for cellulosic biofuels***. The mandate foresees a spectacular growth of cellulosic biofuels from virtually nothing in 2009 up to 16 billion gallons in 2022.

Renewable Volume Obligations (RVO) and *Renewable Identification Numbers (RIN)* are the mechanisms the Environmental Protection Agency (EPA) uses to implement the RFS program. RVOs are the targets for each refiner or importer of petroleum-based gasoline or diesel fuel, while RINs are a type of tradable certificates which allow for flexibility in how obligated parties may choose to comply. RINs have a market price.

[8] Also discussed in: S. Meyer, J. Schmidhuber, J. Barreiro-Hurlé (2013). Global Biofuel Trade: How uncoordinated biofuel policy fuels resource use and GHG emissions. FAO ICTSD, Issue Paper48. May 2013

[9] US EPA. Renewable Fuel Standard (RFS) website

3.1.2. Adjustments to the biofuel mandates

There is an annual RFS review process where the EPA may propose waivers compared to the initial targets. Faced with inadequate production capacity to meet the cellulosic biofuel mandate as legislated for 2010-2013, the EPA was forced to reduce the cellulosic biofuel mandate significantly while choosing to leave the total and advanced mandate in place. The short fall in cellulosic ethanol biofuels coupled with the EPA decision to maintain the other mandates means that the size of the implied undefined advanced gap has grown and even created an extra need for undefined advanced fuels. This prompted an increase of biobased diesel as well as US sugarcane ethanol imports from Brazil, and plentiful supplies of maize starch ethanol in the US prompted increased ethanol exports.

3.2. Brazilian Biofuel Policy

Brazil is the world's second largest producer of ethanol fuel (after the US) and the world's largest exporter. It uses sugarcane as feedstock; the residual cane-waste (bagasse) is used to produce heat and power, which results in a very competitive price and also a low fossil energy input and high greenhouse gas savings. It is therefore qualified as 'advanced biofuel' in the United States, also because it is recognized that emissions due to land use change (LUC and iLUC) for sugarcane ethanol are low.

In Brazil, ethanol is used in two ways: (1) as octane enhancer in gasoline, in the form of 18 to 25% anhydrous ethanol (minimum mandated by law), (2) as pure ethanol in neat-ethanol engines or flexible fuel vehicles (FFV), in the form of hydrated ethanol.

In the past decades ethanol prices have been liberalized along with gasoline and sugar markets, although ethanol still maintained a (state dependent) tax advantage relative to gasoline. It is still required by law that all gasoline should be blended at 18 to 25 percent ethanol inclusion rates. The governments sets the minimum percentage of ethanol blend according to the results of the sugarcane harvest and the amounts of ethanol produced from sugarcane, resulting in blend variations, even within the same year. The shift in supplies available for domestic consumption can occur either through production shortfalls or from increased trade demand.

3.3. Ethanol trade between Brazil and the US

Until 2009, the US was a net importer of ethanol to fulfill the demand of its domestic ethanol market, most of it coming from Brazil and the Caribbean area (most of which was also Brazilian ethanol). However, since 2010, the US is a net exporter of ethanol, mainly to Canada, the EU, and in 2011 also a considerable amount to Brazil. Since 2011 we see the phenomenon that large volumes of sugarcane based ethanol are imported from Brazil, while also considerable amounts of corn based US ethanol are exported to Brazil.

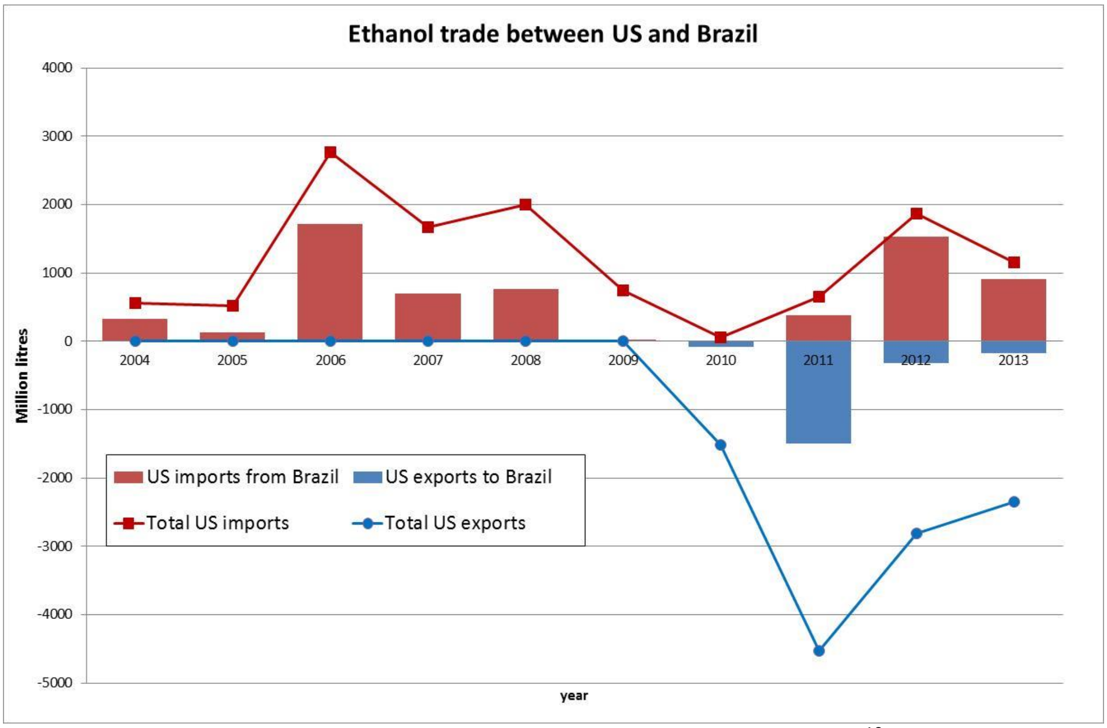

Figure 2. Ethanol imports and exports from the US, and trade with Brazil[10].

There are various factors impacting this trade between the US and Brazil:

- *Seasonal fluctuations*. Brazilian sugarcane harvest season is between March and November. Unlike corn, sugarcane cannot be stored because it goes bad after a couple of days, forcing mills to process the entire crop while harvesting.
- *Varying crop yields*. Typical examples are the low sugarcane yields in Brazil in 2011, and the draught in the US in 2012, leading to low corn yields. 2011 was a particular case with a low production in Brazil and a surplus in the US.
- *Crop prices* (maize, sugarcane) are related to world markets and may favorize one or the other ethanol type.
- *Ethanol market in Brazil*: next to pure ethanol distribution, there is a mandated minimum ethanol blending in gasoline, 18-25%, so there is continuous demand for ethanol on the domestic market. The level may be adjusted according to harvest yields and actual ethanol production. In Brazil, the part of the domestic market that is almost inflexible is the market for anhydrous ethanol (used for blending). In theory, because of FFVs, the market for hydrated ethanol is much more flexible.
- *RFS2 targets in the US*: the biofuel targets in the US make distinction between advanced and non-advanced biofuels, with separate targets (cap on corn based ethanol, minimum target for advanced biofuels). The different biofuel types have different RIN prices.
- *Changes in US policy*, e.g. the ethanol blending credit (0.45$/gallon), and the import tariff of 0.54$/gallon (0.14$/litre) for imported ethanol (waived for Caribbean) both expired end 2011.
- *EU market:* Historically, trade flows (mostly exports from Brazil) were impacted by the European market. The amount currently exported from Brazil to Europe is relatively small, and the US took over this market in the past years.

[10] Source of the data: US EIA (2014), Annual Energy Outlook 2014. US Energy Information Administration, April 2014

3.4. Critical issues and risks

Incentives for technologically advanced biofuels in the RFS2 were insufficient for deploying these types of biofuels

Cellulosic biofuel targets in the RFS2 were very optimistic – at least in the short to medium term. From the start in 2010, cellulosic biofuel targets have been waived, down to less than 1% of original targets, and even those targets were not met on the market. In 2010-2013, the original 'advanced biofuel target' (of which cellulosic biofuels were part) remained as in the original RFS2, meaning that the gap needed to be filled by other advanced biofuels, i.e. biobased diesel and sugarcane ethanol. So the incentives for cellulosic biofuels do not seem to be sufficient, and have merely promoted more imports of Brazilian ethanol and higher production of biobased diesel.

E10 "blend wall" creating uncertainty in the fuel markets.

Ethanol blending in gasoline in the US on average reaches between 9 to 10%, so in practice, the blend wall of 10% (E10) is reached. There are some efforts to further promote E85 (in flex-fuel vehicles) and also to extend the blend wall to E15 for released gasoline models. However, there are lots of concerns from vehicle manufacturers and fuel distributors, which also feed into the public. So the blend wall seems to be a practical barrier, which may impede further expansion of ethanol in the US fleet (corn based, sugarcane based, and in particular cellulose based ethanol due to higher production costs and market uncertainties). This creates uncertainty on how to fulfil the RFS mandates, with higher expected costs, and creates fluctuations in the price of RINs. This in its turn creates instability on biofuel markets.

Volatility of RIN markets

RIN prices have proven to be very volatile which makes it difficult to reach a solid business case for new advanced biofuels (other than commercial ones like sugarcane ethanol or biobased diesel). The uncertainty of the blend wall is an extra barrier for cellulosic ethanol.

Cap on corn ethanol creates exports

The RFS2 caps the amount of 'non-advanced biofuels' (i.e. corn ethanol). With production capacity higher than this cap, the US has now become a net exporter of ethanol, with the main partners being Canada, the EU, some Asian countries, but also Brazil in the past 3 years. So in practice, the US is importing sugarcane ethanol to fulfil its advanced biofuel targets, while it exports an excess of corn ethanol.

Intra-trade between Brazil and the US

At a certain stage (in 2011), there was a high intra-trade between the US and Brazil: the US was importing sugarcane ethanol from Brazil to fulfil its advanced biofuel targets; meanwhile Brazil was falling short of ethanol because of lower sugarcane harvests. Two consequences resulted from this: (1) Brazilian authorities reduced the general blending mandate from 25% to 18% in April 2011, and (2) Brazil started to import corn ethanol from the US. So this created an intra-industry trade of physically identical but policy differentiated biofuels.

This intra-trade of physically identical ethanol incurs additional transportation, adding costs and releasing additional GHG emissions, and therefore moderating some of the anticipated advantages of (advanced) biofuel use. Moreover, substituting Brazilian ethanol (in Brazil) with corn ethanol (having lower greenhouse gas performance) creates a carbon leakage in Brazil. When quantifying the combined effects, through the intra-trade of 2011 around 80-

90% of the GHG advantage for sugarcane ethanol was lost, in 2012-2013 this effect amounted to around 20% of the GHG advantage.

Impact on Brazilian ethanol prices
The intra-trade drives up ethanol prices in Brazil, the extent of which depends critically on the size of domestic supplies relative to Brazil's own blending mandate and where domestic demand sits relative to that mandate. Exports typically represent 10% of Brazilian ethanol production. In 2011 and 2012, Brazilian ethanol (FOB) was more expensive than US corn ethanol[11] – still imports were attractive because import tariffs have been removed and there were quite high RINs for advanced biofuels to compensate for higher costs.

Meanwhile the situation has more or less stabilized and US ethanol exports to Brazil have been largely reduced (while imports of Brazilian ethanol to the US are still important). Prices of Brazilian ethanol have stayed in the higher end and are now in the same range as US ethanol. The main reason is that US markets are now fully open for Brazilian imports since import tariffs has been removed, but also the advantage of higher RINs for advanced biofuels has more or less gone away since 2013.

3.5. Conclusions

The main promotion mechanism for advanced biofuels in the US are the RFS mandates, implemented through Volume Obligations for fuel suppliers and tradable certificates (RINs), which have a certain market value. There are specific separate targets for advanced biofuels, and subtargets for biobased diesel and cellulosic biofuels.

The growth of cellulosic biofuels has clearly stayed below expectations, and in the past 4 years, the subtarget for cellulosic biofuels was consistently reduced by EPA. The question is whether current promotion mechanisms are the right ones to stimulate further growth of technologically challenging cellulosic biofuels. Meanwhile, imports of Brazilian sugarcane ethanol (recognised as advanced biofuel by US authorities) have partly compensated for the underperformance of cellulosic biofuels.

There is a consistent import of Brazilian sugarcane ethanol to the US, being one of the cheaper ways to fulfil the advanced biofuels mandate, and with the current RFS system (and the abolishment of import tariffs on Brazilian ethanol) this seems to remain.
In normal seasons, Brazil is able to export about 2 to 3 Billion litres per year to the US. For these volumes, the domestic prices will not increase a lot. But Brazil will not be able to export much more than that, in short-term, at low prices.

In periods when Brazil is struggling with sugarcane yields (as was the case in 2011), when in fact they only have sufficient volume to cover the domestic ethanol market, this import demand from the US market may lead to intra-trade (also shipping ethanol back from the US to Brazil) and lower blending mandates in Brazil. At the end, this has a large impact on greenhouse gas emissions (carbon leakage), and on prices.

[11] TradingCharts.com (June 2014) & UNICA (June 2014)

4. Straw for bioenergy

Straw is often cited as one of the most promising feedstocks for advanced biofuels. While market uptake so far is limited, we will focus on the impact of using straw for stationary bioenergy, looking at the situation in **Germany, Denmark and Poland**. This will provide issues and learnings which will also be relevant when future markets for advanced biofuels from straw may arise.

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 promotes their application for biofuel production. On national level, support schemes for renewable energy production are increasingly promoting the use of agricultural residues (e.g. the Renewable Energy Sources Act 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.

4.1. Straw potential and use for energy

The technical straw potential in the EU-27 varies between 820 and 1800 PJ annually, depending on the source[12, 13, 14, 15]. Within the EU-27, France, Germany and Poland show the highest technical straw potentials. Altogether more than half of the overall European straw potential is located in these 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.

Germany: Approximately 30 million tonnes of straw (fresh matter) are produced annually in Germany[16]. 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.
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.

[12] JRC (2006): Cereal Straw Resources for bioenergy in the European Union. Proceedings of an Expert Consultation; Pamplona, October 2006.
[13] Zeller et al. (2011): Basisinformationen für eine nachhaltige Nutzung landwirtschaftlicher Reststoffe zur Bioenergiebereitstellung.
[14] Thrän et al. (2009): Regionale und globale räumliche Verteilung von Biomassepotenzialen. Status Quo und Möglichkeit der Präzisierung
[15] Panoutsou et al. (2012): The role of straw for heat & electricity in EU27 member states in 2020 and in 2030 with respect to costs and sustainability criteria.
[16] Weiser et al. (2013) Integrated assessment of sustainable cereal straw potential and different straw-based energy applications in Germany

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[17]. 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.

Denmark: The straw potential in Denmark originates mainly from wheat and barley cultivation. The total amount of straw produced annually is between 5 and 6 million tonnes per year, of which 1 to 1.5 million tonnes is used for energy, approximately 2 million tonnes are used for bedding and forage, and 2 million tonnes are not collected[18].
The introduction of support mechanisms for bioenergy in Denmark can be traced back to the year 1980. As a result of consequent and long-lasting political actions the straw market in Denmark belongs to most developed and stable in Europe. It is strongly dominated by farm scale boilers (7000 units), which represent approximately 30% of the total straw consumption in the home market. Another important sector is the district heating sector: approximately 50 district heating boilers and 7 CHP plants are running on straw, representing around 20% of straw resources used[19]. Next to that there is also one power plant co-firing straw pellets, and one dedicated power plant running on straw.
From the mid-1980s up to the year 2000 straw generated a rather constant amount of renewable energy between 10 and 13 PJ, slightly increasing to 15-20 PJ in the past 10 years[20].

Poland: Straw production Poland varies between 18 and 25 million tonnes per year, of which a surplus of 7 to 12 million tonnes could be available[21]. While all polish regions have substantial straw production, some of them have important surpluses, while others have deficits. This also indicates the heterogeneous availability of straw.
The preferred application of biomass in Poland is co-firing of woody biomass. Technical problems with 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.

4.2. Straw prices

To define prices for straw is a rather difficult task. Because of its low energy density straw is currently not comparable to other biomass commodities like wood chip or pellets. Prices for straw differ significantly between countries and regions and are influenced by a number of local, technical and economic parameters. A number of parameters influencing final straw prices:

- Types of logistical processes including loading/unloading, round trips, operation speed/time;

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[17] Hering, Thomas (2012): Energetische Halmgutnutzung in Deutschland

[18] Bang, C. et al (2013): Analysis of biomass prices. Future Danish prices for straw, wood chips, and wood pellets.

[19] FNR Tagungsband 2012: Gülzower Fachgespräche.

[20] Danish Energy Agency: Annual Energy Statistics. Accessed May 2014.

[21] Wiktor Kozłowski, Krzysztof Cygan (2011): Współspalanie słomy z węglem w dużym kotle energetycznym (in Polish)

- Personnel costs,
- Machinery costs (fixed and running costs),
- Diesel fuel (including refunds for agricultural machines),
- Storage capacities and costs,
- Storage losses,
- Fertilizer costs.

Hence, unlike other biogenic fuels such as 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. This is indicated in the figure below.

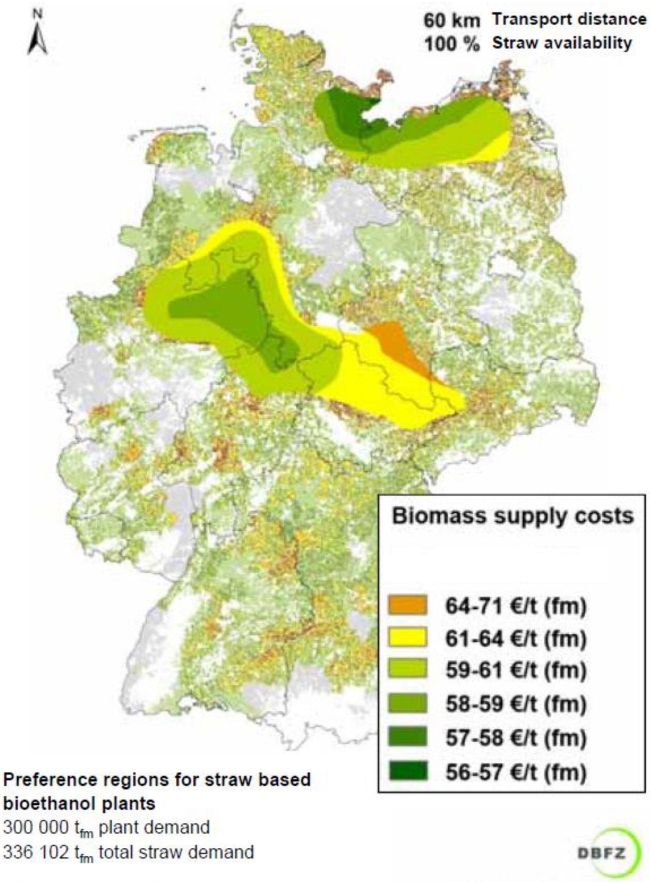

Figure 3. Preference regions and straw supply costs for bioethanol plant[22]

The price level of straw paid by district heating facilities in Denmark is quite constant up to 2007 at about 54€ per tonne for straw, recently increasing to around 70€/tonne[23].

In contrast to the rather stable situation in Denmark, the Polish markets have been much more instable. A drastic fall of green certificate prices in Poland at the beginning of 2013, and the subsequent decrease of demand for agricultural substrates from the large players

[22] Brosowski, A. (2013): Biomass supply costs for cereal straw and preference regions for an ethanol plant in Germany

[23] Danish District Heating Association (2012). Straw to Energy. Status, Technologies and Innovation in Denmark 2011.

resulted in a price drop from 125 to 25 Euro per tonne straw[24]. In many cases, the electricity producing companies have stopped buying the contracted amounts of biomass. Although meanwhile the prices for green certificates have partially recovered, the uncertainty of the investors remains.

4.3. Critical issues and risks

High potential, but heterogeneous: There is a high potential of energy from straw in the EU 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.

Large vs small scale? 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 have to be realised on relatively large scale, and the possible locations for those plants are limited. To explore the unused potential of straw for energy, it may be more efficient to focus on smaller straw conversion units – for heat, combined heat and power and for material use - than for advanced biofuels.

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. An increased bioenergy provision from straw under the current support scheme can lead to the following discussions:

- **Maintaining the humus balance**:
    - The availability of straw in many European regions has been investigated in different studies. Nevertheless the 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.
    - One of the risks related to the sustainable use for straw may be related to the market structure of renewable energy. Renewable energy in Poland is produced by the biggest players (power plants and energy companies), which invest in large installations. 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. 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.
    - Straw availability in developing and especially tropical countries is much more limited than in temperate zones as straw is very important for the humus and nutrient balance in these regions. Import of products provided from straw need a clear framing by dedicated sustainability criteria.
- **Indirect effects of increased straw utilisation**: Is the residue an “unused residue” or does the increased use of straw lead to a shift of material flows, for example in animal feeding. This discussion might even be more difficult if straw based biofuels are

[24] Jadwiga Jarzębowicz, TVP (2013): Słoma tania jak barszcz (in Polish).

imported from outside Europe and especially if they are produced in developing countries.

- 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. The example in Poland shows that instability of the market and price levels may have a long-term negative influence on the entire market, since the potential investors may delay or abandon their projects. Also for advanced biofuels instability in feedstock costs creates a risk for business development.

4.4. Conclusions

The use of residues from agriculture for the production of energy can play a role in the transition towards a more renewable energy supply, both for stationary bioenergy, and in time, also for advanced biofuels. 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. Proposals like a quadruple counting of fuels from straw might create strong incentives to overuse the sustainable share of available straw.

The development of advanced bioenergy technologies (incl. 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. 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. Wood pellets from the US to the EU

Woody biomass is also seen as promising feedstocks for advanced biofuels. While market uptake so far is limited, we will focus on the impact of using wood pellets for stationary bioenergy, and specifically the impact European wood pellets demand has had on the US Southeast region. This will provide issues and learnings which will also be relevant when future markets for advanced biofuels from woody biomass may arise in international markets.

5.1. Introduction

European demand for wood pellets is shaping **international pellet trade**. Belgium, Denmark, the Netherlands and UK are increasingly importing pellets from overseas to meet their renewable energy targets through co-firing of pellets in coal-fired power plants or dedicated biomass plants. Given the lack of coherent EU-wide sustainability requirements for woody bioenergy, these countries create their domestic sustainability systems.

The US Southeast became a key exporter to EU markets in the last years. There are several reasons why this region is a promising export region: feedstock availability, techno-economical capabilities, stable context and relatively close distance to major EU harbours.

The US Southeast is well known as a key fibre basket for sawn timber and pulp and paper products. Pine plantations delineate the US Southeast forest landscape, representing 20 % of the area[25] and providing 60 % of national timber[26]. The economic recession during the 2000s reduced industrial roundwood demand for housing[27], but pulpwood production was maintained almost constant during the last decade[28]. In 2013, the pulp and paper sector dominated demand for wood with a consumption of 68 Mt_{od}/a, while the panel industry uses 9 Mt_{od}/a, and the pellet industry 4 Mt_{od}/a[29]. There is still about 32 Mt_{od}/a unmobilized wood, though much of that might not be available to enter into the markets.

At present, 86 % of forestland is owned by private landowners and 67 % of private forestland is owned by **non-industrial private forest owners** (families or individuals)[30]. **Forest management** responded to population pressures with parcelling timber tracts and reducing harvest tract sizes[31]. More intensive silviculture has significantly increased plantation productivity from less than 100 m^3/ha in 1950s to about 450 m^3/ha in 2010[32] and the productivity is expected to continue increasing[33].

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25 USDA FS 2009: U.S. Forest Resource Facts and Historical Trends.

26 Conrad J.L., et al. (2011): Wood-energy market impact on competition, procurement practices, and profitability of landowners and forest products industry in the U.S. south.

27 Forisk Consulting (2013): Update and Context for U.S. Wood Bioenergy Markets.

28 USDA FS (2013): Southern Pulpwood Production, 2011.

29 Pöyry (2014): The Global Pellet Market Growth prospects and market dynamics.

30 Butler B.J., Wear D.N. (2013): Chapter 6. Forest Ownership Dynamics of Southern Forests; in: Southern Forest Futures Project

31 Conrad J.L. (2011): Anticipated Impact of a Vibrant Wood-to-Energy Market on the U.S. South’s Wood Supply Chain.

32 Munsell J, Fox T (2010): An analysis of the feasibility for increasing woody biomass production from pine plantations in the southern United States.

33 Wear D.N. et al. (2013): Chapter 9. Markets; in: Southern Forest Futures Project.

Best management practices (BMP) are one of the key programs related to forest management activities; most of US South states have adopted them on a voluntary basis. Moreover, several states have developed BMPs focusing on biomass harvesting. Only 17 % of US South forest area is **certified** by forest certification schemes[34].

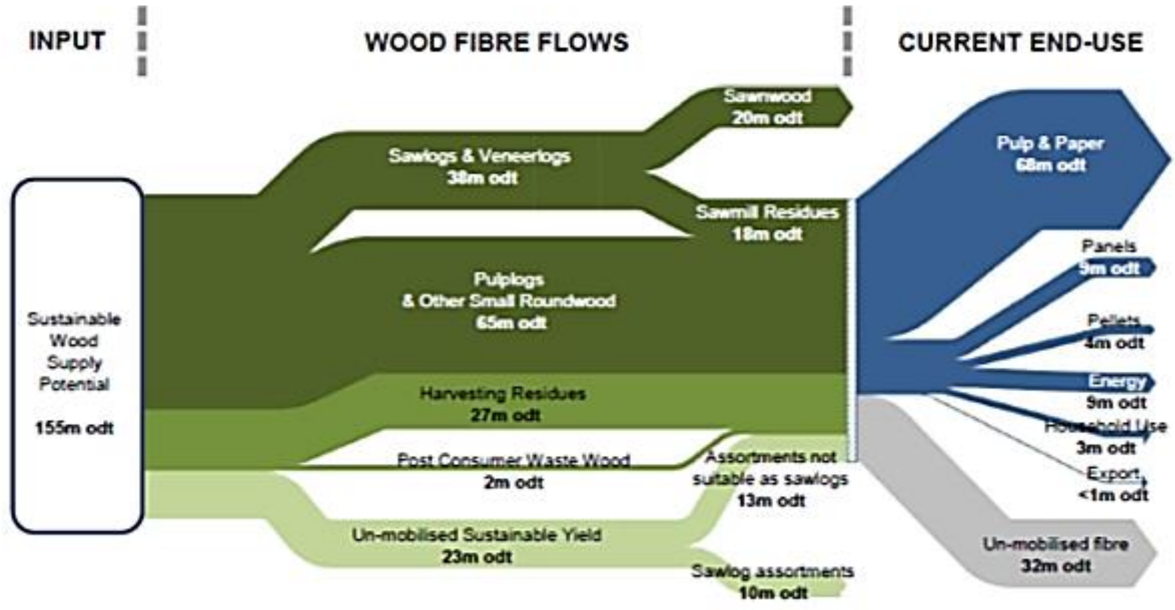

Figure 4. Wood flow in the US SE 2013[35]

There are several **mechanisms** such as the Renewable Fuel Standard (Federal level) and the Renewable Portfolio Standards (State level) to incentivize or support domestic consumption of woody biomass in the US South, but these policies are very diverse among states[36]. The rulemaking on limits for CO_2 emissions from coal power plants announced by US EPA[37] could also increase domestic demand for woody biomass. An additional federal program is the Biomass Crop Assistance Program which promotes the mobilization of specified woody biomass for eligible landowners with 25 million US$ for 2014 distributed between matching payments and technical assistance. It is expected that these promoting mechanisms result in increasing domestic demand for several final uses.

The **pellet production capacity** has increased sharply during last years within the US from 0.36 Mt in 2007[38] to almost 6 Mt in 2012[39]. In addition to domestic demand (about 3 Mt of pellets consumed in 2009), total exports to the EU increased from 0.8 Mt of pellet in 2011 to 2.9 Mt in 2013[40]. The capacity of operational pellet plants was 6.6 Mt and total capacity of operational, under construction and announced plants is 15.3 Mt pellets in July 2014[41].

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[34] Kittler B., et al (2012): Pathways to sustainability.
[35] Pöyry (2014): The Global Pellet Market Growth prospects and market dynamics
[36] Guo Z. (2011): Forest Biomass Utilization in the Southern United States: Resource Sustainability and Policy Impacts.
[37] US EPA (2014): Carbon Pollution Standards.
[38] Cocchi M. et al. (2011): Global Wood Pellet Industry Market and Trade Study.
[39] Bioenergy International (2013): Pellets in the World 2012.
[40] Market Watch (2014): Wood Resources International LLC: Wood pellet exports from North America to Europe have doubled in two years with the US South accounting for 63% of the volume.
[41] Own calculations as of July 2014 based on Biomass Magazine (2014): Pellet Plants

In terms of **costs** the US South is competitive (well positioned in both the stumpage costs and overseas transport) with a delivered CIF ARA costs of about 180 US$/t, equivalent to 143 €/t[42]. The international pellet trade is based on long-term supply contracts so it guarantees some stability on prices but as the growth in volume increase more price volatility is expected[43].

The interaction of the wood pellet sector with other wood-based bioenergy sectors as well as with traditional forest industries or new ones (e.g. biomaterials) will mainly depend on **geographical and temporal scales**. The demand of pellets could have impact on land related issues, biodiversity and climate change (GHG emissions) in different ways. Depending on a long list of issues the relation between the traditional markets and the new pellet industry could be complementary, substitutive or competitor.

5.2. Impact in the past years

A first consequence of the introduction of the pellet mills is the increase in **biomass consumption**. The amount of biomass used in the US South pellet mills increased from 2 Mt in 2012 to 4 Mt in 2013[44, 30], 60 % of the feedstock being pulpwood (45 % softwood and 15 % hardwood) and the remaining 40 % mill residues and it is expected that the share of pulpwood feedstock will continue to increase[45].

The geographical distribution of the pulp and paper industries (and panel industries) and the pellet mills is key on the potential impacts that might occur given the feedstocks transport constraints. At present it is observed that wood **sourcing areas** of pellet mills and paper mills could overlap to some extent at the regional level despite the fact that this has to be assessed at the local level. There might be other reasons than pellet production why the rebound of pulpwood **stumpage prices** has been observed in last years.
The **wood paying capacity** of the pellet industry is typically lower than that of pulp and paper or panel mills, but it might become higher due to climate change policies which could allow higher fuel prices in the bioenergy industry (e.g. due to increased CO_2 certificate prices in the EU).

5.3. Anticipated trends in the future

Many of potential impacts and their extent depend on the **magnitude of the demand and respective supply responses,** taking into account the specific location of industries. It has to be kept in mind that timber supply is quite inelastic so sourcing woody feedstocks in a sustainable way takes time. Both domestic demand from various industries, including the overall bioeconomy, and demand for pellet exports are expected to significantly increase.
Regarding prices, the international pellet trade is based on long-term supply contracts so it guarantees some stability on prices.

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[42] Fritsche U., Iriarte L. (2014): Biomass Policies Task 2.4: Sustainable Imports; Cost supply curves for medium- to longer-term potentials for sustainable biomass and bioenergy (pellets, biomethane, liquid biofuels) imports to the EU-27; forthcoming.
[43] WPAC (2012): Market data and trends from Argus conferences. Wood Pellet Association of Canada
[44] Pöyry (2013): Biomass Sourcing Strategies. Non-Technical Challenges of a Company Intending to Build a Demonstration/Flagship plant.
[45] Abt K.L. et al. (2014) Forthcoming: Draft. Effect of policies on pellet production and forests in the US South.

5.4. Conclusions and recommendations

European **demand of wood pellets** from the US South deems unquestionable in the coming years but the amount and pace of growth will be determined by policy decisions in the EU. If ambitious estimates up to 21 Mt pellets by 2020 (Pöyry 2014) were materialized, this would imply a total relevant demand in comparison with the feedstock consumption of the traditional forest industry in the US Southeast (77 Mt_{od}/a by the pulp, paper and panel mills and 9 Mt_{od}/a by the energy industry).

The trend of traditional forest industry and the readiness of other industries within the bioeconomy framework will dictate to a great extent the **availability of feedstocks** for the wood-pellet sector. Federal and State US policies will determine the domestic demand and hence the availability of resources for pellets to export (to EU), given that domestic consumption would be preferred to international trade.

Relevant **displacement and competition** between the pellet industry and the pulp and paper sector for feedstocks has not been observed yet. In the longer term if the medium to higher levels of projected pellet production capacity expansion (8 to 20 Mt) are realized by 2020 there will be increased competition among sectors and displacement might occur. The pace of growth and supply responses will be key factors for this.

The **feedstocks prices** are expected to continue increasing, although there are several variables playing a role, such as the demand, including the associated sustainability criteria, and the competition, generated by the inelastic response of the demand and supply sides[45].

Synergies between the traditional forestry operations and new forestry techniques as well as between the traditional wood markets and bioenergy markets are deemed achievable in the long term. Nevertheless, the short term perspective should not be forgotten and measures to avoid negative and unintended effects on ecosystems and markets should be put in place. Given the long-term effects of **forest policies**, careful planning is needed.

It is necessary to acknowledge **forest ownership** to better understand real biomass availability and mobilization as well as potential impacts on forest management.
Policy makers should take **precautionary approaches** when uncertainties about impacts, e.g. on biodiversity and climate, exist and encourage research to provide sound answers to open questions.

Forest regulations towards Sustainable Forest Management in the US might seem weak from the EU perspective. This reinforces the necessity to promote mechanisms to assure that woody biomass procurement is in accordance with the principles of SFM and that (EU MS) sustainability criteria are fully met. Additional mechanisms to BMPs are needed to protect biodiversity[46] although it is unlikely to happen since the US South culture is decidedly pro landowner rights[47].

There are several uncertainties[45], including:

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[46] Evans J.M. et al. (2013): Forestry Bioenergy in the Southeast United States: Implications for Wildlife Habitat and Biodiversity

[47] Fledderman R. (2014): personal communication with Robert Fledderman; MWV; May-June 2014

- How increased feedstocks prices might affect land use changes (natural forests to pine plantations or agricultural lands to pine plantations).
- How the sustainability criteria might affect the inventory available (and costs).
- The effects of prices on biomass mobilization (e.g. forest residues) and the viability of traditional timber users.

All in all, and aiming to make the most of this incipient market, decision-makers should consider **short and long-term cross-cutting policies** aiming to capture the complexity of the inter-linked systems and promoting the most efficient development.

6. Conclusions from the case studies

With current discussions on indirect effects of biofuels, 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. 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.

The double counting mechanism in the Renewable Energy Directive, which was intended to promote advanced biofuels in the EU, has merely incentivised the use of used cooking oils and animal fats for biodiesel, a relatively mature and inexpensive biofuel in relation to other biofuels. For market parties this was a very cost-effective way to reach their obligations, but it hardly contributed to technological advances. More specific promotion mechanisms will be needed to achieve that.

Similar story in the US, where targets are set in the Renewable Fuels Standard (RFS2), with specific mandated volumes for renewable fuels, advanced fuels, biobased diesel and cellulosic biofuel. The growth of cellulosic biofuels has clearly stayed below expectations, and in the past 4 years, the ambitious subtarget for cellulosic biofuels was consistently reduced by EPA. Imports of Brazilian sugarcane ethanol (recognised as advanced biofuel by US authorities) have partly compensated for the underperformance of cellulosic biofuels. The question is whether current promotion mechanisms are the right ones to stimulate further growth of technologically challenging cellulosic biofuels.

A clear lesson from the two first case studies is that **markets look for the most cost-effective options to fulfil mandates**. They will preferably focus on proven technologies and cheap feedstocks. To stimulate the development and deployment of real ‘technology challenging’ biofuels, a different policy approach is needed.

Another lesson is that these promotion mechanisms (mandates, double counting) create economic incentives for market players (often valued in tradable certificates, or the alternative cost of reaching mandates without double counting). When the economic value of the extra incentives is higher than the additional cost of certain technologies, this can give an upward push on prices of the concerned feedstocks, and this also increases risks of fraud. One lesson is that **overincentivising** / overcompensation of additional costs through certain promotion mechanisms **should be avoided**. On the other hand a **good tracing and verification system** becomes very important, but is not evident, specifically for materials imported from all over the world.

Differences in policy implementation between countries/regions (i.e. double counting mechanism between EU Member States, and different policies towards advanced biofuels between the US and Brazil) makes **certain markets more attractive**, which leads to trade to these markets. This can induce trade inefficiencies, create displacement effects (displace existing applications in sourcing regions), drive up prices of existing applications, and the carbon impact of trade and displacement (leakage) can also be substantial. Policies should keep a close eye on these effects and in principle a better aligning of policies between countries would be preferred.

The last two case studies (straw and wood pellets) are more prospective when it comes to their use for advanced biofuels. As mentioned, the real challenging advanced biofuel technologies are not really stimulated through the current promotion mechanisms. We tried to describe what has already happened with these feedstocks on energy markets, and what lessons we can learn when demand for these feedstocks increases in future.

The use of residues from agriculture (e.g. straw) for the production of energy can play a role in the transition towards a more renewable energy supply, both for stationary bioenergy, and in time, also for advanced biofuels. 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. 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. This share strongly depends on the local condition. **Sustainability criteria** need to safeguard that agricultural soils are not overexploited.

The trend of traditional forest industry and the readiness of other industries within the bioeconomy framework will dictate to a great extent the availability of woody biomass for energy – both for stationary energy and for advanced biofuels. **Synergies** between the traditional forestry operations and new forestry techniques as well as between the traditional wood markets and bioenergy markets are deemed achievable in the long term. Nevertheless, the short term perspective should not be forgotten and measures to avoid negative and unintended effects on ecosystems and markets should be put in place. Given the long-term effects of **forest policies**, careful planning is needed. It is necessary to acknowledge **forest ownership** to better understand real biomass availability and mobilization as well as potential impacts on forest management. **Sustainable forest management** will be key for further mobilization of woody resources, while also safeguarding forest ecosystems and avoiding negative carbon impacts. All in all, and aiming to make the most of this incipient market, decision-makers should consider **short and long-term cross-cutting policies** aiming to capture the complexity of the inter-linked systems and promoting the most efficient development.

The development of advanced bioenergy technologies (incl. straw) has to be based on **stable political frame conditions**. Especially for the European biofuel sector specific targets for the time frame beyond 2020 should be defined by EU policy makers. 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 biomass-using technologies.