Global Wood Pellet Industry and Trade Study 2017

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Global Wood Pellet Industry and Trade Study 2017

Lead authors

Daniela Thrän, David Peetz, Kay Schaubach

Contributing authors

Sofia Backéus
Luca Benedetti
Lena Bruce
Suani Teixeira Coelho
Laura Craggs
Rocio Diaz-Chavez
Javier Farago Escobar
Jose Goldemberg
Ruben Guisson
Morten Tony Hansen
Jussi Heinimö
Bo Hektor
J. Richard Hess
Martin Junginger
Patrick Lamers
Thuy Mai-Moulin
Gordon Murray
Olle Olsson
Alessandro Pellini
Svetlana Proskurina
Fabian Schipfer
Peter-Paul Schouwenberg
Wolfgang Stelte
Ute Thiermann
Erik Trømborg
Lotte Visser
Michael Wild

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Table of Contents

Executive summary

Introduction to the wood pellet industry and markets

Wood pellets are a renewable energy carrier which is produced from sawdust or other ground woody materials. International standards define product requirements i.e. moisture, energy density, abrasion resistance, particle size and shape for wood pellets (ISO 17225-2) which allowed wood pellets to turn into a commodity. Over the past 10 years, the production of wood pellets increased steadily, driven by a corresponding constantly rising demand. For 2006, the production was estimated between 6 and 7 Mt (excluding negligible production in Asia, Latin America and Australia), expanding globally to 14.3 Mt in 2010 (IEA Bioenergy, 2011) and surpassed 26 Mt in 2015.

There are different pellets from different sources and qualities available today, such as wood pellets, agropellets, torrefied pellets etc. (Figure 0.1). So far, wood pellets of dedicated qualities are dominating and are delivered and consumed in two different markets:

(1) In the electricity generation sector, they are co-fired in coal based power plants and mono-fired in converted coal power plants to reduce greenhouse gas emission of electricity generation.

(2) In the residential heating sector they are widely used as a convenient solid biofuel application in automatic stoves and boilers. Therefore pellets with a dedicated quality (ENplus) are dominant, which are produced closer to the consumer and characterized by trade within the country or between neighboring countries. Delivery is realized in small scale units.

Additional applications are their use as a fuel for mid-sized heat supply systems (district heating, CHP plants), but these applications only constitute a minor market share. In the future, wood pellets might also become a renewable resource for green chemistry and biobased materials.

With a dedicated wood pellet classification system on ISO level (ISO 17225-2) introduced to the market in 2014/15 and adjusted technical quality standards for two established application fields, two quality groups are defined: Pellets for Commercial and Residential use and those for Industrial use by this reflecting the market segregation and the different requirements in the market segments. The majority of non-industrial, mostly heat market pellets traded are A1 quality with certain exception towards A2 for larger installations (>50kW). Often ENplus A1 rated pellets are used for residential heat supply as the small scale units need a high quality to fulfill the operational and environmental requirements.

Figure 0.1 - Pellets examples from different materials and processes (source: DBFZ)

Wood pellet supply chains and cost structures

Distribution of wood pellets starts at the wood pellet plant and ends with the arrival at the end user e.g. at the boiler storage of an individual household as well as of a (co-fired) power plant or at the storage of a large scale gasifier for the production of chemicals. Depending on the transportation distance as well as the time lag between sending and arriving, the most sensitive parameters for calculating distribution costs are costs with regard to (un-)loading, transportation and intermediary storage. Several studies have evaluated the cost of producing and transporting wood pellets. Cost calculation of modelled supply chains differ between 60 and 160 $€_{2016}$ per tonne pellets delivered. Some of the observed cost differences can be explained by differences in scope, such as differences in transport distance or transport mode. In addition there are country specific factors such as feedstock cost, labor cost, transport cost and electricity cost. Assumed feedstock cost varied between 13,5 €/t for a pellet plant in Argentina and 58,7 €/t for an Austrian pellet plant. A large part of the cost variation can, however, not be attributed to case study differences. Different studies analyzed pellet production cost of an US-based pellet plant and came to very different conclusions. These uncertainties in cost data from available literature must be taken into consideration when calculating supply chain cost.

Inventory of the wood pellet production, trade and consumption 2011 – 2015/2016

With this report, we provide an inventory of the wood pellet industries and markets for more than 30 countries with regard to regulatory framework, production capacities, consumption and price trends, trade, logistics and country specific standardization aspects (Figure 0.2). With the considered countries, we cover different regions of the world, driven by different national energy, climate and resource policies and characterized by different levels of export and import orientation. Summing up, the overall pellet flows from the considered countries and comparing them with other studies, the conclusion can be drawn that all relevant pellet producing countries are included.

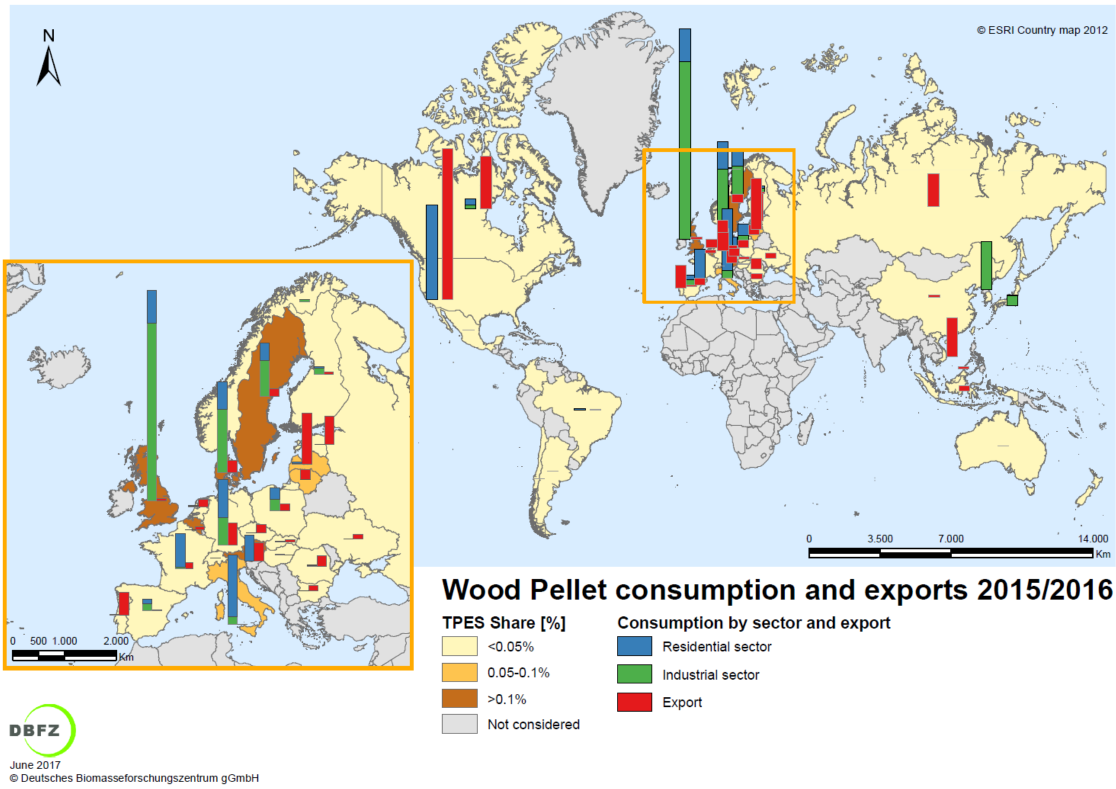

Figure 0.2 - Countries with relevant wood pellet consumption and/or export in 2015

The global wood pellet market has increased dramatically since 2011, with an average increase rate of 14% per year. New countries have entered the market for both, pellet production (such as those from South-East Europe) and pellet consumption (such as East Asia). Also the global wood pellet trade increased. Intercontinental flows are dominated by the trade relation between the U.S. and the UK, while the non-industrial use is still mainly an intra-European business. Russia and the Baltic states are becoming increasingly important for these markets. The Asian markets show also a strong growth, with Japan and South Korea as the main consumers. Reflecting the major demand in Europe, the EU as a region is also by far the largest producer (2015: 54%), followed by North America (2015: 35%), which is mainly export driven. Asia, the Russian Federation, Australia and Latin America play minor roles in the global pellet production (2015: 11%).

Production and consumption patterns differ between the countries. An overview for the year 2015/2016 is given in Figure 0.3. On a country basis the U.S. stands out as the largest pellets producer by far with 7.4 Mt in 2015 (FAO-Estimate) and 6.3 Mt in 2016. Canada is the country with the most dynamic development, having increased the export from 1.6 Mt in 2015 to 2.4 Mt in 2016. Other large producers are Germany (2.2 Mt) and Sweden (1.5 Mt). With regard to pellet consumption, the United Kingdom is the largest consumer with 6.7 Mt pellets in 2015, followed by the U.S. with 2.9 Mt, Denmark (2.8 Mt) and Italy (2.1 Mt).

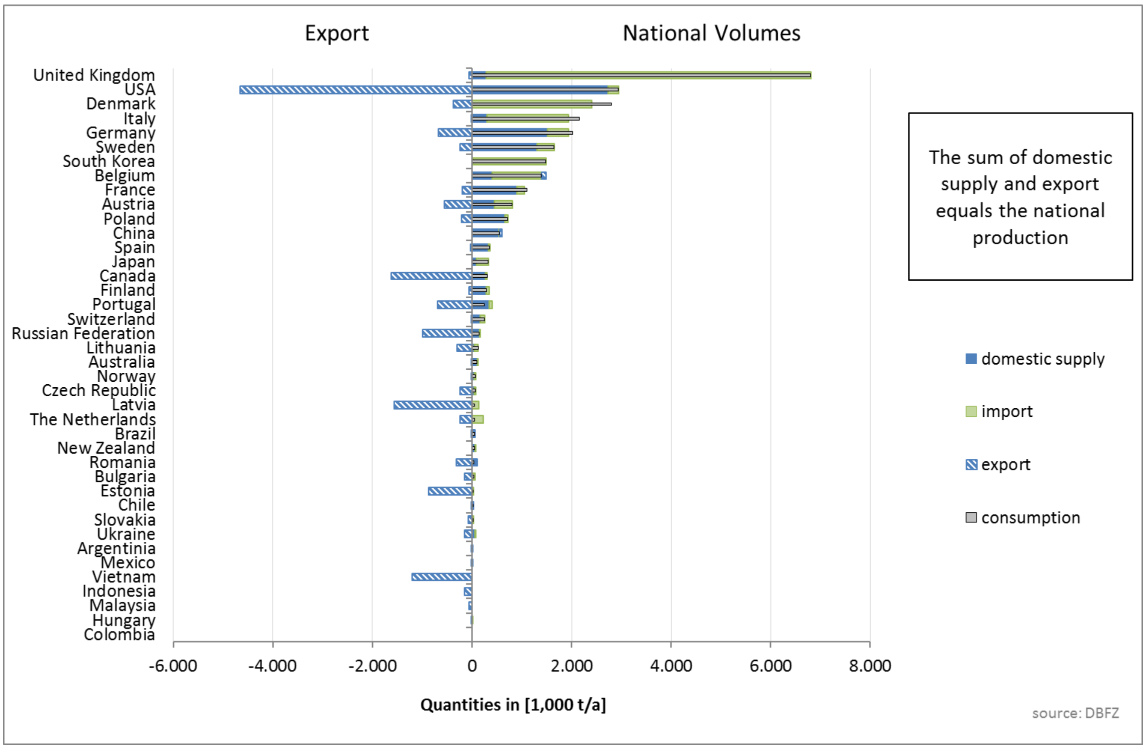

Figure 0.3 - Domestic Production and Import | Export per country for chosen countries in 2015/2016; sorted by consumption

Forecasting supply and demand is a tricky business, whether it is for fossil fuels or biomass commodities. Dynamics differ between different regions:

For Europe, the European Pellets Council identifies the further improvement of efficiency and quality of pellet production, of logistics and heating appliance efficiency. The residential market is expected to grow at a constant pace. Also, new markets need to be addressed, such as medium scale (heat and CHP). The replacement of coal in power plants has been one of the major growth markets in the past within the EU, but has recently slowed down. Nevertheless new plants i.e. in the Netherlands and Denmark are planned to go online within the next two years. One obstacle is the current uncertainty of bioenergy support from the EU policy level. Several national governments in Europe have strengthened their support, yet are waiting for clear signals from EU level (esp. Winter Package and RED II) clarifying the sustainability demands for wood pellets, and the necessity to produce large-scale power only from woody biomass with increasing amounts of other renewable electricity.

In stark contrast to the slow-down in the EU, large-scale power markets in East Asia are rapidly picking up. In Asia, South Korea will continue to be the largest consumer, mainly supplied by Vietnam. However, China has set out a goal of using 30 Mt of biomass pellets consumption in 2020 to replace 15 Mt of coal. In this decision as part of its five-year plan for biomass development, issued on 5 December 2016, it is yet unclear how much of this quantity is planned to be wood pellets and for the time being there are also no related instruments in preparation. It is also uncertain how much of the demand could be sourced domestically, and how much would need to be imported.

Bioeconomy as an emerging client is also discussed. The possibility to use e.g. residues from second-generation lignocellulosic biorefineries for large-scale industrial heat and power applications could be of interest – possibly on the basis on higher pretreated products like torrefied pellets.

The production capacities have grown steadily in the last years, showing fluctuating utilization degrees depending on the demand (see previous chapter). The U.S. will maintain its position as largest producer but faces stronger competition within Europe from Russia and adjacent Baltic countries. Asian countries will also increase their production, as well as other regions in the world.

Last but not least, the supply via international trade might be impacted by rising sustainability certification requirements. In the U.S., the sustainability requirements of e.g. the Netherlands could not be met by voluntary U.S. private forestry initiatives, thus reducing their exports significantly. It remains to be seen if and which EU-wide criteria for solid biomass use will ultimately be included in the final the RED II, and in how far the current exporting regions will be able to comply with these criteria.

Wood pellet prices

Discussions and illustrations on pellet prices and especially on price comparisons have to be treated with care. This is mainly because the substitution of fossil based commodities with this solid bioenergy carrier which is developed in different ways in recent years. On the European continent, pellets for electricity production took off in the UK, the Netherlands, Belgium and Poland, while CHP- and heat plants are using pellets mainly in Denmark, Sweden, Poland and Germany.

No harmonized methodology is applied to collect price data in the differing countries, and so the level of detail differs, ranging from monthly to quarterly or even only yearly data, and is collected for different purchase quantities and only in a few cases for different regions. In Figure 0.4, we attempt a wood pellet price comparison for the small-scale heating market. The illustration excludes the different VAT rates which are as low as 7% for Germany and up to 25% in Sweden, as well as with substantial changes over time as for Italy (from 10-22% in 2015) and for Austria (from 10-13% in 2016).

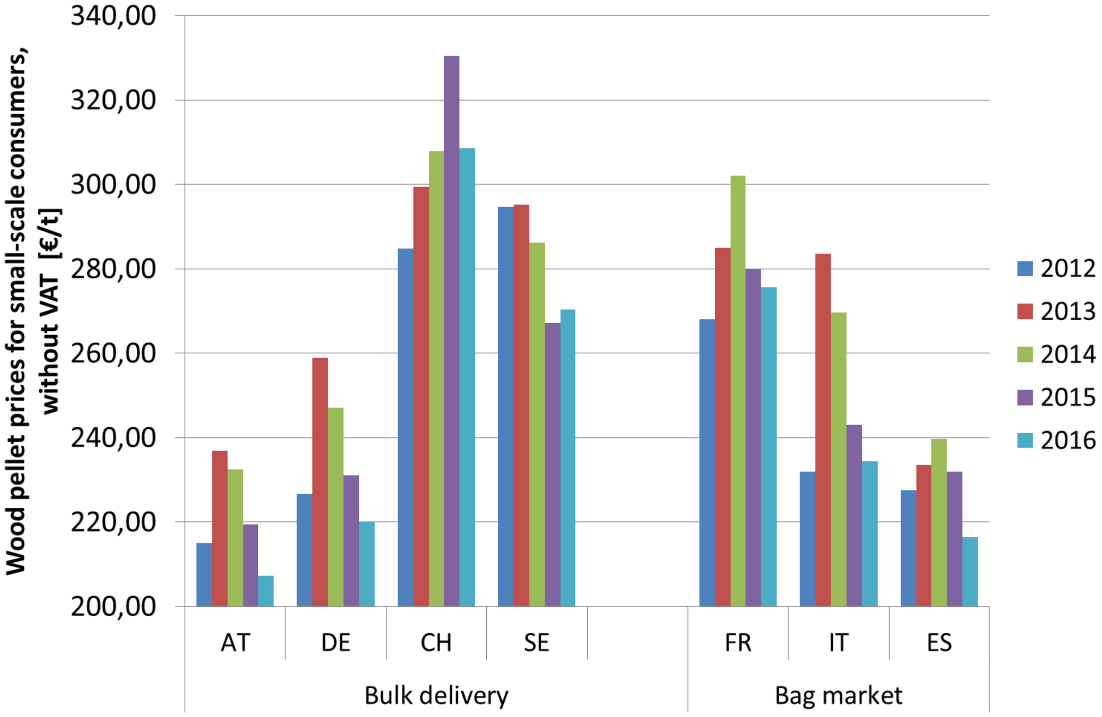

Figure 0.4 - Comparison of wood pellet prices for small-scale consumers, either delivered in bulk or prices for pellets in bags.

Pellet prices for residential consumers (in Europe) are in general between 200 €/t and 300 €/t with the exception of Switzerland and France where pellet prices before VAT are higher. Prices peaked in 2013 in Austria, Germany, Sweden and Italy while they kept increasing until 2014 for Swiss, French, and Spanish consumers. Regarding the heating market there has been three years of soft winters which also caused lower pricing than previous years. Prices dropped in all countries during 2016 due to an oversupply in small-, medium- and industrial pellet markets.

Pellet prices for the largest consumers are confidential since they are bilateral and often subject of long term contracts which are not made public. Pellet price developments for other large scale consumers, further denoted as *pellet prices for industry* are best reflected in the ARGUS shipping market polls. In the industrial market, the main factor causing also a price drop was downtime on the power plant side which caused pressure.

Future pellet prices in the industrial sector, which dominates world trade, will depend on global market conditions, i.e., demand trends and supply capacities. Demand markets are still influenced to a large extent by policy framework providing incentives in different forms to biomass combustion. So far, supply capacities have reacted to policy and demand projections. The pellet market is not supply driven.

Supply chain integration (e.g., upstream investments) and optimization strategies can reduce some fractions in the pelleting operations, transportation and handling costs (e.g. by reducing storage times or optimizing rail cargo operations from production to port facilities). However, cost reductions to achieve costs delivered to the Rotterdam area (CIF-ARA) of $113 per tonne (or lower) are difficult to achieve.

The next couple of years are bound to see an increase in demand, particularly from Asian markets, which will likely increase spot prices again to past levels.

Wood pellets on the way to becoming a commodity

The ongoing development of the wood pellet market also leads to new challenges: Appropriate trade infrastructure has to be developed and built, such as storage, loading and handling capacities in the pellets production regions, as well as in commercial areas and harbors. Additional conversion capacities lead to resource demand, which has to be provided in a sustainable way. To deal with those issues, some actions have been taken by different stakeholders, such as policy, pellet consumers and also technology developers. This includes for example the development of sustainability roles and certification schemes (by certain national governments), the preparation of standards for safe handling instructions (by ISO), development of technologies for provision of pellets from more difficult feedstock (i.e. torrefaction of straw based materials) and adjustment of the infrastructure such as harbors.

On their way to become a commodity, wood pellets need to have certain characteristics such as standardization (fungibility), liquidity and competitive markets, usually business to business. The standardization has proceeded very far both in the industrial and the residential sector. The latter one is usually only on a regional scale aiming at end consumers, which makes the consideration of commodity less applicable for this sector, as "commodity" refers to rather internationally or globally traded goods. The industrial market is characterized by a few large suppliers and consumers (notably the U.S. and UK), which infringes the liquidity (ease of finding a seller/buyer) and competition. With the expected continuous growth, this might change and industrial pellets may achieve the full characterization as a commodity and the benefits associated with this status, e.g. trust in the product qualities, product availability and power equilibrium through a plethora of actors as well on the supplier as on the buyer side. One crucial factor here is the removal of (political) uncertainties to attract more actors and trade volumes. The debate in the Netherlands and in Belgium about wood and wood pellet utilization for large scale power generation might have slowed down the development. The successful establishment of a futures contract can be seen as somewhat of a litmus test in the development of a specific commodity market. For wood pellets, two contracts have been introduced, but not continuously established yet.

Challenges on sustainable wood pellet trade

With regard to the resource base, in the past years sustainability requirements for solid biomass have been established and implemented in a number of countries in the European Union, namely the United Kingdom, the Netherlands, Belgium and Denmark, going hand in hand with the creation of different national initiatives to govern the sustainable production of wood pellets in the European Union. Partly as a response to this, the Sustainable Biomass Program (SBP) was established in 2013. It is a certification scheme designed for woody biomass, mostly in the form of wood pellets and wood chips, used in industrial, large-scale energy production. The SBP is committed to a core strategy that identifies and uses, wherever possible, existing forest certification schemes (such as Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC)) as the principal building blocks for its approach. SBP aims to complement those systems with carbon footprint information. Over the course of 2014-mid 2017, the number of SBP certified wood pellet producers and traders grew strongly to over 100 certificate holders, among them some of the largest wood pellets producers worldwide. As such, it is the largest voluntary system certifying woody biomass for energy purposes.

Additionally, Japan and South Korea have introduced sustainability certification schemes for wood pellets. Wood pellets sold into Japan must be forest management certified, if electric utilities want to purchase electricity generated from renewable energy sources such as biomass on a fixed period contract at a fixed price. In South Korea, an attempt has been made to introduce sustainable forest management criteria, but after problems with fraudulent certificates from neighboring countries, it is unclear if Korea will impose forest management requirements again in the future.

So far, the legislation and support schemes have, to a certain degree, different goals and targets whilst there are also differences among various sustainability criteria and reporting requirements. This situation may cause trade barriers for solid biomass, and thus, a harmonization of sustainability requirements would benefit the global trade of wood pellets. Within the EU, this is under severe discussion. Open questions are on the format (directive versus more open principles for member states support schemes), on the considered biomass (forest biomass only or also agricultural biomass), on considered effects (including direct and indirect land use change or not), on thresholds for greenhouse gases etc. If sustainability requirements are only mandatory for certain countries and (a limited number of) bioenergy applications, but not for others/material purposes, the power of certification is limited. Clear policies and guidance is necessary to increase investor confidence and, most importantly, to shape sustainability as a meaningful approach within the bioenergy sector to combat climate change whilst securing energy supply. This has to be done in the recast Renewable Energy Directive as well as in the national legislations, and ultimately by alignment on a global level (e.g. with other regions such as East Asia) to avoid unintended side-effects and to facilitate global trade of wood pellets.

Torrefaction and international trade

Torrefaction is a thermal pre-treatment technology used to upgrade lignocellulosic biomass to a higher quality and more attractive biofuel. In the torrefaction process, biomass is heated to a temperature between 250-350°C in an atmosphere with low oxygen concentrations, so that all moisture is removed. During the torrefaction process, the biomass partly devolatilizes, leading to a decrease in mass. However, the initial energy content is accumulated so that the energy density of the biomass becomes higher than the original biomass.

The properties of the final product highly depend on the process conditions and on the composition of the biomass feedstock. Depending on factors such as time, temperature and residence time, the biomass can be torrefied to different torrefaction degrees/temperatures. Directly connected to the degree of torrefaction is the net calorific value (NCV) of the resulting product. Theoretically, NCVs of 28+ MJ/kg could be reached, even though the overall process efficiency seems to be best at 20-22 MJ/kg NCV (depending on feedstock).

Table 0-1 - Properties of transportable biomass and competing fuel.

	Fresh Wood	Wood Pellets	Torrefied Pellets	Coal
Moisture (%)	35-50	7-10	1-5	10-15
Calorific Value (GJ/T)	9-12	16-18	19-23	23-28
Bulk Density (T/m3)	.2-.25	.6-.68	.65-.75	.8-.85
Energy Density (GJ/m3)	2-3	9.6-12.2	12.4-17.3	18.4-23.8
Ash (% by wt)		0.4-2	0.4-2.5	9.7-20.2
Grindability	Poor	Poor	Good	Good

Different tests have shown significantly improved water resistance and additionally that torrefied biomass, once compressed into pellets or briquettes, is of non-hazardous character in transportation. A number of full scale tests in co-firing in European power plants have confirmed the expected positive combustion results. Consequently, transportation and storage of torrefied pellets is much cheaper than wood pellets. In some cases there are also advantages in conversion to energy (i.e. better grindability in coal mills than wood pellets).

A variety of torrefaction technologies have been developed. Same input material does lead to almost similar product independent of the torrefaction technology implemented. Significant initiatives are engaged in technologies commercialization, with several demonstration plants in operation and first commercial sized units nearing hot commissioning.

The power sector could well be the leader in torrefied biomass's use, with industry behind. Torrefied biomass is proven for power-plant applications and may become in the coming years a central resource for co-firing of biomass with coal. Industrial-sector usage may indeed not compete with use in the power sector with regard to volumes of torrefied biomass used. Demand from industry could, however, drive development of torrefied-biomass production and markets in general. Another way of succeeding in this sector may be through gasification of torrefied biomass.

Market participants will also develop a clearer understanding of the products once the ISO committee issues a TS (technical specification) under ISO 17225-8, which has been published in Q4 2016. For the European market, a Substance Information Exchange Forum (SIEF) built within the International Biomass Torrefaction Council achieved the clear result that no REACH registration should be necessary. It seems all fundamentals for market success of torrefied biomass are today really provided and ready for market uptake.

Outlook

During the last years, the pellet market has been developed continuously worldwide and for the time being this trend is ongoing. Increasing demands are expected for both- industrial application in large scale power plants and small scale application in residential heating systems. More than one third of the overall consumed pellet amount of 26 Mt in 2015 has been intercontinentally traded, mainly from the Americas to Europe and Asia. The taken efforts for improving product qualities (torrefaction) and market information (contracts/indices) provide new opportunities for wood pellet application and trade, but their market uptake is not yet visible. The development of pellet prices still divers between the countries. Additional effort should be taken to increase market maturity.

Further market development also depends on the regulatory frame conditions, especially the international effort to mitigate climate change and the sustainability requirements for the feedstock. Dynamics in frameworks can be observed in many countries and will be key for the further establishment of wood pellet industry and trade.

1 Introduction

Daniela Thrän, Kay Schaubach

Wood pellets are renewable energy carriers, which are produced from sawdust or other ground woody materials. International standards define product requirements for i.e. moisture, energy density, abrasion resistance, particle size and shape for wood pellets (ISO 17225-2) which turn wood pellets into a commodity. Standardized pellets provide promising properties for large scale production, transport and storage and different application. After the creation of wood pellets in the US in the 1970s, larger scale pellet production started at the end of the 1990s and increased and expanded over the years (FNR Fachagentur Nachwachsende Rohstoffe e. V., 2010). In 2015 more than 25 million tons of wood pellets have been consumed worldwide. Further expansion of wood pellet usage is expected (Hawkins Wright, 2017). Significant trade flows are stated between neighboring countries but also for transatlantic and transpacific exchange (IEA Bioenergy, 2011). There are different pellet types and qualities available today (Figure 1.1).

Figure 1.1 - Pellets examples from different materials and processes (source: DBFZ)

The demand for wood pellets is manifold: in the domestic heating sector they are widely used as a convenient solid biofuel in automatic stoves and boilers, co-fired in coal based power plants they reduce greenhouse gas emission of the electricity generation and also they are finally discussed as a renewable resource for green chemistry (Mussatto, 2016).

With this report we provide an inventory of the wood pellet industries and markets for more than 30 countries with regard to regulatory framework, production capacities, consumption and price trends, trade, logistics and country specific standardization aspects (Figure 1.2). So, the inventory does not only summarize material flows and prices but also provide insights into the heterogeneity of the pellet market development in the different countries, driven by different energy supply infrastructures and market setup, but also by the expression of the wood processing industry and national policies for climate gas reduction and resource exploitation.

We included IEA experts from 11 countries to deliver a comprehensive and up-to-date report for the different regions of the world. After some background information on the wood pellet markets and cost factors along the supply chain (Chapter 2), there are country specific information on wood pellet industry and market given for Europe (Chapter 3), North America (Chapter 4), South America, Asia and Australia (Chapter 5). We refer to the year 2015 and snapshots of 2016, where available.

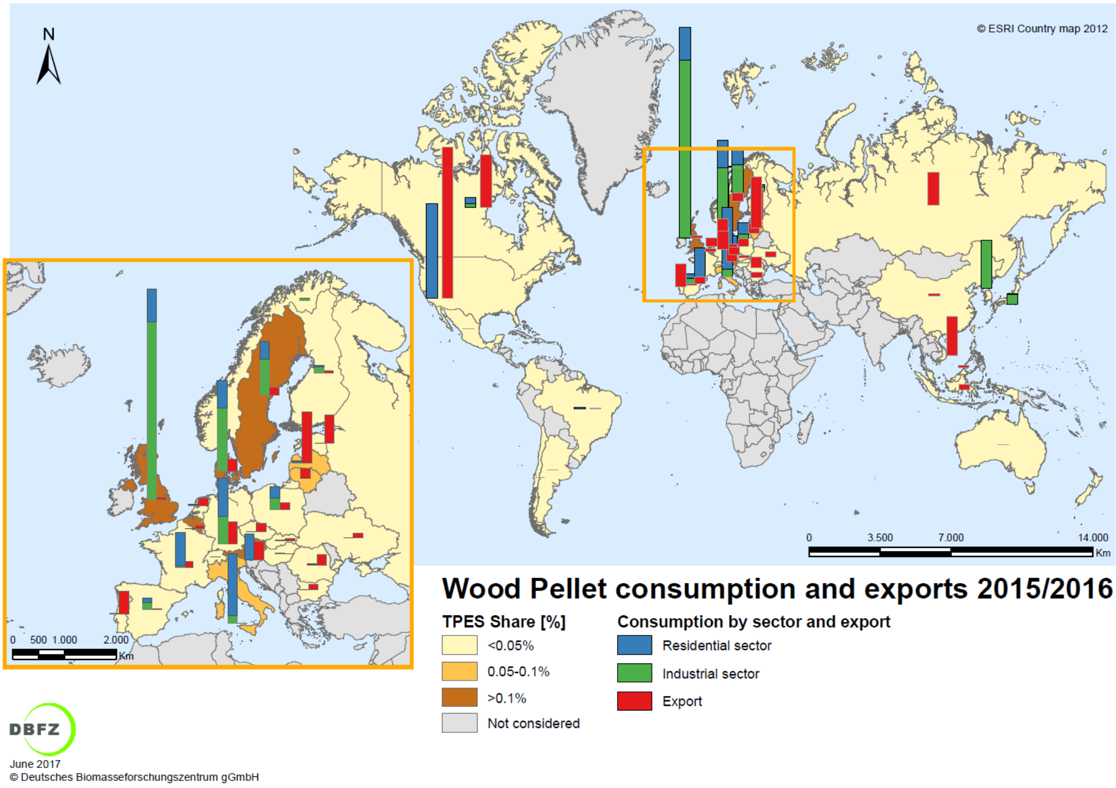

Figure 1.2 - Countries with relevant wood pellet consumption and/or export in 2015

The ongoing development of the wood pellet market also leads to new challenges: Appropriate trade infrastructure has to be developed and built, such as storage, loading and handling capacities in the pellets production regions, as well as in commercial areas and harbors. Additional conversion capacities lead to resource demand, which has to be provided in a sustainable way. Widening the resource base towards lower wood qualities and other lignocellulosic material is an issue as well as tracking the sustainable resource base in general. In Chapter 6 the global developments for some of the prior aspects are included, such as (i) implementation of sustainability standards, (ii) transforming wood pellets to a global commodity and (iii) torrefaction and international trade issues.

Finally, the wood pellet industry is characterized by becoming more mature. Therefore we summarize and conclude the actual and future development of pellet wood flows and wood pellet prices as well as the dynamics in frameworks (Chapter 7).

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2 Background: Development of the global wood pellet market

2.1 Wood pellets use in the electricity and heating sector

Kay Schaubach, Daniela Thrän

The largest global demand of wood pellets stems from Europe (EU28), which accounts for 75 % of the pellet consumption with about ca. 20.3 Mt in 2015 and 19 Mt in 2016 (AEBIOM, 2016, Biomass Magazine, 2017). As about 54 % of global production is located in Europe, the remaining demand is covered by imports. By 2017, the EU wood pellet demand is expected to expand to nearly 22.5 Mt (Global Wood Markets Info, 2016).

Within this market, two main sectors can be discerned: The industrial sector, in which moderate quality pellets are used for electricity generation (industrial CHP, district heating, power plants) and the use in small units mainly for heating purposes with high quality requirements (residential market).

The **electricity sector** with foremost industrial application accounts for 36 % of European consumption (AEBIOM, 2016), which also gains importance in Asia. The industrial use of pellets is dominated by intercontinental trade, most notably between the U.S. and Europe as main consumer. By far largest share of imports (75% of the ca. 6.2 Mt in the EU28) is attributed to the UK (EUROSTAT, 2017), which heavily supports the replacement of coal through biomass to produce electricity. The main consumer of these imports is Drax Power Station. The major sources of the imported pellets are the U.S. and Canada (see Chapter 3.23). Figure 2.1 shows the global trade flows of 2015. This market segment is characterized by very few actors and trade relations.

The main markets in Asia are South Korea, which is mainly supplied by Vietnam, and Japan, importing from Canada and China. The U.S. as main export nation is not very present here as most pellet plants are located in the southeast, aimed for export in Europe. Lower feedstock prices and exchange rates are also obstacles for these trade routes (International Trade Administration, 2016).

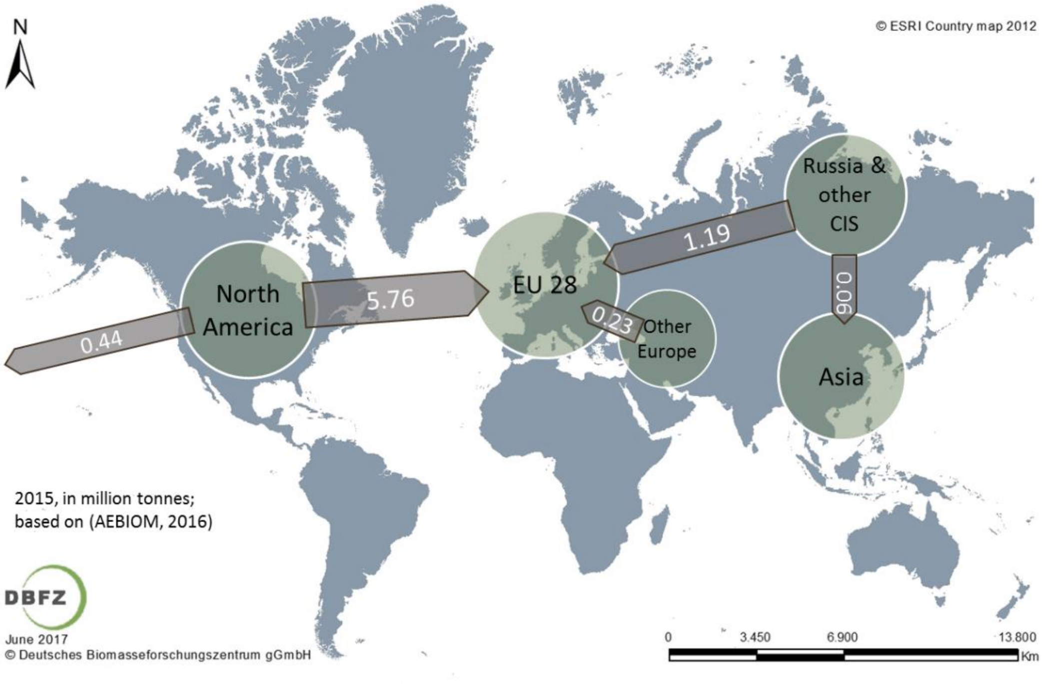

Figure 2.1 - World pellet trade flows (2015) (DBFZ, based on AEBIOM, 2016)

Heat generation caused about 64 % of pellet consumption in Europe (2015). This can be divided further in the markets of residential heating (42 %), commercial heating (16 %) and heat generated from CHP (6 %) (AEBIOM, 2016). The production of pellets within Europe is aimed primarily at the **non-industrial (residential) market.** While in South European countries like Italy single stoves applications dominate, in Central Europe central heating boilers in small scale applications were established. In Scandinavia the market development started with a high number of local heating applications. Presently, the European medium scale pellet sector (>50 kW) is a promising market with a market growth rate of 16 % in 2015 – not only in Scandinavian countries (AEBIOM, 2016).

The trade takes place mostly within countries or between countries within Europe. The main consumer markets here are Italy, Germany and Denmark. Figure 2.2 shows the trade flows for this sector for the period of January 2012 to December 2015. The most active imports and exports can be identified for Italy, Austria and Germany. Italy's largest single supplier is Austria. Vice versa, Italy is the main customer of Austria, establishing Europe's largest trade relationship. Germany and Italy are the largest importers with a broad range of suppliers. The non-industrial market is much fractured with numerous producers, customers, traders and logistic services.

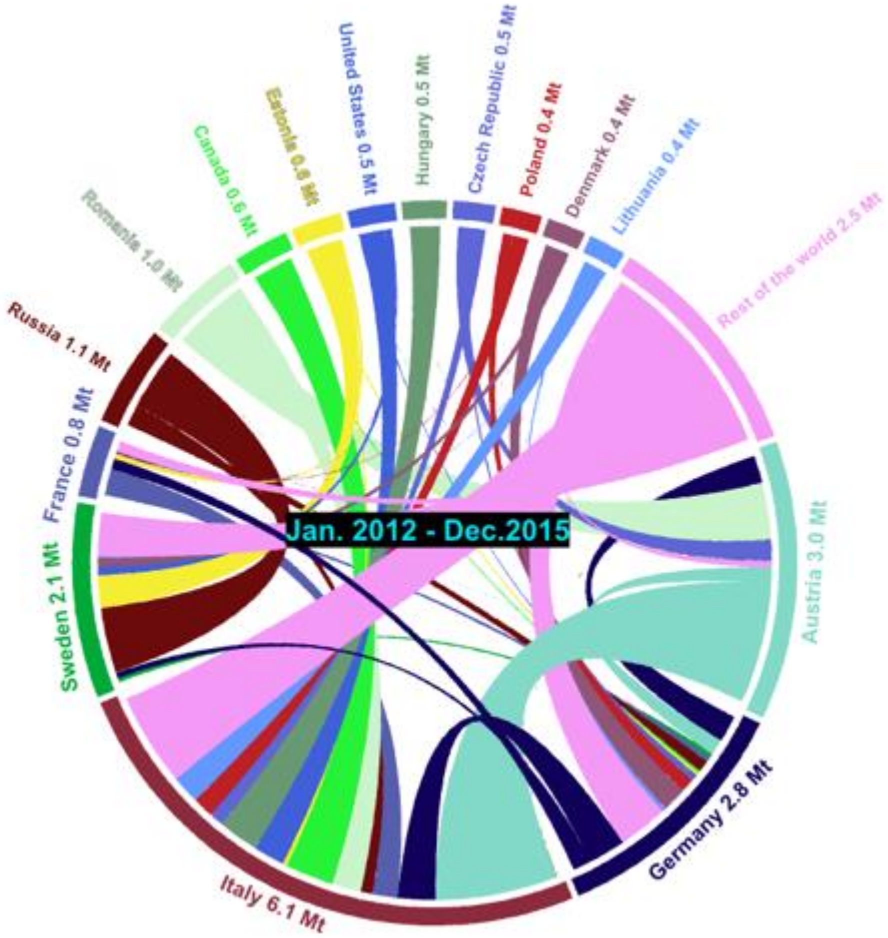

Figure 2.2 - Pellet Trade for small scale heating (Schipfer et al., 2016)

Different wood pellet qualities are used in the two application fields (see next chapter). I.e. ENplus A1 rated pellets are used for residential heating supply as the small scale units require a high quality to fulfil the operational and environmental requirements.

2.2 Wood pellet quality standards

Michael Wild, David Peetz, Daniela Thrän

Newcomers to the pellets sector often express surprise about the array of qualities of wood pellets they can find in the market and also that buyers do really insist on the specific quality they request. Nowadays, as the market is quite liquid and the volumes traded nationally and internationally are significant, a firm definition of quality classes has developed and is internationally recognized. This was not the case in the infant years of the market where countries with growing markets started national standards. Though close to each other, these were in certain cases not compatible, therefore creating an unintended barrier to international trade.

Sweden, Austria and Germany were in the lead to initiate a European standard which was created with EN 14961-2. As Europe did – and does – dominate the pellets market, the European standard was widely accepted also outside the continent.

Standardization is necessary but many market actors did find it insufficient to guarantee a consistent product quality arriving at the customer. Therefore, certification schemes developed also very early in parallel or additionally to the standards. DIN plus was the first widely successful of this certification schemes, later competed and made almost obsolete by ENplus certification scheme of the European Pellets Council.

Requiring from producers regular internal quality control and screening before delivery for quality certification, the ENplus combines this product certification with chain of custody and quality management certification. First aspects of sustainability certification are included already as well. Certified is not only the product but the producer and also the service providers, such as traders, logistics companies etc. Rules of certification can be found at the ENplus Handbook v3 (ENplus, 2015). Producers following the ENplus standard can be found in many countries (Figure 2.3).

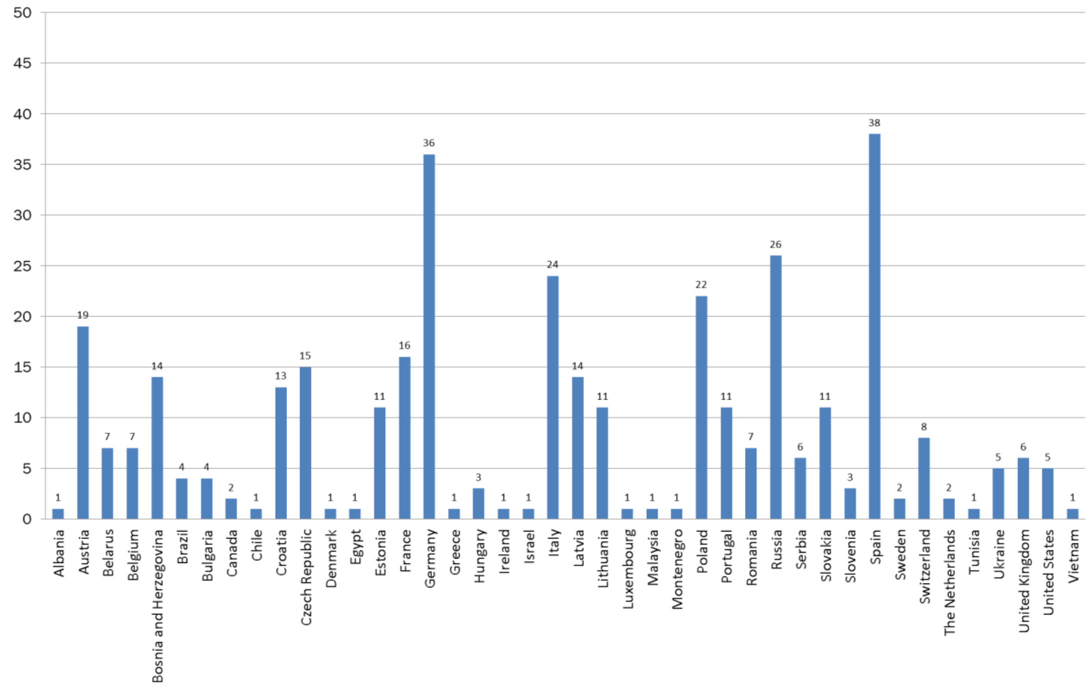

Figure 2.3 - ENplus certified producers in 2016 (ENplus, 2016)

With Europe being the main market, more than 364 production facilities worldwide have been ENplus certified (ENplus, 2016). Other countries have adopted the certification scheme, i.e. CANplus is mirroring the ENplus into the Canadian pellet market .The certification is clearly oriented on the commercial and household market.

The industrial market has certification schemes, like the Sustainable Biomass Partnership (SBP), more oriented on proof of sustainability than on quality (see also chapter 6.1.2).

Hence most of the structure, parameters and values have been taken over or just been adjusted when the work to create an international standard was initiated by the ISO committees. The resulting ISO 17225-2 was introduced to the market 2014/15 (DEPI, 2015).

The ISO 1725-2 defines two quality groups: Pellets for Commercial and Residential use and those for Industrial use by this reflecting the market segregation and the different requirements in the market segments.

While the non-industrial qualities are named A1, A2 and B, the industrial qualities are I1, I2 and I3.

The majority of non-industrial, mostly heat market pellets traded are A1 quality with certain exception towards A2 for larger installation (>50kW). In industry, the I2 quality is the most traded. Industrial grade pellets (ISO 17225-2 A2, B for large CHP or district heating units, I2 for power stations) differ from ENplus A1 as highest quality in ash content, durability, sulfur and chlorine content as well as ash melting temperature. Additionally, further biomass fractions are allowed for their production, such as logging residues and untreated scrap wood (DEPI, 2015). Their lower thresholds demand conversion technology that ensures smooth operation and the fulfilment of environmental standards, which can usually only be achieved by larger units.

Markets are permeable or open from high to low quality. So, better qualities may always be consumed instead of poorer quality but not vice versa. A power plant will have no issues combusting A1 household pellets while a pellets stove may have issues with ash, slagging and eventually overheating when fed I2 quality pellets.

New methods for quality assurance, additional technical requirements (i.e. for handling and safety) and new product specification (i.e. for torrefied material), which are under discussion and preparation in the related ISO working groups, can support further market development, especially the trade for the industrial sector.

Natural wood is the dominating source for the biomass pellet supply, as also specified in the ISO. New market actors clearly focus on forest wood and residues from sawing. The relevance of pellets from residues (i.e. wood from landscape management or waste wood) or from non-woody biomass (straw, hay), has not increased comparably. The higher effort for processing those materials and the wide range of achieved qualities make it difficult for those materials to contribute to the global market. On the other hand, torrefaction and other thermo-chemical treatment approaches can offer the opportunity to provide also more standardized products from a wider range of biomass and might support the integration for those more difficult, but also sustainable biomass in the future, serving both the residential and industrial sector.

2.3 Pellet provision costs – cost components and typical numbers

Fabian Schipfer, Bo Hektor, Lotte Visser

Several researchers have evaluated the cost of producing and transporting wood pellets. Figure 2.4 shows results on supply chain cost components from available literature, converted to $€_{2016}$ values. Some of the observed cost differences can be explained by differences in scope, such as differences in transport distance, for instance, Sikkema et al. (2010) assumed shipping across 16,500 km, whereas Agar (2017) calculated shipping cost across 11,450 km. The geographical scope of different studies affects not only transport distance but also country specific factors such as feedstock cost, labor cost, transport cost and electricity cost. Uasuf & Becker (2011) assumed feedstock cost of 13,5 €/t for a pellet plant in Argentina, whereas Obernberger & Thek (2010) calculated based on feedstock cost of 58,7 €/t for an Austrian pellet plant. A large part of the cost variation can however not be attributed to case study differences. Both Pirraglia et al. (2010) and Mani et al. (2006) analyzed pellet production cost of a US-based pellet plant and came to very different conclusion. These uncertainties in cost data from available literature must be taken into consideration when calculating supply chain cost.

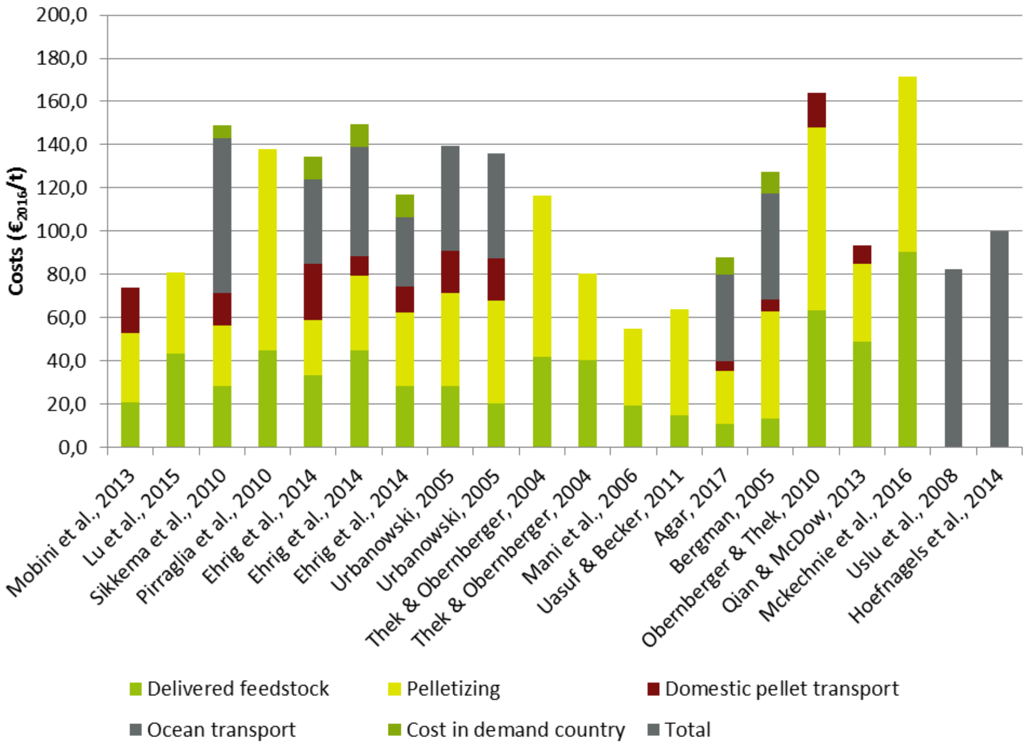

Figure 2.4 – Wood pellet supply chain cost components in literature

Specific pelletization costs can include (1) general costs such as construction, infrastructure and planning costs; costs for (2) dryers and for drying; (3) for grinding the dried feedstock; (4) for pellet mills and the densification process; (5) for cooling; (6) for storage of the raw material as well as produced pellets. Pelletization costs depend on the pellet plant size, electricity-, process heat- and labor costs and on feedstock characteristics, such as moisture content, density and its processability. The majority of the analyzed literature hints at pelletization costs between 25 and 40€/t. This range reflects most recent literature except for Uasuf & Becker (2011), and Mckechnie et al. (2016). Feedstock prices clearly depend on the type of feedstock, and can include harvesting or residuals collection costs, processing- (chipping) costs and material costs. Furthermore, there can be a large difference between feedstock costs and prices paid by pellet companies in case of competition, hence market conditions with various potential buyers. A good seasonal understanding of feedstock yield, -availability and its accessibility as well as possible competition in close proximity to the pellet plants over its life time is therefore crucial for a successful venture. (Schipfer, 2017)

Wood pellets are transported by using different transport modes namely road-, rail-, inland water way- (IWW-) and sea transport. Wood pellets and supply chain models use 'default values' to calculate generic supply chain costs for example to describe the economic and environmental advantages of biomass densification (Hoefnagels, R et al., 2011; Mobini et al., 2013; Sikkema et al., 2010; Svanberg et al., 2013; Uslu et al., 2008) or to optimize pellet plant locations and distribution networks (Batidzirai, 2013). In this subsection we want to highlight a selection of these values, how to generically use them for calculating environmental and economic efficiency of wood pellet supply chains and discuss limitations of such methodologies.

Distribution of wood pellets starts at the wood pellet plant and ends with the arrival at the end user e.g. at the boiler storage of an individual household, for a co-fired power plant or at the storage for a large scale gasifier for the production of chemicals. Depending on the distance of distribution as well as the time lag between sending and arriving most sensitive parameters for calculating distribution costs are costs with regard to (un-)loading, transportation and intermediary storage. For the calculation of emissions fuel consumption of only the transport modes is estimated to be sufficient (Sikkema et al., 2010).

Variable costs for transportation are estimated based on (Hoefnagels, R et al., 2014) and fuel consumption values are adopted from the same reference.

Table 2-1 - Default values for transportation of wood pellets. Source: own estimation based on (Hoefnagels, R et al., 2014)

Transport mode	Parameter	Unit	Value
Truck	Variable costs full load	€/t km	0.0456
Truck	Diesel consumption full load	MJ/t km	0.48
Truck	Variable costs without payload	€/t km	0,0400
Truck	Diesel consumption without payload	MJ/t km	0.30
Rail	Variable costs	€/t km	0.0036
Rail	Diesel consumption	MJ/t km	0.11
Ocean (Supramax)	Variable costs	€/t km	0.0010
Ocean (Supramax)	IFO380 consumption	MJ/t km	0.06
IWW (Large dry bulk)	Variable costs	€/t km	0.0116
IWW (Large dry bulk)	MDO consumption	MJ/t km	0.25

We assume labor costs of 25.0 €/h and a diesel price of 1.1 €/l which is equivalent to about 29.8 €/GJ[1]. These values correspond to EU28 average wages in 2015 from (EUROSTAT, 2016) and average Diesel consumer prices for 2016 (Jan.-Sept.) from (European Commission, 2016). Prices for IFO380, used for ocean shipping, and Maritime Diesel Oil (MDO), used for IWW, can be roughly estimated using Brent crude oil prices as indicator: For the period January 2016 until September 2016 an average Brent Oil price of 8.5 €/GJ is estimated[2]. According to (Ship & Bunker, 2015) IFO380 was priced with an discount at 70-80 % to the crude price while maritime gasoil (MGO) was priced at a premium of 15-20 % over Brent (in the time frame Nov. 2012-Dec. 2014). Since MDO is a blend of MGO and Heavy Fuel Oil (HVO) we roughly estimate MDO with a 15 % premium. For IFO380 we use the averaged 75 % discount. All following variable costs are specified to one metric tonne of wood pellets. Therefore the maximum loads in tonnes of the different transport modes but IWW outlined in (Hoefnagels, R et al., 2014) are used. For IWW we use the maximum load in volume since the design ratio [in $kg*m^{-3}$] is higher than the assumed wood pellet bulk density of about 600 $kg*m^{-3}$. More simply put, in trucks, rail and ocean transport weight is the limiting factor for wood pellets, while for IWW the space occupied by the wood pellet bulk limits haulage. Furthermore for empty trips, which are often necessary to return the vehicle to the wood pellet plant, only values for the road transport are calculated. Here, about 38 % decreased fuel consumption has a significant impact on the variable costs (-12 %), while for other transport

[1] Based on an energy density of 36.9 MJ/l http://www.acea.be/news/article/differences-between-diesel-and-petrol

[2] Based on Euroinvestor.com. Assuming a barrel oil equivalent of 6.1 GJ and an average Euro/US-Dollar exchange rate of 1.116 €/$ for the same time frame. Sources https://en.wikipedia.org/wiki/Barrel_of_oil_equivalent & http://www.oanda.com/lang/de/

modes the difference is assumed to be negligible.

No literature is known to the authors which analyses loading and unloading options of wood pellets. However, (Hoefnagels, R. et al., 2014) states averages of 1.83 €/t for truck and ships and 2.97 €/t for transshipment to and from rails. Depending on the distance of distribution, these transshipment costs can be significant for the overall transportation costs. Assuming for example a 1,000 km train transport (incl. backhaul), the default values result in 12.4 €/t transport cost of which about 48 % account for transshipment.

Furthermore no costs for wood pellet silos could be acquired. Based on (Rotter and Rohrhofer, 2014) we estimate costs for an enclosed intermediate depot yearly operating costs including depreciation, interest rates, maintenance and labor with about 15.56 €/m^3*a. Assuming wood pellets to be stored we derive 0.07 €/m^3*a which is comparable to estimated 0.08 €/m^3*a stated in (Rotter and Rohrhofer, 2014).

According to the default values discussed in chapter 2.3, wood pellet transport costs via truck over 200 km (incl. backhaul) is estimated with about 20.8 €/t. In (Sikkema et al., 2011) prices between 12.0 €/t and 18.0 €/t for the year 2009 and various distances and truck load combinations are discussed and an example for 200 km with 16.0 €/t is outlined. Considering lower current (2016) diesel prices than in 2009 as well as the fact, that we do not include any road tolls (e.g. vignette), the calculated value appears to be overestimated. Without backhaul the same calculation results in costs of 13.1 €/t. Freight costs from North America to Europe in the time frame 2002 and 2010 ranged between 27.0 €/t and 69.0 €/t (Sikkema et al., 2011). Based on the reference values (and incl. backhaul) shipping 15,000 km, which would equal a transportation distance from the US west coast (via Panama channel) to Amsterdam, results in shipping costs of about 34.8 €/t (19.3 €/t without backhaul).

A comparison with market prices for specific cases gives further insights into the validity of the presented method. We find for example long term contracts for hauling (truck transport) for Sweden and Canada of 0.10 €/t_km and 0.06 €/t_km respectively. These prices are based on the exceptional low oil price and already include loading and unloading in 2016. The reasons why the Canadian cost are lower could be related to lower values for all cost factors, but also to the fact that contracts tend to be larger. Furthermore, due to a competitive market in this sector prices tend to be closely related to costs.

However, this cannot be said in general for transport by rail: The cost structure of rail transport is dominated by capital cost, while costs for manpower and oil/electricity are relatively low. Conditions for the pricing vary considerably. Some rail companies are run as monopolies, others in free competition; some cargo traffic is restricted by congestion, etc. However, as the costs overwhelmingly are sunk (fixed), terms for large and long term contracts would be negotiable. We find long distance rail transport prices of 0.026 and 0.027 €/t_km for Sweden and Canada respectively. While these prices are based on free competition in Sweden, Canadian prices are Tariffs. Furthermore, Canadian bulk trains are based on dedicated carriers with higher cargo than in Sweden, thus resulting in lower specific costs.

For ocean transport, shipping contracts are recorded and published and statistical data for actual rates can be followed on a daily basis. Two price components dominate sea operations; the daily cost to hire an operable ship, and the price of bunker oil. In addition, to arrive at the total shipping cost, also terminal costs and fees must be included. At present the costs for ocean transport are extraordinary low. The low activity in the general economy and the high number of new tonnage has led to prices for ship hire on levels about one tenth of the peak values 10 years ago. Also bunker oil prices have decreased considerably. In the (extraordinary) situation of today, terminal, etc. costs dominate the price structure. By following the daily price quotations from dryships.com/pages/report.php and shipandbunker.com/prices, the actual shipping prices can be estimated with about 30 $/t for shipping from “The Gulf” to Rotterdam. This price is based on 17 $/t terminal costs and fees, risk and profit, 7 $/t bunker costs and 6 $/t for the charter with 42 days in total at sea and in ports, including ballast days. It goes without saying that the present charter rates in particular and also the price for bunker oil would not remain at the present levels. Values related to long term time series could be more relevant for future plans.

Especially regarding intercontinental ocean shipping of wood pellets it is difficult to determine generic transport costs. According to (Wright, 2016) long-term contracts play a certain role, with rates typically at about 55.0 $/t from British Columbia and US West Coast to North Europe if signed before the financial crisis. The respective spot price climbed as high as 75-80.0 $/t during 2008 and collapsed to as low as 17-20.0 $/t by the start of 2009. Furthermore, (UNCTAD, 2010) indicates that freight rates from the US to Europe do not necessarily co-move with rates from Europe to U.S. We conclude that price formation of freight rates are steered by supply and demand and would have to be econometrically modelled if their share in total wood pellet prices wants to be accounted for. Freight rates for truck transport within the EU28 can vary strongly, especially due to different labor costs. Beside road tolls (e.g. vignette) also regulatory measurements will have to be priced into truck transport costs in the upcoming years if transport mode shift strategies (from road to rail) (European Parliament, 2015) want to be implemented successfully. Transportation via rail and IWW accounted for 18 % and about 7 % in 2014 in the EU28. Especially for this region, the default values would have to be compared to real costs paid and validated in further research. Rail transport in the EU is mainly fueled by electricity. However, electricity prices payed by European rail transport companies are not known to the authors.

Regarding the environmental efficiency, discussed examples of 200 km road, 1,000 km rail and 15,000 km ocean transport result in a fuel consumption of 1.0 %, 1.4 % and 10.0 % respectively when an empty backhaul and a relatively low energy content of 16.0 MJ/kg for wood pellets from (Thrän et al., 2016) are considered.

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3 Wood pellet industry and market in Europe

3.1 Austria

Fabian Schipfer

3.1.1 Regulatory framework, market drivers and barriers

Since the 1990s wood pellets are established in Austria as a fuel for utilization in automatized, biogenic heating systems for very small to medium boilers. Since then and due to a relatively high oil price in the early years of this century, wood pellets as a renewable alternative became increasingly attractive. Until 2006 a stable annual growth of 30 % to 40 % in consumption can be highlighted and also exports increased significantly. After a drop in consumption after a relatively mild winter in 2006/2007, paired with a price peak in the end of 2006 the consumption continued to increase until 2013. Since then relatively mild winter and relatively low oil price weakened the growing importance of wood pellets in Austria.

The main policy instrument triggering the wood pellet market development can be seen in continuous financial support measures for the installation of wood pellet stoves and boilers. Up to 30 % of investment costs can be reimbursed through the "Klima und Energiefond" for boilers for heating in the non-residential sector (<400 kW thermal), up to 35 % for private (<50 kW) installations and, depending on the location, even more than that if funding from the respective region is available. Funding levels are based on the guidelines for domestic environmental support (UFI) anchored in the Environmental Measures Support Act (UFG) and in regional support schemes. In contrary to pellet heating systems, electricity production based on wood pellets does only play a minor role in small to medium sized CHP-installations. Beside some isolated financial support options for the investment, feed-in-tariffs in Austria are not attractive enough to change this situation.

In summary, financial support for the substitution of very small to medium oil based heating systems and more volatile oil prices than wood pellet prices (Kristöfel et al., 2016) led to a strongly growing Austrian wood pellet market in the current and last decade. No dis-continuation of the support schemes is discussed but the relatively low oil price and reduced heating degree days could have a hampering effect if these unpredictable variables do not change. On a longer term the reduction of heating demand due to a growing stock of passive- and low-energy buildings paired with rising global mean temperatures could lead to a peak of the Austrian wood pellet market in the upcoming two decades.

Furthermore after not complying with the Kyoto protocol and therefore not implementing the last Klimastrategie (2007-2012), Austria is without an "Energy and climate strategy" since 2013. However, following up the ratification of the Paris Agreement a new strategy was discussed publicly in the summer of 2016 and a "white paper" is expected for the beginning of 2017. It is unclear if the new strategy will include additional incentives possibly impacting on the Austrian wood pellet market.

3.1.2 Production capacity, production and feedstock

Production capacity increased from about 300 kt in 2004 to 1.5 Mt in 2015. Investment and planning of new capacities is expected to take several years, thus capacities continuously increased without any visible impact of the consumption drop in 2007. Only a capacity plateau from 2010 to 2013 can be observed followed by capacity increases again in 2014 and 2015. As a result from stronger increases in capacity than in consumption, triggered also from a series of relatively mild winters in the last years, utilization rate dropped to 67 % in 2015.

National capacities of pellet producers are in the range of 1 kt/a to 310 kt/a. Largest producers in Austria with a capacity above 100 kt/a are RZ Pellets (310 kt/a)[3], Pfeifer Holz GmbH & CO KG (175 kt/a), Binderholz GmbH (170 kt/a), Hasslacher (110 kt/a and Peter Seppel GmbH 103 kt/a). However Austrian companies also produce in Romania (502 kt/a Schweighofer) and in Germany and the Czech Republic (Pfeifer Holz Gmbh & CoKG[1] with 245 kt/a and Binderholz GmbH with 180 kt/a).

According to Propellets (2017), Austrian wood pellets are produced entirely out of industrial residual wood and sawmill byproducts. The Austrian wood pellet association reports an ENplus certification rate[1] of national producers of about 86 % and since most pellets are produced for the consumption in small pellet boilers a majority of ENplus A1 certified pellets is expected (Geographical distribution available at http://www.propellets.at/en/heating-with-woodpellets/pellets/).

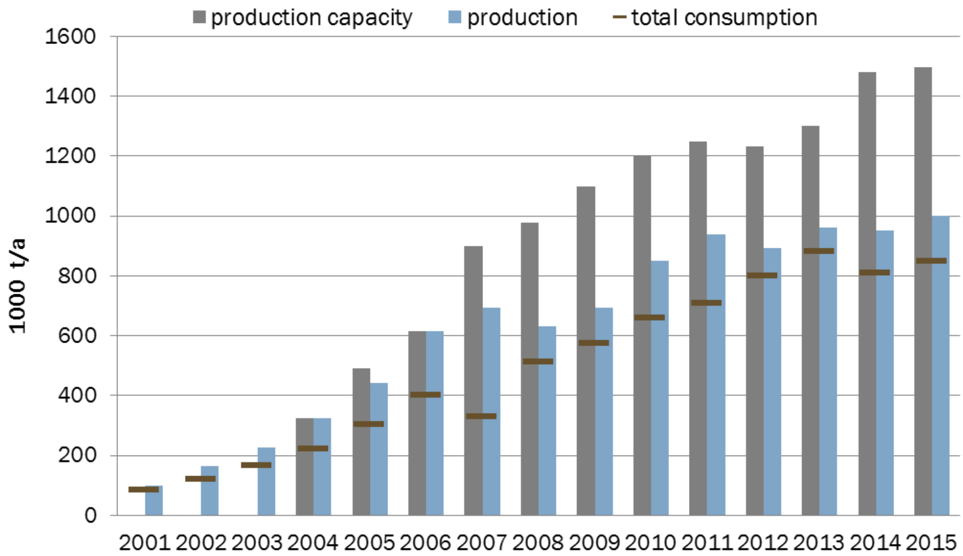

Figure 3.1 – Wood pellet market development in Austria from 2001 to 2015 (Biermayer et al., 2016).

[3] Personal communication Christian Schlagitweit, ProPellets Austria, 30.09.2016

3.1.3 Consumption

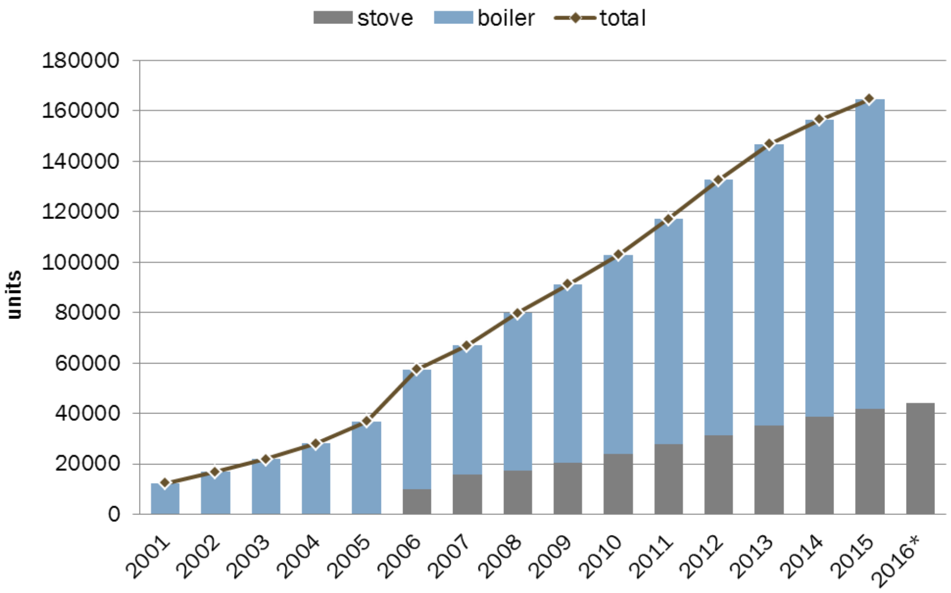

Figure 3.2 – Development of installed pellet heating systems in Austria from 2001 to 2016 (2016* estimated) (Haneder, 2016).

Wood pellet consumption in Austria increased steadily from 85 kt in 2001 to the tenfold (850 kt) in 2015, with the exception of a consumption drop in 2007 and stagnation after 2013. The main consumers are household consumers with very small to medium heating systems. The average boiler size is at about 20 kW thermal. Larger pellet boilers (>100 kW thermal) are for example used in hotels. Pellet stoves play a minor role, with about 40,000 units compared to about 120,000 boilers of which about 6,000 boilers are bigger than 30 kW thermal. These numbers are based on annually sold units not taking into consideration old stock before 1997 for boilers <100 kW thermal and before 2010 for numbers of boilers >30 kW thermal. No wood pellet co-firing in Austria is known to the authors.

3.1.4 Price trends

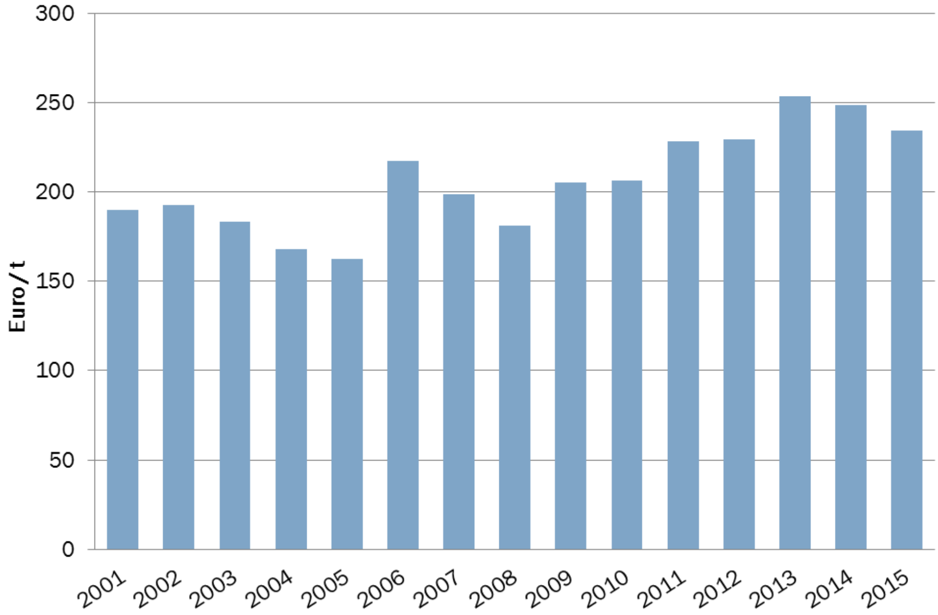

Figure 3.3 – Average wood pellet prices in Austria from 2001 to 2015 (propellets, 2016).

Wood pellet prices are collected and documented on a monthly basis in the "pellet price index 2006 – PPI06" from proPellets Austria. The index is based on prices for Pellets certified according to ISO 17225-2 A1 or ENplus A1, not packed and for an order amount of 6 t. Additional feed-in-flat rates (Einblaspauschale) for delivery into the residential pellet storage of an average of about 6.5 €/t have to be added. In order to derive an absolute price time series, we applied the value for January 2006 of 177,8 €/t (Bürger, 2015). The PPI06 includes changes in VAT as for example the raise from 10 % to 13 %VAT for buying wood pellets in Austria since 2016. Wood pellet prices tend to be highest in the regions Tirol and Vorarlberg (West-Austria) in the last years[4]. Furthermore a co-integration with German wood pellet prices can be highlighted, however with Austrian pellet prices on a lower level than in the neighboring country (Bürger, 2015). Furthermore the PPI06 indicates certain seasonality with price peaks around December and price lows during spring.

[4] http://www.propellets.at/wpcms/wp-content/uploads/201608_regio.pdf

3.1.5 Trade and logistic aspects

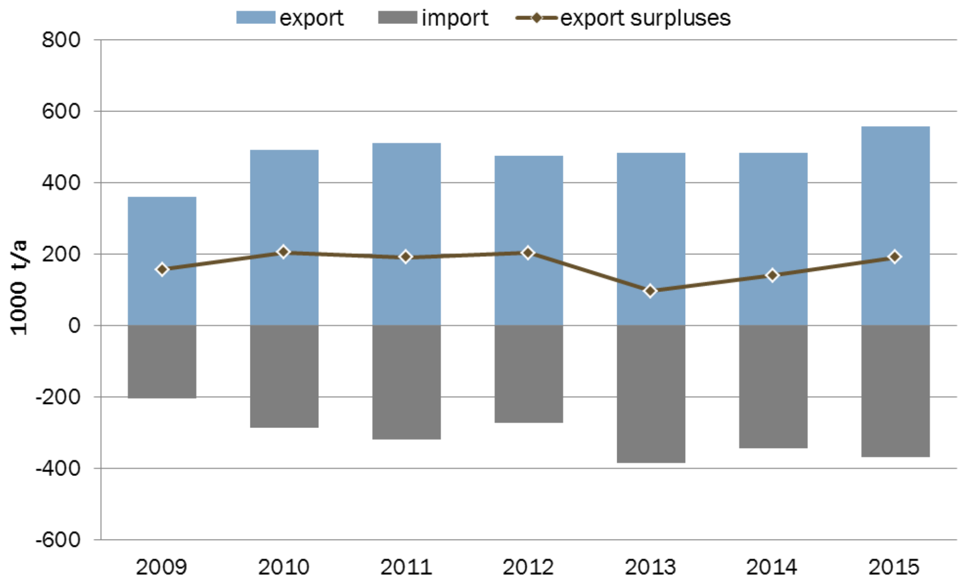

Figure 3.4 – Evolution of export and import in Austria from 2009 to 2015 (eurostat, 2015).

Main countries from which pellets were imported in 2015 according to Eurostat are Romania, the Czech Republic and Germany. The reason behind these strong trade relations are mainly Austrian producers with capacities in the named countries. Furthermore a relatively long border with Germany can make it more profitable to trade cross borders but based on short distances. The latter is also true for Austrian exports, which mainly went to Italy and partly to Germany, Switzerland and other neighboring countries in 2015. We expect that the great majority of imports and exports are handled via truck transport. Imports from Romania are mainly pellets transported in bulk, exports to Italy mainly pellets in bags transported on pallets in trucks[5]. According to an Austrian pellet trader, venture capital to build wood pellet storages is unlikely to be acquired while at the same time traded volumes are too small for commodity traders to invest[6].

[5] Personal communication Christian Schlagitweit, ProPellets Austria, 30.09.2016

[6] Personal communication with Michael Wild, Wild / Partner LLC, Principal, 09.09.2016

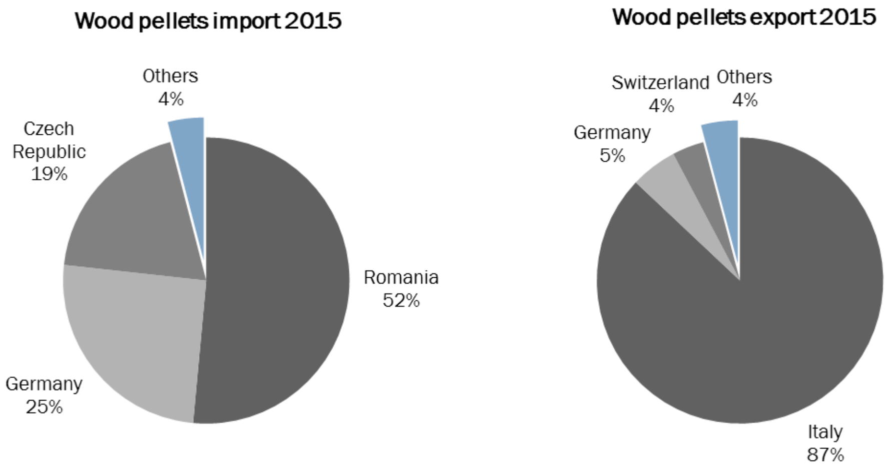

Figure 3.5 - Wood pellets export & import in Austria for 2015

3.1.6 Pellet quality standard

As already discussed, 86 % of Austrian wood pellet producers are ENplus certified and we expect most of the produced pellets to be in ENplus A1 quality for Austrian wood pellet boilers with an average size of 20 kW thermal. This quality is also comparable with the former ÖNORM M7135 for wood pellets and is based on the wood pellet standard EN 14961-2. While the ÖNORM M7135 was used from 2000 onwards, it was substituted by the ENplus standard in 2011 and since September 2015 with the ISO 17225-2 standard (Kristöfel et al., 2016).

For the ENplusA1 quality parameters and ISO 17225-2 standard please see ENplus description for Germany.

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3.2 Baltic States

Svetlana Proskurina, Jussi Heinimö

3.2.1 Regulatory framework, market drivers and barriers

The bioenergy market in the Baltic States is rather unique. Estonia and especially Latvia have a high share of renewables in their energy mix. Lithuania uses a larger RES share than the European Union average. Estonia and Latvia have strong pellet markets. Estonia has the biggest volume of produced pellets per capita in the world. Similar to Lithuania, the wood pellet production are mainly focused on exports (IEA Bioenergy, 2011).

In the Baltic countries, renewable energy is supported mainly by investments. Lithuania has three main instruments which are used to promote RES in heating. These are: guaranteed purchasing of heat from independent RES producers, subsidies from the Lithuanian Environmental Investment Fund and environmental pollution tax relief for solid and liquid biomass. In Estonia investment support for RE in heating is round-based and can be granted for the construction of RE CHP plants, reconstruction of boiler-houses and the district heating network as well as support to the owners of private house and apartment buildings. Latvia has project calls within Climate Change Financial Instrument focusing to transition from fossil fuel to RES in heat supply systems including use of RES in households. The use of wood pellets can be identified in about 70 % biomass projects (without mixed technology) planned by households (Krievina and Melece, 2015).

The Baltic countries have support for renewable electricity. In Lithuania, in addition to feed-in tariff, the producers of renewable electricity may apply for grants from the Lithuanian Environmental Investment Fund (LEIF) and the Fund for the Special Programme for Climate Change Mitigation and are exempt from excise tax. In Latvia renewable electricity generation is stimulated through a complex support system based on a feed-in tariff, which is on hold until 2020 and net-metering which was introduced in January 2014. Estonia has premium tariff and investment supports (Subsidy II) for the use of bioenergy, which is addressed to entrepreneurs who got at least 50 % of their profit share from the processing and sales of agricultural products (European Commission, 2015).

Main drivers for pellet production and trade in Baltic States:

- Relatively low costs of production (raw material, salaries and energy);
- Raw material – there is a wood resource available and cheap labour and energy costs can make the price competitive
- Big ports for pellet transport in Sillamae (Estonia), Klaipeda (Lithiania), Liepaya, Vetspils (Latvia), and Paldiski (Estonia) (IEA Bioenergy, 2011).

Main barriers:

- Lack of domestic equipment producers/consultants/experts;
- Lack of easy and good quality supply chain for any target group.
- Lack of big domestic consumers (IEA Bioenergy, 2011).

3.2.2 Production capacity, production and feedstock

In the Baltic States the condition of wood pellet production is quite favorable thanks to abundant forest land, relatively low costs of production, port accessibility, low energy costs and low taxes. In the Baltic States, the total wood pellet production was 2.65 Mt in 2014 (Fletcher, 2016).

Latvia has showed a real boom in wood pellet production with more than 1.3 Mt in 2014, (Figure

3.6). Latvia has the high raw material availability and the increase of wood pellet production plants. In the country wood pellet production are mainly focuses on industrial users. The increase of Dollars-Euros exchange rate that started by the end of 2014 has created an advantage for the EU industrial producers compared to North American producers. Latvia clearly shows a huge potential for further growth (AEBIOM, 2015).

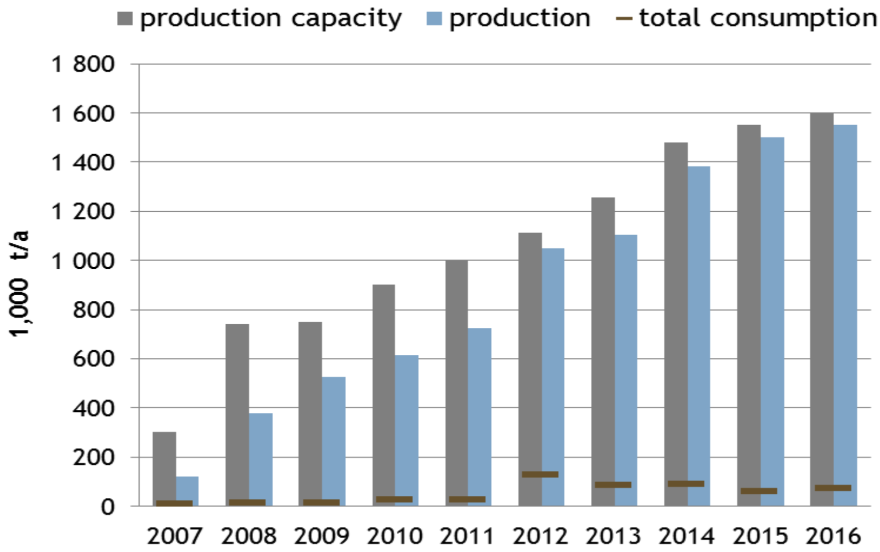

Figure 3.6 - Wood pellet market development in Latvia from 2007 to 2016.

Estonia is the large pellet producer and the 4th biggest EU pellet exporter due to a very quick progress in wood pellet production in 2014. The production has boomed due to the high availability of raw material showing a rather stable price and the growing pellet demand in EU. Strong investments have been made with new plants being built and capacity of existing plants being increased. Estonia clearly presents a huge potential for future growth and will continue being a net exporter. It is very likely that Estonia will follow the same trend as Latvia in the future as the characteristics of these two countries are very similar with having high wood resources and low local pellet demand (AEBIOM, 2015) (Figure 3.7). Lithuania has the bigger share of local consumption of wood pellets compared with Estonia and Latvia (Figure 3.8).

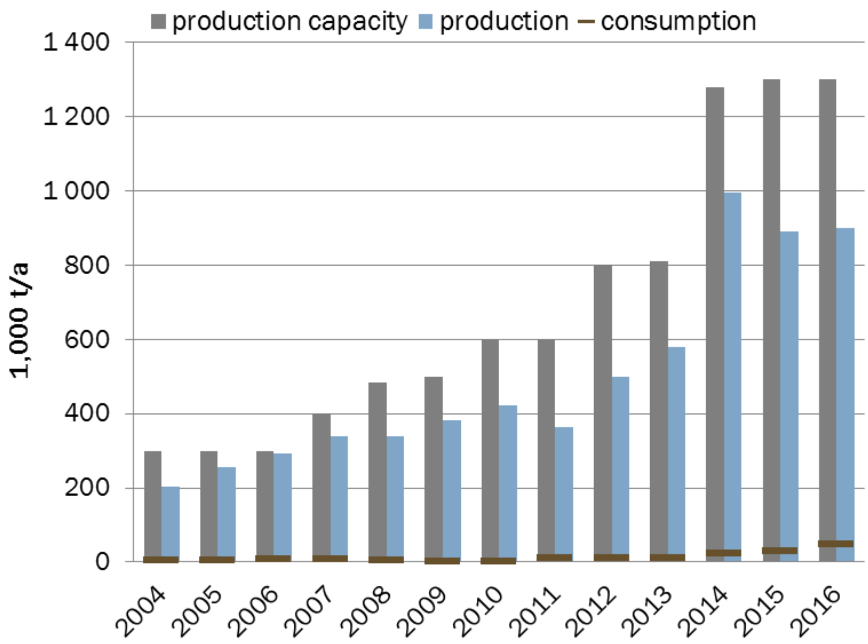

Figure 3.7 - Wood pellet market development in Estonia from 2004 to 2016.

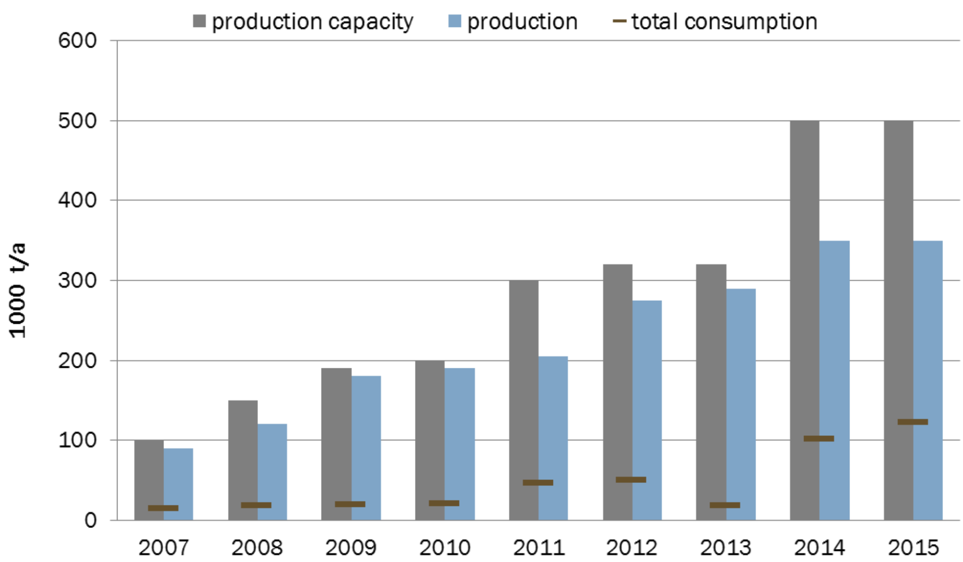

Figure 3.8 - Wood pellet market development in Lithuania from 2007 to 2015.

Table 3-1 shows the main five producers of wood pellets in the Baltic States. In 2015, Graanul Invest which is a large Estonian wood pellet producer acquired Latgran. Thus the total capacity of Graanul Invest is 1.8 Mt of wood pellets and actual production is about 1.6 Mt of wood pellets. More than 95 % of total wood pellets are exported. Graanul Invest has 11 pellet plants from which four in Estonia, six in Latvia and one in Lithuania. In 2016 the company plans to produce 2.15 Mt of wood pellets and to increase the number of production plants. Another large producer is SBE Latvia Ltd., which is a member of Swedish Agroenergi Neova Pellets AB Group with production around 70,000 t of wood pellets annually (Fletcher, 2016). Additionally, there are many small and medium sized producers in the Baltic States.

Table 3-1 - The main wood pellets producers in the Baltic States.

Company	Established year	Country	Production capacity (tonnes)	links
AS Graanul Invest	2003	Estonia	853,000	http://www.pellet.org/images/2015/ArnoldDaleEkman.pdf
Latgran	2004	Latvia	497,000	
SBE Latvia LTD	1997	Latvia	600,000	https://www.sbe.lv/en/about-us/
Newfuels	2010	Latvia	240,000	http://www.newfuels.eu/
Stora Enso (Eesti As)	2008	Estonia	100,000*	
Purutuli OÜ	2010	Estonia	120,000	http://www.purutuli.ee/index.php?cat=lmenu&page=21&lang=2

**actual production*

The main source of wood pellet feedstocks is residues from sawmill industry and low quality round wood which comes from coniferous softwood mainly pine and spruce with small amounts of alder, aspen and birch. The Graanul Invest uses both sources in a proportion of 50/50 %. Latvia has an abundance of the natural forest growth. Over the past 14 years the amount of standing wood in the forests of Latvia has increased by approximately 125 million m^3 or 23 %. In fact, forest resources are growing faster than the demand for energy wood in the Baltic Sea region (every year by over 140 million m^3 (fellings vs. increment) (Fletcher, 2016).

3.2.3 Consumption

The potential of domestic wood pellet consumption is rather limited in the Baltic countries. It can be explained by the use of cheaper solid biofuels such as wood chips which are used in district heating and CHP. In Latvia wood pellet consumption was less than 100,000 t (AEBIOM, 2015). About 74 % of total wood pellets were consumed by households in 2014. On the local market, the price of wood pellets is cheaper than natural gas by around 60 % and is two times more expensive than other solid biofuels such as firewood and wood chips. Thus, wood chips have been preferred for heat and CHP plants. Wood pellets are used as the main fuel in 41 heat plants with 21 MW of the total installed heating capacity. For comparison, there were only 11 heat plants with 9 MW of the heat capacity in 2007. In transformation sector about 800 t of wood pellets were used in 2014 (Krievina and Melece, 2015).

3.2.4 Price trends

In the Baltic States, the average price of ENplus A1 pellets is about 150 €/t for the residential market. In Latvia the average sales price for bagged pellets (15 kg bags) of premium class ENplus A1 certified pellets is around 130-140 €/t. The average price of industrial pellets is around 115-124 €/t free on board prices, depending on the producer and contract (Fletcher, 2016).

3.2.5 Trade and logistic aspects

Latvia is the main exporter of wood pellets among the Baltic countries with 1.5 Mt of exported wood pellets. Estonia and Lithuania exported about 0.9 Mt and 0.3 Mt of wood pellets respectively in 2015. Figure 3.9, Figure 3.10 and Figure 3.11 show export and import of wood pellets in Latvia, Estonia and Lithuania respectively. The Latvian wood pellets are exported mostly to the UK and Denmark (Figure 3.12). Estonia and Lithuania exported wood pellets mostly to Denmark and Italy respectively in 2015 (Figure 3.13 and Figure 3.14).

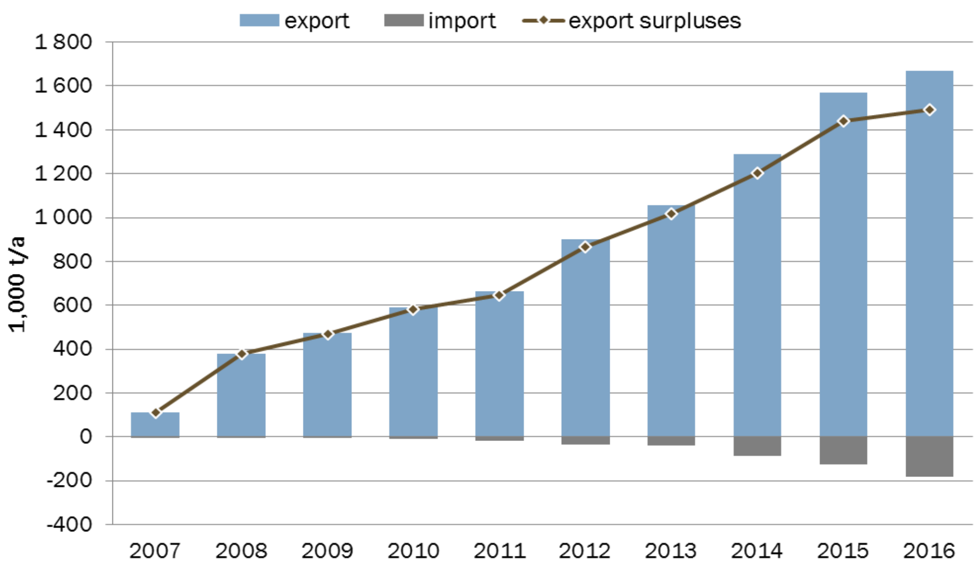

Figure 3.9 - Evolution of export and import in Latvia from 2007 to 2016.

Figure 3.10 - Evolution of export and import in Estonia from 2004 to 2016.

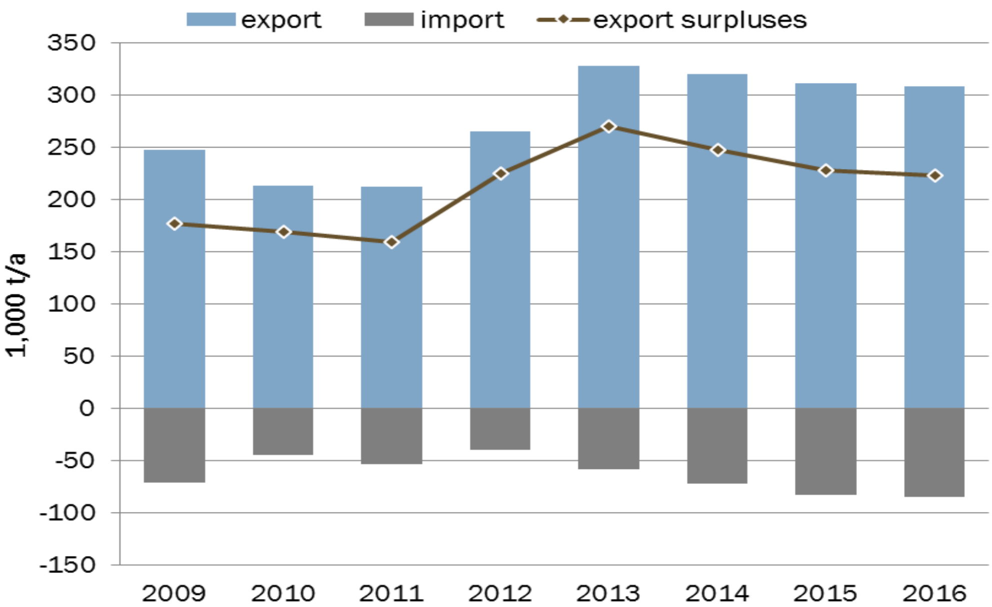

Figure 3.11 - Evolution of export and import in Lithuania from 2008 to 2016.

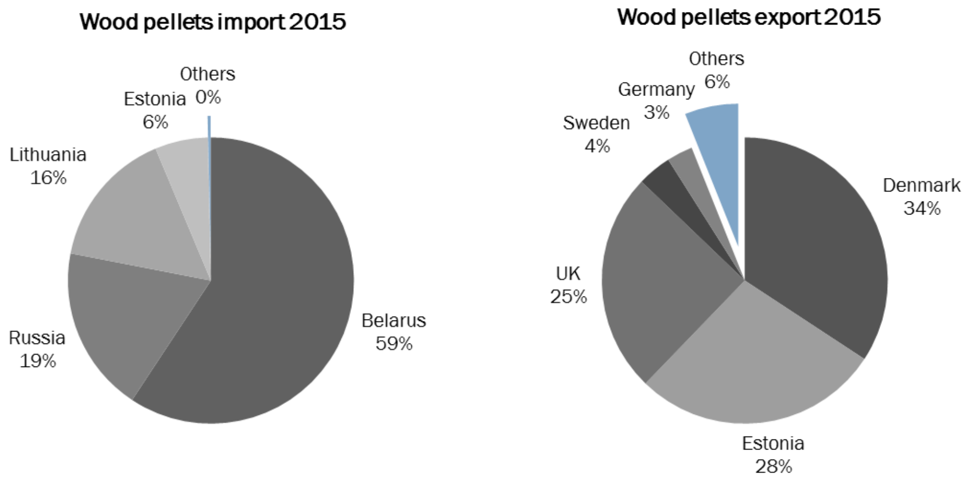

Figure 3.12 - Wood pellets import and export in Latvia (2015), (Trade Map, 2016).

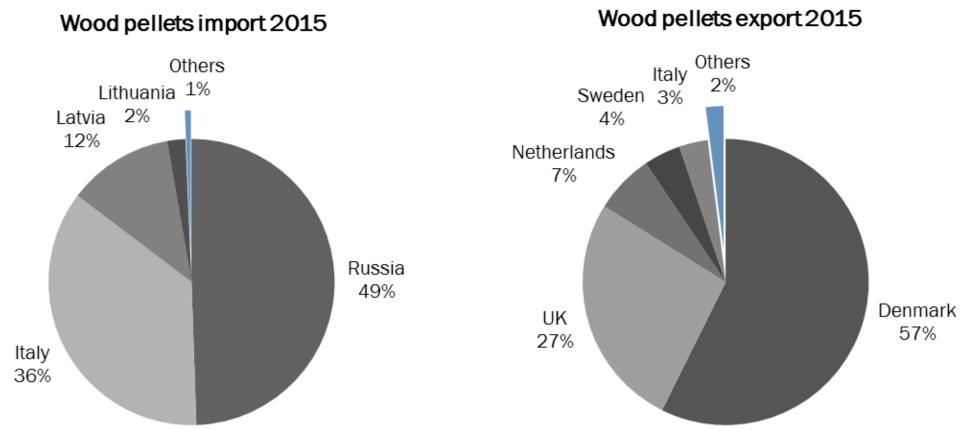

Figure 3.13 - Wood pellets export and import in Estonia (2015), (Trade Map, 2016).

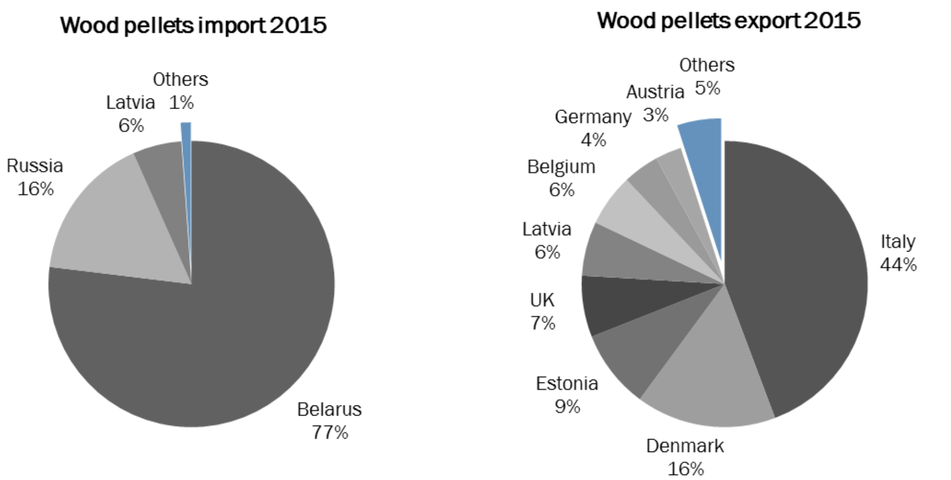

Figure 3.14 - Wood pellets export and import in Lithuania (2015), (Trade Map, 2016).

Concerning imports, Latvia, Estonia, and Lithuania imported 130,000, 17,000 and 83,000 t of wood pellets respectively in 2015. Figure 3.12, Figure 3.13 and Figure 3.14 show imports of wood pellets in Latvia, Estonia and Lithuania respectively.

In 2014 approximately 35 % of the total wood pellet export of the EU-28 was from the Baltic countries, from which 20 %, 10 % and 5 % were from Latvia, Estonia and Lithuania respectively. In Estonia more than 50 % of export and import of wood pellets are transported by sea; transit accounts 70 % of sea fright and 76 % in port of Tallinn. Graanul Invest's production is exported through Latvia's Riga port, the Port of Tallinn and Port of Pärnu in Estonia (Fletcher, 2016).

Big ports for pellet transport are located in Sillamae (Estonia), Klaipeda (Lithiania), Liepaya, Vetspils (Latvia), and Paldiski (Estonia).

3.2.6 Pellet quality standard

There is no local wood pellet standard in the Baltic States. The Baltic countries registered a significant increase by doubling the amount of production and are hence expected to reach 1 Mt certified by ENplus in 2015. The Baltics countries have 27 ENplus producers from which 10 are in Latvia, 9 in Lithuania and 8 in Estonia. Additionally, producers such as the Graanul Invest showed interest in the sustainable Biomass Partnership (SBP) certification framework in addition to their Forest Stewardship Council and Programme for the Endorsement of Forest Certification schemes (Fletcher, 2016). Since May 2016 all Latvian pellet plants of the Graanul Invest group hold certificates of conformity to the internationally recognized Energy Management Systems, ISO 50 001 standard (AS Graanul Invest, 2016).

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Trade Map, 2016. Trade Map - List of supplying markets for a product imported by European Countries [WWW Document]. URL http://www.trademap.org/Country_SelProductCountry_TS.aspx?nvpm=1|276||||TOTAL|||2|1|1|1|2|1|2|1| (accessed 3.1.17).

3.3 Belgium/Flanders

Ruben Guisson

3.3.1 Regulatory framework, market drivers and barriers

Installation quality assurance

The Flemish Region, the Walloon Region and the Brussels-Capital Region have established a harmonized system for the education and certification of installers of small scale (residential) renewable energy installations; including biomass heating boilers.

Support for green heat (Flanders)

Support is provided for green heat generated by large biomass installations (> 1 MW). The support is granted in the form of an investment subsidy and allocated via a call system. A call is issued at least every six months. The applicant indicates the percentage of eligible costs concerned. The percentage is limited to a maximum percentage. The projects are ranked according to the level of the support percentage applied for. Projects receive support until the available budget has been spent.

Support for green electricity (Flanders)

A support system is in place, issuing green certificates for the production of electricity based on biomass resources. The producer of renewable electricity receives, from the regulator (VREG) one (1) green electricity certificate for the production of one (1) MWh_e. This certificate can be sold to the energy suppliers who have the obligation to yearly cover a certain percentage of their total electricity supply with green certificates.

Support for CHP (Flanders)

A support system is in place, issuing CHP-certificates for primary energy consumption reduction through qualitative CHP application, including bio-CHP. The system is for the most part analogue to the green electricity support system.

3.3.2 Production capacity, production and feedstock

The production capacity stayed the same in 2014 and 2015 at 760,000 t from 12 plants. However, the production decreased from 395,000 t to 320,000 t (AEBIOM 2016).

3.3.3 Consumption

No specific pellet consumption data are available for Flanders/Belgium. Indirect data can be derived from the Flemish renewable energy inventory.

Pellet consumption for green electricity production.

The inventory indicates the amount of solid biomass (including pellets) used for green electricity production (including CHP). Under the rough assumption that all solid biomass used for electricity production is under the form of wood pellets (16.5 MJ/kg), the consumption fluctuated the last years roughly between 1-1.5 million tonnes.

Table 3-2 - Estimated pellet consumption for green electricity production. Source: Guisson R. adapted from Renewable Energy Inventory Flanders (2005-2015)

Year	Consumption [t]
2010	961.212
2011	1.159.576
2012	1.635.515
2013	1.482.667
2014	1.181.576
2015	1.595.212

Wood pellet consumption in Belgium is dominated by large scale power plants and that demand is driven by the EU 20 percent renewable fuels target for energy use by 2020. In 2015, Belgium imported $173 million worth of wood pellets of which close to 65 percent were from the United States. This made Belgium the third largest market for American pellets in 2015.

3.3.4 Pellet quality standard

A Royal Decree organizes the quality requirements of wood pellets applied in non-industrial heating systems (Vito, 2017), i.e. stoves and boilers with a thermal power equal to or lower than 300 kW. Under 300 kW no environmental permit is required, hence control is safeguarded through feedstock requirements. Above 300 kW an environmental permit is required.

The following product norms are being applied:

Sustainability:

The origin of the wood: wood used for the production of pellets needs to chemically untreated and originating from sustainable forest management activities, such as FSC- and PEFC-label. Other labels can be used as well as long as the same (as FSC & PEFC) goals regarding sustainable forest management are applied.

Technical requirements:

Table 3-3 - Technical requirements for non-industrial wood pellets (<300 kW installations)

Parameter	Value
Humidity	< 10 % measured in accordance with norm EN 14774-2
Ash content	< 1,5 % measured in accordance with norm EN 14775
Calorific value	≥ 16,3 MJ/kg measured in accordance with norm EN 14918, CEN/TS 15234 annex E formula 2
Length	3,15 ≤ l ≤ 40 mm measured in accordance with norm prEN 14961-2 (*5 % of pellets with L > 40 mm are accepted, L max = 45 mm)

Parameter	Value
Diameter	5 ≤ d < 9 mm measured in accordance with norm prEN 14961-2
Fine fraction (@ point of sale)	≤ 2 % measured in accordance with norm CEN/TS 15149-2
Or mechanical resistance	≤ 97,5 % measured in accordance with norm EN 15210-1
Or wear out	< 2,3 measured in accordance with norm DIN 51731
Fine fraction (@ point of production)	≤ 1 % measured in accordance with norm CEN/TS 15149-2
Bulk density	≥ 600 kg / m3 measured in accordance with norm EN 15103
Binding agent	< 2 % measured in accordance with norm prEN 14961-2
S-content	≤ 0,03 % measured in accordance with norm CEN/TS 15289
N-content	≤ 0,5 % measured in accordance with norm CEN/ TS 15289
Cl-content	≤ 0,02 % measured in accordance with norm EN 15103
As-content	≤ 1,0 mg/kg measured in accordance with norm prEN15297
Cd-content	≤ 0,5 mg/kg measured in accordance with norm prEN15297
Cr-content	≤ 10 mg/kg measured in accordance with norm prEN15297
Cu-content	≤ 10 mg/kg measured in accordance with norm prEN15297
Pb-content	≤ 10 mg/kg measured in accordance with norm prEN15297
Hg-content	≤ 0,1 mg/kg measured in accordance with norm prEN15297
Ni-content	≤ 10 mg/kg measured in accordance with norm prEN 15297
Zn-content	≤ 100 mg/kg measured in accordance with norm prEN15297

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Vito, 2017. https://navigator.emis.vito.be/mijn-navigator?woId=38921

3.4 Bulgaria

David Peetz

3.4.1 Regulatory framework, market drivers and barriers

The basis for wood pellet production in the country is the vast forest cover of Bulgaria (4,1 million ha – 33 % of the national territory) (Holzforschung Austria et al., 2009). However, pellets are hardly used in the energy balance. Due to the high demand of wood pellets in the European Union in the last three years, the number of producers in Bulgaria has increased. Consequently export is the main driver of production, and the installed capacities were over-dimensioned compared to the amount of available raw materials (Branko d. Glanvonjic, 2015). Additionally a deteriorated road infrastructure inhibits proper transport since it is done mainly by trucks (Holzforschung Austria et al., 2009).

Activities such as forest ownership and forest function changes in Bulgaria identified a legal gap within forest legislation which allowed alarming figures of illegal logging, yet in 2009 the change of forest property had a veto in place. However, in the same year, Ratarova, (2009) stated that forest and land can be excluded from this ban for e.g. Renewable Energy Sources. Additionally, the target of Bulgarian Energy Strategy is that in 2020, 16 % of the gross energy consumption should come from RES (of which 70 % comes from biomass). This presents another legal gap questioning the sustainability of RES, related to biomass, in Bulgaria.

Ratarova (2009) describes that the environmental quality of the forest ecosystems in Bulgaria is generally in decline. A combination of illegal logging (mainly unsustainable due to the fact that sustainability aspects are not even considered in the legal logging), and corruption are one of the main causes for deforestation. In 2004 a study conducted by the WWF shows that about 45 % of the annual harvesting in Bulgaria is illegal -the official figure for the same year is 1 %- and forest owners accept that it can go up to 25 % (Ratarova, 2009). Finally, The Bulgarian Minister of Agriculture and Food Desislava Taneva just signed in November 2016, the placement of 109,000 ha of forest as ancient forest of the European program Natura 2000.

3.4.2 Production capacity, production and feedstock

36 % of the installed capacity in Bulgaria is being used to produce wood pellets. The installed capacities of this country are over-dimensioned compared to the potentials for providing adequate raw material. Bulgaria has one of the highest percentages of wood pellet producers in the southeast European region with a total of 24 % in 2015 for the region (Glavonjić et al., 2015).

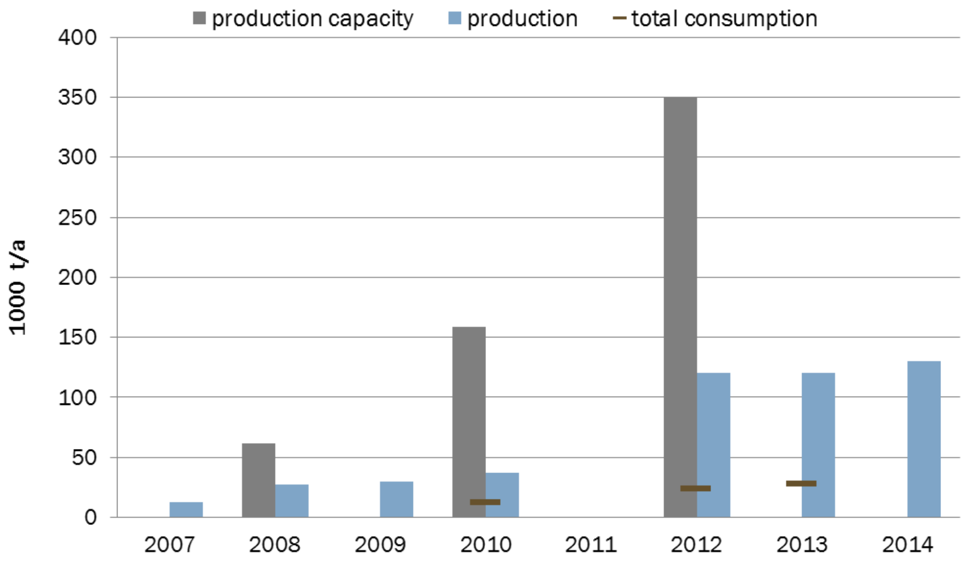

Figure 3.15 - Wood pellet market development in Bulgaria from 2007 to 2014 (AEBIOM, 2013; *European Pellet Report - PellCert Project 2012*, 2012; Holzforschung Austria et al., 2009).

3.4.3 Consumption

The fact that export is the main driver of wood pellet production in Bulgaria implies that the local market is imbedded in a state of under-development. Consumption has increased to the point where it is noticeable in the last 3 years, but still very low compared to the amount produced. It has been limited to households with simple stoves and with efficiencies between 20 % and 40 % (Holzforschung Austria et al., 2009).

3.4.4 Price trends

Increasing prices of raw material and competition with other products such as wood based panels will cause the situation in Bulgaria to grow tense in the wood-pellet industry (Glavonjić et al., 2015).

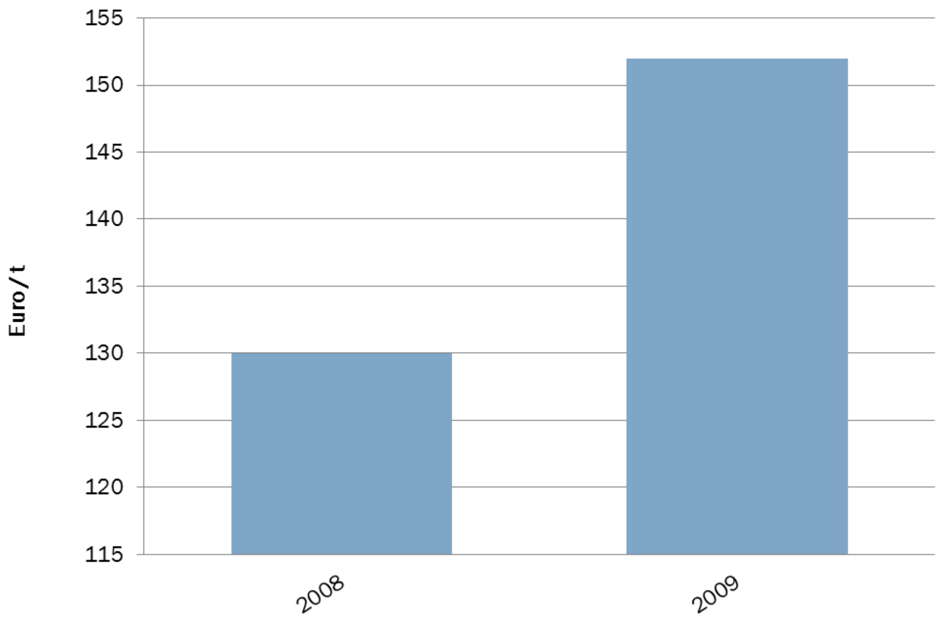

Figure 3.16 - Wood pellet prices in Bulgaria from 2008 to 2009 (no details on VAT) (Holzforschung Austria et al., 2009)

3.4.5 Trade and logistic aspects

Trade volumes are mainly exports to Italy. Pellets imports are hardly apparent due to a very low consumption, and transportation is done mainly by trucks.

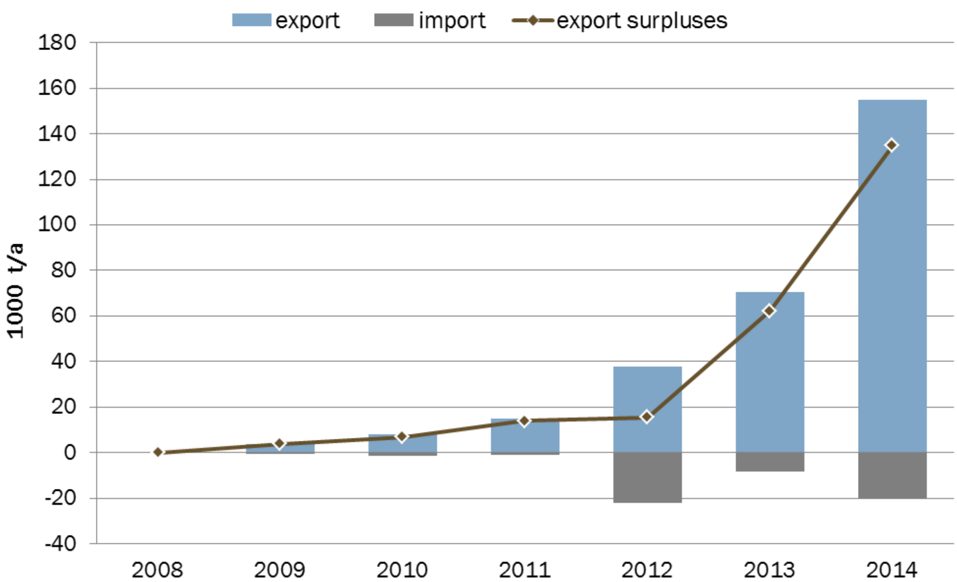

Figure 3.17 - Evolution of export and import in Bulgaria from 2008 to 2014 (eurostat, n.d.)

3.4.6 Pellet quality standard

Since export is the main destination of wood pellets, international receiving standards would be the accepted quality standards in Bulgaria. There is no national standard for the quality control of pellets. However, most producers state they use the German DIN 51731 or the Austrian ÖNORM M 7135 (Holzforschung Austria et al., 2009).

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3.5 Czech Republic

David Peetz

3.5.1 Regulatory framework, market drivers and barriers

The general development of renewable energies is supported by the current regulatory framework, particularly electricity with the Act No 180/2005. In addition: cogeneration, energy efficiency, and tax reliefs (on income using RES) are supported under the Act No 586/1992 Sb. Therefore the use of biomass for energy is steadily growing in recent years. However the internal market demand for briquettes and pellets is very low and thus satisfied by local manufacturers, on the other hand exports to neighboring countries drive the Czech Republic market (data from 2012) (Bastian and Wach, 2009).

Czech Republic has an agricultural area of 4.3 million hectares in total, of which 3.1 million hectares are arable land. Forest areas cover almost 2.7 million hectares, but only 59 % of the total area belongs to the state (Bastian and Wach, 2009; Krejzar, 2015).

3.5.2 Production capacity, production and feedstock

Most of the pellets are produced from spruce or pine sawdust. The pellet production in Czech Republic in 2008 dramatically increased to about 100,000 t. Its growth was stable until 2014 were a new increase in both production capacity and pellet production occurred. The production capacity, or potential, is very high; in 2009 figures the country's main briquettes and pellets producers were Biomac, Iromez, Enviterm, Pelletia, Holztherm and Ekover (Bastian and Wach, 2009). Small-scale production and high utilization are two outstanding aspects of pellet production in Czech Republic.

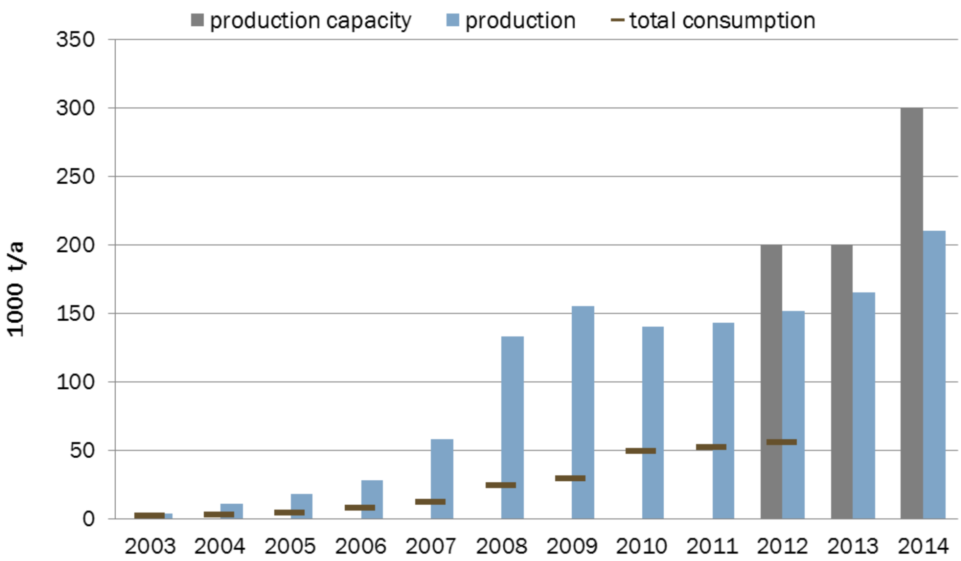

Figure 3.18 - Wood pellet market development in Czech Republic from 2003 to 2014 (AEBIOM, 2013; Česká peleta, 2016a; Euwid, 2014).

3.5.3 Consumption

The internal use of wooden pellets has been mostly driven by individual heating of households; thus the main limit for internal consumption is the low purchasing power for Czech consumers (Bastian and Wach, 2009). Nevertheless the use of biomass for energy has been distinctly growing in recent years for both small-scale level (households) and in larger-scales for industry (heat or power), and district heating. On the other hand due to a high demand for waste wood and price instability, there was a trend to produce pellets from non-wooden biomass such as agriculture by-products (i.e. grains) and bio-waste (Bastian and Wach, 2009).

3.5.4 Price trends

After 2008 the price trend for wood pellets started increasing. In 2013 the price leveled with the 2006 price as it is portrayed in the following figure.

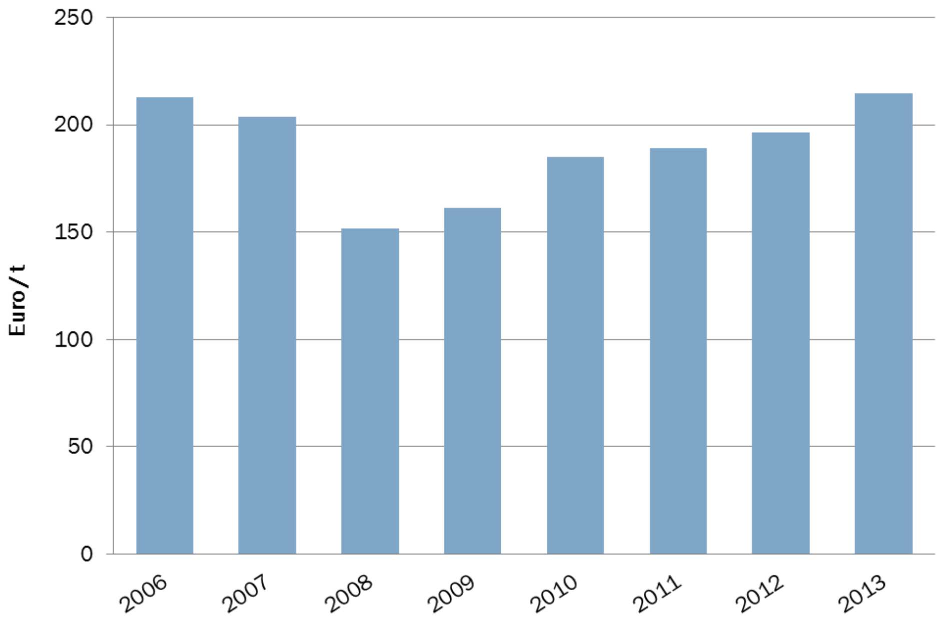

Figure 3.19 - Wood pellet prices in Czech Republic from 2006 to 2013 (no details to VAT) (Ceska peleta, 2016b)

3.5.5 Trade and logistic aspects

Wood pellets are mainly exported to neighboring countries (Germany, Italy and Austria). Packed in small bags (15 kg or 25 kg), or big bags (from 600 kg to 1000 kg) (Bastian and Wach, 2009).

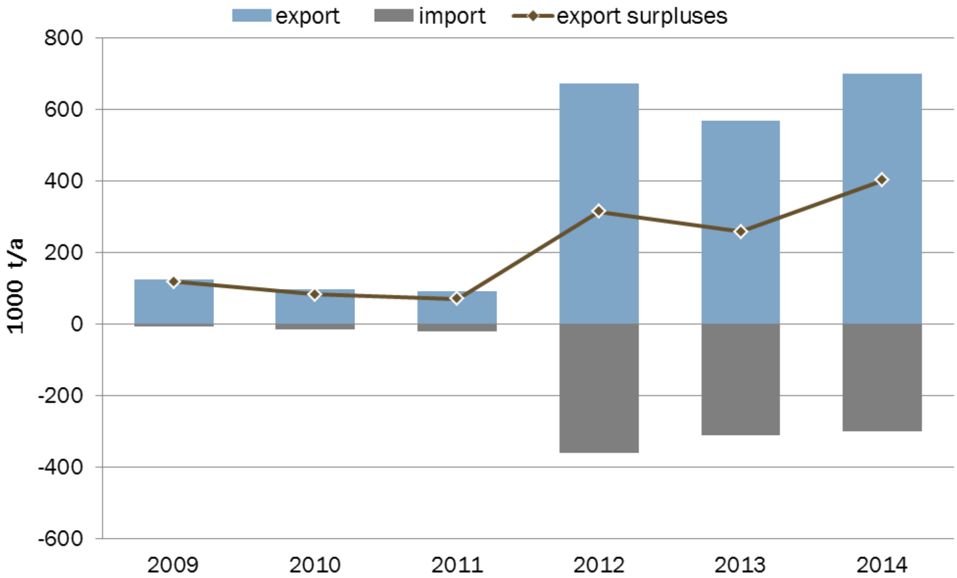

Figure 3.20 - Evolution of export and import in Czech Republic from 2009 to 2014 (eurostat, 2016)

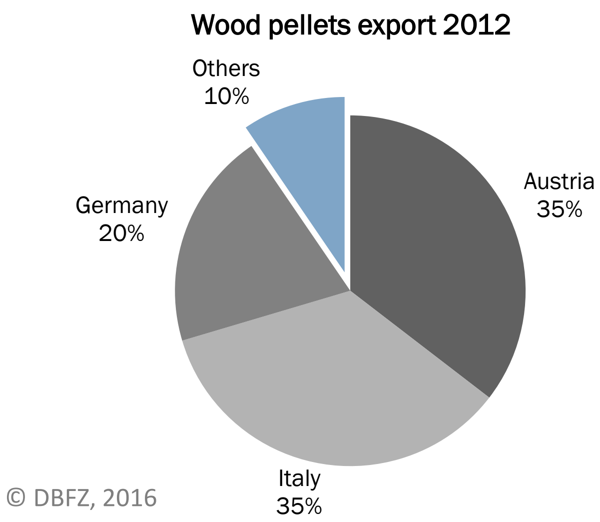

Figure 3.21 - Pellet exports from Czech Republic in 2012 (AEBIOM, 2013)

3.5.6 Pellet quality standard

Quality certificates of some pellet manufacturers are ÖNORM M 7135 or DINplus. This indicates a high quality standard for the industry.

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3.6 Denmark

Wolfgang Stelte, Morten Tony Hansen

3.6.1 Regulatory framework, market drivers and barriers

Bioenergy is a cornerstone in the Danish renewable energy mix. Today, approximately 70 % of renewable energy consumption in Denmark is bioenergy-based, mostly in the form of straw, wood and renewable wastes (Lilleholt, 2015).

Denmark has a long tradition of using biomass and the use of biomass for heat and power production has increased by factor 10 within the past two decades. This increase is mainly due to the transition from coal to biomass-fired heat and power plants and the extensive use of biomass in the district heating sector.

Energy production from renewable resources has been an important component of Denmark's energy supply since the oil crisis in the 70s. At that time Denmark was totally dependent on imported oil and subsequently coal. Political decisions made in the late 70s and 80s have triggered the use of biomass for heat and power production. The developments of biomass capabilities in Denmark started when farmers were prohibited from burning large amounts of surplus straw on their fields. The straw became a traded commodity used as fuel in utility owned CHP units as well as in straw boilers of around 120 decentralized district heating plants for cities and villages and 100.000 smaller boiler installations for households, enterprises and institutions and across the country (Buenger, 2005).

An increased taxation of fossil fuels increased the competitiveness of biomass and further regulations in the 90s resulted in the obligation that centralized electrical power plants had to buy 1.4 Mt of biomass per year, including at least 1 Mt of straw (Svendsen, 2015). The agreement resulted in a significant shift towards substituting coal-based CHP plants with biomass-based CHP plants. Furthermore, the biomass agreement meant that biomass based CHP generation got a higher priority in many local areas, including areas with natural gas.

Biomass is by far the biggest source for the production of renewable energy in Denmark today. The bulk of the bioenergy production in Denmark is used for heating. Almost half of Denmark's district heating is produced from biomass and bio-degradable waste and 11.5 % of the electricity generation in 2013 was biomass-based (Svendsen, 2015).

Today there are more than 250 biomass plants supplying Denmark with sustainable energy. Whereas straw, firewood and biodegradable waste used to be the primary source of biomass in Denmark in the 1980s and 1990s, there has been significant shift towards using wood chips and wood pellets as well as straw because these sources are the most price competitive. Today, more than 60 % of biomass for energy derives from wood materials of which a significant part is imported (Svendsen, 2015).

The share of renewable energy in Denmark in 2015 was 28,6 % (Danish Energy Agency, 2016) and is expected to increase to at about 35 % until 2020 with at least half of it coming from biomass. The Danish government aims to increase the share of renewable energy to at least 50% until 2030 and to become independent from fossil fuels until 2050 (Danish Energy Agency, 2014) Biomass is a key player in this transition and the increasing consumption of biomass has resulted in an increasing import of biomass – mainly wood pellets – from abroad.

Danish heat and power producers DONG Energy A/S and HOFOR as two of the biggest end-users for biomass in Denmark are members of the Sustainable Biomass Program (SBP). The Sustainable Biomass Program (SBP) is an initiative set up by seven major European energy producers that use biomass in their power plants. SBP aims to support a sustainable solid biomass supply chain that contributes to a low carbon economy. SBP does this through the SBP certification framework. SBP certification provides assurance for the origin of woody biomass and provision of carbon related data that are in line with today's legal, regulatory and sustainability requirements. The SBP system covers certification of biomass producers, traders and end energy producers that are end users of biomass products (Sustainable Biomass Partnership, 2015)

3.6.2 Production capacity, production and feedstock

The Danish production of wood pellets was at about 375,000 t in 2015 ("Statistics Denmark," 2016) which is an increase compared to the previous years. The overall production capacity is at about 400,000 t which is at about 15 % of the total Danish pellet demand. There is no significant further increase expected due to limited raw material resources in Denmark. The production over the past 15 years is illustrated in Figure 3.22.

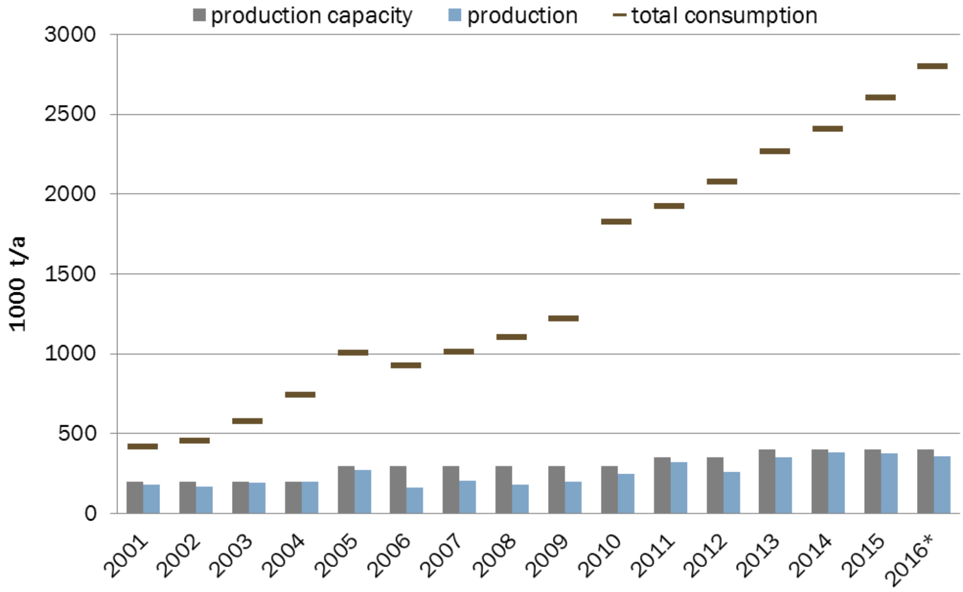

Figure 3.22 - Pellet production in Denmark in the period 2001 to 2016 (2016* estimated) ("Statistics Denmark," 2016).

Feedstocks used for pellet production in Denmark are wood residues from forestry and wood-processing industries. For a period of about 10 years, there was a production of straw pellets to be used in a central CHP plant. The production ceased in 2013 due to economic reasons. There was a periodic production of straw pellets used in local CHP plant until 2013 that was stopped for economic reasons. The pellets produced in Denmark are mainly premium pellets consumed by small and medium sized Danish end-users.

3.6.3 Consumption

The total pellet consumption in Denmark during 2015 was 2.6 Mt. At about 70 % of the pellets consumed in Denmark are used by the large scale utilities for heat and power production. The heat and power plants use almost exclusively imported pellets.

The pellets in Denmark are used mainly in large scale heat and power plants, but also by private users, industry and to heat public buildings as shown in Figure 3.23.

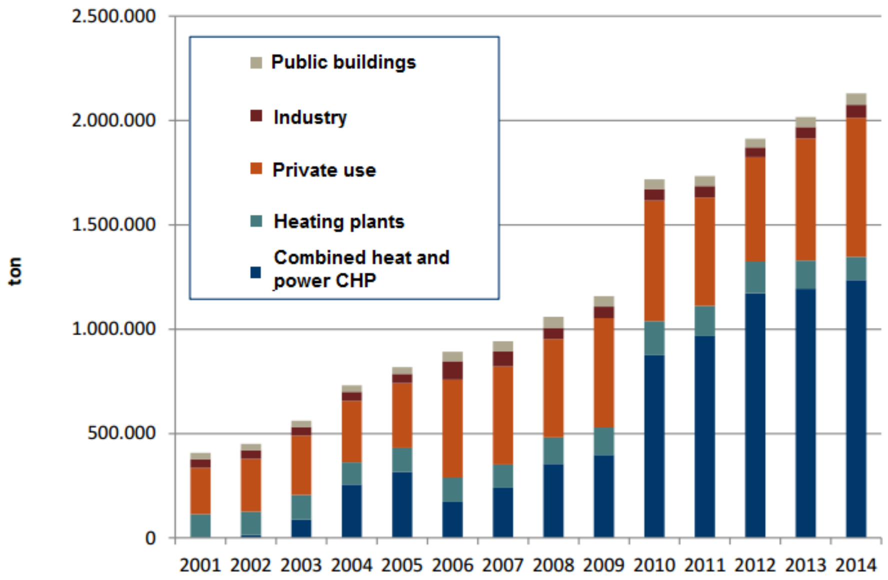

Figure 3.23 - Wood pellet consumption in Denmark by market segment 2001 to 2014 (Hansen, 2016).

In 2014 there have been in total 66 heat and power plants in Denmark using wood pellets with a total consumption of about 1.4 Mt of wood pellets. The biggest end-users are the large CHP facilities around major Danish cities. Currently the central CHP plants Amager, Avedør and Studstrup have been converted to pellets.

The private market for wood pellets in Denmark has increased over the past 15 years and private consumers have invested in more modern pellet stoves and boilers over the past decade that have increased the comfort of using pellets as well as the efficiency.

3.6.4 Price trends

The price for pellets varies quite a bit between the different market segments. Bagged pellets for private consumption are at the higher end of about 236 €/t while the price for bulk pellets is much lower at about 180 €/t excl. VAT Large scale users such as district heating plants pay at about 150 €/t and the big CHP plant operators have individual contracts with suppliers abroad that are not public but to be expected significantly lower.

The price development is indicated in Figure 3.24 based on publicly available data and personal communication with end-users and producers. There has been a moderate decrease over the past 4-5 years connected to the decreasing price for fuels in general.

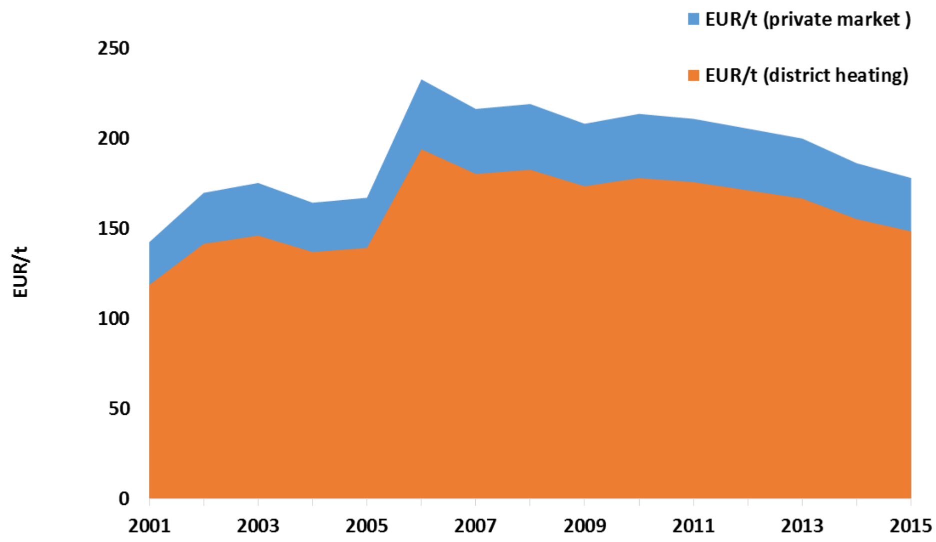

Figure 3.24 - Price development for wood pellets delivered in bulk to private consumers and district heating utilities. Graph is based on data from Danish District Heating organization, Danish Energy Agency and by personal communication with end-users and pellet providers.

3.6.5 Trade and logistic aspects

The import of pellets into Denmark has been steadily increasing over the past 15 years and reached a volume of 2.2 Mt in 2015. The developments on the Danish pellet market for the past 15 years are shown in Figure 3.25 and Figure 3.26.

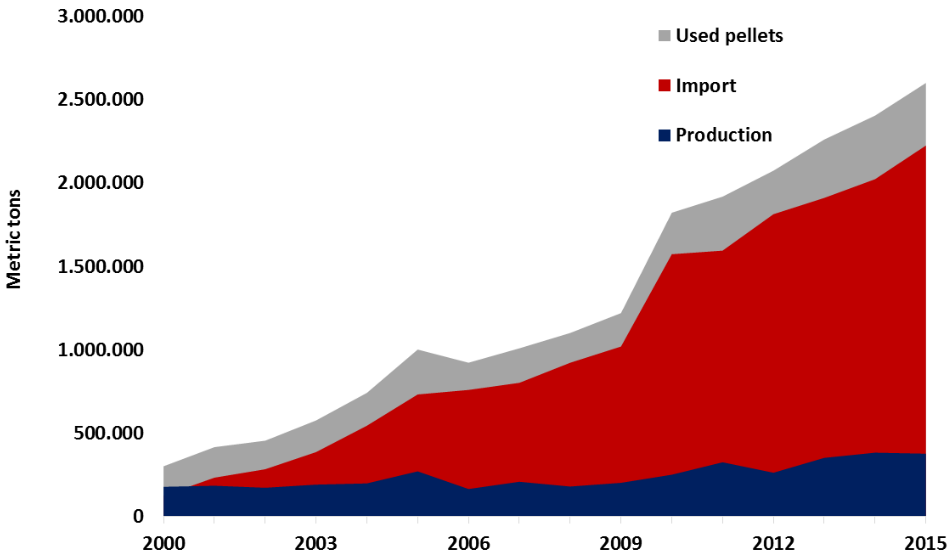

Figure 3.25 - Pellet market development 2000 to 2015

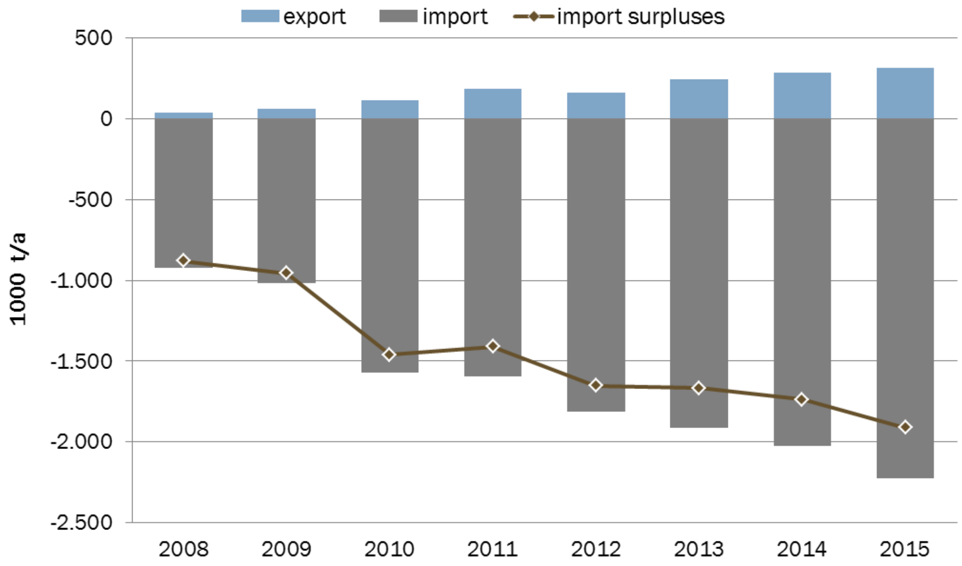

Figure 3.26 - Pellet consumption, Import into Denmark and Export out of Denmark in the period 2008-2015 ("Statistics Denmark," 2016).

Most pellets imported into Denmark are from other European countries, mainly the Baltic countries (Figure 3.27). There has been an increasing import from Russia during the past years due to increased Russian production capacities and favorable prices. It can be expected that the import from outside the EU is going to increase within the next 5 years.

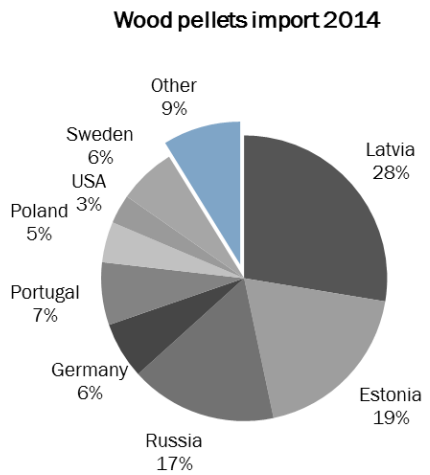

Figure 3.27 - Import of wood pellets into the Danish market by country in 2014 (Hansen, 2016).

3.6.6 Pellet quality standard

The pellet quality requirements vary between the different market segments. Private and small-scale end-users generally expect a higher pellet quality than large scale customers.

The market for small and medium scale end-users is usually based on the European certification for wood pellets ENplus that is based on the EN ISO 17225 standard. Large scale users of pellets often have their own agreements on pellet quality with their suppliers.

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3.7 Finland

Sventlana Proskurina, Jussi Heinimö

3.7.1 Regulatory framework, market drivers and barriers

Forest biomass is the most important source of renewable energy in Finland, covering approximately 80 % of the renewable energy used. Most forest-based bioenergy (over 75 %) is generated from by-products of the forest industry (black liquor, bark, and sawdust). The rest of the wood energy is generated from wood biomass that is sourced from forests for energy purposes (firewood and forest chips). The wood pellet proportion has been negligible (Heinimö, J. and Alakangas E., 2011).

Although Finland has a long history of the use of wood as a fuel and in forest industry, the country is not a leader in wood pellet utilization and production. Other European countries such as Sweden, Germany and Italy have more developed wood pellet markets. Finland has high cost of raw material and competition of wood pellets with other solid biofuels such as wood chips. Historically, the wood chip industry has shown stable growth with 5.7 PJ and 50 PJ in 2000 and 2014 respectively. Wood chip usage is expected to continue to grow (Linden, 2011). The Finnish National Renewable Energy Action Plan (NREAP) has set a target to increase domestic consumption from the current 3 PJ/a to 7.2 PJ/a (0.42 Mt) by 2020. Investments related to the use of pellets in renovated buildings will be subsidized with investment grants (European Commission, 2010).

Main drivers for pellet production and trade in Finland:

- Policy support of bioenergy development
- Stable growth of local demand
- Good logistic infrastructure
- Raw material resources for pellet production (by products from forest industry and directly from forest)

Main barriers:

- Low price competitiveness against fuel oil price
- Competitiveness with other fuels such as wood chips and natural gas

3.7.2 Production capacity, production and feedstock

In Finland the wood pellet production started in 1998, when the first pellet plant was built in Vörå, Ostrobothnia (Heinimö, J. and Alakangas E., 2011). The consumption of wood pellets has a stable growth (Figure 3.28).

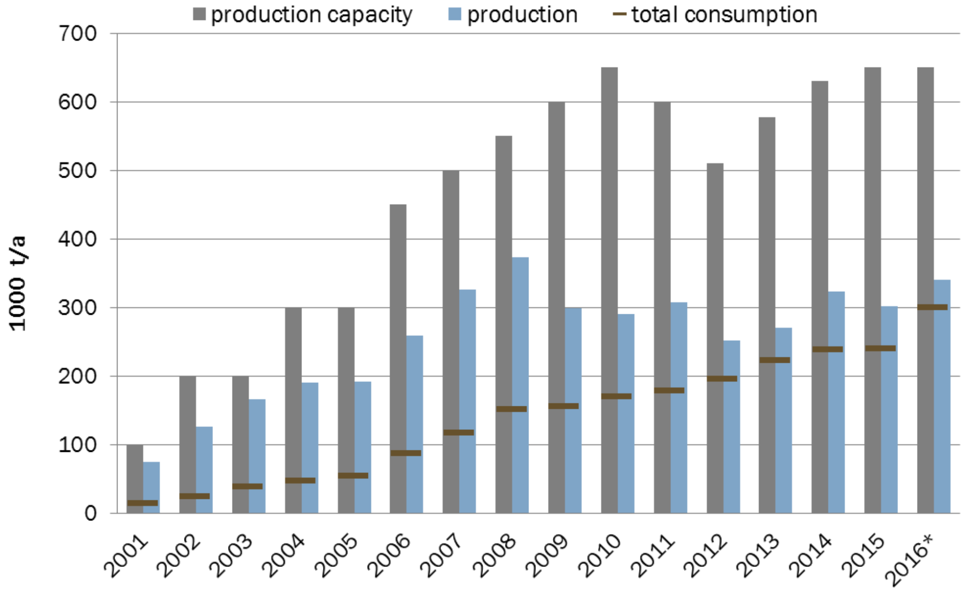

Figure 3.28 - Wood pellet market development in Finland from 2001 to 2016 (2016* estimated) (AEBIOM, 2015; IEA Bioenergy, 2011; Tilastokeskus, n.d.).

At present, approximately 25 wood pellet mills are in operation in Finland. The main wood pellet production plants are located mainly in the southern half of the country, where the greatest concentration of forest industry facilities is located (Figure 3.29).

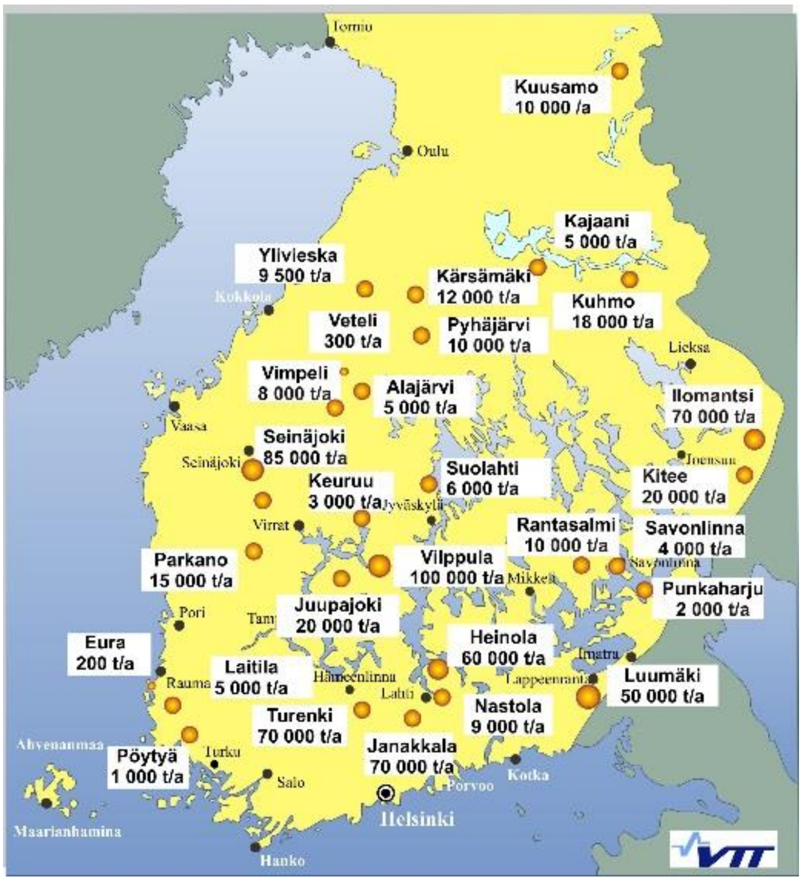

Figure 3.29 - Location of wood pellet production plants and their capacities in tonnes in Finland, in 2014 (Karhunen A. et al., 2014).

Vapo Oy is partly state-owned publicly unlisted company, which is the leader in wood pellet production in Finland, and the biggest producer in the Baltic Sea region. In 2013, Vapo supplied a total of 0.16 Mt of pellets to the Finnish market, from which approximately 30,000 t were delivered to households. In 2014-2015, the volume of wood pellets sold on Finnish markets slightly decreased due to an exceptionally warm winter season, and all pellet producers, including Vapo, were left holding large stocks of pellets.

In 2012, the production potential of wood pellets was 9–27 PJ (0.2–0.6 Mt/a), while use was only about 3 PJ. In Finland, raw material of the wood pellets is mainly by-products and residues from wood processing industry. Dry sawdust has the biggest share and over half of the raw material volume is cutter shavings, wood chips, and fresh sawdust (Karhunen A. et al., 2014). As a result, most pellet plants are located near sawmills, furniture factories and other wood processing facilities. An example is pellet production in Kuhmo, where local raw material resources are the largest in the whole region of Kainuu. Many small- (with capacity under 5,000 t) and medium-scale pellet plants (with capacity from 5,000 to 100,000 t) are integrated with other activities, such as planning mills or carpentry factories, which are the source of the raw material for pelletizing. The scale of the Finnish forest industry creates good availability of raw material for wood pellet production (Proskurina S. et al., 2016).

The consumption growth is supporting the growth of production in Finland. This production is increasingly concentrated in larger plants while the smaller plants are closing. These pellets are produced locally and dedicated to the domestic market (AEBIOM, 2015).

3.7.3 Consumption

The Finnish Pellet Energy Association has set a target number of domestic pellet consumers of nearly 80,000 (75,000 single family houses and 4,000 industrial users) and a domestic pellet consumption target of approximately 1.5 Mt/a by 2020. The consumption target of Pellet Energy Association is much higher than the government's target indicates in NREAP (0.4 Mt/a) (IEA Bioenergy, 2011).

The main obstacle to the increased domestic consumption of wood pellets has been its weak competitiveness against other heating fuels, especially light heating oil. Domestic pellet consumers have to compete for pellets with the consumers in the export countries. This affects the development of the Finnish wood pellet market – prices, production volumes, and export volumes. In addition, heating and power plants are competing for raw material with the wood pellet industry, which has led to increasing raw material prices and caused pressure to increase the market price of pellets (IEA Bioenergy, 2011). Currently, wood pellets are not very attractive for households and other options such as wood chips and heat pumps seem more profitable (Proskurina et al., 2017).

In 2015, the consumption of wood pellets, based on domestic pellet production, was 0.24 Mt of wood pellets, an increase of 1 % compared to the previous year. Wood pellet consumption by households and farms accounted for 58,000 t. Heating and power plants consumed 182,000 t of wood pellets (Luke, 2016a). However, it is a possibility that this estimation includes the annual delivery and excludes several small pellet heating plants. According to another estimation, the total wood pellet consumption was 155,000 t from which consumption of CHP-plants and heat production was 24,500 and 130,700 t respectively in 2015 (Luke, 2016b).

There are several co-firing power plants which use pellets as a fuel. For example, wood pellets are used in a 33 MW capacity heating plant in Tampere, owned by Tampereen Energiantuotanto Oy, which has used wood pellets since December 2012. In addition, pellets are used in Turku Energia's 40 MW pellet boiler, which has been recently ordered for similar duty as the Tampere boiler. Co-firing of wood pellets with coal has been tested e.g. in the Hanasaari and Salmisaari power plants, which are old CHP plants in Helsinki. The test results indicated the possibility of burning 5–7 % wood pellets in coal-based fuel without having to make major modifications to the grinders or burners. The city of Helsinki, the owner of Helsingin Energia, agreed to meet energy demand for wood pellets in the Hanasaari and Salmisaari power plants. The delivery amounts are significant on the Finnish scale, in excess 0.5 Mt/a of wood pellets (Uusitalo, 2014). Table 3-4 lists pellet-fired plants in Finland in 2015 (VTT & Finnish Bioenergy Association, 2015).

Table 3-4 - Wood pellet-fired heating plants in Finland in 2015 (VTT & Finnish Bioenergy Association, 2015).

Plant	MWth	Plant	MWth	Plant	MWth
Nokia Tyres, Versowood	1	Parma Betoni, Äänekoski	1	Savon Voima, Lapinlahti	7*
Halesa Oy, Nokia	1	Keuruu Heat Power	1	Raahe Energy	10*
Kirkkonummi, building centre	1	Ypäjä municipality	1	Forssa Heat, Vapo	10

Plant	MWth	Plant	MWth	Plant	MWth
Akaa, flat houses	1	Mariehamn Energi	1	Hyvinkää Heat Veikkari heat station	10*
Eerikkälä, sport park, Vapo	1	Savon Voima, Sorsakoski	1.5	Tampere Energy**	33*
Nuutajärvi, Vapo	1	Fiskars, Ähtäri, Vapo	1.5	UNDER PLANNING	
Tammela, Vapo	1	Muurame industrial park	2.5	Kalajoki city	4
Vehmersalmi, Vapo	1	Leppäkoski heat, Ikaalinen	3	Fortum Kivenlahti	60*
Kylmäkoski prison, Vapo	1	Parikkala municipality	3	Turun Energy	40*
Vilppula, prison, Vapo	1	Paimio heat station	4.5	Kajaani Power	10
Valkeakoski Energy	1	Leppäkoski heat, Nokia	6	Seinäjoki Energy	80–100*

The wood pellet consumption for heat is foreseen to pursue growth thanks to the increase in medium and large heating plants in Finland (AEBIOM, 2015). The wood pellets consumption will increase due to large-scale applications. For example, by December 2016, as expected, heavy fuel oil combustion will be replaced with biomass-based fuels, including wood pellets in plants in Seinäjoki. Capacity of the plant will increase to 120 MWth (Bioenergy Insight, 2016) (Figure 3.30).

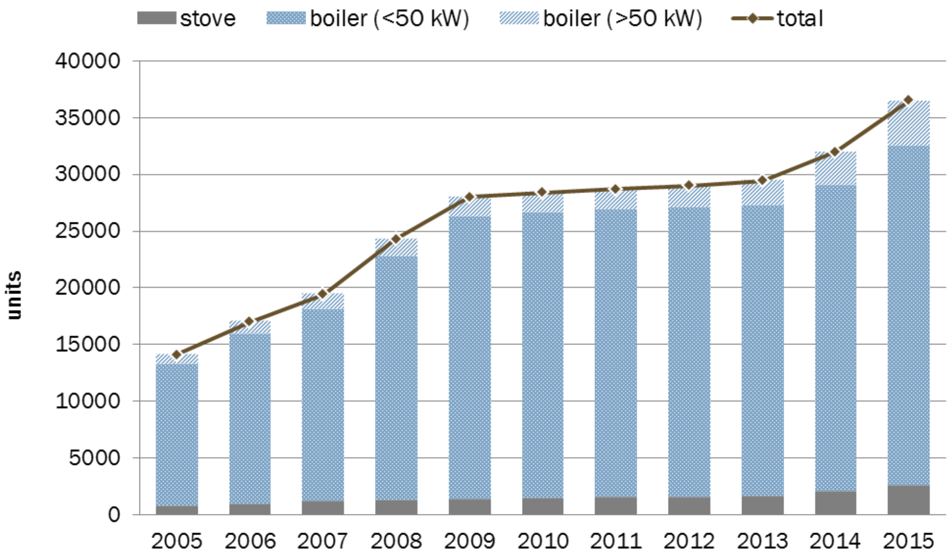

Figure 3.30 - Development of installed pellet heating systems in Finland from 2005 to 2015.

3.7.4 Price trends

When considering the competitiveness of wood pellets, internationalization of the wood pellet market introduces a host of price-affecting factors that are not shared by markets for wood chips. In February 2016, the consumer price of wood pellets was about 273 €/t in Finland (Official Statistics of Finland (OSF), 2016). Figure 3.31 shows the price development in bulk.

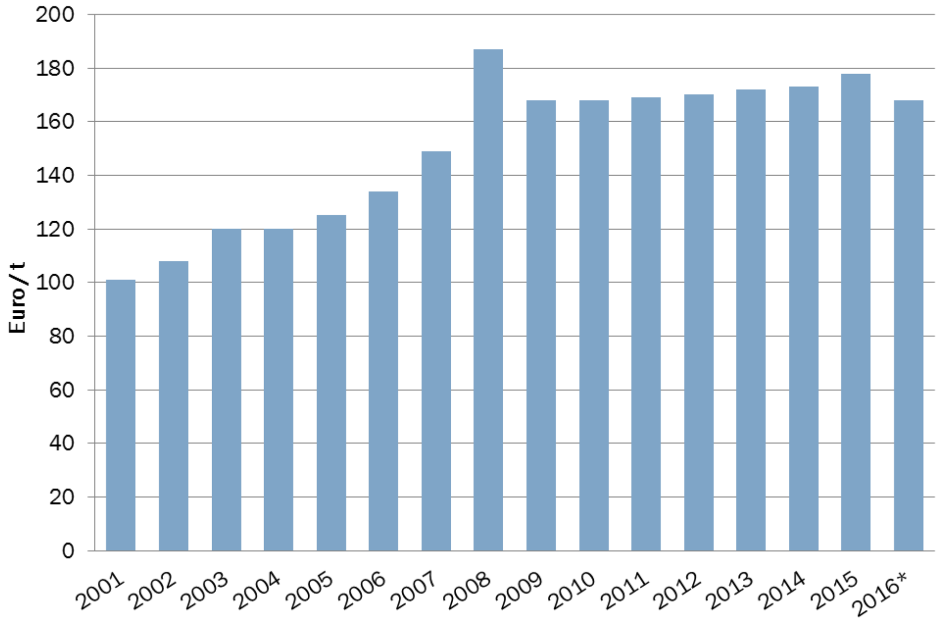

Figure 3.31 - Average nominal wood pellet prices (delivered to (private) customers) in Finland from 2001 to 2016 (2016*estimated) (excluding 24% value added tax).

3.7.5 Trade and logistic aspects

Finnish wood pellet export and import are relatively small (Figure 3.32). In 2015, export and import was 59,800 t and 59,400 t of wood pellets respectively. Denmark and Sweden are major consumers of wood pellets from Finland (Figure 3.33). Import of wood pellets into Finland is mainly from Russia. Considering international trade in wood pellets, large changes in export and import volumes of wood pellets are not foreseeable in the short- and medium-term. Finnish wood pellets producers are planning to increase capacity to satisfy local demand.

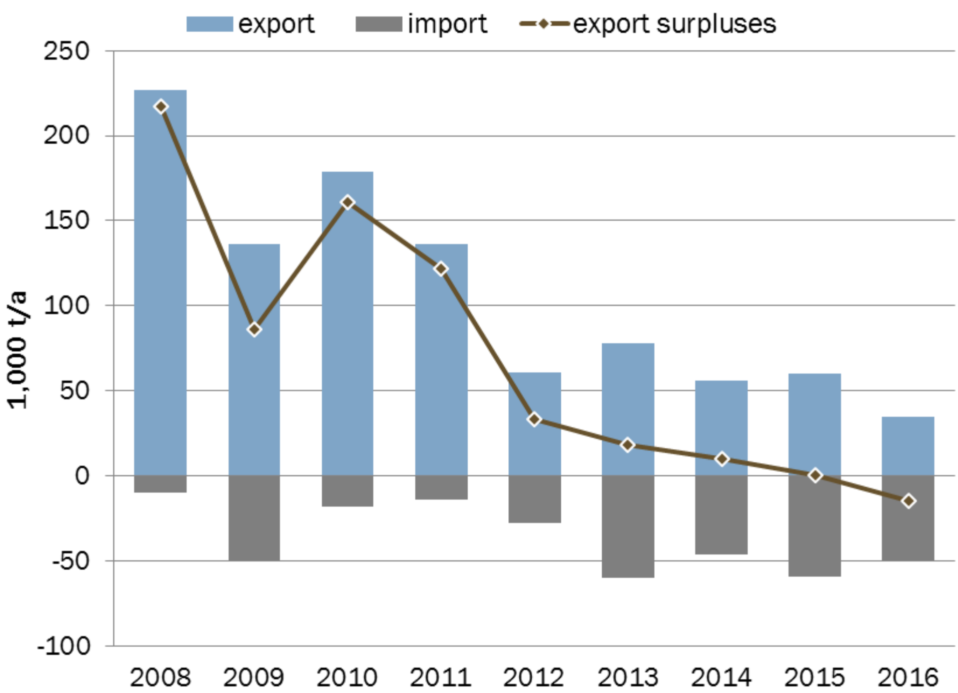

Figure 3.32 - Evolution of export and import in Finland from 2008 to 2016 (Karhunen A. et al., 2014; Tilastokeskus, n.d.).

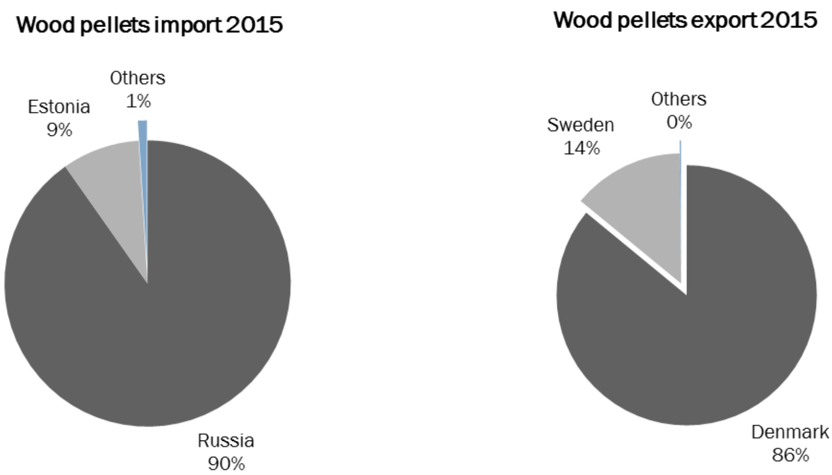

Figure 3.33 - Wood pellets imports and exports in Finland (2015), (Tilastokeskus, n.d.).

The wood pellets are exported from Finland almost totally by maritime transport. As bulk material, wood pellets are relatively easy to transport and ports which are suitable for dry-cargo vessels and barges can be utilized in the wood pellet transportations. Available indoor storage and material handling equipment for dry bulk facilitate the loading of pellets into the vessel in a port. There is plenty of underutilized port capacity available for the handling and transportation of wood pellets in Finland (IEA Bioenergy, 2011).

3.7.6 Pellet quality standard

The International Organisation for Standardisation (ISO) is currently preparing almost 60 standards for solid biofuels. Standards for pellets include: EN ISO 17225-1 (General requirements), EN ISO 17225-2 (Graded wood pellets) and EN ISO 17225-6 (Graded non-woody graded pellets). EN ISO 17225 series also include product standards for wood chips, firewood and non-woody briquettes. Fuel specification standards (EN ISO 17225 series) have been published in May 2014. This ISO standard EN ISO 17225-1 includes the raw material classification of solid biofuels, which is based on their origin and source. Stating origin and source is mandatory for all solid biofuels (Alakangas, 2015a).

International standard (EN ISO 17225-2) for graded wood pellets includes pellets for industrial and non-industrial use. Biomass pellets in EN ISO 17225-1 and industrial wood pellets in EN ISO 17225-2 also include property classes for particle size distribution for disintegrated pellets. This value is important, when pellets are co-fired with coal in pulverized combustion plants.

Wood pellets for non-industrial use will also be specified according to EN ISO 17225-2. Non-industrial use means fuel intended to be used in smaller appliances, such as, in households and small commercial and public sector buildings.

Property class A1 for wood pellets represents virgin woods and chemically untreated wood residues low in ash and nitrogen content. Fuels with slightly higher ash content and nitrogen content fall within A2. In property class B, chemically treated industrial wood by-products and residues (1.2.2), and chemically untreated used wood (1.3.1) is also allowed, if threshold values for heavy metals can be met like by virgin wood.

Non-woody pellets include those made from blends and mixtures, including herbaceous, fruit or aquatic biomass. Blends and mixtures can also include woody biomass. ISO 17225-6 includes two classification tables:

- A and B class pellets produced from herbaceous and fruit biomass and blends and mixtures
- Those made from straw, Miscanthus and reed canary grass pellets.

Non-woody pellets have high ash, chlorine, nitrogen and sulfur contents, as well as major element contents, so non-woody pellets are recommended to be used in appliances which are specially designed or adjusted for this kind of pellet.

When using non-woody materials for combustion, special attention should be paid to the risk of corrosion in small- and medium-scale boilers and flue gas systems. Herbaceous or fruit biomass may influence the fuel ash composition differently depending on growth and soil conditions. The content of chlorine, phosphate and potassium in the material may form chlorides and phosphates and other chemical compounds resulting in high hydrochloric emissions and chemically active ash with low melting temperature, causing corrosion.

In general, non-woody biomass materials have higher content of ash-forming elements and produces ashes with lower melting temperature compared to most woody biomass. This may result in fouling, slagging and corrosion inside boilers. These problems are especially related to materials that contain high contents of potassium and silicate and low levels of calcium. ENplus certification system is based on EN ISO 17225-2 standard and ENplus certification ensures: pellet quality, quality of service and sustainability. In total 6.5 Mt were certified by 180 certified producers and 250 traders (Alakangas, 2015b).

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3.8 France

David Peetz

3.8.1 Regulatory framework, market drivers and barriers

Current developments in France hold a lot of promise for the pellet market. Apart from the United Nations Climate Change Conference, which was successfully held in Paris in December of 2015, an energy transition law was passed by the National Assembly of France in July of 2015 (Rütti, 2015). The law contains goals such as the intended amount renewable energies to have on the final energy consumption in 2020 at 32 %, or their share of electricity at 40 % renewables (in 2015 the renewables share was 16 %) (Rütti, 2015; Statista, 2016). Along with efficiency measurements and insulation of buildings it is said that the amount of electricity generated by nuclear power plants shall be reduced in the so called electricity mix from 75 % to 50 % within 10 years. Doing so, the share of biomass in providing electricity will be increased from about 14 GWh in 2013 to 50 GWh in 2020 (Persem and Gaebler, 2012; Rüdinger, 2014). Additionally an increase in the heat supplied by pellets and wood up to 83 % in 2020 is expected. Due to renewed emission regulations the replacement of 50 % of all momentarily installed heating systems is assumed in the following years.

In order to make the change towards biomass heating plants more tempting there will be tax bonuses on up to 30 % of acquisition costs. Therefore installers who possess a biomass certification are needed. Otherwise the homeowner won't benefit from the bonuses (Pellets Markt und Trends, 2014).

Wood is not only being used for energetic reasons but also it is increasingly being used in private households. In 2014, 7.4 million out of about 28 million households used firewood due to reasons of comfort (Pellets Markt und Trends, 2014; Statista, 2016). Paris plans to provide municipal housings with heat generated by pellets (Pellets Markt und Trends, 2014). The government currently works on a national biomass strategy with special regulations. Within this, the use of biomass in private households, industry and district heating supply systems is meant to be sponsored. Details on the strategy cannot be extracted (BMWi, 2015).

3.8.2 Production capacity, production and feedstock

France's pellet production volume was at a level of about 1.03 Mt in 2014 (Euwid, 2015). Production rates have more than doubled in the past 5 years as there were 465,000 t produced in 2010 (Audigane and Mangel, 2011).

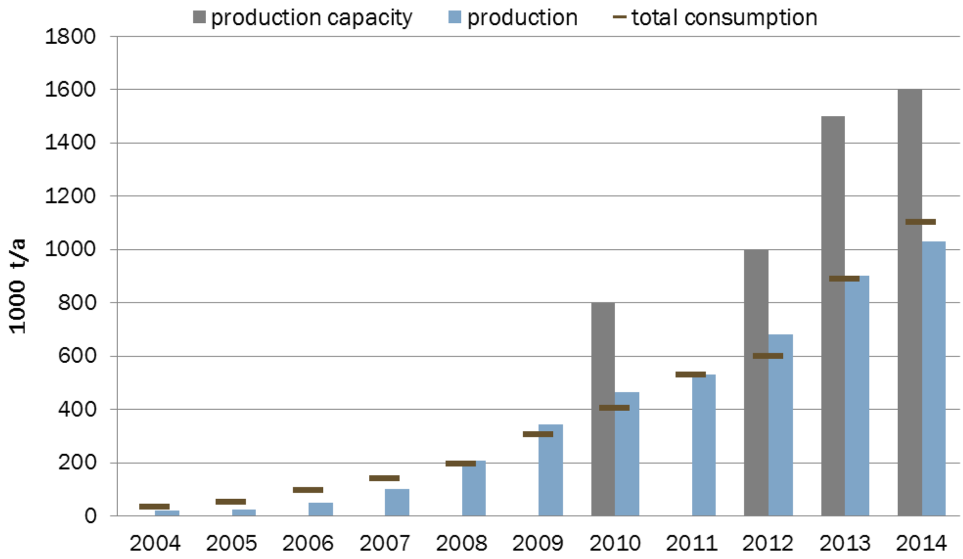

Figure 3.34 - Wood pellet market development in France from 2004 to 2014 (AEBIOM, 2013; Barel, 2009; Euwid, 2014, 2015; SNPGB, 2013).

Here it is noticeable that the amount of active pellet production facilities with production capacities of more than 10,000 t/a each have only increased from 40 to 42 in France since 2010 (Audigane and Mangel, 2011). Those 42 different pellet producers have reached a pellet production capacity of 1.6 Mt in 2014 (Euwid, 2015).

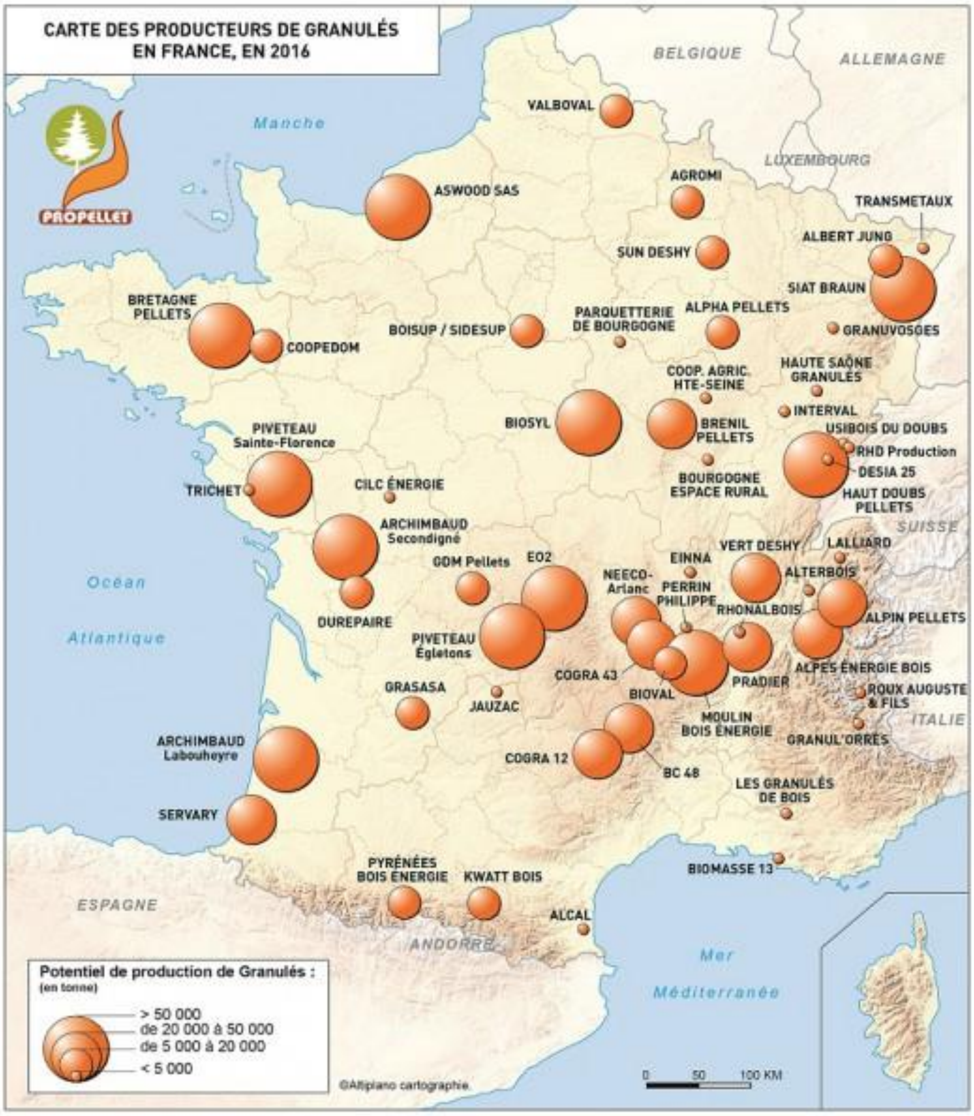

Figure 3.35 - Distributors of Wood Pellets in France 2016 (propellets France, 2016a).

SNPGB, France's pellet association focuses increasingly on the use of hardwood in pellet production. In doing so 5 – 10 % of pellets been made of maple-, beech- or oak tree in 2014, which resembles 100,000 - 150,000 t of hardwood pellets. SNPGB's Managing director Hugues sees several advantages in the production of hardwood pellets. Using hardwoods doesn't interfere with chipboard production or paper manufacturing. Rather than softwood forests there are huge beech- and oak timber reserves located in France. However it is more difficult to pelletize hardwood, which is why they must be combined with softwoods in order to maintain compliance with ISO-Norms. 50 % of the pellets are manufactured by sawmills and 1/3 by independent pellet producers. The spare 15 % are delivered by agricultural businesses, which run pelletizing machines for fodder production, already (Pellets Markt und Trends, 2014).

3.8.3 Consumption

Compared to 2010 the usage of wood pellets increased from 400,000 t to 1.1 Mt in 2014 (Barel, 2009; Euwid, 2014). Reasons for the rapid increase are i.e. a variety of climatic conditions in France, which allows the use of pellets for both boilers as well as stoves. North-Eastern France has a continental climate with long, cold winters. In this region a strong history in wood energy is embedded, such as in Switzerland or Germany. France's Southern and Western parts have less cold winters which limit the use of heating wood. In this area, especially in urban and suburban areas pellet stoves are more successful than boilers as they are above all used to complement electric heating- or central oil fuel heating systems (Cocchi et al., 2011).

The mentioned success of pellet stoves is mirrored by 242,400 installed power plants in 2013. That is almost 35 % more than in the previous year (AEBIOM, 2013). In comparison with the number of installed pellet boilers in 2011, when only 22,400 have been installed. Nevertheless the number of installed pellet boilers is twice as big as it was in 2008 (Pellets Markt und Trends, 2012).

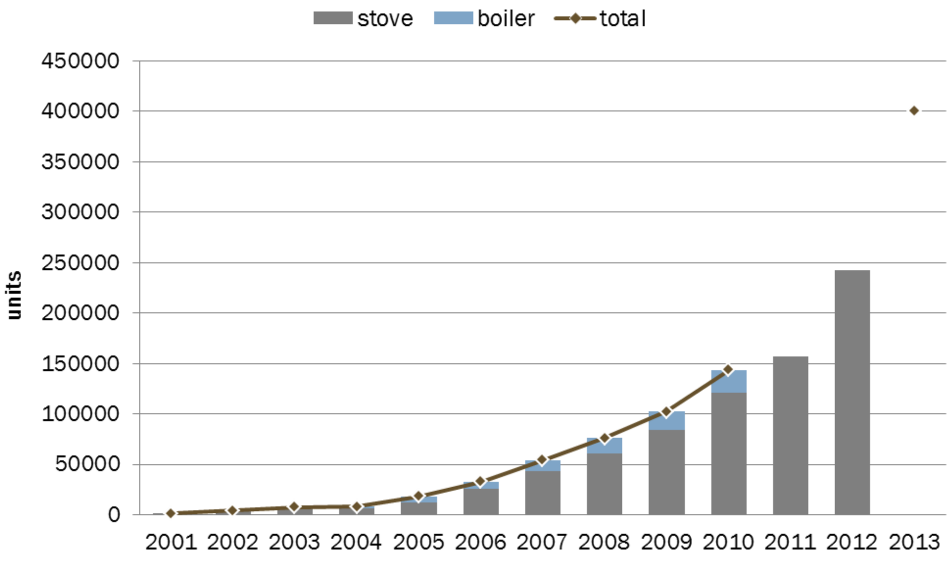

Figure 3.36 - Development of installed pellet heating systems in France from 2002 to 2013 (AEBIOM, 2013; Pellets Markt und Trends, 2012).

From 2011 to 2013 a growth of installed pellet powered heating systems of about 40 % was recognizable. There were approximately 400,000 single-room combustion plants as well as central heating systems in operation (Pellets Markt und Trends, 2014).

3.8.4 Price trends

On the basis of the following diagram prices per bulk and bag are presented since 2007. Clearly costs per bulk have been the same cost of almost 220 €/t within the time span 2007 to 2010. It has then steadily increased up to 280 €/t in 2014. In 2015 the price has once again decreased clearly to 270 €/t.

Price fluctuation is more significant per bulk. In that case, varying costs of around 8 €/t were noticeable from 2007 to 2012. The price rose strongly from 268 €/t in 2012 to 302 €/t in 2014. Nevertheless the mentioned price declined to 280 €/t in 2015 (Ministère de l’Environnement, de l’Énergie et de la Mer, n.d.).

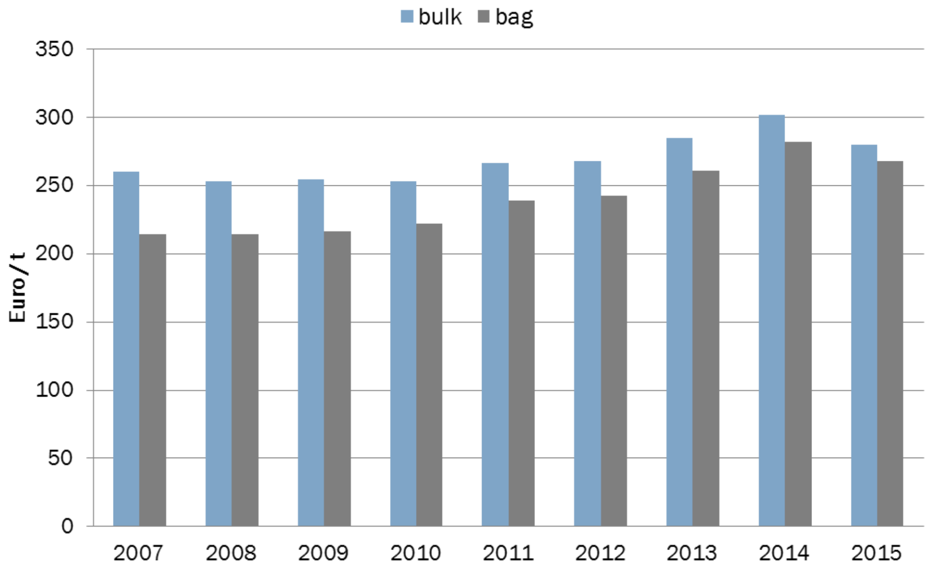

Figure 3.37 - Wood pellet prices in France from 2007 to 2015 (excluding VAT) (Bulk delivery 5 t up to 50 km) (Ministère de l'Environnement, de l'Énergie et de la Mer, n.d.).

Soaring costs until 2014 can e.g. be explained by the increased value added taxes from 1.5 to 3 % in 2012. Additionally, many pellet manufacturing sites have been created in recent years. Also, their owners implement depreciation charges on produced pellets (propellets France, 2016a).

3.8.5 Trade and logistic aspects

In trading, pellets exports have predominated relative to its imports from the years 2008 to 2014. Except for the years 2011 with nearly 20,000 t more imports than exports. Furthermore in 2014 the import with 138,000 t dominated the export with 124,000 t (eurostat, 2016).

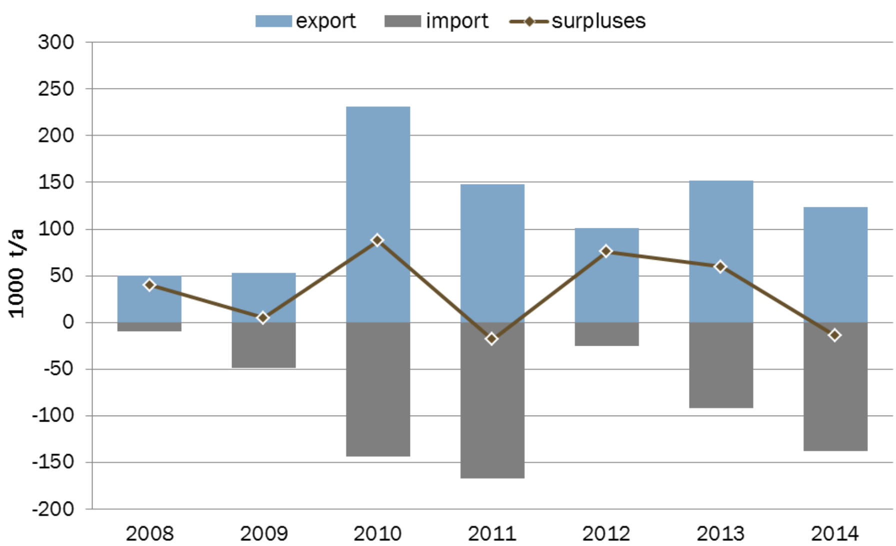

Figure 3.38 - Evolution of export and import in France from 2008 to 2014 (eurostat, 2016)

The majority of exported pellets are shipped to Italy, Belgium and Germany. In 2013, e.g. about 1.5 % of all the used pellets in France were imported from European countries. It is expected that imports will still increase in order to cover the country's need for pellets (Pellets Markt und Trends, 2014).

3.8.6 Pellet quality standard

Most pellet manufacturers are certificated with only a few exceptions. In order to estimate the fuel quality there exist usually 3 different types of certificates. Within these are DINplus, the French NF and the so called Enplus, which notified a large increase in 2014 (Pellets Markt und Trends, 2012).

In 2014, more than 95 % of all pellet manufacturers were certified with one of the before mentioned. 27 manufacturers were certified with NF-granulés biocombustibles, 21 with DINplus (propellets France, 2016b). Additionally 11 pellet producers are certified with the Enplus (ENplus, 2016).

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3.9 Germany

David Peetz

3.9.1 Regulatory framework, market drivers and barriers

The main characteristic of the German pellet market is its fast development, particularly in the ENplus certification scheme for wood pellets (DEPI, 2016a). Both production and total production are covered by the ENplus certification. Additionally, the increase in domestic consumption devices such as pellet boilers and stoves for small and medium scale applications has a continuous growth rate which has not ceased since 2007 with minor setbacks in 2010.

The official target of Germany is to increase the share of renewables in the final energy consumption to 18 % by 2020 (IEA, 2010). Since 2000 bioelectricity increased over 10-fold, while wind electricity increased around 5-fold (Thrän, D. et al., 2014). The use of pellets in the residential sector was supported by the market incentive program (MAP) combined with the Renewable Energies Heat Act (EEWärmeG), which delivered a financial support for the utilization of wood pellets on the small-scale market (Thrän, D. et al., 2014). On the other hand, due to the saw mill industry crisis in 2014 the MAP (market incentive program) had a budget freeze,-plus a stop and go phenomena, which caused uncertainties among the investors leading towards a decrease in demand of pellet heating systems, thus affecting internal demand (Thrän, D. et al., 2014).

The use of certain biomass resources in Germany are either constrained or supported by a feed in tariff system for electricity generation from renewables, and by a financial subsidy for the application of renewable energy sources. Furthermore, the available standardization and transportation costs play relevant roles as market drivers, for example: the required national quality for wood pellets intended for heating systems posed a barrier to international trade from overseas. Subsequently this was thereafter evaded by the international available standardization system ENplus (Thrän, D. et al., 2014). Meaning that US ENplus certified wood pellets entered the German market.

3.9.2 Production capacity, production and feedstock

The production of wood pellets in Germany is one of the largest in Europe, yet in 2015 the wood pellet production in Germany continued with a decreasing rate, i.e. 1.9 Mt for 2015 (see Figure 3.39). Conversely the estimated consumption and production of wood pellets for 2016 in Germany levelled the figures from 2013 describing a recovery of the internal market.

The raw materials used for pellet production in Germany are around 70 % saw mill by-products, i.e. sawdust and the remaining 30 % is low quality round wood (Thrän, D. et al., 2014). The production capacity and production -even though it is still large- stagnated since 2013 due to a stop in operations of mainly small to medium sized producers which shut down operations due to the factors explained in 3.2.1.

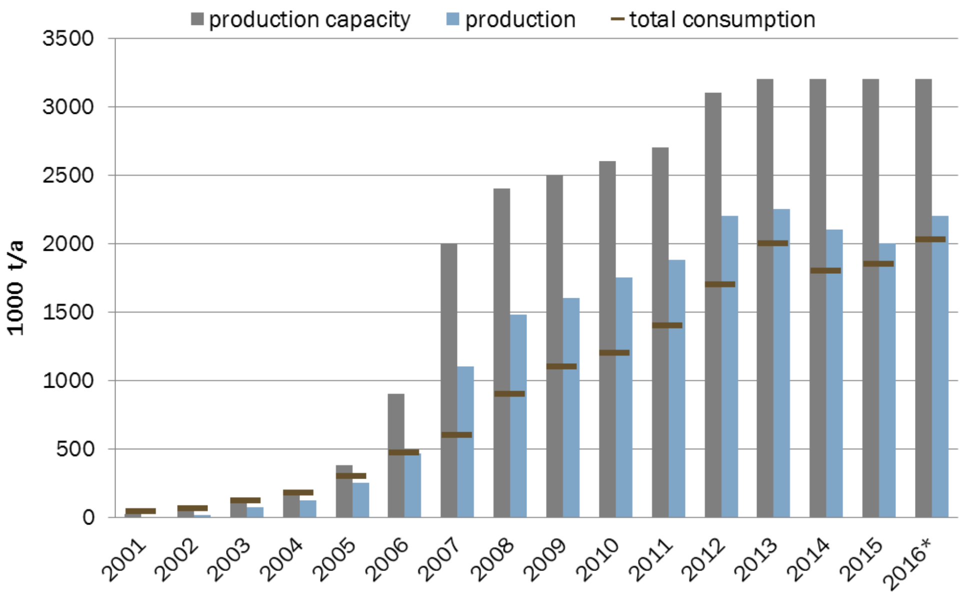

Figure 3.39 - Wood pellet market development in Germany from 2001 to 2016 (2016* estimated) (DEPI, 2016a).

The production facility in Germany is on average between 20,000 and 100,000 t, an installation of medium to large scale (Thrän, D. et al., 2014). The main locations of the different production facilities are where wood-processing industries operate, thus nearby large forested areas i.e.: Western and Southern part of Germany. Hence, indicating that the sustainability of the wood pellet industry in Germany is closely related to forest management practices -and use- from the wood processing industry and government institutions.

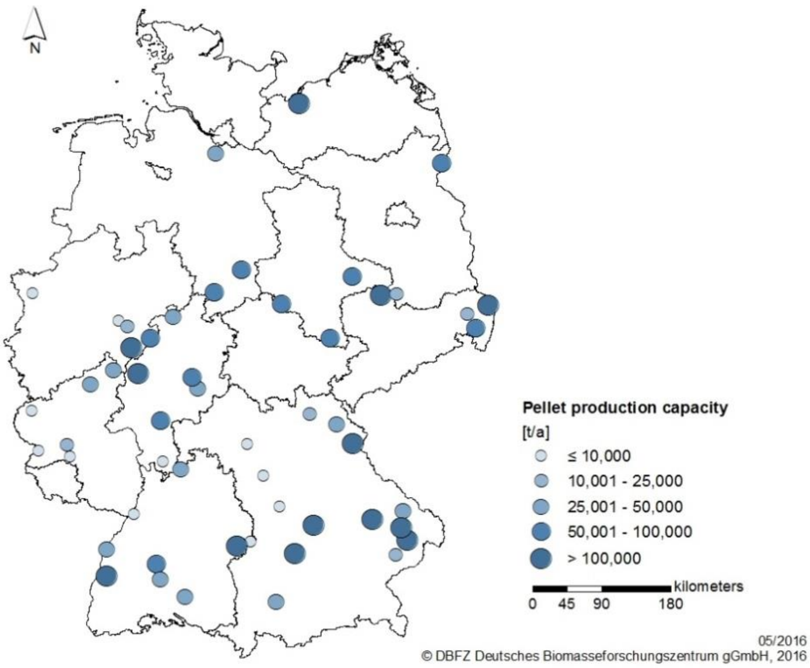

Figure 3.40 - Location of wood pellet production plants in Germany 2015 (this overview makes no claim of being complete) (Berner, 2015).

3.9.3 Consumption

In 2006 the German national demand supply shifted from mostly import dependent to a balanced mix of local production and imports. German quality requirements further supported the shift from imports to internal supply of wood pellets due to the lack of international standard such as the ENplus (Thrän, D. et al., 2014). Consumption of wood pellets in Germany (in tonnes) amounted to 2 Mt in 2013, and continued with a stable similar growth as seen in Figure 3.39.

Pellet heating systems in Germany have been mainly pellet boilers (<50 kW) and stoves. The steady growth of pellet heating systems present in Germany is caused primarily by the MAP program (Thrän, D. et al., 2014). This could be seen in 2010 were the budget for the MAP program experienced a freeze affecting the overall sales for heating pellet systems (see Figure 3.41).

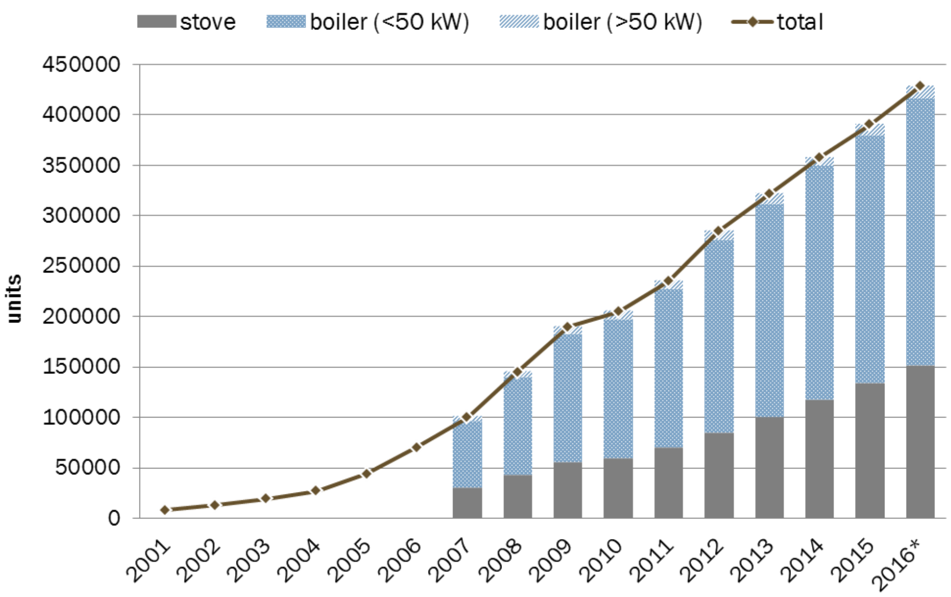

Figure 3.41 - Development of installed pellet heating systems in Germany from 2001 to 2016 (2016* estimated) (DEPI, 2016b).

Within Germany the development of pellet consumption devices shows yet again the divide between East and West Germany. Most of the eastern parts have an internal consumption development of less than 1 %, whereas in the west most of its consumption is above 7 %. Nevertheless, related to the very forested areas, the south of Germany takes the lead with more than 50 % of the overall development of pellet consuming devices (with Baden-Württemberg 18,7 % and Bayern 36,3 %) (DEPI, 2016b).

3.9.4 Price trends

The prices in Germany have been steady for the most part, with variations ranging from approximately 160 to 260 €/t since 2003. The variations are chiefly explained by the shortage of national wood pellet supply due to less feed stock accumulation from saw mills. For example, the production capacity of saw mills was reduced since 2012 because of the financial and economic crises (Thrän, D. et al., 2014).

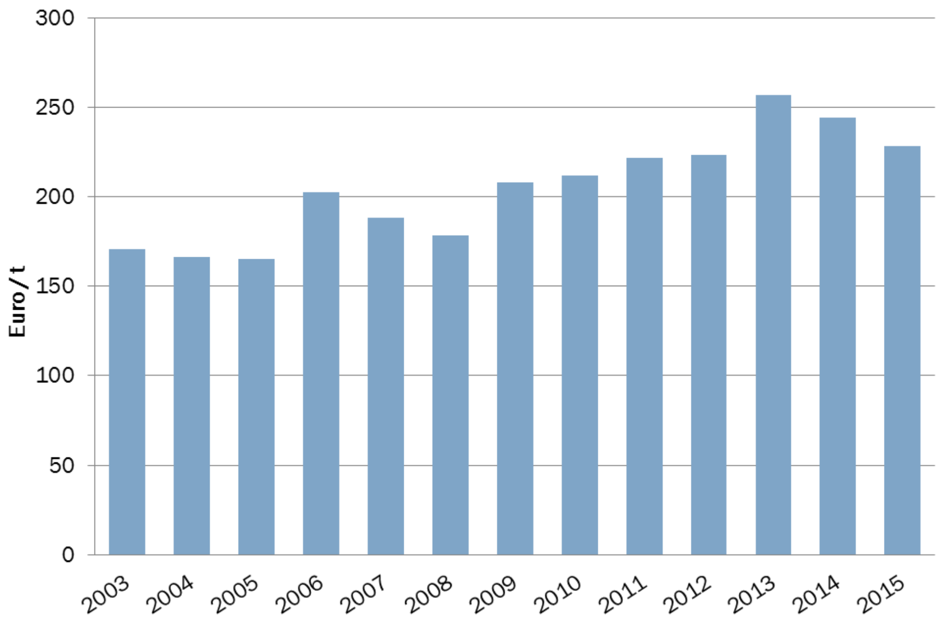

Figure 3.42 - Average wood pellet prices in Germany from 2003 to 2015 (excluding VAT; at ordering of 5 to 6 t) (C.A.R.M.E.N, 2016; DEPI, 2016c)

In an average year, the fluctuations of wood pellet prices deviates with a decrease of 4 % points during the summer and increase also 4 % during winter. This is mainly an outcome of the accumulated availability of feed stock from the wood processing industry see Figure 3.43.

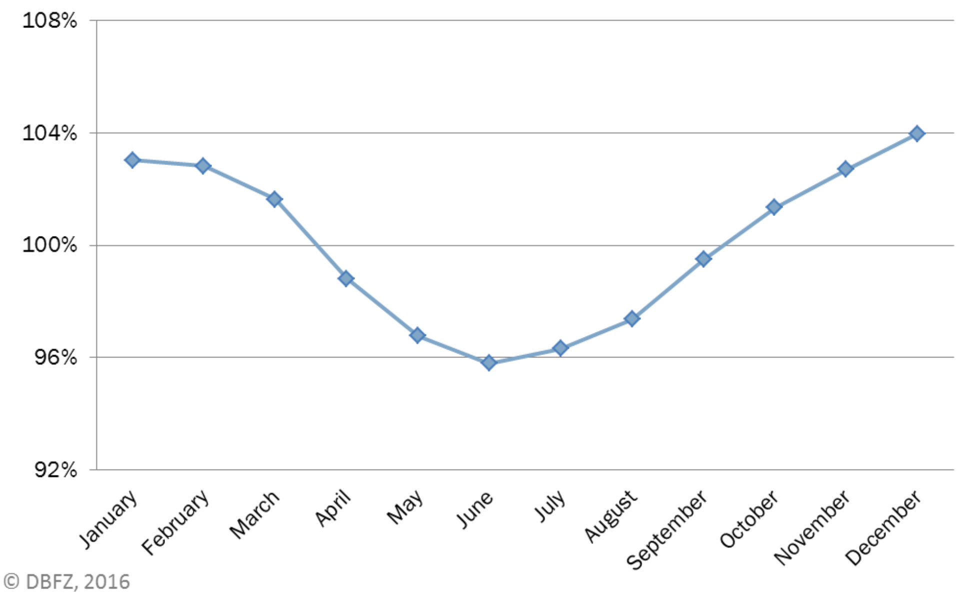

Figure 3.43 – Average fluctuations of wood pellet prices from 2004 to 2015) (C.A.R.M.E.N, 2016; DEPI, 2016c).

3.9.5 Trade and logistic aspects

Overall the wood pellet trade in Germany has increased since 2010, primarily imports increased and exports decreased, both an end result of national demand and supply dynamics, but still Germany has a positive trade balance were exports surpluses are the rule (Thrän, D. et al., 2014). Most of the certified pellets produced in Germany are consumed nationally; however, the wood pellets intended for electricity generation are entirely exported –since co-firing is not present in Germany yet (Thrän, D. et al., 2014). On the other hand, imports have been increasingly coming from Eastern European countries including industrial wood pellets meant for re-exporting (Thrän, D. et al., 2014). Sustainability issues arise in this point since some of these countries, such as Bulgaria, lack the arrangement or means to ensure sustainability of their local forests SOURCE Bulgaria).

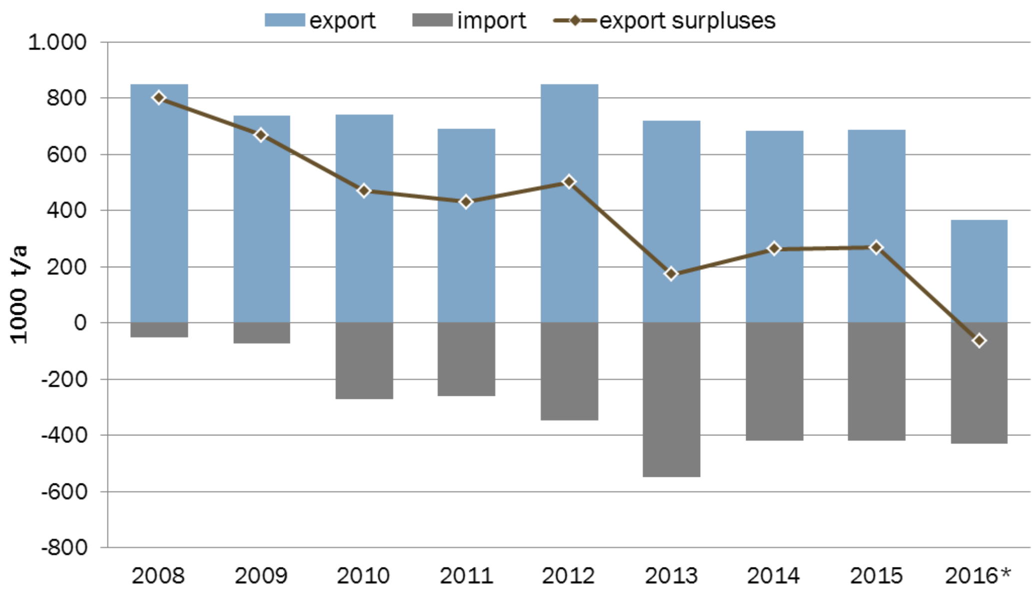

Figure 3.44 - Evolution of export and import in Germany from 2008 to 2015 (DESTATIS, 2016).

Industrial wood pellets are mainly exported to United Kingdom, Austria and Italy. Imports, on the other hand, are coming increasingly Eastern European countries and Denmark.

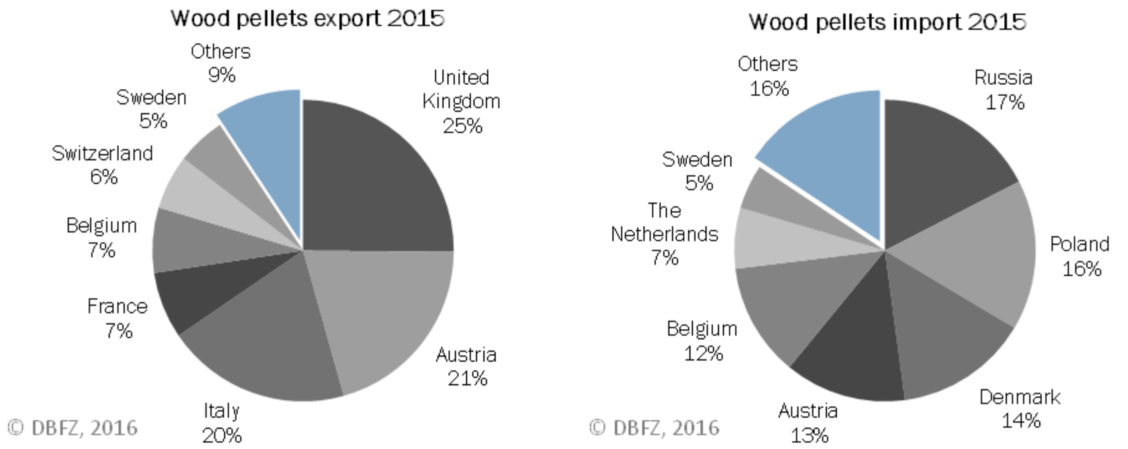

Figure 3.45 - Pellet exports and imports from Germany in 2015 (DESTATIS, 2016).

3.9.6 Pellet quality standard

The ENplus-produced wood pellets caught up by the year 2016 with the total production of wood pellets in Germany as seen in Figure 3.46. This means that most of the German wood pellet production is today covered by the ENplus certification scheme (DEPI, 2016a). Nevertheless, the production capacity for both ENplus and regular wood pellets exceeds the production numbers by far. Note that the production capacity in Germany is today also covered by the ENplus certification scheme.

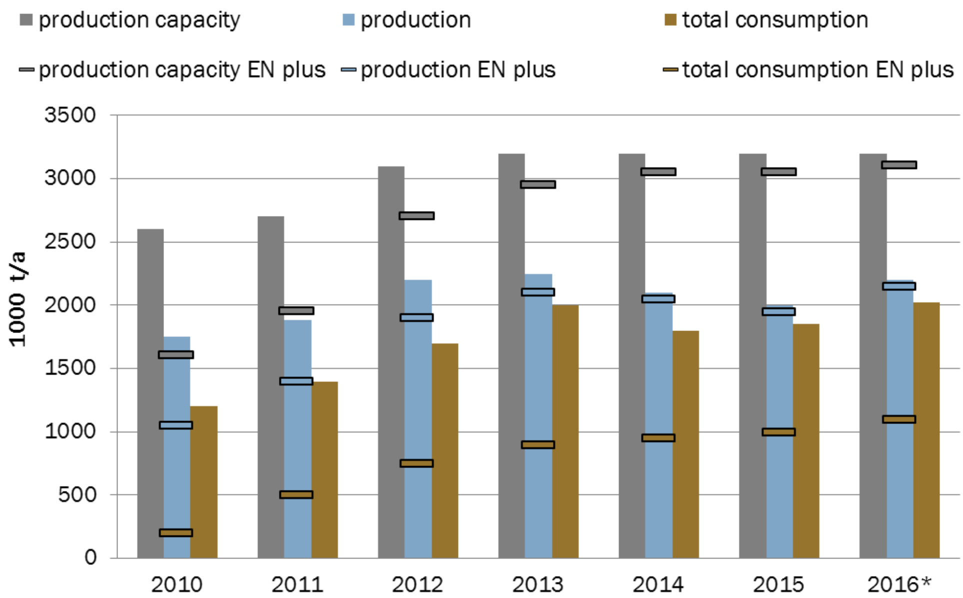

Figure 3.46 - Wood pellet market development in Germany from 2010 to 2016 (2016* estimated) (DEPI, 2016a).

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3.10 Hungary

David Peetz

3.10.1 Regulatory framework, market drivers and barriers

The wood pellet industry in Hungary made a rapid development in the mid 1990´s (Pellets Markt und Trends, 2013). Only after 2008, when most pellet plants really started, was it possible to talk about a pellet sector in Hungary. Moreover the Hungarian Pellet Association (Mapellet) was founded in 2008. Currently about 38 members represent the majority of pellet producers, boilers and fireplaces producers and distributors. (KMEC Engineering, 2012)

The government has approved 15 operational programs from 2007-2013, which are a part of the New Hungary Development Plan and are related to the goals of the operational program *Environment and Energy* of the European Commission (Hungarian Government, 2016). Particularly for the pellet sector an approximate of 5 % of the whole amount of money was provided for increasing renewable energy sources (European Commission, 2015a). Through this program a subsidy system was funded in Hungary which provides investment subsidies up to 50-70 % for the establishment of new pellet plants (KMEC Engineering, 2012). Under these conditions the pellet market grew rapidly which will become clear in the following points.

Besides the operational program *Environment and Energy* exists the *Environmental and Energy Efficiency* operational program with aims to achieve the Europe 2020 targets regarding energy efficiency and use of renewable energy sources. Expected impacts are for example greenhouse gas emissions which have decreased annually by over 1,544,000 t CO_2eq. Currently it is not possible to estimate positive effects for the biomass sector and especially the wood pellet market. (European Commission, 2015b)

In 2013 there is a detectable stagnation in pellet consumption and a low level in pellet boiler sales. Correspondingly, the majority of the pellet customers are idealists when it comes to reasons why using them, driven mostly by environmental arguments and not by the price. At the moment there is no special governmental support for enlarging the pellet market, but instead natural gas is a serious competitor which also is supported by the government. All those circumstances lead to a small heat market for wooden pellets. Additionally there is no conversion into electricity with the pellets. (Pellets Markt und Trends, 2013)

3.10.2 Production capacity, production and feedstock

In 2008 there were 7 pellet plants active with approximately 5,000 t of production that year. Also the domestic consumption of wood pellets was very small in the same year with just 1,000 t/a. Most of the pellets, almost 80 %, were exported to Poland and Italy, while agro pellets were particularly used for domestic consumption in biomass boilers. Also the largest part of wood pellets were sold in small bags (15 kg to 50 kg), followed by big-bags (500 kg to 1500 kg) and bulk pellet.

Two years later, 10 pellet producers were in operation, including 2 agro pellet producing plants. In 2011, 11 pellet plants with small and medium capacity and two larger pellet plants with capacity of more than 30,000 t/a were operating with a total capacity of 126,500 t/a. In 2015 there were 15 pellet producing plants listed. (KMEC Engineering, 2012)

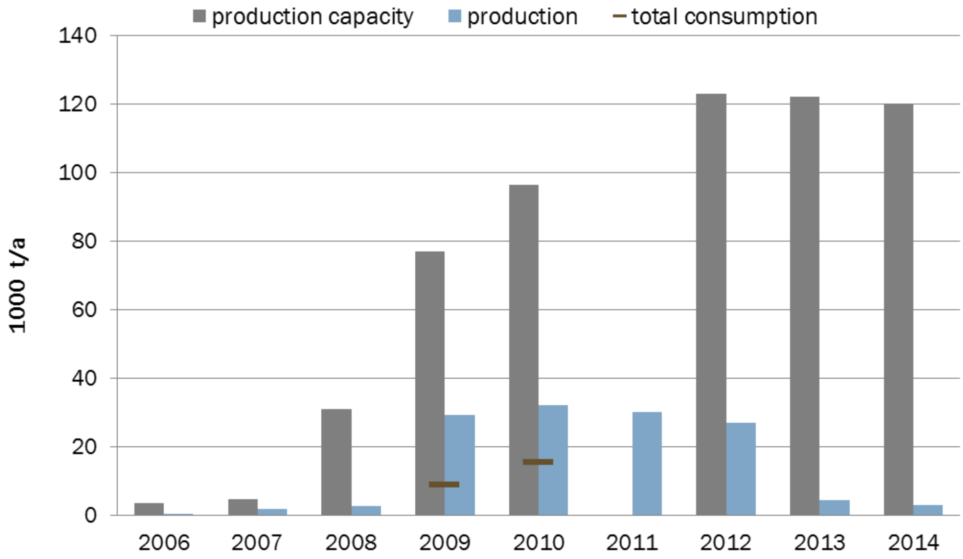

Figure 3.47 - Wood pellet market development in Hungary from 2006 to 2014 (AEBIOM, 2013; Audigane et al., 2012; Bioenergy International, 2014, 2015; eurostat, 2016; Pellets Markt und Trends, 2013).

Noticeable in Figure 3.47 is the negative development of the entire pellet market in recent years. Especially regarding pellet production which almost approaches the value from 2008, when the financial support and the awakening of the pellet sector in Hungary just started. Apart from the low level of production the total consumption is still quiet high with 120,000 t/a.

3.10.3 Consumption

Information towards installed pellet heating systems in Hungary is rare. The only usable statements can be seen in Figure 3.48. Apart from the negative trend of pellet production, the amount of installed pellet systems increased within the last 5 years. The biggest part of growth is represented by pellet stoves with an amount of 840 in 2011 and 2500 in 2015. Also the sale of boilers with a capacity lower than 50 kW increased from 67 in 2011 to 320 in 2015.

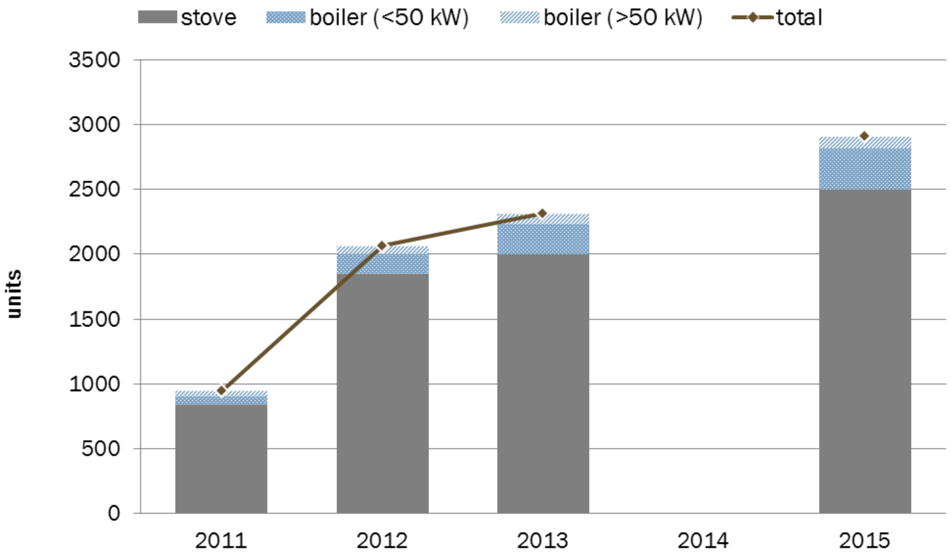

Figure 3.48 - Development of installed pellet heating systems in Hungary from 2011 to 2015 (AEBIOM, 2013).

3.10.4 Price trends

The wood pellet prices in Hungary are not well known. The only usable information is that. In 2008 the price for wood pellets was 178 €/t and in 2009 171 €/t.

3.10.5 Trade and logistic aspects

Apart from the little information about prices, trade and logistic aspects are more significant. As mentioned in Figure 3.49 the relation between export and import changed substantially. In 2009 and 2010 there were more imports than exports with maximum imports in 2010 of 43,360 t/a. In 2011, however, imports dropped to 9,580 t/a. In comparison to that, the export steadily increased from 2009 with 7,950 t/a to an amount of 21,360 t/a in 2012. Since 2012 both values are decreasing to an export of 12,650 and an import of 7,940 in 2014.

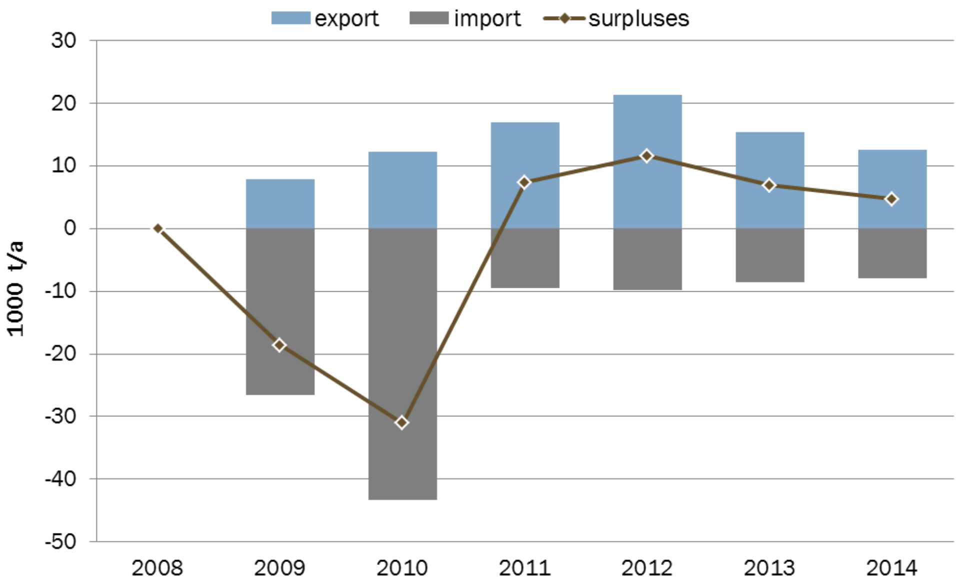

Figure 3.49 - Evolution of export and import in Hungary from 2008 to 2014 (EUROSTAT, 2016)

The main driver for the pellet market in Hungary is the export. Almost 80 % of all produced pellets are exported, especially to Italy. The market situation in Hungary is special, because most of the consumed pellets are imported from Slovakia, Czech Republic or Ukraine. As a result of this, the internal market has no suitable conditions for a positive development.

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3.11 Italy

Alessandro Pellini, Luca Benedetti

3.11.1 Regulatory framework, market drivers and barriers

In Italy wood pellets are mainly used for heating purposes in the residential sector (boiler and stoves). Policies fostering renewable heating sector in Italy are:

- Fiscal incentives
- Grants (Conto Termico)
- White Certificates

Fiscal Incentives

Pellet heating systems can benefit from a support scheme for energy saving in the building sector via tax deductions. This is a voluntary mechanism, whereby individuals or businesses may deduct respectively from their personal (IRPEF) or corporate (IRES) income tax a percentage of 65 % of the expenditure incurred for certain types of energy upgrading works on existing buildings, including the installation of pellet heating systems. The maximum amount of the deduction is of 30,000 €. To be eligible to the deduction the new system must respect well established technical features. The deduction is staggered over 10 years. The fiscal incentive is renewed year by year by the Italian Government through the Budget Law. Government is exploring the possibility of extending the validity of the scheme till 2018.

A tax deduction from personal (IRPEF) or corporate (IRES) income tax is also provided for building renovation; Beneath other things it also covers the 50 % of the expenditure incurred for the installation of renewable heating devices including pellet boilers and stoves. In this case there are no particular technical features to respect to be eligible for the deduction.

The above mentioned tax deductions are not combinable.

Grants (Conto Termico)

The replacement of existing heating systems in greenhouses and rural buildings with biomass devices, including pellet boilers and stoves, is supported by the scheme introduced by the Ministerial Decree 28 December 2012 and updated by Ministerial Decree 2 February 2016. The incentive scheme is known as Conto Termico and is devoted to foster energy efficiency and the use of renewable energy for heating purposes in the Private Sector and in the Public Administration, providing a total maximum budget of 900 million euros. The incentive is proportionated to the amount of renewable thermal energy production of installed systems, the GHG savings obtained and the climate zone where the device is located. The incentive cannot cover more of the 65 % of the investment and is paid in annual constant instalments over a period of two or five years, depending on the system capacity. The wood pellet used to feed boilers and stoves eligible to the incentive needs to be compliant with the UNI EN ISO 17225-2 standard.

White Certificates

White Certificates (or Energy Efficiency Securities- EES) are tradable securities which certify energy savings in final energy uses. The legal basis of the White Certificate scheme was established by the Ministerial Decrees of 24 April 2001, 20 July 2004, 21 December 2007, 28 December 2012 and 11 January 2017. Each certificate has a value of one ton of oil equivalent (toe).

The possible interventions which can be performed giving right to White Certificates also include the use of some types of RES technologies in the heating and cooling sector, such as in case of bioenergy.

The White Certificates scheme was introduced into the Italian Legislation by the Ministerial Decrees of 20th July of 2004, as subsequently amended and supplemented. Under the scheme, electricity and gas distributors (Obliged Parties) with more than 50,000 final customers have the obligation to achieve pre-set annual energy savings targets expressed in terms of millions of White Certificates.

Obliged Parties may fulfil their obligation by implementing energy efficiency projects entitling to White Certificates or by buying White Certificates from other parties ("voluntary parties") in the Energy Efficiency Certificates Market that is organized by GME.

Obliged parties are:

- electricity distributors with over 50,000 final customers connected to their distribution grids as of 31st December of two years preceding each year of obligation;
- natural-gas distributors with 50,000 final customers connected to their distribution network as of 31st December of two years preceding each year of obligation.

"Voluntary parties" are also eligible to implement energy efficiency projects and so to obtain White Certificates.

Voluntary parties are:

- the energy service companies (ESCOs) certified under the UNI CEI 11352 standard
- the companies that appointed an energy manager (a person in charge of conservation and rational use of energy) certified under the UNI CEI 11339 standard
- the companies controlled by obliged distributors
- the electricity or gas distributors not subject to the obligation
- the public or private companies certified under the ISO 50001 standard, which specifies requirements for establishing, implementing, maintaining and improving an **energy management system**

3.11.2 Production capacity, production and feedstock

As can be seen from the graph below, according to the most recent estimations, pellet consumption has grown from 2011 to 2015, remaining significantly higher than the National production, which is quite low. 2016 data are still not available.

Pellet consumptions are so largely satisfied by import. Unfortunately, reliable estimations on production and consumption before 2011 are not still available.

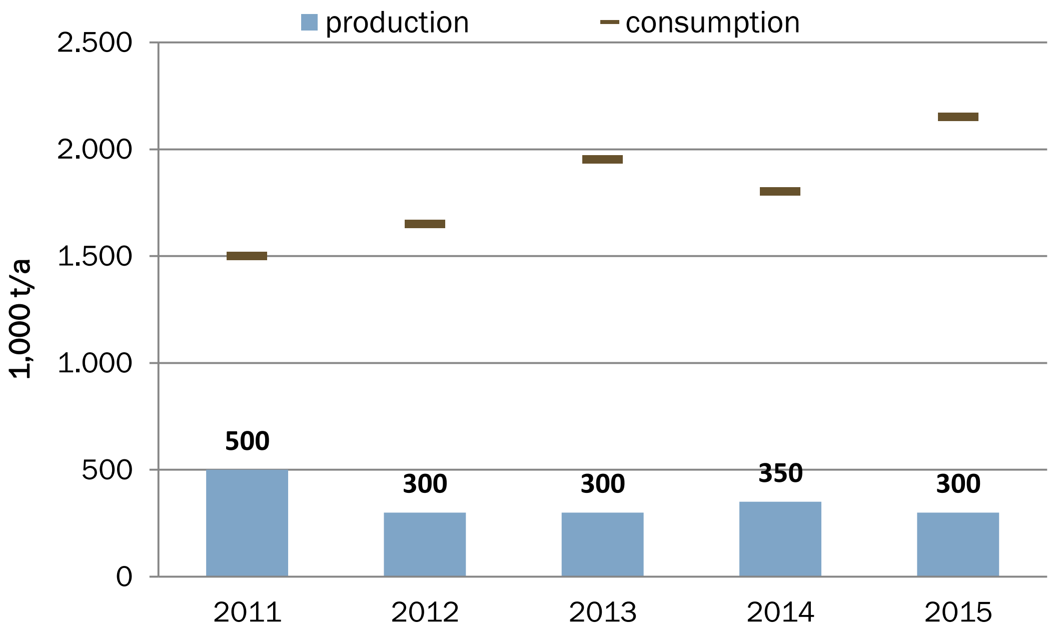


Figure 3.50 – Wood pellet market development in Italy from 2011 to 2015 (GSE 2017).

Geographical distribution of wood pellet production plants and qualitative description of the main producers

The map shows the distribution at a local level (Italian Provinces) of the EN*plus* certified pellet producers, representing the most part of the producers in Italy)

Figure 3.51 – ENplus certified local pellet producers (ENplus, 2017)

The greatest concentration of producers is located in the north-east of the peninsula; it coincides with the industrial district of domestic heating appliances (stoves and fireplaces).

According to AIEL (Associazione Italiana Energia dal Legno) data, Lombardia is the main production site, accounting for 45 % of the national supply, followed by Veneto (18 %), Friuli Venezia Giulia (16 %), and Trentino Alto Adige (8 %) (Annalisa Paniz, 2014).

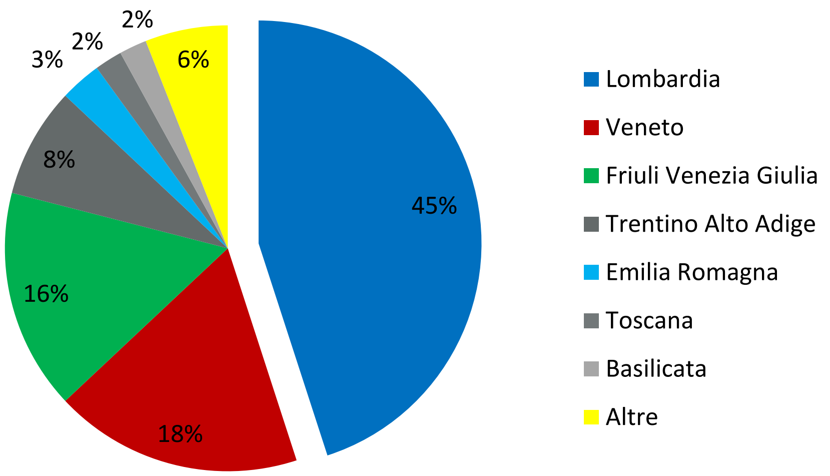


Figure 3.52 - Italy wood pellet's main production sites (Annalisa Paniz, 2014).

Some examples of pellet production companies in Italy are described below.

The TIESSE company in Cimadolmo (Treviso) was the first one in Italy producing pellet for the heating sector. TIESSE began in 1978 with the production of wood briquettes. The development of wood market in the heating sector and the growing need of an environmentally friendly product drove the company for the first time in Italy, in 1994 towards the production of pellets.

In many cases, Italian pellet producers are companies operating for a long time in the wood and furniture industry that have quite recently started to use wooden by-products to produce pellet with the aim of diversifying business, given the opportunities in the residential heating market.

Perlarredi in Azzano Decimo (Pordenone) is a company producing sarking boards from 1979, which started using spruce sawdust for the production of high quality pellet, creating in 2007 an *ad hoc* company called Pe. Pellet produced by the company Pe. Pe obtained the Italian mark of quality called Pellet Gold.

The Meridiana Legnami company in Brienza (Potenza), in the south part of Italy, operates in the wood industry since the' 50s. In 2004 it started to produce ecological pellets in pure virgin wood, diversifying the business from the traditional one (production of wooden crates, railway sleepers and railway points from local forestry).

3.11.3 Consumption

Qualitative description of the main consumers

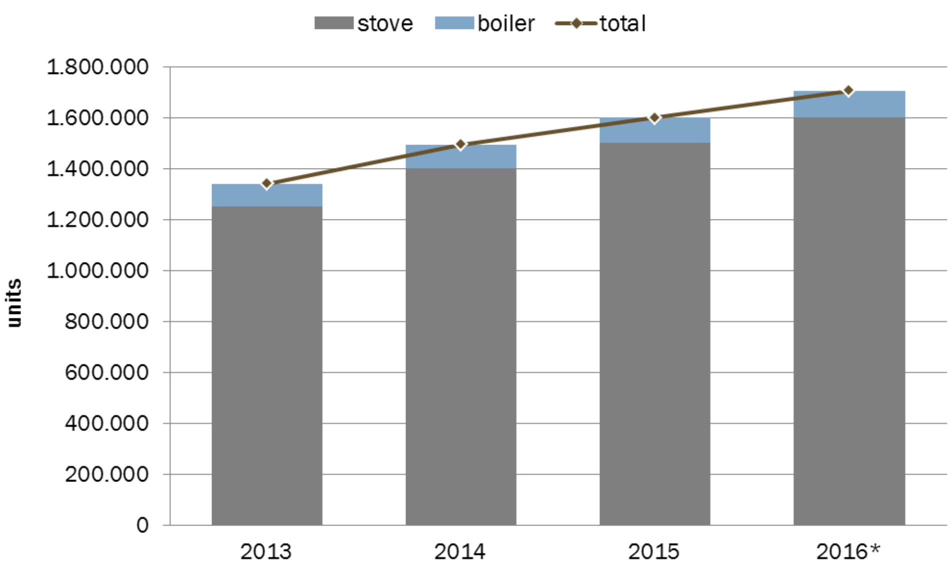
Wood pellets in Italy are mainly consumed in the residential sector. According to Italian estimation wood pellet consumption by households has grown from about 1,7 Mt in 2013 to about 1,9 Mt in 2015.

According to the survey on household consumptions carried out by Italian National Statistical Institute (ISTAT) in 2013 the average expenditure of households that bought pellet for heating purposes was about 459 €. Pellet consumers are mainly concentrated in the northern part of the country and in the mountain areas where the use of wood for heating is traditional (Valle d'Aosta, Trentino Alto-Adige, Friuli Venezia Giulia) but also in Umbria, a region in the central part of Italy and in Sardinia

According to ISTAT estimates, in 2013 7,4 % of the families based in mountain areas used pellet for heating purposes.

Quantitative description of the development of pellet boilers/pellet stoves, including a time trend for 2008 till 2016* (all 2016 data are to be considered as preliminary)

As can be seen from the graph below, the large majority of wood pellet heating devices installed in Italy are stoves (1.6 million units in 2016). Unfortunately reliable estimations on wood pellet installed appliances before 2013 are not still available.



SOURCE: GSE 2017

Figure 3.53 – Development of installed pellet heating systems in Italy from 2013 to 2016 (GSE, 2017).

3.11.4 Price trends

In 2015 the price of a pellet bag was about 229 €/t excluding VAT. As can be seen in the graph below, prices did not change much from 2009 to 2015.

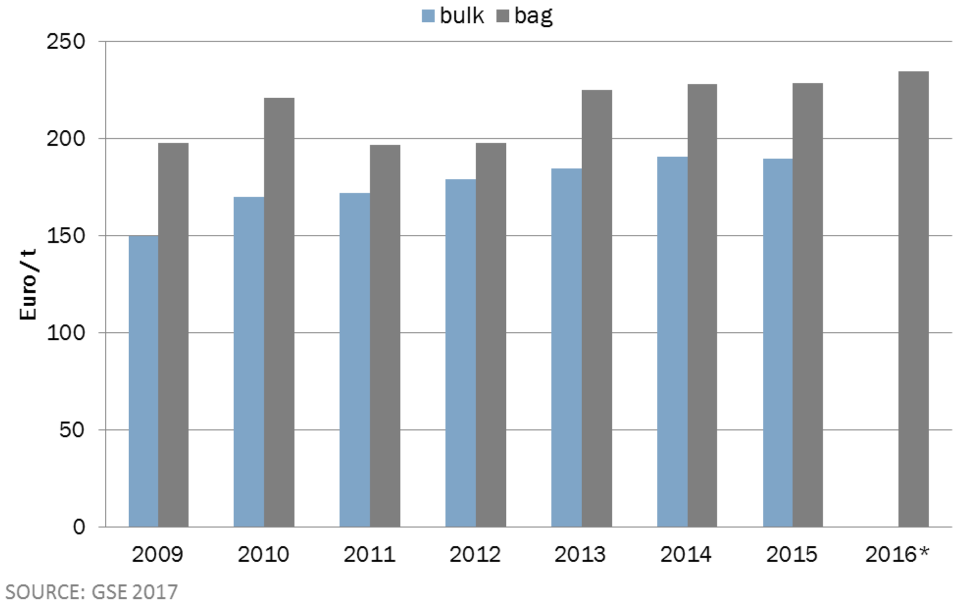


Figure 3.54 – Average bag pellet price in Italy from 2009 to 2016 (GSE 2017).

3.11.5 Trade and logistic aspects

As can be seen in the graph below, Italy is a net importer of pellet

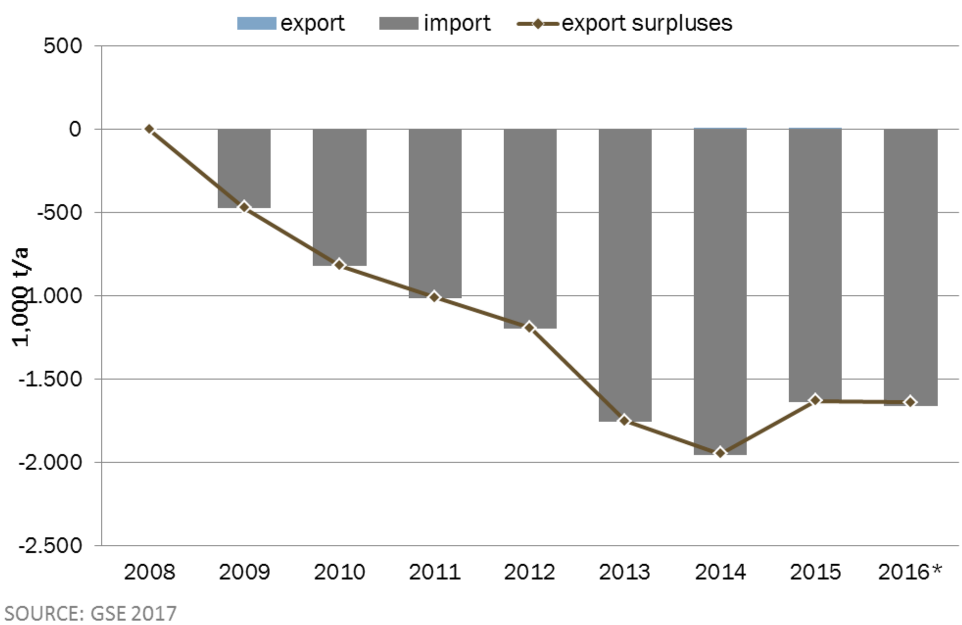
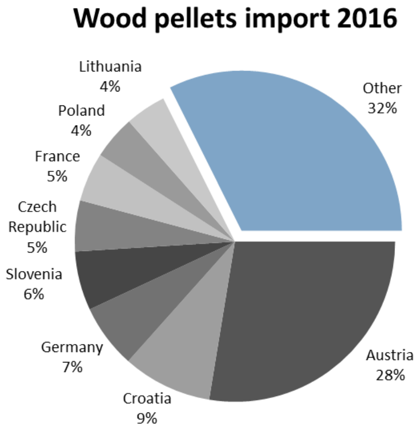


Figure 3.55 – Evolution of imports and exports in Italy from 2009 to 2016 (GSE 2017).

In 2015 Italy imported 1,6 Mt of pellets mainly from Austria and exported 0,009 Mt mainly to Slovenia.



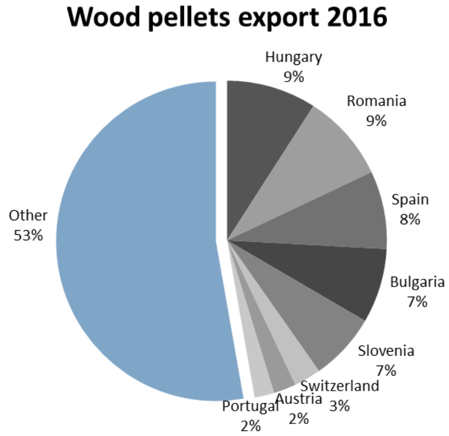


Figure 3.56 – Pellet imports and exports in Italy in 2016* (GSE, 2017; Italian National Institute of Statistics, 2017).

3.11.6 Pellet quality standard

The growing demand for pellets in the heating sector and the high technological standards achieved for domestic boilers and stoves, in terms of efficiency and thermal yield, increases the need for certified high quality pellets. In 2011 the European standard EN 14961-2 was published, replaced in 2014 by the international standard ISO 17225-2.

The standard establishes three levels of quality for pellets

- A1 for high quality pellets
- A2 and B, destined to large combustion plants for commercial or industrial use.

The most widespread pellet quality certification scheme in Italy is the EN*plus* (the latest available data are of 100,000 t of EN*plus* certified pellets sold in Italy in 2013). The ENplus quality seal accounts for the whole wood pellet supply chain, from production to delivery to the final customer, therefore ensuring high quality as well as transparency.

The quality classes ENplus A1, ENplus A2 and ENplus B are based on the level established by ISO 17225-2. Standard, but the EN*plus* product requirements exceed the ISO 17225-2 standard for some pellet properties. The ENplus quality classes exceed the requirements of ISO 17225-2 on the following points:

- For ENplus A1, the mechanical durability shall be ≥ 98,0 w-%.
- For ENplus B, the mechanical durability shall be ≥ 97,5 w-%.
- Limit for the amount of fines in bags and sealed Big Bags 0,5 w-% at factory gate.
- Limit for the temperature of pellets at the loading point for end-user deliveries: 40 °C.
- Mandatory requirements on ash melting behavior.
- The ash used for the measurement of the melting behavior is produced at 815 °C.

An overview of pellet properties and the related threshold values are shown in the following table.

Table 3-5 - Overview of pellet properties and the related threshold values.

Property	Unit	EN*plus* A1	EN*plus* A2	EN*plus* B	Testing standard[11)]
Diameter	mm	6±1 or 8±1			ISO 17829
Length	mm	3,15<L≤40 [4)]			ISO 17829
Moisture	w-% [2)]	≤10			ISO 18134
Ash	w-% [3)]	≤0,7	≤1,2	≤2,0	ISO 18122
Mechanical Durability	w-% [2)]	≥98,0 [5]	≥97,5 [5]		ISO 17831-1
Fines (<3,15 mm)	w-% [2)]	≤1,0 [6)] (≤0,5) [7)]			ISO 18846
Temperature of pellets	°C	≤40 [8)]			
Net Calorific Value	kWh/kg [2)]	≥4,6 [9)]			ISO 18125
Bulk Density	Kg/m^3 [2)]	600≤ BD ≤750			ISO 17828
Additives	w-% [2)]	≤2 [10)]			
Nitrogen	w-%[3)]	≤0,3	≤0,5	≤1,0	ISO 16948
Sulphur	w-% [3)]	≤0,04	≤0,05		ISO 16994
Chlorine	w-% [3)]	≤0,02		≤0,03	ISO 16994
Ash Deformation Temperature [1)]	°C	≥1200	≥1100		CEN/TC 15370-1
Arsenic	mg/kg [3)]	≤1			ISO 16968
Cadmium	mg/kg [3)]	≤0,5			ISO 16968
Chromium	mg/kg [3)]	≤10			ISO 16968
Copper	mg/kg [3)]	≤10			ISO 16968
Lead	mg/kg [3)]	≤10			ISO 16968
Mercury	mg/kg [3)]	≤0,1			ISO 16968
Nickel	mg/kg [3)]	≤10			ISO 16968
Zinc	mg/kg [3)]	≤100			ISO 16968

1. ash is produced at 815°
2. as received
3. dry basis
4. a maximum of 1 % of the pellets may be longer than 40 mm, no pellets longer than 45 mm are allowed
5. at the loading point of the transport unit (truck, vessel) at the production site

6. at factory gate or when loading truck for deliveries to end-users (*Part Load Delivery* and *Full Load Delivery*)
7. at factory gate, when filling pellet bags or sealed *Big Bags*
8. at the last loading point for truck deliveries to end-users *Part Load Delivery* and *Full Load Delivery*)
9. equal ≥ 16,5 MJ/kg as received
10. the amount of additives in production shall be limited to 1,8 w-%, the amount of post-production additives (e.g. coating oils) shall be limited to 0,2 w-% of the pellets
11. as long as the mentioned ISO standards are not published, analyses shall be performed according to related CEN standards

Concerning raw materials, the types of wood indicated in the following table can be used according to the standard ISO 17225-2 for the production of wood pellets. The raw material assortments are defined in ISO 17225-1.

Table 3-6 - Types of wood as raw material.

EN*plus* A1	EN*plus* A2	EN*plus* B
1.1.3 stern wood a) 1.2.1 Chemically untreated by-products and residues from the wood processing industry b)	1.1.1 Whole trees without roots a) 1.1.3 Stern wood a) 1.1.4 Logging residues a) 1.2.1 Chemically untreated by-products and residues from the wood processing industry b)	1.1 Forest, plantation and other virgin wood a) 1.2.1 Chemically untreated by-products and residues from the wood processing industry b) 1.3.1 Chemically untreated used wood c)

a) Wood which was externally treated with wood preservatives against insect attack (e.g. lineatus), is not considered as chemically treated wood. If all chemical parameters of the pellets comply with the limits and/or concentrations are too small to be concerned with.

b) Negligible levels of glue, grease and other timber production additives use in sawmills during production of timber and timber product from virgin wood are acceptable, if all chemical parameters of the pellets are clearly within the limits and/or concentrations are too small to be concerned with.

c) Demolition wood is excluded. Demolition wood is used wood coming from the demolition of buildings or civil engineering installations.

ENplus deviates from the standard ISO 17225-2; the use of demolition wood and of chemically treated wood is not allowed for any EN*plus* pellets.

Additives are allowed to a maximum of 2 % of the total mass of the pellets. The amount of additives in production shall be limited to 1,8 w-%, while the amount of post-production additives (e.g. coating oils) shall be limited to 0,2 w-% of the pellets. The type (material or trade name) and quantity (in w-%, as received) of all additives shall be documented. Water, steam and heat are not regarded as additives. Additives, such as starch, corn flour, potato flour, vegetable oil, lignin from sulfate kraft process etc., shall originate from processed or unaltered farming and forestry products. The Board of ENplus may exclude the use of a particular additive if concerns are raised that it creates operational problems in heating devices or poses health or environmental risks. The company may file an objection against the exclusion.

The ownership of the ENplus trade mark remains with the European Biomass Association AEBIOM (which hosts the European Pellet Council – EPC). The right to award the license to use the ENplus brand to qualifying companies is passed by AEBIOM to national pellet associations that have been accepted as National Licensers.

Italian National Licenser is AIEL (Associazione Italiana Energie Agroforestali). ENAMA (Ente Nazionale per la Meccanizzazione Agricola) is the Italian certification body for EN*plus*.

The other quality certification schemes available in the Italian market are the German pellets Din and Din Plus, the Austrian ÖNORM M7135, the Swiss SN 166000 and the Swedish SS 187120.

There are no Italian certification schemes significantly on the internal market.

In 2006 AIEL introduced the pellet label known as "Pellet Gold", now very widespread in Italy. Pellet Gold is not to be intended as a certification because AIEL is not a certification body. Pellet Gold aims at ensuring that pellet production meets the standards outlined in the labelling requirements. It also provides for formaldehyde content testing (HCHO), essential in order to detect the presence of materials (glues and paints) dangerous to the health of consumers, as well as the presence of radioactivity.

Table 3-7 - Italian "Pellet Gold" label parameters.

Parameter	Unit	Pellet Gold A1	Pellet Gold A2
Diameter	mm	6±1	
Length	mm	3,15<L≤40	
Moisture	w-%	≤10	
Ash	w-%	≤0,7	≤1,5
Mechanical Durability	w-%	≥97,5	
Fines (<3,15 mm)	w-%	≤1,0	
Additives	w-%	≤2	
Net Calorific Value	MJ/kg	16,5≤ Q ≤19	16,3≤ Q ≤19
Bulk Density	Kg/m^3	≥600	
Nitrogen	w-%	≤0,3	≤0,5
Sulfur	w-%	≤0,03	
Chlorine	w-%	≤0,02	
Arsenic	mg/kg	≤1	
Cadmium	mg/kg	≤0,5	
Chromium	mg/kg	≤10	

Parameter	Unit	Pellet Gold A1	Pellet Gold A2
Copper	mg/kg	≤10	
Lead	mg/kg	≤10	
Mercury	mg/kg	≤0,1	
Nickel	mg/kg	≤10	
Zinc	mg/kg	≤100	
Formaldehyde	mg/100g	≤1,5	
Radioactivity	Bq/kg	≤6	

The labelling procedure requires an initial inspection visit which checks:

- Production process control;
- Pellet quality control system.

During the inspection visit, the auditor collects samples on which laboratory analysis will be performed in order to check their compliance with the certification standards handbook. If the inspection is positive, the pellets are labeled with the Pellet Gold seal.

Refereces:

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3.12 The Netherlands

Thuy Mai-Moulin, Martin Junginger, Peter-Paul Schouwenberg

3.12.1 Regulatory framework, market drivers and barriers

The share of energy from renewable sources including solid biomass in the gross final consumption of energy in the Netherlands was set to increase from 3.7 % in 2010 up to 14 % in 2020 according to EU Renewable Energy Directive (2009/28/EC). The Dutch government encourages the production of renewable energy (heat or combined heat and electricity (CHP), power and biogas) through the Stimulation of Sustainable Energy Production (SDE and SDE+) subsidy with the aim of improving the environment and making the Netherlands less dependent on fossil fuel whilst also bringing benefits to the economy.

Changes have been made several times, including the transition from SDE to SDE+ as well as sustainability requirements for solid biomass use. Changes and concrete requirements of sustainability are expected to be complete in 2017 that would help investors and generators of wood pellets and other renewable energy to participate effectively into the support scheme.

3.12.2 Production capacity, production and feedstock

The wood pellet production capacity is rather small in the Netherlands, consisting of two plants (Energy Pellets Moerdijk and Plo-Span Bio-energy) with a combined capacity of approximately 280 kt/a. Annually, they have a typical utilization of 80-90 % (KMEC Engineering, n.d.) of which 150 kt and 130 kt are of industrial and residential quality, respectively. This production capacity has been constant for the past few years, and given the limited availability of the main feedstock for wood pellets (sawdust from wood processing industry), no further increase in domestic production capacity is expected. The pellets are manufactured in accordance with the Dutch DIN 51731 quality standards.

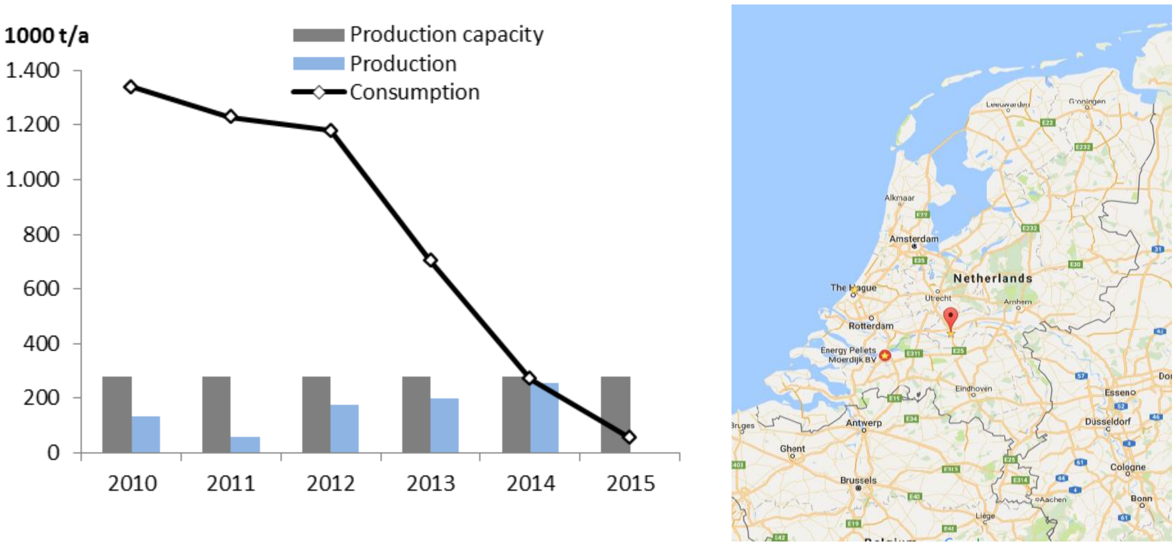


Figure 3.57 - Production and consumption of wood pellets in the Netherlands.

3.12.3 Consumption

Compared with rather small size of wood pellet production, the Netherlands is one of the main importers of wood pellets in Europe and the world (Centraal Bureau voor de Statistiek, 2016; Fiona Matthews, 2015). Most of wood pellets are used for co-firing in large-scale coal fired power plants in the last few years and RWE Generation Netherlands accounts for about 80 % of the total co-firing volume. However, RWE Generation Netherlands and other energy companies have reduced their biomass use from 1,300 kt in 2010 to 640 kt in 2013 and to almost zero in 2015 and 2016 due to budget unavailability for co-firing plants within the SDE+ scheme. The consumption of wood pellets in heat and power plants is expected to grow once SDE + subsidy scheme is reopen for grant applications.

3.12.4 Price trends

On average the wood pellet price for industrial pellets arrived at Rotterdam port and has a large range ranging from 155 in February 2015 to 149 €/t in November 2015 (ARGUS MEDIA, 2016; Biomass Magazine, 2017). Communication with RWE Essent expert also confirmed this range. In 2016, the price continued decreasing to 111 €/t. Pellet price is higher for the retail market, ranging from 168-176 €/t of ENPlus A1 wood pellets for a bag of 15 kg in the same period.

3.12.5 Trade and logistic aspects

The CBS extracted data indicated that the Netherlands is in general a net importer of wood pellets (Figure 3.58). However, there is an exception for the year 2015 when export surplus import of wood pellets. The Netherlands is also an intermediate country where wood pellets are imported for the industrial and residential market but they are also reprocessed or distributed directly to other European countries. The year 2015 was exceptional when Netherlands became an exporter of wood pellets. This could be explained whilst no pellets were used in co-firing plants, exported and produced pellets were distributed to the neighboring countries, notably Belgium and Germany where there are always high demand for wood pellets use.

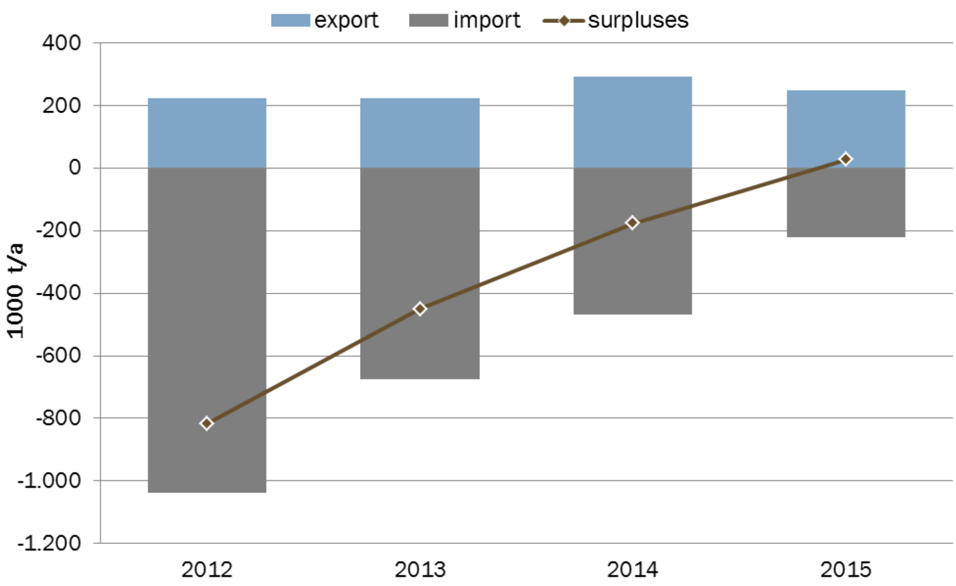
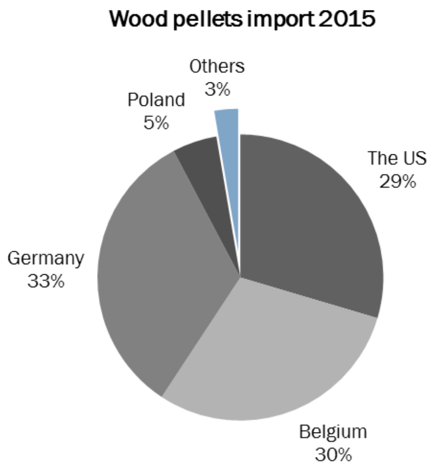


Figure 3.58 - Evolution of export and import in Netherlands from 2012 to 2015 (Centraal Bureau voor de Statistiek, 2016).



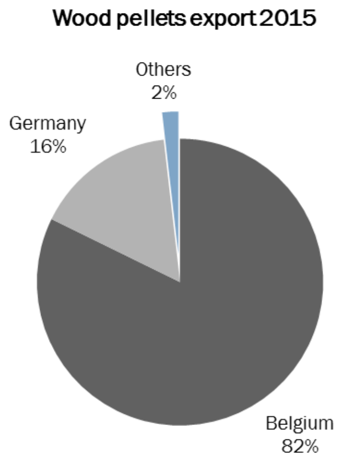


Figure 3.59 - Wood pellet import and export of the Netherlands 2015.

3.12.6 Pellet quality standard

Reporting information (Platform Bio-energie, 2015; Rijksdienst voor Ondernemend Nederland, 2015) have identified that less than 10 % of total solid biomass used for co-firing plants in 2015 in the Netherlands come from wood pellets which are mainly made of fresh wood (Rijksdienst voor Ondernemend Nederland, 2015). The major energy producers, accounting for about 23 % of the reported biomass, declare utilizing mainly pellets. Regarding fresh wood which is about 35 % of all wood use, the producers indicate that 70 % was demonstrably sustainable - this is similar to 2012 report in the Netherlands. Concerning the biomass co-fired in coal power stations it has been reported that over 95 % a sustainability system has been used. This is an increase of more than 20 % compared to 2013 (Rijksdienst voor Ondernemend Nederland, 2015).

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3.13 Norway

Erik Trømborg

3.13.1 Regulatory framework, market drivers and barriers

In Norway there is a relatively small market for wood pellets compared to the vast wood resources and the number of inhabitants. Norway has based the electricity production on hydro power and oil and gas production as about ten-fold the domestic energy consumption. In 2015 electricity (96 % hydro) made up 52 % of the net domestic energy consumption, fossil fuels 43 % and biomass and waste 5 % (Statistisk sentralbyrå, 2016a).

Residential heating is mainly based on electricity in combination with wood stoves. The consumption of pellets is around 70,000 t/a, and they are used in pellets stoves, central heating and district heating. The main barriers for pellet consumption in Norway is a lack of co-firing due to non-existing coal plants, relatively high share of wood stoves that are used in combinations with electric heating and/or heat pumps in residential heating and preferences for wood chips in a relatively small market for district heating. In Norway, district heating is growing but still low compared to direct space heating. District heating accounted for about 8 % of the heat demand the residential and service sectors in 2015 (Statistisk sentralbyrå, 2016b). 62 % was delivered to the service sector and 21 % to households. Refuse incineration plants produced 49 % of the delivered heat, wood and biofuel boilers 21 %, electric boilers 12 %, heat pumps 10 % and oil and gas boilers 5 %.

According to Statistics Norway (Statistisk sentralbyrå, 2016a), the stationary consumption of petroleum products in household and service sector was 2,6 TWh in 2015 and represents a potential for biomass energy including wood pellets in pellet stoves, central and district heating systems.

Wood chips seem to be preferred in district heating due to lower fuel costs and business opportunities for local forestry. Wood pellets will take a share in central heating, but the market share will depend on electricity prices, technical development of larger heat pumps and the price of wood pellets. Increase demand for cooling will also favour heat pumps.

The use of wood pellets in pellet stoves and small scale boilers for single houses has stagnated in Norway. Even if hydronic heating distribution is common in new houses, the systems are rarely designed for biomass heating. Direct electric heating or air-to-air heat pumps in combination with wood stoves on colder days is the most common system in detached houses. The Norwegian Association for heat pumps in Norway, reports that more than 600,000 heat pumps are installed in Norway (www.novap.no). Air-to-air heat pumps are most common, but heat pumps linked to water based heat distribution are becoming more common.

Lower electricity prices, caused by increased production of renewable electricity will imply stronger competition for biomass heating. Increased transmission capacity between Norway and the European continent will also influence the price level and seasonal structure for electricity prices in Norway. Lower prices during the heating season when the demand is high, higher prices from spring to fall when demand is low and production of hydro power is a possible scenario.

3.13.2 Production capacity, production and feedstock

There are currently 6 producers of pellets in Norway of which only 3 have an installed capacity above 10,000 t. The Biowood Norway plant at Averøya on the Norwegian west coast started its operation in 2011 at an installed capacity of 450,000 t, but the plant was closed down in 2012. About half of the domestic plants are based on pulpwood or wood chips as the main feedstock, while the other half uses dry materials. The comparative advantages of Norwegian pellets production was studied in Trømborg et al., (2013).

Domestic consumption of pulpwood is reduced by more than 50 % the last 10 years because of the shut down of pulp and paper mills. Pulpwood prices have declined and about 40 % of domestic harvest is currently exported.

The production in 2015 was 57,000 t, a slight increase from 2014 (Figure 3.60). Arbaflame AS is currently planning for a new 200,000 t plant. Arba Follum is producing steam treated wood pellets for co-firing (www.arbaflame.no). Arbaflame has a 40,000 t capacity demonstration plant.

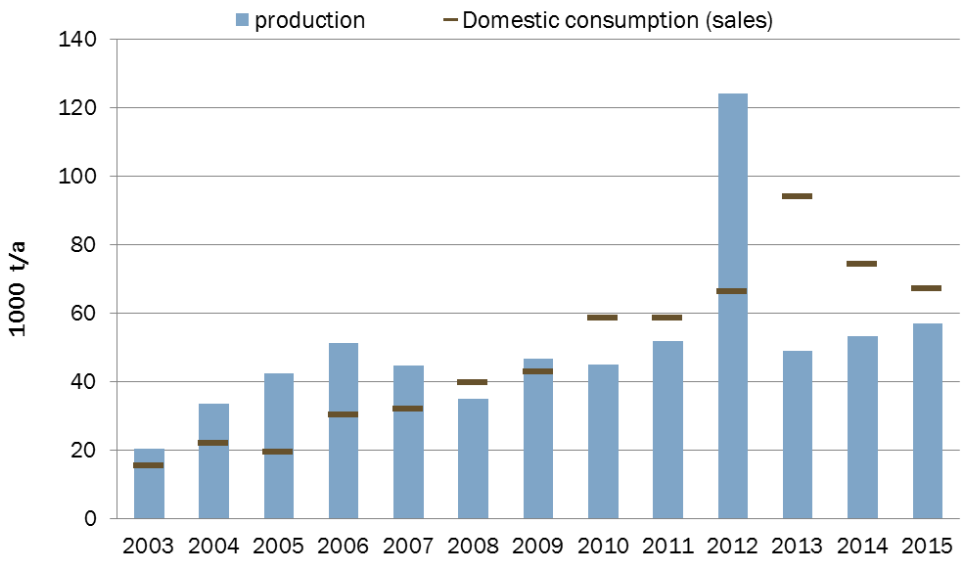

Figure 3.60 - Production, import and export for wood pellets in Norway in tonnes. (Norsk Bioenergiforening, n.d.).

The production of briquettes was 34,236 t in Norway in 2012 and the domestic consumption 38,238 t.

3.13.3 Consumption

The variability in consumption is caused by annual differences in outdoor temperatures (heating degree days), 2014 and 2015 had mild winters. 10 % of the 2015 consumption was in small bags (16 kg), 20 % in large bags and 70 % in bulk.

3.13.4 Price trends

The pellet prices in Norway have been relatively stable in recent years. A weaker Norwegian krone compared to Euro has reduced the prices for bulk pellets in Euro/ton (€/NOK was 20 % higher in 2015 compared to 2012).

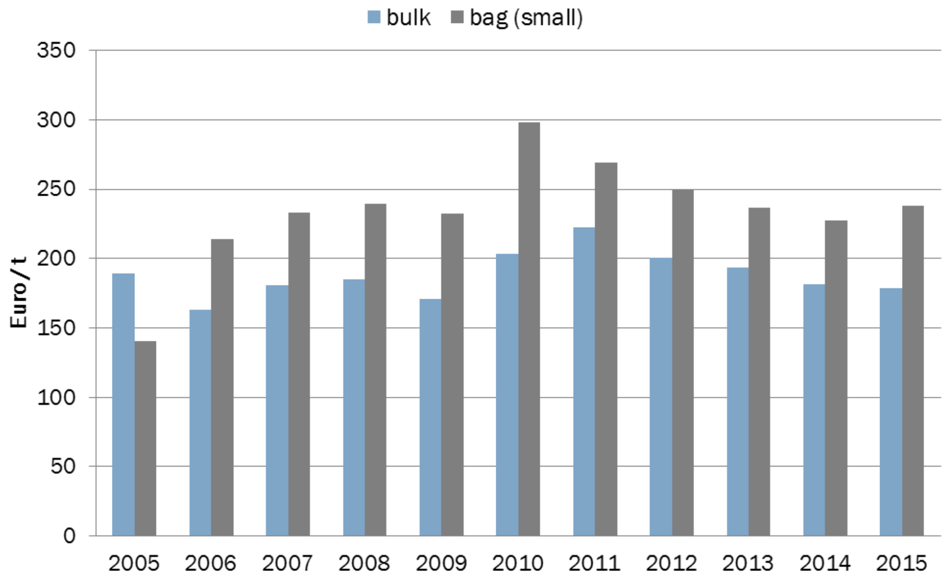

Figure 3.61 - Pellet prices fob and ex VAT at producers plant in Norway. Note uncertainty caused by a limited number of producers (Norsk Bioenergiforening, n.d.).

3.13.5 Trade and logistic aspects

As for most small and medium scale European pellet producers, the pellets production in Norway is mainly targeted on domestic consumers. The import in 2015 was 25,000 t of which 98 % came from Sweden. Export was 13,000 t of which about 81 % was exported to Canada, 13 % to Denmark and 5 % to Sweden (Figure 3.62 and Figure 3.63). The export to Canada is a test from Arbaflame for co-firing pellets. The export to Canada is a test from Arbaflame for co-firing pellets.

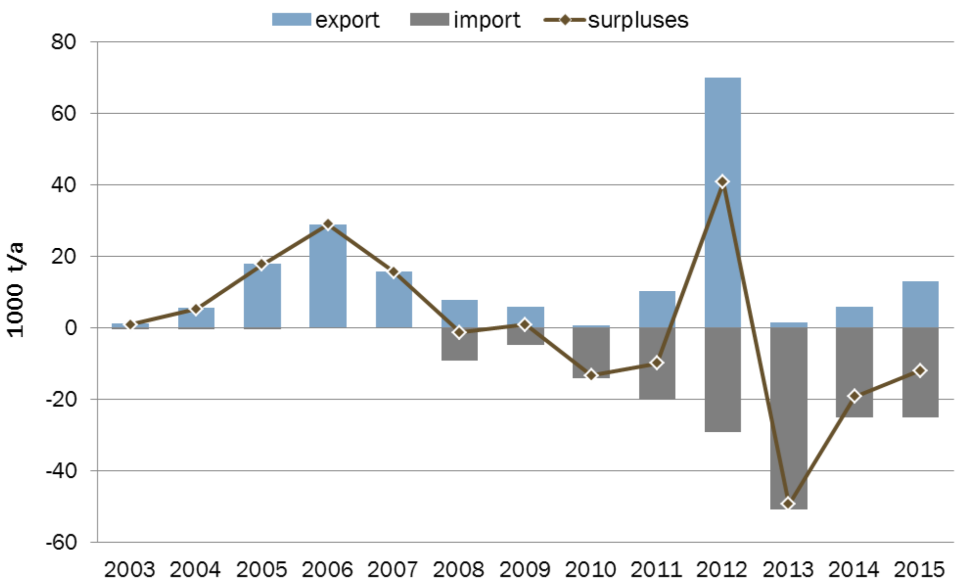

Figure 3.62 - Export and import of wood pellets in Norway. (Norsk Bioenergiforening, n.d.).

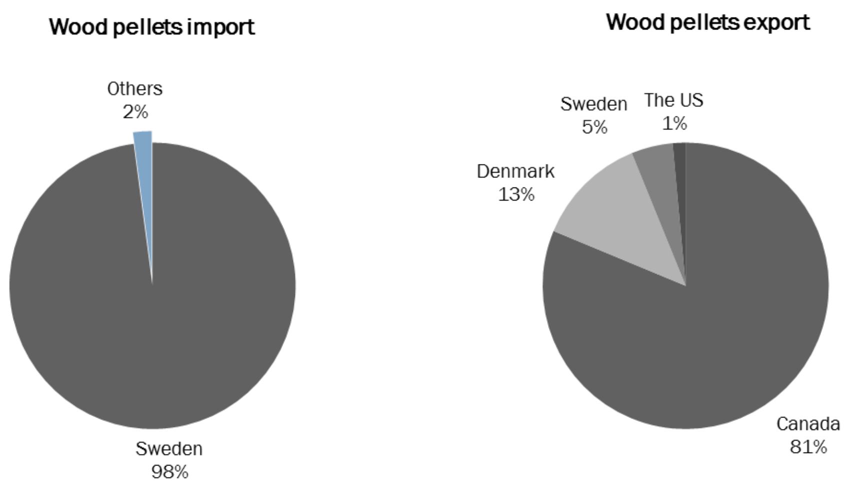

Figure 3.63 - Major import and export countries for wood pellets in Norway. (Statistisk sentralbyrå, 2016c).

3.13.6 Pellet quality standard

In Norway quality standards for pellets are NS3165 Biofuel - Cylindrical pellets of pure wood - Classification and requirements and NS 3166 Biofuel - Determination of mechanical strength of pellets. Important figures of the standards are shown in Table 3-8.

Table 3-8 - Important figures from NS 3165: Classification and requirements. source: Pellets atlas

Property	Test method	Unit	Group 1	Group 2	Group 3
Length	Measure 10 pellets	mm	Max 4xØ	Max 5xØ	Max 5xØ
Bulk density	SS 187178	Kg/m^3	>600	>500	>500
Durability	NS 3166	fines	0,8% < 3 mm	1,5%< 3 mm	1,5%< 3 mm
Lower H_u	ISO 1928	MJ/kg	>16,9	>16,9	>15,1
Ash	SS 187171	% w/w of DM	< 0,7	< 1,5	<1,5
Moisture	SS 187170	% w/w	< 10	< 10	< 12
Sulphur	SS 187177	% w/w of DM	< 0,08	< 0,08	To be stated
Chlorides	SS 187185	% w/w of DM	< 0,03	<0,03	To be stated
Ash melting	ISO 540	°C	Initial temp.	Initial temp.	Initial temp.

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3.14 Poland

Svetlana Proskurina, Jussi Heinimö

3.14.1 Regulatory framework, market drivers and barriers

Poland has a loan and three subsidy schemes for heating production from renewable energy sources. One subsidy scheme is done by a state-owned bank and another two by National Fund for Environmental Protection and Water Management respectively. Renewable electricity is promoted mainly through a quota system (European Commission, 2015).

One of the key motivator of wood pellets development is the Polish NREAP, in which wood pellets are included in the total wood biomass volume. Additionally, more specific Policy Instruments (PIs) have an effect on electricity generation from renewable resources, including biomass and wood pellets use. Pls have decisive impact on the total biomass flow and, indirect impact on the pellet-to-heat pathway in Poland. All bioenergy pathways are shaped by markets reaction to support schemes for renewable electricity generation (BIOTEAM, 2014).

Polish government requirements limit the biomass use in power generation in favour of agricultural biomass. This limit caused an increase in the use of straw for pellet production and pelletization. Thus, consumption of pellets has decreased in 2013.

Main drivers for pellet production and trade in Poland:

- Potential of agropellets development
- Local demand

Main barriers:

- Green certificates system collapsed in 2012
- Increase of pellet prices on the local market

3.14.2 Production capacity, production and feedstock

In Poland, wood pellet production started in 2003 and showed quite a strong development (Figure 3.64). The growth was rather limited from 2012 to 2013 but subsequently it strongly increased from 2013 to 2014. The recovering economy has supported the redeployment of the wood industry, resulting in better raw material availability and better prices. New plants have been built lately and some already existing plants have increased their capacity (AEBIOM, 2015).

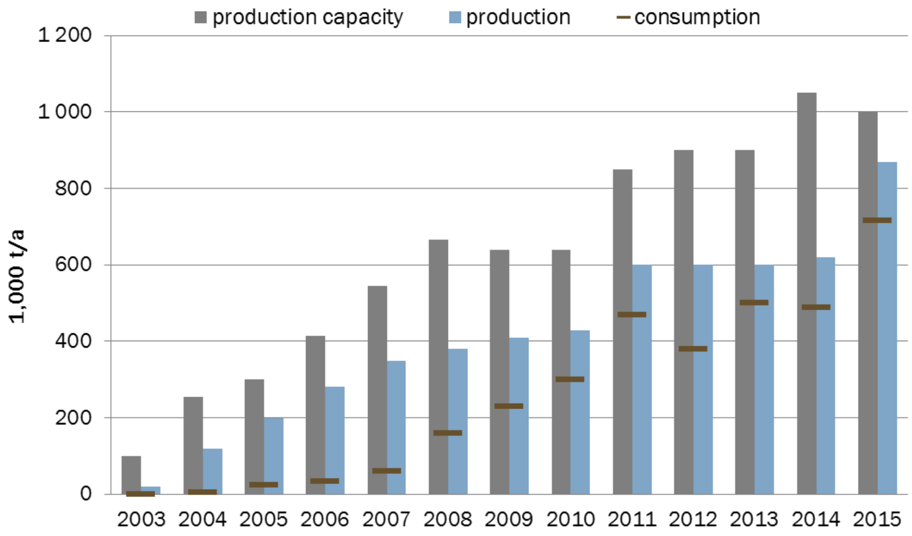

Figure 3.64 - Wood pellet market development in Poland from 2003 to 2015.

After Ukraine, Poland is a main leader in European agropellet production with 0.53 Mt in 2014 (AEBIOM, 2015). For domestic use the wood pellets produced come mainly from sawdust, which accrues as residue from sawmills and wood processing plants (BIOTEAM, 2014). The production of wood pellets in Poland is distributed as follows: less than 10 plants produce over 50,000 t/a, and around 20 plants produce approximately over 10,000 t/a. Other plants have annual wood pellet production below 10,000 t. There are also a number of smaller wood pellet producers with a yearly fluctuating production volume. Figure 3.65 shows pellet production plants in Poland in 2014 (BIOTEAM, 2016).

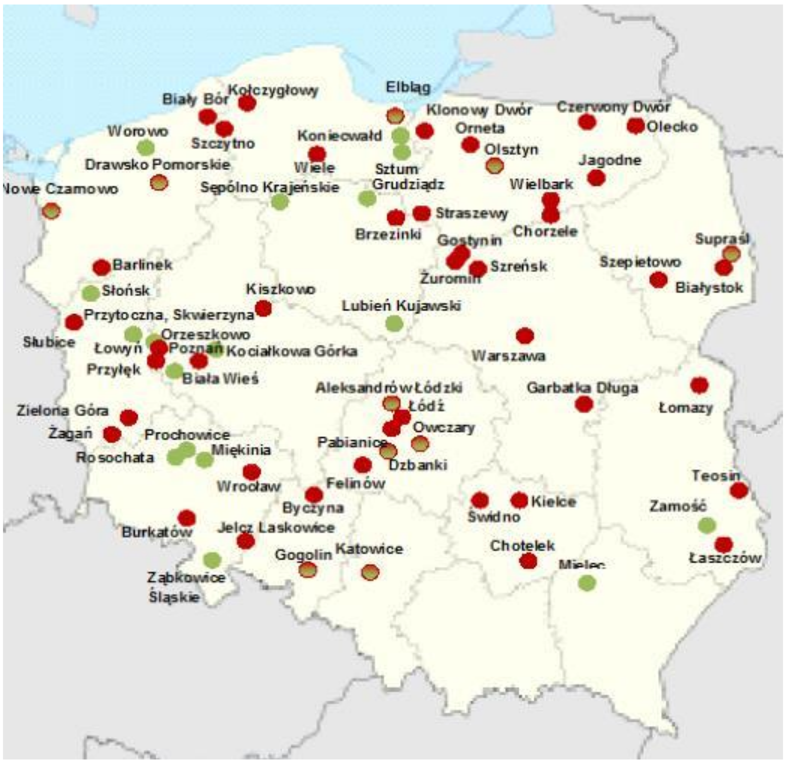

Figure 3.65 - Wood pellet production plants in Poland (2014); red wood pellets, green agropellets (BAPE own study), (BIOTEAM, 2016).

The main feedstocks of wood pellets are wood shavings and saw dust originating from furniture or construction industry, and small sawmills. So far, wood chips are used only in tiny amounts (Bastian and Wach, 2009).

3.14.3 Consumption

The pellet consumption for heat is growing mainly due to a demand increase in the domestic sector in Poland. No important growth is foreseen in the larger plants as other fuels such as agropellets and wood chips are being used (AEBIOM, 2015). About half of the total consumption belongs to power and CHP plants. Due to the green certificates system collapse, demand and domestic consumption of wood pellets has decreased since 2012 (BIOTEAM, 2016).

For households, wood pellets are distributed via delivery truck and then sold as bagged goods or delivered and loaded to silos of pellet boilers. In households the wood pellets are burned in specific wood pellet boilers for heat production. Wood pellets are competitive with light fuel oil for heating mainly in the countryside (BIOTEAM, 2014).

3.14.4 Price trends

In Poland, demand and prices of wood pellets on the international market have a direct impact on the price for domestic users. In case of an export decrease, the bigger amount of wood pellets goes to the domestic market, which consequently reduces wood pellets prices and as a result causes problems with production profitability. The reduction of the income from pellet sale can lead to problems with loan repayments (BIOTEAM, 2014). However, after 2013, demand has increased thanks to recovery of economy.

Since 2013, the pellet price has increased due to: changes of supply and demand conditions, a tightening of import regulations of solid biofuels in Poland, and a reduction of deliveries from abroad. The lowest prices of wood pellets are found in the south and east of the country, due to the geographical proximity of the region to the main exporters (Ukraine and Belarus). The highest prices of pellets were recorded in the western regions.

The wood pellet price is not very competitive compared with other fuels in Poland. Figure 3.66 shows the comparison of fuels and the energy prices for heating plants.

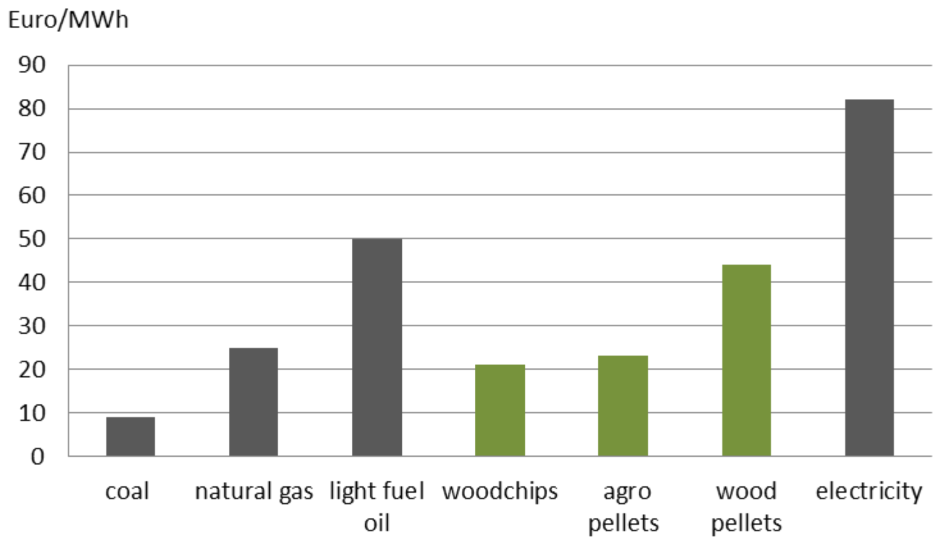

Figure 3.66 - Comparison of energy price in fuels in Poland [EUR/MWh], (BIOTEAM, 2016).

3.14.5 Trade and logistic aspects

Poland has changes in the proportion of exports and imports of wood pellets (Figure 3.67)

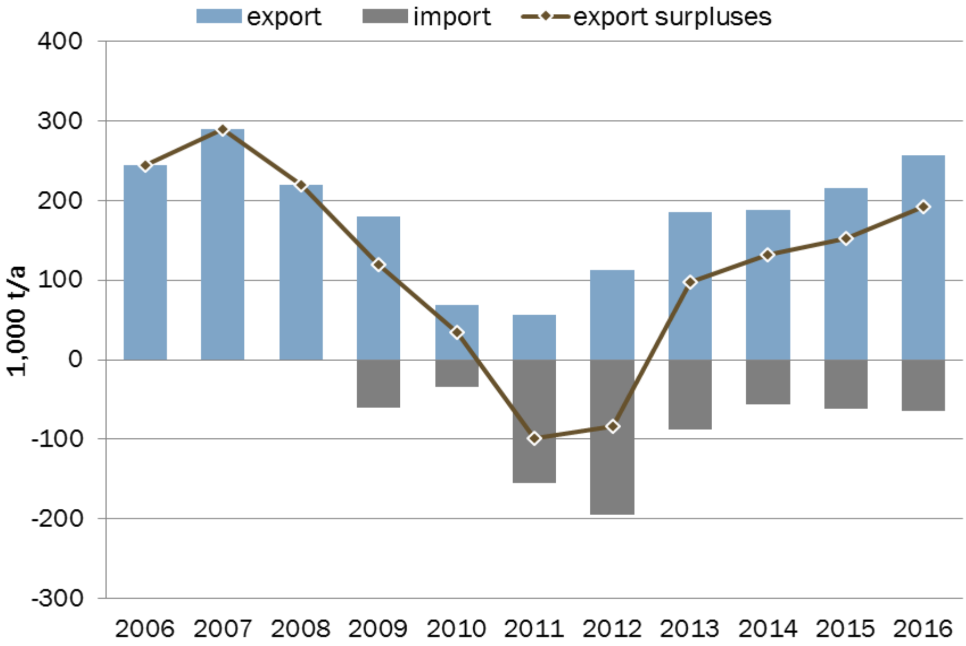

Figure 3.67 - Evolution of export and import in Poland from 2006 to 2016.

Poland exported 0.2 Mt of wood pellets and imported about 62,000 t of wood pellets in 2015. Figure 3.68 shows wood pellet import and export respectively.

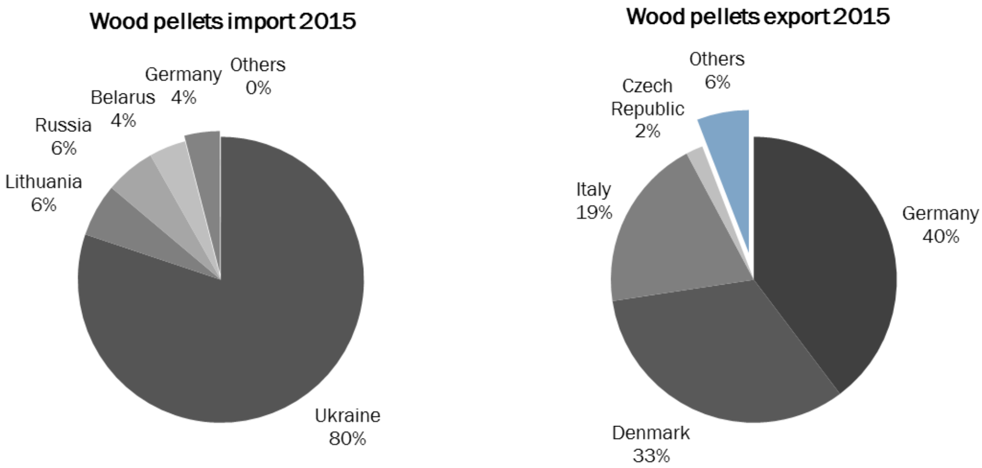

Figure 3.68 - Wood pellets import and export in Poland (2015) (ITC, 2016).

3.14.6 Pellet quality standard

Polish Committee for Standardization (PKN) is a national unit dedicated to the problems of standardization in Poland. The PKN has not undertaken initiative or actions related to the preparation of own national standardization solutions regarding solid biofuels. In response to the activities of the European Committee for Standardization, in particular the Technical Committee CEN/TC 335, solid biofuels topics were assigned to Technical Committee 144 on Coke and Other Solid Formed Fuels. This standard includes sold biofuels. The main objective of TC 144 is the development, evaluation and voting on standardization documents as well as applying to assign a status of Polish Standards (PN) to international standards after their publication. Standards of particular importance for the coke, heat and electricity industry should be prepared in Polish language versions. In particular, one of the most common standards was DIN 51731 characterizing properties of wood briquettes and pellets in Poland (SolidStandards, 2013).

Currently laboratories are in transition process between old methods and the ones set in the European standards in Poland. One of the leading institutions in this field is the Solid Biofuels Research Laboratory of the Institute of Wood Technology, where 24 European standards are used to assess the properties of solid biofuels. There is also a slow but growing interest in these standards expressed by solid biofuels producers. Currently, 35 European Standards related to solid biofuels have the status of Polish Standards (PN-EN) (SolidStandards, 2013).

In view of, sometimes, imprecise provisions set in Polish law regarding the use of biomass fuels for energy production in combustion processes, legible and clear records of EN 149611 specifying sources of biomass (wood biomass in particular) are a very useful tool for the proper classification of waste biomass intended for combustion. This situation is of particular importance in relation to the waste from chemically processed wood materials. The provisions of EN 14961-1 allowed classifying a significant group of residues (mainly residues from wood materials) as biomass accordingly defined by the Polish law. With expertise carried out based on the requirements of EN 14961-1, entrepreneurs gained satisfying solutions accepted by the governmental and self-governmental institutions (SolidStandards, 2013).

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3.15 Portugal

David Peetz

3.15.1 Regulatory framework, market drivers and barriers

In 2013 the Portuguese government published the Plano Nacional de Ação para as Energias Renováveis (PNAER 2020) and the Plano Nacional de Ação para a Eficiência Energética (PNAEE 2016). These action plans for renewable energy and energy efficiency have several aims for 2016 and 2020. On the one hand the primary energy consumption shall be reduced by 25 % and especially in public administration 30 % of energy shall be saved by 2020. On the other hand there are three sectors for PNAER 2020: Electricity, heating & cooling as well as traffic and transport. For the use of pellets the heating and cooling sector is quiet important. In 2013 the share of renewable energies in this sector was 34.5 % and the target for 2020 is 35.9 %. This difference doesn't seem to be much but most of the energy was applied for the simple and inefficient combustion of fuel wood in ovens (Radel and Nonnenmacher, 2014).

Also for 2020 the share of renewable energies regarded to primary energy consumption shall rise to 34.5 %. Compared to 2013 this is a growth of almost 8 %. The use of biomass for producing electricity nearly doubled from 2005 to 2013 with 2,516 GWh (Neubert, 2015). Moreover the electricity sector shall also raise its part of renewable energies from 41 % in 2010 to 59.6 % in 2020. On this way an increase of pellet consumption for combined heat and power plants is possible (Radel and Nonnenmacher, 2014).

In Portugal one third of the country is covered with forests which get barely cleaned out resulting into the risk of wildfires. With the aims of PNAER the use of forest shall be changed. Furthermore biomass is quiet cheap, especially locally produced pellets cost 30 % less than German pellets (Radel and Nonnenmacher, 2014).

The wood pellet market in Portugal is not well structured. Just a small amount of the produced pellets are used in the country, most of them are exported to other European countries. During winter period from October to April there are small and medium peaks in consumption. The domestic sector, public services and industries using thermal energy are the main consuming sector for pellets. Large building heating systems for bakeries or other familiar facilities, schools and sports facilities are the largest pellet consumer (Nunes et al., 2016).

3.15.2 Production capacity, production and feedstock

The pellet production, consumption and production capacity increased significantly in the last 9 years. Production capacity from 2009 to 2011 was one exception, when the amount decreased from 875,000 t/a to 853,000 t/a (AEBIOM, 2013a). Apart from that, the total production capacity of wood pellets rose to 1 Mt in 2014 from 171,000 t in 2007 (Euwid Holz und Holzwerkstoffe, 2015; Gauthier, 2015a). In contrast to that, the pellet consumption got a value in 2014 of only 250,000 t (Gauthier, 2015b).

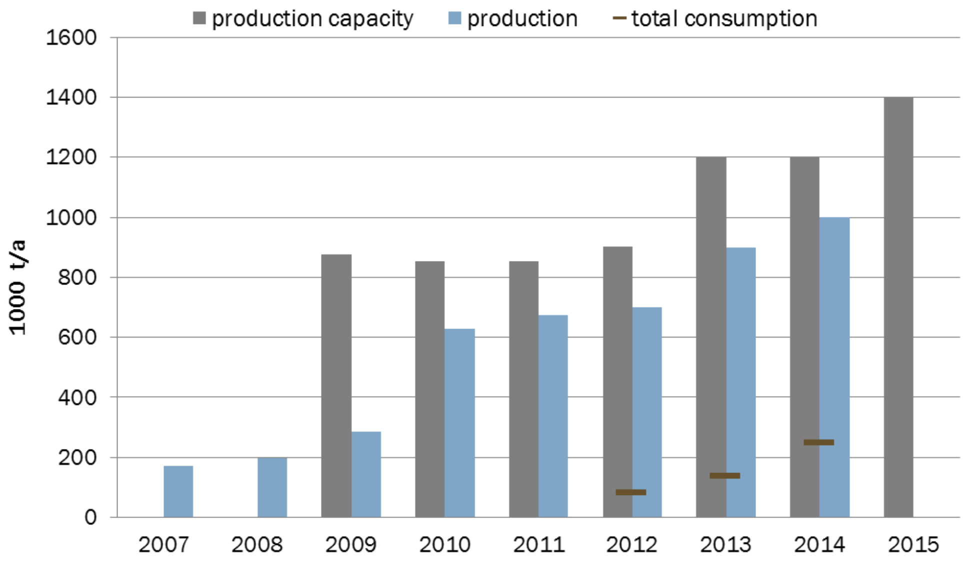

Figure 3.69 - Wood pellet market development in Portugal from 2007 to 2015 (AEBIOM, 2013a, 2013b; Euwid Holz und Holzwerkstoffe, 2015; Gauthier, 2015b; Nunes et al., 2016).

There is one central aspect for the relation of the large amount in production and the small amount in consumption. There are large factories of over 100,000 t/a capacity, which export industrial pellets to European consumers. The factory owners are large energy investors and do not have any or just little connection to the wood industry.

Most of the pellets consumed in Portugal are produced in small or medium sized wood pellet plants of 4,000 to 50,000 t/a. Those factories are for example sawmills, the furniture industry or pallet production plants, which use their biomass waste from production process for pellet production. (Nunes et al., 2016)

3.15.3 Consumption

Pellet combustion equipment has been and continues to grow and become fully automated. The advantage of this technological developed equipment is less maintenance. As a consequence of this, it is getting more attractive for the end user.

3.15.4 Price trends

Currently it is not attractive to produce electric energy from biomass and especially from pellets. The indicative average rate is 119 €/ MWh. In comparison to that, England has a financially attractive feed-in-tariff with approximately 148 €/ MWh. The selling price for the residential pellet type ranges between 3.5 € to 5 € including VAT for 15 kg bags in supermarkets. Pellets sold in bulk for residential sector varies between 155 € and 185 €.

In 2015 the average price for wood pellets was 0.035 €/kWh regarded to the domestic market. Apart from that the price for natural gas is more than twice as much as that of wood pellets with 0.079 €/kWh. Heating diesel average cost 0.141 €/kWh and propane gas 0.349 €/kWh. (Nunes et al., 2016)

3.15.5 Trade and logistic aspects

As mentioned in 4.12.1 most of the produced wood pellets in Portugal are exported to northern European countries. Almost 90 % is exported to Belgium, England, Sweden or Denmark. Only a small amount of 10 % is used for pellet stoves in private households or industrial boilers. The major national companies export their pellets because the domestic market cannot absorb the entire production. Also industrial type pellets are solely exported. (Nunes et al., 2016)

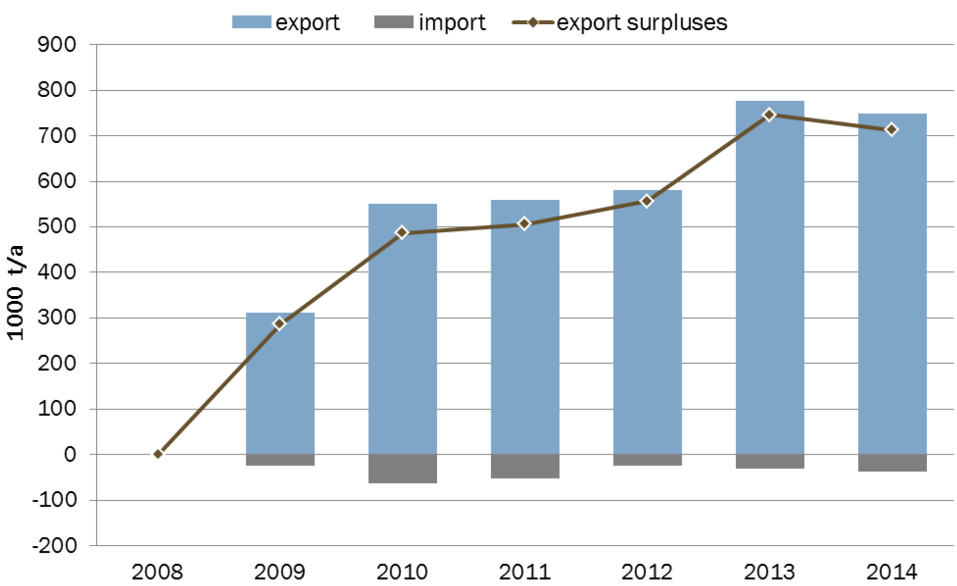

Figure 3.70 - Evolution of export and import in Portugal from 2008 to 2014 (eurostat, 2016)

As the Figure above shows export is dominating with 20 times more than the import in 2014. The trend is going to reduce the export because of the mentioned use of pellets in Portugal in the following years. (eurostat, 2016)

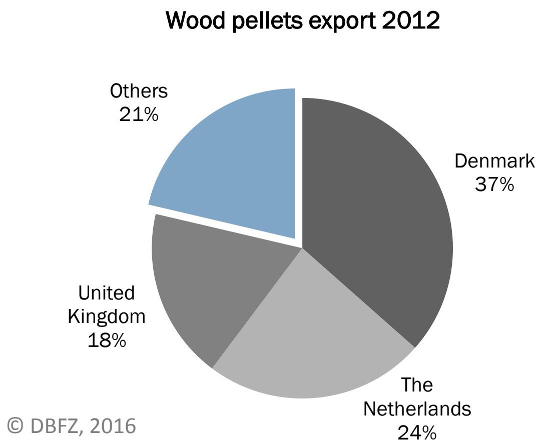

Figure 3.71 - Pellet exports from Portugal in 2012 (AEBIOM, 2013b)

In 2012 the wood pellet export is mainly distributed to the countries shown in Figure 3.71

3.15.6 Pellet Quality Standard

There are 11 pellet plants which are certified by Enplus ("ANPEB – Associação Nacional de Pellets Energéticos de Biomassa," n.d.) (ANPEB, 2016)

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3.16 Romania

Michael Wild

3.16.1 Production capacity, production and feedstock

Production capacity for wood pellets has been growing and will continue to do so as the availability of raw material in form of wood from industrial by-products will increase (ARBIO, 2014). Although some of the early movers in the sector had to go out of business, the new capacity taken in operation is outnumbering the losses. This situation is likely to continue.

Statistics report a capacity of 750,000 t/a of which just one producer´s capacity in 3 locations is holding half. This producer´s dominance is extended by the opening of another plant with capacity of 186,000 Mt/a in the end of 2015. Of the remaining 19 production sites only one comes up to 100,000 t capacity, some are around 50,000 t, however most are smaller.

Table 3-9 - Romania production in 2015 (AEBIOM, 2016).

Number of operating production plants	Production capacity (tonnes)	Actual production (tonnes) ARP
22	750,000	420,000

Discrepancy between real production and name plate capacity does exist but with only 20 % in the past seems to be lower than in other Balkan Countries (Glavonjić et al., 2015) This may have been due to the fact that bigger capacity plants are connected to saw mills and hence volatile raw material costs have less influence, but might also be understood as proof that the design, operation and maintenance of many mills in Romania is of high level. However, several facts have led to a widening of the gap in 2015 of which reduced saw mill utilisation, weaker demand and low prices in consuming countries are the most important.

Romania has a 6,399 million ha forest of which 1,931 million ha are coniferous wood and 4,468 million ha of hardwood. In 2015: 18.13 million m^3 of wood has been harvested. Volumes harvested in spruce and softwood equalled those of beech/oak harvest, both at approx. 7.5-8 million m^3 each. According to (AEBIOM, 2016) 5.06 million m^3 were used as firewood, the authors assume to be mostly hardwoods.

Major part of Romanian pellets is produced from by-products of spruce saw mills. The smaller part is produced from mixtures of spruce and beech.

3.16.2 Consumption

The lowest ratio of national consumption to national production of all Balkan countries is to be found in Romania. Only 6.2 % of production is consumed in the country, the rest is produced to be exported (Glavonjić et al., 2015).

Table 3-10 - Romania consumption (estimations only) (AEBIOM, 2016).

Residential heating < 50 kW (tonnes)	Commercial heating > 50 kW (tonnes)	CHP (any output)	Power Plant (any output) (tonnes)	Total wood pellet consumption
33,000	17,000		n.a.	

Domestic consumption is mainly for heating purposes in small to medium applications. Fastest growing in commercial applications and district heating is where the biggest potential is seen (ARBIO, 2014). It is rather the lower end of the produced quality that remains in domestic applications, while export qualities did improve over the next years.

3.16.3 Price trends

Almost 90 % of pellet production is exported. Therefore the price trends in Romanian pellets sector are not resulting from any local market developments but only from the price developments on the export markets which are basically Italy, Austria and Greece, minor percentages have UK, Ireland, France and Germany. To remain competitive with producers in other countries the Romanian FCA prices need to be set at destination market price minus transportation costs. This does result in a situation in which Romanian FCA prices are lower than those in countries of former Yugoslavia reflecting transport costs differential of 10-20 €/t.

This differential is almost independent from absolute prices and can be seen in 2016, at very low absolute prices as it could be seen in 2013 when pellets prices in consuming countries were peaking (Prislan et al., 2014).

This pricing situation can be managed by pellet producers from by-products of timber industry but does easily bring pellet producers who are depending on forestry biomass under heavy economic pressure when round wood prices are climbing.

3.16.4 Trade and logistic aspects

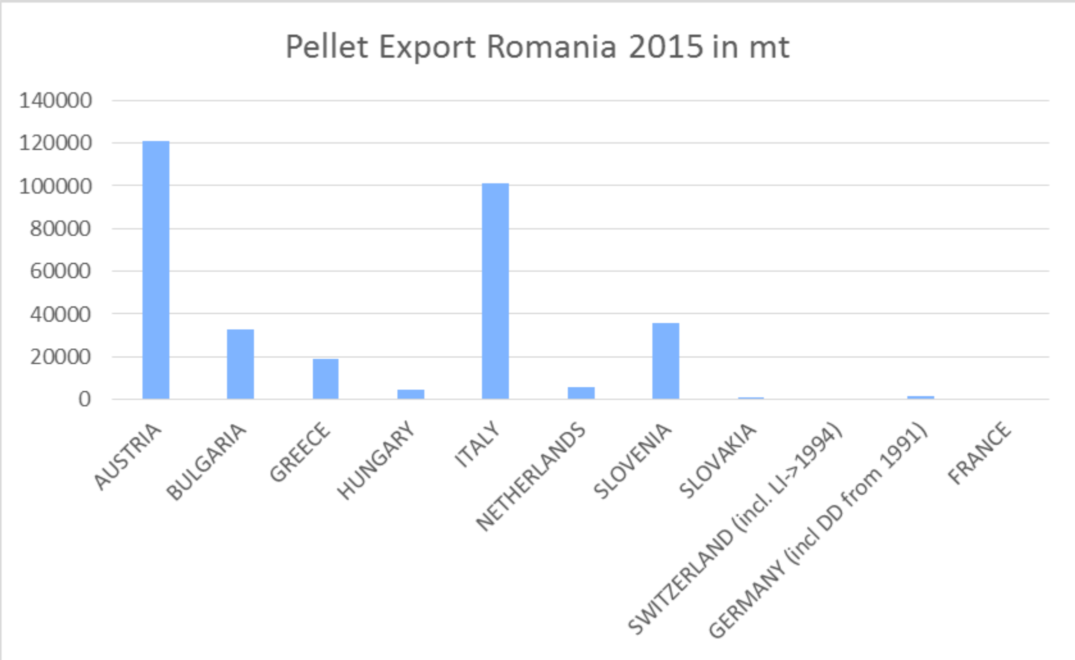

Figure 3.72 - Export of Pellets from Romania 2015

Source: http://epp.eurostat.ec.europa.eu/newxtweb/getquery.do?queryID=100763674&queryName=/AnonymQuery_1476270122715&datasetID=DS-045409&keepsessionkey=true

Romania is a pellet export country, no imports are reported. Romania is taking the prices developing on the EU markets supplied as well as the quality and the packing requirements. At the same time Romanian producers are price takers at the transport markets as well.

Most of pellets traded abroad are trucked to destination, only a handful of producers is railing the products to Austria or Slovenia. Slovenia as such is mostly only the hub for pellets supply to Italy as Italian customers would pick up the pellets at boarder railroad warehouse and could by this take advantage of the higher payload allowance in Italy in respect to trucks that would go all the way from Romania to Italy.

Generally there would be the option of shipping in break bulk on the Danube River or out of the port of Konstanta. Konstanta offers also the option of container shipping to ports in Italy but also further.

Today's pellet market does prevent any broken transport because of the extra costs in handling. Therefore the shipping options are hardly ever utilized currently but will surely come into play once the overall situation on the pellets market will have changed.

Trade as of today does mostly happen in 15 kg bags or big bags. Bulk supplies going abroad are currently a quantitative minority. Producer's brands as well as customer branded bags are traded.

The number of boarders a shipment from Romania to the markets need to pass has proven in 2015/16 when inner EU (and also inner Schengen) boarders were closed or heavily controlled to be the opportunity for unwelcome cost increased and delivery delays. A continuation of this tendency of EU governments could cause a shift from truck to train/ship as preferred transportation means.

3.16.5 Pellet quality standard

Since Romania is oriented towards export, but has a slight transport cost disadvantage against other producers in the Balkans area, has understood that the quality of their product is one of the keys for success. This is why today 7 Producers in Romania are ENplus certified. Although this is not the majority of producers in numbers it represents more than 80 % of the total pellets production.

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ID-Nr. RO 007

435200 Borsa

tecno.pellet@yahoo.com

AGI Capital Investment srl

ID-Nr. RO 008

125100 Buzau

www.agi-capital.com

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3.17 Russian Federation

Svetlana Proskurina, Jussi Heinimö

3.17.1 Regulatory framework, market drivers and barriers

The Russian government has official targets for stimulating renewable energy. For instance, in 2012 the Russian government adopted "The Comprehensive Program for Development of Bio technology in the Russian Federation through 2020" which partly covers bioenergy without mention of the wood pellet industry. In 2007 Russian government adopted a program titled "Energy saving and energy efficiency for the period till 2020", with no regards to renewable energy. There are no specific targets for wood pellets, and little interest from the Russian federal government in the development of wood pellets industry, only local programs are working towards the incentives of wood pellet production in several regions (Proskurina et al., 2016).

Main drivers for pellet production and trade in Russian Federation:

- Availability of raw material.
- Municipality support in several regions such as Arkhangelsk Oblast and Komi Republic.
- The new ruble to euro exchange rates promotes wood pellet exports.

Main barriers:

- Weak promotion of renewable energy in the country.
- Lack of large ports and weak logistic infrastructure.
- Lack of big domestic consumers.

3.17.2 Production capacity, production and feedstock

In Russia pellet production started at the beginning of 2001, with the first plants being built in the Leningrad area. The production facilities used in these early production plants had poor efficiency and operated with second-hand machinery producing low quality pellets. Later, owners of the pellet plants closed many of these early facilities and opened new plants, in which new modern machinery was installed and used. The number of pellet plants increased significantly from 2001 to 2009 reaching 180 production plants (Proskurina et al., 2015). However, the wood pellet production capacities are higher than actual production (Figure 3.73).

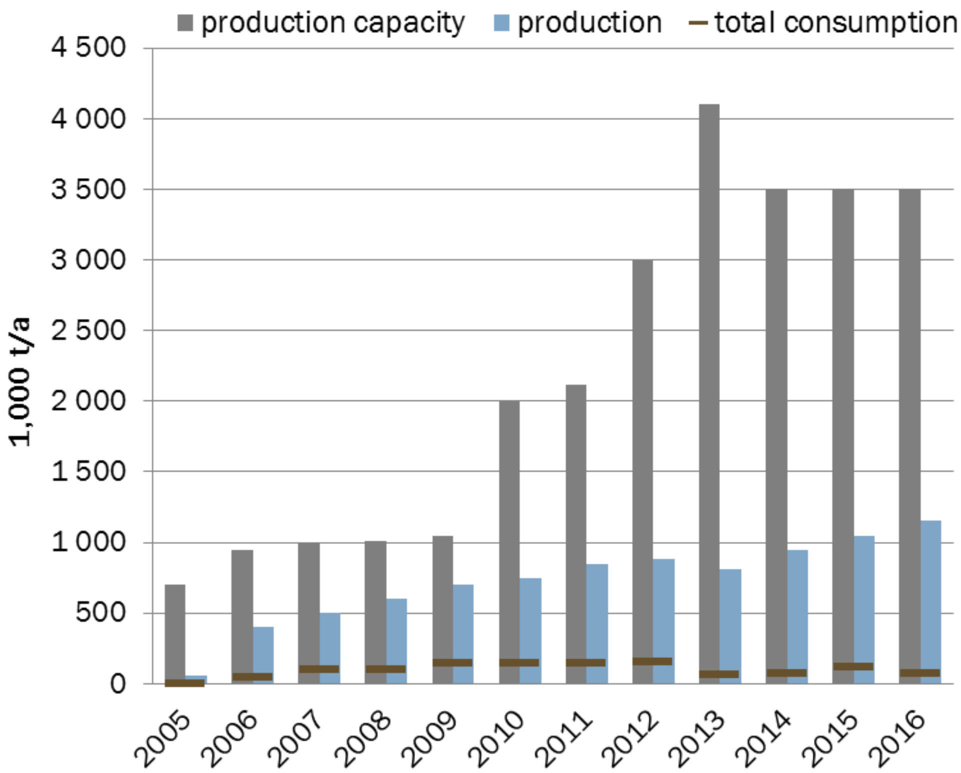

Figure 3.73 - Wood pellet market development in Russia from 2005 to 2016.

Pellet production distribution by region is uneven. Currently, the majority of wood pellet production plants (approximately 60 %) are concentrated in the North-West regions of Russia. About 30 % of Russian pellet production is located in the Central regions and about 10 % of pellets are produced in other Russian regions.

At the beginning of 2014, there were 12 large wood pellet plants that exported between 20,000 to 300,000 t/a (Figure 3.73). In 2014, new wood pellet production plants were put into operation such as OAO "Arkhangelsk LDK-3" (Arkhangelsk region), LLC "Doc" (Bryansk) LLC "Lesresurs" (Irkutsk region) with 100,000, 80,000 and 30,000 t/a respectively. By 2016, Irkutsk region plans to build new additional wood pellet plants in the region and reach production of 0.5 Mt/a. The production focuses on the export to the EU and South Korea (АЕСПРОМ, 2015).

Table 3-11 - Main plants/exporters of Russian wood pellets in 2014 (АЕСПРОМ, 2015).

Company	Region	Export (tonnes/year)
JSC Vyborgskaya Cellulose	Leningrad Oblast	300,000
"Arkaim"	Krasnoyarsk Krai	70,000
JSC "Novoyeniseiskiy Wood-Chemical Complex"	Krasnoyarsk Krai	50,000
"Mir of granules"	Leningrad Oblast	45,000

Company	Region	Export (tonnes/year)
"Lesozavod 25"	Arkhangelsk Oblast	45,000
DOK "Yenisei"	Krasnoyarsk Krai	45,000
North West Holding	Leningrad Oblast	40,000
Swedwood Tikhvin LLC	Leningrad Oblast	35,000
Russian Wood Alliance Ltd	Republic of Karelia	30,000
OOO Setnovo	Novgorod Oblast	20,000
OOO STOD	Tver Oblast	20,000
"Russian pellets"	Mari El Republic	20,000

One torrefied pellets production plant, owned by OAO Bionet, was built in Onega, Arkhangelsk Oblast (the north of European Russia) in 2015. It is expected that the plant will produce 150,000 t of torrefied pellets per year. The torrefied pellets production was built at the site of the former Onega Hydrolysis Plant. Lignin, which was dumped as waste from hydrolysis production, is used as a by-product. It is estimated that lignin stocks in dumps and landfills can satisfy demand from the plant for the next 15 years. The Onega plant has the potential to be one of the biggest manufacturers processing timber waste not only in Russia but also in Europe (Bionet, 2015). Investments into the torrefied plant were about 2 billion roubles (~2.7 million euros). The company plans to build additional two torrefaction plants in Arkhangelsk Oblast and Eastern Siberia (Infobio, 2015). Torrefied pellet production is mainly oriented to the export market.

3.17.3 Consumption

The domestic market started to develop only several years after the commissioning of the first plants. Domestic consumption data given in different Russian documents varies considerably and is often contradictory, varying from 20 % to 10 % or even less. Lower-grade pellets are mainly used in domestic markets. Wood pellets that satisfy quality standards are mostly exported. Expectations for an increase in domestic wood pellet consumption are low in the short- and long-term perspective (Proskurina et al., 2016). The high exchange rates of euro to Russian rouble make wood pellets very profitable for exportation purposes, and not for local use. Most of the small producers are interested in cooperating with others for export purposes.

3.17.4 Price trends

In 2014, Russian pellets sales in the world markets fell on average by 14 % reaching about 129 €/t. In 2013, the price was about 140 €/t (LesOnline, 2015). 72 % of the total wood pellet export through the port of Sankt-Petersburg is based on FCA. The average price of which is 96,40 €/t in 2015 (Rakitova, 2016).

3.17.5 Trade and logistic aspects

The Russian pellet industry is heavily reliant on exports (Figure 3.74), mainly to the EU and South Korea. The main consumers of Russian wood pellets are presented in Figure 3.75

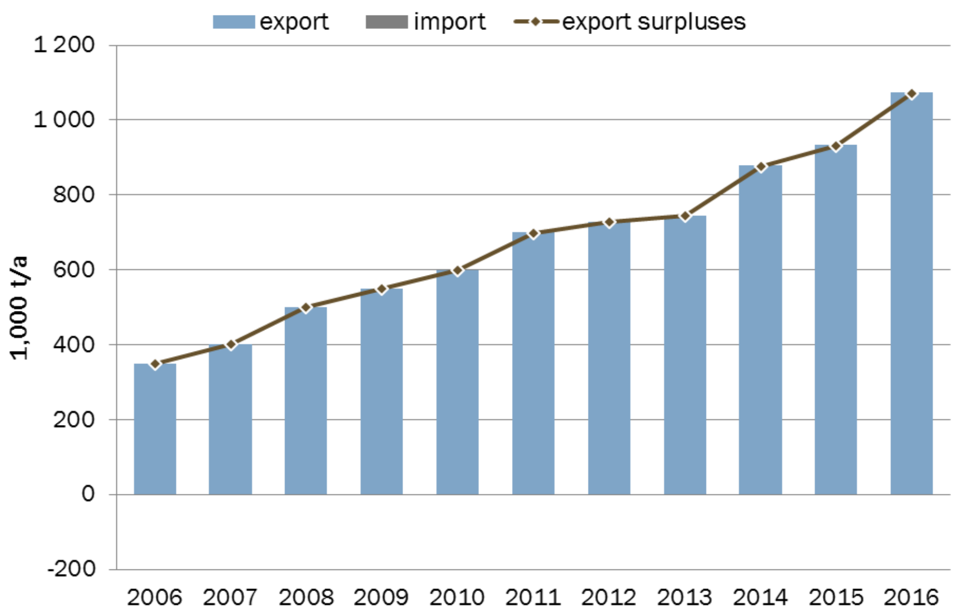

Figure 3.74 - Evolution of export and import in Russia from 2006 to 2016.

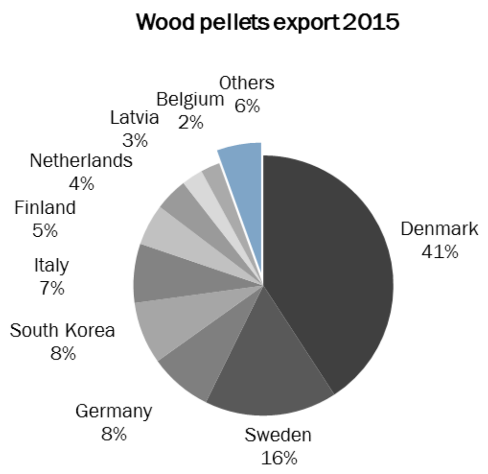

Figure 3.75 - Wood pellets export in Russia (2015), (TradeMap, 2016).

Russian wood pellets are transported mainly by sea (about 80 %), truck and railway make up for 15 % and less than 5 % respectively (Rakitova, 2016). The biggest volumes of wood pellets pass through the St. Petersburg port. Companies follow DAP (11 %) and FCA (80 %). Following are: the port of Vyborg, which is used mainly by the large company "JSC Vyborgskaya Cellulose", and the port of Vanino, through which also, distributes the only joint venture: "Arkaim". The port of Arkhangelsk and the Ust-Luga port are used mainly by "Lesozavod 25" and JSC "Novoyeniseiskiy Wood-Chemical Complex" respectively. Swedwood Tikhvin LLC and "Engineering Center" from

Tikhvin focus on the port of St. Petersburg. Petrozavodsk port is used by "Russian Wood Alliance Ltd". Ports in Lodeynoye Pole, Podporozhye and Sovetskaya Gavan are also pointed at one company. Thus, a universal port and the most common among wood pellets exporters is the port of St. Petersburg. This port works with the largest number of wood pellet suppliers. Others ports, even the port of Ust-Luga focus on one or two wood pellet suppliers (Infobio, 2015). Table 3-12 shows the main ports of wood pellets export in Russia in 2014.

Table 3-12 - The main ports of wood pellets export in Russia in 2014 (АЕСПРОМ, 2015).

	Export (tonnes/year)
St. Petersburg	110,615
Vyborg	102,430
Ust-Luga	18,830
Arkhangelsk	15,275
Bryansk	14,385
Nebolchi	10,620
Petrozavodsk	6,855
Vanino	5,200

Generally, the future of the Russian pellet industry is unclear. Increase in local wood pellet demand is uncertain and the wood pellet industry will continue to be export-oriented. Growing interest in the European Union for wood pellets will continue to be a major incentive for Russia to increase the production of wood pellets, and wood pellet demand from Scandinavia will continue to be attractive to the Russian wood pellet industry. However, in order to make full use of these opportunities, Russia will need to make large investments to upgrade facilities and expand its production. Additionally, political and economic aspects exist. The political situation in Russia, including the conflict in Ukraine, and the impact of sanctions on the EU–Russia relationship are likely to affect the solid biofuel trade. Most industrial European consumers are seeking new players/countries for wood pellets import. Existing partners from the EU are wary of long-term contracts with Russian suppliers. Russian wood pellets cannot compete with export from USA and Canada, which have a leading position with regards to wood pellet exports to Europe. It is unlikely that Russian trade volumes will be close to these two leading exporters of pellets in the near future (Proskurina. et al., 2015).

Russian wood pellets could make their own niche in the Asian market. Exports of Russian pellets have increased to South Korea. Despite the long distance, even a few Russian producers from North West of Russia export wood pellets to South Korea. This indicates that it is possible that Russian pellet exports as a whole may become more oriented to the Asian market and the supply of Russian pellets to Asia, mainly to South Korea, could be an important factor in global wood pellet trade (Proskurina. et al., 2015). China is interested in Russian wood pellet export. For example, "Arkaim", which is the major producer of wood pellets in the Khabarovsk Krai (the

Russian Far East), agreed with Chinese's investors on modernization of the wood pellet production plant. Currently plants have a capacity of 0.2 Mt but do not operate on a full capacity due to financial challenges. Investments from China can improve the situation (Rakitova, 2016).

3.17.6 Pellet quality standard

Currently, there is no national standard for wood pellets in Russia. Russian producers are mainly oriented to the international standards (Proskurina et al., 2015). Annually, the number of Russian wood pellets producers, which have standardization, has increased. Sixteen Russian companies had ENplus certification by May 2016. Since 2015, eight Russian companies accepted SBP (Sustainable Biomass Partnership) and a few others are in the process (Rakitova, 2016). Standards provide Russian companies benefits for export. It avoids any uncertainties with wood pellets quality and the sustainability of the supply chain.

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3.18 Slovakia

David Peetz

3.18.1 Regulatory framework, market drivers and barriers

Slovak pellets market is relatively new (end of the 90s) and small -in 2012, annual domestic consumption was approximately 50,000 t. Therefore, its development has impacted relatively high prices of heating devices (boilers) and -owing to its low competitiveness compared to natural gas and firewood- pellets supply chain is still in a very low development state (Oravec and Slamka, 2013). Consumption of wood pellets is limited to the residential sector and small or mid communal houses (i.e. schools). The devices used for pellets are boilers automatically stocked with a heat input of up to 100 kW (Oravec and Slamka, 2013).

Pellet production is fixed on dry sawdust from wood processing industry and on import of technologies for production and combustion. Its production depends on the international market (demand and prices) thus it is unstable. Production of Slovak pellets in 2012 was of 80,000 t, and exports amounted for 30,000 t. For energy supply Slovakia uses black liquor from the pulp paper industry (450,000 t/a) and wood waste from wood processing (i.e. sawdust 470,000 t/a) (Oravec and Slamka, 2013).

An NGO called WOLF (campaigning to protect Slovakia's forests and fauna since 1993) calculated using government statistics that 8 Mt of wood (beech density) are logged each year from the country's forests. Yet it estimates the sustainable yield at only around 4,2 Mt. The amount of wood burned for energy and heating is around 2,5 Mt, this sector represents almost the entire overharvest. Indeed, the government aims to meet 14 % of its electricity demand from biomass by 2020, which would mean using an increase of 3,3 Mt of wood annually (Pearce, 2015). For example in eastern Slovakia the consumption of timber for biomass burning is now over 700,000 t, twice the available supply of low-grade timber (Pearce, 2015).

3.18.2 Production capacity, production and feedstock

Pellets are standardized products which consist solely of sawmill dry residues from coniferous (mainly spruce) and broadleaves (mainly oak and beech) and is traded in tonnes only. Wood pellet production in Slovakia is over 70 % of the installed capacity. From 2008 wood pellet production has been increasing starting from 60,000 t to 100,000 t in 2013. However the consumption of wood pellets is around 20,000 t, and there is not much information available regarding pellet consumption (Oravec and Slamka, 2013).

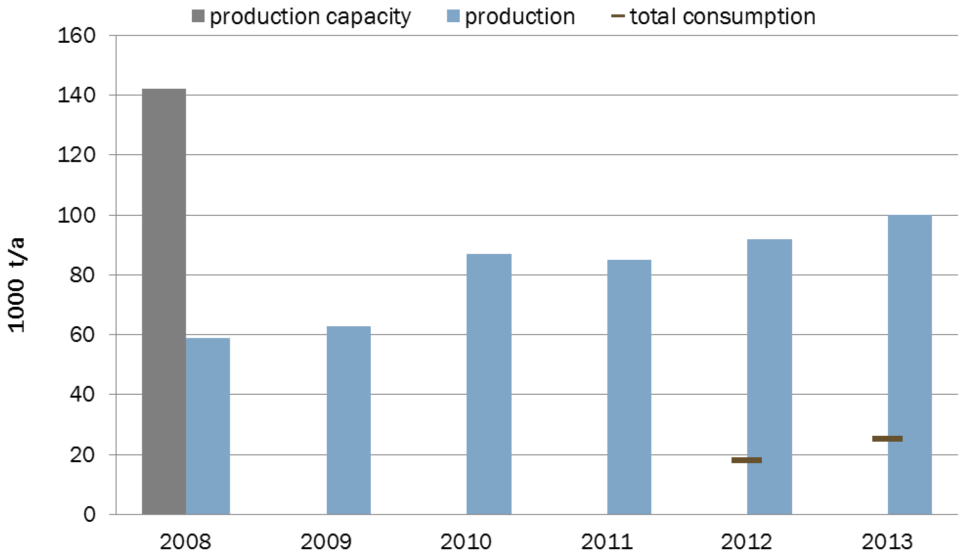

Figure 3.76 - Wood pellet market development in Slovakia from 2008 to 2013 (AEBIOM, 2013; Bastian and Wach, 2009; eurostat, 2016).

3.18.3 Consumption

Most of the producers depend on the international market (exports), since the consumption of wood pellets in Slovakia is very low (Figure 3.76).The government aims to meet 14 % of its electricity demand needs from biomass by 2020, which would mean using an increase of 3,3 Mt of wood annually (Pearce, 2015). Heating systems in Slovakia have had an increase mainly due to stoves and boilers under 50 kW as it is depicted in the following image.

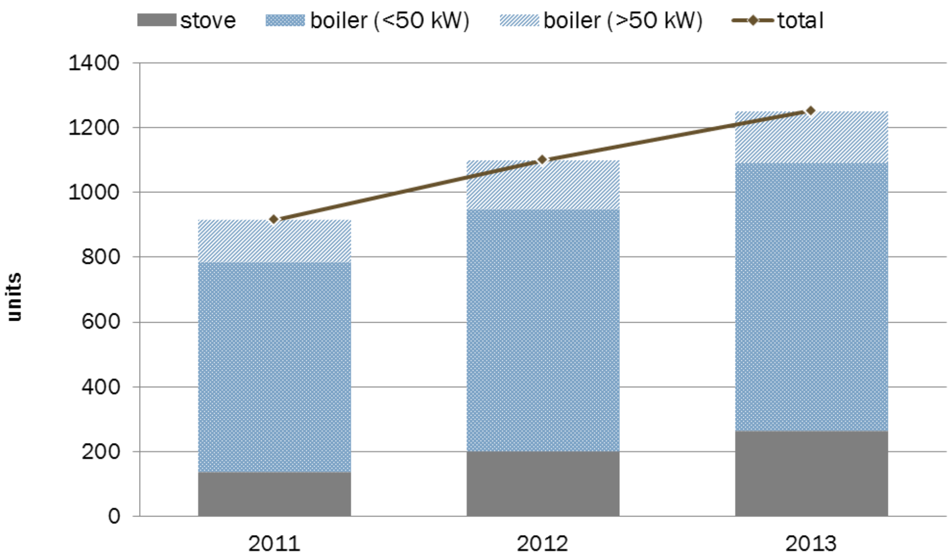

Figure 3.77 - Development of installed pellet heating systems in Slovakia from 2011 to 2013 (AEBIOM, 2013)

3.18.4 Price trends

The low demand –of about 1,000 households and 100 small or medium sized end users –with a consumption of 3,000 t/a - of pellets in Slovakia has hindered its market development (Milan Oravec, 2013). Domestic prices of pellets depend on export possibilities and seasonality and regional conditions. The price level in spring 2013, of pellets in Slovakia is 170 –210 €/t (Oravec and Slamka, 2013).

3.18.5 Trade and logistic aspects

Pellets export and imports in Slovakia are shown in the Figure 3.78. Exports have dominated imports over time. In 2012 there was a plunge in exports that quickly recovered. In 2014 approximately 100,000 t of pellets were exported.

Figure 3.78 - Evolution of export and import in Slovakia from 2008 to 2014 (eurostat, 2016)

3.18.6 Pellet quality standard

Foreign standards are accepted in Slovakia, especially from countries that receive Slovakia's wood chips exports, such as Italy, Austria, Germany, Netherlands, etc. There are no internal specific standard for wood pellets in Slovakia (Oravec and Slamka, 2013).

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3.19 Spain

David Peetz

3.19.1 Regulatory framework, market drivers and barriers

Special structural problems are responsible for wood pellets being not in mind of many Spanish inhabitants. The majority of people are living in cities with narrow roads and less space for fuel storage. Moreover people live in apartment blocks with more than 100 flats unlike the usual single-family houses in Germany. Furthermore the heating period is comparatively short.

Besides these problems, the possibilities to replace existing oil boilers with pellet systems are limited, because floor heating is common. Additional oil boilers are rare. In this way there are more room stoves than boilers. Many Spaniards are using natural gas for cooking and for heating. Therefore gas is a strong competitor to wood pellets, but the price for pellets in 2014 was 10 % lower than natural gas and 60 % cheaper than oil. (Pellets- Markt und Trends, 2015)

There is no financial support for the use of wood pellets, except for one region where heating systems based on pellets are promoted with about 50 - 100 €/kW (Pellets- Markt und Trends, 2015).

The amount of newly installed pellet systems increased to 500 MW in 2014. This leads to 6,000 MW installed power in 2014. (Niederhäusern, 2014) If the pellet market carries on growing like it did in the previous years, the supply of raw material wood is not ensured. Only 29 % of the available wood can be used because Spain does not have that regulated forestry as Germany. (Pellets- Markt und Trends, 2015)

3.19.2 Production capacity, production and feedstock

Until 2005 the first pellet production plants were built up. Two years later first national wood pellets were produced. Since then the production was greatly boosted (Pellets- Markt und Trends, 2015b). In 2011 140,000 t of pellets were produced (Larrañaga, 2014). But the amount almost has tripled to 410,000 t by 2014.

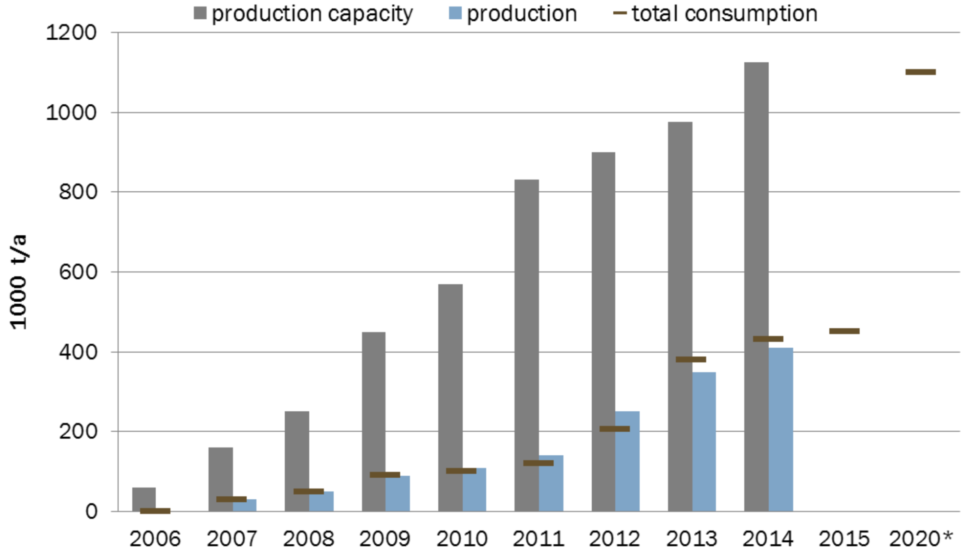

Figure 3.79 - Wood pellet market development in Spain from 2006 to 2020 (Euwid, 2015; Larrañaga, 2014)

Even the pellet consumption in 2015 with 450,000 t is more than 14 times higher compared to 30,000 t in 2007. For 2020 a production of 1.15 Mt in Spain is expected. (Pellets- Markt und Trends, 2015)

3.19.3 Consumption

The main customer is the industry, especially the food industry as well as the wood and furniture industry related to the pellet consumption in Spain (Pellets- Markt und Trends, 2015).

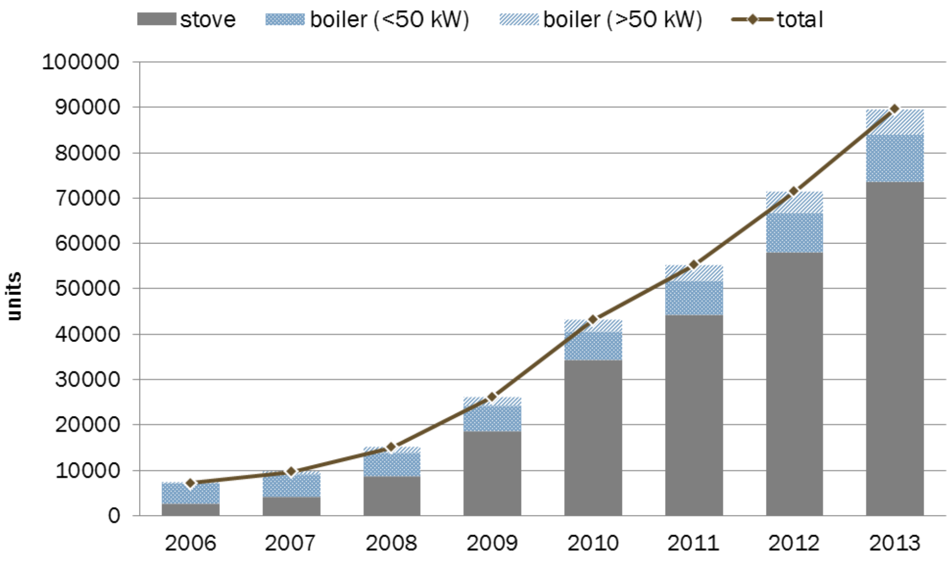

Figure 3.80 - Development of installed pellet heating systems in Spain from 2006 to 2013 (AEBIOM, 2013, 2012; AEBIOM´s National Biomass Boiler Observatory, 2011)

There is a huge difference between the amounts of installed stoves to installed boilers in Spain. In 2013 73,591 stoves and nearly 16,000 boilers were integrated in buildings. In 2010 the development of installed pellet heating systems had achieved a further leap forward. So installed stoves increased by nearly 46 % from 2009 to 2010 (cf. Figure 3.80)

3.19.4 Price trends

The wood pellet prices achieved its highest point in 2014. Pellets delivered in dump trucks at a cost of 229 €/t and wood pellets in bags 195 €/t. This price applies for distances up to 200 km (Asociación Española de Valorización Energética de la Biomasa, 2016).

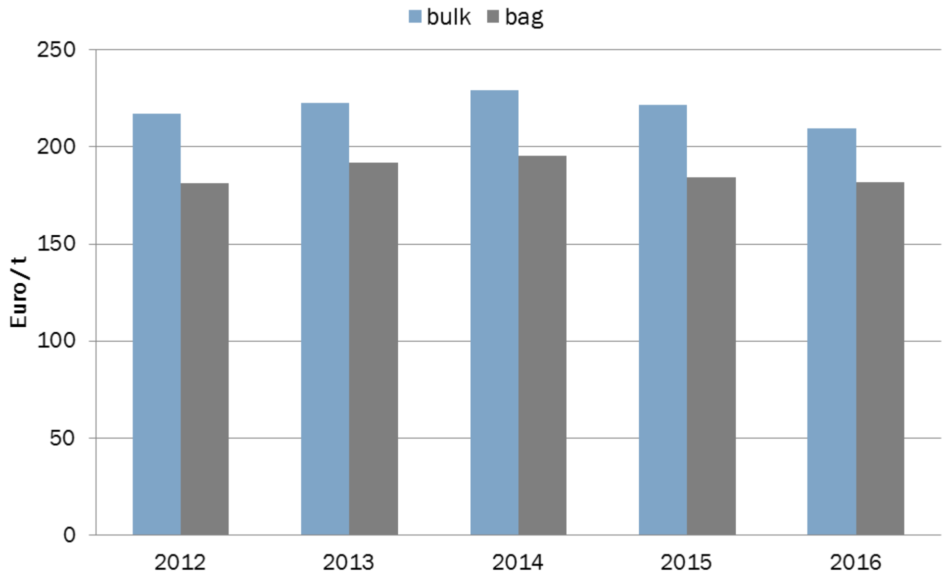

Figure 3.81 - Wood pellet prices in Spain from 2012 to 2016* (*first three months) (excluding VAT and delivery up to 200 km) (Asociación Española de Valorización Energética de la Biomasa, 2016).

After 2014 the pellet price decreased step by step. In the first three months of 2015 an average price of 210 €/t for pellets in bags and 180 €/t for pellets delivered in dump trucks could be recognized (Asociación Española de Valorización Energética de la Biomasa, 2016).

3.19.5 Trade and logistic aspects

Wood pellets are mainly imported from Portugal (Pellets- Markt und Trends, 2015). However Spanish pellets are exported particularly to Ireland, United Kingdom, Italy and France. Almost 60 % of pellets produced in 15 kg sacks are transported with trucks to Italy. The producers figured out that 50 % of income gets lost by logistics. In this way the desire for a well-developed heat market which uses biomass is very big. (Avebiom´s National Biomass Boiler Observatory, 2011)

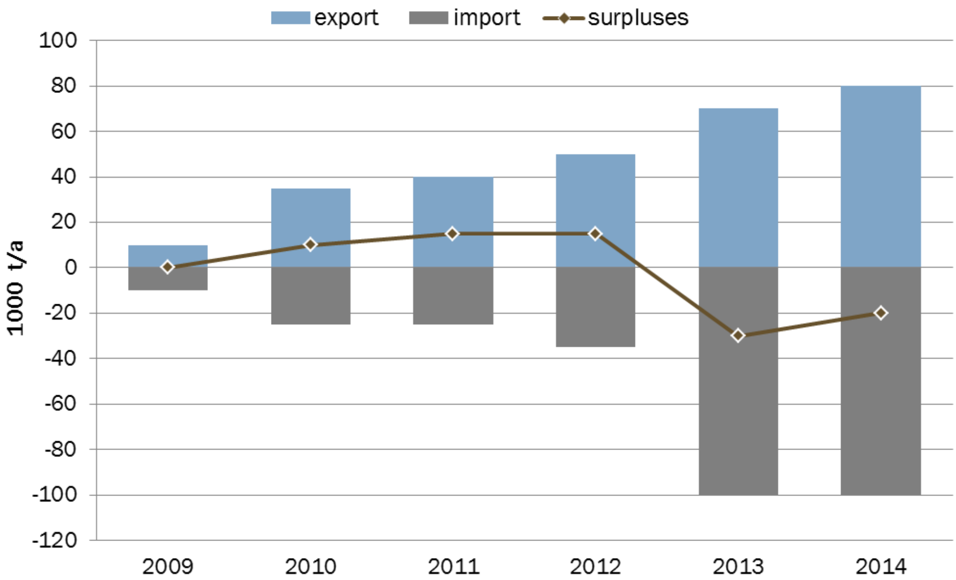

Figure 3.82 - Evolution of export and import in Spain from 2009 to 2014 (Larrañaga, 2014)

As it is shown in the figure above the import of pellets increased obviously in 2013 from 35,000 t to 100,000 t. Before 2013 the import has dominated the export and since 2013 the amount of imports is higher than exports (cf. Figure 3.82)

3.19.6 Pellet Quality Standard

Most of the pellet production sites are producing DINplus pellets. That includes 20 producers and 10 distributors. The first certified pellets were established in Spain in 2011. (Pellets Markt und Trends, 2015)

Furthermore there were 31 Enplus certified pellet producers in 2015 (Gauthier, 2015).

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3.20 Sweden

Olle Olsson, Lena Bruce, Sofia Backéus

3.20.1 Regulatory framework, market drivers and barriers

The Swedish market for wood pellets has its origins in the late 1980's as several district heating operators began to use pellets instead of heating oil and - beginning after the introduction of a CO_2 tax in the early 1990s - also coal (Vinterbäck 2000; Mahapatra et al. 2007).

Medium and large-scale consumption of wood pellets for district heating (DH) and combined heat and power (CHP) completely dominated the Swedish market up until the early 2000's, when small-scale residential consumption began to take off. The growth of the residential market was due mainly to favorable prices of wood pellets compared to heating oil and electricity but partly also due to different forms of governmental subsidies for biomass-based heating systems (Mahapatra et al. 2007).

The early 2000's also saw further growth in the large-scale market with the introduction of an electricity certificate system that promoted the production of renewable electricity and led to increased demand for wood pellets in Combined Heat and Power (CHP) plants (Selkimäki et al. 2010).

From around 2010 and up to the time of writing (September 2016), wood pellet market development in Sweden is in a phase of stagnation. The small-scale heating market is largely saturated as most of the conversion away from fossil-fuel based heating systems is already completed while at the same time; pellet-based systems are facing heavy competition from district heating and different forms of heat pumps (Hektor et al. 2014).

Simultaneously, in the large-scale market (DH & CHP), there is also somewhat of a relative move away from pellets. New investments are made primarily in boilers capable of burning lower-cost fuels such as forest residues, recovered wood and municipal solid waste.

Market expansion is currently taking place primarily among industrial users (i.e. excluding DH or CHP). Worth noting here is a recent taxation change that will increase CO_2 taxes for industry outside the EU ETS. This is expected to lead to increasing interest in industrial conversion from heating oil to pellets for production of process heat (Hektor et al. 2014).

3.20.2 Production capacity, production and feedstock

As can be seen in Figure 3.83, wood pellet production capacity and production expanded strongly during the first decade of the 2000s, after which a more stationary market situation has developed. Production capacity has in some years actually decreased as some producers have gone out of business, although recently new production facilities are also being opened up. In the time period 2014-2016 production capacity has grown by about 10 %.

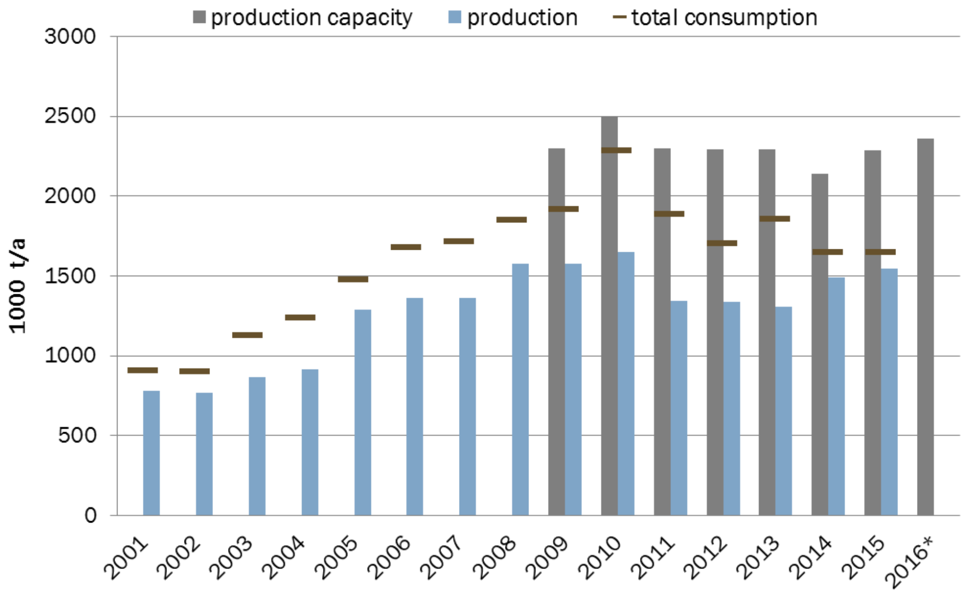

Figure 3.83 - Wood pellet production, production capacity and consumption in Sweden 2001-2016 (capacity data for 2009-2016) (AEBIOM Statistical Reports & Haaker 2016b).

Swedish pellet production facilities range from very small operations of only a couple of hundred tonnes per annum, to large-scale production plants of almost 200,000 t/a (Haaker 2016b). The three largest actors on the production side are Lantmännen Energi (an agricultural cooperative), Neova (part of the Finnish-owned Vapo group) and SCA Energy (a division within the forest industry concern SCA) (Haaker 2016a). Feedstock used in Swedish pellet production is almost exclusively different forms of sawmill by-products, especially sawdust but also cutter shavings.

3.20.3 Consumption

Swedish pellet consumption development since 1997 is visualized in Figure 3.84. Here the strong expansion up until 2010 can be clearly seen, as can the subsequent more stagnant phase of. It is important here to note that the peak in 2010 was largely a result of a very cold winter which resulted in exceptionally strong pellet demand especially in the district heating sector where pellets are used in peak load boilers.

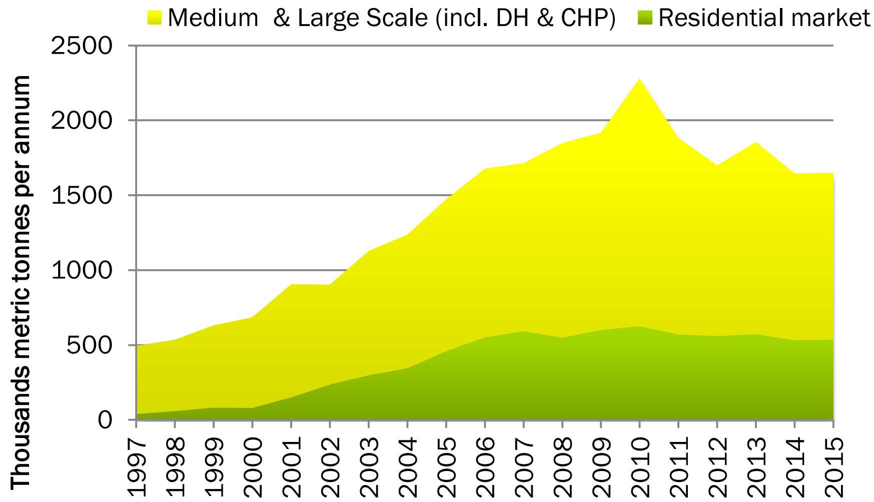

Figure 3.84 - Wood pellet consumption in Sweden 1997-2015 (Pelletsförbundet: The Swedish Pellets Association).

The number of units in operation in **the residential market** has undergone a small decline in the time period 2009-2015, as can be seen in Figure 3.84. There has been a reduction in the number of pellet boilers although at the same time also a small increase in the number of pellet stoves.

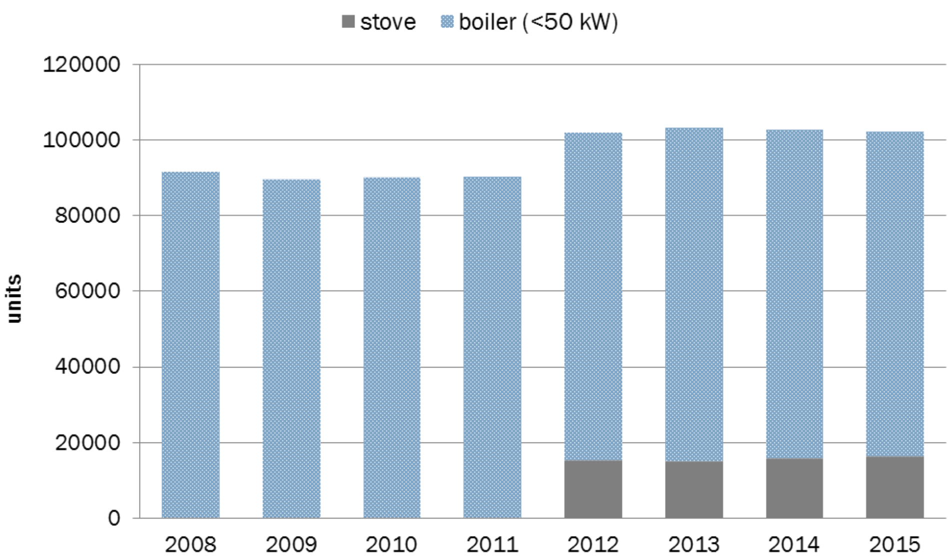

Figure 3.85 - Number of pellet boilers and stoves in operation 2008-2015. Note that data on pellet stoves is only available from 2012 (Swedish Civil Contingencies Agency MSB).

The medium- and large-scale market segment is quite diverse in Sweden. There is still substantial demand from the district heating sector although pellets-fired boilers are increasingly used as peak load rather than base load. However, use of wood pellets for process heat is becoming increasingly common. Out of the top ten largest consumers of wood pellets in Sweden, five are DH utilities and five are users in process industry (Haaker 2016b). Especially worth noting regarding the latter is that the fourth largest single consumer of pellets (at 55,000 t/a) in Sweden in 2015 was the GoBiGas plant in Gothenburg. This is a pilot facility producing biomethane from wood pellets with the objective to shift to forest residues as raw material.

3.20.4 Price trends

As can be seen in Figure 3.86, wood pellet prices in Sweden have been stable or decreasing in the recent 5-year period due to a situation of oversupply with actual production at only around 60 % of production capacity. The generally low prices of energy - including heating oil and electricity - also affect wood pellet demand. At the same time, there is ample supply of raw material in the form of sawdust from Swedish sawmills that are producing at close to record-high levels (Swedish Forest Industries Federation 2016).

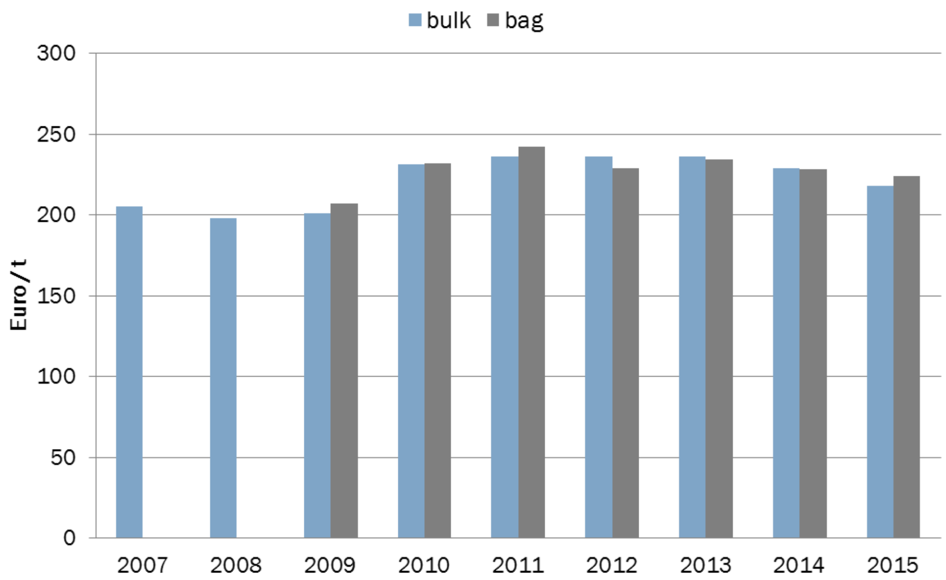

Figure 3.86 - Residential wood pellet prices in Sweden 2007-2015, excluding 25 % VAT (Pelletsförbundet: Swedish Pellets Association).

3.20.5 Trade and logistic aspects

Since the early 1990s, Sweden has overwhelmingly been a net importer of wood pellets with trade flows predominantly coming from Estonia, Latvia, UK and Russia. There have also been periods of significant imports of pellets from Canada although this is no longer the case.

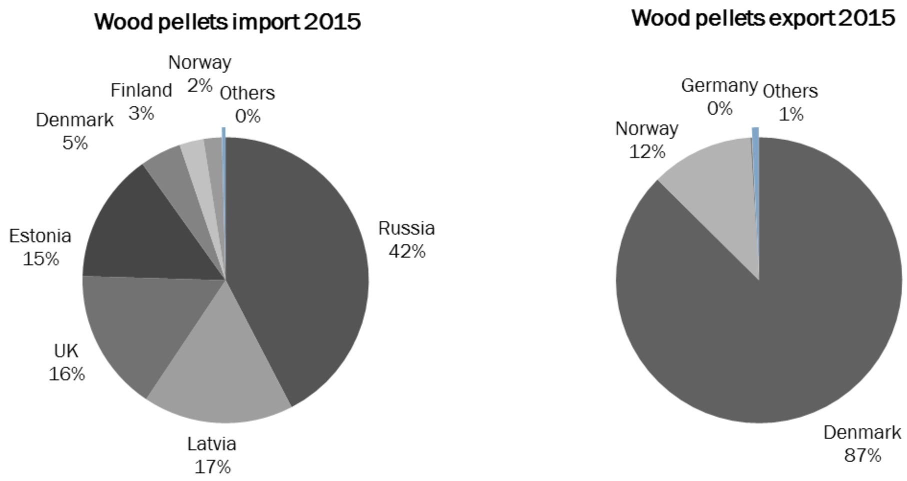

Figure 3.87 - Swedish wood pellet import origins & export destinations in 2015 (Eurostat n.d.).

Wood pellet exports from Sweden are increasing and have primarily been going to Denmark (see Figure 3.87), which for quite some time has been a large importer of wood pellets from several different countries (Olsson and Hillring 2014). With decreasing imports and growing exports, Swedish international trade in wood pellets is close to being in balance between imports and exports, as can be seen in Figure 3.88.

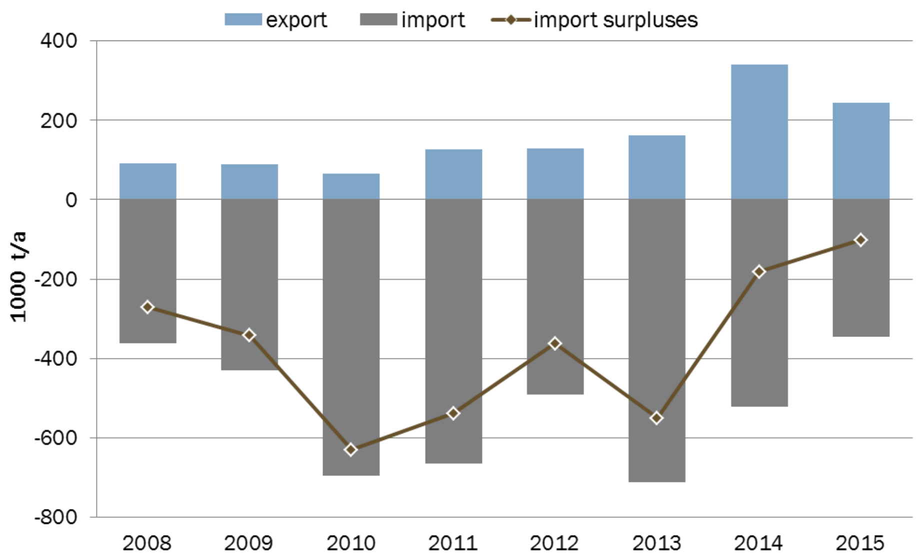

Figure 3.88 - Swedish wood pellet imports and exports 2008-2015 (Pellstförbundet: Swedish Pellet Association).

3.20.6 Pellet quality standard

Wood pellets produced in Sweden are almost exclusively of A1 quality under the EN 14961-2 standard. This is connected to the facts that clean sawmill by-products in the form of sawdust and cutter shavings make up the vast majority of raw materials. When it comes to certification however, only two Swedish pellet producers are currently ENplus-certified. However, there is growing interest among Swedish producers in becoming certified in response to customer requests for this (Ramstedt 2015).

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3.21 Switzerland

David Peetz

3.21.1 Regulatory framework, market drivers and barriers

In Switzerland different frameworks to develop the energy politics towards sustainability and modernity, exist. These include for example energy articles in the Swiss Federal Constitution, the Energy Act, the CO_2 Act and several more (BFE, 2015). There is also the program *Energie Schweiz* with central targets towards the reduction of energy consumption, improving energy efficiency and reducing the CO_2 emission from 1990 till 2020 to 20 %. Moreover the share of renewable energies in total energy consumption shall increase about 50 % between 2010 and 2020. This program is likely to become more important in the following years due to the step-by-step performed nuclear phase out (BFE, 2013).

Switzerland is divided in 26 different cantons. With *Das Gebäudeprogramm* each canton has the possibility to support individual with special financial support for example the use of renewable energies or heat recovery regarding building renovation. Furthermore there is a national part connected to that program which includes a standardized financial support for thermal insulation in buildings built before the year 2000 (BFE, 2016a).

The electricity generation of renewable energy technologies is developing rapidly. Actually the production costs are higher than the price for electricity itself. On this way the operator can apply for a feed-in-tariff. This strategy is supported by the *Bundesamt für Energie.* (BFE, 2016b).

One third of the country is covered with forest and as of 2006 to 2013 the forest has increased about 2 %. Nevertheless the forest is not in a good condition because of too much nitrogen from traffic or agriculture, a rare timber use or parasites. Due to the monetary situation the wood industry does not claim cost-covering prices for wood at the moment (BAFU, 2016). Also the use of wood energy holds strong barriers. In 2013 about 90 % of all new buildings and 80 % of all renewed heating systems used heat pumps as energy source. There are fewer possibilities for other energy sources. In comparison to Austria the amount of energetic wood was 4 times less and the sale of pellet stoves was 10 times less. The reason for that situation can be found in the non-existing political support for energetic wood in the last decades (propellets Austria, 2013).

3.21.2 Production capacity, production and feedstock

As mentioned in the previous section, pellets are not as popular in the replacement or in new installation of heating systems. The statistics also give that impression from Swiss energetic wood trade (cf. Figure 3.89). The production capacity of pellets increased steadily from 2002 to 2008 from 6,000 to 170,000 t. In 2009 the amount increased to 60 % to 280,000 t. But in the following years the development decreased and stagnated. Other countries have also got significant growth in this sector while Switzerland still got only small positive effects on the wood market.

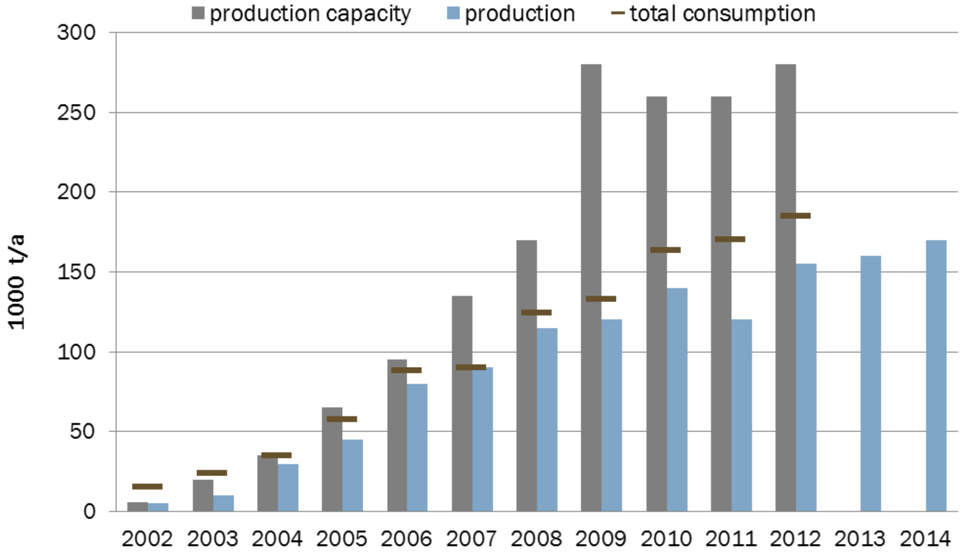

Figure 3.89 - Wood pellet market development in Switzerland from 2002 to 2014 (Goodwin, 2014; propellets Schweiz, 2012).

In 2011 the production of wood pellets decreased by 20,000 t. The relation between production and consumption is negative which can be seen in exports and imports. The required amount of wood pellets cannot only be produced in Switzerland. More information can be extracted from 3.21.5.

3.21.3 Consumption

In Switzerland the *Bundesamt für Energie* exists, which includes a well-structured monitoring for heating systems and especially the pellet heating system. So the situation for pellet stoves and boilers is still positive. Starting in 2001 only 765 boilers with a capacity of less than 50 kW where installed. 13 years later almost 14,000 boilers are installed in Switzerland. An equal growth can be seen with stoves. There was an amount of 636 in 2001 and 9,943 in 2014 of installed systems.

Most of the wood energy is used in domestic sector or private households. An argument for this statement is the small amount of pellet boilers with a capacity of more than 50 kW. The development here is also positive from only 14 installations in 2001 and 839 in 2014, but in comparison to the pervious mentioned systems those boilers don’t have a great impact on the wood market (Kaufmann and Dr. Eicher + Pauli AG, 2015).

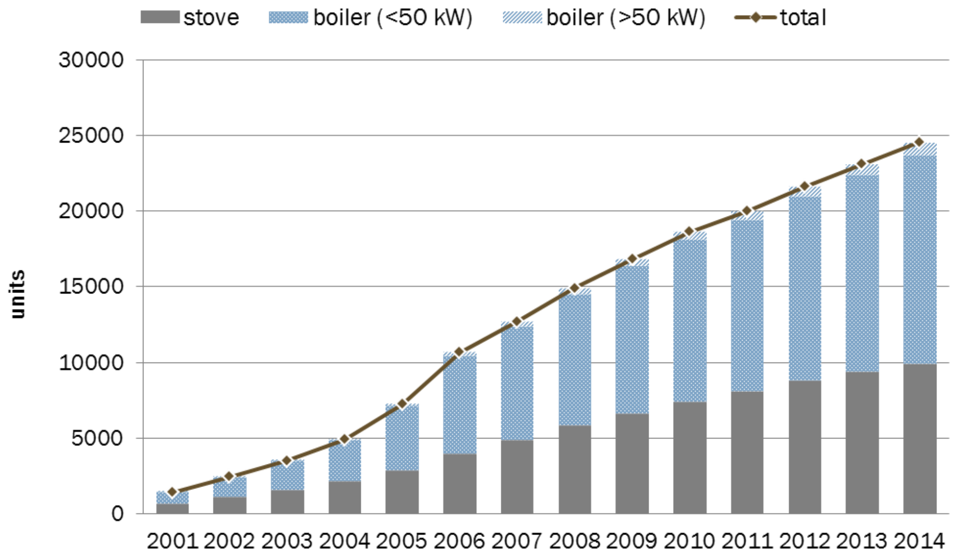

Figure 3.90 - Development of installed pellet heating systems in Switzerland from 2001 to 2014 (Kaufmann and Dr. Eicher + Pauli AG, 2015).

3.21.4 Price trends

Switzerland has got high wage levels, difficult topographical conditions for timber harvest and the heavy vehicle fee for trucks with more than 3,5 t. All those points have bad influences on the pellet price. In August 2011 for example 5 t Swiss pellets cost 115 €/t more than those produced in Austria or Germany. In the same year local pellet provider had to restrict their pellet production because of less demand. (Pellets- Markt und Trends, 2012b)

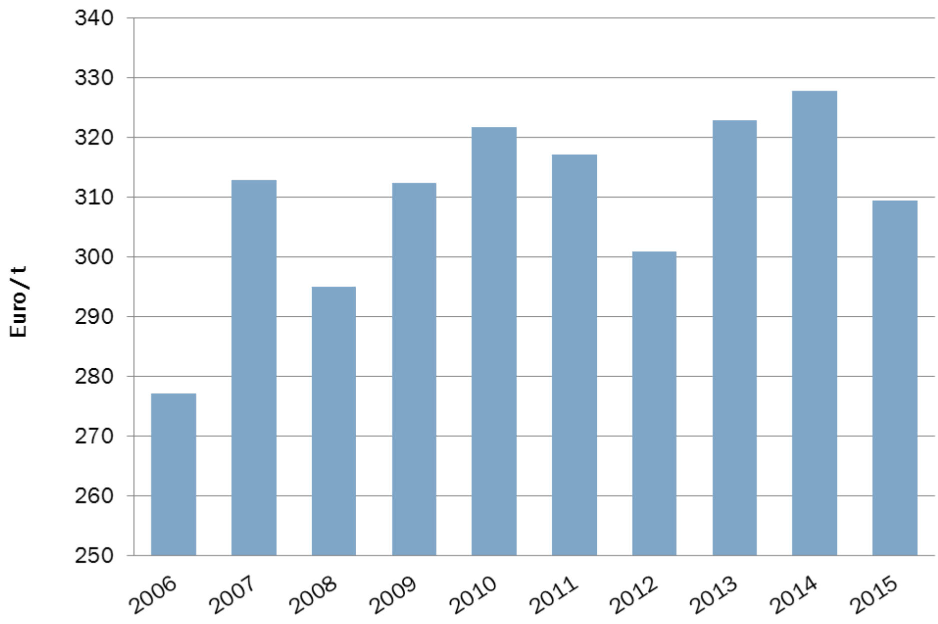

Figure 3.91 - Wood pellet prices in Switzerland from 2006 to 2015 (excluding VAT) (BFS, 2017).

During the last 10 years the price for pellets varied around 50 €/t. In 2015 the price decreased on a level near to 300 €/t (cf. Figure 3.91). With the different political framework the price might lower its value in the following years. In comparison to natural gas the price for 1 kWh of pellets is cheaper and regarded to fuel oil, it depends on the strong varied value of oil. In 2016 pellets and fuel oil almost got the same price level (PelletPreis, 2016).

3.21.5 Trade and logistic aspects

The previous chapters mentioned the import which is important to the pellet market in Switzerland. Along with difficult conditions for harvesting wood and thus higher prices for pellets, import is often cheaper than local products. The relation between import and export was always dominated by the export throughout the past 5 years. In 2013 the export reached surpluses and got its climax when 90,000 t where imported and just 4,000 t exported (Figure 3.92).

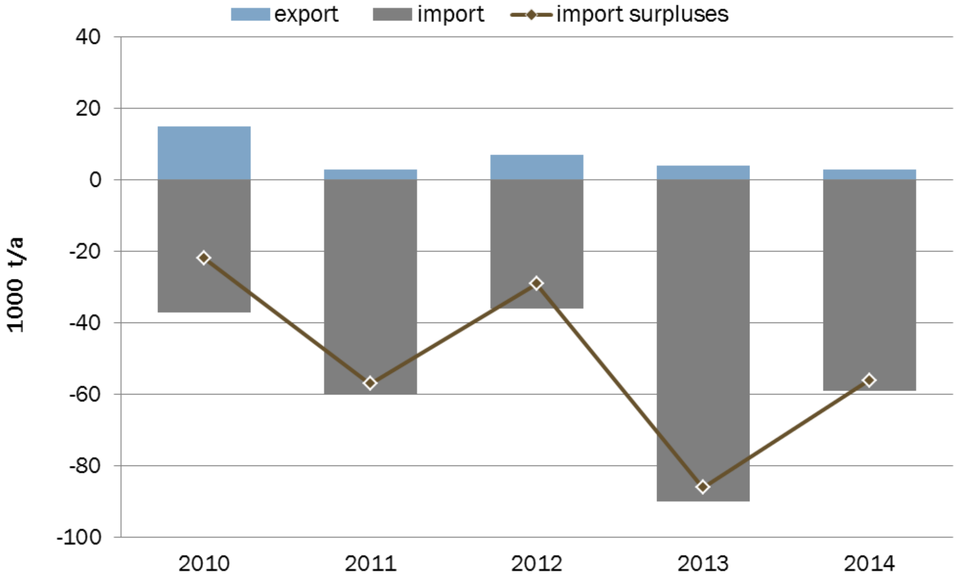

Figure 3.92 - Evolution of export and import in Switzerland from 2010 to 2014 (AEBIOM, 2013; Albertone et al., 2013; Helminger et al., 2015; Mahieu et al., 2016; Pellets Markt und Trends, 2012).

In 2014 the development changed and the amount of imported pellets was reduced by 30 %. With the same political reasons of why the pellet price might decrease in the following years, the same will most certainly happen to the export and import. With a better organized pellet market, a higher demand for pellets due to more installed pellet heating systems could be envisioned. However, the import could neither increase nor decrease depending on the general development.

3.21.6 Pellet quality standard

In Switzerland it is necessary for the pellet production to hold on ISO-Norm SN EN ISO 17225-2. This norm separates quality segments A1, A2 and B. Customers can identify the pellets by looking for the ENplus symbol (propellets Schweiz, 2016). By the end of 2015 there were 6 pellet producers certified by ENplus (ENplus, 2016).

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3.22 Ukraine

Svetlana Proskurina, Jussi Heinimö

3.22.1 Regulatory framework, market drivers and barriers

In 2014, Ukraine adopted a number of governmental regulations for natural gas replacement by alternative fuels. These regulations stimulated bioenergy development in the country. Currently, the bioenergy sector actually substitutes more than 1.93 billion m^3/a of natural gas in Ukraine. The National Action Plan on renewable energy up to 2020 set a target to replace further 5.27 billion m^3/a of natural gas by solid biofuels to achieve total gas replacement at the rate of 7.2 billion m^3/a by 2020. The biomass usage for heat generating should increase from 3,670 MW in 2013 to 16,150 MW in 2020 (Geletukha et al., 2015).

Ukrainian pellet manufacturing is predominantly export-oriented. Due to the conflict in Eastern Ukraine, the support for renewable energy producers has undergone significant changes in the beginning of 2015. The acts introduced by the energy regulator were adopted as emergency measures. Following the amendments to several laws adopted in June 2015, National Energy and Utilities Regulatory Commission (NEURC) shall quarterly index the feed-in tariffs to account for average official EUR-UAH currency exchange rate. This framework is currently not attractive anymore for the development of new renewable projects. Almost all new investment decisions for new projects have been postponed. The legislative inconsistencies (namely unexpected reduction of feed-in tariffs, cancellation of tax exemptions, etc.) are detrimental to the investment climate. This is jeopardizing the fulfilment of the 11 % renewable energy target by 2020 (Energy Community, 2016).

Main drivers for pellet production and trade in Ukraine:

- Low price of production
- Huge potential for agro-pellet production (IEA Bioenergy, 2011)
- Decrease dependency from fossil fuel imports.

Main barriers:

- Low production capacities
- Some logistical problems (IEA Bioenergy, 2011)
- Weak current economy situation in the country.

3.22.2 Production capacity, production and feedstock

The first specified pellet plant in Ukraine started to operate approximately in 2005. The number of pellet and briquette plants is growing rapidly. In 2009 Ukraine have more than 150 companies for the production of briquettes with different productivity and about 50 of pellet production plants (IEA Bioenergy, 2011).

Ukraine is a main leader in European agro pellets production with 0.98 Mt in 2014 (AEBIOM, 2015). Most of the producers focus on sunflower husk pellet production and smaller share of producers make wood pellets. Other kinds of pellets produced in Ukraine are cereal straw pellets, corn stalk pellets, and sunflower stalk and head pellets. More than half of producers focus on the pellet production while the rest combine it with other activities, the most common of which is wood processing (International Finance Corporation, 2015). The number of pellet producers increased from 182 (2014) to 191 (2015) (Bioenergy Portal of Ukraine, 2016a). In 2015, the pellet production was about 1.3 Mt from which wood pellets accounted for about 360,000 t or 30 % from total pellet production (Figure 3.93) (UNDP, 2016). Figure 3.95 shows wood pellet production in Ukraine.

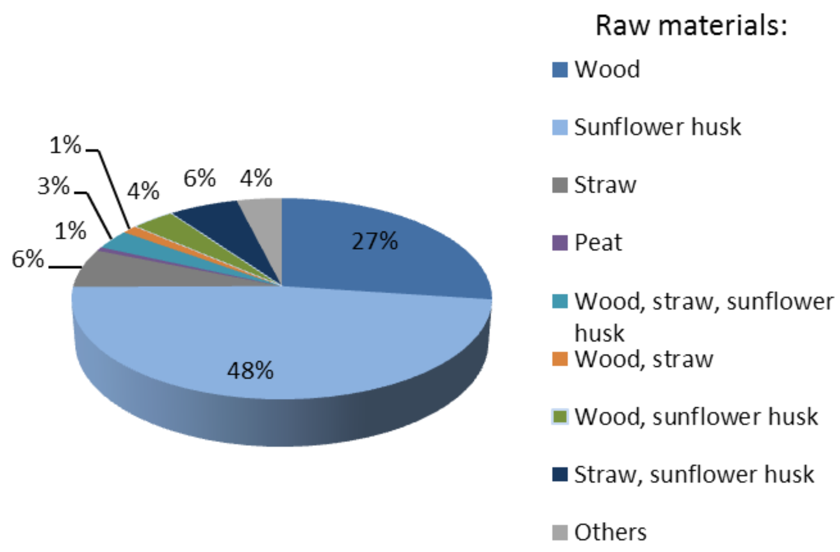

Figure 3.93 - Pellets production from different raw materials (incl. mixed) in Ukraine in 2015 (UNDP, 2016).

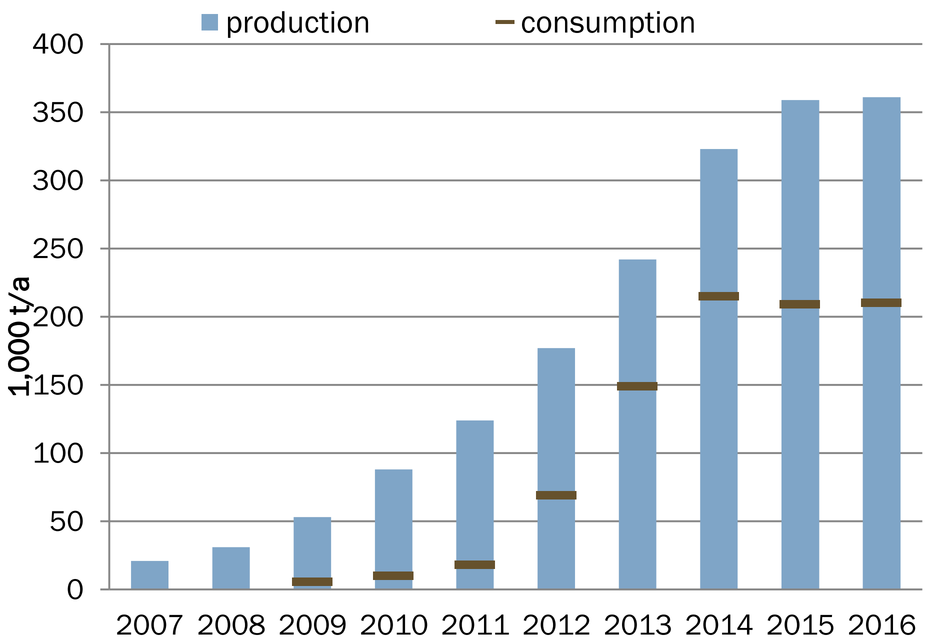

Figure 3.94 - Wood pellets production and consumption in Ukraine in 2007-2016 (UNDP, 2016).

As can be seen, wood pellets production has grown in Ukraine. The most production plants of wood pellets are located on the northwest of Ukraine Figure 3.95 shows the location of wood pellets production.

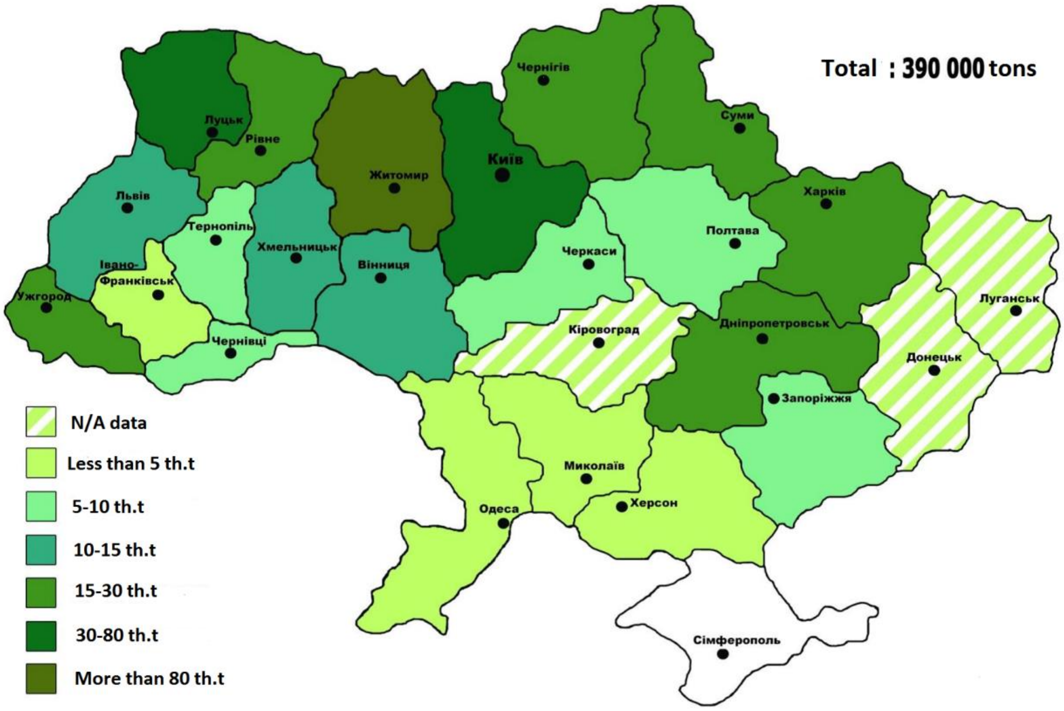

Figure 3.95 – Location of wood pellets production in Ukraine in 2015 (UNDP, 2016).

In Ukraine, the main raw material for wood pellets is wood waste with 87 % of total feedstock. The use of agricultural waste and sunflower husk is rare. 88 % of raw materials are mainly supplied by external vendors, while the remaining 12 % are obtained from producer´s own enterprises. In most cases, the pellet producer cooperates with 2 to 5 vendors on a regular basis. Frequent changes of suppliers are usually avoided (International Finance Corporation, 2015).

Ukraine has good opportunities to become a European leader in pellet production. However, more than a hundred of Ukrainian pellet production plants which are mainly small producers with 300 to 500 t per month suspended its work in July 2015. It can be explained by a few reasons. Firstly, wood pellets have only third of the total production of pellets. A large part is produced from sunflower husks and other agricultural crops. Producers of pellets from sunflower husks depend on the major oil-extraction plants. Secondly, participants of the pellets market complain about the actions of the state, which set a new Tax Code of the country from April 2011. One of the paragraphs of the document provides restrictions on the conduct of economic activities for entities operating on a single tax. This calls into question the profitability of the pellet business for small and medium-sized enterprises. Thirdly, technical barriers are inhibiting the pellet production by Ukrainian enterprises. The technological backwardness of the equipment is noticeable. The owners of the companies are not ready to lay out large investments in new equipment, thus business profitability falls due to low production efficiency on older units (Nicholas Biofuel Portal, 2015).

Despite the challenges and the solid biofuel market in Ukraine being quite young, generally wood pellet production has a stable development. According to experts, Ukraine has begun the process of redistribution of the biofuels market which existed in Russia. This process means the decrease of small and medium-sized producers of pellets and the growth of large wood pellet producers (Nicholas Biofuel Portal, 2015).

3.22.3 Consumption

During the 2014, Ukrainian producers and traders of wood pellets have noted a significant growth in wood pellets demand on the domestic market. In 2014, more than 400 facilities for wood pellets usage was installed, mainly in the western regions of the Ukraine where main biomass resources are concentrated. This tendency can be explain by tense situation in the gas market of Ukraine (Ukraine Biofuel Portal, 2015). The production of sunflower husk pellets was about 1.4 million in 2014. More than 80 % is exported and only 20 % consumed within the country. The average price was about 110-115 €/t (Granuly.ru 2015).

3.22.4 Price trends

Wood pellets price is higher than the price of other pellets (Figure 3.96). The latest estimation shows that wood pellets price varies depending on the region. In Kyiv and Chernivtsi, the highest wood pellet price was 3,000 UAH/t (~107 euro/ton). While in Lviv, the lowest wood pellet was 1,000 UAH/t (~36 euro/ton) in April-July 2016 (UNDP, 2016).

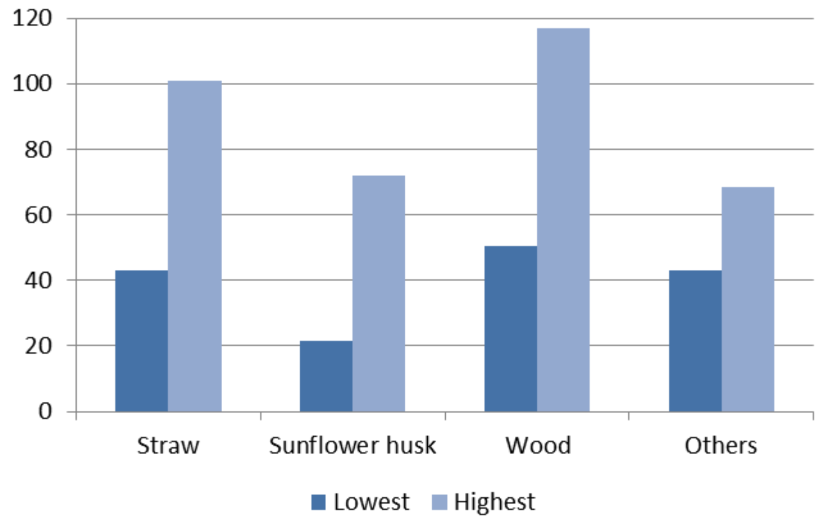

Figure 3.96 - Pellet's prices by April-July in Ukraine in 2016 (in euro/t) (UNDP, 2016).

3.22.5 Trade and logistic aspects

Wood pellets export increased from 0.13 Mt (2014) to 0.15 Mt (2015) in Ukraine (Figure 3.97). The main importers were Poland, Italy and Czech Republic (Figure 3.98) (Bioenergy Portal of Ukraine, 2016b).

Figure 3.97 - Wood pellets export and import in Ukraine in 2010-2015 (UNDP, 2016).

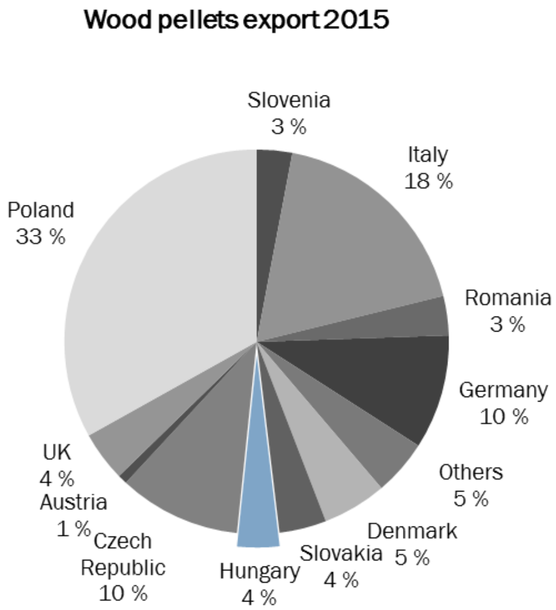

Figure 3.98 - Wood pellets export in Ukraine (2015), (TradeMap, 2016).

Ukrainian pellets are exported overseas though Baltic ports Klaipeda and Liepaya (Lithuania), Vetspils (Latvia), Paldiski (Estonia), Sillamae (Estonia), and Tallinn (Estonia). Probably, some pellets go via Black Sea ports, but this is not a systematic path. Pellets are also transported to Europe by trucks and via railway (IEA Bioenergy, 2011).

3.22.6 Pellet quality standard

In 2012, ENplus certification system was adopted in Ukraine. Ukrainian Pellet Union (UPU) implements cooperation as the main instrument of biofuel industry creation to harmonize Ukrainian and European standards for solid biofuels and to create conditions for the development of cost-effective production. In 2014 UPU arranged public lobbying for ISO 17225 implementation in Ukraine. For non-woody pellets, ISO EN 17225-6 standard determines the fuel quality classes and specifications of graded non-woody pellets (Ukrainian Pellet Union, 2014).

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3.23 United Kingdom

Laura Craggs

3.23.1 Regulatory framework, market drivers and barriers

The European Union has collectively set a target for 20% of total energy generation to be from renewable sources by 2020. The share of this target is split across different member states and translates into a 15% target for the UK's total energy generation, which is legislated through the Climate Change Act (Climate Change Act, 2008). This 15% target for renewable generation can be separated into: 30% of electricity, 10% of fuel and 12% of heat (Renewable Energy Directive, 2009).

The different forms of renewable energy (electricity, heat and transport fuel) are controlled through separate support mechanisms in the UK. The Renewables Obligation (RO) places an obligation on every electricity supplier to provide a certain proportion of their electricity from renewable sources and this requirement can be met by purchasing proof of renewable electricity generation (Renewables Obligations Certificates) from generators (Connor, 2003). The RO is monitored and regulated by OFGEM (Office of Gas and Electricity Markets) (www.ofgem.gov.uk). Renewable transport fuel is supported through the Renewable Transport Fuel Obligation (RTFO) and renewable heat is subsidized through either the Renewable Heat Incentive (RHI) or the Renewable Heat Premium Payment (RHPP) (DUKES, 2014).

The main drivers for wood pellet use in the UK is through climate change targets, renewable energy targets and the subsidy regimes set in place to support these. The low cost of fossil fuels means that without financial support for biomass, uptake would likely be virtually zero. Wood pellet use in electricity generation has increased significantly in the UK, in line with the support provided through the RO. Legislative changes to limit the life of coal generation in the UK have left coal generators looking for ways in which to retrofit their plant to change fuel source, which could also provide another driver for the increase in biomass use (Industrial Emissions Directive). In 2015, the UK Energy Minister announced the intention to cease all coal fired power generation in the UK between 2023 and 2025 (DECC, 2015). Coal is currently still an important part of the UK electricity mix, so new generation must be introduced to fill this gap and conversion to biomass could be one option to replace this electricity capacity without building new infrastructure and connections to the grid.

Policy Changes

In 2011 a significant change to the RO was introduced, changing the support provided from co-firing biomass with coal in relatively low proportions, to encourage larger levels of coal displacement. The RO has undergone a number of changes in the last decade, with developing sustainability criteria leading to multiple iterations of the legislation. Between 2011 and 2015, these incremental changes to the RO culminated in the December 2015 update which included specific criteria on Sustainable Forest Management for woody biomass, giving the UK the most stringent criteria for biomass sustainability in Europe (Renewables Obligation, 2015).

More recently, the UK government has introduced a new method of incentivizing renewable energy generation, called the CfD – Contracts for Difference. CfDs were introduced to support low-carbon electricity generation, and from 31 March 2017, all new applicants for sustainable biomass use will be considered under CfDs, effectively replacing the RO. Under this regime, the renewable energy generator contracts with the government at a specific 'strike price', providing longer term income security to the generator. The Department of Energy and Climate Change (DECC, now incorporated into BEIS) have awarded two of these CfDs to biomass generators: one to the 420MW Lynemouth CHP project and the third unit conversion at Drax Power Station.

Outlook

There does not appear to be any evidence of future policies to encourage further uptake of the use of wood pellets in bioenergy. Current support for biomass use in electricity generation under the Renewables Obligation is due to end in 2027, meaning that any new conversion projects would be limited to a 10 year period in which to recover the investment required to convert. This limited time horizon on the current policies makes significant future uptake of biomass use in the UK more unlikely.

Across Europe, bioenergy is predominantly used in heating, so the UK is an outlier in its focus on the use of biomass for electricity generation. Even though the UK generated 20% of its renewable electricity from biomass in 2014, the government have stated their belief that this is a transitional technology only (DECC, 2013b). The UK is currently below target for both renewable heat and transport; however, future support for wood pellets for heating in the UK appears limited. In December 2016, the Department for Business, Energy & Industrial Strategy concluded on a consultation on the future of the RHI. The reform of the RHI changed the subsidy levels to encourage further uptake of renewable heat technologies other than biomass (BEIS, 2016). Although support has increased for larger scale use of biomass (over 1MW), tariffs for small to medium scale use of biomass have been reduced (BEIS, 2016). The impact assessment published with this consultation projects that overall renewable heat will be between 54-55 TWh in 2020, constituting only 9% renewable heat, falling short of the 12% target set for 2020 (DECC, 2016).

3.23.2 Production capacity, production and feedstock

UK Wood Pellet Production Capacity

The UK has very limited production of wood pellets. Domestic pellet production in 2015 stood at 343,000 tonnes, compared to an import of wood pellet imports into the UK comprised 6.5 million tonnes in 2015 (Forestry Commission, 2016a).

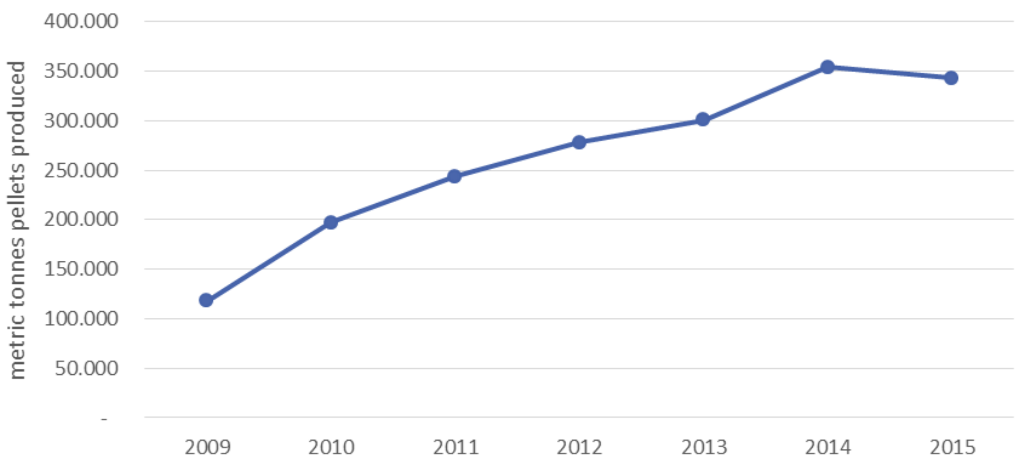

Figure 3.99 - UK Pellet Production between 2009 and 2015 (Forestry Commission, 2016b)

UK Wood Pellet Producers

Table 3-13 - Wood Pellet Producing Facilities in the UK (UK Pellet Council, 2016)

Facility Name	Technical Capacity (tonnes)	Region	Source	Heat/ Industrial
Balcas, Invergorden	100,000	Highlands	http://www.brites.eu/about-brites	EN Plus
Land Energy, Girvan	100,000	Ayrshire	http://www.land-energy.com	EN Plus
Balcas, Enniskillen	55,000	Fermanagh	http://www.brites.eu/about-brites	EN plus
Verdo Renewables Ltd	55,000	Hampshire	http://www.verdorenewables.co.uk	EN Plus
Verdo Renewables Ltd	55,000	Falkirk	http://www.verdorenewables.co.uk	EN Plus (not listed)
Blazers Fuels	30,000	Denbighshire	http://www.cjtimber.com	EN plus
Puffin Pellets	30,000	Aberdeenshire	http://www.puffinpellets.com	EN Plus
Duffield Wood Pellets	5,000	North Yorkshire	http://www.duffieldwoodpellets.com	
Arbuthnott Wood Pellets (Stovies)	4,000	Kincardineshire	http://www.hotstovies.com	
Ecowood Fuels	4,000	Devon	http://www.ecowoodfuels.co.uk/page/about_us/6/index.html	
Eco Energy	4,000	Wiltshire	http://www.ecoenergy-sw.co.uk	
Intervate Limited	20,000	West Midlands	http://www.intervate.co.uk/#/about-us/4533845119	EN plus
Equestrobed Limited	?	Suffolk	http://www.equestrobed.co.uk/wood-fuel	EN Plus
MiGeneration Ltd	?	Cornwall	http://www.mi-generation.com/	EN Plus

Reference: Industry Knowledge, UK Pellet Council and Internet Searches. Reference: UK Pellet Council[7]:

The UK pellet council lists the majority of these pellet plants as the EN plus certified pellet producers in the UK, suggesting that the majority of wood pellets produced in the UK are produced for the heat market, rather than for industrial use. Many of the wood pellet producers listed above declare the feedstock used in their wood pellets as locally sourced virgin timber, sawdust and wood chips.

[7] http://www.pelletcouncil.org.uk/consumer-information/producers

3.23.3 Consumption

Since the introduction of the non-domestic RHI 4 years ago, 32 large biomass boilers have been installed and there were 13,349 installations of small and medium biomass boilers. Under the domestic RHI, 8,436 systems have been installed since the introduction of the regulation. In the UK, the use of biomass for electricity generation has increased significantly from 2011. This increase can be correlated against the change of support from low level co-firing of biomass to full conversion of coal generating units to use biomass.

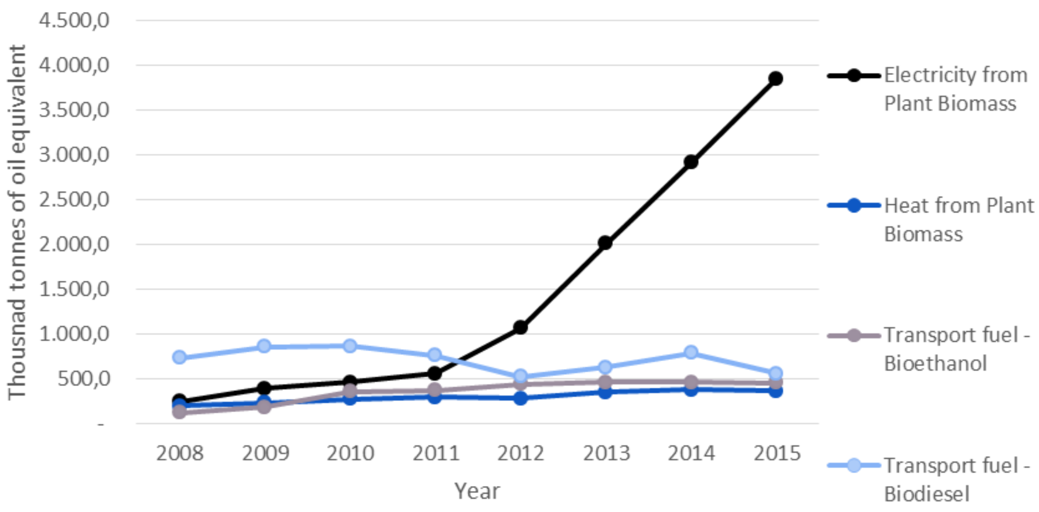

Figure 3.100 - Development of plant biomass use in different energy sources (2008 – 2015) (Department for Business, Energy & Industrial Strategy, 2016b).

Table 3-14 - Use of woody biomass for electricity generation in the UK between April 2013 and March 2014, showing the origin of the pellets (Ofgem, 2015)

Units: tonnes	Canada	UK	Europe	South Africa	USA	USA, Canada	Total
Clean Wood Chip		245,238					245,238
Forestry Wood		79,436					79,436
Pellets	1,402,051	14,230	473,810	5,160	1,579,387	1,704	3,476,342
Sawdust		33,728					33,728
Steam exploded pellets			218				218
Torrified black pellets					184		184
Virgin Chip		8,114					8,114

Units: tonnes	Canada	UK	Europe	South Africa	USA	USA, Canada	Total
Virgin Wood		658,107					658,107
Woodchip		283,788					283,788
	1,402,051	**1,322,641**	**474,028**	**5,160**	**1,579,571**	**1,704**	**4,785,155**

The major consumer of wood pellets in the United Kingdom is Drax Power Station, which has upgraded almost half their generating capacity to use wood pellets in place of coal. Future development of large scale use of wood pellets in the UK is currently expected to be limited to the table below (Hawkins Wright, 2015).

Table 3-15 - Expected major users of biomass for electricity generation in the UK

Company	Electrical Capacity	Start Date and Subsidy
Drax Unit 1	630 MW	2013
Drax Unit 2	630 MW	2014
Drax Unit 3	630 MW	2015 (85% co-firing) awaiting future CfD
RWE Lynemouth	420 MW	Expected mid-2017. Awarded CfD
MGT Power (CHP)	295 MW	CfD. 2019 expected start date

3.23.4 Trade and logistics

The following section focusses on wood pellet trade in the United Kingdom. As highlighted in above, there is relatively little domestic production in the UK, so much of the biomass demand is met through imports. Figure 3.101 shows the significant increase in wood pellet imports to the United Kingdom between 2008 and 2015, with the total imported volume increasing 20 times, from 0.3 Mt in 2008 to over 6.5 Mt in 2015. The comparison of exports of wood pellets compared to imports into the UK highlights that the UK is dependent on imports to meet the demand for wood pellets.

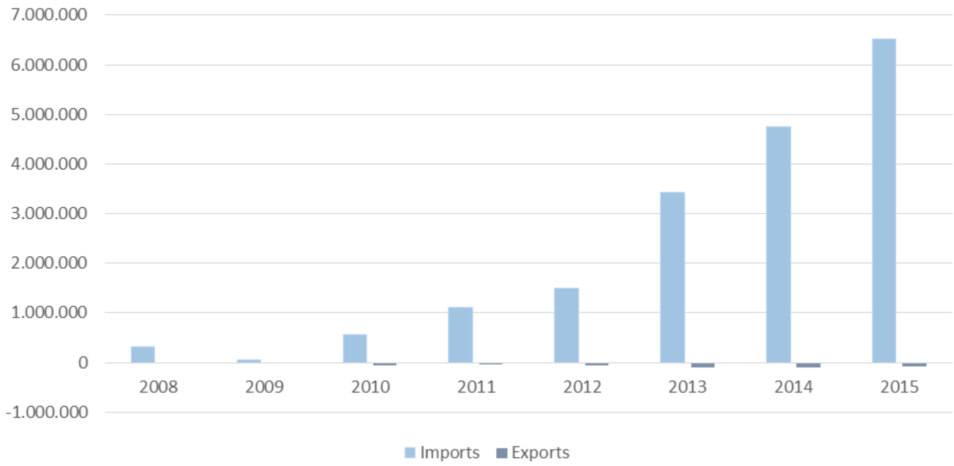

Figure 3.101 - Wood Pellet Imports to the United Kingdom (Department for Business, Energy & Industrial Strategy, 2016b).

Trade Routes for Imported Wood Pellets

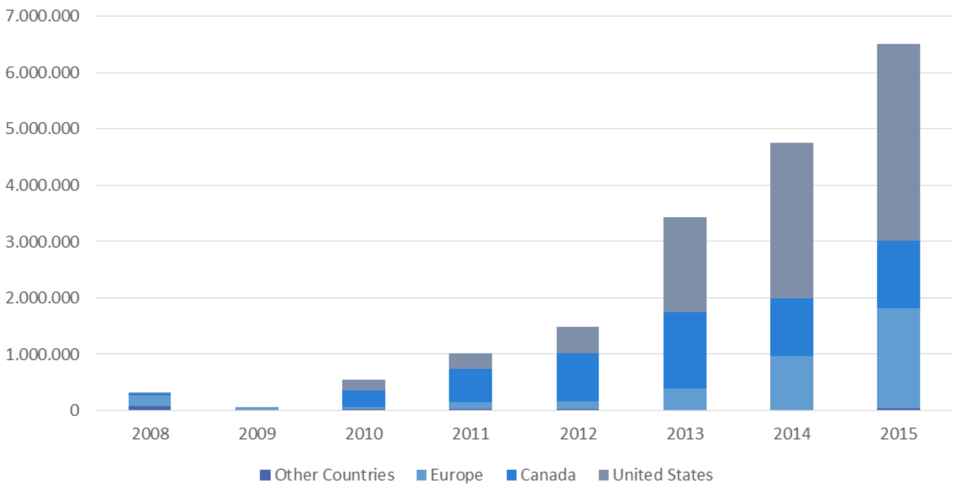

Figure 3.102 - Wood Pellets Imports to the UK by Sourcing Region (Department for Business, Energy & Industrial Strategy, 2016b).

The United Kingdom is a major importer of wood pellets, with relatively low volumes of pellets produced domestically. Data published by Ofgem shows that over 5.5 Mt of wood pellets were used in the UK for electricity generation in the financial year 2014/15, suggested that in 2015, of the 6.5 Mt of imported pellets, around 1 Mt of pellets were used in the heating sector.

The United States is a key supply region to the UK, making up 54 % of all imported wood pellets in 2015. 27 % of imported pellets were of European origin, with 18 % sourced from Canada, as shown in Figure 3.102. The notable increase in imported wood pellets to the UK between 2008 and 2015 has led to a necessary development in the supply chain infrastructure required to meet this import demand. Drax Power Station, the largest user of wood pellets in the United Kingdom has invested significantly into this infrastructure, including investment into 4 UK ports (Liverpool, Hull, Tyne and Immingham) and development of specialized rail wagons to maximize the volume of pellets which can be moved on one train, reducing fuel use.

3.23.5 Pellet quality standard

The ENplus standard has been adopted for wood pellets for heating in the UK, with the majority of UK pellet producers producing pellets to the ENplus standard. Industrial pellets will follow different requirements for pellet quality, dependent on the customer.

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4 Wood pellet industry and market in North America

4.1 Canada

Patrick Lamers[8], *Gordon Murray*[9]

4.1.1 Regulatory framework, market drivers and barriers

The increase of wood pellet production and consumption within Canada is mainly driven by international demand as well as potentially new domestic policies. The federal government has announced plans to phase out the use of coal-fired electricity in Canada by 2030 as part of its overall clean-energy strategy. The goal is to increase Canada's share of sustainably produced electricity to 90 % from today's share of 80 % (the majority being derived from hydropower). Coal power accounts for roughly 10 % of Canada's total greenhouse gas emissions. Coal plants are concentrated in the provinces of Alberta (10 plants), Saskatchewan (1-2 plants), New Brunswick (1 plant) and Nova Scotia (exempt from coal out-phase).

The New Brunswick government has plans to phase out coal as an electricity source under a new climate change plan that also puts a price on carbon. The plan sets 2030 as the target for phasing out coal, but says that it could be delayed by as much as 10 years with interim emission reductions aligned with new federal regulations (Church, 2016).

Alberta also announced plans to phase out coal by 2030. The province hosts a number of older units which cannot be converted to co- or mono-firing, but five newer units could be converted by 2030. At present there appears to be a lack of awareness within the Alberta government to consider pellets as a transition option for newer coal power units.

Within the residential heating market, woodstove change-out or replacement programs in the provinces of Nova Scotia, Quebec, New Brunswick, British Columbia, and Ontario could facilitate a domestic market growth for wood pellets (HPBAC, 2016).

4.1.2 Production capacity, production and feedstock

In 2010, Canada had around 2 Mt/a production capacity. Its pellet plants operated at 65 % capacity that year, producing 1.3 Mt and exporting 1.2 Mt. In 2011, production increased to 1.5 Mt with 1.3 Mt of pellets being exported.

By 2012, nameplate production capacity had risen to around 3 Mt. In 2015 and 2016 alone, an additional 1 Mt of new annual capacity was added. By the end of 2016, Canada counted 42 plants with a total nameplate capacity of just over 4 Mt. At present there are no new plants under construction, although Canadian producers are currently researching potential new projects.

British Columbia (BC) accounts for 60 % of the total Canadian nameplate capacity, followed by Ontario (ON) and Quebec (QC) provinces. Pellet plants in BC tend to be large with production rates of over 150,000 t/a. The plants supply domestic (in the case of ON) and oversea large-scale heat and power plants (in the case of BC). Pellet plants in the other provinces predominantly supply regional markets and tend to be smaller. Their nameplate production capacities are in the range of about 50,000 t.

[8] Idaho National Laboratory, Idaho Falls, ID, USA
[9] Wood Pellet Association of Canada, Revelstoke, BC, Canada

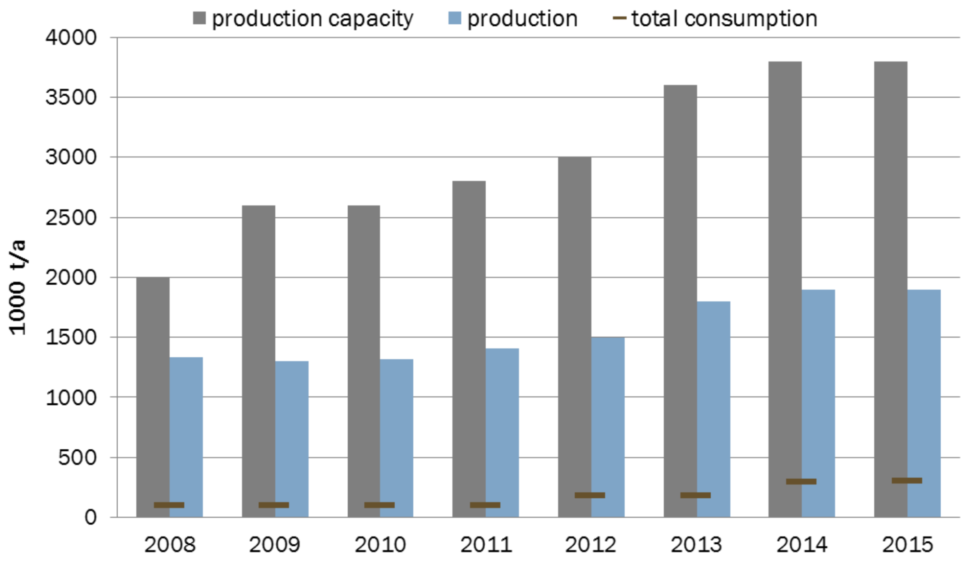

Figure 4.1 - Wood pellet annual production capacity development in Canada from 2008 to 2015 (Biomass magazine, 2017; FAOSTAT, 2016; Statistics Canada, 2016).

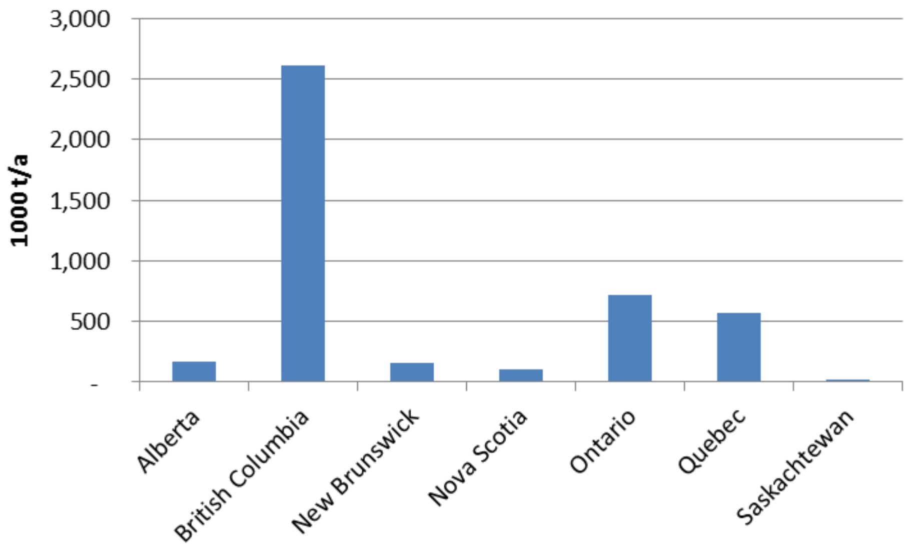

Figure 4.2 - Capacity distribution across Canadian provinces.

4.1.3 Consumption

Export markets

The main markets for Canadian produced wood pellets are in oversea (large-scale) heat and power stations in Europe (including the UK, Belgium, and others) and Asia (including Japan and South Korea) as well as residential heating markets in the U.S. Statistics Canada reports the quantities shown in Table 1 for the last 4 years. Cross-checking these with the respective import volumes reported by the destination countries revealed some deviation, particularly in the case of Belgium and Japan (Table 4-2).

Table 4-1 - Canadian wood pellet exports by destination (Statistics-Canada 2016).

metric tonnes	2012	2013	2014	2015
United Kingdom	794,379	1,026,527	982,809	1,205,928
United States	86,665	152,271	218,889	205,743
Italy	85,238	219,551	204,528	85,513
Japan	105,640	76,018	61,807	80,203
South Korea	2,084	113,077	150,004	49,029
OTHER	295,171	52,787	19,355	1,366
TOTAL	**1,369,177**	**1,640,231**	**1,637,393**	**1,627,784**

Table 4-2 - Cross-check of imports from Canada reported by countries of destination (Eurostat; Japan Ministry of Finance).

metric tonnes	2012	2013	2014	2015
United Kingdom	854,602	1,466,782	889,353	1,161,424
Japan	n/a	72,151	90,676	146,150
Belgium	205,469	160,151	107,238	227,940

Domestic consumption

Current domestic pellet consumption is calculated at just over 300,000 t/a (see Section 4.1.5), used in residential heating stoves and the Atikokan power station in Ontario.

Atikokan is North America's largest 100 % biomass-fueled power plant generating renewable, dispatchable, peak capacity power. The plant stopped using coal in 2012 and underwent a CAN$ 170 million conversion to solely run on wood pellets. Since 2014, Ontario Power Generation runs Atikokan as a peak-load plant, with an annual wood pellet demand of about 100,000 t, representing only about 30 % of its potential capacity. The wood pellets are sourced domestically.

A second Ontario plant in Thunder Bay (i.e., one of the plant’s two boilers) has also been retrofitted to use biomass as fuel. It is currently only run experimentally using roughly 8,000 t of torrefied pellets from Norway.

4.1.4 Price trends

Sale prices for export pellets in bulk shipments for oversea markets range between CAN$150 to CAN$180 per tonne FOB. Residential heating markets in the U.S. are supplied in bagged form stacked on pallets and achieve higher sale prices between CAN$210 to CAN$280 per tonne (Statistics Canada 2016).

Anecdotal evidence suggests regional prices of $5.24 per (40 lbs) pellet bag equaling $262 per tonne or $15.41 per GJ. A case study in British Columbia calculated pellet heat prices (including operation and electricity) at roughly $15.92/GJ, compared to $24.36/GJ for propane (including delivery, carbon tax and electrical fan), $29.47/GJ for electricity, and $33.93/GJ for heating oil (Murray, 2015).

Table 4-3 - Canadian export sale prices (Statistics Canada 2016).

CAN$/tonne	2012	2013	2014	2015
Average	*152.10*	*158.56*	*168.55*	*174.90*
United Kingdom	147.11	145.84	152.38	157.80
United States	209.78	211.32	232.53	278.02
Italy	167.87	182.67	188.53	172.07
Japan	148.69	164.19	181.17	171.61
South Korea	220.17	159.66	149.62	170.17

4.1.5 Trade and logistic aspects

Canadian exports have been primarily shipped out of the province of British Columbia via the harbors of Vancouver and Prince Rupert. The inland logistics are done exclusively via rail from the pellet mill to harbor and by truck from the forest to the pellet mills.

Newer trade routes leaving eastern Canada to Europe as well as pellet mill facilities located inland and/or in the eastern provinces, including Ontario, Quebec, and New Brunswick have been reported to also utilize barge shipping.

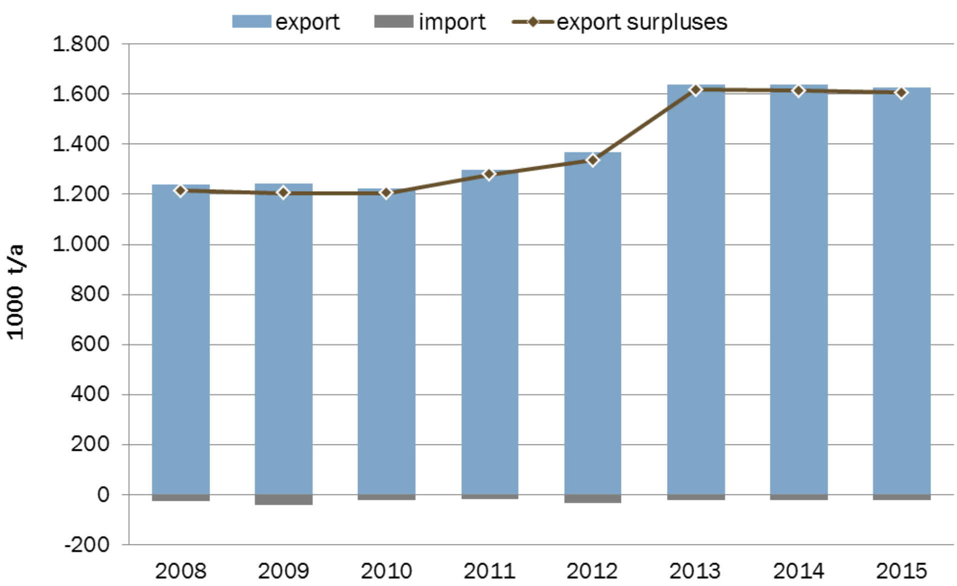

Figure 4.3 - Evolution of export and import in Canada from 2008 to 2015 (Statistics Canada 2016).

Due to its geographic location, British Columbia has also emerged as one of the first suppliers of wood pellets to Asian markets in South Korea and Japan. In some years Canadian exports have made up two thirds or more of all Japanese wood pellet imports (Strauss 2016).

In 2016, exports increased by exceptional 46%, reaching 2.37 Mt. The largest increase by percentage went to Japan with 240% (192.173 t), the largest increase by volume went to the U.K. with 458.217 t (plus 38%). (WPAC, 2017)

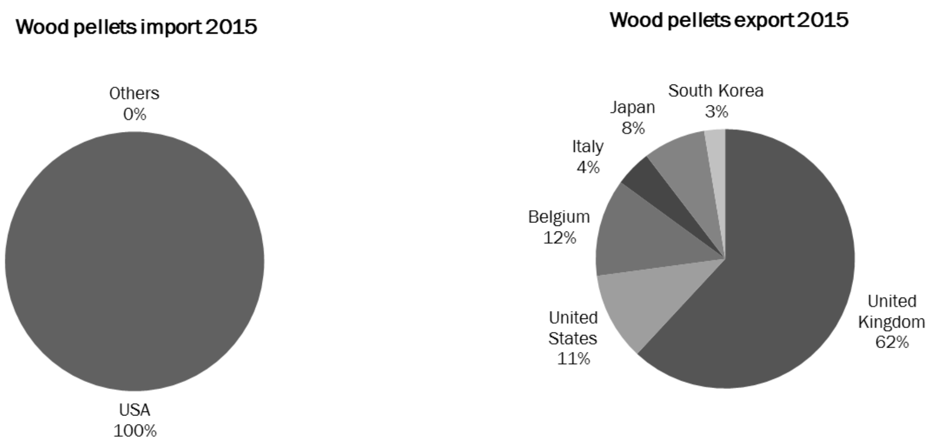

Figure 4.4 - Pellet exports and imports from Canada in 2015 (Statistics Canada 2016).

Figure 4.5 - Canadian wood pellet production-consumption and trade balance.

4.1.6 Pellet quality standard

Canadian pellet production adheres to international technical standards including the ISO/CEN. The Canadian Standardization Association created the CAN CSA ISO Standard which follows the ISO Technical Committee 238. CANPlus mirrors ENPlus and is also accepted by the U.S. EPA.

4.1.7 Proposed pellet plants

Table 4-4 - Proposed pellet plants in Canada (Status December 2016).

Plant	Location	Feedstock	Capacity (t/a)
Atlantic Fiber Resources (*unlikely*)	Chandler, QC	Hardwood and Softwood	209,000
Atlantic Fiber Resources (*unlikely*)	Goosebay, NL	Softwood	120,000
Aurora Wood Pellets	Hay River, NT	Softwood	200,000
Mission Wood Pellet (*unlikely*)	Mission, BC	n/a	160,000
Muskoka Timber Mills Ltd.	Bracebridge, ON	Hardwood and Softwood	50,000
New Forest Industries Pellet Mill	New Richmond, QC	Hardwood and Softwood	125,000
Northern Energy Solutions Ltd.	Miramichi, NB	n/a	200,000
Protocol Biomass Corp. (*unlikely*)	Prescott, ON	Hardwood and Softwood	400,000
Wawasum Group (*unlikely*)	Greenstone, ON	Hardwood	60,000
Whitesand First Nation Pellet Plant (*unlikely*)	Armstrong, ON	Hardwood	60,000
		Total proposed capacity	**1,584,000**
		Of which unlikely	*1,009,000*

4.1.8 Future projections

Export markets are expected to continue dominating the Canadian demand portfolio. The domestic co-firing market could provide new growth potential, but wood pellets would need to compete with other biomass as well as other low-carbon options to replace current coal fired power stations. Domestic residential heating markets are expected to remain relatively stable unless there will be a significant increase in crude oil and heating prices. New uses could emerge in industrial processes, e.g., the concrete industry. Canadian biofuel production from wood pellets is generally a desired future pathway. However, wood pellets are still perceived to be expensive and their benefits (including homogeneous quality, storability, flowability, etc.) are not yet valued sufficiently across the industry.

European and Asian demand for wood pellets will remain a critical outlet for Canadian producers in the future. Across Asia, South Korea is expected to remain an opportunist market where some independent power producers and industry sectors (e.g., steel mills) are starting to utilize wood pellets. Japan could have the largest future growth depending on how many coal plants decide to convert. The upper expectations of the Japanese market demand are around 10-12 Mt annually.

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4.2 United States

Patrick Lamers, J. Richard Hess

4.2.1 Regulatory framework, market drivers and barriers

Drivers for domestic wood pellet consumption and production

Consumption

The main drivers for wood pellet consumption in the U.S. have been regional price competitiveness with residential heating oil and propane as well as replacements of fuelwood burners with respect to comfort and automatic feed-in. There are some incentives for bioheat targeted at the residential and commercial building sector. Industrial use of wood pellets in heat and power is not incentivized. In fact, industrial consumption of wood pellets for heat and power production is marginal at best. The main use of woody biomass is limited to direct by-product (residue) use in the forest products sector, e.g., pulp and paper. Renewable Portfolio Standards (RPS) mandates the production of renewable electricity, including biopower, but wood pellets are usually not used in biopower facilities due to price. The Clean Power Plan could increase domestic wood pellet consumption in the electricity sector, but its implementation is uncertain and its market impact unknown and potentially limited.

Production

The U.S. wood pellet production started in the Northwest and Northeast, where small-scale production based on sawmill residues supplied regional residential heating markets. These markets grew but were ultimately limited by the expansion of the natural gas network and a limited price competitiveness of wood pellets. The U.S. production grew exponentially over the past years due to demand from oversea markets. The expansion took place almost exclusively in the Southeast (with some production increases along the East Coast) due to strategic factors including proximity to EU markets, traditional wood basket including availability of biomass resources, labor, infrastructure, and know-how.

Bioheat

New Source Performance Standards (NSPS) by the EPA

In March 2015, the Environmental Protection Agency issued New Source Performance Standards (NSPS) for new residential wood heaters, including pellet stoves. Details see Section 4.2.6.

Biomass Stove Tax Credit

The Biomass Stove Tax Credit is a federal incentive that gives a $300 tax credit for purchasing a fuelwood or wood pellet stove with a minimum 75 % efficiency rating until December 31, 2016. Details of the law at: https://www.law.cornell.edu/uscode/text/26/25C.

Rebates through regional Woodstove Changeout Programs

Woodstove changeout programs are aimed at providing consumers with incentives to remove old, inefficient wood stoves or wood heating appliances, and replace them with clean, efficient new heating appliances. Incentives mainly include rebates for new stoves. 14 U.S. states currently provide such incentives. Details per state/region at: http://www.hpba.org/government-affairs/woodstove-changeout-program/current-changeout-programs.

Biopower

The Clean Power Plan (CPP), proposed by the U.S. Environmental Protection Agency (EPA) plans to cut carbon pollution from power plants. The EPA published the final rule for the CPP in the Federal Register in October 2015. More than two dozen states and a variety of industry groups and businesses have since filed challenges against the program. In February 2016, the Supreme Court stayed implementation of the CPP Plan pending judicial review.

The exact role biomass can play in meeting CPP requirements is still unclear. In November 2015, U.S. EPA's acting assistant administrator for the Office of Air and Radiation, Janet McCabe, published a blog that addresses the potential role of biomass in the CPP. In addition, the agency held a workshop on the role of biomass in the CPP in April 2016 (Biomass magazine, 2017).[10]

Independent of the CPP, most states have renewable portfolio standards or goals in place (Figure 4.6). These standards require that utility companies generate a certain amount of energy from renewable resources by a certain date. For example, a certain percentage of the utility's electric power sales must be generated from renewable energy sources. Biomass is however only one from of renewable energy eligible to meet these targets – in addition to wind, solar, hydropower, etc.

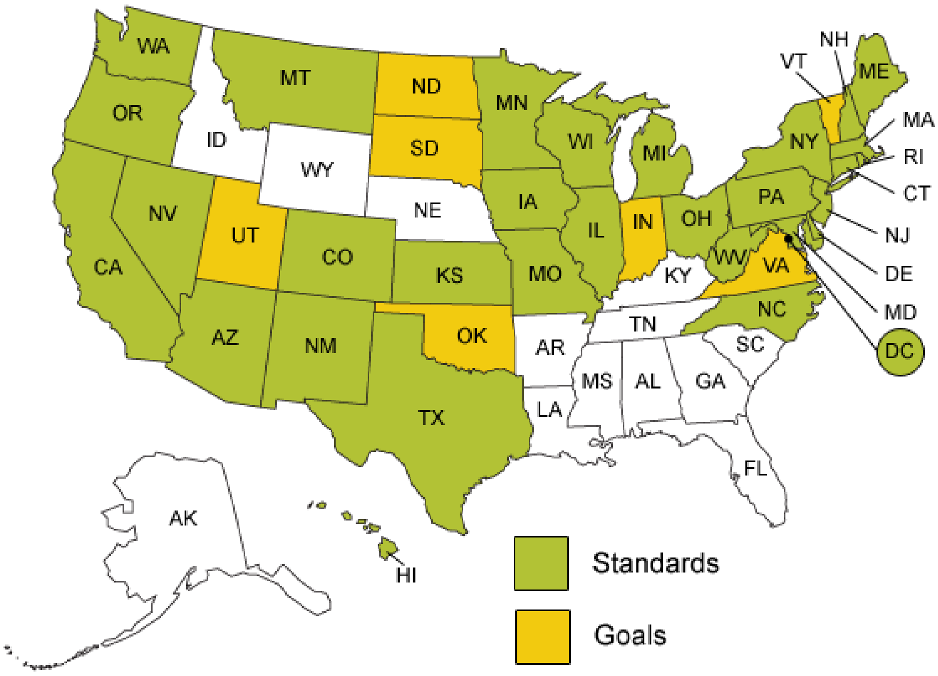


Figure 4.6 - U.S. states with renewable portfolio standards (mandatory) or goals (voluntary) – by January 2012 (EIA, 2012).[11]

[10] http://biomassmagazine.com/articles/13124/bpa-commends-epa-on-substantive-biomass-workshop [October 4, 2016].

[11] U.S. EIA. (2014). Today in Energy: Most States have Renewable Portfolio Standards. http://www.eia.gov/todayinenergy/detail.cfm?id=4850, Accessed 14 January 2015.

Biofuels

Wood pellets have the potential to become a key input feedstock to biorefineries producing advanced biofuels. At this point however, the nascent industry has not yet triggered a vast expansion of wood pellet production. The key underlying policy to the growth of the advanced biofuels industry is the 2007 Energy Independence and Security Act (EISA), amending the Renewable Fuel Standard (RFS) as established by EPACT in 2005. By 2022, the U.S. shall produce 36 billion gallons of biofuels. Of that, 21 billion gallons shall be advanced biofuels (derived from feedstock other than corn starch). Of the 21 billion gallons, 16 billion shall come from cellulosic ethanol. The remaining 5 billion gallons shall come from biomass-based diesel and other advanced biofuels.[12] The U.S. Environmental Protection Agency (EPA) is revising its current RFS to reflect the changes in the EISA. The figure below lists the new targets for biofuels production as prescribed by EISA. For details see IEA Bioenergy Task 40 U.S. Country Report (Hess et al. 2015).

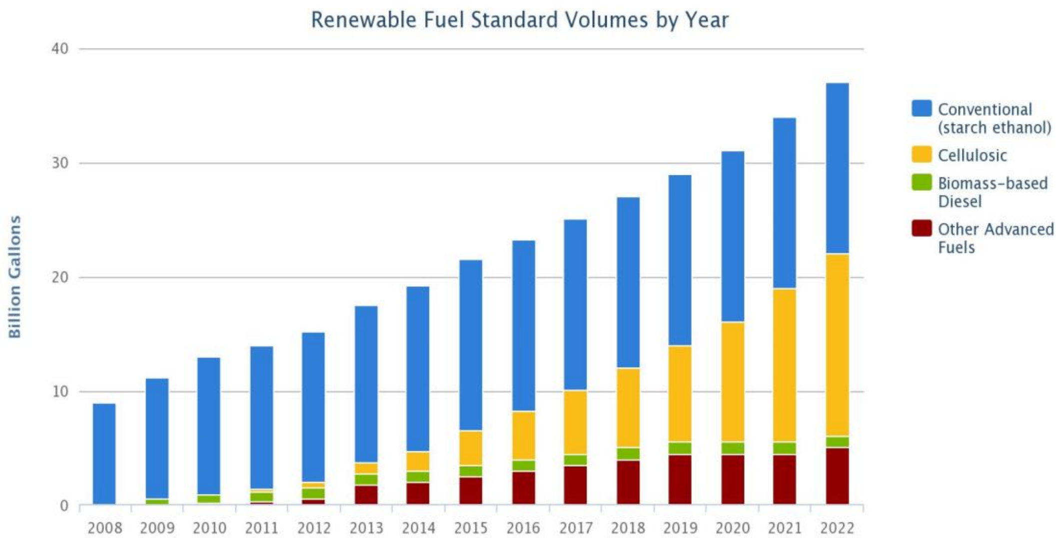


Figure 4.7 - Renewable Fuel Standard Volumes by Year (US Department of Energy, 2015)

Biomass Crop Assistance Program (BCAP)

A detailed analysis of subsidies provided in the energy sector including biomass was undertaken by the Energy Information Administration for the year 2010 (EIA, 2015)[13]. In relation to wood pellets, the Biomass Crop Assistance Program (BCAP) is relevant to discuss.

While tax credits for ethanol and biodiesel have been terminated (ethanol at the end of 2011, biodiesel at the end of 2014), the biofuel industry is still able to benefit from indirect financing via agricultural and forest feedstock support programs, predominantly the Biomass Crop Assistance Program (BCAP).

The BCAP for USDA's Farm Service Agency (FSA) was created as part of the 2008 Farm Bill (The Food, Conservation, and Energy Act of 2008) to reduce U.S. reliance on foreign oil, improve domestic energy security, reduce carbon pollution, and spur rural economic development and job

[12] Energy Independence and Security Act of 2007, P.L. 110-140.
[13] http://www.eia.gov/analysis/requests/subsidy/pdf/subsidy.pdf [November 8, 2016]

creation (USDA, 2010)[14]. It is now in its 4th Amendment and supported by the 2014 Farm Bill (United States Department of Agriculture, n.d.)[15].

BCAP was initially set in place to help address bioenergy's "chicken-and-egg" challenge of establishing commercial-scale biomass conversion facilities and sufficient feedstock supply systems simultaneously:

- Conversion facilities must have reliable, large-scale feedstock supplies to operate, but there are no existing markets for accessing these materials
- Biomass feedstock producers do not have sufficient incentive to produce these materials because of the lack of existing markets to purchase their biomass.

The BCAP provides two categories of financial assistance to owners and operators of agricultural and non-industrial private forest land who wish to establish, produce, and deliver biomass feedstocks:

First, establishment and annual payments may be available to certain producers who enter into contracts with the *Commodity Credit Corporation* (CCC) to produce eligible biomass crops on contract acres within BCAP project areas.

Second, *matching payments* may be available to eligible material owners (EMO) for the sale and delivery of eligible material to qualified biomass conversion facilities (QBCF). Qualified biomass conversion facilities produce research, heat, power, biobased products, or advanced biofuels from biomass feedstocks. These payments are available to EMO's at the rate of $1 for each $1 per dry ton paid by QBCF to EMO's, limited to a maximum of $20 per dry ton and limited to a 2-year payment duration. All payment rates used in sales transactions between EMO's and QBCF's must reflect fair market values for the various types and varieties of eligible material biomass.

QBCF operations need to register and be accepted as an eligible facility under BCAP. In FY16 (10/15-09/16), most accepted facilities were based on forest residues (followed by agricultural/orchard residues), including the following wood pellet plants (USDA, 2010)[16]:

- Confluence Energy, CO (at locations in Walden and Kremmling), sourcing primarily dead (mountain pine beetle kill) trees: combined capacity 190,000 dry tonnes
- Forest Energy Corporation, AZ (Show Low location): 56,000 dry tonnes capacity
- Zilka Biomass, AL (Selma plant): 270,000 dry tonnes capacity

4.2.2 Production capacity, production and feedstock

Production capacity and regional industry trends

With the latest commissioning of the Highland Pellets plant in Pine Bluff, AR, at the end of 2016[17], the U.S. pellet industry had reached an operational production capacity of 13.7 Mt (Table 4-5). The majority of the plants produce wood pellets, representing 13.2 Mt of the operational capacity.

Wood pellet production has seen a steady growth since 2004, with an exponential increase across the U.S. South (Figure 4.9). In the U.S. South, 119 mills consuming pulpwood and residual chip

[14] http://www.fsa.usda.gov/Internet/FSA_File/bcapoctrules.pdf [October 8, 2016].
[15] http://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Energy/1bcap-a4.pdf [October 17, 2016]
[16] http://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Energy/bcap_facility_listing_FY2016.pdf [October 17, 2016].
[17] http://www.biomassmagazine.com/articles/14001/highland-pellets-commissions-arkansas-pellet-plant [December 8, 2016]

fiber were operating by 2015; the same amount as in 2000 (Forest2Market 2015). However, there had been an internal shift in the sector from pulp and paper to wood pellet production. 16 new wood pellet facilities were built in the U.S. South since 2005. Between 1995-2015, 14 pulp and paper mills permanently closed across the U.S. South (Forest2Market 2015). The panelboard and oriented-strand-board (OSB) sector experienced both openings and closings across the same period with a net loss of three panelboard and a net growth of four OSB facilities (Forest2Market 2015).

Nationally however, the number of forest product establishments has declined since 2002 with the rate of decline increasing after 2007 (Hodges *et al.* 2012). Reasons for the decline have been structural such as an increased internationalization but also singular such as the global recession. Although the industries may not return to pre-recession levels, the recent slow but steady recovery of the U.S. housing market is expected to support a recovery of the sawmill and engineered wood product sectors. The pulp and paper sector however has seen a structural decline in newsprint and paper mills due to the increase of digital content.

Table 4-5 - U.S. Pelleting Capacity by feedstock – Status: December 2016 (Biomass-Magazine 2016)

Feedstock	Capacity [t]	Subtotal
Agricultural processing residues	n/a	
Biomass Crops	22,680	
Crop Residue	32,024	
SUM Ag feedstock		54,703
Hardwood	1,661,917	
Softwood	4,568,219	
Hardwood and Softwood	6,365,402	
SUM Woody feedstock		12,595,539
Paper Waste	154,221	
Unknown	282,148	
SUM other		436,369
SUM operating	13,685,354	
Under construction	2,324,434	
Proposed	3,603,156	

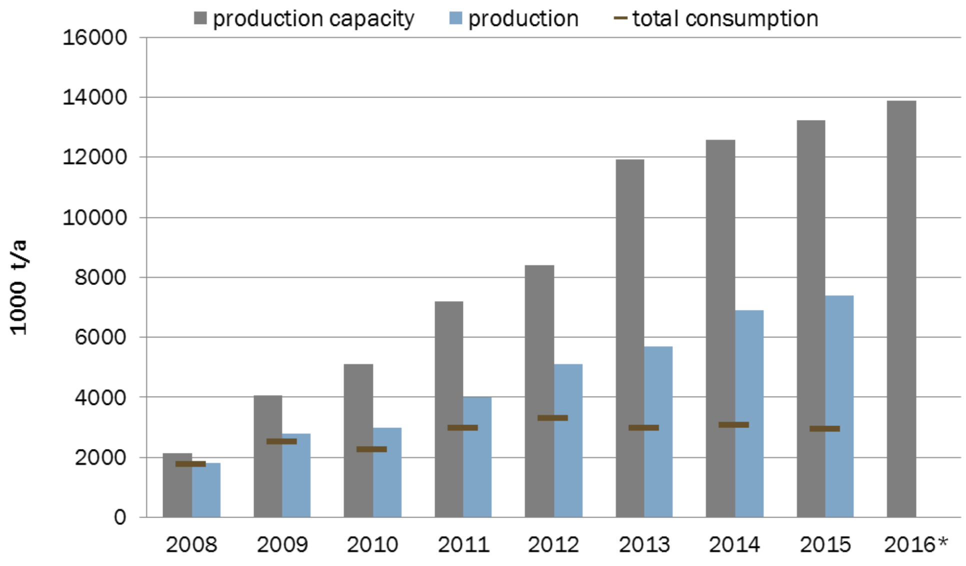


Figure 4.8 - Wood pellet market development in USA from 2008 to 2016 (2016* estimated).

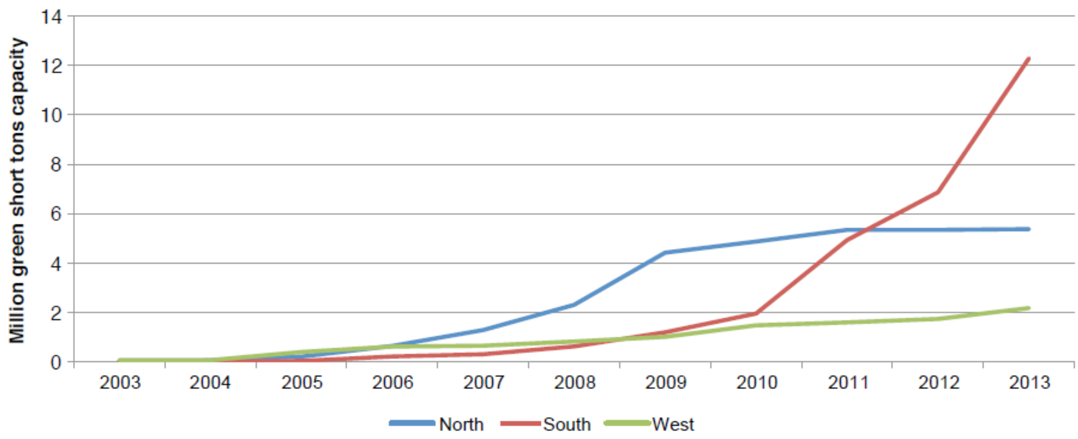


Figure 4.9. - Growth in pellet production capacity by U.S. region from 2003 through 2013 (Forisk Consulting in Abt et al., 2014)

Geographic concentration

Pellet mills across the U.S. are located mainly in the key wood producing regions, including the Southeast, Northeast, and Northwest (Figure 4.10).

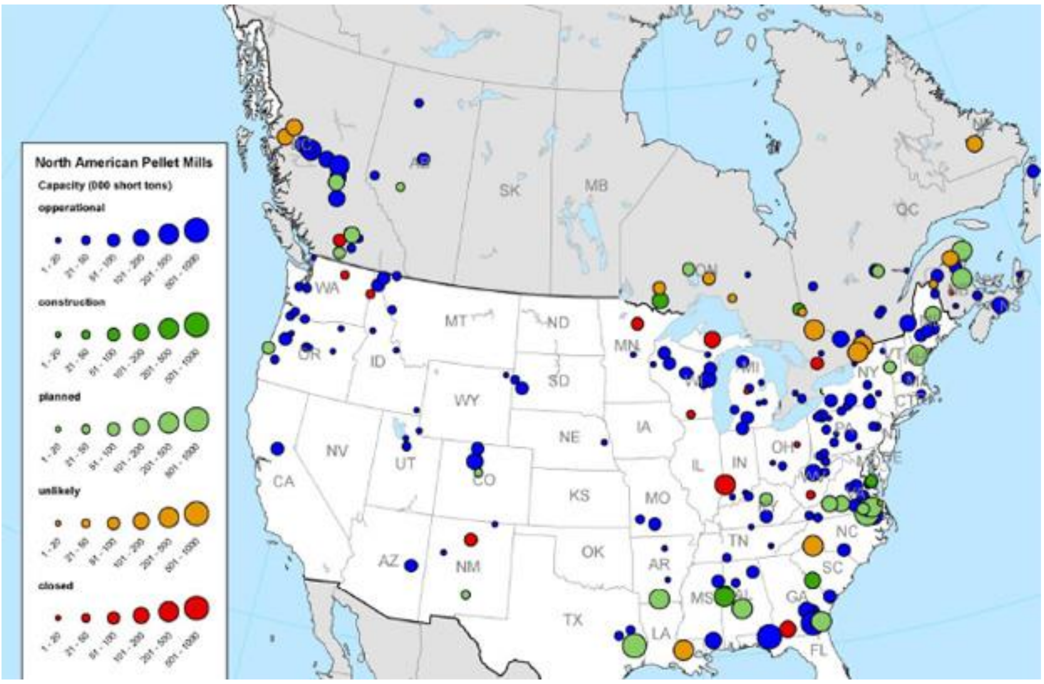


Figure 4.10. - Geographic location of North American Pellet Mills (Source: http://i.bnet.com/blogs/north-american-pellet-mills.jpg)

Main operations

There are 15 wood pellet plant operations above 300,000 short tons annual capacity (272,155 t/a); all located within the Southeastern U.S. (Table 4-6). The main operations and market actors include:

- Enviva: most plants (seven) with a total capacity of 3 Mt (2.7 Mt)
- Drax: a combined capacity of 996,000 tonnes (890,000 t) with its Amite BioEnergy and Morehouse BioEnergy plants
- Georgia Biomass: largest single plant in the U.S. with 825,000 tonnes (740,000 t) capacity, owned and operated by RWE Innogy
- German Pellets used to be a significant market actor, but filed for insolvency of two U.S. subsidiaries in 2016 reducing its overall production share

Table 4-6 - U.S. wood pellet plant operations above 300,000 short tons annual capacity (272,155 t/a) (Biomass-Magazine, 2016, adapted).

Plant	State	Feedstock	Capacity in short tons (tonnes)
Georgia Biomass (RWE)	GA	Softwood	825,000 (748,427)
Hazlehurst Wood Pellets	GA	Softwood	700,000 (635,029)
Enviva Pellets Cottondale	FL	Softwood	660,000 (598,741)
Highland Pellets	AK	Softwood	660,000 (598,741)
La Salle Bioenergy (Louisiana)	LA	Softwood	578,000 (524,353)

Plant	State	Feedstock	Capacity in short tons (tonnes)
German Pellets Texas	TX	Hardwood and Softwood	551,155 (499,999)
Enviva Pellets Northampton	NC	Hardwood and Softwood	550,000 (498,952)
Enviva Pellets Southampton	VA	Hardwood and Softwood	550,000 (498,952)
Enviva Pellets Hamlet	NC	Woody Biomass	550,000 (498,952)
Blue Sky Biomass Georgia	GA	Woody Biomass	540,000 (489,880)
Amite BioEnergy (Drax)	MS	Softwood	500,000 (453,592)
Morehouse BioEnergy (Drax)	GA	Softwood	496,000 (449,964)
Enviva Pellets Ahoskie	NC	Hardwood and Softwood	449,000 (407,326)
Westervelt Renewable Energy	AL	Softwood	309,000 (280,320)
Zilkha Biomass - Selma	AL	Hardwood and Softwood	303,000 (274,877)

Feedstock selection – U.S. South (east)

As shown in Figure 4.11, pellet mills typically use residual chip fiber and pulpwood; the same feedstock as panelboard, OSB or pulp and paper mills.

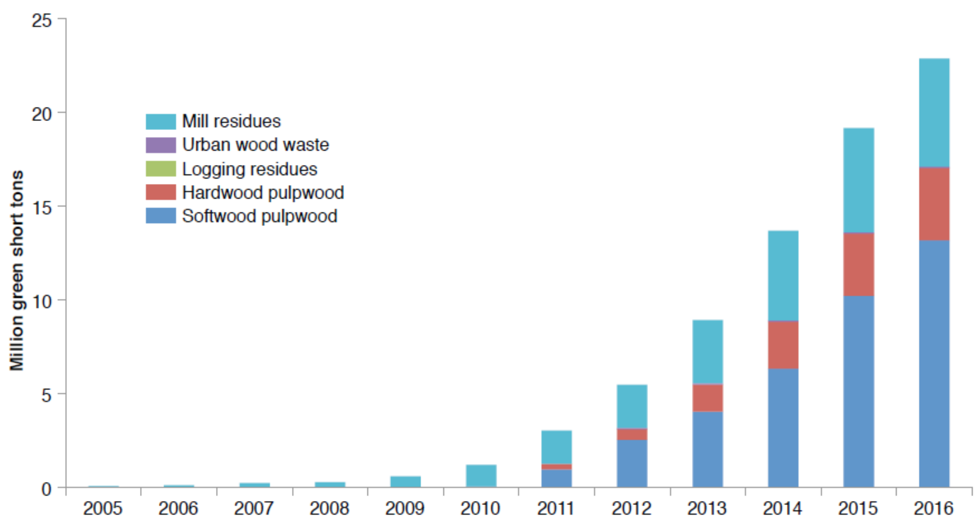


Figure 4.11 - Actual and announced feedstock source for use in pellet production in the U.S. South for 2005–2016 (Forisk Consulting in Abt et al., 2014).

It is estimated that 2-4 % of the wood market volume in the southeastern United States is wood based pellets as pellets have a much lower market value compared to timber and pulp for paper.[18] Therefore bioenergy feedstock is most often a byproduct of management for higher value forest products.

[18] Information gathered during the ORNL Bioenergy Study Tour 2016: https://www.ornl.gov/news/ornl-hosts-southeast-bioenergy-meeting-study-tour

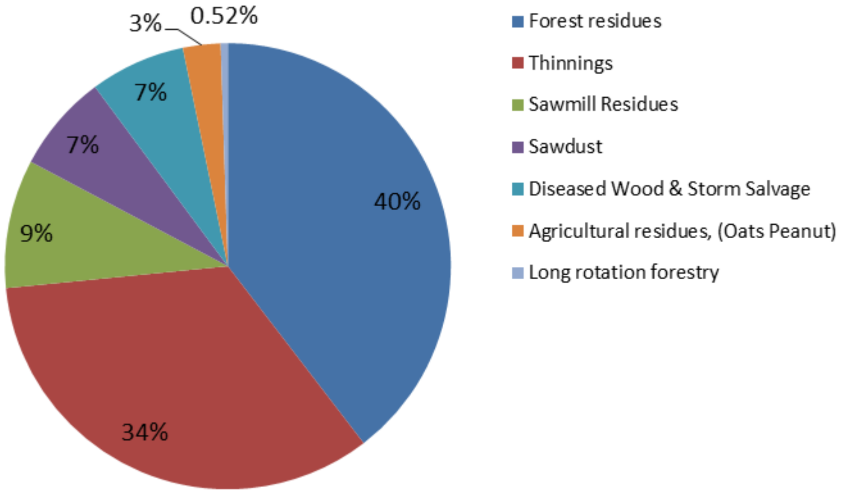


Figure 4.12 - Drax 2014 U.S. feedstock sourcing portfolio (http://www.drax.com/media/56583/biomass-supply-report-2014.pdf).

4.2.3 Consumption

Wood energy consumption

The U.S. biomass consumption for energy has increased by almost 2 trillion Btu (roughly 2 EJ) over the last decade (Figure 4.13). This increase however was solely observed in the liquid biofuels sector. Woody and waste biomass for energy use remained stagnant. The overall trend may not be reflected across all regions of the U.S.

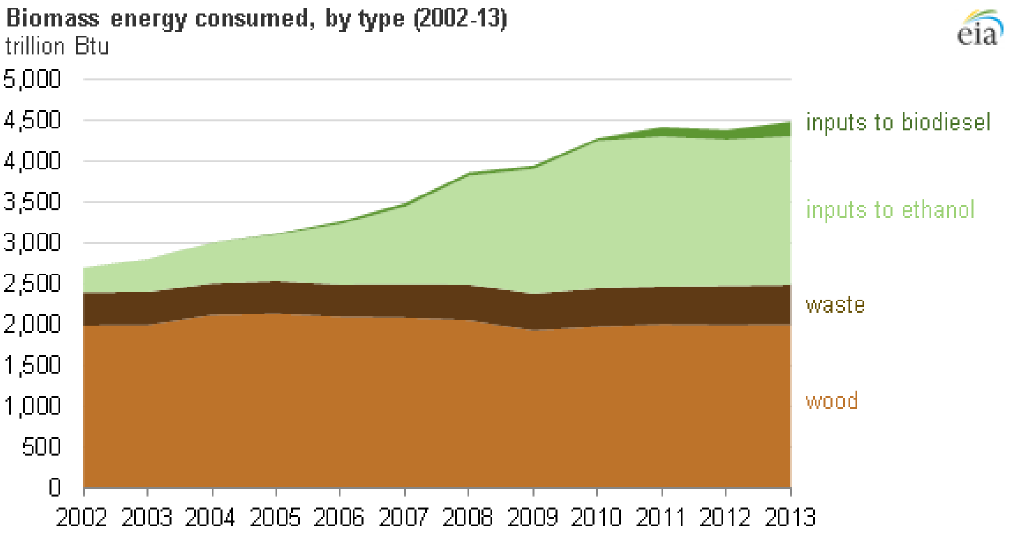


Figure 4.13 - Biomass energy consumed by type between 2002-2013 (Source: EIA, http://www.eia.gov/todayinenergy/detail.cfm?id=15451).

Wood pellet consumption

No official statistics on domestic wood pellet consumption exists. However, it can be approximated via the following formula: $C_i = P_i + I_i - E_i$

Where C_i: Consumption in year i

P_i: Production in year (Sources: Lamers et al. 2012, FAOSTAT 2016)

I_i: Imports in year i (Sources: Statistics-Canada 2016, USDA 2016)

E_i: Exports in year i (Sources: EUROSTAT 2015, USDA 2016)

Table 4-7 - Estimated domestic consumption based on production, import and export statistics (metric tonnes).

	2008	2009	2010	2011	2012	2013	2014	2015
P_i	1,800,000	2,800,000	3,000,000	4,000,000	5,100,000	5,700,000	6,900,000	7,400,000
I_i	440,000	293,000	40,000	50,000	86,736	152,442	219,987	207,172
E_i	490,000	577,742	794,955	1,081,834	1,898,117	2,882,423	4,055,689	4,668,552
C_i	1,750,000	2,515,258	2,245,045	2,968,166	3,288,620	2,970,019	3,064,297	2,938,620

Main consumers

The main consumers of U.S. produced wood pellets are export markets, accounting for 63 % in 2015. The remaining share is consumed domestically in residential heating. It is estimated that over 13 million wood heaters are in operational use across the U.S., the minority (roughly 10 %) of which is wood pellet stoves (Figure 4.14). Commercial use is limited and expected at less than 1 % total consumption (Table 4-8).

U.S. biopower and/or -heat facilities are not known to use wood pellets in significant quantities. Rather, these installations are regionally integrated and make use of local wood waste fractions. A key reason is that – apart from state Renewable Portfolio Standards setting mandatory renewable electricity production levels for power companies – there are no U.S. incentive schemes which could close the gap between the oversea and domestic market willingness-to-pay (WTP). Hence, U.S. biopower and CHP installations are usually in the vicinity of wood processing industries or urban agglomerations where they can make use of construction and demolition wood (Figure 4.15, Figure 4.16).

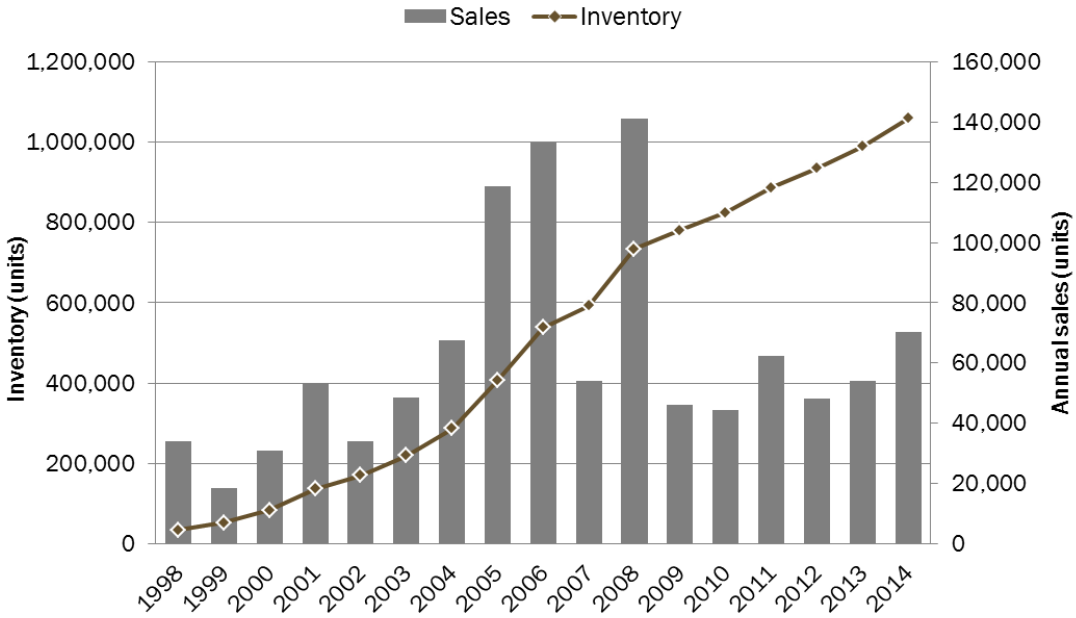


Figure 4.14 - U.S. pellet stove sales and inventory (Source: Hearth, Patio, and Barbeque Association; RISI; own calculations).

Table 4-8 - Wood and wood-derived fuel consumption by sector as projected in EIA 2016 (PJ).

Peta-Joule	**2012**	**2013**	**2014**	**2015**	**Comments**
Marketed Use (PJ)					
>> Residential: Wood: Reference case	468	615	646	498	Fuelwood dominates
>> Commercial: Biomass: Reference case	112	127	127	127	
Electric Power Generation (PJ)					
>> Dedicated Plants: Reference case	109	122	114	117	
>> Co-firing: Reference case	72	72	65	66	
Million tonnes (theoretical)					
Marketed Use (Mt)					
>> Residential: Wood: Reference case	26.6	34.9	36.7	28.3	10% wood pellets
>> Commercial: Biomass: Reference case	6.3	7.2	7.2	7.2	<1% wood pellets
Electric Power Generation (Mt)					
>> Dedicated Plants: Reference case	6.2	7.0	6.5	6.6	<1% wood pellets
>> Co-firing: Reference case	4.1	4.1	3.7	3.8	<1% wood pellets
Calculated wood pellet consumption	2.8	3.7	3.8	3.0	Sum of estimates

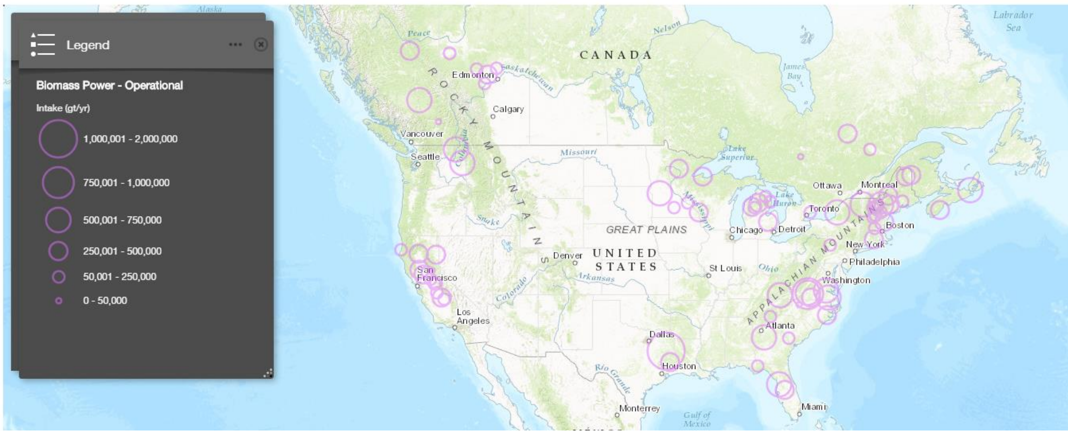


Figure 4.15 - Biomass power operational (www.wood2energy.org).

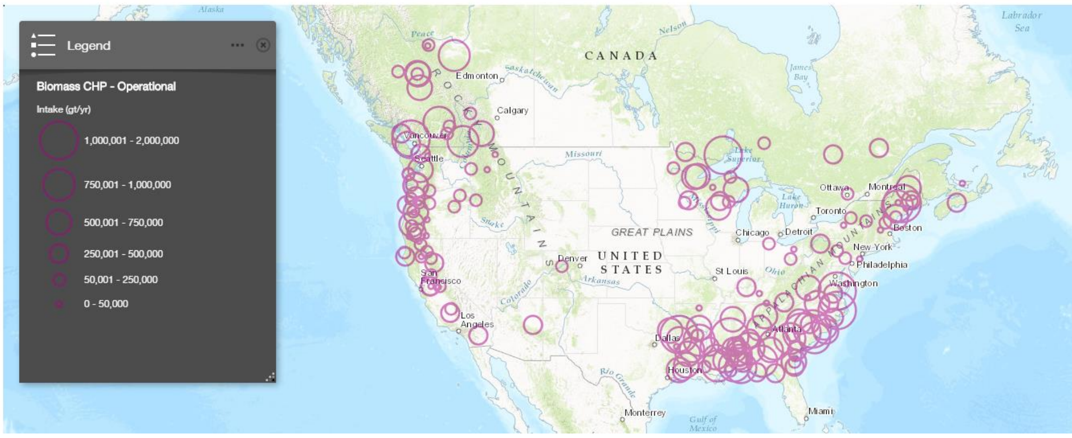


Figure 4.16 - Biomass CHP operational (www.wood2energy.org).

4.2.4 Price trends

Historically, industrial wood pellets sold for $155 to $175 per tonne at Amsterdam, Rotterdam, or Antwerp (ARA) harbors (CIF-price: Cost, Insurance and Freight). U.S. FOB (Free-On-Board) or FAS (Free-Alongside-Ship) export prices have ranged between $140 and $155 per tonne in main distribution harbors along the Southeast (e.g., Savanna, GA, and Mobile, AL).

Residential markets are supplied by bagged pellets, stacked on pallets for bulk distribution. Prices vary, but are typically in the range of $5 (standard) to $7 (premium) per 40 pound bag (18.14 kg), equaling $275 to $385 per tonne (excl. tax) at a final user distribution center, e.g., supermarket.

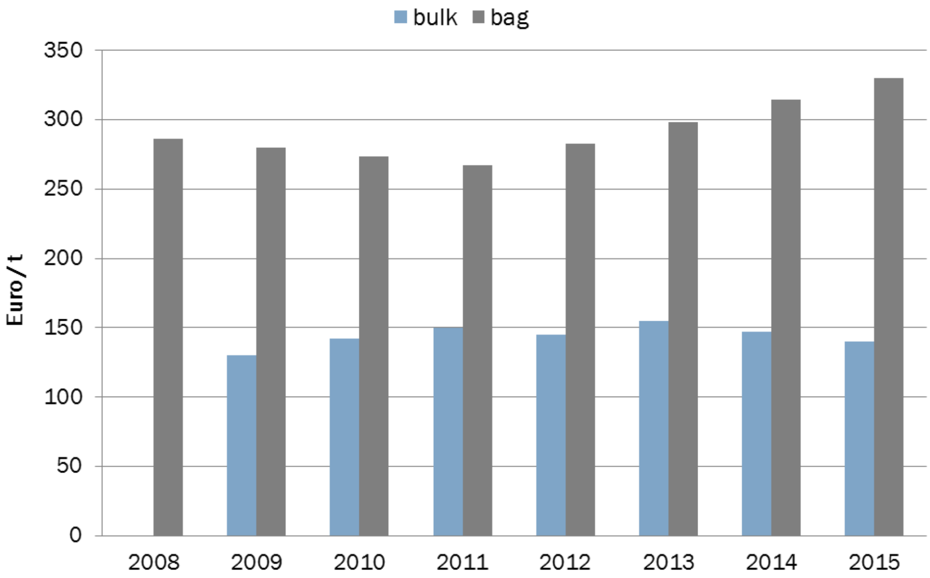


Figure 4.17 - Average wood pellet prices in USA from 2008 to 2015.

A comparison of residential heating alternatives reveals that wood pellets are price-competitive against all alternatives except for natural gas (Table 4-9).

Table 4-9 - Example heating price comparison (Source: http://www.pelletheat.org/compare-fuel-costs).

Fuel	Costs	Appliance efficiency	Cost per GJ
Wood pellets	$275 per tonne	78%	$18.25
Fuel oil (#2)	$0.86 per liter	78%	$28.48
Electricity	$0.12 per kWh	100%	$33.18
Natural Gas	$0.04 per kWh	78%	$14.51
LP gas / Propane	$0.77 per liter	78%	$38.80
Hardwood air-dry	$97 per m^3	63%	$26.21

*: one million Btu equal: 293 kWh or 1.06 GJ

4.2.5 Trade and logistic aspects

U.S. pellet production grew from just under 2 Mt in 2008 to about 7.4 Mt by 2015 (Figure 4.18). Domestic consumption has remained relatively stable around 3 Mt. Annual cross-border trade with Canada is in the range of 250,000 t and exports, 98 % of which go to the EU, have reached almost two thirds of total production (Table 4-10,

Table 4-11).

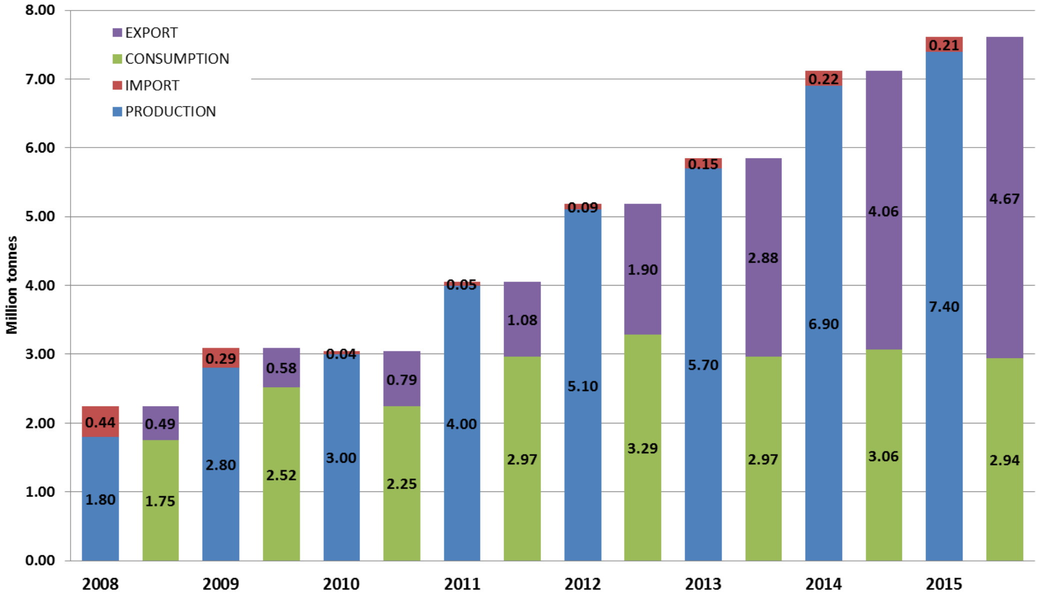


Figure 4.18 - U.S. wood pellet production, consumption, imports and exports from 2008-2015 (EUROSTAT, 2015; FAOSTAT, 2016; Lamers et al., 2012; Statistics Canada, 2016; USDA, 2016).

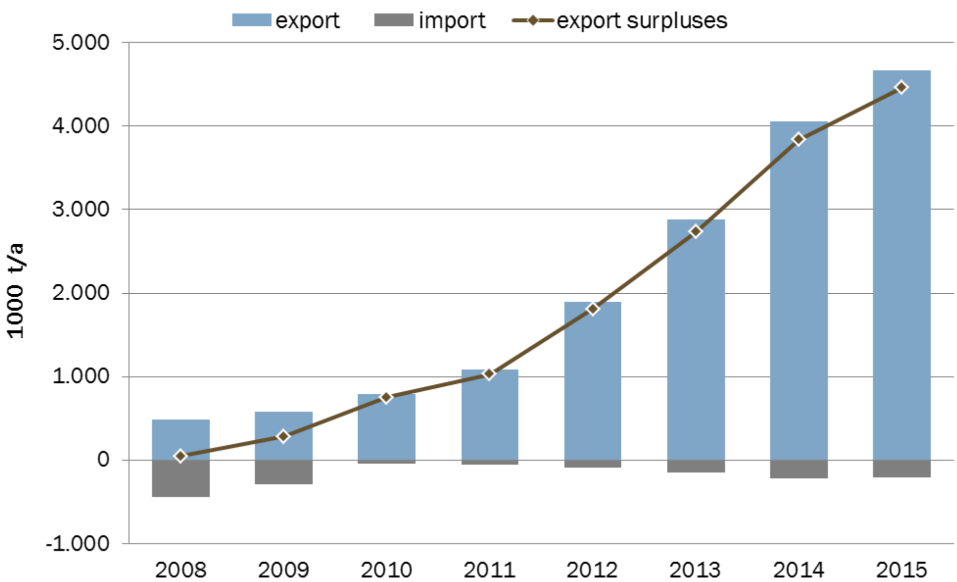


Figure 4.19 - Evolution of export and import in the USA from 2008 to 2015.

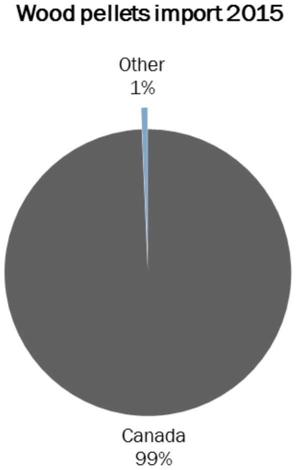
Traditionally, the U.S. wood pellet industry was medium- to small-scale, supplying residential heating market segments via truck. The largest increase in pelleting capacity was seen across the Southeast, where large-scale production destined for EU export markets has emerged since 2007/2008. Logistics in this region are dependent on large-scale bulk transport including barge and rail transport of wood pellets to transloading stations at harbors and oversea transport to Europe.

Table 4-10 - Imports in metric tonnes (USDA, 2016)

	2012	2013	2014	2015
Canada	86,665	152,271	218,889	205,743
Other	71	170	1,097	1,428
Total imports	86,736	152,442	219,987	207,172
of which from Canada	*99.9%*	*99.9%*	*99.5%*	*99.3%*

Table 4-11 - Exports in metric tonnes (USDA, 2016).

	2012	2013	2014	2015
United Kingdom	672,977	1,682,244	2,962,786	3,914,785
Belgium (and Luxembourg)	495,553	534,668	472,272	610,044
Netherlands	499,162	178,414	299,631	63,617
France	0	90	1,019	48,821
Canada	32,705	21,579	22,869	22,352
South Korea	26	33,600	54,956	3,797
Italy	13,580	150,319	119,736	1,792
Denmark	29,201	195,589	105,108	1,343
Sweden	45,932	22,352	14,768	0
Other	108,983	63,568	2,544	2,000
Total exports	1,898,117	2,882,423	4,055,689	4,668,552
of which to EU28	*93%*	*98%*	*98%*	*99%*



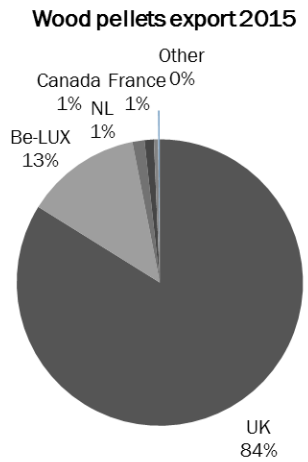


Figure 4.20 - Pellet exports and imports from USA in 2015.

4.2.6 Pellet quality standard

63 % of the total 2015 U.S. production was exported, with 99 % of this volume destined for the European Union (EU) market. Hence, EU specific quality standards predominantly for industrial applications apply to this production share. The remaining production share is largely targeted towards the domestic market and within this market largely the residential heating segment.

The New Source Performance Standards (NSPS) for new residential wood heaters including pellet stoves, issued by the EPA in 2015, requires any new non-commercial wood-burning appliance to utilize fuel that has been graded through an EPA-authorized standards program list. Currently the Pellet Fuels Institute (PFI) Standards Program is listed as the only U.S.-based quality scheme. For appliances such as pellet stoves, manufacturers will be required to state that their products have been tested with fuel from a particular grading program. Manufacturers also must state such claims in the owner's manuals and in their product warranties or they will be voided.

The PFI Label is provided in a *Standard* and *Premium* class. Table 4-12 compares the key criteria to ENplus criteria. Naturally, U.S. producers could also apply the 2014 ISO standard 17225-2. The ISO and ENplus standard are mainly aligned, with a few stricter requirements in the ENplus. At this point, ten U.S. wood pellet producers are currently certified under the ENplus scheme.

Table 4-12 - Quality parameters for PFI and ENplus pellets.

	PFI Standard	PFI Premium	ENplusA1	ENplusA2	ENplusB
Bulk density (kg/m^3)	609-769	641-769	600-750		
Diameter (mm)	5.84-7.25		6-8 mm		
Durability (w%)	≥95.0	≥96.5	≥98.0	≥97.5	
Fines (w%)	≤1.0	≤0.5	≤1.0		
Ash content (w%)	≤2	≤1	≤0.7	≤1.2	≤2.0
Length (mm)	≤1% >38mm	≤1% >38mm	3-40 mm		
Moisture (w%)	≤10	≤8	≤10		
Chlorides	≤300 ppm		≤0.02 wt%	≤0.03 wt%	

Sources: http://www.pelletheat.org/; http://www.enplus-pellets.eu/

4.2.7 Proposed plants

About 3.5 Mt of additional capacity are currently proposed across the U.S.

Pellet plants which are already in operation in the U.S. are listed in Table 4-13.

Table 4-13 - Operational U.S. wood pellet plant list by capacity (Biomass-Magazine 2016).

Plant	Location	Feedstock	Capacity (short tons/yr)	In metric tonnes (t/a)
Biograss Industries	Cashiers, NC		1,000	907
Iowa Biomass Pelleting Inc.	Kilduff, IA	Crop Residue	12,000	10,886
ATP-SC LLC	Allendale, SC		13,000	11,794
HTC1	Hillsborough County, FL		15,000	13,608
Woodshed Renewables LLC	Finley, ND	Hardwood and Softwood	22,000	19,958
Kingdom Pellet	Gilman, VT	Softwood	30,000	27,216
Zilkha Biomass - Monticello	Monticello, AR		41,300	37,467
The Fair Haven Energy Center	Fair Haven, VT	Hardwood and Softwood	110,000	99,791
Thermogen Industries	Millinocket, ME	Woody Biomass	110,000	99,791
American BioCarbon, LLC	White Castle, LA		200,000	181,439
Fulghum Graanul Oliver LLC	GA	Hardwood and Softwood	200,000	181,439
Cornerstone Biomass Corp.	Live Oak, FL		220,500	200,036
Centennial Renewable Energy of Idaho (CRE)	ID		231,000	209,562
F.E. Wood & Sons - Natural Energy	West Baldwin, ME	Hardwood and Softwood	344,000	312,075
Ogeechee River Pellet Mill	Millen, GA	Woody Biomass	397,000	360,156
General Biofuels - Georgia	Sandersville, GA	Softwood	440,000	399,165
International Biomass Energy LLC	Jackson, AL	Hardwood and Softwood	485,000	439,989
Enviva - Laurens County	Laurens County, SC		550,000	498,957
Enviva Pellets Hamlet	Hamlet, NC	Woody Biomass	550,000	498,957
			3,971,800	3,603,193

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5 Wood pellet industry and market in Asia, Australia and Latin America

5.1 Australia and New Zealand

Thuy Mai-Moulin, Martin Junginger

Currently, in New Zealand are some small white pellet producers mainly for domestic use. The Norwegian paper manufacturer Norske Skog plans to increase production from 20,000 t of wood pellets to 80,000 t in 2016 (mainly for domestic market). In the future Norske Skog aims to expand its production up to 200 kt. Additionally, there are some companies further investigating the market for exports.

In Australia, there are a number of wood pellet plants producing wood pellets for export markets. The plant: Plantation Energy Australia (PEA) built a wood pellet export facility at Albany, Western Australia with a two line production of 125,000 t/a. However, given the market conditions such as falling price for pellets in Europe, cost of shipping, the rising currency (Australian dollar), the plant closed down. According to Dr. S. Schuck, Manager of Bioenergy Australia, PEA might be open again but focusing on the domestic market (or parts of it, as only the southern states have a domestic heating market).

Another company, Altus Renewables Limited has one plant in north Brisbane with capacity of 100,000 Mt/a but currently producing at about 60-70,000 Mt/a. Altus Renewables Limited exports wood pellets to markets in the UK, Korea, Japan and has a vessel going to Europe in early October. They plan to increase the capacity to 125,000 Mt in 2017.

In addition, there are several companies such as Recycling Technologies Pty Ltd which recently set up a pellet line at Eden, southern New South Wales targeting a local domestic heating market or a small pellet producer at Broadwater NSW, mainly servicing the animal bedding/kitty litter market plus some chicken feed and possibly some energy pellets. In Tasmania, in the most southern state, the forest industry produces millions of tonnes of residues each year and the Tasmanian Government has called for expressions of interest from the private sector, to put them to good use (Fromberg, 2015). Representative of Wood Pellets Tasmania, there was huge potential for native timber residues to be made into wood pellets for bio-energy. Currently Wood Pellets Tasmania produces 1,200 t of hardwood pellets a year, but there is already demand for 3,000 t of domestic market.

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5.2 China

Thuy Mai-Moulin, Martin Junginger

Unlike Japan and South Korea, other Asian countries are mainly wood pellet exporters such as China, Thailand, Vietnam, Indonesia and Malaysia. China's renewable energy sector is growing fast in recent years. In 2013, the Chinese National Energy Administration released "Guiding Opinions on Establishing Renewable Energy Portfolio Standards (RPS)" which set renewable energy consumption targets for China to achieve 15 % and 20 % of renewable energy in the total primary energy consumption by 2020 and 2030 respectively. The RPS is a regulation that requires the increased production of energy from renewable energy sources, such as wind, solar, biomass, and geothermal. It stipulates electricity supply companies to produce a specified fraction from renewable energy sources, however many aspects of the policy are left undeveloped such as lacking of monitoring and compliance requirements and insufficient monitoring for trading and insufficient penalty for not demonstrating compliance with the mechanism (Xin-gang et al., 2014).

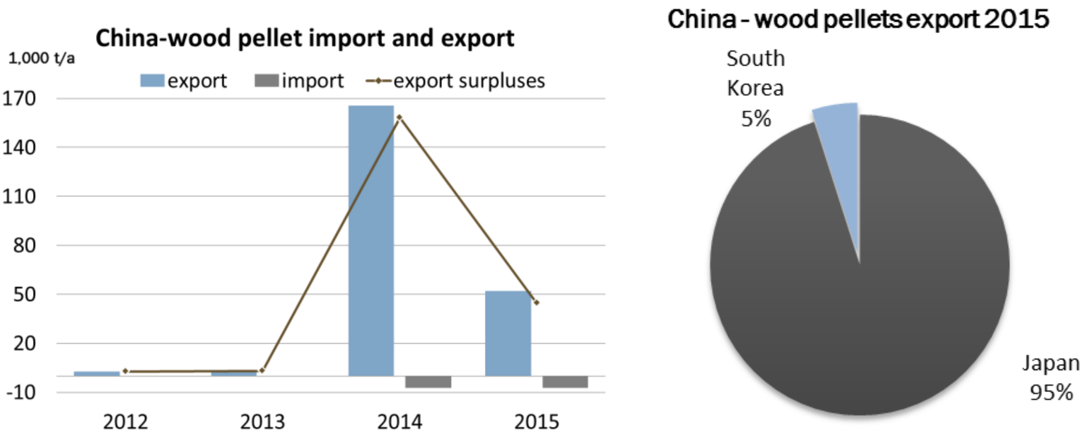

Figure 5.1 - Pellet exports and imports from China in 2015.

Biomass energy resources in China are diverse, including crop stalks, tree branches, animal manure, energy crops, industrial organic waste water, municipal sewage and garbage. Availability from wood (forest) wastes is about 900 Mt in which 300 Mt can be used as energy use. Energy crops such as *sorghum, jatropha curcas* dominate about 2,000 million hectares, to meet the annual output of about 50 Mt of bio-liquid fuel raw materials demand (Chinese national bureau of energy, 2012). China's domestic demand for wood pellets is growing, largely in the east and in Guangdong province, where the local government has prohibited coal-fired boilers and the cost of pellets is lower than elsewhere in the country (Murray, 2015).

In addition to biomass production for the domestic market which has grown since the last few years, China is also an exporter. In 2014, China exported 287 kt of wood pellets to South Korea. In 2015, the export fell sharply as Chinese producers had to compete with Vietnamese producers for cheaper wood pellet prices; however it gained a growing Japanese biomass market which supports growth in the coming years (Argus Media, 2016). High production costs as results of tight wood resources supply renders Chinese wood pellets less competitive as price increases (€105/t), Chinese wood pellets trader have limited room for negotiation (Argus Media, 2016).

5.3 Japan

Thuy Mai-Moulin, Martin Junginger

5.3.1 Regulatory framework, market drivers and barriers

In Japan, there are a number of policies and incentives established to promote the renewable energy production as well as biomass utilization for heat and power generation. The 2009 Basic Act for the Promotion of Biomass Utilization aimed to establish a comprehensive and planned promotion of biomass utilization policy or the 2010 National Plan for the Promotion of Biomass Utilization aimed to set basic policies on the development of technologies for biomass utilization (Honda et al., 2015). The most important policy after the 2011 Japan Earthquake and Fukushima nuclear power plant accident is Feed-in Tariff (FIT) Scheme for Renewable Energy which has been implemented since July 2012. Under this scheme, electric utilities are obliged to purchase electricity generated from renewable energy sources such as solar PV and biomass on a fixed-period contract at a fixed price (METI, 2012). Pellet consumption in Japan has grown rapidly since then. Japan has diversified its power mix after the Fukushima disaster in 2011. Purchase price of FIT has been reexamined every year by the Ministry of Economy, Trade and Industry (METI) and under this scheme, generators receive 0.15-0.28 €/kWh depending on the wood source they use. There are regular changes and amendments of FIT scheme which make it sophisticated and challenging for generators to understand and to demonstrate compliance with the scheme requirements.

5.3.2 Production capacity, production and feedstock

Data from (FAOSTAT, 2016) indicated that domestic production of wood pellets in the last 5 years was about 90 kt. However, a higher quantity of wood pellets import has indicated a larger consumption of wood pellets in Japan. Import from Canada, China and Vietnam has reached 230 kt in 2015 (Argus Media, 2016).

Japanese pulp and paper firms Oji Green Resources, a subsidiary of Oji Holdings, and Mitsubishi Paper Mills have formed a joint venture to build a 75 MW biomass power plant supposed to be operational in 2019 at Mitsubishi Paper's Hachinohe mill, in Japan's Aomori prefecture.

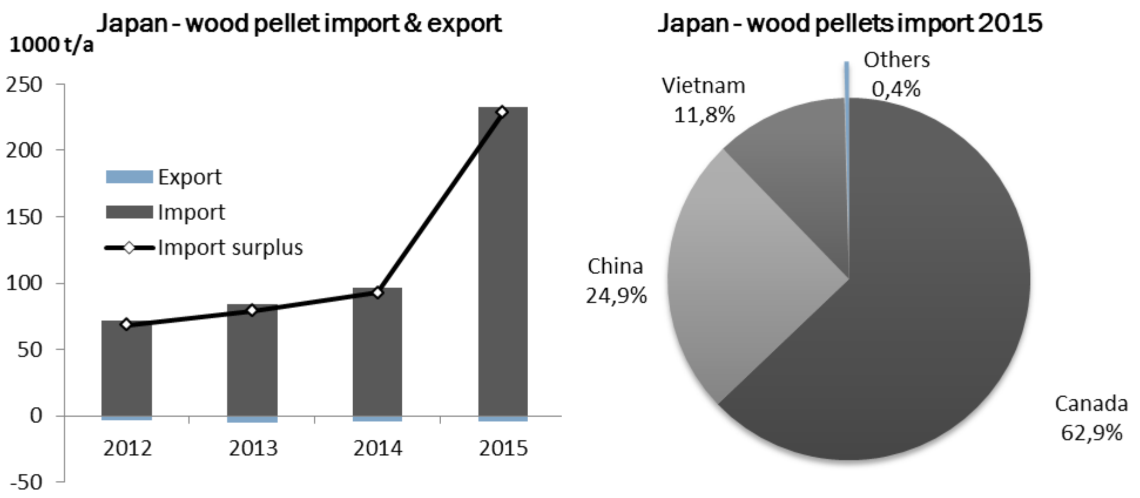

Figure 5.2 - Wood pellet import and export in Japan. (Bassett and Young, 2015; FAOSTAT, 2016).

5.3.3 Consumption

Taking into account the domestic production, import and export, the consumption of wood pellets is about 320 kt in 2015 (FAOSTAT, 2016; Argus Media, 2016).

5.3.4 Price trends

Japan tends to import high quality and export lower quality of wood pellets (FAOSTAT, 2016). The import price of wood pellets has decreased from 207 €/t in 2012 to 178 €/t in 2015. In contrast, the export value was about 110 €/t in 2012-2014 and increased to 129 €/t in 2015.

5.3.5 Pellet quality standard

In general, there is a variety of wood to be used for power generation in Japan. The higher the quality of pellet is, the higher the purchase price. Unused wood represents the highest quality and price (0.23-0.29 €/kWh) (Shen, 2015). Other woods such as sawmill residues, import wood, wood wastes, etc. are also used in biomass generation plants.

The Basic Act for the Promotion of Biomass Utilization has a number of requirements for wood pellets and general biomass use including:

- Comprehensive, Uniform and Effective Utilization of Biomass
- Mitigation of Global Warming
- Development of Recycling-based Society
- Promotion of industrial Development and International Competitiveness
- Revitalization of Rural Areas
- Full Utilization of Different Types of Biomass
- Diversification of Energy Sources
- Promotion of Community-based Voluntary Actions
- Raising of Social Awareness for Biomass
- Consistency between Stable Food Supplies and Biomass Utilization
- Considerations for Environment Preservation

Illegal logging for wood pellets is prohibited in Japan. The Japanese government promotes international efforts to combat illegal logging and implements a governmental procurement policy under the principle that "illegally harvested timber should not be used" (MAFF Japan, 2012). In 2010, the GOJ also developed a tracking system for wood products in cooperation with the Indonesian Government which is applicable to wood exporting countries. Wood pellets sold into Japan must be Forest Management (FM) certified (Argus Media, 2016).

5.3.6 Proposed pellet plants

Since the FIT scheme started in 2011, over 100 wood bio-mass electric power generation plants are under consideration and another 84 projects have been approved (Shen, 2015). The government aims to rapidly increase renewables by 2030 so that solar makes up about 15 % and others (biomass and hydro) make up about 10 % (Bassett and Young, 2015). In addition, government aims to establish a Biomass Town area where a comprehensive biomass utilization system is established and operated through the cooperation of various stakeholders in the area. Approximately 300 Biomass Town Plans have been developed to date since 2005 in Japan. Ministry of Agriculture, Forestry and Fisheries (MAFF) has compiled the guidebook aimed to promote the Biomass Town Concept throughout the East Asian countries and approximately 300 Biomass Town Plants have been developed to date since 2005 in Japan (MAFF Japan, 2015).

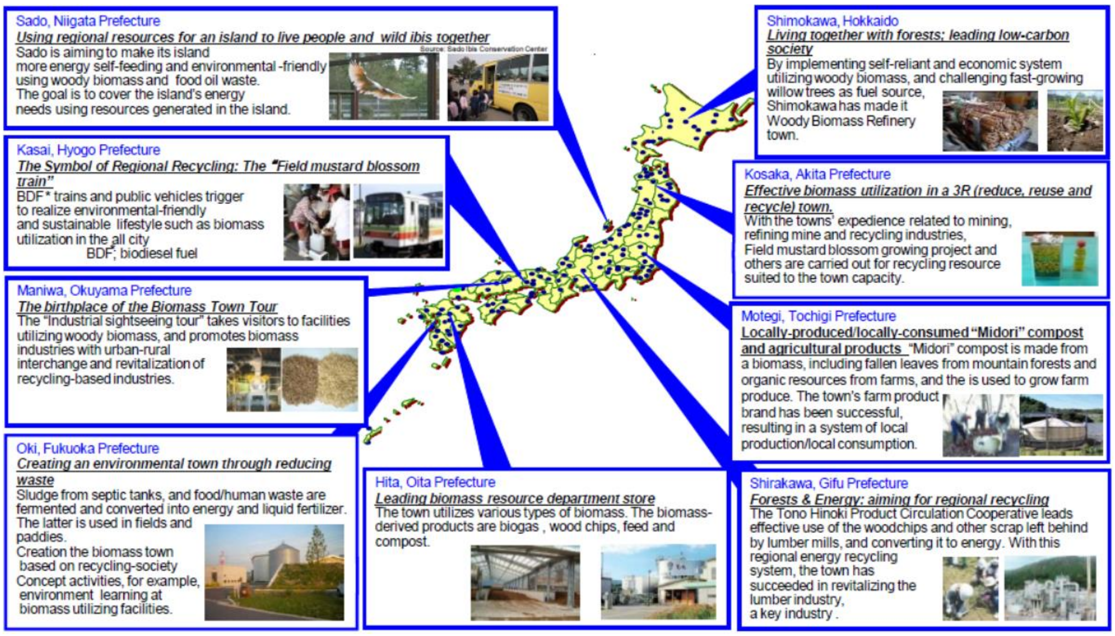

Figure 5.3 - Biomass Towns in Japan.

5.3.7 Future projections

The FIT scheme is predicted to continue driving biomass use in Japan. According to (Strauss, 2016), under one plausible scenario, Japan could be demanding well in excess of 15 Mt/a of wood pellets by the mid-2020s.

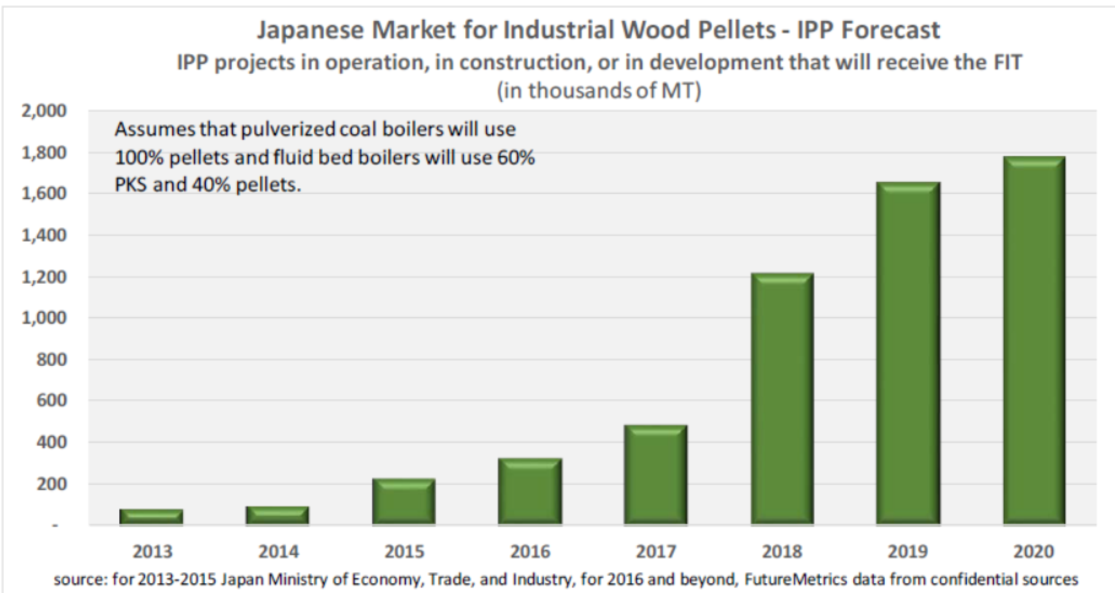

Figure 5.4 - Japanese market forecast for industrial wood pellets.

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5.4 Malaysia, Indonesia

Thuy Mai-Moulin, Martin Junginger

Compared to Vietnam, the three countries Malaysia, Indonesia and Thailand are small producers and exporters of wood pellets (Argus Media, 2016; Murray, 2015). Indonesia and Malaysia have exported about 150 and 60 kt of wood pellets respectively to South Korea in 2014 and 2015. Palm kernel shells (PKS) are exported from these two to Japan but the supply markets are still rather small (Bioenergy International, 2015). Buyer prices are still high and influenced by the cost of supply/quality, longevity, and quantity trade-off.

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5.5 South Korea

Thuy Mai-Moulin, Martin Junginger

5.5.1 Regulatory framework, market drivers and barriers

The Renewable Portfolio Standard (RPS) plays an important role in the wood pellet market in South Korea since the establishment in 2012. It requires that power utilities must deliver 2 % of their generated energy from renewables and progressively to 10 % in the coming decade (2022). Compared to other renewables such as wind, solar, or hydropower, biomass is expected to deliver the bulk of the clean energy capacity estimated at 50-60 %. Wood pellet demand in South Korea began to rise after the implementation of RPS with more import quantity from other countries.

There are advantages with the RPS including cost minimization by penetration of competitive technologies and accomplishments of renewable supply obligation. However, investors might bear the risk of excessive management costs or low-cost oriented power supply.

5.5.2 Production capacity, production and feedstock

According to FAOSTAT 2016 estimate, an average annual production of wood pellets in South Korea is only about 15 kt in the last five years which does not meet the domestic demand. Forest products are mainly for watershed conservation and water purification, soil erosion prevention, forest recreation and forest landscape (Korean Forest Service, 2015).

5.5.3 Consumption

Consumption of wood pellets is much higher than the domestic production of wood pellets in South Korea. Imported wood pellets increased from 122 kt in 2012 up to 1,850 kt in 2014 and slightly decreased to 1,471 kt in 2015 (FAOSTAT, 2016).

5.5.4 Price trends

Imported price in bulk ranges from 109-135 €/t but 2015 it stood at 110 €/t (FAOSTAT, 2016).

5.5.5 Trade and logistic aspects

The South Korean government has set a target to import 5 Mt of wood pellets by 2020 to meet 75 % of pellets requirement (Roos and Brackley, 2012). Wood products including pellets are imported mainly from Vietnam (70 %) and other countries such as Malaysia and Canada (FAOSTAT, 2016). Other suppliers are from USA, Canada, Russia, Indonesia and Australia.

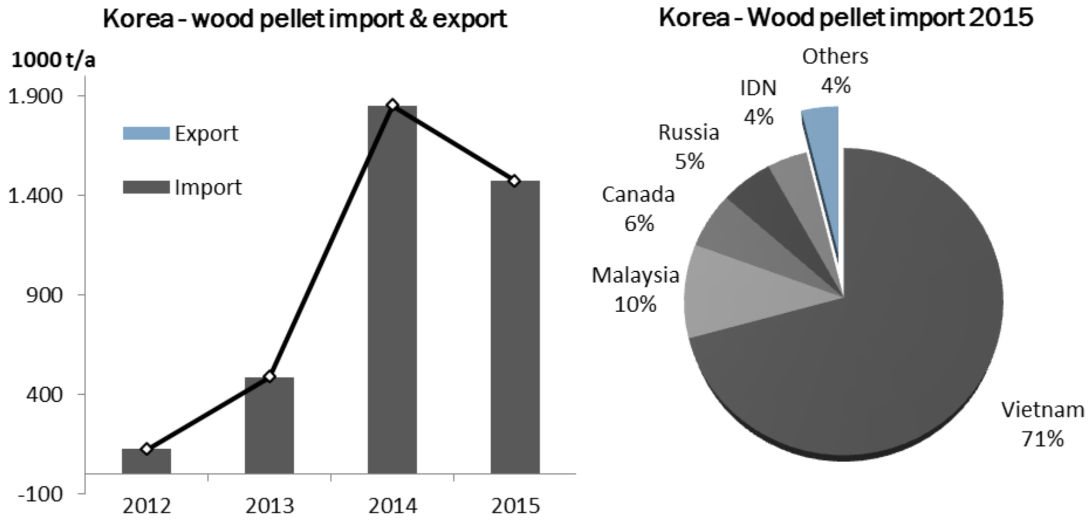

Figure 5.5 - Pellet exports and imports from Korea in 2015.

5.5.6 Pellet quality standard

Unlike most other countries, South Korea does not accept chain-of—custody certification as evidence of fiber source (Murray, 2015). South Korea Ministry of Environment requires that wood pellets need to be legally sourced and they also need to be made from pure wood fiber, and they don't have any non-woody material mixed in (Murray, 2015). The Ministry of Environment (MOE) also issued the Act on the Promotion of Saving and Recycling of Resources which has been revised. Under the act, an importer or manufacturer of SRF should report to the Minister of Environment or the head of local government after going through the quality test based on quality standard and in case where the product does not meet the standard, the ministry may impose a ban on import and production of SRF or request improvement. According to Murray, rice husks are one of the main concerns because pellets containing any material other than wood are considered biomass solid refuse fuel. Imports of Solid Refuse Fuel (SRF) made from wastes such as palm shell will be permitted but quality test for the import, production and use of these products will be reinforced while public and private organizations for waste-to-energy will be established.

The import of palm shell, a source of biomass fuel, to Korea will be allowed. It is expected to expand distribution of renewable energy to replace fossil fuel. And, this will help resolve concerns of power generation companies to fulfill Renewable energy Portfolio Standard (Ministry of Environment of Korea, 2014).

5.5.7 Proposed pellet plants

As of 2012, approximately 700,000 t of SRF were used annually at paper mills, cement plants and cogeneration plants. With the revised act, the use of SRF is forecast to sharply increase as production and import of SRF will grow.

MOE is preparing subordinate statutes covering import procedure, standard for quality indication and quality test, supervision standard for production and use facilities and the launch of Waste-to-Energy Center and Korea Waste-to-Energy Association, which will take effect from July, this year.

5.5.8 Future projections

According to (U.S. Energy Information Administration, 2016), demand for wood pellets also is increasing in South Korea and the introduction of a renewable portfolio standard in 2012 increased interest in the use of biomass and wood pellets for energy generation. Imports to the two countries come predominantly from Canada, Southeast Asia and the U.S. According to Bloomberg New Energy Finance, South Korea's demand for wood pellets in 2014 was estimated at 2.2 million short tonnes, equal to approximately 40 % of the U.K.'s total.

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5.6 Vietnam

Thuy Mai-Moulin, Martin Junginger

Vietnam has large furniture manufacturing industry producers. Therefore it benefits from the plentiful wood waste thus enabling the lowest production costs in the Asian region. Large wood pellet factories in Vietnam have also helped to improve its economies of scale compared with competing exports from Thailand, Indonesia and Malaysia (Argus Media, 2016). Vietnam is the main exporter dominating 70 % of South Korean market, it also offers a competitive wood pellet price at about 90 €/t to Japanese and South Korean markets (Murray, 2016). Vietnamese producers also low shipping cost (0.9 €/t) to South Korea.

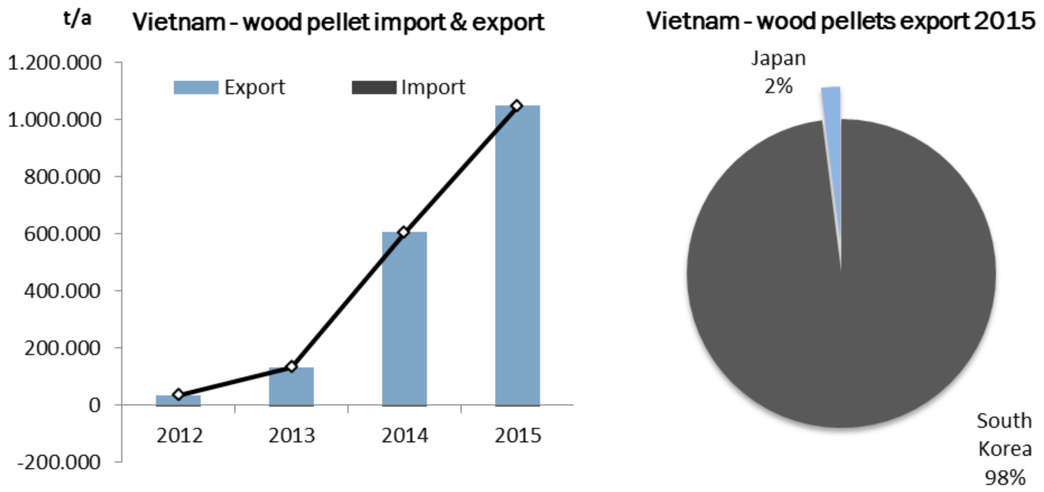

Figure 5.6 - Pellet exports and imports from Vietnam in 2015

South Korea will likely tighten the sustainability criteria for wood pellets as well as traders to announce early bidding, trade to South Korea might not be easily accessed as in the past. Similar situation arise in Japan with biomass sustainability criteria implementation, which impede Vietnamese traders to enter the Japanese market.

5.7 Latin America - an overview

Rocio Diaz-Chavez, Ute Thiermann - Contributing authors: Javier Farago Escobar, Jose Goldemberg, Suani Teixeira Coelho

Latin-America has well-established forestry and agricultural sectors, with large technical potential for pellets production from planted forests, wood residues and agricultural residues. However today, only Argentina, Brazil and Chile produce pellets at industrial level for the national market, while the number of exports is still insignificant. Other countries with tangible potential to produce pellets are Mexico and Colombia (FAO, 2016).

Table 5-1 - Overview of wood pellets production and export, and volume of wood residues produced per country in 2015 (FAO, 2016)

2015	Pellets produced (t)	Pellets exported (t)	Wood residues (m3)
Argentina	11,000	5,840	3,351,000
Brazil	49,000	24,368	17,194,000
Chile	30,000	794	1,916,000
Colombia	0	0	361,000
Mexico	4,000	2,447	n.a.

A recent study (Singh et al, 2016) rated the attractiveness of Latin-American countries in terms of their investment security and logistical performance for pellet production. Chile was identified as the most attractive Latin-American country for investments in pellet mills, offering the best results between the availability of biomass, annual yields and low investment risk. Argentina, Brazil, Colombia and Mexico may be suitable for investors willing to accept greater risk, with Argentina and Brazil being the countries with the highest mean annual increment yields which could compensate for the risk with greater rates of return (Singh et al, 2016).

5.8 Brazil

Rocio Diaz-Chavez, Ute Thiermann - Contributing authors: Javier Farago Escobar, Jose Goldemberg, Suani Teixeira Coelho

5.8.1 Regulatory framework, market drivers and barriers

Brazil benefits from favorable characteristics for the sustainable large-scale production of wood pellets. Not only does it provide adequate soil and climate conditions, but also policy makers do explore options for sustainable development and GHG emissions reductions through programs and actions in the areas agro-energy, integrated agricultural production, integration between crop, livestock and forest, conservation of soil and water and the recovery of degraded areas (Brazil, 2013).

In 2008, the Sao Paulo State set up the Agro-environmental Planning Map in a partnership between the Environmental and the Agricultural Secretariats of São Paulo State (ZAA). The objective of the Plan is to organize the expansion of the sugar cane and energy sector as well as subsidized public policies related to this sector (SMA, 2015 in Diaz-Chavez, 2016).

The Brazilian forestry sector is subject to a large number of regulations concerning the environment, land use, energy security and agro-ecological zoning which all together form a solid regulatory basis for the implementation of new policies for solid biomass production in Brazil (Pelkmans et al, 2016). The most important legal framework is the recently reviewed Forest Code (Law 12727/2012) and the National System of Conservation Units ("National System of Conservation Units - SNUC", Law 9985/2000), laying out regionally adapted rules about the relation of productive areas versus Permanent Preservation Areas (APPs), Legal Reserve areas (LRs), and Private Natural Heritage Reserves (RPPNs). The Rural Environmental Registry (CAR) is one of the main achievements of the new Forest Code and a fundamental instrument to progress in the regularization of rural properties, laying the ground for new public policies and conservation projects (IBÁ, 2015). The Forest Code also defines rules for the supply of forest raw material, the origin of the products, and provides economic and financial instruments which potentially could facilitate the sustainable production of solid biomass for pellets.

Even though there do not exist any specific policies regulating the production of pellets in Brazil yet, it is expected that the topic will advance in the years to come due to Brazil's commitments to the Paris Agreement of COP21. Also, in recent years the federal and state governments reacted to rising concerns about the negative impacts from land-use change and adopted policies to determine areas appropriate for biofuel production from sugarcane and palm oil (agro-ecological zoning). In the future, this could also be considered for the case of bioenergy production from wood.

5.8.2 Production capacity, production and feedstock

Brazil has a total of 851 million hectares of land, from which about 38 % is arable land and 62 % are preserved native forests (ABRAF, 2013). As one of the largest agricultural producers globally, Brazil generates large amounts of agricultural residues with pelletizing potential. States with the largest sustainable potential for agricultural residues are São Paulo with 81 Mt, Paraná with 19 Mt and Minas Gerais with 17 Mt. However, it is common to use part of these residues for electricity generation (90 % of sugarcane bagasse) or animal feed (60 % of corn residues). Consequently, the net sustainable surplus potential of agricultural residues in the seven most productive Brazilian states amounts to a total of 627 PJ, from which sugarcane straw has the largest share with 279 PJ (Figure 5.7) (Junginger et al, 2016).

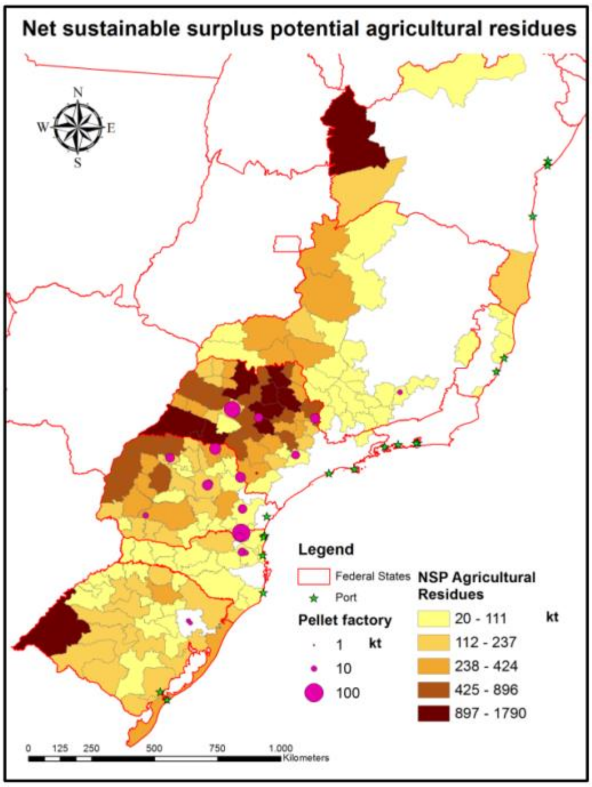

Figure 5.7 - Net sustainable surplus potential agricultural residues per micro-region in 2012 (Junginger et al, 2016).

This potential is concentrated in the western part of Bahia (soybean), the center and west of São Paulo (sugarcane), the west of Paraná (soybean, sugarcane, corn), and the west of Rio Grande do Sul (rice). São Paulo has the largest net surplus residue potential of 327 PJ which consists almost entirely of sugarcane residues (Junginger et al, 2016).

Transport logistics become an important factor for activating this potential, as agricultural zones tend to be further west of those states and hence, further away from ports. São Paulo and Paraná are the only states with a well-developed railroad system connecting the hinterland with international harbors. Another limiting factor for pellets from agricultural residues is the missing pelletizing capacity as there are no pellet mills in proximity to agricultural concentrations; today, existent pellet mills are based on pine residues (Junginger et al, 2016).

Planted forests occupy about 7.74 million hectares of land which equals approximately 1 % of the national territory (IBÁ, 2015). Production rates of Brazilian forest plantations are high with in average 20 t of wood per hectare per year (IBÁ, 2015). A total of 105 million hectares of land in Brazil is degraded and could potentially be used to grow crops and forests for energy use (IBGE, 2104). Tree species such as eucalyptus are especially resistant and can be planted in degraded areas unsuitable for other crop types. Today, Brazil is the largest producer of planted eucalyptus which has become economically and environmentally viable to deliver all branches of the wood industry. In the future, eucalyptus plantations potentially could provide wood exclusively for energy purposes and the expansion of the wood pellets production to a global scale. In that case, adequate forest management practices such as short-rotation plantations would have to ensure economic competitiveness and the qualitative standard of the pellets (Escobar, 2016).

Until present, the Brazilian pellets industry is based on wood residues. In Brazil, the main source for residual wood is the timber industry, which contributes to 91 % of all residues generated. Others are construction residues (3 %) and wood residues from urban areas (6,3 %) (Table 5-2).

Table 5-2 - Quantity of wood waste generated in Brazil (MMA, 2009; STCP, 2011; SAE, 2011).

Sector	wood residues 10^3 tonne/yr	%
wood industry	27.750	90,7
construction sector	923	3,0
urban area	1.930	6,3

Wood residues are mostly generated close to forest production centers and the timber industry in the states of Minas Gerais, São Paulo, Paraná and Santa Catarina, or in the East along the coast in the states of Bahia, Espírito Santo and Rio Grande do Sul (Table 5-3). Of all those residues, about 83 % are generated by the paper and cellulose industry, in sawmills and furniture factories (sawdust, bark, etc.). Only 17 % of residues come from the forest management itself in form of bark and small branches (Diaz-Chavez, 2016; Junginger et al, 2016).

Table 5-3 - Technical potential of residual dry wood from planted forests of Pinus and Eucalyptus in Brazil (Junginger et al, 2016).

Residues		Rio Grande do Sul	Santa Catarina	Paraná	São Paulo	Minas Gerais	Espírito Santo	Bahia
Eucalyptus & Pinus	Field	0,36	1,00	1,41	1,21	0,59	0,22	0,63
	Ind. Process	0,84	1,98	3,33	2,22	1,28	0,24	0,62
	Total (Mt)	1,20	2,98	4,74	3,43	1,87	0,46	1,25

Especially in the Southern and Southeastern regions of Brazil, industrial wood residues are used for the production of secondary products and for thermal and electric energy generation. Harvesting residues remain in the field as a common soil management practice (Hora and Vidal, 2011).

However, only a fraction of the 30 Mt of wood residues available in Brazil is used for economic, social or environmental purposes. The collection and processing of agricultural and forestry residues still present major difficulties related to logistics and economic scale. The material is generated decentralized in more than 5,000 municipalities, in an area of 8,500,000 km^2. Access and centralization of these residues is impracticable which hinders the achievement of productive scale and uniformity. Consequently, most residues are left in the field or used to generate thermal energy when demand is close. Today, only 3 % of all residues are processed into briquettes and pellets (Escobar, 2016). Other barriers to the recovery of wood for by-products are the dependency on specific technology and the lack of an internal market for wood waste.

Production capacity and production

Currently there are 13 pellet plants in Brazil which together produce around 75,000 t/a. They operate at only 37 % of their total installed capacity of 200,750 t due to the use of mostly residual biomass which prevents scale production (ABIPEL, 2013). Furthermore, another 10 pellet plants are on stand-by or still being at a project stage (Table 5-4).

Table 5-4 - Capacity and production of wood pellets in Brazil (Escobar, 2016; based on ABIPEL, 2016)

Nº	Industry	City	Capacity (t/yr)	Produc. (t/yr)	Biomass	Since (yr)	current.
1	Briquepar	Telêmaco Borba/PR	7.000	4.800	pinus	2004	On
2	PelletsBraz	Porto Feliz/SP	12.000	4.800	pinus	2004	On
3	Energia Futura	Benedito Novo/SC	9.000	4.800	pinus	2007	On
4	BR Biomassa	Maringá/PR	22.500	0	pinus	2008	Off
5	Ecopel	Itaju/SP	22.500	0	pinus	2008	Off
6	Koala Energy	Rio Negrinho/SC	60.000	30.000	pinus	2008	On
7	Wood Tradeland	Tunas/PR	24.000	0	pinus	2009	Off
8	Ecoxpellets	Bandeirantes/PR	37.500	0	pinus	2010	Off
9	Piomade	Farroupilha/RS	3.750	2.400	pinus	2010	On
10	Biopellets	Lins/SP	30.000	2.000	pinus	2010	On
11	Timber S.A.	Piên/PR	45.000	6.000	pinus	2012	On
12	Resisul Pellets	Itapeva/SP	3.000	2.400	pinus	2012	On
13	Iemol Pellets	S.João B. Vista/SP	3.000	2.000	pinus	2014	On
14	ARAUPEL pellets	Quedas Iguaçú/PR	6.000	5.000	pinus	2014	On
15	Vale Tibagi	Telêmaco Borba/PR	7.000	5.000	pinus/eucaliptos	2014	On
16	Champe Pellets	Vale Real/RS	3.000	1.800	pinus	2014	On
17	Tanac Pellets	Rio Grande/RS	80.000	0	acácia-negra	2015	Projeto
18	Pellets Nordeste	Recife/PE	60.000	0	capim elefante	2015	Projeto
19	Línea Paraná	Sengés/PR	30.000	0	pinus	2008	Stand by
20	Raízen pellets	Jaú/SP	120.000	0	bagaço de cana	2015	Stand by
21	Forespel	São José Ausentes/RS	100.000	0	pinus	2015	Projeto
22	Incobio pellets	Concórdia/SC	12.000	4.000	pinus	2015	On
23	Cosan	Jaú/SP	175.000	0	palha/bagaço	2015	Stand by
Total			**200.750**	**75.000**			

The majority of the Brazilian pellet production (approximately 81.4 %) is concentrated in the Southern states of Paraná, Santa Catarina and Rio Grande do Sul. The remainder (18.6 %) is produced in the state of São Paulo which hosts the largest concentration of pine and eucalyptus plantations in Brazil and also generates around 73 % of the waste from the wood processing industries (Figure 5.8).

Figure 5.8 - Pellet Plants in Brazil (Escobar, 2016).

The actual low production of pellets shows the reality of a weak domestic market for pellets, which can be partially explained by the lack of information on the potential of pellets as a modern biofuel in Brazil. Table 5-5 shows numbers for the Brazilian pellet production in recent years.

Table 5-5 - Capacity and production of wood pellets in Brazil from 2011 to 2015 (Escobar, 2016, based on ABIPEL, 2016).

Pellets Industry	2011	2012	2013	2014	2015
Capacity (t)	222.375	232.600	218.650	176.640	200.750
Production (t)	50.080	56.580	61.500	49.390	75.000

5.8.3 Consumption

The wood pellet consumption in Brazil is developing slowly. Most consumption happens at a small-scale and is related to thermal energy needs for heating in bakeries, hotels, water parks, swimming gyms, industrial laundries and food industries, among others. These applications consume about 95 % of the total national pellets production of 75,000 t/a (ABIPEL, 2016). Other applications such as the traditional "cat sand" granulates constitute the remaining 5 %.

The low internal consumption of Brazilian pellets is related to:

(i) Cultural barriers and lack of knowledge about pellets as biofuel;

(ii) Security of supply of biomass for pelletizing and seasonality of the price of wood waste;

(iii) Variation of pellet quality offered in the market;

(iv) Exclusive use of residual biomass impedes production at larger scales.

However, the market for wood pellets in Brazil can grow rapidly. The rising demand for wood pellets for heating and electricity in the EU brings important growth potential which can turn Brazil into a major supplier of wood pellets (Biotrade2020plus, 2016; ABIPEL, 2015; Pöyry, 2013). Today, three Brazilian companies export pellets based on pine tree waste complying with international quality standards but hardly achieve competitive market prices and scale.

5.8.4 Price trends

Currently there is no stable market for wood for energy in Brazil.

The production cost for wood pellets is high due to the small scale of production with low efficiency rates, producing from 0.5 to 4 t/h. The cost of production per ton of wood pellets of a standard pellet plant in Brazil is around 108 €/t, from which 50 % is absorbed by capital investment, operation and maintenance and another 50 % by the acquisition of residual biomass (Escobar, 2016).

Pellets prices evolve closely linked to the average production cost for sustainable wood for industries with thermal energy demand, such as firewood or wood chips. Estimations of export prices for Brazilian pellets to the European market range from 122 €/t to 180 €/t (Junginger et al, 2016).

5.8.5 Trade and logistic aspects

The international trade of Brazilian wood pellets still has not reached significant numbers. This is reflected in a poorly developed transport and storage infrastructure for trade both on domestic markets and export. The transport of pellets from the field to the sea port is dependent on road transport, especially for long distances. Railroads and the waterway network in Brazil are scarce and loading stations often are distant and precariously equipped (Escobar, 2016).

The production of pellets in proximity to adequately equipped sea ports potentially could reduce transport costs and enhance competitiveness of Brazilian wood pellets on the international market. Table 5-6 and Figure 5.9 display the potential of wood pellets to be produced at a radius of 150 km from Brazilian ports, depending on available land to produce energy forests. With only 20 % of this potential, Brazilian pellets exports could achieve higher volumes than currently exported from Canada and the US to the EU.

Table 5-6 - Potential area for biomass production for wood pellets, 150 km from the seaport (Escobar, 2016).

State	Sustainable area (hectare)			Potential (t) (dry/ha.yr)* *short rotation***	Potential/ woodpellets (t/ano)
	degraded	no degraded	Total area		
BA	99.971	346.385	446.356	20.086.006	13.390.671
RJ	21.337	403.060	424.397	19.097.876	12.731.917
MG	5	210.884	210.889	9.490.007	6.326.671
SP	663	139.455	140.118	6.305.288	4.203.526
ES	-	128.767	128.767	5.794.499	3.862.999
SC	4.124	-	4.124	185.584	123.722
PR	234	100	333	14.994	9.996
Total				**60.974.254**	**40.649.502**

* Dry mass per hectare year. ** Average Annual Increase (45 t/ha*a)

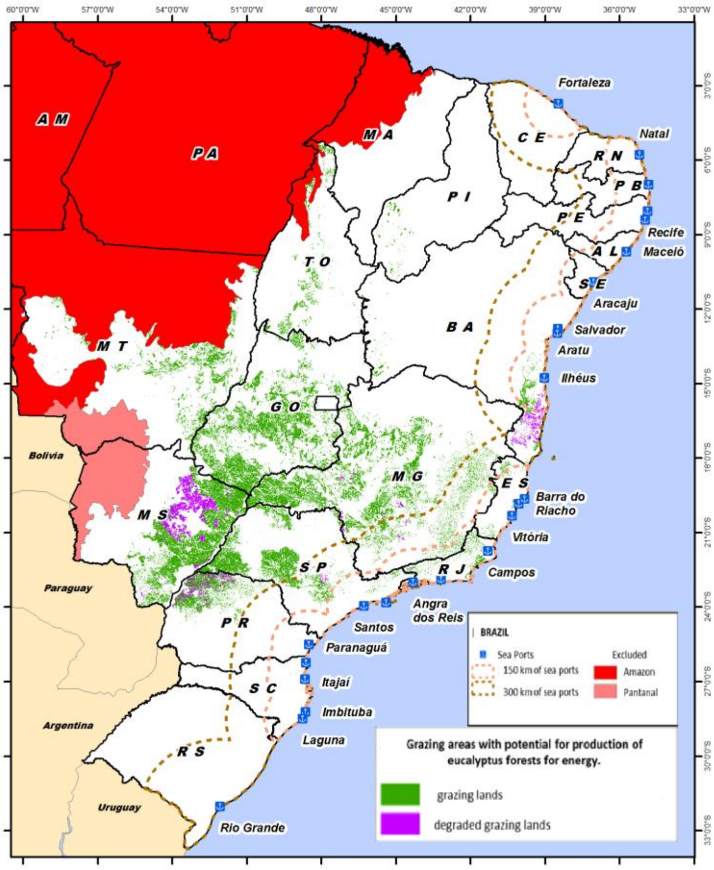

Figure 5.9 - Potential wood pellets production in Brazil, 150 km from the seaport (Escobar, 2016).

These numbers show that Brazil has the potential to become a major producer of wood for the global market. For 2020, a production volume of 4.4 Mt is expected (Escobar, 2016), representing 10 % of the potential areas for export oriented wood pellets production in Brazil.

5.8.6 Pellet quality standard

Most of Brazilian wood pellets are produced from residual biomass which makes them vary strongly in quality and price. There are no standards for Brazilian wood pellets, which also fail to reach the quality and scale required for the European market.

In Brazil, the chlorine (NaCl) content of eucalyptus wood is in average five times higher than that allowed by international standards for wood pellets. Other inorganic substances in the ash of combusted pellets reach up to four times the permitted standard value. This is due to the country's geographical location, with rainfalls coming from the oceans containing high rates of chlorine and elevated amounts of inorganic particles in the soil which are absorbed by the biomass during its growth process (Table 5-7). First removal methods are being explored, involving pre-treatment of the biomass before pelletization.

Table 5-7 - Pellet standards for the international market compared to Brazilian pellets (Escobar, 2016; based on ENplus 2015; ISO18122).

Wood Pellets Standard		Unit	(Cl)	(S)	Ash
Residential	*(Enplus)*-A1	w-%	≤ 0,02	≤ 0,04	≤ 0,7
	(Enplus)-A2	w-%		≤ 0,05	≤ 1,2
	(Enplus)-B	w-%	≤ 0,03	≤ 0,05	≤ 2,0
Industrial	*(ISO18122)*-I1	w-%	≤ 0,03		≤ 1,0
	(ISO18122)-I2	w-%	≤ 0,05	≤ 0,05	≤ 1,5
	(ISO18122)-I3	w-%	≤ 0,06		≤ 3,0
Brazilian Wood Pellets	*Pinus ssp.*	w-%	≤ 0,02	≤ 0,04	≤ 0,3
	Eucaliptus ssp.	w-%	0,02 ≥ 0,1	≤ 0,05	≤ 0,5
	short rotation Eucaliptus ssp.	w-%	0,02 ≥ 0,1	≤ 0,05	≤ 2,7

Only a small number of pellet plants in Brazil are producing pellets from pine trees, which stay within the permitted chlorine rates for the residential market. However, pine trees do not achieve the same technical yield than short rotation eucalyptus important to reduce the market price of the pellets.

5.9 Other Latin-American countries

Rocio Diaz-Chavez, Ute Thiermann - Contributing authors: Javier Farago Escobar, Jose Goldemberg, Suani Teixeira Coelho

5.9.1 Argentina

In Argentina, 70 % of forestry activities are in the north-eastern regions of Misiones, Corrientes and Entre Ríos (Uasuf and Becker, 2011). In total, the forestry sector in Argentina generates a large amount of around 3.4 million m^3 of wood residues per year. However, in 2015 Argentina only produced 11,000 t of wood pellets from which roughly half of it is exported (FAO, 2016). With an estimated production cost of around 13 €/t, Argentinian pellets are competitive with pellets from other countries (Usuaf and Hilbert, 2012). Despite the large potential for the production of wood pellets, few pellet plants have developed in Argentina, mostly in the region of Corrientes. This can partly be explained by a weak national market for wood pellets in Argentina because of the competition with cheap natural gas. Also, the logistics for transporting the residual biomass to pelletizing plants are still challenging and costly (Uasuf and Hilbert, 2012). Furthermore, pellet producers are affected by Argentina's monetary policies worsening their position on the international markets (Usuaf and Becker, 2011; TodoAgro, 2013).

5.9.2 Chile

Chile is an important producer and exporter of forest products. The country holds a total of 2.8 million ha of planted forests and produces around 2 million m^3 of wood residues per year (FAO, 2016). In 2015, Chilean companies produced 30,000 t of wood pellets, mainly destined for the national market (FAO, 2016). The production capacity for wood pellets in Chile is estimated at 100,000 t/a (UDT, 2013). The biggest pellets producer in Chile is the company Ecomas, a Chilean-Japanese joint venture, which produced around 24,000 t of wood pellets for a self-created market. Other producers are Propellet Chile and Andes Biopellet (Corma, 2016). The production costs for pellets in Chile are estimated at around 177 €/t, leading to a sales price per tonne around 230 € (UDT, 2013).

The Chilean domestic market developed slowly due to long payback periods for the investment in new pellet stoves. Another reason for the slow uptake of the national market is that sawmill owners and pulp and paper producers still prefer using residues to generate heat and electricity (Azeus, 2016; Cocchi et al, 2011; Goh, 2013). However, wood pellets could become especially relevant for the region Biobío where large parts of Chile's wood industries are located and the government is becoming increasingly aware of the high level of air pollution caused by residential heating systems based on firewood, often of poor quality and high humidity content. In 2016, the regional government plans a heating and wood policy which includes incentives to increase the use of wood pellets in the region (Corma, 2016). Even though there are no long-term plans by the Chilean government, there is a potential for export of wood pellets due to the availability of large resources of biomass from the forest industry. Nevertheless, challenges such as old port infrastructures and the long shipping distance from the pacific coast to the European market would have to be overcome.

5.9.3 Colombia

Even though Colombia generates a limited amount of 361,000 m^3 of forestry residues per year, there is a potential for pellets production from agricultural residues, namely trash and bagasse from sugar cane and oil palm residues (Diaz-Chavez et al, 2016). Colombia produces palm oil in four zones, from which the north and central zones are most promising for export of pellets. The northern region is about 100 km from port facilities in the north of Colombia, while transport from the central region could be made via the Magdalena River. In 2030, those regions together have a potential of producing between 556,900 t to 2 Mt of mill residues (dry material) for pellets production. The estimated costs for oil palm pellets exported to Rotterdam range from 118– 135 € from the northern region and 148 € - 165 € from the central region (Biotrade2020plus, 2016b). However, these prices are not directly comparable to wood pellets as they usually are of a lower quality. The potential for exporting sugarcane pellets is highest from the Cauca River Valley, an important sugarcane region located at only 100 km distance from the port of Barranquilla. Together, the export potential for pellets from both biomass sources range from 1 to 4 Mt in 2030, depending on production volume and exporting conditions. Another potential resource to be explored for pellets production in Colombia is bamboo (Diaz-Chavez et al, 2016).

5.9.4 Mexico

With 75,800 ha of planted forests and a total of 66,147,400 ha of native and naturally regenerated forests, Mexico has devoted large parts of its land to different aspects of forestry. Even though Mexico does not have dense forests, the country produces wood for their national market at two large ridges parallel to the Pacific and the Gulf of Mexico (FAO, 2016; Moreno-Lopez, 2011). According to FAO (2016), in 2015 Mexico produced a small amount of 4,000 t of pellets, from which it exported around 2500 t.

These numbers do not reflect the potential for pellets production from forestry residues in Mexico, especially in the wood producing states of Chihuahua and Durango which mostly plant diverse types of pine trees (Moreno-Lopez, 2016). Production estimates for pellet production in the state of Chihuahua showed that pellets could be delivered at a rate of 3 t per hour with a specific cost of 146 €/t of pellets when the raw material is paid by the pellet producer. In case of sawmill producers installing their own factory pelletizer, pellet production cost could come down to 22 €/t.

The main barrier for the development of a pellets industry in Mexico is the lack of knowledge about its advantages and the technical and economic feasibility of pellets production. This results in a lack of internal market demand for both pellets and pellet equipment (Moreno-Lopez, 2016).

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6 Challenges for a sustainable wood pellet trade

6.1 Ensuring sustainability along the value chain

Martin Junginger, Thuy Mai-Moulin

In the past years, sustainability requirements for solid biomass have been established and implemented in a number of countries in the European Union and in Japan and South Korea. In this section, we provide an overview of the sustainability criteria as part of existing legislation / agreements in EU countries in section 6.1.1. Next, in section 6.1.2, we provide a brief introduction to the voluntary SBP scheme, as one possibility to meet multiple criteria in different EU member states. A discussion on how to best set up and integrate sustainability criteria for wood pellets is included at the end of section 6.1.

6.1.1 Sustainability criteria for industrial wood pellets

In recent years, as part of an effort to increase renewable energy whilst reducing fossil fuel consumption, a number of countries have stimulated the use wood pellets for heat and power generation. Within the EU, given the fact that EC did not mandate sustainability criteria for the use of solid biomass or biogas for electricity and/or heat within the Renewable Energy Directive (European Commission, 2016), Belgium, Denmark, the Netherlands and the United Kingdom, the largest importers of solid biomass, have developed their own governance frameworks such as legislation or voluntary agreements with the industry to safeguard sustainable production of solid biomass.

In the UK, there are four schemes with sustainability requirements for solid biomass which have been implemented. The most popular scheme is the Contract for Difference (CFD), a private law contract between a low carbon electricity generator and the Low Carbon Contracts Company (LCCC) - a government-owned company. A generator party to a CFD is paid the difference between the 'strike price' – a price for electricity reflecting the cost of investing in a particular low carbon technology – and the 'reference price'– a measure of the average market price for electricity in the GB market. In addition to CFD, there are other schemes Renewables Obligation (RO)[19] which is now the main governmental mechanism but will be replaced by CFD in 2017, the Renewable Heat Incentive (RHI)[20], and the Renewable Transport Fuel Obligation (RTFO)[21] with similar subsidies with each of these having sustainability requirements for solid biomass. Renewable energy producers with a capacity larger than 1 MW have to demonstrate compliance with sustainability criteria which are mandatory and effective by submitting sustainability certificates or providing risk based assessment.

In the Netherlands, the government aims to attain the renewable energy goals in 2020 and 2023 (14 % and 16 % respectively of the total gross energy consumption) through a stimulation of solid biomass used for co-gasification and co-firing under the SDE+ scheme - Stimulation of Sustainable Energy Production which is an operating grant. Producers receive financial compensation for the renewable energy they generate. Production of renewable energy is not always profitable because the cost price of renewable energy is higher than that of energy derived from fossil fuel. The difference in cost price is called the unprofitable component. SDE+ compensates producers for this

[19] RO is the main support mechanism for large-scale renewable electricity projects in the UK
[20] RHI includes Domestic RHI for homeowners, private landlords, social landlords and self-builders as well as Non-domestic RHI to provide payments to industry, businesses and public sector organisations
[21] RTFO is the mechanism to support the UK government's policy on reducing greenhouse gas emissions from vehicles by encouraging the production of biofuels that don't damage the environment.

unprofitable component for a fixed number of years, depending on the technology used. The Dutch sustainability criteria, a part of the SDE+ scheme, have been issued in 2015 and are supposed to be revised a final time in 2016 before they will be effectively implemented. Solid biomass generators need to demonstrate compliance with sustainability criteria though certification schemes or verification process.

In Belgium, mechanisms to promote the usage of renewable sources for electricity production as well as the sustainable certification and subsidies for the investment and utilization of renewable electricity were introduced in 2002 (Najdawi and Wevers, 2014). Renewable electricity generation is promoted through a quota system based on obligations, tradable certificates and minimum prices. The trade of certificates is subject to federal legislation, while the quota obligations are defined in regional regulations. Electricity suppliers need to provide evidence that they have supplied a certain quota of renewable energy determined by three regions Wallonia, Flanders and Brussels-Capital to their final consumers. In general, all renewable electricity generation technologies are eligible for financial support including solid biomass for electricity production (Junginger and Mai-Moulin, 2016)

In Denmark, the Danish Ministry on Climate, Energy and Building had declared that energy sector should find a good and ambitious solution by a voluntary agreement that matches the rules in the UK (Dansk Energi, 2016). Energy companies will demonstrate that the wood pellets and wood chips that turn into electricity and heat comes from sustainably managed forests, resulting in substantial CO2 reductions. By refurbishing existing central power stations in the cities of pellets and chips, they aim to get significant CO2 reductions in a cost effective way, and ensure consumers a green electricity and heat at a competitive price (Junginger and Mai-Moulin, 2016). Price supplements for renewable energy and other environmentally friendly energy supply is provided in Denmark as a price supplement, a fixed settlement price, contract for difference, basic amount or as plant support (Danish Energy Agency, 2016).

Outside Europe, Japan also imports large quantity of wood pellets for generating renewable energy. Wood pellets sold into Japan must be forest management certified and as mentioned in section 5.2 and under the Feed-in Tariff (FIT) Scheme which has been implemented since 2012, electric utilities are obliged to purchase electricity generated from renewable energy sources such as biomass on a fixed-period contract at a fixed price. Since its enforcement, purchase price of FIT has been re-examined every year by METI, the Ministry of Economy, Trade and Industry (in 2013, 2014 and 2015). Cost for purchasing is paid by electricity users in the form of a nationwide equal surcharge. And electric power companies pay a part of the cost (the equal amount to the generation cost that they could avoid to pay by purchasing renewable electricity from the producers). The purchase price is re-examined and published in each year.

Also in South Korea, the 2nd country in East Asia which has started to import wood pellets on a large scale, an attempt has been made to introduce sustainable forest management criteria. According to ITA (2016), the Korean utilities have attempted to impose requirements in early 2015 for Forest Stewardship Council (FSC) chain–of-custody (COC) certificates to accompany bids for wood pellet tenders. However, Vietnamese pellet producers apparently were found to provide fraudulent certificates. This caused the Korean Government to implement new requirements. The authentication process required government-issued documentation for all fiber sources in each wood pellet shipmen, but this policy has been reversed in the meantime, putting the sourcing verification responsibility on the importer rather than the exporter. As it currently stands, it is unclear if Korea will impose forest management requirements again in the future (ITA, 2016).

6.1.2 Sustainability criteria for industrial wood pellets – Sustainable Biomass Program (SBP)

As was shown in the previous section, the absence of EU-wide mandatory sustainability requirements has led to the creation of a patchwork of different national initiatives to govern the sustainable production of wood pellets. Partly as a response to this, the Sustainable Biomass Program (SBP) was established in 2013. It is a certification scheme designed for woody biomass, mostly in the form of wood pellets and wood chips, used in industrial, large-scale energy production. SBP's first objective has been to develop a SBP Framework comprising a set of standards and processes for voluntary certification enabling any biomass producers and European generators to demonstrate compliance with regulatory, including sustainability, requirements relating to woody biomass. The SBP does not develop its own forest-level certification scheme but is committed to a core strategy that identifies and uses, wherever possible, existing forest certification schemes (such as Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC)) as the principal building blocks for its approach. Whilst FSC and PEFC schemes mainly focus on sustainable forest management, they lack the accounting of carbon/ greenhouse gas emissions. SBP aims to fill these gaps (at the moment of writing this chapter by December 2016, FSC is proposing to develop a new procedure for calculating the carbon footprint of FSC-labelled products). Looking ahead, SBP will invest in building a strong scientific evidence base that contributes to a greater understanding of the issues associated with the use of solid biomass for energy production, with the intention that this will inform SBP's approach as well as public policy development and public debate. Over the course of 2014-2016, the number of SBP certified wood pellet producers and traders grew strongly to over 70 certificate holders, amongst which some of the largest wood pellet producers worldwide. As such, it is the largest voluntary system certifying woody biomass for energy purposes.

6.1.3 How to best set up and integrate sustainability criteria for wood pellets?

Sustainability criteria for solid biomass have been developed and implemented in a number of countries and are linked to bioenergy support schemes. However, the legislation and support schemes have, to a certain degree, different goals and targets whilst there are also differences among various sustainability criteria and reporting requirements. This situation may cause trade barriers for solid biomass, and thus, a harmonization of sustainability requirements would benefit the global trade in wood pellets. In November 2016, the EC issued a proposal for the new directive on renewable energy indicating that existing various national support schemes have led to the sub-optimal situation and this has in turn negatively impacted investor confidence (European Commission, 2016). A better option might be the introduction of principles for support schemes that Member States can put in for the protection for investors against retroactive changes. Whilst there are several sustainability criteria for solid biomass that may be harmonized in the aforementioned EC countries, clarification and agreement on what sustainability criteria should be considered and included is necessary at the EC level. How the sustainability criteria applying to agricultural biomass differ to the requirements to forest biomass? Is (indirect) land use change (iLUC) should be a criterion? What level of GHG emissions reduction is acceptable? Should sustainability criteria be applied to a generation capacity below 20 MW? To what extent certification schemes (such as FSC, SBP and PEFC) should be recognized by national legislations? There are many questions that need to be answered. However, this proposal will be debated in the European Parliament and council in the coming months, and so a final agreement on such general sustainability criteria is probably still years away.

In addition, sustainability criteria have been developed and apply only to large-scale industrial use whilst criteria for use of wood pellets for heating in households (a substantial share of the total wood pellet demand in Europe) are not in place. Similarly, criteria for traditional or new material use (e.g. woody biomass for bioplastics or biochemicals) are missing (Junginger and Mai-Moulin, 2016). If sustainability requirements are only mandatory for (a limited number of) bioenergy applications, but not for others/ material purposes, this may again lead to leakage, i.e. sustainable feedstocks are used for industrial energy use, and the use of unsustainably produced feedstocks 'leaks' to use for residential heating or biochemical production, which is obviously unwanted. At the same time, inclusion of iLUC and carbon debt etc. for other end uses would further complicate matters and perhaps even further reduce the chances to align and harmonize the national requirements. Clear policies and guidance in the recast Renewable Energy Directive as well as in the national legislations are therefore needed to increase investor confidence and importantly make sustainability a meaningful approach of bioenergy sector to combat climate change whilst securing energy supply. Ultimately, the governance of sustainable production and use of biomass for energy and material purposes should also be aligned on a global level (e.g. with other regions such as East Asia) to avoid leakage effects and to facilitate global trade of wood pellets.

The development of a harmonized certification scheme that could be used to meet criteria in all countries is recommended. SBP is currently the only single certification scheme set at the EU level but its standards will likely have to be extended on a regular basis (Junginger and Mai-Moulin, 2016). Much effort of industry is required including consultation and discussions with national policy makers and related stakeholders to structure such a comprehensive certification system.

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6.2 Transforming wood pellets into a global commodity

Olle Olsson

Wood pellets are arguably the solid biomass fuel that has come farthest in terms of overall market maturity. In terms of logistics and handling properties, wood pellets are superior to other forms of solid biomass such as wood chips. For this reason, hopes have been raised that wood pellets can evolve into a proper commodity (Wynn, 2011). In this chapter we provide an overview of the overall status of wood pellet markets in terms of development towards commoditization.

6.2.1 Establishment as commodity

A "commodity" is defined by Clark et al (2007) as "*…intermediate good with a standard quality, which can be traded on competitive and liquid […] international physical markets*". This wording can be taken apart to outline the four most important characteristics of (physical) commodities:

1. Commodities tend to be **intermediate goods** and mostly traded in business-to-business settings.
2. They are **standardized** and available in certain specific qualities depending on physical characteristics.
3. Commodity markets should be **competitive** with no single market actor able to exert influence over market prices.
4. Well-functioning commodity markets are **liquid**, in the sense that it is easy to find a buyer for/seller of the good in question.

It is important to note that these characteristics to a significant extent are interconnected. For example, standardization facilitates liquid markets and internationalized markets can reduce the likelihood of individual actors becoming too dominant.

Commodities also tend to be linked to futures contracts. These are financial instruments that are connected to the commodity in question (Radetzki, 2010) and can be used either by actors in the physical commodity market to hedge price risks or by financial traders for speculation (i.e., betting on price movements). However, establishing a futures contract for a given commodity is not a simple feat. In fact, historically, most agricultural futures contracts have failed within a couple of years (Brorsen and Fofana, 2001), often because of less-than-optimal functioning of the underlying physical commodity market. For this reason, successful establishment of a futures contract can be said to be something of a litmus test for the maturity in a commodity market.

In the following, we discuss briefly the current status of the wood pellet market in a structure based on the above framework[22].

6.2.2 "Intermediate goods": demand side structures

From a general market structure perspective, wood pellet markets are interesting in their separation into different consumer segments. On the one hand, wood pellets are used in large industrial facilities where annual purchases of individual consumers – say, a power station – can reach several hundred thousand tonnes or more. On the other hand, wood pellets are also sold to homeowners where annual consumption might only be as low as a few tons only.

The market structures differ significantly between the two, with the large-scale business-to-business market characterized by long-term contracts and vertical integration between consumers

[22] For a more detailed and comprehensive discussion of these issues, see Olsson et al (2016).

and producers. Here, there is also significant market concentration, with a few large consumers having a large share of the total market. The small-scale market on the other hand is vastly more fragmented with hundreds of thousands of end consumers (concentrated across Europe and North America) that are connected to producers through a network of distributors and retailers.

Prices in the large-scale and small-scale markets differ significantly with per-tonne prices in the 100-150 € range for pellets delivered in bulk to the ARA (Amsterdam-Rotterdam-Antwerpen) region, whereas pellets sold in 16 kg bags in hardware supply stores have been priced at around 200-250 €. Stricter quality criteria in small-scale markets and more complex distribution channels explain the cost differences.

The extent of interaction between the large-scale and small-scale market is an issue that has not been investigated to a large extent, but it is clear that the two do interact with certain producers selling into both markets. There is also an ambition among some producers currently focused on the large-scale market to expand their business in the small-scale sector in order to improve margins. Expanding into another market segment would expand the portfolio and reduce risks to the producer.

The small-scale market is less affected by political framework conditions as pellets have tended to be able to compete with fossil fuels in residential heating markets even without subsidies. However, current price levels for competing energy carriers – electricity, heating oil & natural gas – present clear challenges to the competitiveness of pellets in the heating sector as well. This competition seems likely to increase with continuing developments of heat pumps as well as emerging technologies such as power-to-heat that uses excess electricity for heating purposes.

6.2.3 Standardization & fungibility

A key feature of commodities is that they are fungible, i.e. one batch of the commodity is supposed to be equal – in terms of its physical (and chemical) properties – to any other batch of the same quality category. In order to achieve this in an evolving market like wood pellets, standardization is crucial. An ISO standard for wood pellets (ISO 17225-2:2014) is in place that delineates "pellets" into different categories depending on physical characteristics such as energy density, ash content and so on. This definition was key in enabling the establishment of a trade code for wood pellets (on HS-6 level), which means that wood pellet trade flows are now covered in official trade statistics.

When it comes to standardization and product quality criteria, there tends sometimes to be a tension between the strictness of the quality criteria and the liquidity in the market. This has previously been a discussion in coal markets, where the failure of coal to develop into a "proper" commodity is sometimes (partly) attributed to too strict quality demands of power stations.

An interesting characteristic of markets for biomass fuels in general is that quality criteria are an issue not only for the physical characteristics of the fuel itself but for the sustainability in the supply chain as well. As of 2015, there is an ISO standard for bioenergy sustainability criteria (ISO 13065:2015). This could be a key facilitator in combining commoditization and fungibility with sustainability, an issue that previously has been raised as a potential obstacle to further commoditization of biomass markets (Mathews, 2008).

6.2.4 Competition and market concentration

As was noted in chapter 2, the demand side of industrial wood pellet markets is quite concentrated, dominated by a handful of European utilities. Most prominently, Drax Power Station in the UK has an especially important role. This has attracted the attention of the European Commission, which carried out an investigation of the matter, but in the end found that effects on wood markets from Drax's conversion to wood pellets were only limited (European Commission, 2016).

When it comes to the extent of market concentration in the small-scale market and on the overall supply side of wood pellet markets, these issues have so far not been investigated in sufficient detail. What can be said is that there are certainly more actors in total in the small-scale markets simply in order to get pellets from producer to consumer. This could be an indicator of reduced risks of any one actor being able to dominate markets.

6.2.5 Market liquidity

Market liquidity is a measure of how easy it is to buy or sell a good, i.e., how easy it is to transform an asset into cash. Liquidity is clearly connected to fungibility in the sense that if one shipload of industrial quality wood pellets can be replaced with any other shipload of the same quality, each transaction can be carried out more swiftly and smoothly. Furthermore, fungibility should make it easier to find shipments from other suppliers in the case of disruptions. However, one factor that could limit market liquidity is the volumes aspect, where it might be difficult for a large consumer to procure large volumes at short notice, or conversely to offload large contracted volumes onto spot markets if internal demand for some reason turns out to be lowered than projected.

But liquidity is also a more long-term matter of expectations on supply and demand balances. If there is too much uncertainty regarding whether there is a market demand for a specific product, very few producers will enter the market. Similarly, few consumers will convert their equipment to use, e.g., wood pellets, if it is not certain that there will be sufficient supply to meet demands. In wood pellet markets, there are large uncertainties (including political risk) when it comes to demand and supply (i.e., whether producers are able to meet demand should it materialize and how sustainability criteria will affect raw material potential). These uncertainties are likely important reasons for the prevalence of long-term contracts and vertical integration in industrial-scale wood pellet markets.

6.2.6 Internationalization

International trade in wood pellets occurs both in the large-scale and the small-scale market, but market characteristics differ somewhat. The large-scale market is dominated by transatlantic trade flows from the Southeastern U.S. (SE US) and Canada to North-Western Europe, especially the UK, as well as emerging trade flows in East Asia. The small-scale market also has an international component, but this tends to be more limited in geographical extent, with cross-border trade between Canada and the United States and an active trade between countries in central Europe.

However, internationalization is not only about trade flows but also about interactions between supply-demand balances in the respective countries. For intra-European markets, this has been investigated in a series of studies by use of analysis of price series (Olsson et al., 2011; Olsson and Hillring, 2014). In general, it seems that although there is substantial trade between European countries, significant market interactions are predominantly to be found between countries in Central Europe (Schipfer et al., 2016). (see also chapter 2.1)

To the best of our knowledge, no such analysis has been done of the transatlantic trade in large-scale pellets. Given the large trade flows, it is however very likely that the trade flows especially from the SE U.S. to the UK are instrumental in connecting European and North American pellet markets and leading to competition between European and North American producers.

6.2.7 Wood pellet futures contracts?

As was noted in section chapter 6.2.1, the successful establishment of a futures contract can be seen as somewhat of a litmus test in the development of a specific commodity market. For wood pellets, two contracts have been introduced. The first one was established by APX-Endex in 2011 and was a contract for industrial-quality wood pellets for delivery in the ARA region. However, there was very little interest from market actors (Maroo, 2012) and in 2013, the contract was discontinued. The second wood pellet futures contract was introduced by Euronext in late 2015 and was – in contrast to the APX-Endex contract – focused on pellets used for residential heating. Given that the contract has only been available for less than one year at the time of writing, it is yet not clear whether the Euronext contract will be more successful. However, with wood residential pellet markets currently being rather slow, it might take some time before the outcome here becomes clear.

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6.3 Torrefaction and international trade

Michael Wild

6.3.1 Torrefaction – an overview

Torrefaction is a thermal pre-treatment technology used to upgrade lignocellulosic biomass to a higher quality and more attractive biofuel. In the torrefaction process, biomass is heated to a temperature between 250-350°C in an atmosphere with low oxygen concentrations, so that all moisture is removed. During the torrefaction process, the biomass partly devolatilises leading to a decrease in mass; however the initial energy content is preserved so that the energy density of the biomass becomes higher than the original biomass. Consequently, transportation of torrefied pellets is much cheaper than wood pellets.

The typical mass and energy balance for woody biomass torrefaction is that 70 % of the mass is retained as a solid product, containing more than 85 % of the initial energy content. The other 30 % of the mass is converted into torrefaction gas which contains up to 15 % of the energy of the biomass. Ideally, the energy contained in these released volatiles equates to the heating requirements of the process. A thermal efficiency of around 95 % can thus be achieved.

The properties of the final product highly depend on the process conditions and on the composition of the biomass feedstock. Depending on factors such as time, temperature and residence time, the biomass can be torrefied to different torrefaction degrees/temperatures. Directly connected to the degree of torrefaction is the net calorific value (NCV) of the resulting product. Theoretically, NCVs of 28+ MJ/kg could be reached, even though the overall process efficiency seems to be best at 20-22 MJ/kg NCV (depending on feedstock).

Most types of biomass contain hemicellulosic and cellulosic polymers. For this reason, torrefaction can be performed on virtually any lignocellulosic type of biomass, and it is possible in theory to design a torrefaction plant for a wider diversity of feedstock to produce a more homogeneous product. In this respect, torrefaction can also offer an opportunity for cheaper feedstock such as by-product streams, forestry or plantation residues or agricultural-material. However, the chemical composition of the biomass material is a factor to consider. Because of the relatively low temperature of the torrefaction process, most critical chemical fuel components (alkali metals, chloride, sulfur, nitrogen, heavy metals and ash) remain in the fuel after torrefaction. This makes clean biomass feedstocks the preferred option for the foreseeable future.

Besides the chemical composition, the physical characteristics of biomass play an important role when assessing the potential for torrefaction, biomass bulk density and content of hemicellulose, cellulose and lignin.

Torrefaction results in a high quality fuel with characteristics comparable to coal, as the table below illustrates. The increase in calorific value is caused by the removal of moisture and some organic compounds from the original biomass. A fundamental difference with charcoal is the difference in volatile matter; in torrefaction processes, the aim is to maintain volatile matter (and thereby energy) in the fuel as much as possible producing a fuel with wanted characteristics at much higher efficiency than in charcoaling.

Table 6-1 - Properties of transportable biomass and competing fuel (Bradley et al., 2013).

	Fresh Wood	Wood Pellets	Torrefied Pellets	Coal
Moisture (%)	35-50	7-10	1-5	10-15
Calorific Value (GJ/T)	9-12	16-18	19-23	23-28
Bulk Density (T/m3)	.2-.25	.6-.68	.65-.75	.8-.85
Energy Density (GJ/m3)	2-3	9.6-12.2	12.4-17.3	18.4-23.8
Ash (% by wt)		0.4-2	0.4-2.5	9.7-20.2
Grindability	Poor	Poor	Good	Good

6.3.2 Torrefaction technologies

A variety of torrefaction technologies were developed. Same input material does lead to almost similar product independent of torrefaction technology implemented. (Thrän, 2016)

Table 6-2 - Torrefaction technologies

Developer	Technology	Location(s)	Production capacity (t/a)	Scale and status Pilot scale: - 500 kg/h Demo scale: > 0,5 t/h – 2 t/h Commercial scale: > 2 t/h)	Full integration (pre-treatment, torrefaction, combustion, heat cycle, densification)	Status
Clean Electricity Generation (BV, UK)	Oscillatingbelt	Derby (UK)	30,000	Commercial scale	Yes	Available/ operational
New Biomass Energy (USA)	Screw reactor	Quitman (USA/MS)	80,000	Commercial scale	Yes	Available/ operational
Topell Energy (NL)	Multistage fluidized bed	Duiven (NL)	60,000	Commercial scale	Yes	idle
Arigna Fuels (IR)	Screw conveyor	County Roscommon (IR)	20,000	Commercial scale	Yes	Available/ operational
Airex (CAN/QC)	Cyclonic bed	Bécancour (CAN/QC)	16,000	Demonstration scale		Available/ operational
Andritz (AT)	Rotary drum	Frohnleiten (AT)	8,000	Demonstration scale	Yes	new ownership
Andritz (DK) / ECN (NL)	Moving bed	Stenderup (DK)	10,000	Demonstration scale	Yes	stand by
BioEndev (SWE)	Dedicatedscrew reactor	Holmsund, Umea (SWE)	16,000	Commercial demo	Yes	Available
CMI NESA (BE)	Multiple hearth	Seraing (BE)	Undefined	Demonstration scale		Unknown

Earth Care Products (USA)	Rotary drum	Independence (USA/KS)	20,000	Demonstration scale		Available/ operational
Grupo Lantec (SP)	Moving bed	Urnieta (SP)	20,000	Demonstration scale		Unknown
Integro Earth Fuels, LLC (USA)	Multiple hearth	Greenville (USA/SC)	11,000	Demonstration scale		Unknown
LMK Energy (FR)	Moving bed	Mazingarbe (FR)	20,000	Demonstration scale		Unknown
Konza Renewable Fuels (USA)	Rotary drum	Healy ((USA/KS)	5,000	Demonstration scale		Unknown
River Basin Energy (USA)	Fluidized bed (Aerobic)	Rotterdam	7000	Demonstration scale		in commissioning
TSI-Teal Sales Inc (USA)	Rotary drum	White Castle (USA/LA)	15,000	Demonstration scale		Available/ operational
Agri-Tech Producers LLC (US/SC)	Screw conveyor	Raleigh (USA/NC)	Undefined	Pilot stage		Available/ operational
Airex (CAN/QC)	Cyclonic bed	Rouyn-Noranda (CAN/QC)	Undefined	Pilot stage		Available/ operational
Airex (CAN/QC)	Cyclonic bed	Trois-Rivières (CAN/QC)	Undefined	Pilot stage		Available/ operational
CENER (SP)	Rotary drum	Aoiz (SP)	Undefined	Pilot scale		Available/ operational
Terra Green Energy (USA)	Multiple hearth	McKean County (USA/PA)	Undefined	Pilot scale		Available/ operational
Wyssmont (USA)	Multiple hearth	Fort Lee (USA/NJ)	Undefined	Pilot scale		Unknown
CEA (FR)	Multiple hearth	Paris (FR)	Undefined	Laboratory scale		Available/ operational

Rotawave, Ltd. (UK)	Microwave	Chester (UK)	Undefined	Laboratory scale		probably closed
Bio Energy Development & Production (CAN)	Fluidised bed	Nova Scotia (CAN/NS)	Undefined	Unknown		Unknown
Horizon Bioenergy (NL)	Oscillating belt	Steenwijk (NL)	45,000	Commercial scale	Yes	Dismantled to CEG

Significant initiatives are engaged in technologies commercialization, with several demonstration plants already in operation and first commercial sized units nearing hot commissioning. A minimum of 4 technologies is commercially available to the market with a group of technologies right in their last steps towards full commercialization. The current trajectory of development indicates that a broad array of technologies will become commercially available within the next 2 years. Although it seems that by now the "valley of death" for the technology developers is left behind and most of critical process steps are controlled well, same with the links along the logistical chain and in co-firing there is still the "chicken and egg" problem when it now comes to the rolling out of technologies. It seems still very difficult to find investors willing to invest without a long term take or pay contract by a bankable consumer like a utility.

But it is not only the mastering of the technological challenges on torrefaction but also the next steps in processing – densification – and all further steps in the value chain which need to be developed and put under control to present the product successfully on the market. Many of these steps are taken or in progress of being taken, sometimes in close co-operation with customer groups, regulatory bodies and consuming technology providers. The current status can be best illustrated by a traffic light implementation indicator for torrefaction.

Table 6-3 - Traffic light implementation indicator for torrefaction (Wild et al 2016).

Torr-gas Handling		done
Torr-gas Utilization		done
Continuous torrefaction		done
Predictability and consistency of product		for many raw materials
Densification		in optimization
Feedstock flexibility		mostly done
Plant Safety		done
Indoor storage		done
Outdoor storage		in optimization
Standardization of product		ISO 17225-8 TS
Safety along supply chain		in progress
Trade Registrations and Permissions		in progress
Co-firing trials		done in EU
Co-firing burn tests		several done
Co-firing full scale		mostly open
Heat application trials		in progress
Heat application acceptance		open

6.3.3 Advantages of torrefaction

The impact of the roasting on the biomass raw material does change many of the particulars of the material leading to a fuel with many advantages with respect to standard wood pellets.

1. Significant cost reductions in transport and handling
2. Broader feedstock basis - geographically + types of raw material
3. Much easier storage – improved water resistance, 0 biodegradation

4. Broad variety of applications - Energy & Non Energy
5. Reduces CAPEX&OPEX at end user – Immediate use in existing coal fired plants – grindability and water resistance significantly superior to wood pellets
6. Combusts cleaner, gasifies easier and cleaner
7. Can be made to measure to clients requirements
8. Helps commoditization of the bioenergy markets

At the same time all examinations on densified (pellets or briquettes) torrefied biomass concerning health and safety issues did result in equal or lower risks and hazards than are seen with wood pellets.

6.3.4 Impact of torrefaction on international trade

Torrefaction does provide clear advantages over wood pelleting or wood steam explosion processes as it not only is more flexible on feedstock, by this providing the potential for significant savings on feedstock costs, but it also can create output products with significantly increased calorific values, reduced chlorine contents down to 1/10th of original amount in feedstock and a similarity to coal in morphology once ground by coal mills to name only a view of the advantages listed in literature.

Beside its advantages over untreated or just pelletized biomass in combustion, torrefied biomass managed to prove in recent years that the expected advantages along the whole supply chain (in logistics, storage and handling) are realistic and will bring costs down per GJ along this chain. Therefore overcompensating eventually higher capital costs in the processing. Different tests have shown significantly improved water resistance and additionally that torrefied biomass, once compressed into pellets or briquettes, is of non-hazardous character in transportation. A number of full scale tests in co-firing in European power plants have confirmed the positive combustion results expected.

The power sector could well be the leader in torrefied biomass's use, with industry behind. Torrefied biomass is proven for power-plant applications and may in the coming years become a central resource for co-firing of biomass with coal. Industrial-sector usage may indeed not compete with use in the power sector with regard to volumes of torrefied biomass used. Demand from industry could, however, drive development of torrefied-biomass production and markets in general.

The technical possibilities for use of torrefied-biomass in several industries were shown in several studies and first sets of testing. In the iron and steel industry, even full replacement of pulverized-coal injection with torrefied biomass injection (150−200 kg/t hot metal) could be possible. It is possible for a pulverized-coal boiler to be fired with 100 % torrefied biomass without a decrease in boiler efficiency or permitting of fluctuation in boiler output. Also, in the pulp and paper industry, replacement of traditional lime kiln fuels may be possible.

The non-metallic-mineral industry too is willing to use torrefied biomass. The most likely applications are co-firing with coal at pulverized-coal-fired power plants and in cement kilns, dedicated combustion in small-scale pellet-burners, and gasification in entrained-flow gasifiers that normally operate on pulverized coal. Use of biomass in the chemical and petrochemical industry and also for production of transport equipment and fabricated metal products, including machinery and equipment, is to date still negligible; here, torrefied biomass is the most promising of all biomasses even though the right form of application need still to be found.

Many of the consumers in these sectors do have the advantage for torrefied biomass suppliers, that the demand is much smaller than for instance in coal power plants. This can achieve a more organic growth of the production facilities, which will also be much more to the taste of the investors.

Another way of succeeding in this sector may be through gasification of torrefied biomass. First gasification demonstration plants are in operation and results are so far promising. This on both levels, the energetic utilization of gases but also in the detachment of certain chemicals from the torrefaction gases in the normal torrefaction may open up doors to derivation of higher value products in co-production. As issues around energetic utilization of torrefied product are no further a priority subject to research, scientists are very much focusing on chemicals derivation. Some major breakthroughs are to be expected here as well.

All these results will help torrefied biomass to achieve more acceptances from consumers and eliminate barriers in international trading. Market participants will also develop a clearer understanding of the products once the ISO committee issues a TS (technical specification) under ISO 17225-8, which is planned to be in Q4 2016. For the European market, a SIEF consortium built within IBTC achieved the clear result that no REACH registration should be necessary.

Higher energy density and weatherability of torrefied biomass are the basis for the significant advantages in logistics. However, factors like no biodegradation during storage and no offgasing at ambient temperatures are important ingredients as well. Especially if it comes to compare the costs of supply chains, the risk exposure and the possibility to take arbitrary advantages through long time storage or geographical transfer. With this advantages torrefied biomass is not only the solid biomass with lowest costs and least risks in biomass storage, transport and handling but does also fit best of all solid biomass fuels in requirements for a true global commodity which in turn, once sufficient liquidity is seen in the market, will also make the creation of all kind of hedging tools in trade more simple and by this realistic.

By all this it seems that the struggles of torrefaction on level of technological development and logistical approval seem to be overcome. First industrial scale plants have proven scalability, the addressing of additional consumer sectors in parallel to coal/biomass co-firing has widened the potential market, the R&D concerning the processing of non woody and often significantly cheaper biomasses has proven that marketable and ISO conforming fuels will result, existing and new plants for torrefied-biomass production in various parts of the world could stimulate demand for torrefied biomass in different sectors of the economy significantly.

It seems all fundamentals for market success of torrefied biomass are today really provided and ready for market uptake. The reporting of success stories will be the duty of a future update of this study.

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M.Cremers et al Status overview Torrefaction technologies

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7 Conclusions and Outlook

7.1 Development of pellet production, trade and consumption

David Petz, Kay Schaubach, Daniela Thrän

The provided inventory from more than 30 countries covers the pellet production and consumption in Europe and Russia, North and Latin America as well as South-East Asia and Australia. Production and consumption patterns differ between the countries. An overview for the year 2015 with partial information from 2016 is given in Figure 7.1. On a country basis the U.S. stands out by far as the largest pellets producer with 7.4 Mt in 2015 (FAO-Estimate) and 6.3 Mt in 2016. Canada is the country with the most dynamic development, having increased the export from 1.6 Mt in 2015 to 2.4 Mt in 2016. Other large producers are Germany (2.2 Mt) and Sweden (1.5 Mt). With regard to pellet consumption, the United Kingdom is the largest consumer with 6.7 Mt pellets in 2015, followed by the U.S. with 2.9 Mt, Denmark (2.8 Mt) and Italy (2.1 Mt).

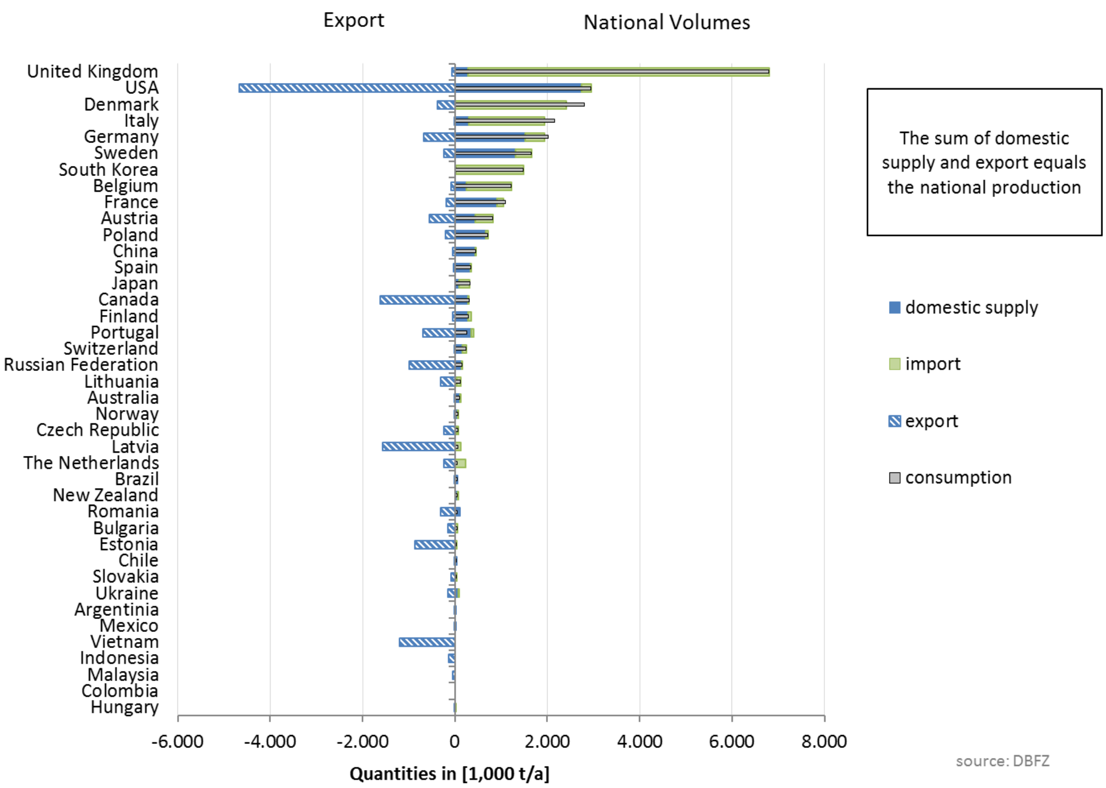

Figure 7.1 - Domestic production and Import | Export per country for chosen countries in 2015

The reported production in 2015/2016 sums up with an overall production and use of 26 Mt wood pellets worldwide. Compared to the given amounts of global wood pellet production in other existing studies (e.g. Goodwin, 2014; AEBIOM, 2016; Goetzl, 2015), the integration of the most relevant pellet production countries can be stated (Figure 7.1). Comparing the overall numbers with the last IEA report on wood pellets (IEA Bioenergy 2011), we see that since 2010, wood pellet markets develop all over the world and grow stable with about 14 % per year.

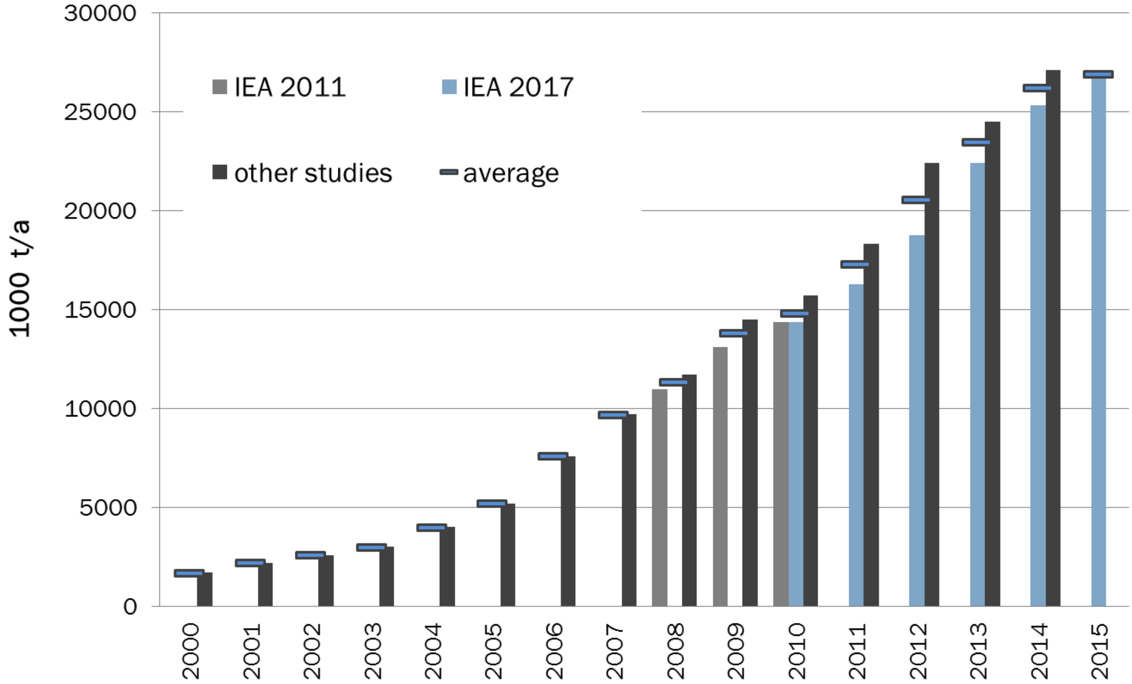

Figure 7.2 - Comparison of the found out wood pellet production development with other studies

Since 2011, new countries have entered the market for both, pellet production (such as countries from South-East Europe and Canada) and pellet consumption (such as countires from South-east Asia) (Figure 7.3). Also the global wood pellet trade increased. The first is dominated by the trade relation between the U.S. and the UK, while the non-industrial use is still mainly an intra-Europe business. Russia and the Baltic states are becoming here increasingly important as producers. The Asian markets show also a strong growth, with Japan and South Korea as the main consumers and Vietnam as the fastest growing exporter. Reflecting the major demand in Europe, it is also by far the largest producer (2015: 54%), followed by North America (2015: 35%), which is mainly export driven. Asia, the Russian Federation, Australia and Latin America play minor roles in the global pellet production (2015: 11%).

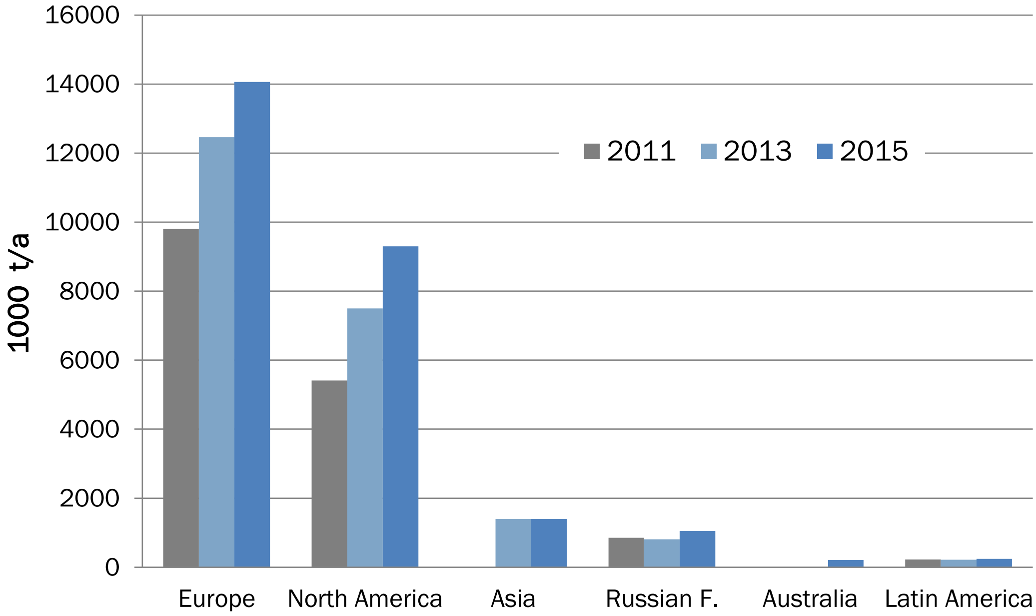

Figure 7.3 - Pellet production by continent in 2011, 2013 and 2015

Nevertheless, there are still two major markets the pellets are produced for: small scale and large scale application. The main related pellet consumers are households and the service sector on the one hand side, and industrial coal power plant operators on the other hand. The relevance of those two end user markets differs between the countries. Households use wood pellets for heat provision in small scale combustion as a convenient solid biofuel is relevant in countries where individual heating systems dominate and a distribution infrastructure is available. The main markets here are Germany and Italy (AEBIOM, 2016). The high quality pellets for these small scale appliances are produced mainly within Europe on a continuous basis but consumed mainly in the winter. The use of pellets in coal power plants is motivated by greenhouse gas reduction instruments, which are – as long as emission certificates are traded at very low prices – dedicated national support instruments, such as the Renewables Obligation in the UK (Bingham, 2016). The largest pellet consumer for industrial application is Drax Power Station in the UK.

Medium scale appliances such as district heating, CHP and industrial units for process heat follow their respective diverse consumption pattern. District heating has also a peak in winter but might also deliver continuous heat for hot water supply all over the year, which can result in a steady supply with pellets.

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7.2 Expected pellet production, trade and consumption

Martin Junginger, Kay Schaubach, Daniela Thrän,

Forecasting supply and demand is a tricky business, whether it is for fossil fuels or biomass commodities. For example, AEBIOM (2008) published a roadmap in which the combined residential and industrial demand was estimated to reach possibly up to 50 million tonnes by 2020 – prospects which are nowadays clearly out of reach. Nevertheless, as wood pellet markets are largely demand-driven, below, we first discuss a number of trends observed and expected for wood pellet demand for various end-uses, followed by an assessment of possible global supply and trade of wood pellets.

The increase of demand is influenced by a range of factors. The European Pellets Council identifies the further improvement of efficiency and quality of pellet production, of logistics and heating appliance efficiency. Also, new markets need to be addressed, such as medium scale (heat and CHP). One obstacle is the current uncertainty of bioenergy support from the EU policy level. Several national governments in Europe have strengthened their support, yet are waiting for clear signals from EU level (esp. Winter Package and REDII). (AEBIOM, 2016; Hawkins Wright, 2017)

The main driver for an expansion of pellet demand in the heating sector is still the replacement of fossil installations either through because of personal belief in the fuel and technology, economic viability and/or through policy requirements and/or support. Especially for the residential heating sector, the demand in Europe depends on the weather conditions. Mild winters, as in the last few years have capped the demand, as has the competition with cheap fossil fuels and the installations of alternative renewable heat sources, especially heat pumps. In the heating sector, a strong emphasis is laid upon energy efficient building, reducing the heating demand but increasing the demand for even smaller scales, flexible heating appliances. The development of micro-CHP systems and the stronger utilization of excess heat from e.g. industry processes might influence the future heat market. In addition, the research and utilization of Power-to-X concepts has gained momentum. The heat production from excess power generated by fluctuating wind and solar installations might also decrease heating demand from biomass or call for smaller, more flexible applications. Large and frequent oversupply of renewable electricity and commercially viable power-to-concepts are likely only to occur at the end of the next decade, and also the implementation of building insulation and heat pumps will take time, so on the shorter term, there is likely still a growth market for residential wood pellet. However, beyond 2030, it is deemed unlikely that the amount of wood pellets used to produce low-temperature heat only will further increase. In contrast, use of wood pellets in medium to large scale application, mainly industrial plants for process heat and district heating combined with grids might further increase, also on the longer term. High temperature heat for industry is still difficult to produce with other forms of renewables, so this could provide an important future market.

The replacement of coal in power plants has been one of the major growth markets in the past in the EU, but has recently slowed down. As the largest share of industrial use pellets is caused by the U.K., their legislation and operation of the power plants (DRAX) will determine a large share of the future demand. A notable increase is expected by Lyemouth Power Station (conversion) in Northumberland (1.6 Mt/a pellets, expected start 2018), MGT Power (CHP) in North Yorkshire (1 Mt/a, expected start in 2020) and Drax Powers Unit #1 (conversion) in South Yorkshire (2 Mt/a, 2017). While the further use of pellets for electricity generation in Belgium is not clear at the moment (Handelsblatt, 2017; GWMI, 2017)), new plants in the Netherlands (total 1.5 Mt/a, ultimately up to 3.5 Mt/a) and Denmark (total 1.1 Mt/a) are planned to go online within the next two years. The project is part of their new renewable energy commitments and is expected to be completed in 2018. Also the Finnish utility Helen Ltd reported plans for building a pellet-fired heating plant, with fuel capacity of about 100 MW till 2018 (GWMI, 2016). This heavily import reliant business is affected by the exchange rate between the U.S. Dollar and the Euro (Bingham, 2016), but also about the sustainability of wood pellets, and the necessity to produce large-scale power only from woody biomass with increasing amounts of other renewable electricity.

In the Netherlands, a discussion has been ongoing over the 2016 and early 2017 to close all remaining coal power plants, which would mean an end to all plans to co-fire up to 3.5 million tonnes of wood pellets. Alternatively, the remaining four coal power plants might be adapted to 80% woody biomass or even 100% conversion to biomass. It remains to be seen after the election in March 2017 what the new Dutch government will decide.

In summary, growth for small-scale residential heating and large-scale industrial markets may slow down, but still continue for a decade or so. With the advent of other forms of renewable electricity, which (via heat pumps) can also be sued to produce low-temperature heat, the long-term outlook for both options in the EU looks uncertain – industrial heat might be one of the few growth markets left.

In stark contrast to the slow-down in the EU, large-scale power markets in East Asia are rapidly picking up. In Asia, South Korea will continue to be the largest consumer, mainly supplied by Vietnam. The country has already tendered 660.000 t for 2017, mostly for KOSEP's Yeongdong unit conversion – the first plant to run on 100 % biomass in the country. Japan's market is also expected to grow continuously as co-firing is substantially increased at Tokyo Electric Power's Soma Kyodo Power Station in Shinchi and the start-up of co-firing at Osaka Gas' Nakayama Nagoya Unit 2 is planned (Hawkins Wright, 2017). The demand could rise to 15 Mt/a of wood pellets by the mid-2020s (see chapter 5.3.7).

However, China has set out a goal of using 30 Mt of biomass pellets consumption in 2020 to replace 15 Mt of coal. In this decision as part of its five-year plan for biomass development, issued on 5 December 2016, it is yet unclear how much of this quantity is planned to be wood pellets (Hawkins Wright, 2017) and for the time being there are also no related instruments in preparation. It is also uncertain how much of the demand could be sourced domestically, and how much would need to be imported.

A clear additional market potential for the coming decade is seen due to a rising demand in Asia and a continuous growth in Europe, especially in the heating market, replacing fossil fuels. As this market is momentarily under pressure due to mild winters in Europe, low fossil fuel prices, concurring renewable options and efficiency increases in building, the new markets in medium scale applications (district heating, industrial units, CHPs), are coming into focus. Bioeconomy as an emerging client is also discussed. The possibility to use e.g. lignin streams from second-generation lignocellulosic biorefineries for large-scale industrial heat and power applications could be of interest – but such biorefineries would likely take in wood chips or higher pretreated products like torrefied pellets rather than wood pellets.

The production capacities have grown steadily in the last years, showing fluctuating utilization degrees depending on the demand (see previous chapter). The U.S. will maintain its position as largest producer but faces stronger competition within Europe from Russia and adjacent Baltic countries. Asian countries will also increase their production, meeting the regional demand (International Trade Administration, 2016). Although this may be linked to severe sustainability issues (many potential exporting countries face net deforestation, and large-scale exports could exacerbate these problems). (On the other hand, growth in Latin America (a major supplier of pulp wood) and in sub-Saharan Africa has so far been negligible. This could be due to various factors, e.g. the investment climate (especially in Brazil and Africa), difficult logistics (Africa), and a stronger policy focus on other forms of bioenergy (Brazil).

It also will need to be seen how successful initiatives to bring non woody biomass into the energy markets will be. New pretreatment processes such as HTC, torrefaction or steam treatment have the potential to open up the feedstock basis to non woody biomass.

One key element to satisfy demand in an economic and environmentally sustainable way is the continuing development of pretreatment processes such as torrefaction, HTC and steam treatment. These processes by eliminating many of the mineral components and salts from the feedstock prior to pelletizing allow diversification of the feedstock base from only woody into low cost agro byproducts or dedicatedly grown grasses and the like leading to homogeneous- and specific properties adjusted to various end uses and feasible global trade in terms of logistic and commodity.

Last but not least, the supply via international trade might be impacted by rising sustainability certification requirements. In the U.S., the sustainability requirements of e.g. The Netherlands could not be met by voluntary U.S. private forestry initiatives, thus reducing their exports significantly (International Trade Administration, 2016). Currently, the UK, Belgium, the Netherlands and Denmark all each have (slightly) different sustainability criteria and requirements in place, which are partially also still under development. While the sustainable biomass program (SBP) aims to provide a single certification scheme that will meet the requirements of all countries, the development of diverging criteria causes non-technical barriers for wood pellet trade. It remains to be seen if and which EU-wide criteria for solid biomass use will ultimately be included in the final RED–II, and in how far the current exporting regions will be able to comply with these criteria.

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7.3 Development of pellet prices

Fabian Schipfer, Peter-Paul Schouwenberg

Discussions and illustrations on pellet prices and especially on price comparisons have to be treated with care. This is mainly because the substitution of fossil based commodities with this solid bioenergy carrier developed in different ways in recent years. On the European continent, pellets for electricity production took off in the UK, the Netherlands, Belgium and Poland, while CHP- and heat plants are using pellets mainly in Denmark, Sweden, Poland and Germany (AEBIOM, 2015). Pellet prices for the largest consumers are confidential since they are bilateral and often long term contracts which are not made public. Pellet price developments for other large scale consumers, further denoted as *pellet prices for industry* are best reflected in the ARGUS shipping market polls (ARGUS, 2017), representing spot market prices. The PIX Nordic index "is a wood pellet price index concentrating on industrial use of pellets in Nordic countries and other Baltic Sea region" (FOEX, 2017). Pellet markets for *medium scale commercial consumers* including small heating plants and commercial buildings are mainly found in Sweden, Germany and France, for *small scale household consumers* in Italy, Germany, Austria and France. Depending on the scale of the respective user storages, relevant pellet prices are best represented by various purchase quantities. While Italy, France and Spain have a high share in pellet stoves, the small scale segment in Austria, Germany, Sweden and also Switzerland are dominated by pellet boilers most likely attached to dedicated pellet storages with the capability to store pellets for a full heating season. It can be expected, that pellet bag prices (e.g. in 15kg bags) are more informative for final consumers for stove markets and bulk delivery on pallets or in dedicated pellet trucks with pellet blowers for boiler dominated markets.

Industrial pellet prices are polled from market actors throughout the entire supply chain, based on standardised methodologies and prepared in a way to reflect key information of the data e.g. lowest, highest and average values on a weekly basis. However, these extensive pellet price time series are not publiclly available and can only be purchased. Current prices and price developments ("price time series") for medium and small scale consumers are publically available in a few countries including Germany, France, Sweden, Spain, Switzerland, Finland and Latvia of which Finland, France, Latvia and Switzerland commissioned their national statistical authorities to collect and publish the pellet price data. In the remaining countries, pellet associations or consumer associations are doing this job. In Austria, Italy, Denmark and Norway prices are also collected by associations; current prices can be found online and time series can be acquired upon request from the respective association (see Table 7-1).

The quality of *price data for bagged and bulk pellet delivery to small- and medium scale consumers* is unfortunately lower than their industrial counterpart. No harmonized methodology is applied to collect price data in the differing countries, and so the level of detail differs, ranging from monthly to quarterly or even only yearly data, and is collected for different purchase quantities and only in a few cases for different regions. Prices for pellets based on different feedstock types are only available for the Spanish market and for some publically available data points for Poland and Ukraine. A valid comparison of pellet prices for small-scale users would have to be based on a standardized collection methodology, e.g. with a fixed amount of pellets delivered (e.g. 6 t), a fixed delivery distance, exclusion of VAT and of additional costs like the costs for blowing pellets into the dedicated storage. Also exchange rates and their impact on the comparability would have to be considered and inflation correction would have to be undertaken for longer time series. In Figure 7.4, we attempt a wood pellet price comparison for the small-scale heating market. The illustration excludes the different VAT rates which are as low as 7% for Germany and up to 25% in Sweden, as well as with substantial changes over time as for Italy (from 10-22% in 2015) and for Austria (from 10-13% in 2016).

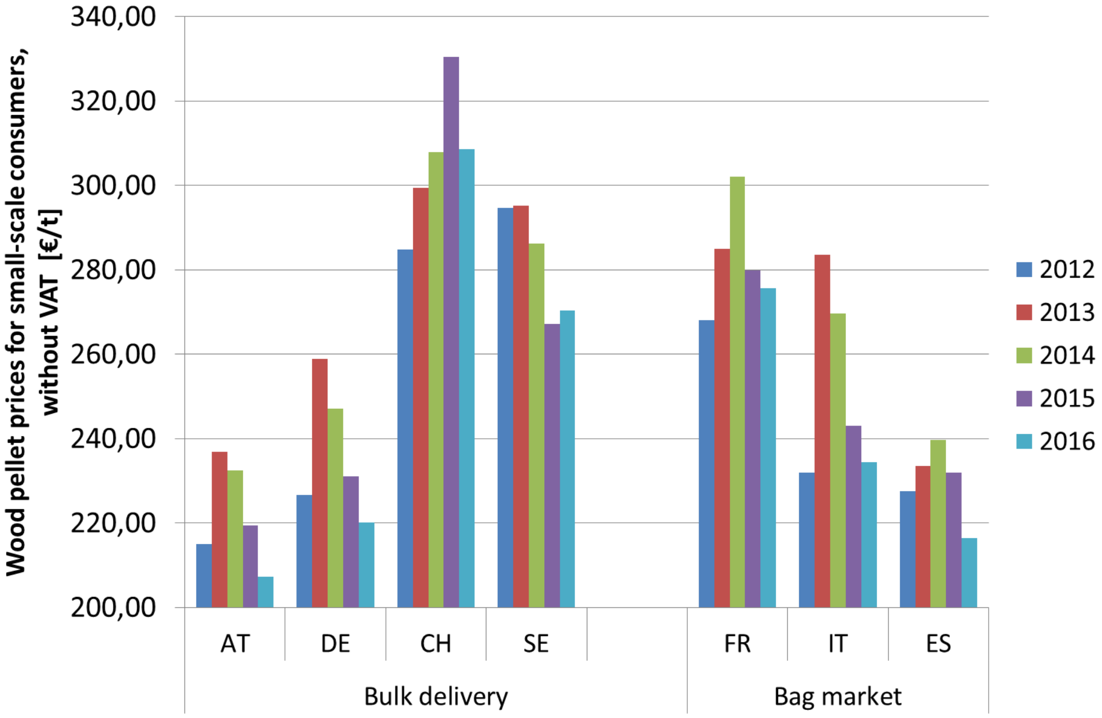

Figure 7.4 - Comparison of wood pellet prices for small-scale consumers, either delivered in bulk or prices for pellets in bags. AT, DE, CH & SE with delivery (different distances) for 6 t,5 t, 6 t and 3 t. FR, IT & ES are for 15 kg sacks without transportation for FR and IT and with transport costs in the case of ES. Average exchange rates are derived from OANDA, (2017). Sources; (AIEL, 2017; AVEBIOM, 2017; BFS, 2017; CARMEN, 2017; GSE, 2017; MEEM, 2017; Pelletsförbundet, 2017; ProPellets, 2017)

Pellet prices for residential consumers (in Europe) are in general between 200 €/t and 300 €/t with the exception of Switzerland and France where pellet prices before VAT are higher. Prices peaked in 2013 in Austria, Germany, Sweden and Italy while they kept increasing until 2014 for Swiss, French, and Spanish consumers. 2015 prices for Switzerland in Euro did still increase due to strongly devaluating Swiss Francs. Prices dropped in all countries during 2016 due to an oversupply in small-, medium- and industrial pellet markets. In the industrial market, the main factor causing also a price drop was down time on the power plant side which caused pressure. Regarding the heating market there has been three years of soft winters which also caused lower pricing than previous years.

In the first few months of 2017 the market seems to be turning and the stock situation is changing to the lowest levels we have seen in the last three years. This is all caused by low outage in the industrial market, an extended winter with low temperatures in early May and a capacity reduction on the pellet producer side.

International trade of wood pellets is a necessity for countries with strong demand but small resources to make up for absolute shortages of domestic resources. Imports are also used for arbitrage reasons, i.e. to acquire less expensive fuel from international markets than would be available domestically. Physical trade between the spatial distinct small-scale heating markets, but also between small-, medium- and industrial heating markets increased significantly in the recent years. However, no definite equilibrating effect for end user prices between the small-scale heating countries can be determined so far (Schipfer et al., 2016). For the commoditisation process of wood pellets, it is albeit vital for market actors to work towards spatially equilibrated price developments (hence improving market efficiency), to increase access and affordability for end users on a long run. Important barriers that will have to be tackled include (1) consumers intrinsically valuing regionality and pellet color despite these factors being unrelated to the pellets' quality, and (2) the relatively low market transparency. For the latter, availability of pellet prices and other related data would have to be improved significantly, starting from harmonized approaches of collection and joint publication on multilingual homepages through to the development of price benchmarks for small-scale wood pellet heating.

Table 7-1 - Accessible pellet price information (at the time of writing); harmonized methodologies for data collection and joint publication on multilingual homepages are necessary to improve data accessibility. The table is presented without claims for completeness.

Country	Publisher	Link
AT	proPellets Austria	http://www.propellets.at/en/pellet-price/details/
CH	National statistics agency (BFS)	https://www.bfs.admin.ch/bfs/de/home/statistiken/kataloge-datenbanken/tabellen.assetdetail.1740342.html
DE	Central Agrar-Rohstoff-Marketing- und Energienetzwerk (C.A.R.M.E.N.) e.V. & Deutscher Energie-holz- und Pelletverband (DEPV) e.V.	https://www.carmen-ev.de/infothek/preisindizes/holzpellets http://www.depv.de/de/home/marktdaten/pellets_preisentwicklung/
FR	Official Statistics from Ministry (MEEM)	http://developpement-durable.bsocom.fr/Statistiques/
ES	Asociación Española de Valorización Energética de la Biomasa (AVEBIOM)	http://www.avebiom.org/es/ind-precios-biomasa
FI	National statistics agency (Tilastokeskus)	http://pxnet2.stat.fi/PXWeb/pxweb/en/StatFin/StatFin__ene__ehi
IT	Statistics from funding agency (GSE) & Associacione Italiana Energie Agroforestali (AIEL)	http://www.gse.it/it/Statistiche/RapportiStatistici/Pagine/default.aspx http://www.aiel.cia.it/download-rubrica-prezzi.html
LV	National statistics agency (CSB)	http://data.csb.gov.lv/pxweb/en/vide/vide__ikgad__energetika/EN0190.px
SE	Pelletsforbundet	http://pelletsforbundet.se/statistik/
US	U.S. Energy Infor-mation Administration (EIA)	https://www.eia.gov/biofuels/biomass/#table_data

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7.4 Expected pellet prices

Patrick Lamers, Olle Olsson, Michael Wild

Future pellet prices in the industrial sector, which dominates world trade, will depend on global market conditions, i.e., demand trends and supply capacities. Demand markets are still influenced exclusively by policy framework providing incentives in different forms to biomass combustion. So far, supply capacities have reacted to policy and demand projections. The pellet market is not supply driven.

This can be briefly illustrated by past global pricing trends. The average CIF-ARA pellet price between 2009 and 2015 was around $169 per tonne, which resembled pricing in a growing global market with overall balanced demand-supply volumes. Following a high point in mid-2014 at $185 per tonne, CIF-ARA prices dropped almost continuously due to a lower than expected demand (e.g., from the Netherlands) and a resulting global oversupply particularly throughout the second half of 2015 and 2016. This caused a historic minimum price in December 2016 of just under $113 per tonne (Figure 7.5).

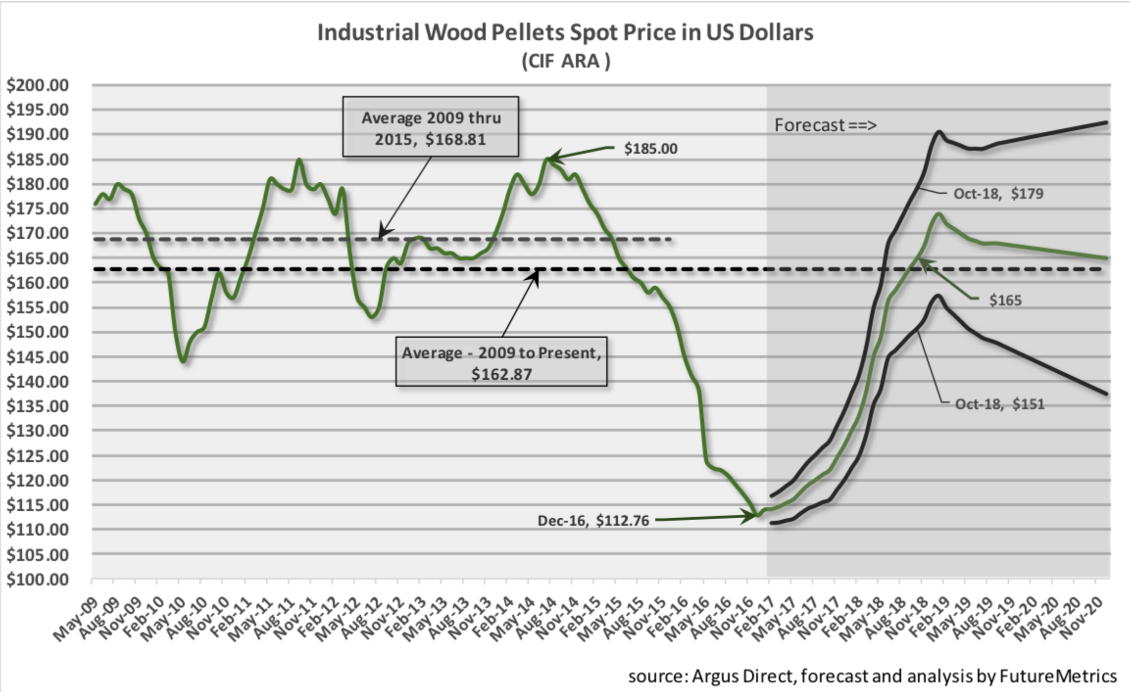

Figure 7.5 - CIF-ARA price development since 2009. Source: FutureMetrics & Argus Media.

What this drop in spot market prices meant to producers can be shown by reviewing some typical pellet supply chain cost structures. Present pellet cost structures are dominated by fiber costs, which make up roughly half of the plant gate costs. CIF-ARA prices are generally made up of about one third fiber costs, one third pellet production and plant costs, and one third transportation and handling (Table 7-2).

Table 7-2 - Three pellet production cost ranges.

Supply chain step	Low	Medium	High
Fiber cost & transport	$39	$55	$70
Pelleting OPEX	$20	$23	$25
Pelleting EBITDA	$25	$33	$40
Plant gate	**$84**	**$110**	**$135**
Mill to port	$8	$10	$12
Port storage & handling	$8	$10	$12
FOB	**$100**	**$130**	**$159**
Ocean freight & handling	$18	$20	$22
CIF-ARA	**$118**	**$150**	**$181**

Supply chain integration (e.g. upstream investments) and optimization strategies can reduce some fractions in the pelleting operations and transportation and handling costs (e.g., by reducing storage times or optimizing rail cargo operations from production to port facilities). However, cost reductions down to achieve a CIF-ARA of $113 per tonne (or lower) are difficult to achieve.

The next couple of years are bound to see an increase in demand, particularly from Asian markets, which will increase spot prices again to past levels. Nevertheless, a key challenge facing the wood pellet industry in the long-run is a continued push towards cost reduction given higher international competition and a policy trend away from direct subsidies on the conversion side. The future competitiveness of utilizing wood pellets for power generation will depend on pellet production, carbon, and coal prices. This could result in changes in business models including increased industry integration and cross-sector partnerships to co-share facilities and infrastructure. It could also imply a reduced EBITDA for some pellet plants owned by combustion facilities.

7.5 Dynamics in frameworks

Daniela Thrän, Patrick Lamers

The global pellet market has been increased and geographically diversified during the last five years dramatically. Nevertheless, there are still two, comparably independent markets: the residential heat market and the industry related power market. It is important to keep in mind that not only pellet qualities and actors, but also different policies driving the actual and future demand:

- The residential heat market is a slowly developing market, depending on the attractiveness of other heat supply systems, such as fossil fuels but also renewables, which is different for each supply case. Typically there are only slight support mechanisms, such as special credits or grants for the investment in pellet boiler.
- The electricity market is mainly driven by engagement in greenhouse gas emission reduction in the energy sector. International agreements and clear national targets have led to dedicated implementation instruments in some countries, which shifted the input in large scale power production from fossils to wood pellets. The support instruments often provide tariffs or premiums for every produced energy unit. During the last decade the global wood pellet market gained strong momentum from those policies. But in parallel there are also debates about the further development of those instruments in general.

In conclusion, more dynamics in the electricity/industrial market are expected also in the future:

The next couple of years are predestined to see an increase in short-term demand particularly from Japan and South Korea. This level of new demand is bound to swing the current conditions from a long (oversupply) to a short (undersupply) market. Overall, Asia is expected to provide the largest future growth opportunities in the medium- to long-term. China, e.g., is looking into replacing 30 Mt of coal as part of the 5-year plan – a part of which could be replaced with wood pellets. In the near term, the main growth markets in South East Asia include Japan and South Korea.

Japanese authorities recently approved regulation that now allows major energy generating companies to benefit from the national Feed-in-Tariff. While the exact level of co-firing is still uncertain, a 10-20% co-firing level of only the largest utilities would put Japanese wood pellet demand at 4-7 Mt in the near-term. Biomass imports to Japan reflecting this policy change are expected to start in 2017. By the time energy utilities are complying with the governments energy mix target (set for 2030), Japan is expected to have similar import and wood pellet use levels as the UK. The biggest challenge facing Japanese energy companies in the near-term is to secure the biomass in an increasingly short market.

In South Korea biomass co- and mono-firing is regulated via a Renewable Portfolio Standard. Renewable Energy Certificates (RECs) are issued per MWh of electricity generated. Dedicated (100%) biomass combustion facilities are eligible for 1.5 RECs per MWh. At present, REC levels are in the range of $180/MWh. This would imply a subsidy of $270/MWh for dedicated combustion facilities. South Korean demand for wood pellets could increase from current levels (of roughly 2 Mt) into the range of 7-8 Mt in 3-4 years with announced full plant conversions and additional co-firing at other locations.

Additional future growth markets may include Australia and Canada. Australia could increase wood pellet use through coal plant conversion. Canada has introduced a carbon tax and several provinces have outlawed coal based electricity production by 2030, including Alberta which has several newer coal fired power plants. Should Alberta convert two newer coal fired plants, wood pellet demand could reach 3-4 Mt (each plant would have a 1.5-1.8 Mt annual demand). This demand would most likely be supplied from within Canada.

The EU is expected to see a modest growth in the industrial sector over the next two years with additional conversions, e.g., in the UK. Overall EU demand (in the industrial sector) is expected to peak by 2020 and stay level at least until 2026 which marks the end of the present UK support scheme. Wood pellet and coal prices as well as carbon tax levels will determine the UK biomass use in 2027 and beyond unless a new policy scheme is put into place. Additionally Europe as the major market is in the process of defining new policies (Winter Package, REDII), which will impact the demand and the connected sustainability requirements. Together with the national legislations, this will be a decision point for the wood pellet development.

A reduced UK (and overall EU) demand could shift the supply contracts (permanently) to growing Asian markets. So with the already existing production capacities and trade flows, in the global pellet market the dynamics in the different regions might affect each other in the future.

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List of Figures

List of Tables