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Global Wood Pellets Markets and Industry: Policy Drivers, Market Status and Raw Material Potential

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1 Executive summary

Introduction and rationale

In 2006, given the present situation of the international wood pellets industry and market, members of the IEA Bioenergy Task 40 ”Sustainable International Bioenergy Trade: securing supply and demand” decided that a better understanding of the markets of wood pellets at global level and a more accurate assessment of the raw material for wood pellets production was needed.

Prepared within the work of IEA Bioenergy Agreement Task 40, this study “Global Wood Pellets Markets and Industry: Policy Drivers, Market Status and Raw Material covers the recent market and industry developments over the last decade for the most existing and emerging wood pellets markets, with the special focus on present situation (July 2007).

Recent policy and market changes have stimulated an increasing demand for wood pellets. However, despite their high potential and the growing demand, no overview studies at global level with a specific focus on wood pellets markets have been carried out before.

The overall structure of the study is divided into seven sections. Similar structure for the sections on markets and industry has been adopted in order to facilitate reading and allows easy comparisons between markets.

- Section 1 - Wood pellets
- Section 2 – Policy context in the main wood pellet markets
- Section 3 – The wood pellets markets and industry in Europe
- Section 4 – The wood pellets market and industry in North America
- Section 5 – Emerging wood pellet industry and market in Latin America and Asia
- Section 6 – Solid forest industry by-products
- Section 7 – Evaluation of the global raw-material potential for wood pellets from sawdust

Key trends in the global market

Sweden, together with USA and Canada, are the world’s largest producers of pellets with an annual production capacity exceeding 3,500,000 tonnes of wood pellets (about 16,5 TWh) in 2006. A second group of countries is composed of several EU Member States with a production ranging from 200,000 to 600,000 tonnes, including Austria, Germany, Italy, Estonia, Latvia, Russia, Poland and Denmark (Figure nr 1). The remaining countries produce much lower amounts.

Sweden is also the largest market so far, and trends show that Sweden will be still leading market in the short term. Other large markets include mainly central European countries, such as Austria, Italy, Germany, the Netherlands, Denmark and Belgium.

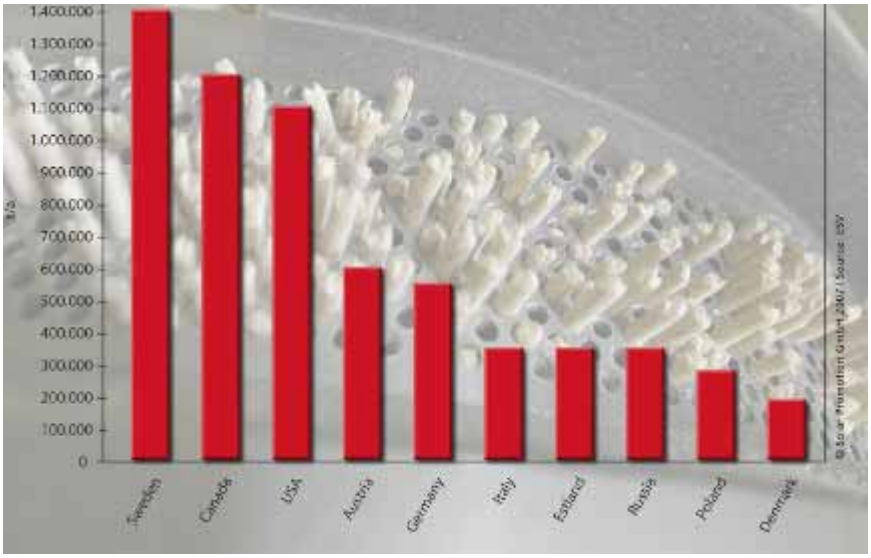


Figure nr 1. International wood pellets production in 2006. (Source: Solar Promotion GmbH 2007; ESV)

Policy as driver for pellet demand

Strong policy drivers in all regions investigated, but they differ by region. In Europe, concerns about climate change and targets to realize renewable electricity targets are a predominant driver, especially for large-scale co-firing. For small-scale heating applications, also the price advantage/competition with fuel oil plays an important role. This second driver is also the predominant one for North America, combined with a desire to diversify fuel supply. For Asia, the general need for (new) energy carriers and shifting from the heavily polluting energy technologies towards low carbon ones may be the most important drivers behind increasing demand for biomass pellets.

Export and import opportunities for wood pellets

Several markets are mostly driven by export potential opportunities: the Baltic States (Estonia, Latvia, and Lithuania), Finland, Russia, Poland and Canada. They all have low internal sales. Canada produced around 1,200,000 tonnes of pellets in 2006 year, of which a high proportion was sent to Europe through the Rotterdam harbor in the Netherlands. The Canadian Pellets Association estimates that 700,000 tonnes of Canadian wood pellets will be used in European power stations in 2007. Russia, with its 880 million hectares of woodland, is already exporting its pellets but with its huge potential, it could become one of the largest market globally for wood pellet provided economic and political conditions are in place. Some large potential producers like Brazil, Argentina, Chile and New Zealand are in the phase of planning the necessary infrastructure. Furthermore, under the Kyoto Protocol the use of biomass for energy production gives credit to the user, not to the producer of the fuel. As such, Sweden, Italy, Denmark and other industrialized countries have a strong interest in importing pellets.

Globalization is taking place

Globalization is taking place and trade is becoming a key feature of wood pellets markets. A rising number of pellet producers from around the world, especially Canada and Russia, are already selling in Europe and are looking for new business contacts. The pelletizing technology mainly comes from Europe and is exported to other parts of the world. Producers of pellet stoves and boilers are operating on a Europe-wide level and have been opening up new sales markets. Emerging markets are opening up both in Latin America and Asia. While in Latin America, pellet production is so far marginal, the European demand for pellets may trigger further investments in the near future.

Theoretical utilization potential of sawdust residues

The analysis of globally produced sawdust residues revealed that an estimated gross sawdust potential exists of over 300 million m^3. Five countries (USA, Canada, mainland China, Brazil and Russia) cover over two-thirds of this gross potential. However, when the estimated demand for fibre by the particle board and fibreboard industry is substracted, net available potentials may only be about 80 million m^3. The largest part of this potential is situated in Brazil, the Russian Federation and Canada. Assuming 6 m^3 sawdust for one tonne of wood pellets[1], this would imply a net potential of about 13 million tonnes, compared to a total production of an estimated 6 to 8 million tonnes in 2006 (Heinimö and Junginger, 2007).

Acknowledgements

The authors of the study would like to thank you all those from all over the world who have been given us input to update our market data. Without their help, it would have been very difficult to collect the necessary information.

The main data collection and writing of this report was carried out until July 2007. While this report was commissioned and reviewed by the members of IEA Bioenergy Task 40, the analyses and views do not necessarily represent the view of IEA bioenergy Task 40, or of the IEA Bioenergy implementing agreement.

[1] Source: http://www.woodenergy.ie/iopen24/defaultarticle.php?cArticlePath=7_34

2 Wood pellets

2.1 Background

Compared to other fuels in use today, wood pellets can be considered as a relatively new type of fuel. However, wood pellets came into existence already in the 1970s in North America as an alternative fuel. At that time wood pellets' primary purpose was to help resolve the energy crisis. In the beginning they were used mainly by industrial, commercial and institutional sectors for heating. When the first residential wood pellet stoves were sold to consumers in 1983, a residential wood pellet industry was created Today North America has over 80 wood pellet manufactures and produces about 2,300,000 tonnes of pellets (2006).

In Europe wood pellet production began later, led by the Swedish at the beginning of the 1980s. The Swedish market development was later driven forward by fossil carbon taxes and high oil prices. Since then several European Union Member States have joined Sweden in the development of the wood pellet market, as shown in the section 3 of this report (Wood Pellet Market and Industry in Europe). Today, Europe is the location of more than 300 wood pellets manufactures (2006) totaling 4,500,000 tonnes.

In the rest of the world, the wood pellet market development remains limited despites an undeniable large potential e.g. in Brazil, Argentina, Chile and New Zealand.

Wood pellets may be stored and traded on the regional, national and international level: these features combined with the other advantages such as environmental benefits, relatively high energy density, and easiness to use and economic interest make pellets attractive in many countries from both the demand and supply side of the market.

2.2 Wood Pellets production[2]

Wood pellets are usually made from dry, untreated, industrial wood waste such as sawdust, shavings or ground wood chips. This material under high pressure and temperature is compressed into small pellets, cylindrical in shape. As a source softwood (e.g. conifers, pines) and hardwood (e.g. oak) may be used. Both the bark and the xylem of the trunk can be used for making wood pellets, although it is most common to use the xylem. Wood pellets are manufactured at wood pellet mills (as called in North America) or wood pellet plants (as called in Europe). The manufacturing process is determined by the raw material but usually includes the following steps: reception of raw material, screening, grinding, drying, pelletizing, cooling, sifting, and packaging (Figure1a).

[2] The wood pellets production will be described based on description prepared by Jeremy Karwandy, industry advisor from Sakatchewan Forest Centre.

Before sawdust, shavings or chips can be pelletized, it is important that the material is dry and homogeneous. Particles which are too big damage wood pellet quality therefore usually the raw material is pulverized using e.g. a hammer grinder. Wet material is dried to a moisture level of about 8-10%. The material is then pressed through a pellet die whose holes determine the diameter of the wood pellets, and then the pellets are cut into the desired length. The wood's lignin and resin act as natural binding agents and no additional additives are required.
Because of the lower rate of lignin in hardwoods, expensive additives such as starch may be required to produce wood pellets out of hardwoods (such as those derived from willow chip). Additional moisture is extracted from the material during the compression process. New developments in manufacturing technology have been improving the wood pellet quality from both sources: softwood and hardwood.

Wood pellets are the product of a relatively simple mechanical process that relies on pressure to form wood fiber into a pellet. Figure nr 1a provides an overview of the process that occurs at a typical pellet plant. The raw material arrives in a variety of partially processed states (chips, shavings, sawdust, stripped bark, etc.) from which it must be dried and ground into a uniform size. It doesn't matter what order the pre-processing steps of drying and grinding happen in. Once the raw material is dry and uniform in size, it is forced through a press under a very high pressure to create the pellet. Pellets are then cooled to allow the natural bonding agents to set. Once the pellets have hardened, any loose material is screened out and fed back into the pelletizng process. Pellets are then ready to be distributed to the market.

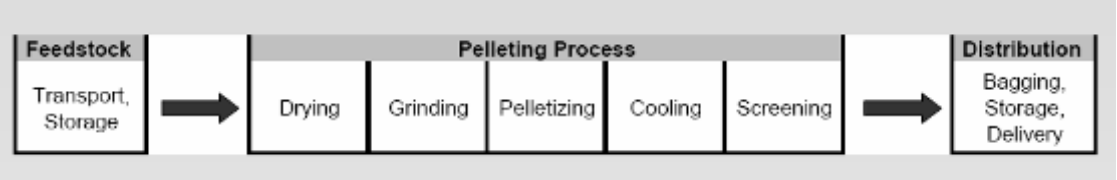


Figure nr 1a. Typical pelletzing operation (Source: Jeremy Karwandy, 2007)

Even though the process is straightforward and the technology relatively simple, there are a host of unique considerations to be made. Experts have indicated that new facilities can take from 12 to 18 months to reach the desired production rate (NEOS Corporation, 1995).

Feedstock

Managing the feedstock is one of the greatest areas of concern for a pelleting facility. Raw materials have to be sourced locally because their low bulk density makes them too costly to transport over long distances. As such, feedstock availability becomes the main determinant of plant scale. Plant scale, in turn, impacts the efficiency and ultimately the profitability of the operation. Most plants today, in response to market demand, consume only white wood residues; thereby, restricting their production potential.

The transport limitation on raw materials also limits the potential number of suppliers to those within the geographic region. Frequently pelleting operations are heavily dependent upon the operating decisions of only a few local sawmills. Long term supply agreements are a common method of ensuring facilities ability to operate into the future.

Finally, raw materials are delivered batch by batch, but the pelletizing process operates continuously. This means pelleting facilities need some capacity to stockpile raw materials. This can take the form of bins, covered buildings, a cement pad or piles on the ground. The cost of a storage system is balanced against the need for a clean and dry feedstock. Keeping the inputs clean minimizes the need for unnecessary maintenance costs. Open air storage systems have been used to reduce the moisture content of some raw materials like chips, thus reducing the cost of the downstream drying process. In cases where there is a wide range in the types of raw material being received, some facilities incorporate a blending process. This can be as simple as mixing batches with a front end loader on a cement pad or as advanced as using separate bins for each input material and an automated metering system for the mixing process. Feedstock blending helps to create a more consistent input (i.e., moisture content and lignin content) that requires fewer adjustments in the pelletizing stage.

Drying

Drying is a necessary part in the production of pellets. While some inputs, like planer shavings, do not need to be dried, most do. Drying consumes a large amount of energy. This raises concerns with the net energy value of wood pellets as a fuel source.

Drum driers are the most common type of equipment used in North America. In the past, natural gas was the most common fuel source. However, with a rise in fossil fuel costs, many producers have been switching to waste wood. In contrast to using natural gas, waste wood is cheaper and provides the opportunity to market environmental benefits associated with green house gas (GHG) emissions. These environmental benefits can be important when selling to markets with significant environmental regulations like the European market.

Wood fibre can be pelletized at moisture contents as high as 17%. However, the optimal level is 12% or less if a final product with a moisture content of six to eight percent is to be achieved. Raw materials can also be too dry to pelletize so finding the right balance between high and low moisture content raw materials is necessary.

Drying is a focal point of research as the industry attempts to minimize costs and improve the quality of wood pellet energy.

Grinding

The grinding process is also known as milling or comminution. Material should be ground to a size no bigger than the diameter of the pellet (~6 mm) producing a substance with a consistency similar to bread crumbs (figure 3.4). Raw material should be filtered before grinding to remove materials like stone or metal. Some raw materials like logging waste must be pre-processed (i.e.. chipped) into a more manageable size for the milling equipment. It should be noted that material can be ground too fine, causing the material to lose its 'fibre' nature and thus not bind in the pelleting stage.

Conditioning

Many pelletizing machines come with a built-in steam conditioning chamber. Super-heated steam, at temperatures above 1000 C (2120 F), is used to soften the wood before it is compacted. Steam conditioning is not necessary but does make the raw material less abrasive to the pelleting equipment. This helps reduce the maintenance costs. Steam conditioning has also been linked to a stronger, more durable pellet (Kyto& Aijala, 1981a as cited in Alakangas & Paju, 2002:19). It works by heating the wood fibre without moistening it. As the fibre heats up, it allows the lignin to separate and act more effectively as the bonding agent in the pellet. This process is also known as steam explosion.
The steam conditioning chamber is also the mechanism through which additives can be introduced into the pelletizing process. Additives are rarely used because they increase costs, impact the environmentally-friendly branding and are not completely necessary.

Pelletizing

Pelletizing machines, also known as extruders, are available in a range of sizes. Generally, every 100 horsepower provides a capacity of approximately one tonne of pellets per hour. Pelleting machines come in two common forms:

- Flat die: where raw material is pressed through the top of a horizontally mounted die.(Figure nr 1b).
- Rotary die: where two (or more) rotary presses push raw material from inside a ring die to the outside where it can be cut into the desired length (Figure nr 1c).

Both systems create a pellet by using a great deal of pressure to force the raw material through holes in the die. As pressure and friction increase so does the temperature of the wood. This allows lignin to soften and the fibre to be reshaped into pellet form.

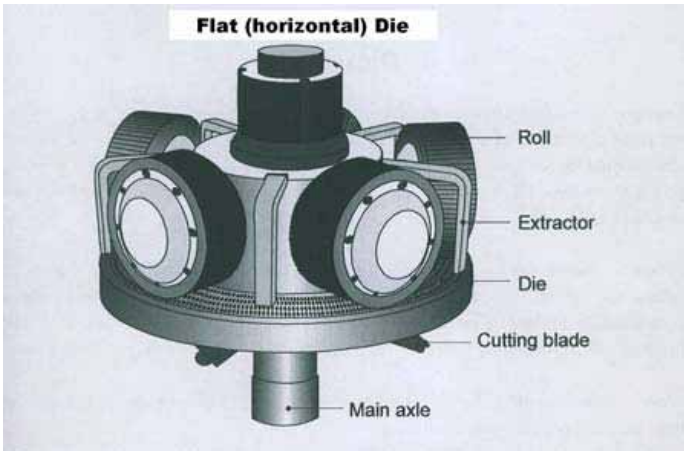


Figure nr. 1b. Flat die pelletizing system. (Source: Source: Alakangas & Paju, 2002)

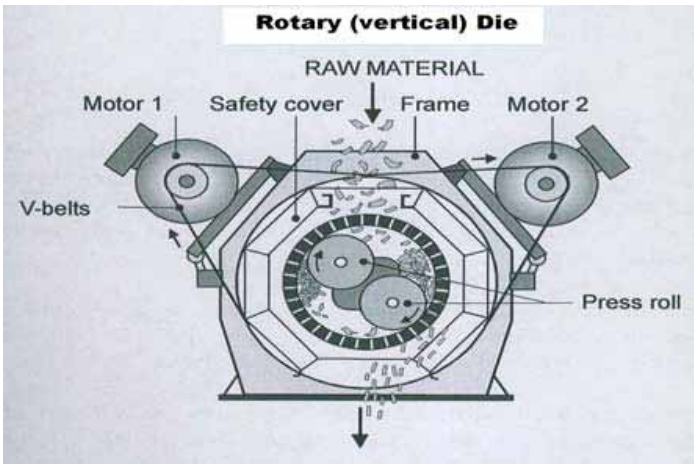


Figure nr 1c. Rotary die palletizing system (Source: Alakangas & Paju (2002).

Depending on the material being palletized, a delicate refining and balancing of settings is needed. The most critical adjustments are made by changing the die. A die is essentially a metal plate with holes in it. A die works by providing the appropriate amount of resistance as the press wheel attempts to push the raw material through the holes in the plate. The appropriate amount of resistance allows the raw material to heat up and soften so that it can be reshaped and compacted into the desired shape. If a die provides too much resistance the material being palletized can become scorched. If too little resistance is provided, the raw material will not be compressed and simply pass through the holes. Resistance is adjusted by changing the size of holes, the tapering or the number of holes on the die. Bigger holes, less tapering or more holes lead to less resistance.

Cooling

The cooling process is critical to the pellets strength and durability. As pellets leave the extruder they are hot (90 to 95C) and soft. They are gradually air cooled, which allows the lignin to solidify and strengthen the pellets. In contrast to the drying process, cooling does not involve the addition of the energy. There are three types of coolers: vertical, horizontal and continuous flow.

Screening

Once pellets have cooled, they are passed over a vibrating screen to remove any fine material. These “fines” are augured back into the palletizing process to ensure that no raw material is wasted. Screening ensures the fuel source is clean and as near to dust free as possible. Once screened, pellets are ready to be packaged for the desired end use.

Distribution and Storage

Pellets can be distributed in bulk form, by truck, rail or ship or bagged in smaller quantities. Pellets can be purchased either bagged or in bulk and price can be calculated per total weight according to the moisture content. Bulk delivery of pellets is very similar to a delivery of home heating oil and is carried out by the lorry driver blowing the pellets into the storage space, while a suction pump takes away any dust. Storage solutions include underground tanks, container units, silos or storage within the boiler room.
Wood pellets do not degrade over time, as long as they are stored in dry conditions. Wood pellets are available from a number of suppliers and producers and ordering is as simple and convenient as ordering oil or other fuel. Wood pellets can be ordered online from some suppliers. Although more expensive, they are compact, uniform in size, easy to store and handle and are used for fully automatic heating in pellet boilers or stoves. Modern pellet heating appliances offer a high level of comfort. They are used for many purposes ranging from domestic stoves and boilers to commercial units.

Sophisticated transport systems are being developed to improve pellet quality and increase convenience. Pellet delivery systems are being modeled after the livestock feed industry using pneumatic tanker trucks. Gentle pellet loading, storage and transport systems are essential to minimize the amount of dust or fines generated during handling operations. Research continues to improve pellet durability to increase resistance to mechanical abrasion. Design of more efficient pellet storage, charging and combustion systems for domestic users is on-going, in order to optimize delivery of wood pellets to residential markets. One option is the development of pneumatic ash retrieval mechanisms on pellet delivery trucks to provide a ‘one stop’ fuel and waste removal service.

2.3 Quality standards

Countries with well developed pellet industries, like Austria, Sweden and Germany, have developed their own pellet standards (appendix A) while other major producing regions, like Finland and Denmark, have chosen to wait for a common European standard for solid biofuels CEN/TS 14961 to be developed. This common pellet standard is being developed by technical committee 335 of the European Committee for Standardization (CEN). This means existing national standards will be harmonized but special national or regional requirements will still be respected. The common European standard is essentially the platform for a labeling program. It identifies which attributes will

be mandatory to test and report and which will be voluntary. It also determines appropriate ranges or categories to report within each attribute.

Generally limit values for bulk density, unit density, ash content, water content, calorific value, sulphur, nitrogen and chlorine are fairly similar. The German standard defines a number of chemical parameters. Austrian and German standards do not mention the amount of fines, while in Sweden and the USA fines must not be more than 0.5 to 1.5%. The Austrian standard is currently being reviewed in this respect. The standards do not usually define durability or mechanical stability despite the importance of these attributes: during transport in tankers and the pneumatic filling of storage bunkers mechanical strain on pellets is high and pellets of bad quality produce large amounts of dust.
The amount of fines in fuel pellets is of special importance in the case of small heating systems, which need extremely high pellet quality. If the amount of fines is too high, small heating systems will not work properly. Combustion units in large district heating systems are unaffected by fines. Because of the different requirements of small and large combustion units, a definition of different groups of standards regarding the percentage of fines might be useful.
With the exception of Sweden, all standards prohibit the use of binding agents in the production of pellets. In Sweden if binding agents are used amount and sort have to be declared.
In several countries, additional environmental or quality labels for pellets or pellet heating have been published. In some countries these quality labels functions as a substitute for the lack of a national standard, while in others they function as a supplement the national standard.

Wood pellets quality norms		**ÖNorm M 7135**	**DIN 51731**	**DIN plus**
Diameter	mm	4 to 10 mm	4 to 10 mm	
Length	mm	5 x D[1]	< 50	5 x D[1]
Density	kg/dm³	> 1,12	1,0 < Dichte< 1,4	> 1,12
Humidity	%	< 10	< 12	< 10
Ash	%	< 0,50	< 1,50	< 0,50
Heating value	MJ/kg	> 18	17,5 < HW< 19,5	> 18
Sulphur	%	< 0,04	< 0,08	< 0,04
Nitrogen	%	< 0,3	< 0,3	< 0,3
Chlorine	%	< 0,02	< 0,03	< 0,02
Abrasion	%	< 2,3	-	< 2,3
Press aid	%	< 2	([2]	< 2
[1]	no more than 20% of the pellets may be longer than 7.5 x Diametre			
[2]	DIN prohibits additional matter. This prohibition however, is not valid for small heating systems			

Table nr 1 Comparison of examples of wood pellets Ssandards: ÖNorm M 7135 DIN 51731 and DIN plus.

3 Policy context in the Main Wood Pellet Markets

3.1 International Agreements

3.1.1 Kyoto Protocol

The Kyoto Protocol (KP) to the United Nations Framework Convention on Climate Change (UNFCCC) is one of the first steps to address the serious global threat of climate change. The ultimate goal of the UNFCCC is to stabilize atmospheric concentrations of greenhouse gases at a level that prevents dangerous human interference with the climate system. The Kyoto Protocol was adopted in 1997 and entered into force on 16 February 2005 . It contains legally binding obligations for developed countries[3] to limit their overall emissions of six greenhouse gases at least of 5 percent below 1990 levels between 2008 and 2012 (the first commitment period) with specific targets varying from country to country. For EU countries this target was set at 8 percent.

In contrast to the consuming of fossil fuel, the use of wood fuels produced I sustainable way does not result in net release of carbon dioxide into the atmosphere, since the CO2 released through the consumption of biomass fuel is taken up by growing biomass. Therefore, the use of bioenergy is a significant option for signatory states in accomplishing their emissions reduction targets. Biomass fuels including wood pellets serve the strategic purpose of reducing CO2 emissions.

The Kyoto Protocol foresees flexibility in meeting the targets. These allow industrialised countries to meet their targets through trading emission allowances between themselves and gaining credits for emission-curbing projects abroad. One concept is emissions trading mechanism. For example, countries that over-comply with their targets can sell emission allowances to countries that would otherwise not meet their targets. CO2 trading provides the flexibility of investing in those places where energy investments (either replacement of existing facilities or investments to meet new energy demand) are due anyway, thus reducing the costs of CO2 mitigation.

The Kyoto Protocol also established two other flexible mechanisms to assist the countries in meeting their national targets cost-effectively: Joint Implementation (JI) where emission-reducing projects are carried out in other industrialized states and the Clean Development Mechanism (CDM) where projects are located in the developing countries.

[3] More specifically, Annex 1 Parties (Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Economic Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States of America).

3.1.2 Johannesburg Plan of Implementation

The Plan of Implementation of the Johannesburg Summit on Sustainable Development 2002 contains adopted commitments towards increasing the use of renewable energy. The Plan includes specific measures to be taken for achieving this target. Some of these measures are as follow: improving access to environmentally sound energy services, improving access to modern biomass technologies and wood fuel sources and supplies; and promoting sustainable use of biomass through improving forest resources management and efficiency in the energy use of wood. According to the Plan national energy policies and legal frameworks should be created and international and regional cooperation should be enhanced to straighten the deployment of renewable energies with a special emphasis on bioenergy.

3.1.3 The Asia Pacific Partnership on Clean Development and Climate

The Asia Pacific Partnership on Clean Development and Climate is an agreement between six Asia-Pacific nations: Australia, China, India, Japan, South Korea, and the United States. The partnership had its official launch in January 2006. Since then, the six nations have initiated around 100 projects aimed at clean energy, capacity building and market formation. Building on these activities, long-term projects are schedule to deploy clean energy and environment technologies and services. The pact allows those countries to set their goals for reducing greenhouse gas emissions individually, but with no enforcement mechanism. Supporters of the pact see it as complementing the Kyoto Protocol whilst being more flexible while critics have said the pact will be ineffective without any enforcement measures and ultimately aims to void the negotiations leading to the Protocol called to replace the current Kyoto Protocol.

3.2 European Union

Currently, the European Union (EU) meets about 4% of its energy needs from biomass. In March 2007 the European Union Member States agreed to a 20% binding target by 2020 for renewable energy sources as a response to the European Commission package proposed early 2007 (see next paragraph). Biomass will be the main contributor to achieve that target. According to the European Commission biomass technology could achieve at that time up to 215-239 Mtoe (only using the indigenous resources). As woodfuels (including wood pellets) are the most available biomass form in most of European countries, they will play a crucial role in achieving the 2020 objective. In addition, bioenergy trade (imports) represents a great opportunity to achieve even higher shares.

On 10 January 2007 the European Commission (EC) proposed a comprehensive package of measures to establish a new Energy Policy for Europe to combat climate change and boost the EU's energy security and competitiveness. The package of proposals set a series of ambitious targets on greenhouse gas emissions and renewable energy and aims to create a true

internal market for energy and strengthen effective regulation of the energy market.

The European Commission proposal is to maintain the EU's position as a world leader in renewable energy, by proposing a binding target of 20% of its overall energy mix will be sourced from renewable energy by 2020. This will require a massive growth in all three renewable energy sectors: electricity, biofuels for transport and heating and cooling. This renewables target will be supplemented by a minimum target for biofuels of 10%. In addition, as a response to the agreement at EU Member States level, in the beginning of 2008 the EC will put forward in the legislative package for renewables which will include specific measures to facilitate the market penetration for both biofuels and heating and cooling.

The regulatory framework of the European Union towards biomass is not new, in 2001, the European Commission put forward the directive on the promotion of electricity from renewable energy sources, followed by the directive on promotion on biofuels in transport in 2003 and continued in 2005 by a comprehensive EU Biomass Action Plan.

Renewable electricity, including bioelectricity, is promoted by Directive 2001/77/EC requiring all EU Member States to adopt national indicative targets for the proportion of electricity consumption from renewable energy sources. Electricity from solid biomass is generated based on the combustion of forestry and agricultural products and residues in thermal power stations. As with the progress of total biomass, the development of solid biomass accelerated significantly in 2004 and 2005. Annual growth rates in recent years amounted at EU-25 level to 20% in 2002 13% in 2003 and 25% in 2004 reflecting the impetus those legislations gave to the markets.

The main objective of the European Union Biomass Action Plan, put forward in December 2005, is to double share of 4% by 2010. It promotes use, research, development and demonstration, regarding new and efficient technologies for energy generation and use of biomass, including raw materials. The plan states that due to biomass origin as a cultivated or grown resource, bioenergy has a direct relationship with agriculture and forestry. Therefore it creates positive impacts security of energy supply, environment and rural development.

An additional support instrument has been provided through the newly set up (January 2005) European Emission Trading Scheme (ETS). The main objective of this instrument is to mitigate the EU CO_2 emissions. Since large parts of European electricity generation take place in fossil-fuelled power plants, the emissions trading scheme has had and will continue to have a profound effect on the European energy sector. Co-combustion of biomass and coal or gas is an example of such practices and leads to a substitution of fossil fuels and to a net reduction of CO_2 emissions. In many countries co-firing is the most economic technology to achieve the target of CO_2 reduction frequently using wood pellets as a biomass input.

3.3 Russian Federation

Bioenergy is developing in Russia, but not as fast as in Europe. Utilization of all renewable energy resources in Russia is less than 3% at the moment. Situation could be changed after opening of the emission trading market in Russian and the State Bioenergy Program passing. A possible adjustment (increase) of energy prices to the levels of the international markets would make bio-energy competitive to fossil fuels. Joint Implementation Projects in the framework of the Kyoto Protocol realisation could push the process of fuel-switch for wood especially in the Northwest Russia, the richest forest region in the European part of Russia. Development of bioenergy on the base of wood waste could provide combining benefits of optimal waste utilization and increasing of energy effectiveness. Not a strong market currently, Russia with its significant potential could become one of the largest wood pellets markets in the world provided regulatory framework is in place.

3.4 North America

Specific drivers for increasing energy from woody biomass in a North American context include the development of alternative markets for currently non-economic wood fibre sources, and the associated economic benefits to rural resource dependent communities.

3.4.1 United States

There are a number of instruments in use in the US at either the federal or state level influencing biomass energy production or use. At the federal level two programs were introduced in the early 1990s as part of the Energy Policy Act of 1992, providing incentives for electrical generation from green energy sources.

1) The Renewable Energy Production Incentive (REPI) provides financial incentive payments for electricity produced and sold by new qualifying renewable energy generation facilities. Qualifying facilities are eligible for annual incentive payments of 1.5 cents per kWh (1993 dollars and indexed for inflation) for the first ten year period of their operation, subject to the availability of annual appropriations in each Federal fiscal year of operation.

2) The Renewable Energy Production Tax Credit allowed the same 1.5 cents per kWh (real 1993 currency) incentive to private facilities in the form of a tax credit available to facilities generating electricity from wind, closed-loop biomass, or poultry waste. This was initially a 10-year program as well, but was renewed in 2004 for another decade and the list of eligible energy sources has been expanded to include open-loop biomass, solar, municipal solid waste, geothermal, and small irrigation power.

At state level, a relatively common instrument for supporting environmentally friendly electricity generation is green pricing. These are voluntary programs where consumers pay a premium for electricity generated from environmentally

friendly sources. These programs are available from over 500 utilities in 34 states, and over 50% of all US consumers can purchase green power, with the mean level of premium being 2.6 cents per kWh.

Several recent key laws, Executive Orders, and regulations are helping to drive bioenergy production and use in the United States including: Presidential Executive Order 13101, Greening the Government Through Recycling and Waste Prevention (required Federal agencies to give preference in their procurement and grant programs to the purchase of specific recycled content products); Presidential Executive Order 13134, Developing and Promoting Biobased Products and Bioenergy (set a goal of tripling the U.S. use of bioenergy and bioproducts by 2010.); the Biomass Research and Development Act of 2000, (Title III of the Agricultural Risk Protection Act of 2000, P.L.106-224); and Section 9002 of the Farm Security and Rural Investment Act of 2002 (FSRIA) (the first farm legislation containing a separate title (Title IX) devoted to energy, which creates a Federal government preferential purchasing program for biobased products in order to help promote emerging markets for these products.

On August 8, 2005, the Energy Policy Act of 2005 (Public Law 109-58) was signed into law. The act promotes investments in energy conservation and efficiency, including provisions for promoting residential efficiency, reducing Federal government energy usage, modernizing domestic energy infrastructure, diversifying the nation's energy supply with renewable sources (including biomass energy), and supporting energy-efficient vehicles.

State of California is one of the most dynamic among US states in its commitment to meetigatig climate change and promotion of renewable energy sources. In June 2007, as an intergral part of California’s Renewable Energy Portfolio Standard (RPS), Governor Arnold Schwarzenegger announced the Bioenergy Action Plan which outlines ways for California to bring alternative energy into the mainstream and reduce dependency on foreign fossil fuels.
The Bioenergy Action Plan focuses on ways to create a positive environment for bioenergy development to help attract new facilities and investment in California. It commits state agencies to take detailed actions within a specific timeframe to advance the use of bioenergy in the state. The plan is also designed to improve state agency coordination on bioenergy and expand and accelerate research and development, including partnerships with the federal government and private sector.

According to the executive order, California will produce a minimum of twenty percent of its own liquid biofuels by 2010 and forty percent by 2020. Currently, of the 900 million gallons of ethanol consumed in California (which is 25 percent of the entire nation's consumption), only five percent is produced in California. Reaching the new targets will help California achieve the accelerated RPS while signaling a long-term commitment to encourage investment.

The executive order also calls for the use of biomass for electricity to reach 20 per cent within the state's RPS goals for 2010 and 2020.

California is currently party to eight climate change and energy agreements with other states, nations and Canadian provinces, including British Columbia, Ontario and Manitoba. These agreements, the Governor's office states, are important because they expand markets for clean fuels, cars and emissions credits across borders, allowing emission reductions at the lowest possible cost. California is working with other governments so that reporting, measuring, verifying and emissions markets have consistent protocols.

3.4.2 Canada

In Canada, the energy market values a secure, reliable and safe supply, coupled with sustainable economic growth. The policy context has evolved as environmental awareness increased. Canada was one of the first countries to sign the Kyoto Protocol, in April 1998, and formal ratification came in December 2002. The government pledged that Canada would reduce its greenhouse gas emissions by 6% below 1990 levels by the 5-year commitment period of 2008-12. Canada's 2002 climate change plan committed the country to cut greenhouse gas emissions by 240 million tonnes a year the end of 2012. It proposed a three-stage strategy to achieve that goal through a combination of incentives, regulations and tax measures.

Policy development on emissions reflects climate change, acid rain and harmful emissions. The federal government's main energy department is Natural Resources Canada, which is the primary source of public funding for bioenergy. Federal programs cover two key approaches: technology push, and market pull. Technology push programs encompass basic research, applied R&D, demonstration and pre-commercialization. Funding of energy R&D is carried out in partnership with provinces, universities, the private sector and international organizations. The 2003 federal budget announced $30 million for bio-based technologies. Programs include: basic research, support for BIOCAP research on bio-based products including bioenergy, Canadian Foundation for Innovation, applied R&D, Program of Energy Research and Development (PERD), Sustainable Technology Development Canada, RETScreen- pre-feasibility assessment tool.

The federal government also has several market-pull programs in place to support utilization of bioenergy technologies. Tax related incentives include:
- Canadian Renewable and Conservation Expenses- flow through financing for early intangible project expenses;
- Capital Cost Allowance 43.1- accelerated write-off for generation equipment
- Biofuels exemption from federal excise tax.

Other bioenergy measures include:

- Renewable Energy Deployment Initiative (REDI)- Originally a 25% incentive toward purchase of certain biomass combustion systems, this program is being phased down to 15% and then 10% by the end of the REDI program in 2007. A one-time capital contribution of $78 million toward the construction of new ethanol capacity, announced in February 2004;
- - Incentives for industrial-scale biodiesel plants
- The Renewable Power Production Incentive (RPPI) announced in the 2005 federal budget is the newest and potentially most effective policy support for bioenergy. Designed to stimulate the installation of up to 1500 MW of renewable non-wind energy, when implemented it will pay 1¢ per KWh of production in the first 10 years of operation.

In May 2007 US State California Governor Arnold Schwarzenegger and British Columbia Premier Gordon Campbell signed a Memorandum of Understanding (MoU) between the state of California and the Canadian Province of British Columbia to fight global warming. The agreement outlines key actions that California and British Columbia will take to reduce greenhouse gas emissions. Like California, British Columbia is committed to reducing its greenhouse gas emissions to below 1990 levels by 2020 and beyond. British Columbia is the first Canadian province to sign the Western Regional Climate Action Initiative with California, Arizona, New Mexico, Oregon, Washington and Utah. Members commit to reaching greenhouse gas targets, participating in a regional market-based program, like a cap-and-trade system for emissions, and participating in a multi-state registry.

3.5 Latin America (Argentina, Brazil and Chile)

It was not found both for Argentina, Brazil and Chile, any specific policy regarding pellets. At policy statement levels, forestry and agricultural residues are taken as important renewable energy alternatives. Charcoal, briquettes, chips and firewood are presently mentioned in the Brazilian National Agroenergy Plan which states the need for using wood biomass for energy, and for undertaking R&D, but it does not mention pellets. Institutional development in the pellet field is also discrete. Concrete initiatives have been made almost exclusively by private sector, based on the European domestic and industrial demand and their attractive prices. It means that European Policies at industrial level, and the its opportunity energy costs at domestic level are the most important drivers for Latin American pellet production at the moment. Furthermore, there is no information about power production from pellets in Brazil.

3.6 Asia

With booming economic development spurring energy consumption in Asian countries, it is estimated that this region will be the biggest global energy consumer by 2030. It is estimated that CO_2 emissions in developing countries will increase to be three times those of developed countries by 2100.

The Asian region has the largest biomass resources in the world. Important tasks in this region are the promotion of sustainable biomass production, the creation of a circulation system of renewable energy and useful products, and to make this system practical by the mutual collaboration of Asian countries and research institutions (including the collaboration between agricultural and industrial sectors) with the aim to prevent global warming and improve energy efficiency.

Asia is endowed with abundant biomass resources due to its climate, etc., with more than 30% of the world's biomass resources distributed in this area. However, it is a worrying trend that in many Asian countries, rapid economic development and rising population result in increased energy consumption and greenhouse gas emissions. The destruction of land in some parts of Asia is accelerated by desertification and deforestation. Therefore, there is a growing need to create a biomass production system aimed to prevent desertification and to help regeneration of forests. The establishment of biomass utilization techniques, the creation of a well-grounded recycling-based and sustainable eco-friendly society, and designing sustainable agriculture, forestry, and fishing industries in the Asian region are essential.

3.6.1 China

China is currently in a phase of rapid industrialization and integration into the world economy. But this has come at a high price, putting great strain on the environment through extensive use of fossil fuels and other natural resources. The difference in living standards between urban and rural areas – and between the east and west of the country – has also widened, and unemployment is rising fast. Many are concerned that China's long-term prosperity could be harmed by increasing social inequality and conflicts resulting from environmental pressures and eco-system degradation. Unemployment is projected to hit 100 million by 2010, and most of these people will be in the poor western regions, where farmers are desperately trying to survive and seek better lives for their families. It is clear that China needs alternative solutions for its ailing agricultural sector, which some 900 million farmers depend on.

Agriculture in China has developed at a much slower pace than industry over the past two decades, which has led to increasing inequality between rural and urban residents. The majority of migrant workers in China's cities come from rural areas for economic reasons: low income from farming and land loss due to urban expansion and increased mechanization of agricultural production. Sustainable rural development in China's west is faced with major challenges: farmers still lag behind in income compared to residents of coastal regions; ecosystems are vulnerable; poverty is persistent; and the majority of farmers rely on agriculture residues, forest biomass or coal-burning for cooking and space heating, which can have severe health effects as a result of indoor air pollution. Above all, current reliance on the exploration of industrial raw

materials and burning fossil fuels cannot make farmers rich, but instead pollutes their living environment, as well as damaging their land and their means of making a living.

The Chinese government has realized how urgently it needs an alternative solution. Under the banner of creating a “harmonious society”, the government is looking into new options for sustainable rural development, utilizing resources more efficiently, prioritizing new and renewable energy technologies with wider market applications. With its vast territory and diverse geographical regions, China has a large stock of biomass resources from agricultural and forest residues, as well as vast areas of wasteland that can be used for bioenergy development, such as small and decentralized electricity and heat generation, household applications and biofuels cultivation.

Bioenergy development has become a top government priority, and China’s law on renewable energy was implemented in January 2006. The current focus is on electricity generation from surplus agricultural residues, which are estimated at 200 million tonnes yearly. The government has set up a long-term target of 30 gigawatts of electricity generated from biomass by 2020, which will require billions of dollars in investment. There is also a growing interest in the development of biofuels such as biodiesel and ethanol, intended to reduce oil imports, which currently account for more than 46% of China’s total oil supply – a major energy security concern for the government. This explains the Chinese government’s surprise announcement that it will import one million tonnes of ethanol each year from Brazil, a development that no doubt paves the way for new business opportunities in China and the rest of the world.

While biomass-burning power plants could help improve the quality of life for poor people living in remote areas without access to electricity, the current plan is to build dozens of demonstration biomass power plants in economically-developed regions, such as in eastern China’s Jiangsu province and Shandong province. Rural residents will only benefit from bioenergy development if it comes to where they live and takes their daily needs into account.

China needs to make a massive transition from traditional to modern uses of biomass as part of its strategy for sustainable rural development. This act of leapfrogging requires innovative policy support from the government. It can benefit farmers by improving their health and living conditions, reduce fossil fuel use, create jobs and generate income. Today, most of the country’s agricultural residues are burnt in the fields, causing air pollution and wasting resources. In addition to other environmental and social benefits, the same amount of investment in household biomass utilization as in biomass power plants could generate five to 10 times more local jobs for rural residents and five to nine times more income for small companies.

3.6.2 India

Currently, some 6,800 MW (5.9%) of the country's power is coming from renewable sources. It has been estimated that the potential would be as high as 80,000 MW which could come from such sources and official policy is to see at least an increase of 10,000 MW by 2012. There is now positive support for foreign investment in this sector and a Foreign Investment Promotion Board is in operation chaired by the Secretary for the Department of Industrial Policy and Promotion. Among the policies being followed are the provision a five year tax holiday for projects established to developed renewable energy and the provision of soft loans through Indian Renewable Energy Development Agency (IREDA).

The National Small Industries Corporation (NSIC) within the Ministry of Industry and Commerce provides marketing and financial services to entrepreneurs involved in renewable energy and includes the operation of a Technology Transfer Centre (TTC) which can provide technical assistance as required.

The Ministry of Non- Conventional Energy Sources is implementing a National Biomass Gasifier Programme and in mid 2005 a new programme on Biomass Energy and Co-generation in Industry was announced to encourage the wider use of biomass resources within the country. Gasifiers in the range of 5kW - 1MW are already widely manufactured within the country. The new programme provides a series of subsidies for capital investment with for example Rs 8.00 lakhs/100kWe for 100% producer gas operating system linked to an operational gasifier.

3.6.3 Japan

The Japanese government considers the use of biomass, particularly as a source of renewable energy, to be a key element in the achievement of its commitments under the Kyoto Protocol.
The Japanese have enacted legal incentives for public utilities and private companies to invest in biomass technologies. For example, the Renewables Portfolios Standard (RPS) Law requires energy suppliers to utilize renewable energies to supply customers. In 2002, the RPS Law was amended to include biomass sources. The marketable opportunities for biomass technologies have also been strengthened by the wide acceptance of the 2002 Biomass Nippon Strategy (BNS). The strategy envisions a future where biomass would be widely used as a renewable source of energy and in the production of biomass-plastics hybrids. To solidify its commitment to the RPS and BNS, the Japanese government is supporting an increase in energy production from biomass sources from 218 000 kilowatts (kW) in 2002 to 330 000 kW in 2010.

3.7 New Zealand

The New Zealand Government wants to increase the amount of renewable energy used in New Zealand 163.5 PJ by 2012, an increase of 30 PJ from the 2002 level. Bioenergy currently provides about 5% of New Zealand's total primary energy supply, primarily from burning wood processing residues or lignin liquors from part of the kraft pulping process used in the manufacture of paper.
The Bioenergy Association of New Zealand has indicated that there is sufficient biomass fuel resource to realistically contribute around 14PJ. In addition to contributing energy into the industrial heat market a range of other sectors can also use biomass as an energy source. These include the domestic heating and hotwater markets, space heating for commercial and institutional buildings and potentially for liquid transport fuels. Where biomass is used to substitute for existing electricity or fossil fuels for heating markets then substantial energy efficiency gains can be achieved as well as greenhouse gas reductions.

4 The Wood Pellet Industry and Market in Europe

The availability of raw material, competitive prices and diversified energy policies favor development of a wood pellet industry in Europe. Sweden, Denmark, Germany and Austria have the most highly developed pellet markets; the others like Italy, Belgium, France and UK recently have been following that trend. In 2006 the production of pellets in Europe was about 4,500,000 tonnes, with Sweden, Austria and Germany as main producers. Almost 300 pellet plants are located in EU ranging from small scale producers with an annual capacity from 2,000 to 150,000 tonnes of pellets. The figure nr 1 presents a map of wood pellets locations (for details see Annex 1.)

Figure nr.1 Pellet Plants location 2006/2007 (Source: Bioenergy International)

In 2006 in Europe, wood pellets consumption accounted for around 5,500,000 tonnes, which indicates significant amount of import. Wood pellets are used both in electricity and heat production (in large, medium and small scale) and their application varies from country to country. Nevertheless, their primary use (in stoves, furnaces or industrial applications) depends significantly on the national renewable energy policies, forestry structures, the scale of woodworking industries and the heating habits.

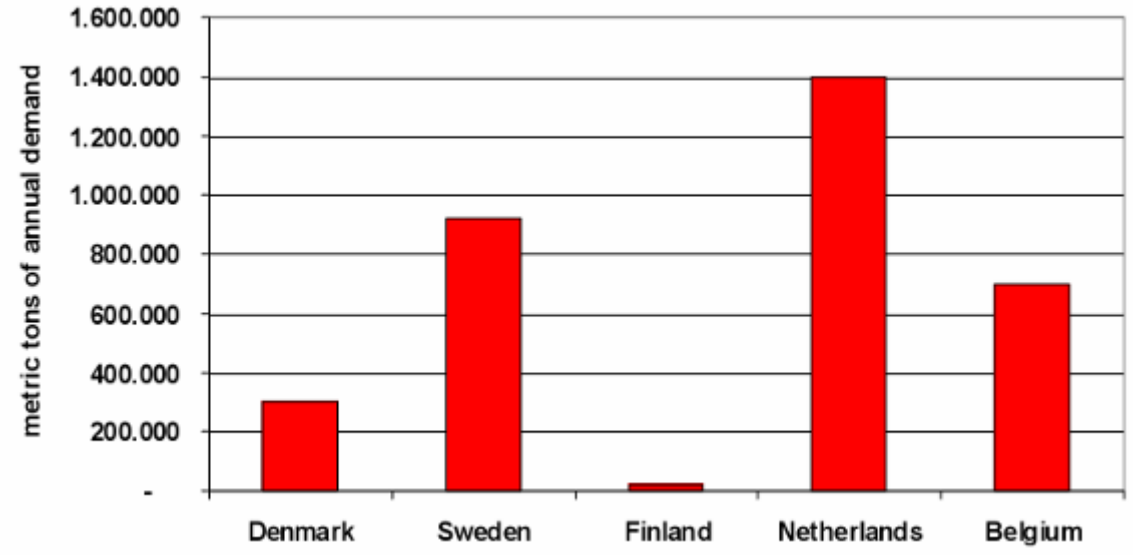


Figure 2. Pellets use in the power plants in Europe in 2005 (Source Propellets Austria, 2006)

Heat demand is a very important part of energy market in European Union (accounting for about 50% of the European energy market) where low temperature heat from quality heat sources such as pelletized biomass are considered essential to meeting future energy needs.

In Sweden, Denmark and Finland wood pellets are used for both: electricity and heat production. In Netherlands and Belgium utilities use pellets in co-firing in power production while in Germany, Austria, Italy and France pellets are used almost entirely in central heating and single stoves (Figure 1 and 2).

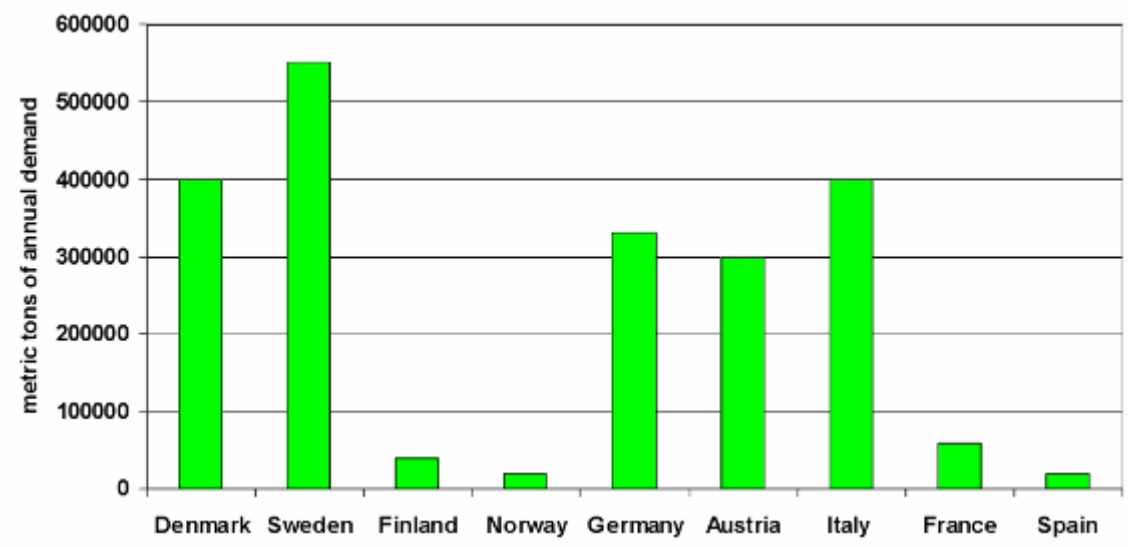


Figure nr 3. European markets for residential pellet heating in 2005 (source: proPellets Austria)

Foreign trade with pellets showed the highest dynamic within the last years. Figure nr 4 presents the example of trade patterns: wood pellets export and import in the Central Europe.

Figure nr4. Cross border trade of pellets in the Central European Countries (CEE) in 2005 (Source: Eurostat, MPO, CZSO, EEG)

In Europe, prices of wood pellets vary from country to country what intensify the trade in wood pellets. The comparison of average prices in Austria, Finland, Germany, Spain and Sweden in 2005 and 2006 are presented in Figure nr 5.

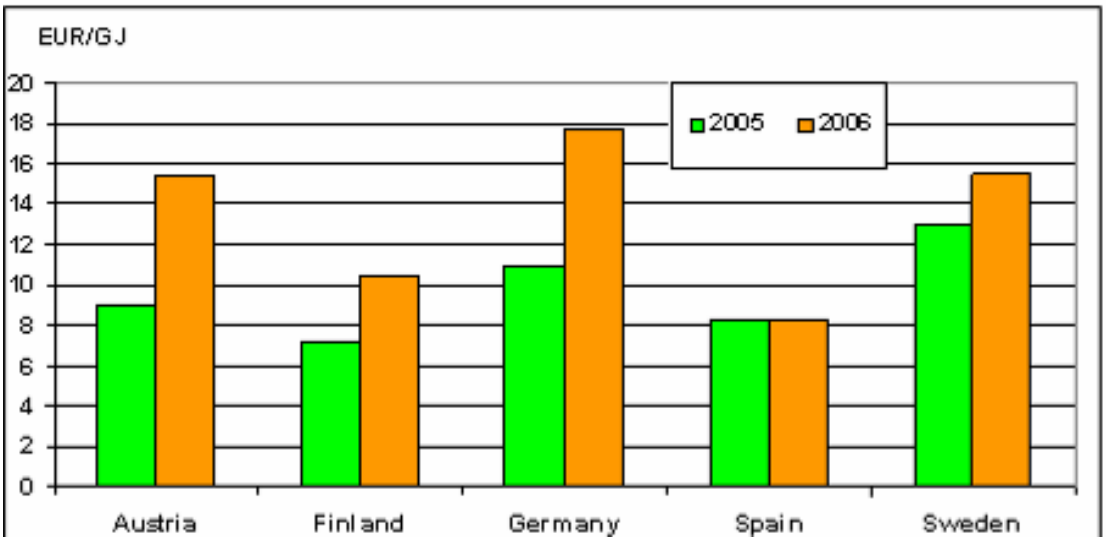


Figure nr 5. Pellet prices in Austria, Finland, Germany, Spain and Sweden in 2005 and 2006. (Eubionet II)

4.1 Sweden

Wood pellet production started in Sweden in 1982, however due to high production costs, low demand, and lack of combustion technology, the pellet fuel didn't really take off until after 1992 when the Swedish government introduced a tax on fossil fuels (presently 59 per cent for CO_2 on all fossil fuels) Virtually overnight it became cheaper for utilities and private consumers to burn biofuels rather than oil, coal or gas. An important factor behind the fast growth was the fact that big utility (Stockholm Energy) invested in a large scale pellet plant to secure its requirements of pellets before a conversion of its boilers. Thus, the introduction of pellet use in large-scale boilers (of up to 100W capacity) and later introduction of the green electricity certificate system in 2003, were major factors behind the pellet market growth in the country.

4.1.1 Production, capacity and raw material

Sweden is the biggest European producer of wood pellets accounting for 1,458,000 tonnes in 2006. Total capacity of 35 pellet plants in Sweden is estimated for an over 1,600,000 tonnes/year (with 2 plants producing over 130,000 tonnes and 15 producing over 30,000 tonnes a year). The pellets distribution network is well established, with truck transport common for shorter distances, while sea shipping proving economical for longer distances.

Figure nr 5a. Pellet plants in Sweden (Source: Svebio 2006)

The raw material used for Swedish pellets production includes sawdust, shavings, chippings and a wide range of other forestry by-products, depending on the quality requirements for the different fields of application. Several of the new plants and the plants under construction aim at using also round wood for raw material. Recently built pellet plants, especially the bigger ones, have installed dryers to handle also wet fraction of sawdust. So far, it is only the pellet plant at the Mönsterås pulp and paper mill, which produces pellets from bark (obtained as by-product from the logs debarked before pulp production). The amount of bark is so high that the plant today has a capacity of 50,000 tonnes a year.

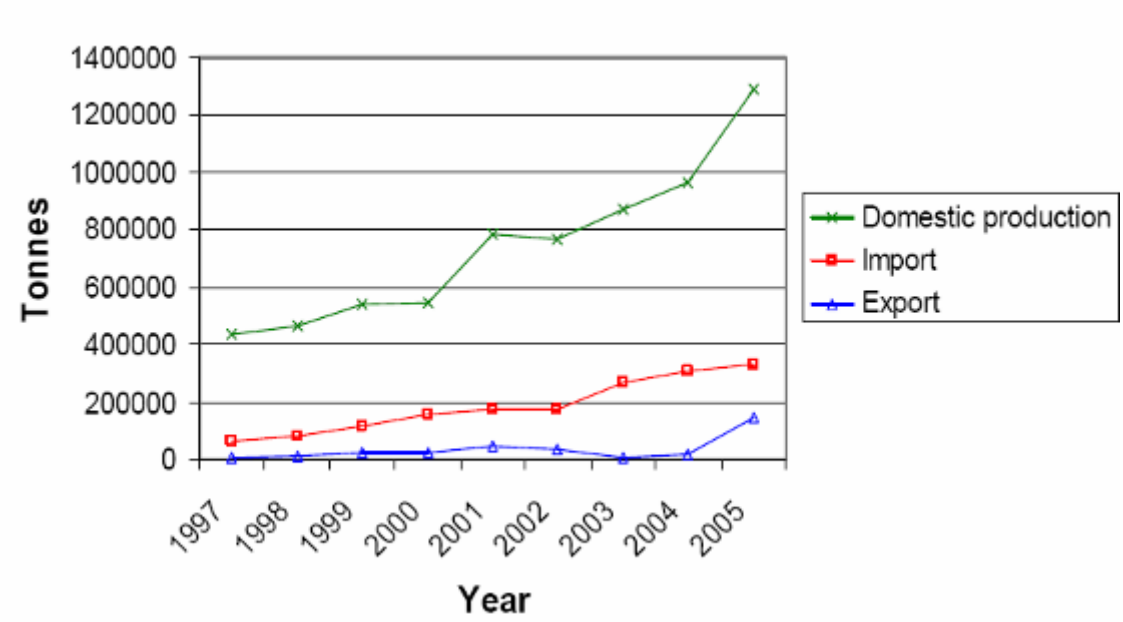


Figure nr 6. Development of production, import and export of wood pellets in Sweden from 1997-2005 (Source: Energidalen, 2006)

According to information from industry, the amount of raw material (white wood in the form of sawdust, planning shavings, and chips) available for pelletizing is not sufficient to satisfy the increasing installed production capacity. This means that new pelletizing projects will need other types of woody raw material.

4.1.2 Consumption

The Swedish pellets market is the largest in the world. The numbers for 2006 show the consumption of approximately 1,670,000 tonnes of pellets, an increase by 4400,000 tonnes from 2004. Sweden pellets make up a large proportion of the fuel market, with almost 60 per cent being used in the large power stations, in district heating, combined heat and power plants as well as in private houses. In recent years, also industry boilers have been converted to pellet combustion.

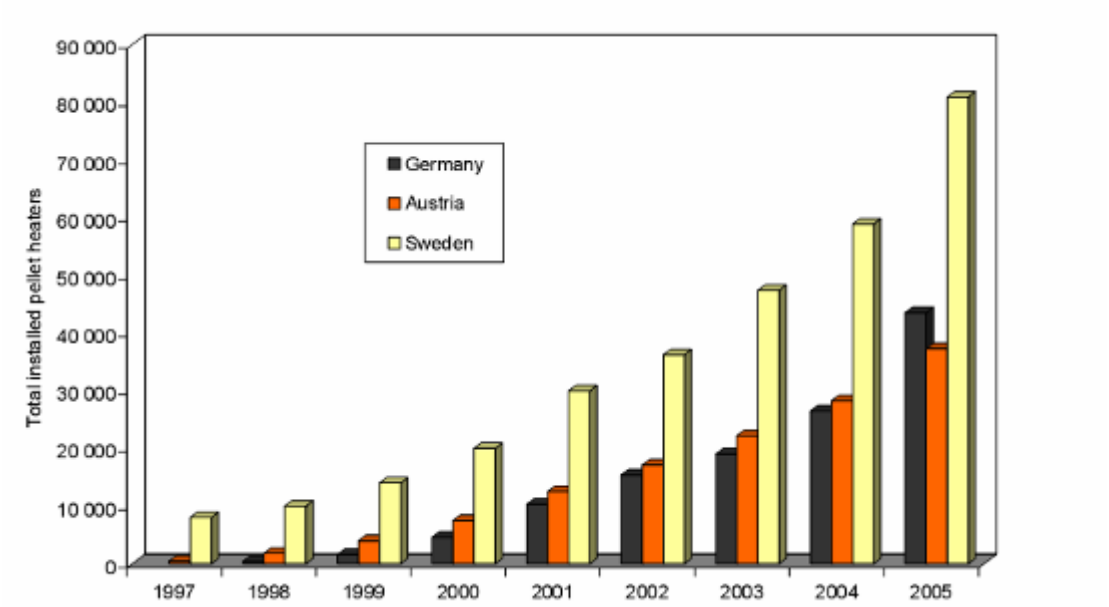


Figure nr7. Total number of installed pellet boiler and pellets heating stoves in one-or two-dwelling houses in Sweden comparing to Austria and Germany (Source: , SBBA 2006, Solar-Promotion 2006, EVA 2006,)

The use of pellets grows in heating market with 20-25% a year and in 2005 80,000 family homes had pellets heating with the use of around 600,000 tones pellets in single family house an increase of 33% compared to 2004. The sale for heating oil to domestic sector decreased by 18% and at the same time the sale for pellets to residential use increased by 34%. Figure nr 7. shows the Swedish wood pellet consumption increase with comparison to the situation in Austria and Germany in the period 1997-2005.

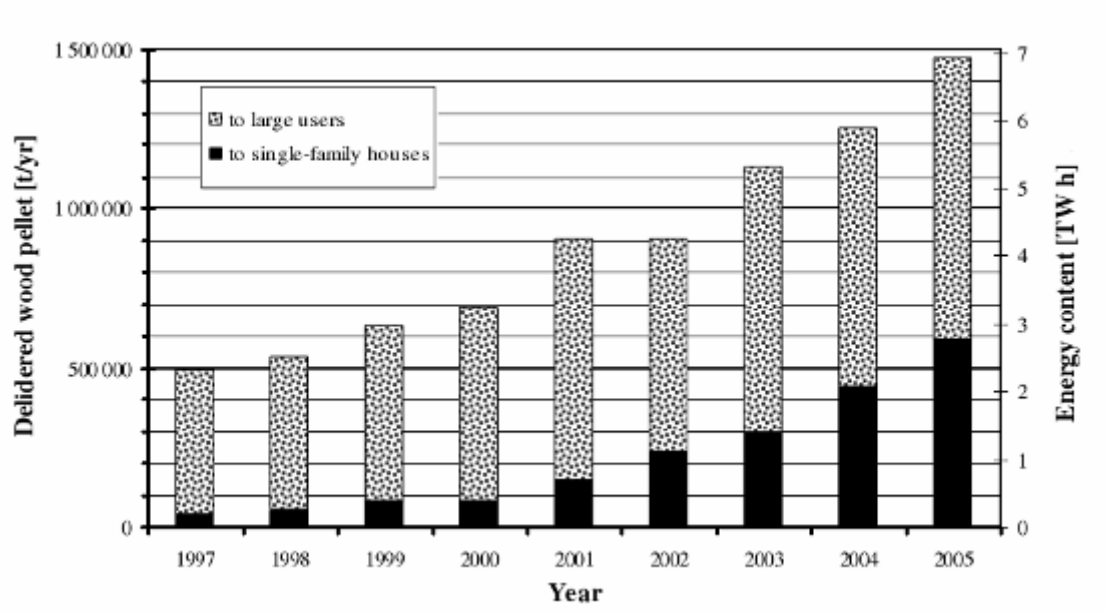


Figure nr 8 Delivered amount of wood pellets to users in Sweden (PiR, 2006) and energy content for a lower heating value of 4.7 kWh/kg (Svensk standard SS 18 71 20).

Regarding year 2006, statistics compiled by the Swedish pellets industry (see Figure nr 9) indicate that pellet sales reached record levels in 2006. Total pellet supply to the Swedish market increased by 14% compared to 2005. Medium size customers, i.e. boilers with an effect between 25 kW and 2MW and owners of isolated houses, increased their consumption most of all. The former category showed an increase of 31% and the latter an increase of 46%.

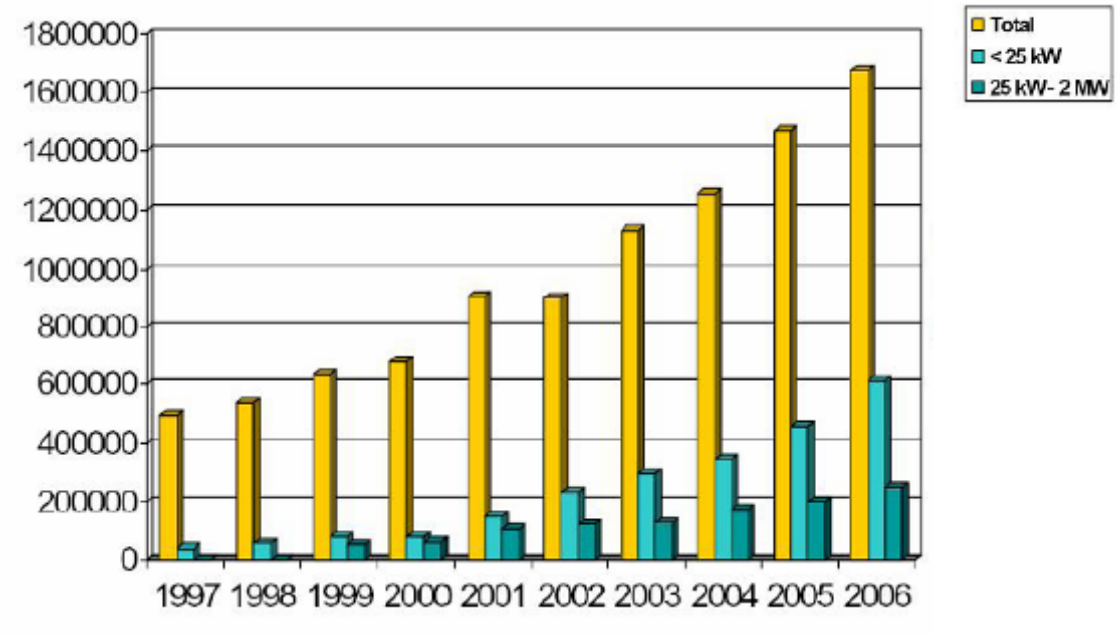


Figure nr 9, Pellets sales in tonnes in Sweden (Source: Pelletsindustries Rverband)

4.1.3 Import/Export of wood pellets

In 2005 about 330,000 tonnes of wood pellets were imported to Sweden, mostly from Canada. Some also came from the Baltic States, Poland and the Netherlands. In 2006 the import increased by 26,000 tonnes. Low transportation costs make it profitable to transport pellets from Canada to Sweden in large ocean vessels. At the same time Sweden exports part of its wood pellets production, approximately 140,000 tonnes in 2005 and 129,000 tonnes in 2006. Figure nr 6 illustrates the development of the export and import of wood pellets in Sweden.

4.1.4 Pellets quality standards

The Swedish Standard SS 18 71 20 defines quality parameters for fuel pellets. It describes three classes of fuel pellets. These differ primarily in size and ash content. Table nr 1a presents classification of fuel pellets according to standard SS 18 71 20.

Property	Test Method	Unit	Group 1	Group 2	Group 3
Dimensions: diameter and length in producer's store	By measuring at least 10 randomly selected fuel pellets	mm	To be stated as max 4 times ∅	To be stated as max 5 times ∅	To be stated as max 5 times ∅
Bulk density	SS 18 71 78	kg/m^3	≥ 600	≥ 500	≥ 500
Durability in producer's store	SS 18 71 80	Weight of fines < 3 mm, %	≤ 0.8	≤ 1.5	> 1.5
Net calorific value (as delivered)	SS-ISO 1928	MJ/kg	≥ 16.9	≥ 16.9	≥ 15.1
		kWh/kg	≥ 4.7	≥ 4.7	≥ 4.2
Ash content	SS 18 71 71	% w/w of DM	≤ 0.7	≤ 1.5	> 1.5
Total moisture content (as delivered)	SS 18 71 70	% w/w	≤ 10	≤ 10	≤ 12
Total sulphur content	SS 18 71 77	% w/w of DM	≤ 0.08	≤ 0.08	To be stated.
Content of additives		% w/w of DM	Content and type to be stated.		
Chlorides	SS 18 71 85	% w/w of DM	≤ 0.03	≤ 0.03	To be stated.
Ash dissolution	SS 18 71 65 / ISO 540	^{0}C	Initial temperature (IT) to be stated.		

Table nr 1a Classification of Fuel Pellets according SS 18 71 20

4.1.5 Fuel prices

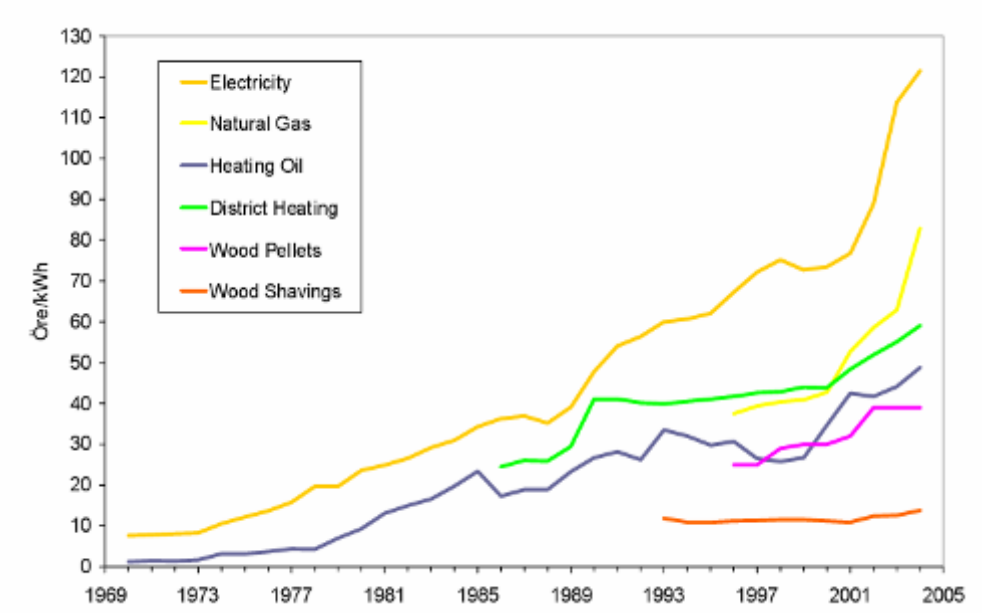


Figure nr 10 Commercial energy prices development in Sweden Öre/kWh (Source: STEM, Äfab)

4.2 Germany

The use of wood in the energy sector has developed continually and recently received extraordinary impetus due to the huge increases in oil and gas prices. Heating with CO_2-neutral wooden pellets has become a cost effective alternative to conventional fuels. So much use was made of the support options offered by the Federal Government that the budgetary funds were completely exhausted in 2005. In 2006, 160,000 applications have already been made - 50 percent more than the total number supported in 2005. This has now exhausted the existing support funds. The support programme will be continued in 2007, but will use support rates which have been adapted to the rapid market development. The pellet production is developing into another economic mainstay for an increasing number of enterprises in the sawmilling and timber industry, often in addition to their own generation of heat or electricity based on bark and wood residues.

4.2.1 Production, capacity and raw material

German wood pellet production is still relatively small. However, favorable tax laws for installation of biofuel combustion systems and large quantities of available wood fibre (7 million tonnes of scrap wood from sawmills and commercial timber alone) make Germany one of the most promising pellet markets in Europe. About 30% of the country is covered in woodland.

Commercial wood pellet production has started in several locations in Germany in the last decade. Currently 32 processing facilities produce an estimated

550,000 tonnes of wood pellets, thereof 420,000 tonnes for domestic consumption. The main sources for the raw material are saw dust, wood chips and other wood residues.

The pellet producer German Pellets GmbH is going to increase pellet production in Germany. By October 2007 its installed annual capacity will draw up 780,000 tonnes of pellets. Thus it will be the biggest pellet producer in Europe. The production capacity for wood pellets is forecast to reach the 1,200000 tonnes in 2007.

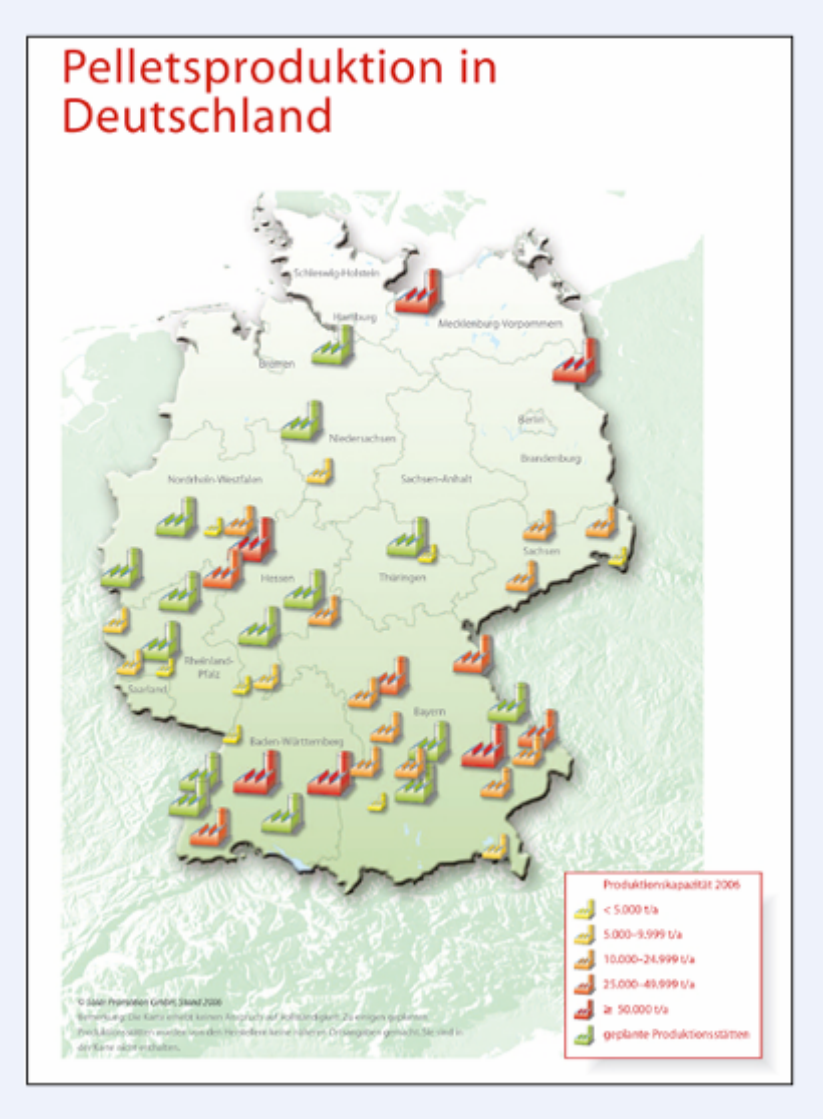


Figure nr 11. Distribution of wood pellet plants in Germany

Biomass experts estimate that between 800,000 and 1,100,000 tonnes of raw material are annually available for pelletizing. If pellet demand increases in the future, wood residues from the woodworking industry will be re-routed for pellet production. Whether wood residues will be used for energy or non-energy purposes will depend to a large extent on the prices that suppliers can achieve for their products. However safeguarding against possible shortage of cheap residues, large scale pellet plants designed to use also round wood for raw

material. Figure nr 11. shows the location and scale of present German wood pellets manufacturers and planned pellet plants (green colour).

4.2.2 Consumption

The German wood pellet market has so far expanded primarily in the small-scale sector. Together with growing wood pellet market the interest in wood pellet production increased rapidly over last decade. In 2005 unprecedented demand for pellet heating systems could be observed (central heating and single stoves), with 14,000 new systems installed (representing 2% of all new heating installations in Germany in 2005). This brings the total number of pellets heating systems installed in Germany up to 44,000.

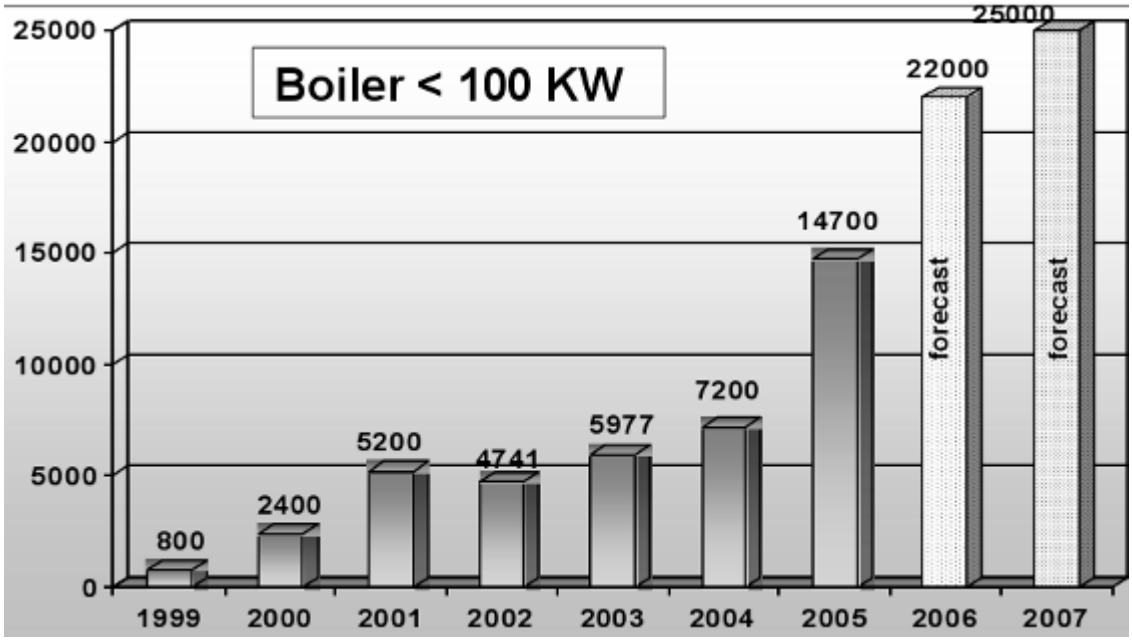


Figure nr 12. Pellet boiler (up to 100kW) market growth in Germany (Source: ÖkoFEN)

In 2005 unprecedented demand for pellet heating systems could be observed (central heating and single stoves), with 14,000 new systems installed (representing 2% of all new heating installations in Germany in 2005). This brings the total number of pellets heating systems installed in Germany up to 44,000.

Figure nr 12 illustrates the development of German boilers market below 100kW. Moreover, figure nr 13 presents the annual and monthly distribution of small scale pellet heating systems (up to 50kW) supported by the Market Incentive Programme for renewable energies. Currently, there are about 40,000 pellet fuelled small scale combustion systems (up to 50kW) supported by this programme.

The following figure (Figure nr 14) shows the development of pellet fueled small scale combustion systems in Germany in the period 1999-2006. The German Pellet Association (DEPV) expects the number of pellet-fuelled heating systems in Germany to rise in 2006 by 26,000 units to a total of 70,000. By 2015, it is expected that there will be between 70,000 and 100,000 new installations of pellet-fuelled heating systems per year. This would mean that 3.5-5 million tonnes of pellets would be needed in 2015 and as a result 6.2-8.8 million t of woodchips.

Figure nr 13. Development of the pellet fuelled small scale combustion systems (up to 50 kW) supported by the German Market Incentive Programme. (Source: Bafa/BMU, Solar Promotion, October 2006)

It is important to mention that, German market forecasts vary from source to source. According to a market scenario recently released by the organizer of the Pellets 2006 trade fair and the 6th Pellets Industry Forum, taking place in October in Stuttgart, annual market growth of 15% can be expected in 2006. This would give pellets an 8% share of the German heating market by 2015, with an estimated 57,000 new installations being made each year and an annual industry turnover of €1.35 billion. (The market forecast assumes a stable policy environment and oil price of between $50 and $100 a barrel.)

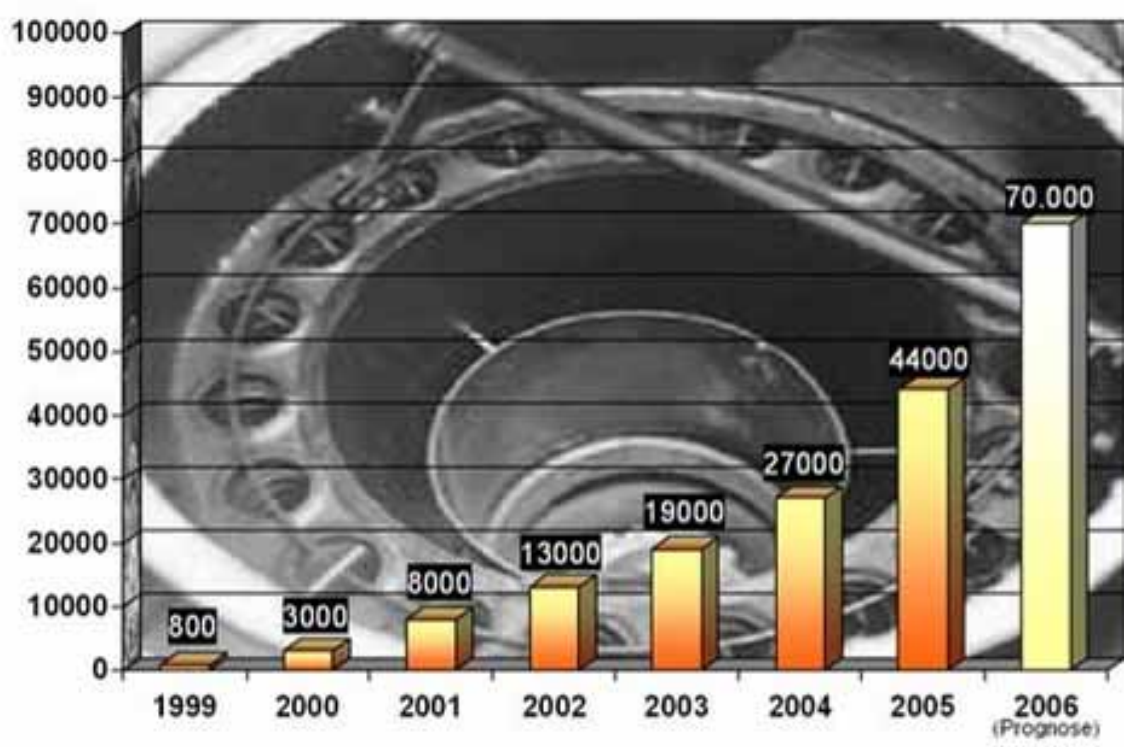


Figure nr 14. Development of total installed pellet heating systems in Germany 1999-2006 (pellets stoves and pellet boilers). (Source: BAFA/DEPV)

The German wood pellet industry reports that already 52,000 household installed wood pellet heating equipments, which is an increase of 100 percent over 2005. Trade experts forecast that by 2015 up to 100,000 pellet heating equipments will be installed in German households.

4.2.3 Import/Export of wood pellets

Wood pellets import comes mainly from Austria, Czech Republic, Poland and Slovakia, while main pellet export destinations are Austria, Switzerland and Northern Italy.

4.2.4 Pellets quality standards

The certification of pellets in Germany is based on standard DIN 51731. The certification is based on an initial assessment and conformity assessments as well as periodical surveillance. The limit values and conditions for wood fuel pellets or briquettes are shown in the table (DIN 51731). Apart from the pellet or briquette shape the unit density and the chemical composition are defined. In the following the boundary values and conditions for wood fuel pellets or briquettes are compiled:

	DIN-Norm	DINplus
Thermal value	> 18 MJ/kg	> 18 MJ/kg
Density	1,0- 1,4 kg/dm³	1,12 kg/dm³
Water content	max. 12,0 %	max. 10,0 %
Ash content	max. 1,5 %	max. 0,5 %
Length	max. 50 mm	max. 5 x Ø
Diameter	4 – 10 mm	4 – 10 mm
Fines		max. 2,3 %
Composition	natural wood	natural wood

Table nr2. DIN 51731 and DINplus

4.2.5 Fuel prices

While prices for wood pellets remained relatively stable in 2005 ranging from 170 to 185 Euro/tonne for a minimum 6-ton delivery within 100 to 200 km, they went up significantly to 265 Euro in December 2006. Presently the prices decreased again to the level of the beginning of 2006 (188 Euro per tonne) The development of the prices over the

Monat / Jahr	2006 [€ pro Tonne]	2007 [€ pro Tonne]
Januar	187,30	262,28
Februar	194,13	234,48
März	194,13	203,86
April	194,06	194,15
Mai	199,67	188,15
Juni	200,78	
Juli	205,72	
August	222,61	
September	236,11	
Oktober	249,34	
November	256,59	
Dezember	264,73	

Table nr 3: Pellet price development from January 2006-May 2007 (price of bulk pellets including VAT; radius 100-200km) (Source: DEPV/Solar Promotion GmbH)

Following figures nr 15 and nr 16 presentation of the development of the wood pellet prices during 2006 and 2007 are shown in the table nr.3 and figure nr. 15.

Additionally, the comparison of development of price of wood pellets in comparison to heating oil and natural gas prices in the period from January 2002 to April 2007are presented in the figure nr.16.

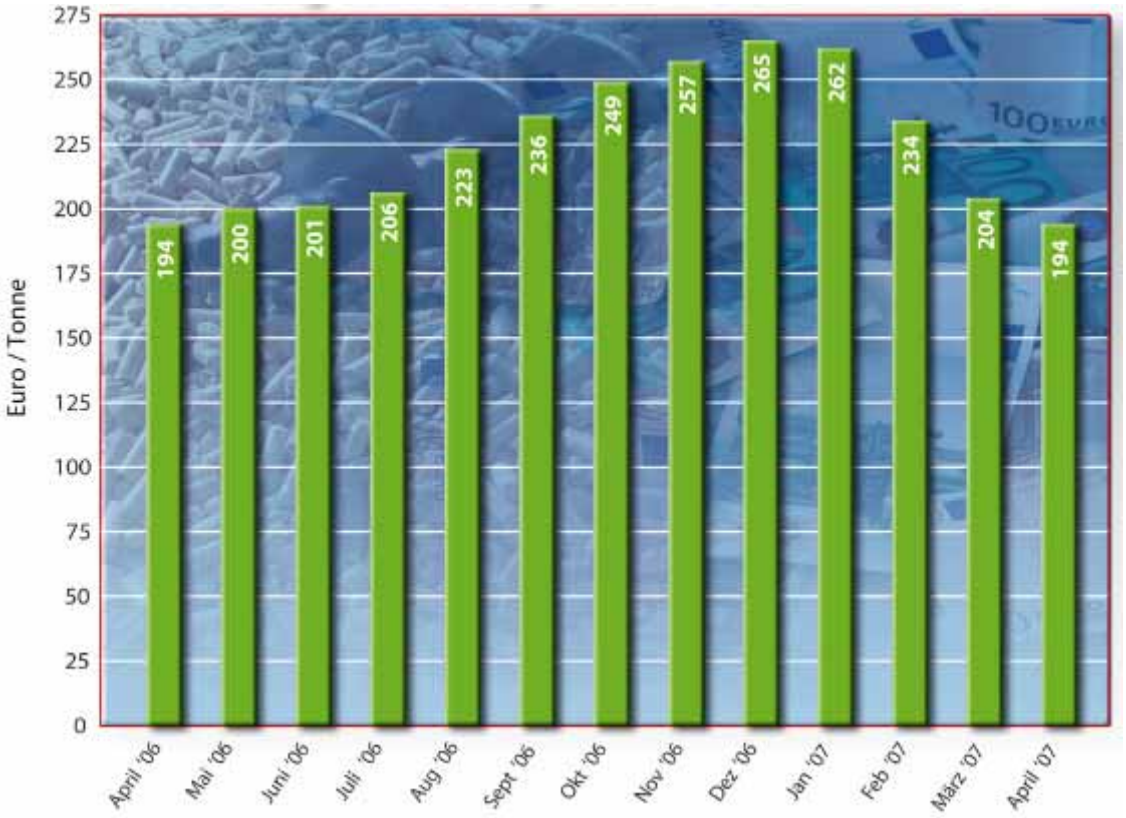


Figure nr 15. Annual pellet price development in Germany (Source: Solar Propmoition GmbH/DEPV; May 2007)

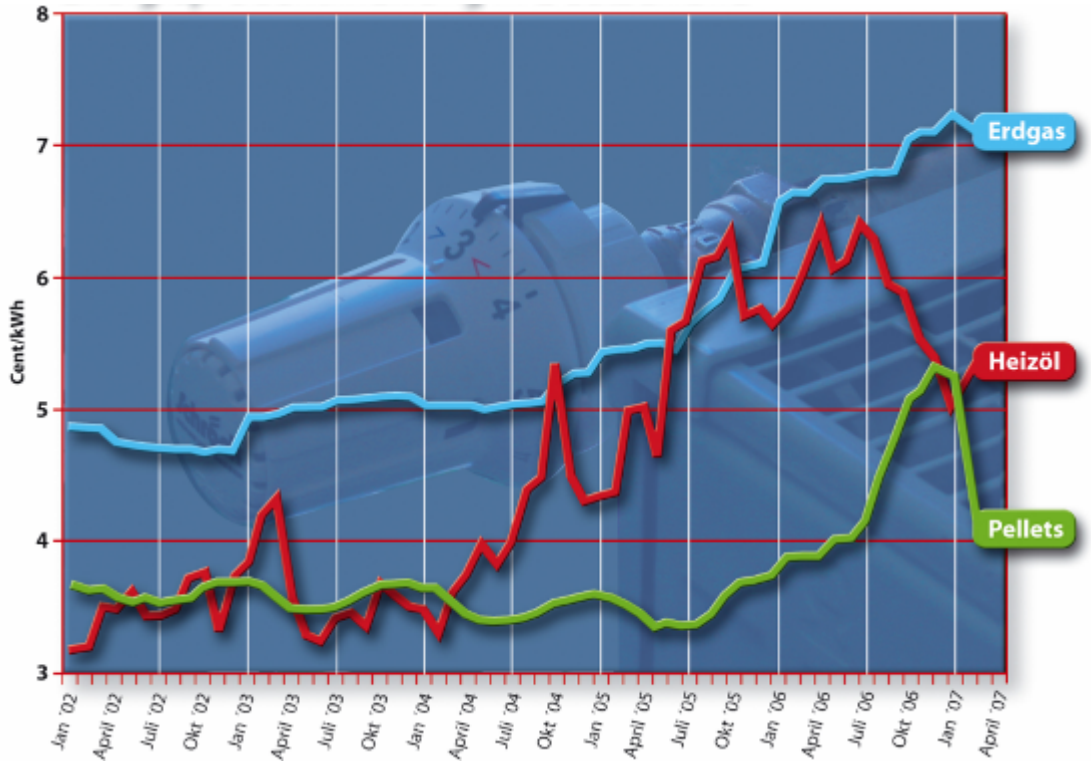


Figure nr 16 Bulk pellet prices in Germany 2002-April 2007 , with comparison to gas (Erdgas) and heating oil (Heizol). (Source: Solar Promotion GmbH, May 2007)

4.3 Austria

In Austria, rapid growth of pellets market started in 1997 when the first systems were introduced into the market. The market for pellets in the residential sector in Austria is presently expanding rapidly. Several actors, quality standards and subsidies are supporting this development. Proven feeding and combustion technologies are available from many furnace manufacturers which ensure a fully automatic operation.

The energetic use of biomass in Austria is traditionally strongly based on residential space-heating and the wood processing industry. Use of biomass fuel has been promoted in Austria by the introduction of tax incentives and subsidies. There are also commercial programmes to encourage business to convert to biomass heating. These programmes represent a very important factor in the promotion of pellet fuel in Austria and are encouraging the take up of more expensive pellet boilers through subsidised equipment.

Furthermore, the energy sector has experienced a particularly lively development for several years. Thanks to the incentives of the Eco-Electricity Act numerous new biomass installations, in particular co-generation plants, have been built or are in construction. Until the end of 2007 many other plants will start operation and will further increase the consumption of energy wood. According to a study by the Austrian Energy Agency an additional demand for wood of at least 2 million m³ energy wood per year will occur as a result of the raising of the share of renewable energy sources for energy production provided for in the Eco-Electricity Act; this higher portion will presumably become fully manifest as from 2007.

4.3.1 Production, capacity and raw material

In Austria pellets production is an attractive business for the wood-processing industry therefore it has been developing very dynamically.
In 2006, about 27 companies are producing pellets, three of them with a production capacity of more than 70,000 tonnes/year. The total production capacity at present amounts to about 600,000 tonnes/year, which is expected to increase in the years to come. According to the Austrian Energy Agency, for 2007 a production capacity of one million tonnes of pellets is forecasted.

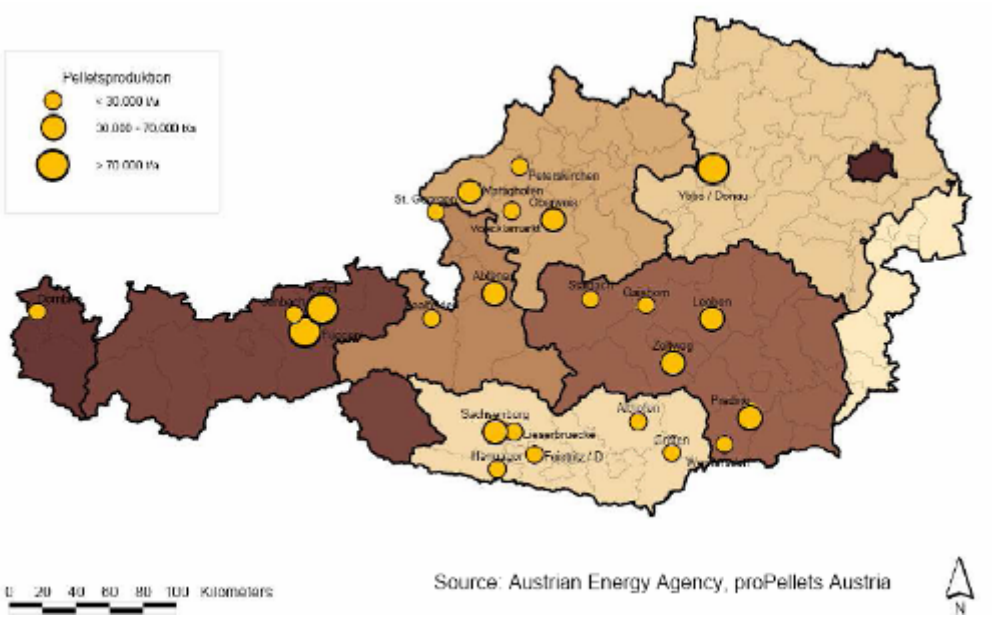


Figure nr 17. Main pellets production sites in Austria, 2007 (source: Austrian Energy Agency, proPellets Austria)

In 2005, Austrian pellet plants produced approximately 450,000 tonnes of pellets and for 2006 the domestic pellets production raised above 600,000 tonnes. For 2007 a production capacity of one million tonnes of pellets is forcasted by the Austrian Energy Agency.
The following figure (Figure nr 18) illustrates the development of the pellets production and production capacity in Austria from 1995 to 2007.

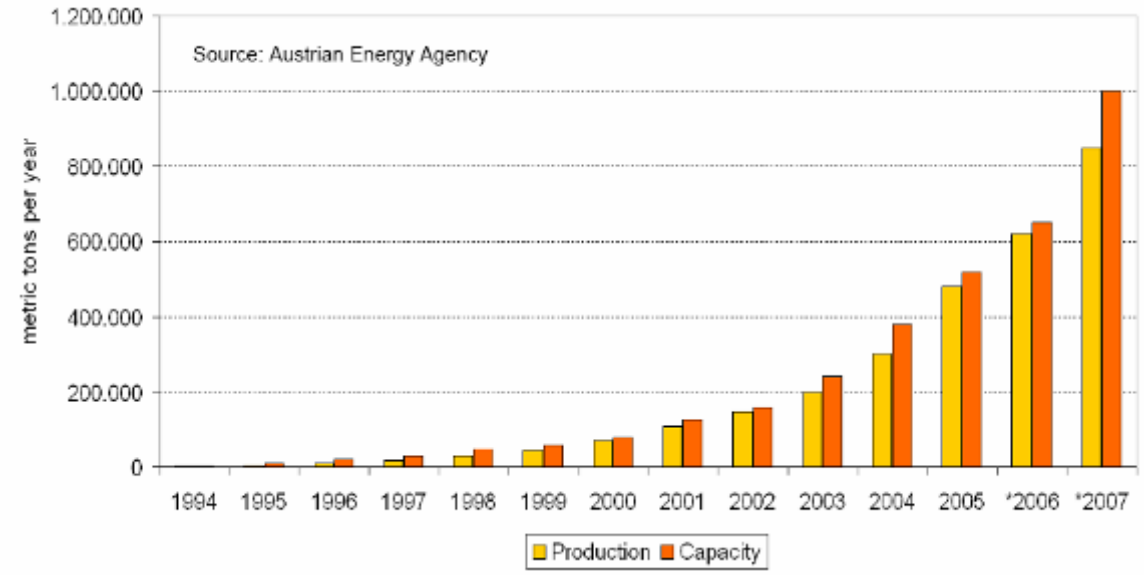


Figure nr 18. Production and production capacity of pellets in Austria (source: Austrian Energy Agency, 2007)

An efficient distribution network has also been established in Austria, with pellets usually delivered loose in a special pellet truck.

4.3.2 Consumption

About 30 manufacturers of small-scale pellet furnaces are currently active. An overall number of 21,959 pellet central heating systems with an entire nominal boiler capacity of 404,742 kW have been installed in Austria until the end of 2003.

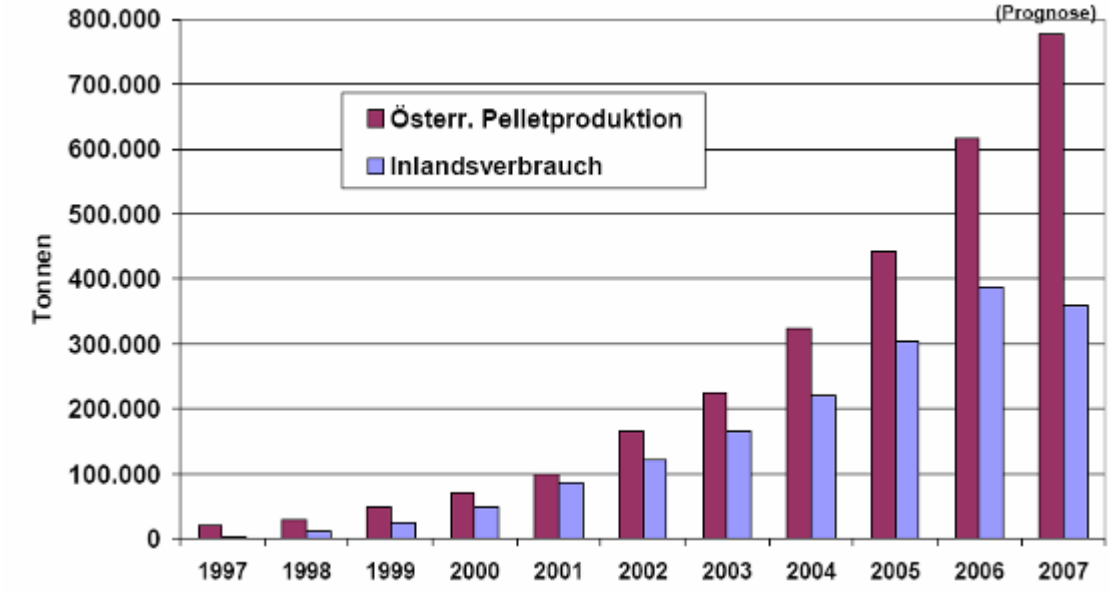


Figure nr 19. Production and domestic demand for pellets in Austria (source: Propellets Austria)

Moreover, the market for pellets boilers has seen a dramatic growth over the past few years. Only the marked rising of the pellet prices since January 2006 now curbs the increase rates for pellet heating systems. According to estimations the domestic consumption of pellets will rise from 300,000 tonnes in 2005 to over 400,000 tonnes in 2006.

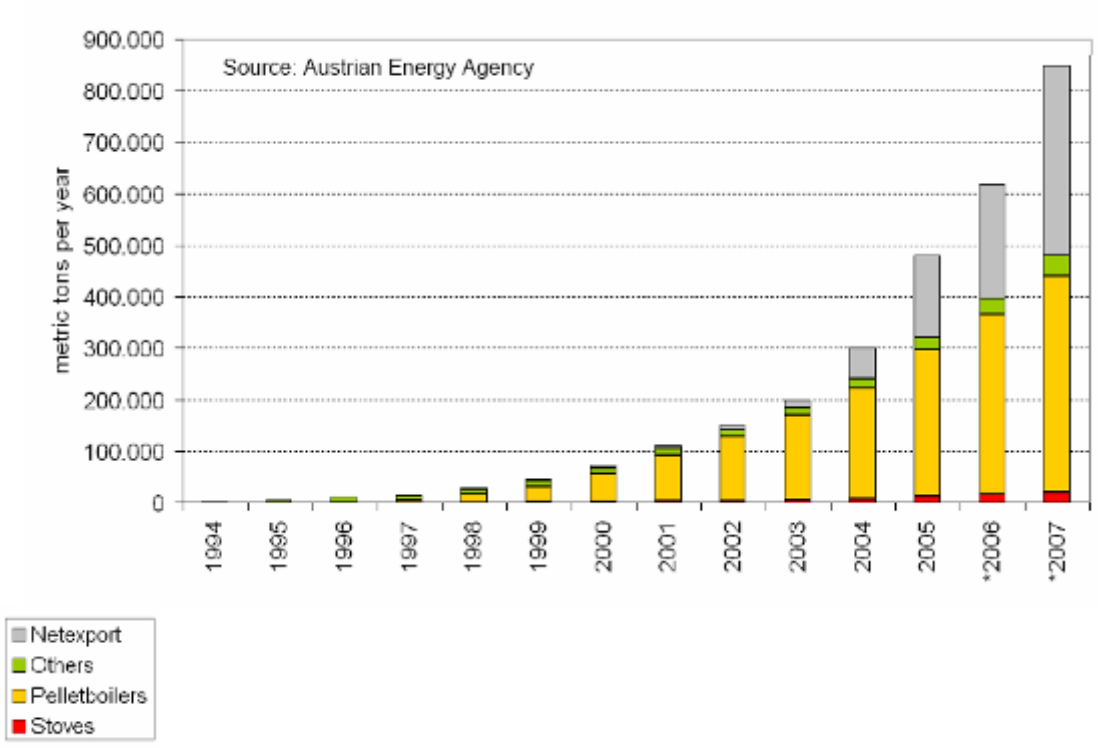


Figure nr 20. Demand for pellets by sectors (Source: Austrian Energy Agency)

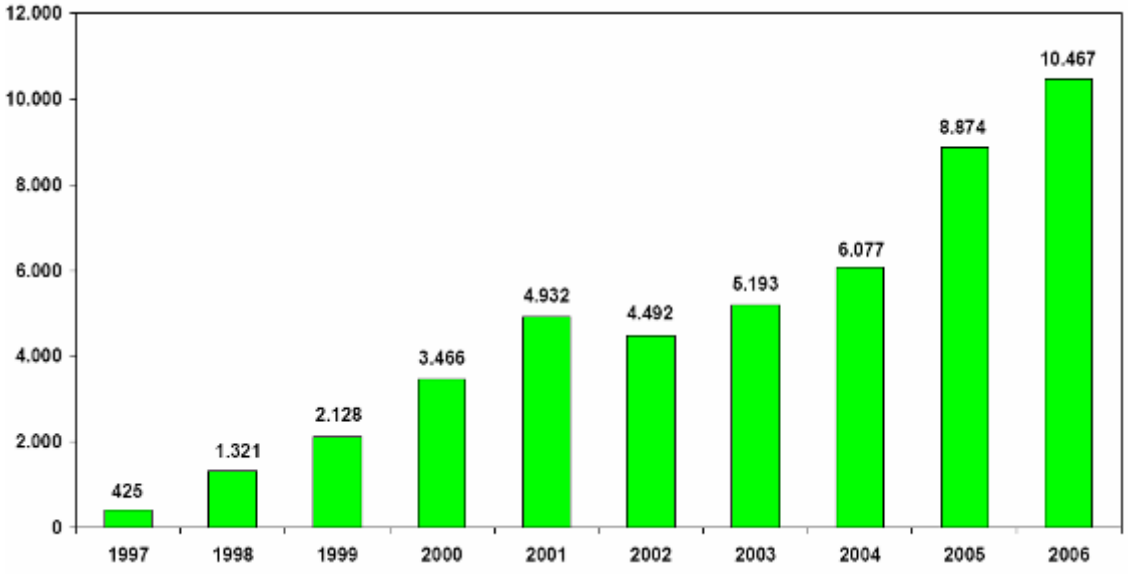


Figure nr 21. Annually installed pellet boilers in Austria (source: Propellets Austria)

2005 was an exceptional year for heating installations operating on biomass (all sectors) with a newly installed capacity of 1136 MWth, ie. Market growth of 59.4% with respect to 2004. All types of burners and boilers benefited from the growth. Out of 23 319 installations sold in 2005, there were 8 874 wood pellet burning boilers (46% growth rate) and 3 780 wood pellet burning heaters (66.5 % growth rate).

Following figure (Figure nr 22) presents the annual amount of installed pellets and wood chip boilers in Austria from 1984 to 2005. Since 1997 significant growth of pellet boilers installation can be noted with an average annual growth above 25%.

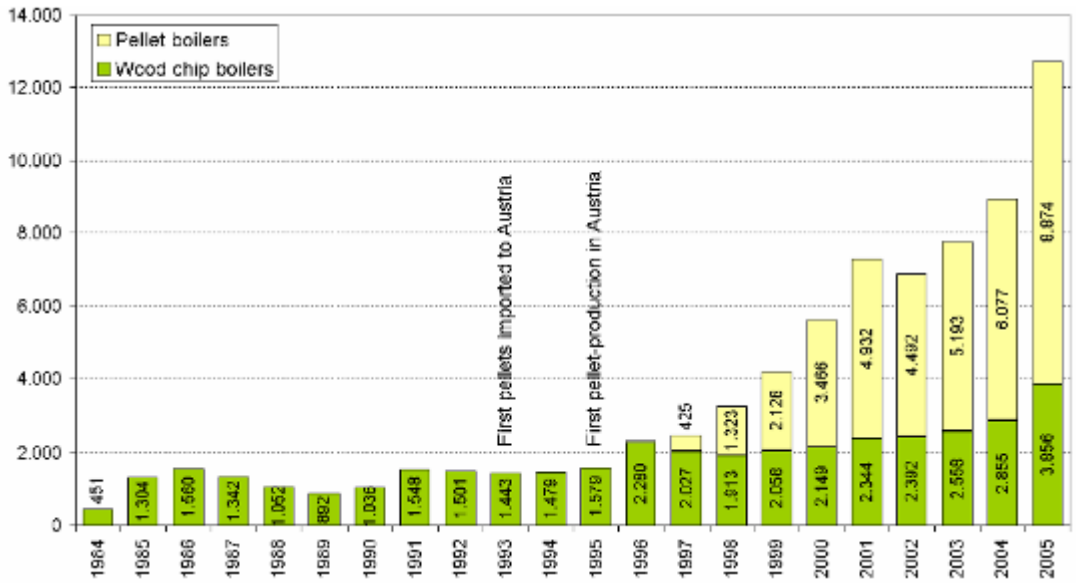


Figure nr 22. Annually installed automatic biomass boilers (<100kW heatload) Source: Austrian Energy Agency)

To illustrate customers' decisions in the age of rapid improvement of heating technologies (notably the feeding systems of the boilers), the figure nr 23 gives the historical overview of different systems in use.

The price of pellets especially in Austria rose significantly in winter 2006/2007. The first half of 2005 was characterized by oversupply and relatively low pellet prices. As oil prices reached their historic maximum in autumn 2005 sales of pellet stoves and pellet boilers boomed and sales grew by 45 per cent. A particularly cold winter heated up demand for pellets. It caused shortage of pellets supply but the prices remain stable. Consequently boiler and stove producers experienced excellent demand during the first half of 2006.

Nevertheless, simultaneously a price rally for raw material developed. Saw dust prices increased in two years from 4 Euro per m³ to up to 15 Euro per m³ in the second half of 2006. Both demand (especially pressure from Italian market) and raising raw material costs drove up pellet prices at unrecorded speed.

In Austria the general public awareness for high energy prices turned to pellets and their price increased up to 70 per cent. The former good image of wood pellets suffered severely. Pellet boiler and stoves sales dropped immediately and overall sales in Austria did not grow as optimistically forecasted.

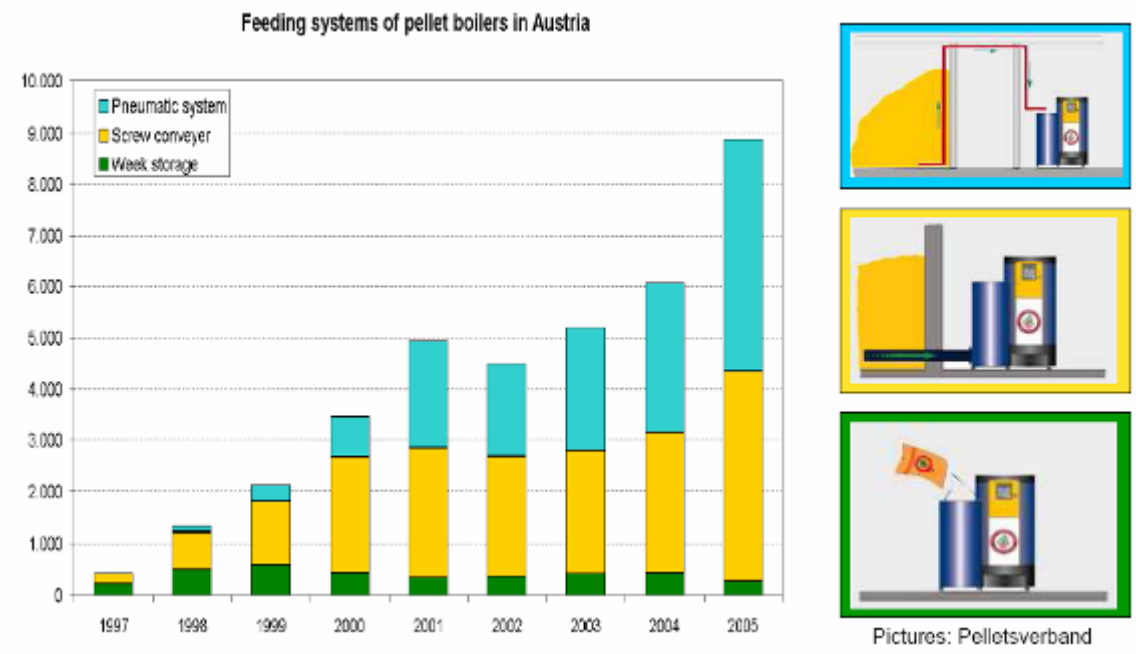


Figure nr 23. Feeding systems of pellet boilers in Austria over the years 1997-2005 (Source: Austrian Energy Agency, NÖLWK)

Figure nr 24 compares the sales of pellet boilers in 2005 and 2006 where the latter reflects the potential customers' reaction to the rapid growth of pellets price at this period.

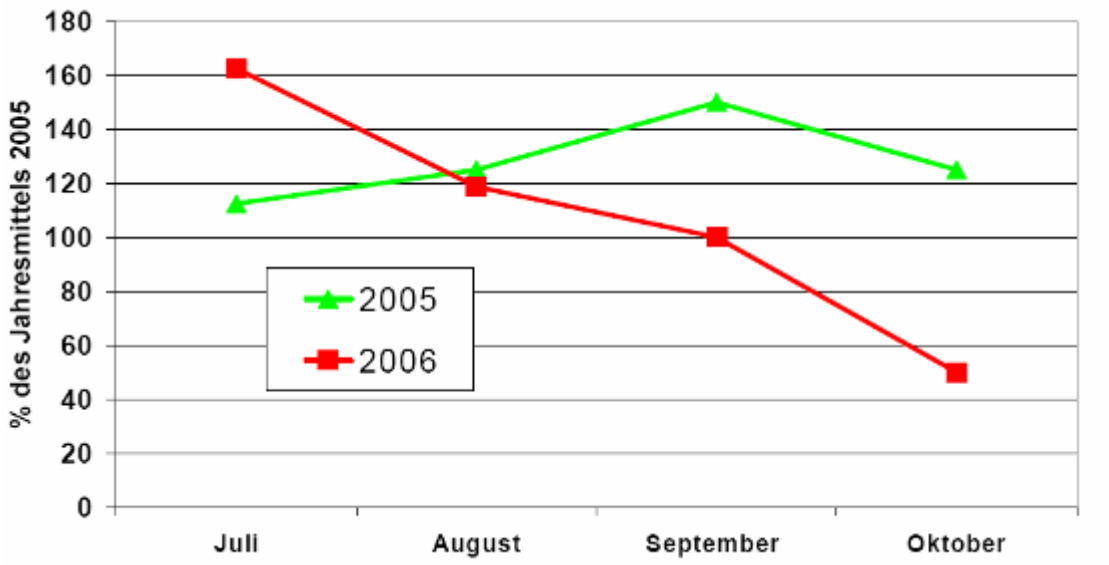


Figure nr 24. Development of pellet boiler sales in Austria: comparison of situation in 2005 and 2006) (Source: proPellets Austria)

4.3.3 Import/Export of wood pellets

Foreign trade with pellets showed the highest dynamic within the last years. Only 10 Years ago (1997) the production and consumption in Austria was below 50,000 t/yr and just a very limited international market existed. In contrast to this starting point, in 2005 about 150,000 tonnes of pellets produced in Austria is exported to Italy and about 45,000 tonnes to Germany. Imports from Czech Republic and Slovakia are quite below the amounts of exports (see figure above). The share of exports on the total pellet production in Austria accounts for about 40%. Due to the development of the pellets market in Europe a further increase in the demand for pellets is expected (both for small scale applications and for large scale CHP). The gap between production and consumption of pellets in Austria probably will increase even further within the next few years.

4.3.4 Pellets quality standards

Standard ÖNORM M 7135 was elaborated in 1998 and updated since then. This is a uniform product standard for pellets and briquettes - concerns compressed wood in natural state or bark in natural state with requirements and test specifications. Pellets or briquettes must be made only of pure wood, only natural binding agents up to 2 % are allowed. Limit values of chemical and physical parameters are shown in the Table nr. 4.

	Ö-Norm M 7135
Thermal value	> 18 MJ/kg
Unit density	> 1,12 kg/dm³
Water content	max. 10,0 %
Ash content	max. 0,5 %
Sulfur	max. 0,04%
Nitrogen	max. 0,30%
Chlorine	max. 0,02%
Length	max. 5 x Ø (6mm)
Diameter	4 – 10 mm (6mm)
Fines	max. 2,3 %
Composition/biding agents	max. 2% (only natural wood)

Table nr 4. Ö -NORM M 7135

In order to assure the quality of wood pellets produced according to Ö NORM M 7135 during transport and storage certain requirements are specified under the Ö NORM M 136 and Ö NORM M 7136 respectively.

4.3.5 Fuel prices

Log wood and wood chips are relatively inexpensive in Austria, but wood pellets are a more expensive heating option in Austria than Germany or Sweden. Figure 25 illustrates the development of prices of heating oil and pellets over the period 2000-2007.

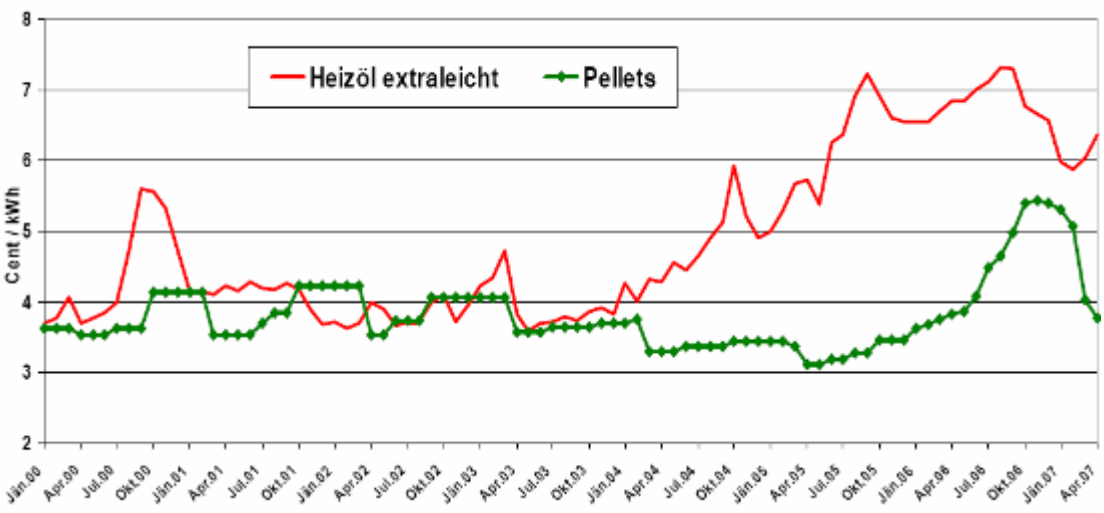


Figure nr 25. Development of pellet prices with comparison to development of heating oil (Heizoil extralicht) in Austria 2000-2007 (Source: IWO, Genol, proPellets Austria, situation in April 2007)

The sharp interest and attraction for this type of fuel has led to a rise in the price of a ton of wood pellets, which went from 178 Euro/tonne in December 2005 up to 267 Euro/tonne in November 2006 (the highest value). Since then the price of pellets is slowly decreasing reaching 184 Euro/tonne in May 2007.

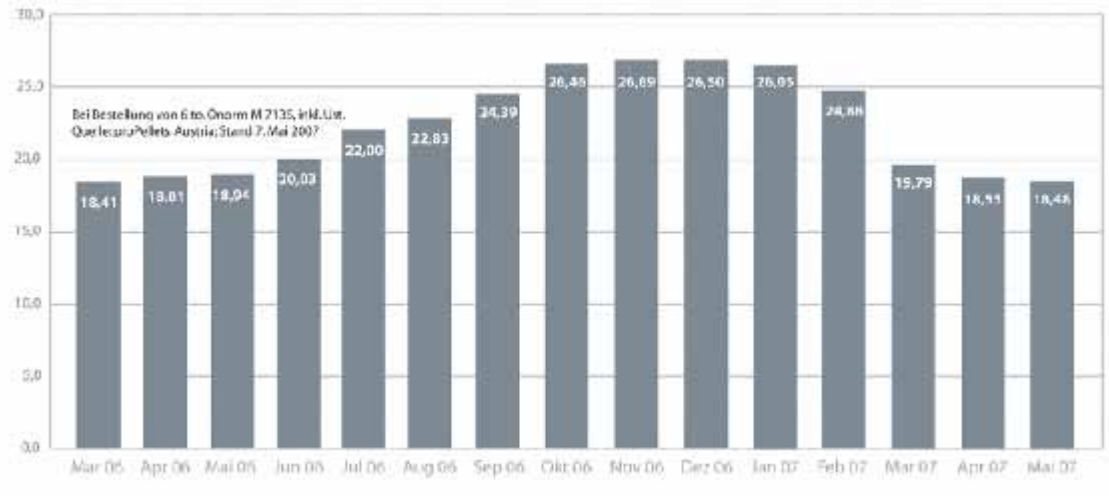


Figure nr 26. Pellet price development in Austria in 2006/2007 in cent/kg

The following figure (figure nr 27) illustrates the change in the pellet boilers sales in percentage due to the increase of the price of pellets in 2006.

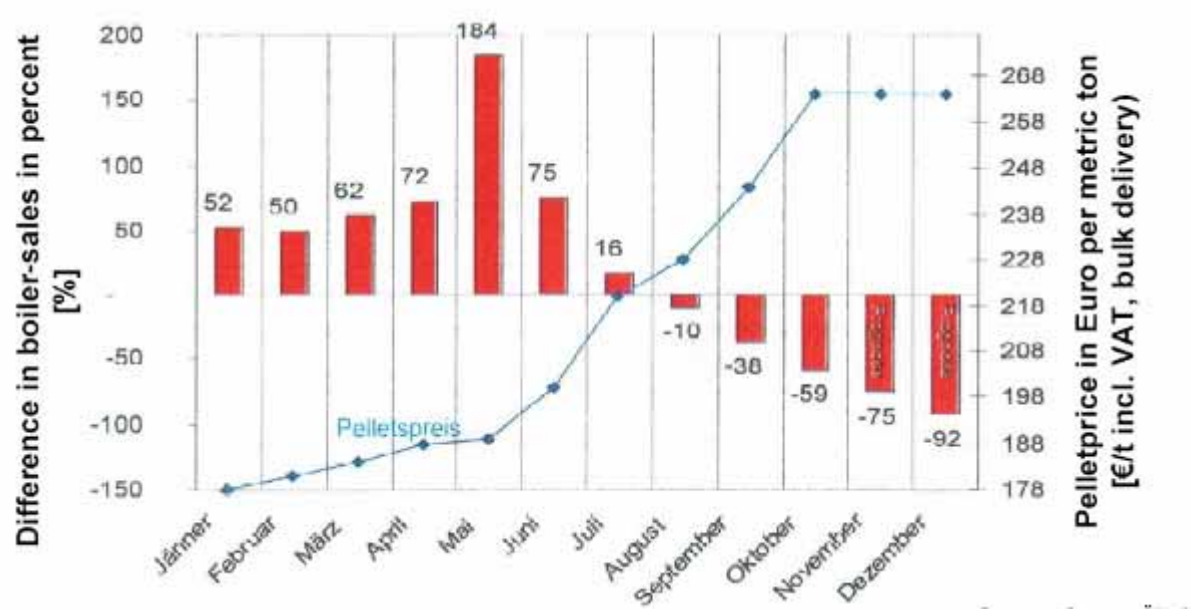


Figure nr 27. Development of pellet boiler sales in percentage in Austria in 2006 (source Ortner, Okofen)

4.4 Denmark

Denmark started using wood pellets in the late 1980s mainly in the district heating sector where they replaced coal firing. From 1993 onwards, the annual pellet use in district heating was about 110,000 tones. An increase in pellet consumption in the last decade is due to increased consumption in both public buildings and residential sector. For some years, pellets had been primarily used for heat production only, but since 2003 a new CHP plant partly fuelled by pellets (Avedore II) started operation and increase significantly total Danish pellet consumption.

4.4.1 Production, capacity and raw material

Danish production of wood pellets reached 200,000 tonnes in 2005, and according to Force the production level remained at the same level in 2006. It is growing over the years but relatively slowly (since 2000 the production increased only by 40,000 tonnes). Denmark is the location of 3 large pellet plants: one with the capacity of 280,000 tonnes and two above 80,000 tonnes. Overall pellet production capacity is 400,000 tonnes which unused represents only 50% of the 2005 pellet demand in Denmark. Therefore import plays an important role in the country pellet supply (Figure nr 27).

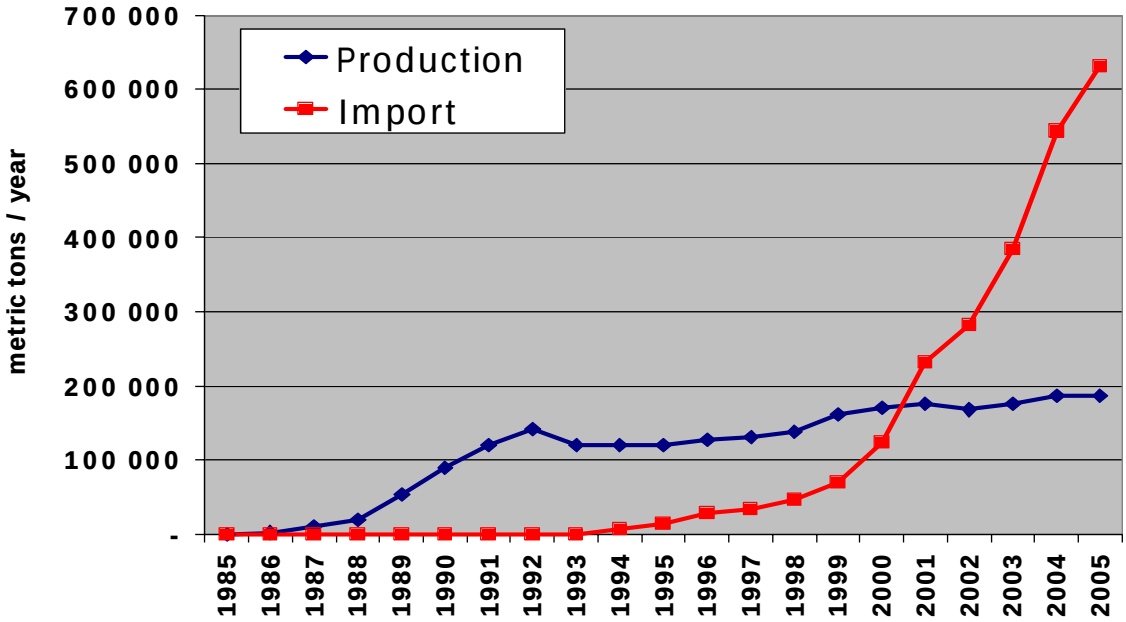


Figure nr.28 Development of wood pellet production and import in Denmark from 1985 to 2005. (Source: Jonas Dahl, 2007)

4.4.2 Consumption

Since 2000, consumption of wood pellets has increased significantly for both large plants and private consumers reaching 820,000 tonnes in 2005 and 870,000 tonnes in 2006 (forecasted). However, as can be seen from figure nr

29, the CHP plants (using negligible amount of pellets before year 2003) have overtaken the private consumers and therefore make up the largest market segment in 2005. The steep increase in consumption by plants is due almost exclusively to the establishment of Avedøre Unit 2, which consumes large amounts wood pellets (250,000 tonnes per year). Private consumption has increased by more than 90,000 tonnes, corresponding to a 41 per cent increase. A smaller increase of 4 per cent is discernable for consumption by industry. In 2006, approximately 310,000 tonnes of pellets were used in small households.

In 2009, the new multi-fuel boiler (Amagerværket Unit 1) with the diet of coal, oil, wood and straw pellets will be in commercial operation. The projected yearly consumption of wood pellets is 40,000 tonnes (110,000 tonnes of straw pellets).

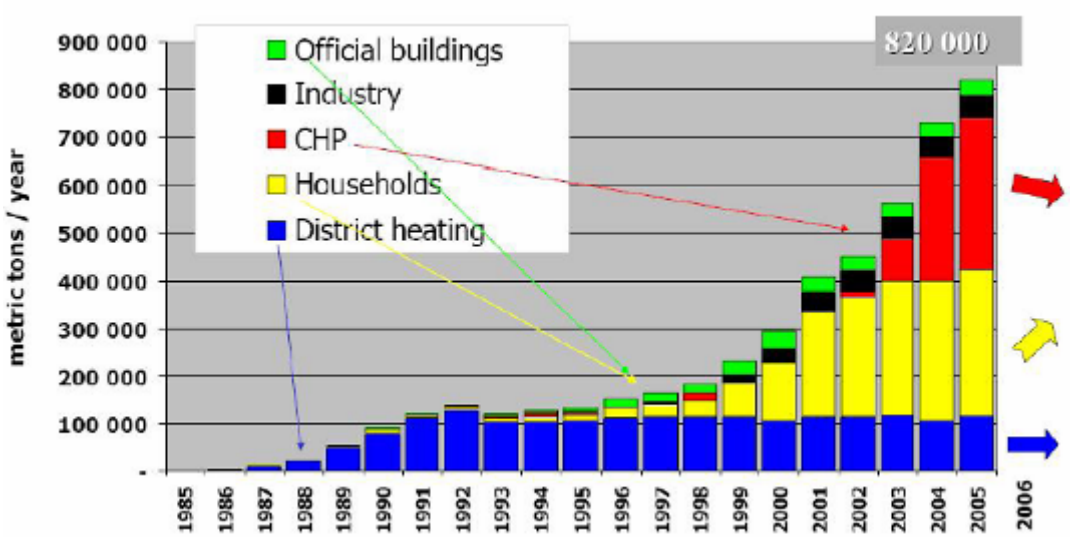


Figure nr 29. Danish pellet market (Source: Jonas Dahl)

4.4.3 Import/Export of wood pellets

The number of Danish wood pellet importers has increased from 17 in 2001 to 29 in 2005. Over this period, the amount of wood pellets imported has likewise increased from 200,800 tonnes to 500,000 tonnes; an overall increase of 149 per cent.

The increase is due, amongst other things, to the wood pellet consumption by Avedøre Unit 2, which is a major consumer of imported wood pellets.
There is a trend toward market consolidation of large importers. As can be seen in Table 2, importers which import more than 20,000 tonnes annually account for 83 per cent of the total amount imported in 2004, whereas they accounted for 79 per cent in 2001. The change is greater for importers which import between 10,000 and 20,000 tonnes annually: in 2004 they accounted for 11 per cent of the total amount imported, whereas their share was 5 per cent in 2001.
The main suppliers for the Danish market are: Baltic States, Poland, Sweden, Canada and Finland.

4.4.4 Pellet standard

Although Denmark is a huge consumer of pellets, and a national standard for pellets have been in great demand for the Danish consumers and suppliers, there have never been developed national standards or rules for characterizing wood pellets in order to sell them to the consumers. The only legislation in this area is the Biomass regulation (BEK nr 638 af 03/07/1997), of which it appears that wood pellets must be produced from clean wood without any kind of contamination. A maximum of 1% remains of glue (e.g. from fibre boards) is allowed, but there are no rules or demands for e.g. water or ash content which are important for the combustion characteristics.
As pellets have mainly been fired in large scale heat or power plants, pellet quality has not been so important. As a substitute to the national standard three quality labels from respectively FORCE Technology, Teknologisk Institut and soon the Danish environment label "Svanemærket" have entered the market and offer quality certifications for pellet manufactures and suppliers.

4.4.5 Fuel prices

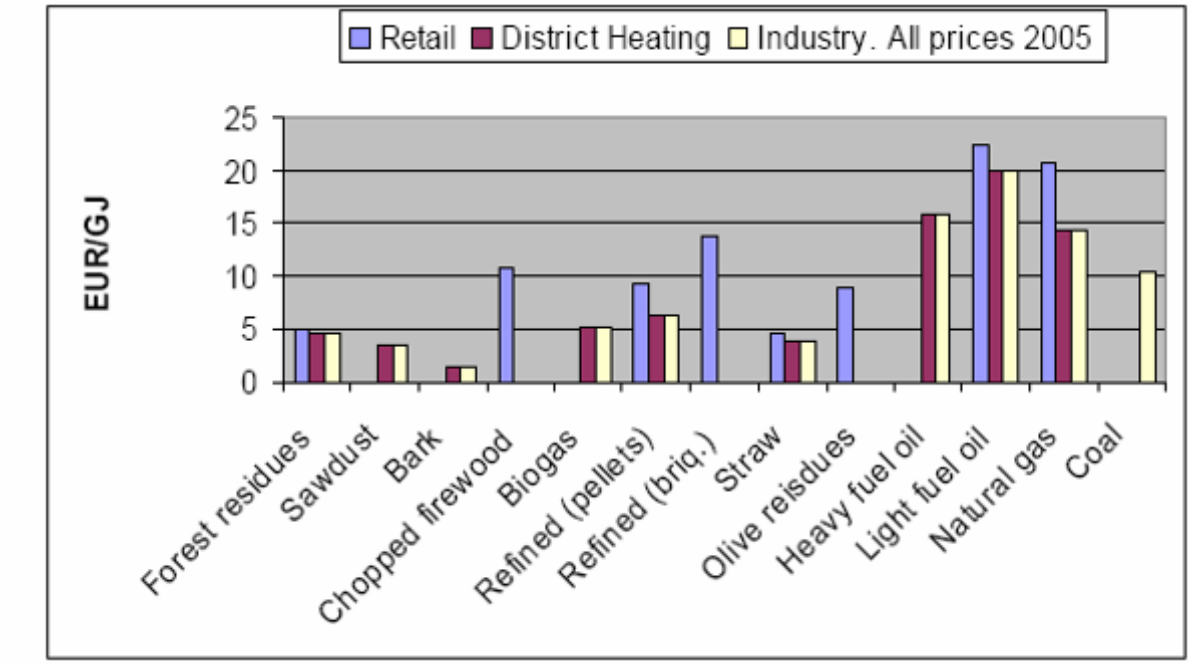


Figure nr 29a. Fuel prices for private consumers, district heating and industry in June 2005 2005, including excise taxes and without VAT.

4.5 Finland

4.5.1 Production, capacity and raw material

The production of wood pellets started in the late 1990s. Since then pellet production has increased steadily and was 235,000 tonnes in 2005. Last year the production increased rapidly and reach 350,000 tonnes (2006). Nevertheless, the full capacity is still much higher and amounts for 450,000 tonnes, which gives an opportunity to further production growth.
Dry by-products from the sawn timber refining industry are the major raw material in wood pellet production. At the end of 2006, there were 19 wood pellet factories in operation.
The most important player in the Finnish wood pellet markets is Vapo Oy, which has expanded its pellet business heavily in recent years and become the largest producr of wood pellets in Europe. Total production capacity of Vapo Pellets is totally 850.000 tonnes annually and factories are located in Finland, Sweden, Denmark, Estonia and Poland. Vapo Oy continues its strategic expansion into new markets.

4.5.2 Consumption

In 2005, the indigenous consumption of pellets was 59,000 tonnes, and increased in 2006 to 100,000 tonnes. When comparing direct fuel prices in heat production, pellets are competitive against fuel oils, but are more expensive than coal. Consequently, pellets are used in applications where light fuel oil is an alternative fuel. However, the price difference in the total heating costs between pellets and fossil fuels has been relatively small, which has retarded the growth of the domestic consumption of pellets.

4.5.3 Import/Export of wood pellets

Around 80% of pellets (refined wood fuels) produced are exported, mainly to Sweden and Denmark. This may derive from the fact that pellets are rather novel product in the residential heating markets.
In 2004, the export of wood pellets was 157,000 tonnes, whilst the total pellet production in Finland was 190,000 tonnes. This means 82.6% of the pellet production was exported. In 2006 the forecasted export accounts for 250,000 tonnes.

4.5.4 Pellet standard

In Finland there have been activities to define good practice guidelines and internal factory instructions for quality control, and these are still used by the market actors in their daily work. A public instruction for pellets quality was developed in 2001-2002 by FINBIO - the Bioenergy Association of Finland. Instruction includes several similar rules as internal instruction of some pellet producers. The quality of pellets was divided into two categories and border values were close to the Swedish Standard for pellets. In 2002, the

development work for the national standard was stopped, and involved actors concentrated on the standardization activities on the European level.

4.5.5 Fuel prices

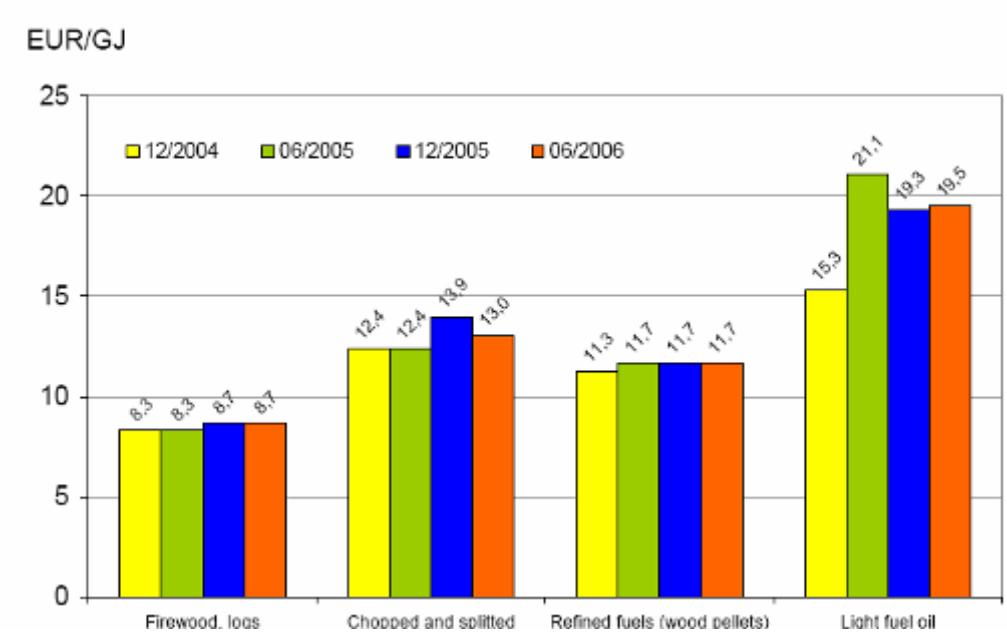


Figure nr 29b Small scale user fuel prices in December 2004, June 2005, December 2005 and June 2006 (VAT not included). (Source: Terhi Lensu and Eija Alakangas, 2006)

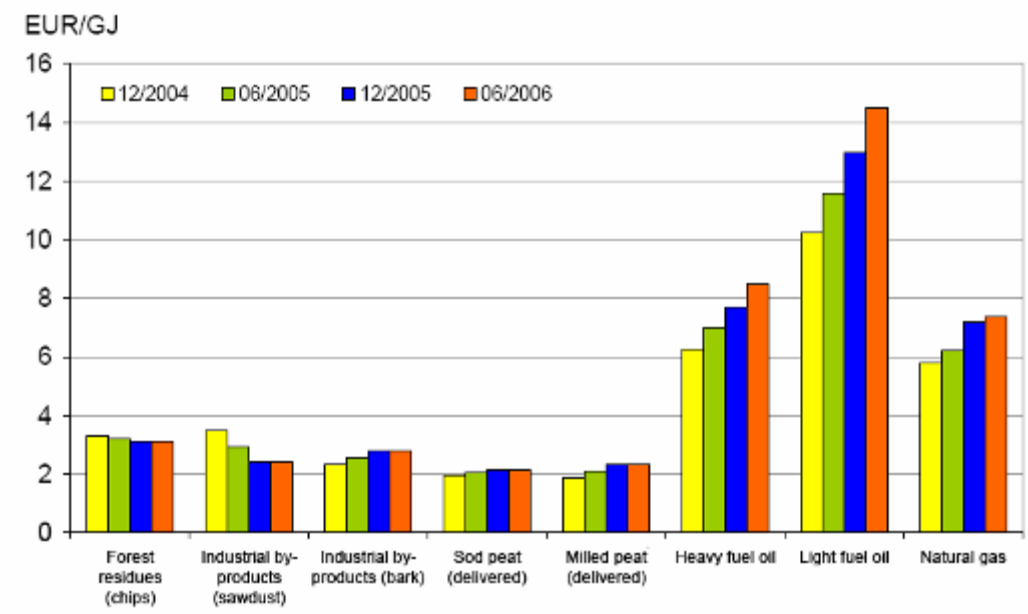


Figure nr 29c Fuel prices in municipal energy plants in December 2004, June 2005, December 2005 and June 2006 (VAT not included). (Source: Terhi Lensu and Eija Alakangas, 2006)

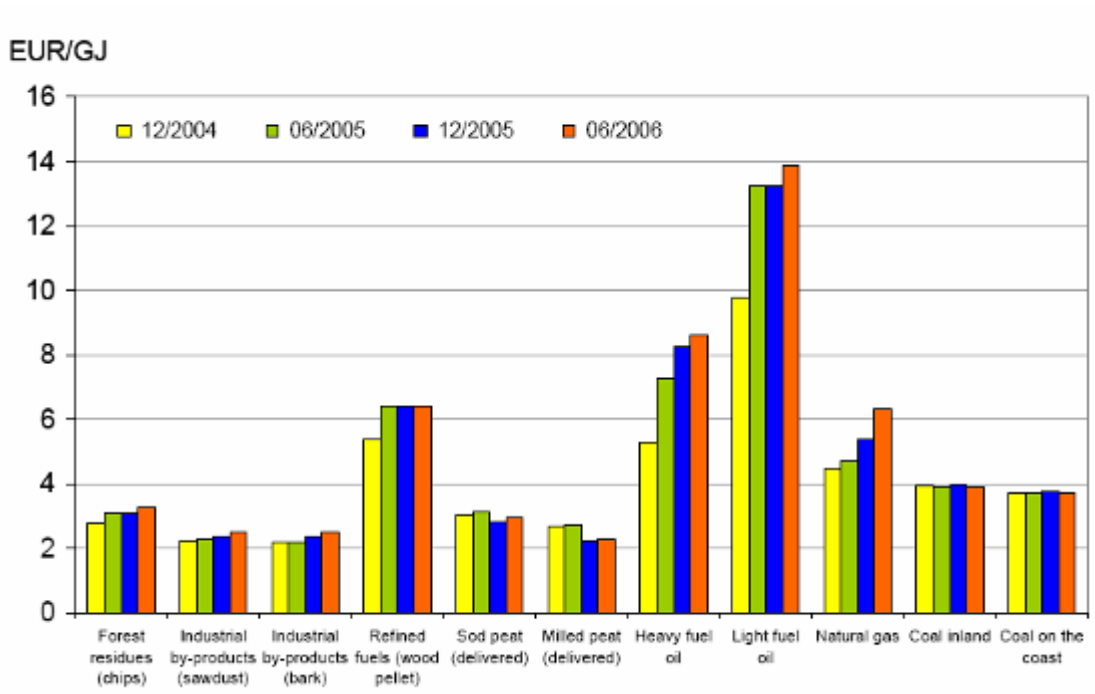


Figure nr 29d Fuel prices in industrial energy plants in December 2004, June 2005, December 2005 and June 2006 (VAT not included). (Source: Terhi Lensu and Eija Alakangas, 2006)

4.6 Italy

4.6.1 Production, capacity and raw material

Italy is the most important Mediterranean pellet market, with over 90 production sites. Nevertheless, national production, of approximately 300,000 tonnes in 2006, cannot satisfy the growing demand. Recently the pellets market has seen significant growth. Pellets producers are very variable in size and hence the production varies considerably: the smaller producer produces 300 tonnes/year, while the biggest ones produce 25-30,000 tonnes/year.

Regarding the distribution on the territory of pellets producers, nearly the 80 per cent of them is located in the North of Italy, where the largest producers are located. In the North, the Veneto region covers about 35% of the market; in fact, the North-East is one of the most industrialized zone in Italy and it is also a "wood industrial district", that is an area specialized in the wood industry. With the market increasing, the proportion covered by the North Italy has decreased, passing from more than 80 per cent to about 77 per cent; this decreased has been in favour of the producers located in Central Italy, where the production has increased of about 4.5%.

This situation, in which a certain type of industry expands from a restricted area to the entire national territory, is typical of sector that is going towards expansion. Moreover, in South Italy are installed more and more plants for the energetic valorisation of biomass, thanks to the presence of abundant woods and regional and European funds that secure the necessary economical and financial resources. In perspective this is a good signal also for a future pellet production.

4.6.2 Consumption

Italy has one of the largest and fastest growing markets for pellet heating systems in Europe. Despite strong annual increase, domestic wood pellet production cannot satisfy the growing demand, which reached 500,000 tonnes in 2006. This situation makes it necessary to import large quantities of pellets. In Italy, almost all pellets are burned in over 125,000 domestic heaters, while less than 2% are used for larger heating boilers (approximately 500 units installed).

Presently, the small scale appliance market (10-50 kW) for domestic heat is approximately several dozens of thousands of units per year.
Moreover, pellets are increasingly used in mini district-heating networks, which serve public structures such as sporting centres, schools and fairs, and have boilers with an average power output of 600-1000 kWth.

4.6.3 Import/Export of wood pellets

In 2006 wood pellets were imported mainly from Austria, Switzerland, Slovenia, Germany and Slovakia. For the next years strong increase of wood pellets consumption is estimated with the import forecasted at approximately 200,000 tonnes per year. This situation is also influenced strongly by the limited experience and investments that entrepreneurs are making to increase the quality of the supply chain for pellet production.

4.6.4 Pellet quality standards

In March 2004 the Italian Standard CTI-R 04/5 for solid biofuel was published and gives quality parameters for biopellets for energetic purposes. This standard already relates to the technical specification defined by CEN/TC335.

This standard classifies 4 categories of pellets and includes the origin of the raw material. Categories A (with/without additives) include woody biomass such as forest and plantation wood (no stumps), by-products from wood processing industry and chemically untreated used wood. Categories B and C include herbaceous and fruity biomass as well as blends and mixtures.

Limit values are given for diameter, length, moisture, ash content, durability and fines, additives, nitrogen, sulfur, chlorine and heating value.

4.6.5 Fuel prices

In Italy the pellets stoves market is booming. As a consequence of massive growth of demand the prices are high, exceeding 170 Euro/tonne for bagged pellets in 2006.

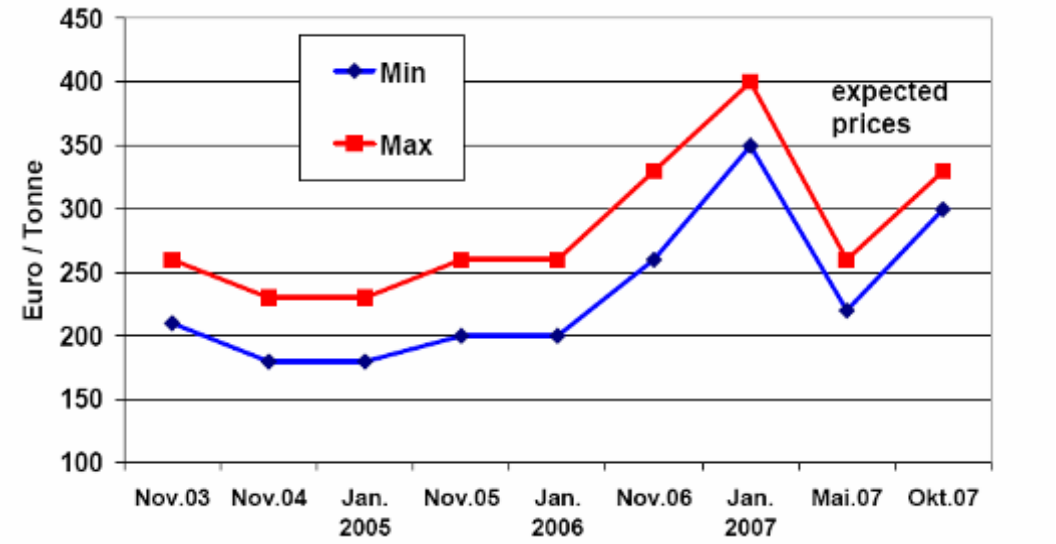


Figure nr 30. Development of bagged pellets prices in Italy 2003-2007 (Source: AIEL 1/2007, proPellets 04/2007)

In the end of 2006, the Italian market registered also purchase cost more than 350 €/ton.

4.7 Belgium

4.7.1 Production, capacity and raw material

There is no significant pellets production in Belgium. Up to date, there is only one pellet plant in Bievre (company Granubois) which started operation in the end of 2005 with the production capacity of 18,000 tonne/year.

4.7.2 Consumption

Significant amounts are imported to produce electricity since the end of the year 2005: 400 000 tonnes of wood pellets per year for the Awirs 4 power plant. Nevertheless, significant amounts are imported to produce green electricity since August 2005 en the start-up of Electrabel Awirs4 and Rodenuize4 power plants firing wood pellets, about 600 000 tonnes of wood pellets/year are being imported by Electrabel in 2005.

Both retrofitted plants Rodenhuize (Unit 4) and Les Awirs (Unit 4) operate at nominal load since September 2005. The capacity of both plants together is about 2500 tonnes of wood pellets per day or 700 000 tonnes a year.

The domestic pellet heating market has been growing since 2005. Its detailed development is illustrated by the Figure nr. 31.

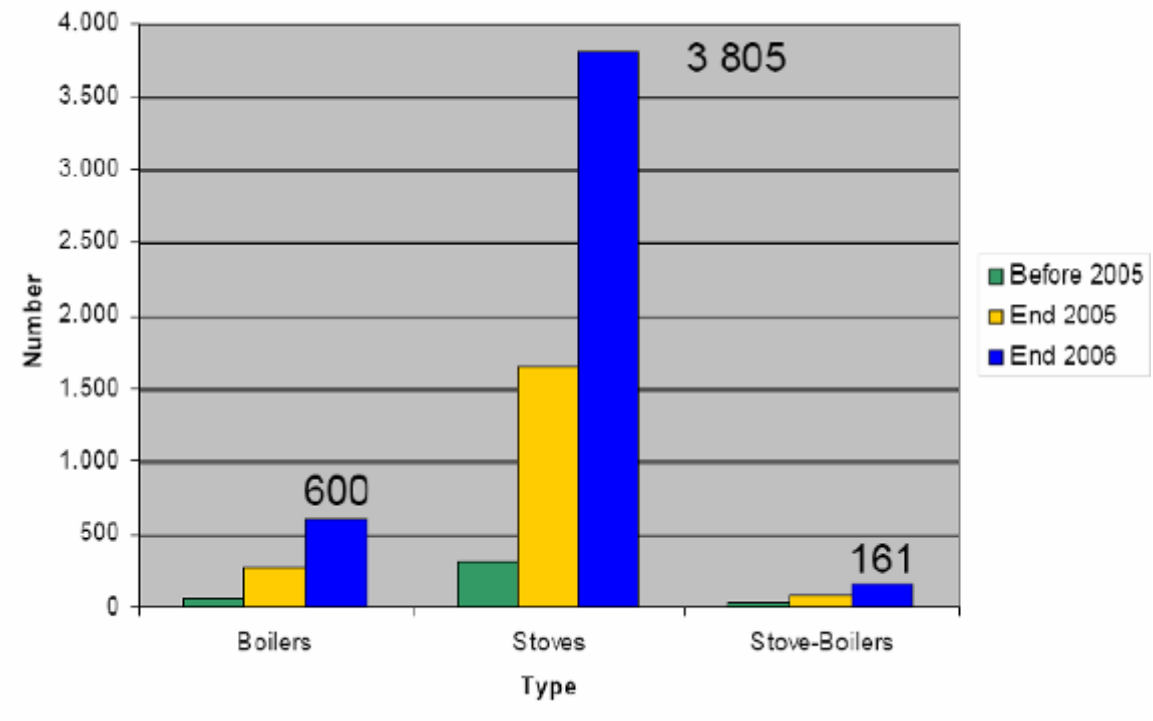


Figure nr 31. Domestic pellet heating market in Wallonia (Source: Didier Marchal)

4.7.3 Import/Export of wood pellets

The suppliers are spread all over the world. Globally about 15% of the feedstock is expected to originate from Belgium, about 40% from Scandinavia

and Eastern EU as well as bordering countries (Russia, Ukraine) and 45% from overseas (Northern and Southern America, Asia, South-Africa).

4.7.4 Pellets quality standards

N/a

4.7.5 Fuel prices

N/a

4.8 Other countries of European Union and EEA (European Economic Area)

4.8.1 France

France represents a new and rapidly growing wood pellet market (Figure nr 32). In 2006, the wood pellet production in France accounts for around 90,000 tonnes with the target in residential sector with 3,000-5,000 installed pellet boilers and about 200,000 pellet stoves. 27 new pellet plants were established in 2006.

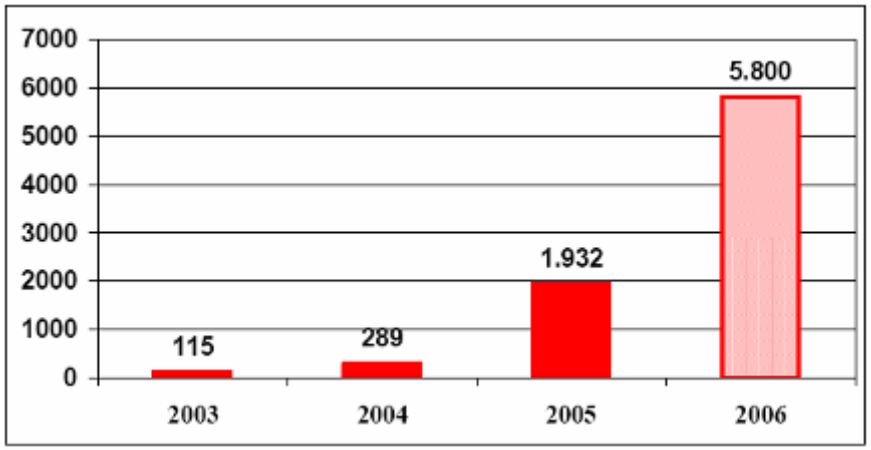


Figure nr.32. Development of pellet boiler sales in France (Source: Rhone-Alp Energie)

4.8.2 Poland

Significant increase of the pellet production as well as the consumption can be observed in Poland. In 2006, 25 pellet plants produced 280,000 tonnes of wood pellets (Figure 32b). The pellet production capacity now exceeds the amount of available cheap wood residues, which has led to increasing prices for raw material. Consumption of wood pellets is still limited (35,000 tonnes) but represents growth of 40 per cent from 2005.

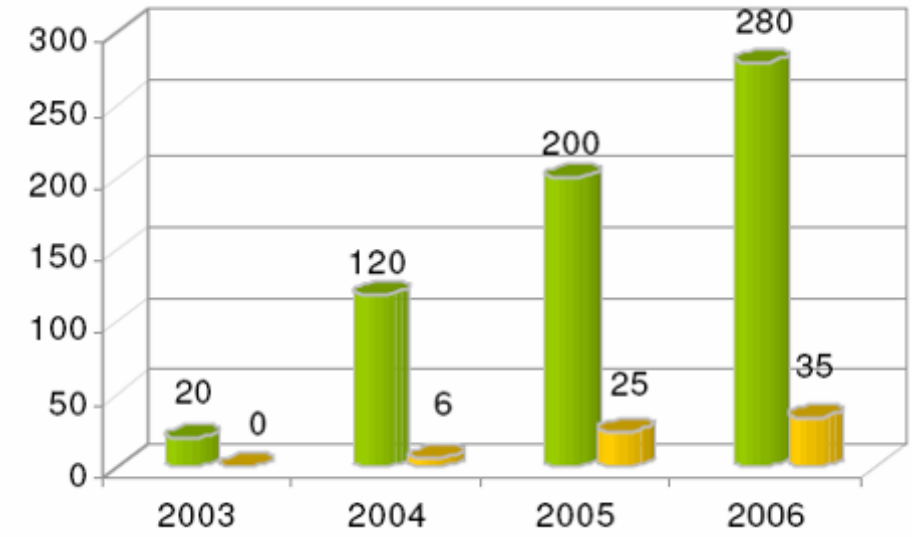


Figure nr 32a Development of production (green color) and consumption (yellow color) of wood pellets in Poland

There are 2,500 boilers of 10-25 kW installed and 40 medium boilers (50-250 kW). Figure 32a shows the development of production of wood pellets from 2003 to 2006. The current wood pellet price for households is about 150 €/tonne.

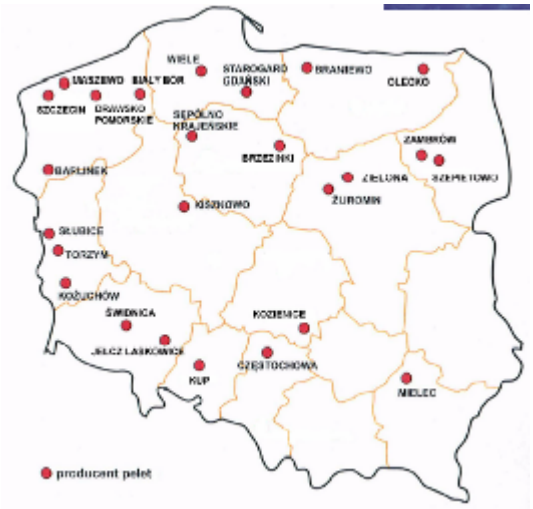


Figure nr 32b Map of the pellet plants locations in Poland

4.8.3 Baltic States: Estonia, Latvia, Lithuania

Latvia is the bigger producer of wood pellets among the Baltic States where production reached 350,000 tonnes with one plant of capacity over 100,000 tonnes and 4 plants above 30,000 tonnes.

Estonia is second largest producer with 6 pellet plants which total production accounts for 235,000 tonnes (2006). Lithuania is a location of one pellet plant, which produces around 100,000 tonnes per year. All the three countries experience a raw material shortage due to over establishment of pellet plants and a reduction of the saw mill production. Thus, the raw material costs are among the highest in Europe, a drastic change in a short period of time.

AS Graanul Invest is the biggest wood pellet producer in the Baltic States with annual production 2007/2008 season around 400,000 tonnes. Company has 4 production units: 2 in Estonia, 1 in Latvia and 1 in Lithuania. They produce wide range of different products aimed to different markets. Starting from packed 6 mm pellets (15, 16 and 25 kg bags) and ending up with 10 mm industrial pellets (ash content less than 1%).
In the Baltic States, the consumption of wood pellets is not significant; more than 90 per cent of production is exported, mainly to Sweden and Germany.

4.8.4 Czech Republic

In 2006 in Czech Republic, production of pellets reached 28,000 tonnes, but comparing to 2004 the number of producers fell from 11 to 7. One of the main negative factor destabilizing the wood waste market was reduction of total wood harvest by Lesy České republiky, a national company (Forests of the Czech Republic) administering 51 % of the total area of forests in the Czech

Republic; in the comparison with 2004, total 2005 wood harvest has fallen by approximately 50%. Number of wood harvest and processing companies found themselves at the edge of their existence or went bankrupt.
Heating by wooden pellets is still very limited. Approximately 10% from the total pellets produced in the Czech Republic is used on domestic market; other 90% is exported mainly to Austria and Germany.

4.8.5 The Netherlands

In Netherlands, wood pellets are used mainly in co-firing in large power plants. According to ProPellets Austria the annual demand for pellets is around 1,400,000 tonnes. Pellets are exported inter alia from South Africa, North America (mainly Canada) and South America (e.g. Chile and Brazil),

4.8.6 Norway

Norway is steadily increasing its wood pellets production, with the volumes of 34,000 tonnes in 2004, 42,000 tonnes in 2005 and 51,000 tonnes in 2006. Production is rather equally allocated to domestic use and for export.
The Norwegian heat market is characterized by extensive use of electricity for heating in private households and limited availability of water borne heat distribution. About 70% of all households use electricity as the main heating source, while only 5% have common central heating and less than 1% has access to district heating. Electricity is often used in combination with stoves for fire wood or fuel oil. Approximately 60% of the households have stoves for solid fuels and 16% have stoves/boilers for oil or kerosene. The low share of households with water borne heating (12%) and district heating systems (4.5%) represents a major barrier for increased use of bioenergy because of high investment costs (Bolkesjø, Trømborg and Solberg 2006).

The production of pellets in Norway is increasing and reached 51 340 tons in year 2006. The increased production has to a large extent been exported, but domestic consumption increased significantly in 2006 due to increased sales of pellets stoves for private households. The consumption is expected to continue to grow also in 2007.

4.8.6.1 Production, capacity and raw material

The production of pellets in 2006 reached 50 000 tons in Norway (Figure 32c). The total capacity of 11 pellet plants in Norway is estimated to be 121 000 tons. The raw material used for the pellets production is mainly bi-products from the forest industries, mainly sawdust and shavings. As these raw materials are fully utilized, new capacity will be based on round wood, mainly from pine. Research is going on how to produce pellets without debarking of the round wood in order to avoid an extra operation in the production process.

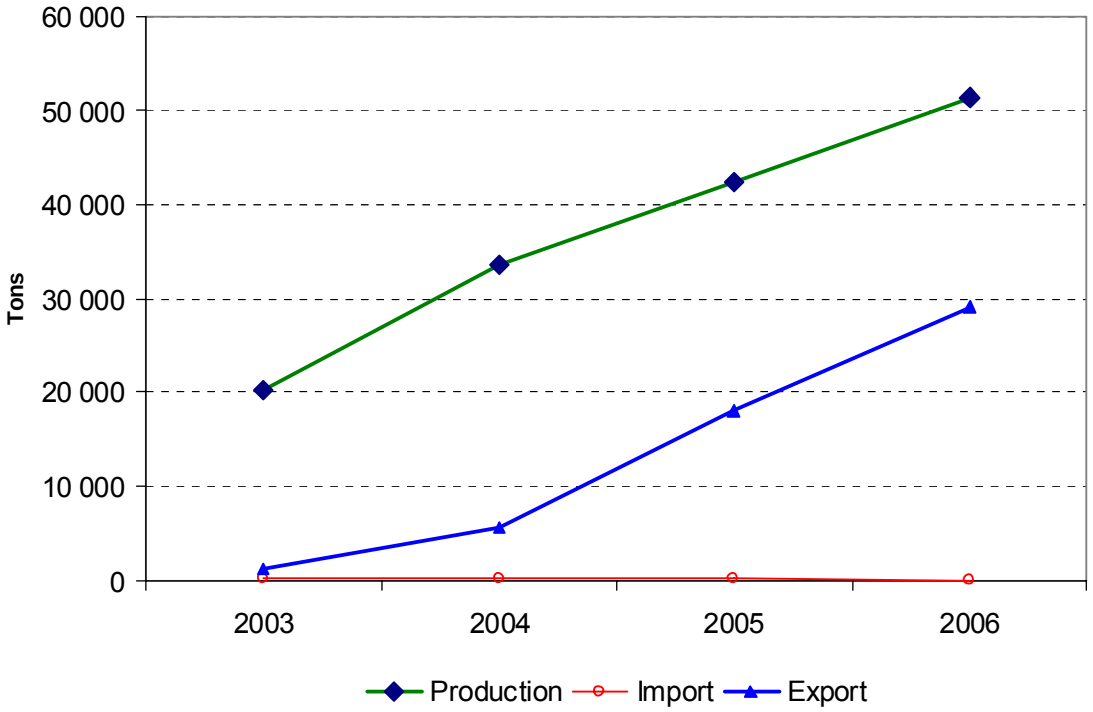


Figure nr 32c. Development of production, import and export of wood pellets in Norway from 2003-2006 (Source: Nobio 2007)

Two larger pellets plants with capacity of 60 000 tons and 400 000 tons are currently under planning in Norway. Both plants will by based on roundwood and the production will mainly be for export.

In addition to pellets, the production of briquettes produced of wood materials as 42 000 tons in 2006. Briquettes are mainly sold in bulk in the domestic market and the price is about 40% lower than the pellet price.

4.8.6.2 Consumption

The consumption of pellets in Norway is mainly in pellet stoves, and smaller pellet boilers with effect up to 25 kW. Domestic pellets sales increased by 55% from 2005 to 2006 and were 30184 tons in 2006. The total number of pellets stoves is about 10 000 units. Annual sales of pellet stoves increased from 1352 units in 2005 to 2937 units in 2006, which is likely to affect the consumption from 2007. Procurement of pellet stoves was supported by the government with NOK 4000 per unit in 2006 (about 500 Euro). The sales of pellets in small bags are increasing and makes up about 60% of the market, whereas the sales in bulk is decreasing and was about 35% in 2006.

4.8.6.3 Import/Export of wood pellets

Import is of pellets to Norway is very limited, whereas export is increasing and was 56% of the production in 2006 (Figure 32c).

4.8.6.4 Pellets quality standards

Wood pellets have a specific standard in Norway, NS 3165. The standard has - three product groups and is identical to the Swedish standard SS 18 71 20. When produced on wood from spruce or pine, the following specifications will be normal:

Density:	550-750 550 – 750 kg/m³
Diameter:	5 – 12 mm
Net calorific value:	17,0 – 17,9 MJ/kg /4,72 – 4,97 kWh/kg
Total moisture content:	6 – 10 % w/w
Ash content	0,3 – 0,8 % w/w
Sulphur:	5 – 10 mg/MJ of DM / 0,01 – 0,02 % av of dry weight
Nitrogen:	ca. 0,05 % of dry weight
Share of fine particles:	Large variations

4.8.6.5 Fuel prices

Figure 2 shows historical development of net energy prices, including taxes, for fire wood, light fuel oil, kerosene and electricity. Oil, electricity and kerosene prices are from Statistics Norway, whereas the price development of fire wood is based on historical timber prices and processing costs according to Hole (2001). The data includes all costs except capital costs of heating equipment. The historical price figures explain a large portion of the relatively minor use of bioenergy in Norway, compared to neighboring countries like Sweden and Finland. Until about 2000, fossil fuels and electricity have been cheaper than fire wood and other solid biofuels in Norway. After 2000, the rising prices of oil and electricity internationally, and corresponding decline of Norwegian timber prices, have made solid biofuels like fire wood economically competitive towards electricity, light fuel oil and kerosene (the main competitors). It should be stressed though, that high investment costs hamper the substitution of bioenergy for electricity and oil in existing buildings, although fuel prices are substantially lower.

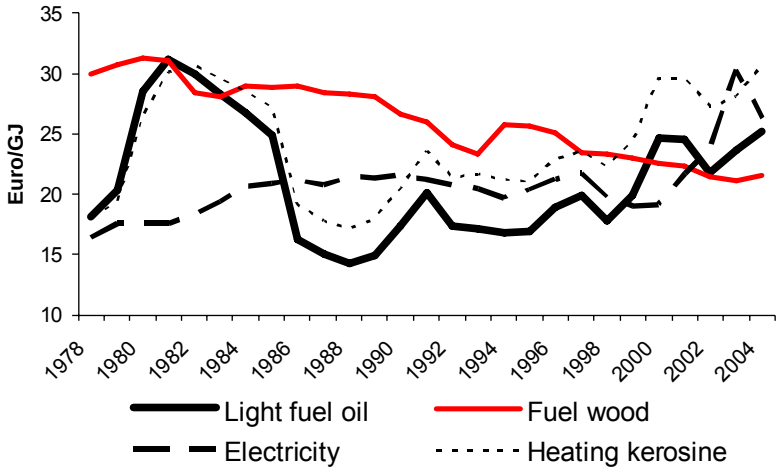


Figure 32d. Real (1998) prices of net energy (including all taxes) for oil, electricity and fire wood (Sources: Statistics Norway (www.ssb.no) and Hole, 2001).

The prices for pellets are given in Table 4a:

Table 4a. Market prices for pellets in Norway given at industrial site exclusive of VAT (25%). Source: www.nobio.no

Unit	2004		2005		2006	
	Euro/ton[1]	Euro/MWh[2]	Euro/ton	Euro/MWh	Euro/ton	Euro/MWh
Small bags	193	40.2	191	39.7	217	45.2
Big bags	164	34.3	165	34.3	184	38.4
Bulk	144	30.0	141	29.5	166	34.5

1. Exchange rate Euro-NOK is 7.94

2. 4800 kWh per ton pellets

4.9 Russian Federation

Russia has about 22 per cent of the world's forests located on its territory. Forests cover about 40 per cent of the entire landmass, with the current annual allowable cut of 542 million m³. The largest forests are in the Siberian taiga, the Far East and the northern European territories. The forest industry is important for the Russian economy, and it is a large potential supplier and consumer of biomass (wood waste) products. At present, these products are only being minimally exploited. Agricultural wastes are another source of biomass fuel. The agricultural sector is also important in Russia, accounting for 8 percent of GDP, and employing 11 percent of the labour force. The technical potential of biomass is estimated at more than 50 Mtoe.

Currently, Russia uses only forestry industry waste for the production of wood pellets that can be used for bio-energy production. Pellets are primarily exported, while domestic consumption of wood pellets is very limited. According to some estimates, the share of bioenergy in the Russian "small energy" market is less than 0.3 per cent, and the share in the total energy market is negligible. Minor use of wood pellets for production of energy (by burning) takes place in some private boiler houses and in some communal boilers in the forest regions of Russia.

Present production of wood pellets is concentrated in the forest regions of Russia close to border exit points and mainly in Northwestern Russia, as most wood pellets are exported to Europe. The capacity of all wood pellet-producing plants in the Northwestern federal district of Russia is 200,000 tonnes a year, but only a quarter of this capacity is used. Plant location and cost of production are prohibitive for production. Currently, several companies, including three German companies, one Italian, one American and several small Russian companies sell equipment for wood pellet production, and their businesses are growing. The companies offer lines that can produce from 0.5 to 4 tonnes of pellets per hour.

For 2006, three plants are planned at the expense of federal budget loans: in Tomsk oblast, in Komi Republic (near Syktyvkar), and in Nizhniy Novgorod oblast (near Vetluga). The total cost of construction of these plants will be 1.1 billion rubles (approximately $40.7 million), including 50 million rubles ($1.9 million) of federal money. There are also private projects in Arkhangelsk oblast, in Kaluga oblast, in Tver oblast, in Leningrad oblast, in Kareliya republic, and in Krasnoyarsk kray.

5 The Wood Pellet Industry and market in North America

5.1 Canada

5.1.1 Production, capacity and raw material

Manufacture and export of wood pellets in Canada has grown exponentially in the past several years, primarily on the west coast. There are at least 23 pellet plants in Canada, out of which almost half in British Columbia. Production has reached 1,400,000 tonnes in 2006 and several new pellet mills as well as expansion of existing mills are being planned or implemented in the next year. Princeton has recently upgraded to 75,000 tonnes and Armstrong to 50,000 tonnes. These plants are being built to take advantage not only of the surplus mill residue situation in British Columbia, but also the huge potential wood supply from Mountain Pine Beetle affected stands.

Figure nr 33 illustrates the location of pellet plants in operation and the one presently built.

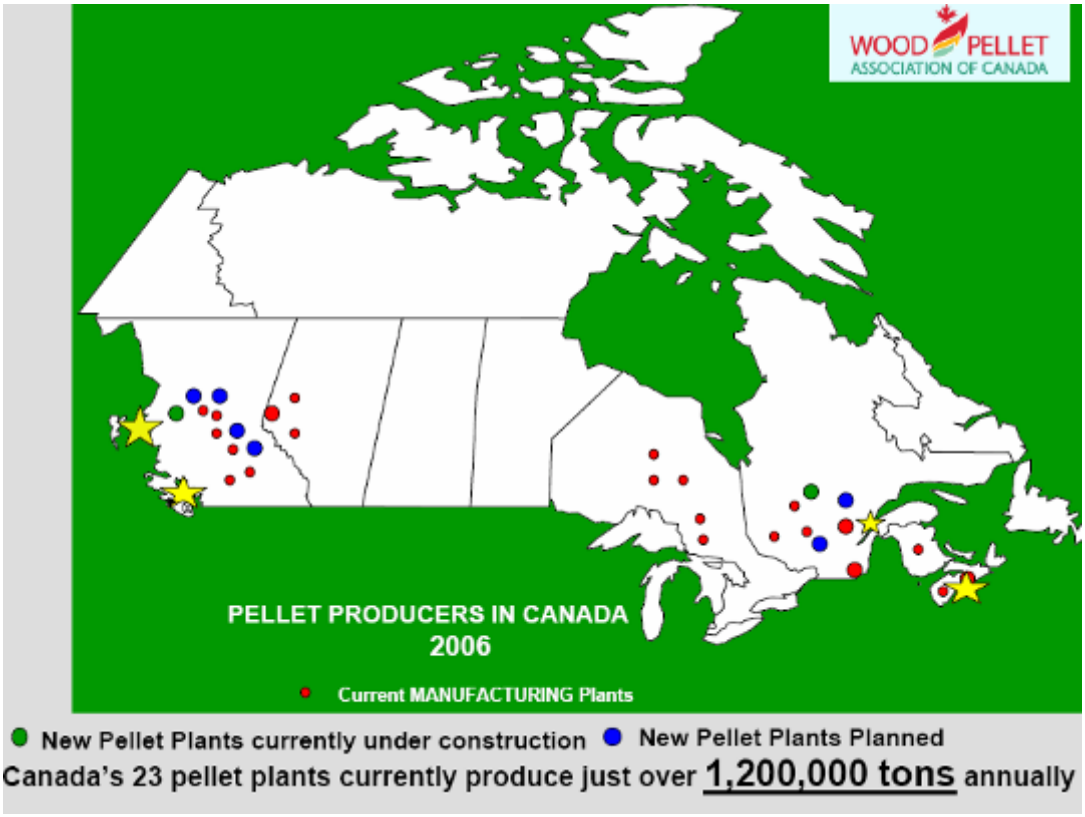


Figure nr. 33. Pellet plants in Canada (Source: Wood Pellet Association of Canada, 2006)

For companies in BC, with ocean ports in close proximity, the market is primarily Europe. Similarly McTara in Nova Scotia sells largely into Europe. Companies in Alberta and Quebec export, but sell largely into the US. It is planned to produce 3 million tonnes in British Columbia alone by 2010. British Columbia is already a major producer of pellets, together with its western

Canadian neighbour, Alberta. In fact, western Canada is currently responsible for over 70% of Canada's production, exporting over half a million tones of pellets overseas each year.
One reason behind the fast growth in the region is the vast amount of forestry timber in the region that has suffered attack from the mountain pine beetle. In the past, this pest has been killed off by the low winter temperatures, but warmer winters are allowing it to survive. A vast area of forest has been affected - 8.5 million hectares, representing over 400 million m³ of timber. While this is a serious problem, it represents a massive biomass opportunity for the next 25 years.

5.1.2 Consumption

Consumption of pellets in Canada is relatively small and did not excide 150,000 tonnes in 2006. Pellets are used mainly in domestic heating sector. Figure nr 34a presents the actual domestic consumption of pellets in comparison to their export from 2003 to projected values in 2007.

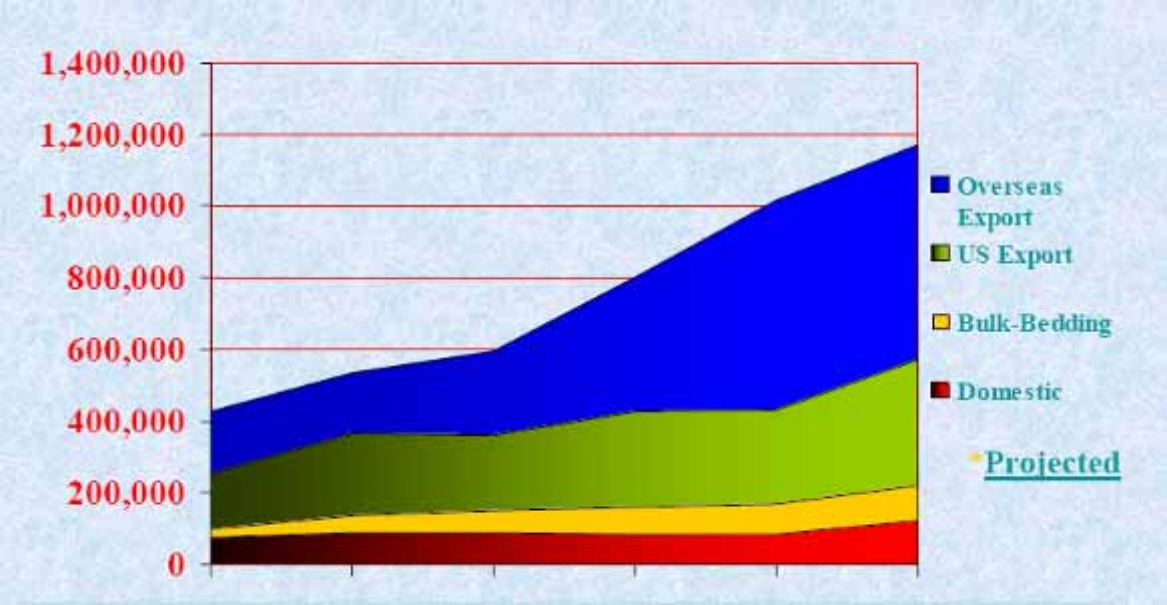
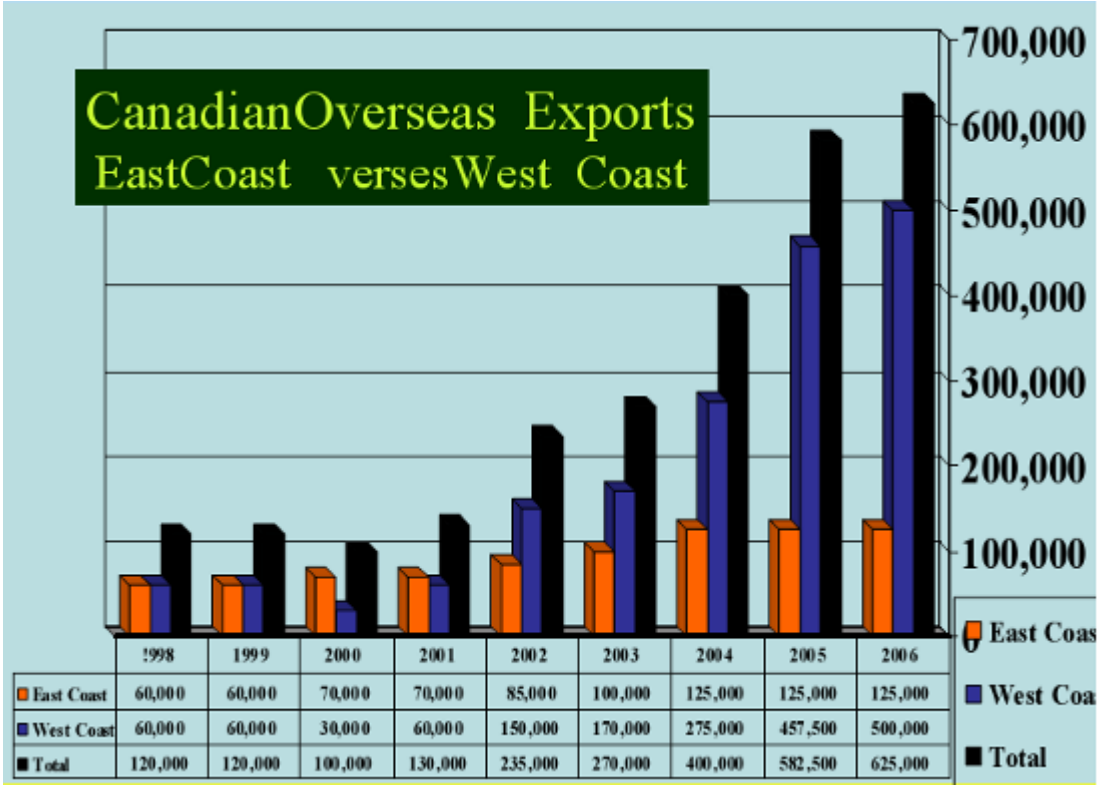


Figure nr 33a. Canadian Wood Pellet Production divided into domestic, US export and Overseas export sectors (Canadian Wood Pellet Association, 2006).

5.1.3 Import/Export of wood pellets

The greatest opportunity for pellet exports from Canada is in BC. Exports to Europe from Western Canada alone (primarily BC) exceeded 500,000 tonnes in 2006. Capacity in central Canada is not near ocean ports and thus production is largely destined for the US market.
A new dedicated pellet loading facility was erected in Port of Vancouver and started operation in the end of 2005. This terminal may handle 1,000,000 tonnes per year and could be expanded to handle twice that volume over time.

Construction of a new loading terminal in Port of Prince Rupert to replace the one just closed is being pursued and could be a reality in nearest future.



	1998	1999	2000	2001	2002	2003	2004	2005	2006
East Coast	60,000	60,000	70,000	70,000	85,000	100,000	125,000	125,000	125,000
West Coast	60,000	60,000	30,000	60,000	150,000	170,000	275,000	457,500	500,000
Total	120,000	120,000	100,000	130,000	235,000	270,000	400,000	582,500	625,000

Figure nr 34. Pellet oversees export of Canada (Source: Wood Pellet Association of Canada, 2006)

The East Coast has little mill residue available for additional pellet capacity and the province is not currently predisposed to use harvest waste. In Quebec, reduced wood harvesting will put pressure on the demand for mill residues; however, there is an opportunity to manufacture pellets from unutilized forest slash. Quebec plants would also be near the port of Montreal. However, the use of harvest waste is still an environmental question and is not yet supported.

5.1.4 Pellets quality standards

Canada has no national standard for wood pellets; however, the BC Pellet Fuel Manufacturers Association is attempting to establish such a standard based on the Swedish, Austrian and other standards.

5.1.5 Fuel prices

N/a

5.2 United States

5.2.1 Production, capacity and raw material

In the US, pellet mills across the country receive, sort, grind, dry, compress, and bag wood and other biomass waste products into a conveniently handled fuel. Today, over sixty pellet mills across North America produce in excess of 800,000 tonnes of fuel per year, a figure that has more than doubled in the last five years.
Figure 35 illustrates the location of pellet plants in United States.

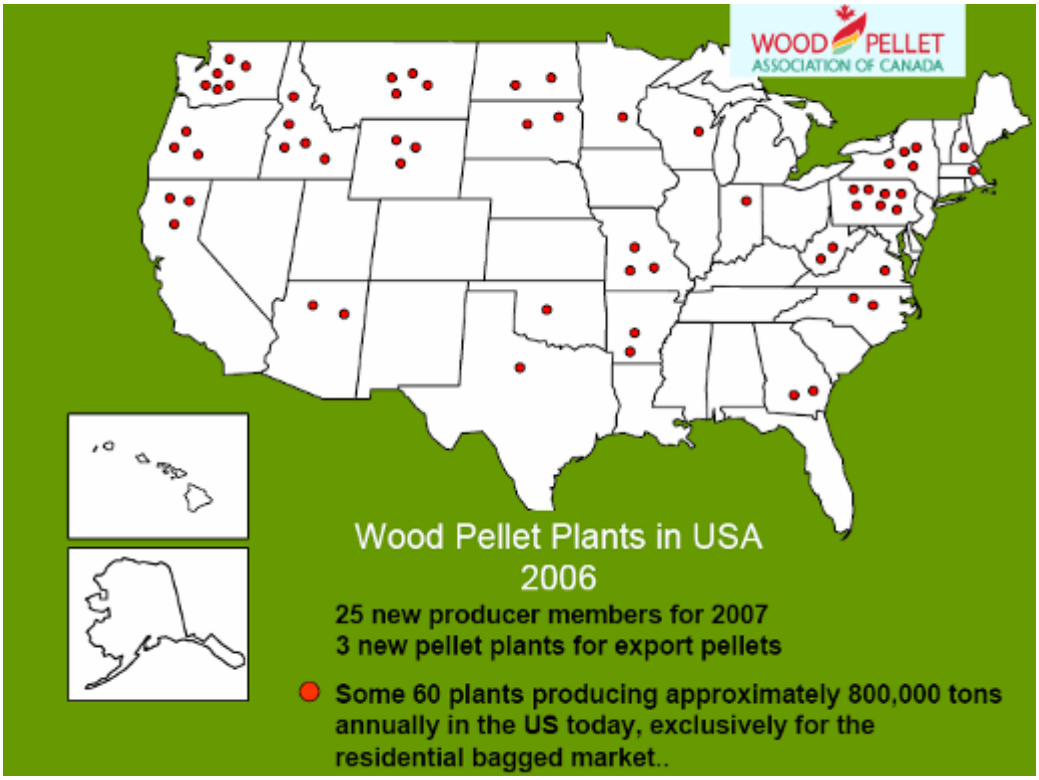


Table nr 35. Pellet plants in US (Source: Wood Pellet Association of Canada, 2006)

Pellets are available for purchase at stove dealers, nurseries, building supply stores, feed and garden supply stores, and some discount merchandisers. Pellets are usually packaged in forty pound bags and sold by the bag or by the ton (fifty bags on a shipping pallet). Some mills offer twenty pound bags for easier handling.

Green Circle Bio Energy Inc., a newly established renewable energy company is in the phase of constructing wood pellet plant in Florida. The plant has a planned production capacity of 500,000 tonnes of wood pellets, and will be the largest wood pellet plant in the world. Its production is targeted mainly for export to European Union.

5.2.2 Consumption

Wood pellets have been in use as heating fuel for more than 30 years in the much colder New England States and the Pacific Northwest. It's only recently that they have become popular in the southeastern United States.

	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
USA West	425	400	395	372	374	359	325	324	351	344
USA East	975	624	550	444	387	368	329	245	251	274
Canada	150	120	85	87	88	92	76	71	79	72
Totals,000	1550	1144	1030	903	849	819	730	640	681	690
	Projected									

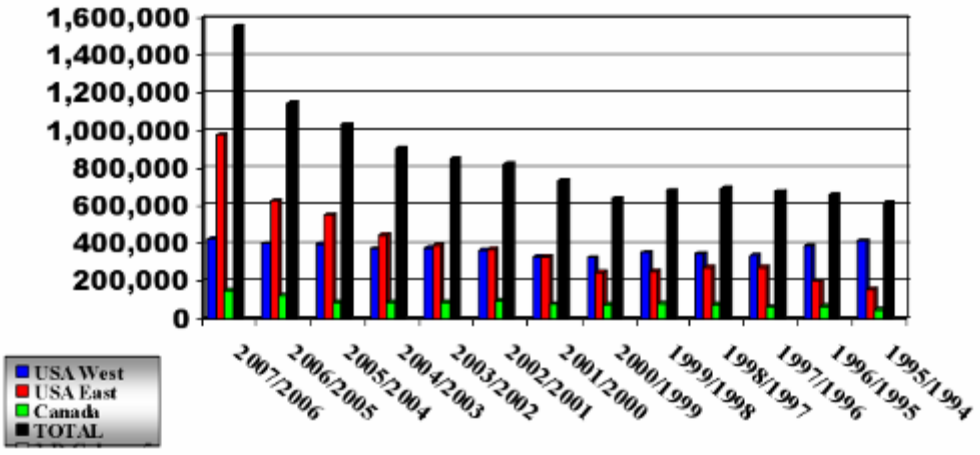


Table nr 38. North American residential pellet fuel sales. (Source: Wood Pellet Association of Canada, 2006)

This increase in popularity was made most evident western North Carolina during the winter of 2005-2006 when the soaring price of liquid propane and natural gas boosted sales of both wood pellets and pellet burning appliances. The 2005/2006 heating season saw an increase of domestic (private homes) market wood pellet sales up to 120,000,000 tonnes, this is an increase of almost 200,000 tonnes.

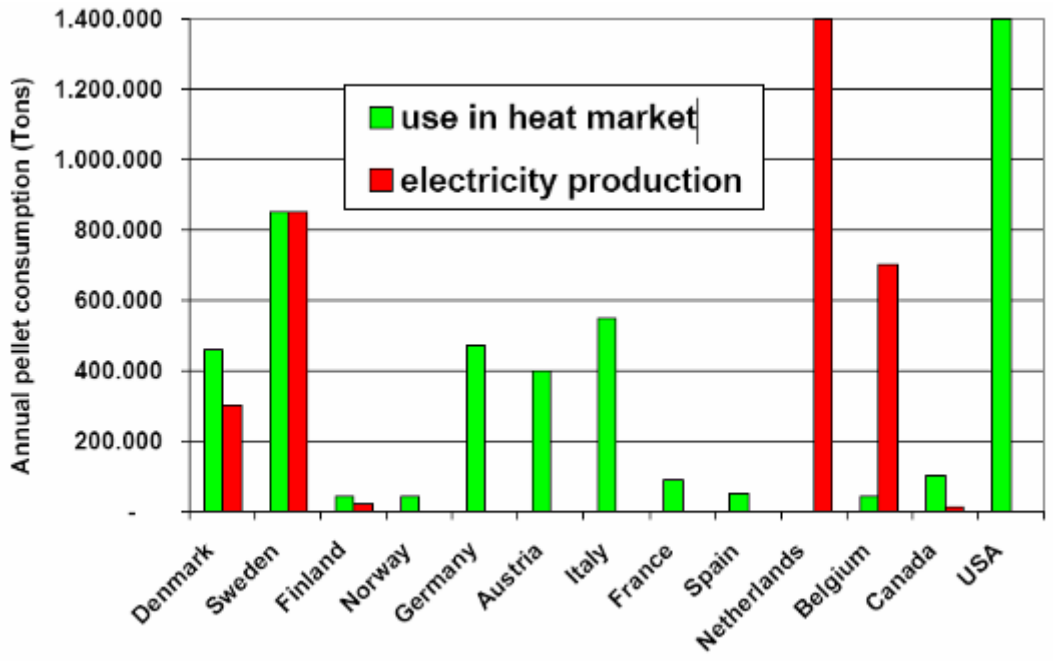


Figure nr 36. Pellets demand by sector in some European countries, Canada and USA in 2006. (Source: proPellets Austria)

Continued higher oil prices are responsible for the growth of pellets sales as private home owners in the New England States look for a more economical way to heat their homes. It's expected this market will grow by 300,000 tonnes for the 2006/2007 heating season.

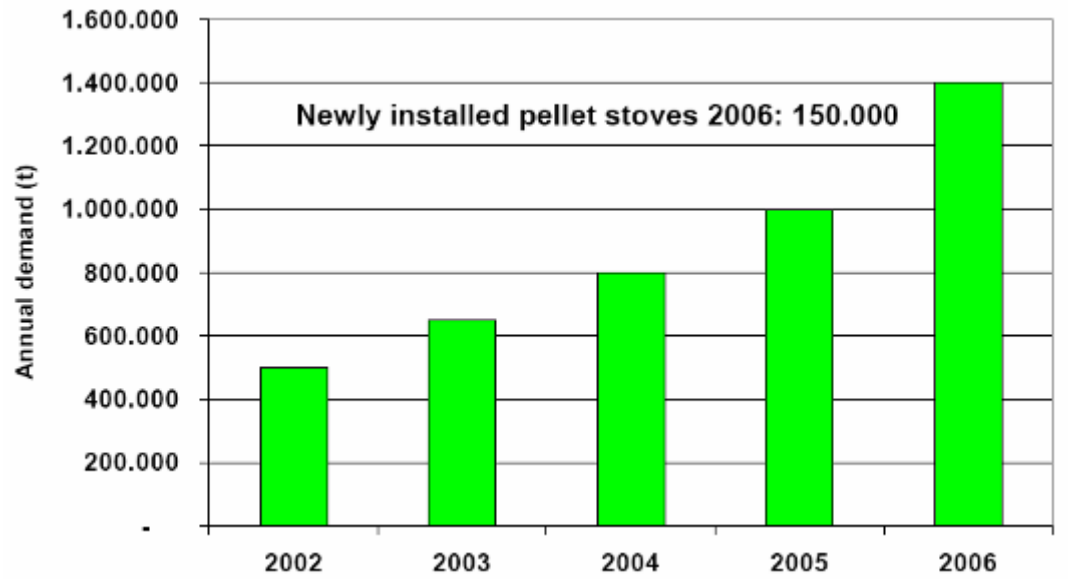


Figure nr 37. Development of pellet demand in United States (Source: Stan Eliot)

5.2.3 Import/Export of wood pellets

Growth in North America put pressure on any new pellet production capacity for the Western Canadian Producers, any extra volumes are directed towards this market rather than towards Europe.

5.2.4 Pellets quality standards

In 1995 the Pellet Fuels Institute (PFI) established national standards for residential pellet fuel (residential pellet fuel standard). This standard is only an unofficial non-binding recommendation. Fuel quality certification is the responsibility of the pellet manufacturer. Two fuel grades have been defined, premium and standard. Five fuel characteristics are prescribed in the grades. The only difference between the two grades is in the inorganic ash content. Sodium (salt) may cause unacceptable corrosion of the appliance if present in high quantities. Natural wood uncontaminated with salt will have less than 300 ppm of water soluble sodium. Certain fuel made from plywood; particleboard, some agricultural residues, paper and other materials, and wood contaminated with salt may have elevated sodium levels. Producers should identify sodium level in their guarantee analysis.
It is recommended that manufacturers label their product as meeting the PFI standard or as premium grade. They are asked to disclose various types of material (e.g. wood, paper, agricultural residues).

Differences between premium and standard grade fuel

All of the measurable characteristics defined by PFI standards are the same for both fuel grades except ash content. Standard grade pellet fuel (up to 3% ash content) is usually derived from materials which result in more residual ash, such as sawdust containing tree bark (which contains more impurities) or agricultural residues like nut hulls. Standard pellets should only be used in stoves designated for their use. Premium grade pellet fuel (less than 1% ash content) is usually produced from hardwood or softwood sawdust containing no tree bark. Ash content varies in premium fuels from about .3% in some western softwoods to about .7% in eastern hardwoods. Premium pellets, which make up over 95% of current pellet production, can generally be burned in stoves calling for either standard or premium fuel. Increased availability of standard fuel is anticipated as stove designs continue to improve ash tolerance. Ash content determines fuel grade because of its role in maintenance frequency. It is the prime factor that determines maintenance frequency of ash removal from the appliance and venting system. In early pellet stove designs, fuel compatibility was the critical factor that determined whether a stove worked well or not. Fuel grade and specific ash content within a fuel grade are still to be considered, but advances in pellet stove technology are making fuel choice wider and easier. The size of the ash drawer, fuel feed and grate design, proper venting, correct operation and maintenance all play a part in maintenance frequency. The experienced pellet stove professional is the best source of information about stove and fuel compatibility.

There are a number of variations in pellet fuels that are not included in PFI standards. For example, BTU (heat) content may range from just under 8,000 to almost 9,000 Btu, depending upon species and region of the country. Other characteristics like trace minerals in pellet raw materials vary not only from region to region, but even in close by growing areas. Some trace minerals

promote clinkering, the formation of clumps of fused ash that can block air inlets in the burn pot. A fuel's tendency to form clinkers in a stove cannot be predicted by laboratory analysis both because of variations in the raw materials and the different burning conditions that affect the process. Clinkering can increase routine maintenance, but professional recommendations for matching available fuels to stove design can minimize the problem. Pellet mills strive for consistency despite the nature of the raw material. Slight variations in fuel even from bag to bag are inevitable, but the differences are usually insignificant and much smaller than found in the original raw material before processing. Pellets consistently deliver enjoyable, predictable comfort when burned in well designed, operated, and maintained stoves.

	Premium	Standard
Diameter	6 mm to 8 mm (¼″ to 5/16″)	
Length	≤ 38 mm (1.5″)	
Density	≥ 640 kg/m^3 (≥ 40 lbs/ft^3)	
Ash Content	< 1%	< 3%
Fines (passing through an 1/8″ screen)	< 0.5% of weight	
Chlorides	< 300 part per million	

Table nr 5. North American pellet standards

5.2.5 Fuel prices

In the US, pellets are sold by the bag (40 lb), by the ton (50 bags), and by the skid (60 bags). The selling price currently ranges from $120 to $200 per ton ($2.40 to $4.00 per bag) and averages $150 per ton ($3.00 per bag). Price varies by region, availability, and season, just like other heating fuels.

Because bags of pellets stack and store easily, many prudent customers take advantage of lower off season prices and ensure their winter fuel supply by buying early. Selling price, of course, is only a part of the cost picture. The primary issue is the cost of energy, which is measured in dollars per million British thermal units. Pellets purchased at the average $150 per ton and burned in a typical pellet stove cost about $11.50 per million Btu, a figure that is less than the cost of electric heat and competitive with average energy costs of some other fuels.

6 Emerging Wood Pellet Industry and Market in Latin America and Asia

6.1 Brazil, Argentina and Chile

Regarding forests, Argentina, Brazil and Chile, comprise more than 82% of the overall Latin American sawnwood production and about 90% of the industrial round wood (FAO, 2007). Furthermore, these countries have more than 85% of the LA planted forests (FAO, 2004). Uruguay is one of the largest round wood exporters, but it has a small amount of wood processed and sawn, which results in reduced timber residues (sawdust and shavings). Paraguay has higher production of round wood and sawn wood than Uruguay, but resources come mostly from native forests (about 99%) (FAO, 2007; FAO, 2002). Therefore in this analysis the three first countries were chosen to have identified their pellet market and potential.

Pellets production is just starting in Latin America and supply of biomass residues for that purpose is not a barrier at the moment. However, the lack of industrial capacity and the logistic barriers are serious constraints.
Exports of pellets, at present, have been made for domestic uses. However, pellets costs from given Brazilian sites, according to some analysis, showed competitiveness if compared with market prices also for large scale uses in Europe.

Most aspects related to pellet production for domestic market are dependent on which substitutive energy sources are available and at which price they are. Looking at prices, logistics and tax policies, the non renewables gas and fuel oil are the main pellet's competitors. Among the renewables, wood chips, charcoal, firewood and briquettes are the most common solid biofuels employed in theses three countries, for several purposes.

Opportunity costs of wood for pulp, timber, steel/iron industries, as well as some logistic constraints, as referred in the following paragraphs, play also the role of retarding the use biomass for pellet production, mainly for the domestic market. For exports, European willing to pay, powered by concrete incentive measures, open recently opportunities for developing an export oriented/dedicated pellet production almost at the same time in Argentina Brazil and Chile.

6.1.1 Domestic Market and Opportunity Costs

Timber industry in Brazil was paying in December 2006 about 34 Euro/t for ordinary logs able to be sawn (pine and eucalypt). Wood chips market for pulp and paper production from abroad (Japan, USA) is also an attractive option for biomass. In fact, recently the largest Brazilian wood chips plant (including plantations), strategically located in the State of Amapá, was sold to the Japanese groups Marubeni Corporation and Nippon Paper Industries (CEPEA,

2007). The plant is able to produce about 1 million tonnes of wood chips per year, amount that was also sold to Europe in 2004 and 2005 for energy purposes. As of December 2006, domestic market paid 20-24 Euro/t (CIF industry) for pulp production (CEPEA, 2007). Furniture, construction and charcoal production keep wood biomass prices under competition with most of other alternative uses, as well as pulp and paper industry does. Thus, forestry and timber residues appear to be the best economical option for pellet production. Production costs for these residues at about 18.5 Euro/t referred by Dolzan & Walter (2007) are coherent with firewood average market price at 21.2 Euro/t (margin included) (CEPEA, 2007).

6.1.2 Emerging market

For all three countries considered in this report, national statistics for both energy and forestry sector do not mention pellets in their figures. Regarding the National Energy Balance, pellets, briquettes, wood chips and any other wood debris and residues are aggregated in “other renewables”, which makes impossible to identify each one. Looking at the trade statistics from the forestry sector, the NCM – Mercosul Harmonic System Code number 44013000 embraces: sawdust, wood waste and scrap, agglomerated or not in logs, briquettes, pellets or similar forms. Considering the initial phase of this sort of biomass trade, the lack of information is also motivated by the strategy of working silently demanding/buying cheaper residues and supplying/selling more profitably. Thus, in this report market identification was made from different sources gathered out of the national/official data, mostly from producers, traders and consultants.

From the information obtained, it seems that Argentina was the first LA country to export pellets. Brazil has already started this year, and Chile is doing the same along the year. In case of Brazil and Chile, as it can be observed in the Table nr 6, below, exports will be smaller than the production capacity due to the late period some plants are starting to produce along the year.

Country	Production capacity (1,000 t/yr)	Current production* (1,000 t/yr)	Domestic consumption (1,000 t/yr)	Exports* (1,000 t/yr)
Brazil	60	25	___	25
Argentina	7.2	7.2	___	7.2
Chile	80	20	___	20

* Forecasts

Table nr 6. Pellets production, consumption and exports for three LA countries in 2007 (Sources: Rosan 2007, Bertagni 2007, Campino 2007, Dominguez 2007, Solostocks 2007)

6.1.3 Trends and prices

Currently, the attractive European market of pellets for domestic use, with prices at 150-185 Euro/t as observed in the Table nr 7 below, is absorbing the small amount produced in LA, assuring net earnings despite some high logistic costs such as port tariffs, containers freight, domestic and destination handling.

However, the largest market in Europe is for bulk supply, for heat and power generation (co-firing or not), which is paying 100-120 Euro/t in average, without delivery costs (Pigaht et al, 2005). Thus, regarding European market, the trends for LA pellets, mainly from Brazil and Argentina, are towards price reduction, due to the demand for pellets being for different (large scale/non-domestic) purposes such as mention above. For Chile and other countries located at the Pacific Coast, market for pellets in Asia/Japan remains unknown, differently than the existing for wood chips/pulp production (Campino, 2007). The United States may become an option depending on the future policies for renewables. However, Canada is one of the largest pellet exporters, and it may supply US market at competitive prices. Looking at the European market, pellets from Chile will have to confront the additional freight cost distance plus the Panama Canal toll.

Country	Market	Pellets use	Price (CIF)	Trends
Brazil (a)	Europe / Italy	Domestic (15kg bags)	185 E/t (container)	Price reduction
Argentina (b)	Europe / Italy	Domestic (15kg bags)	150-180 E/t (container)	Price reduction
Chile (c)	Asia / Japan /USA	n/a	n/a	n/a

Table nr 7. Pellets market destination, use, prices and trends for three LA countries in 2007 (Sources: Rosan 2007, Bertagni 2007, Campino 2007, Dominguez 2007, Solostocks 2007)

6.1.4 Brazil: logistic barriers and pellets competitiveness

6.1.4.1 Logistic barriers

Transportation

A considerable amount of planted forests in Brazil is presently located at places were freight is quite expensive up to maritime ports, mainly because of the high cost of transporting biomass by trucks. Values may increase about 150% on the biomass price (FOB) in some places, three times the maritime value from the Brazilian coast to Europe. Fluvial transport may be a solution for the Northern and Center-Western region due the existence of several rivers (Madeira, Tapajós, Amazonas, Xingu, Araguaia) appropriated for this purpose. For the North-Eastern and South-Eastern (Parnaíba, São Francisco, Doce, Tietê) regions fluvial transport should be mixed with railway as the main alternatives. For all those regions, crops transport has already started through a multi-modal way, in which one, connections are made by trucks. Increasing biomass density through pellet and briquettes production may be an alternative to reduce costs of transportation for some cases but it depends on an appropriate cost-benefit analysis.

Average participation of biomass cost component as percentage from the production place to the Rotterdam port accounts 78% (truck + maritime), for traditional sites under the existing logistics, against 65% (truck+train+fluvial) if an ideal logistic configuration is considered. For the potential/expansion sites, logistic costs account 91% (truck + maritime) under the existing logistics, against 81% (truck+train+fluvial) if an ideal logistic configuration is considered.

Most of such sites have F1higher distances than the traditional ones, which it will require logistic infrastructure improvement to reach competitive costs.

Ports

Brazil is highly privileged in terms of places for structuring. However, most of the existing ports are public and their services are both expensive (outstanding tariffs) and inefficient (there are some exceptions). In addition they are not equipped for fast carrying of wood pellets or chips which have both low aggregated value. To solve this problem, private ports located at strategic places and conveniently equipped with belt-carriers have been used for wood chips exports. A least three big companies for both energy and pulp purposes have their own ports (Amcel – AM, Aracruz -ES and Tanac - RS). These companies have presented highly competitive prices at outstanding levels if ordinary freights and port taxes are taken into account. Also, higher aggregated value products such as pellets, high density briquettes and packed charcoal for residential uses, may confront higher logistic prices such as shipping through containers.

6.1.4.2 Pellets Competitiveness

Regarding the potential of pellet production, it is necessary also to assess whether the availability at a given place is going to provide competitiveness due to its logistic costs, at least in the short term. For that, seventeen (17) production sites were analysed by Dolzan & Walter (2007). From the total, 6 are traditional producers of wood biomass and 11 present potential for either expand or begin to be it. Overall costs, biomass plus production and transportation up to the Rotterdam port, were compared with Dutch market prices.

Transportation costs

Considering biomass marketable prices in The Netherlands, and the possibility of an ideal multimodal logistic composition, just the Amapá showed to be competitive for pellets regarding the traditional sites. For the potential/expansion sites, Minas Gerais, Piauí, Maranhão, Pará, Tocantins, Mato Grosso and Roraima have presented competitive costs. Regarding wood chips, no one has shown competitiveness. Overall transportation costs found ranged from 65% to 91% compared to the production cost.

Production costs

As wood chips are not competitive in any scenario, installation of pellets plants close to biomass production may be the first step in order to achieve competitiveness (prices and standards) regarding co-firing consumers. Costs ranged from 4.0 to 16.6 Euro/GJ against biomass market prices in Rotterdam

from 3.05 (wood chips) to 6.5 (pellets) Euro/GJ (see Figures 2 and 3 below) (Junginger & Faaij, 2005).

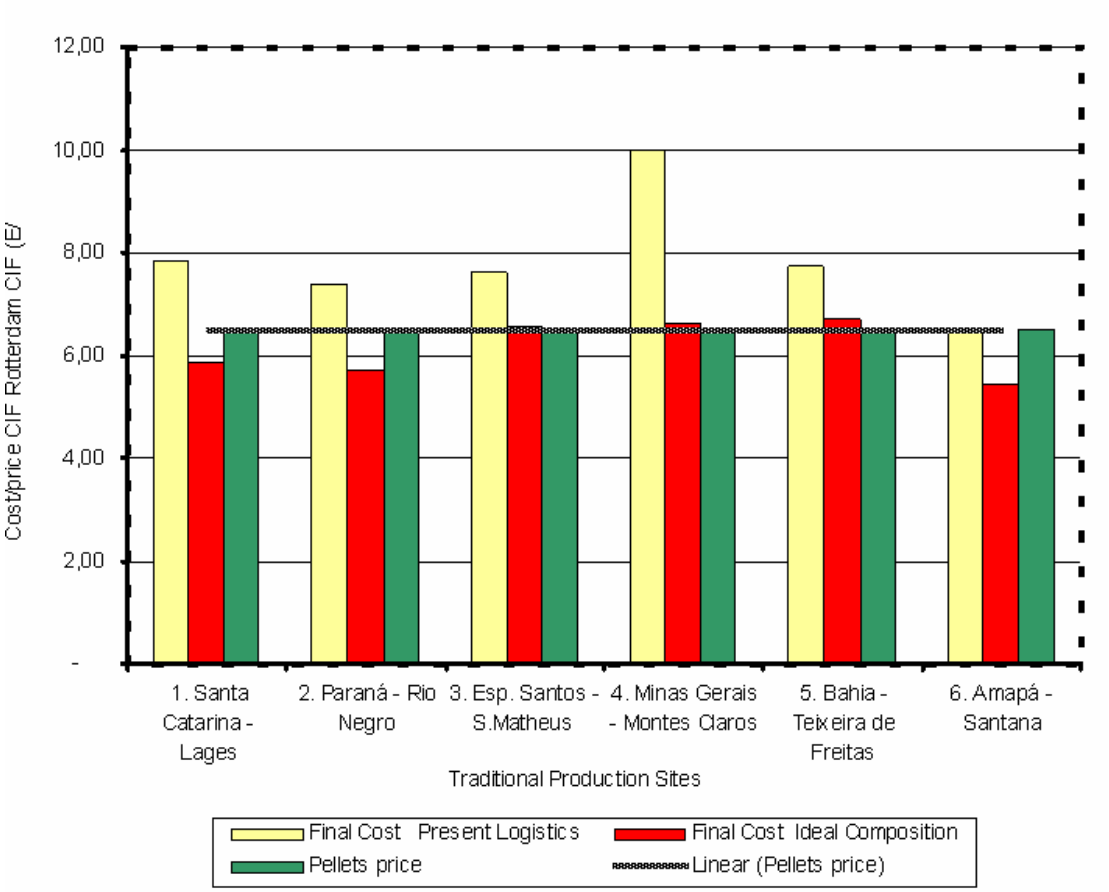


Figure nr 39. Pellets' prices transported from traditional production sites in Brazil up to the Rotterdam (Euro/GJ) for 2006 (source: Dolzan & Walter, 2007)

Logistic barriers costs

Overall logistic costs found ranged from 65% to 91% in relation to the wood chips production cost as referred above. Looking at differences between the existing transportation costs and those ones from the ideal logistic composition scenario, figures of 1.69 E/GJ higher costs for traditional sites and 3.27 E/GJ for the potential ones confirm the importance of removing those barriers. The average barrier cost found in relation to the entire pellet biomass cost was: 21,6% (1.69 Euro/GJ) for traditional and 35.75% (3.7 E/GJ) for the potential sites.

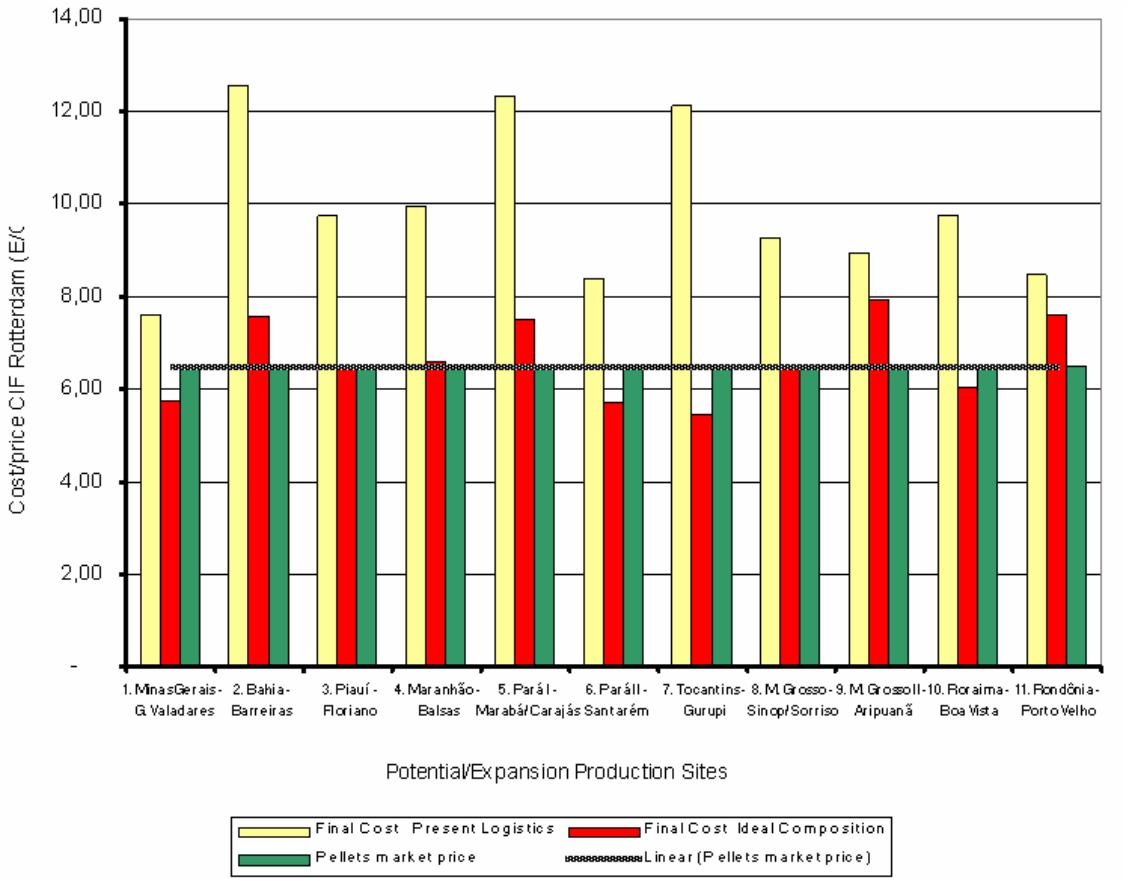


Figure nr 40. Pellets' prices transported from potential production sites in Brazil up to the Rotterdam (Euro/GJ) for 2006 (source: Dolzan & Walter, 2007)

6.2 China

China plans for renewables to meet 10% of total energy consumption by 2020, and has extensive biomass resources with the special focus of the agricultural residues. In general, the potential biomass resources to be used in this country includes wood waste and straw, and feed grain that is now too old to use. China plans to produce 50 million tonnes of pellets by 2020. Chinese government has declared that 50 combined heat and power stations are to be built using straw pellets as fuel.

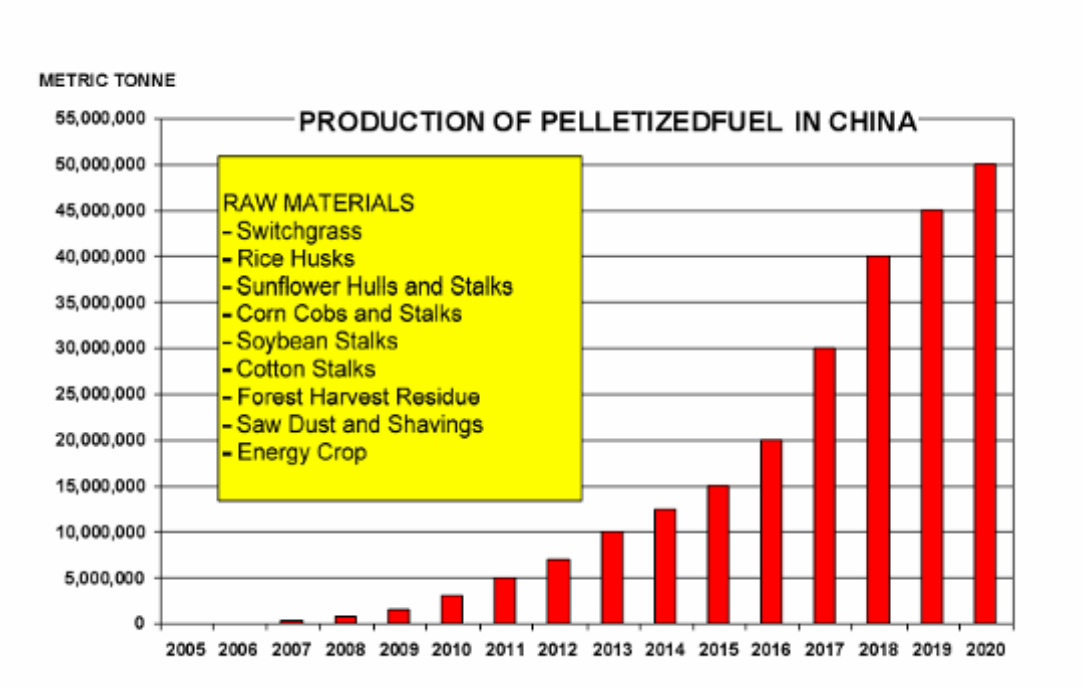


Figure nr 41. Estimation of future pellets production in China

China has been steadily introducing wood-pellet production technology, and all the equipments can mostly be manufactured domestically now. The production cost is much lower than that of abroad. The price is comparable with low calorific value electricity coal. However, the wood-pellet industry is still at its preliminary stage, but China plans to produce 50 million tonnes of pellets by 2020. Following Chinese experts analysis, potential market for wood pellets is described below.

6.2.1 Potential markets

Urban Market

Chinese urban residents normally get their energy from LPG and electricity. People are used to clean energies but the prices have been up-going continually and they are pushing the limits of people's affordability. Winter heating is especially a difficult problem, and wood-pellet furnace can suit this purpose well. The fuel cost is low and it's a clean and environmental friendly energy in a real sense. From Above analysis we can see the unit energy price is the lowest among all kinds of energies. But due to its particular nature, special furnace must be equipped.

Up till now, some of the manufacturers imported and exploited some European styled Wood-pellet heating stove. Because of the complicated structure and high price the suitable price of a wood-pellet heating stove for a common family is from 8000 to 20000 Yuan/stove. Price for homemade wood-pellet stove is from 3500 to 5500 Yuan/stove. The output of homemade ones is limited and can't meet the needs of practical use in large scale.
In the initial stages of market exploration this will be a big burden. So the large scale industrialization and generalization is hard to achieve in a short period of time. It only suits some superior high environmental demand consumers to replace electronic air-conditioner or make up heating shortage in winter at present.

Rural market

The rural Chinese residents use coal as their main energy source, some areas even still keep the old tradition of burning firewood and grass to cook. For the former, to substitute wood-pellet for coal must first change the old ovens to special wood-pellet oven, this cost of adding a new oven is at about 600~800 Yuan/unit. This cost isn't much in more developed area, but inflict a huge burden on the poor areas. For the latter, the firewood and grass cost almost nothing, and using wood-pellet and buying a new oven inflict double burdens.
After changing to wood-pellet, running cost is about the same as using coal. As before, a dedicated oven must be used. A production line with annual output of 15,000 ton wood-pellet would require a manufacturing base for dedicated ovens as well to consume all the produced wood-pellet fuel. To calculate using the same methods, we can get that to produce 10,274 units of ovens and investment of 4.77 million Yuan is required; together with the investment for wood-pellet production line, which is 5.22 million Yuan, the total investment would be 9.99 million.

Industrial (Heating) Boiler Market

Coal is the biggest part of China's energy consumption, accounting for 65.6% of the total energy consumption (1.482 billion tones) in 2002, among which, 217.3014 million tonnes were used in industrial manufacturing, 53.3836 million tonnes in heating, 468. 5714 million tonnes in power generation, accounting for 14.59%, 3.60%, and 31.61% of the total consumption respectively. Industrial and heating boilers together had consumed 269.685 million tonnes.
The boilers still in service can be classified by their usage as industrial steam boilers, thermal-electricity industrial boilers, centralized heating and hot water boilers, civil household boilers, special purpose boilers(hot wind, heat conducting oil), and extra heat boilers, etc. Classified by combustion form, the layer combustion boiler takes the majority. In big-size boilers, Cycle Flow Boiler (CFB)s are gradually replacing the Stratum Burnt Boiler (SBB) s. According to the mechanisms of these two types of boilers, wood-pellet fit them well in terms of fuel size and calorific value requirement. The most commonly used boilers in

industries are chain-style boilers, circular-style boilers and coal boilers, which all have high requirement for fuel size.
Wood-pellet burning does not introduce SO2, so the de-sulfuring cost can be eliminated too. Even though wood-pellet is more expensive than coal for the same amount of heat generated, this reduction alone can cover the cost difference. There is no extra cost to buy special boilers, the only cost would be to set up the wood-pellet production line, the investment risk is lower than in other markets.

Thermo-boiler Market

Nearly half of the coal consumption (48.02% in 2002) has been consumed on thermo-boilers. The fuel supply experiences seasonal shortage. In recent period the wood-pellet output is not so much. It cannot meet the large scale needs of power stations. But it has some market entry points in some small sized power stations or self-prepared company thermo-boilers. Small sized power boiler mainly uses Cycle Flow Boiler boilers.

6.3 India

In a country like India, biomass holds considerable promise as 540 million tonnes of crop and plantation residues are produced every year, a large portion of which is either wasted, or used inefficiently. Conservative estimates indicate that even with the present utilization pattern of these residues and by using only the surplus biomass materials, estimated at about 150 million tonnes, about 17,000 MW of distributed power could be generated.

6.4 Japan

Three general types of biomass are relevant for the supply of Japanese biomass market. The first is biomass from waste sources. Approximately 305 million tonnes on a wet basis (56 million tonnes on a dry basis) are produced from these sources, the equivalent of 930 PJ of energy produced. While these sources are the most abundant type, they are inefficient for use in energy producing purposes because of high moisture content. However, food waste and wood-based construction waste are easily collectable and transportable, making them economical for use in energy or other production processes.

The second type is unused biomass sources that result from harvesting raw materials. Approximately 16 million tonnes on a wet basis (12 million on a dry basis) are produced annually, which have an energy equivalency of 210 PJ. While these sources offer significant potential as efficient feedstock for biomass technologies, the cost of transporting them to processing facilities makes them uneconomical for large-scale productive uses. They do offer some potential use for small-scale recycling and energy production uses.

NYK Global Bulk Corporation, a wholly owned subsidiary of NYK, has signed a long-term contract with Kansai Electric Power Co. Inc. (KEPCO) to transport wood pellets from Canada. Some 60,000 tonnes of wood pellets will be shipped annually for five years from Prince Rupert in the Canadian province of British

Columbia to Maizuru in Japans Kyoto prefecture for delivery to the utility company. The contract will start in 2008.

The multiyear contract is the first of its kind in Japan. Demand for biomass fuels, including wood pellets, has grown steadily in recent years as a countermeasure to environmental problems such as global warming.

6.5 Korea

Recently, Korea opened its first biomass power plant. The plant uses 145 tonnes of wood chips and pellets daily to generate 52 tonnes of steam and 50 kW of electricity an hour. Korea has an estimated four million tonnes of leftover wood chips, equivalent to 1.6 million tonnes of oil.

6.6 New Zealand

Bioenergy provides a real alternative to fossil fuels for many applications. New Zealand's geography and climate have placed it at the forefront of countries internationally for the production of food and fibre. This same natural advantage has a prime role in making New Zealand internationally competitive in bioenergy production of many forms.
The annual production of woody biomass residues from plantation forestry alone is estimated to be between 4 and 6 million tonnes. At an energy value of 9MJ/kg this biomass quantity equates to around 45TJ, roughly equivalent to 10 per cent of New Zealand's total consumer energy demand.

Pellets burners are relatively new in New Zealand, but they could become a major force in New Zealand home heating. There is significant amount of wood-waste from timber-processing industries.
There are now 5 pellet plants throughout the New Zealand. Total national production capacity is around 100,000 tonnes per year, but in 2006 production was around 20,000 tonnes. There is still room for the growth in the industry.

Pellets can be obtained in New Zealand from some hardware chains and home-heating shops. Bulk delivery can be arranged by calling the hotline 0800 PELLET. Prices vary from 8.75$ to 12$ per 20kg bag, depending on delivery distance.

Draft AUS/NZ Standard 4014.6

Length	*max. 38 mm*
Diameter	*max. 10 mm*
Calorific Value	*18 – 21 MJ/kg*
Density	*not specified*
Piled Weight	*min. 640 kg/m3*
Water Content	*max 8%*
Ash Content	*max. 0.5%*
Abrasion	*not specified*
Sulphur content	*not specified*
Nitrogen Content	*not specified*
Chlorine Content	*not specified*
Pressing additives	*none*

7 Forest biomass resources and wood use in forest industry

Wood pellets can technically be manufactured from almost all kinds of wood materials. Until recently, wood pellet manufacturing has been based on the forest industry's by-products, the major raw materials being dry and fine-grained by-products from the carpentry industry, and sawdust. The aim of this section is to give an overview of forest biomass resources and their use in the forest industry at a global level and to consider the transformation of round wood into forest products and by-products within the forest industry.

7.1 An overview on forest biomass resources and mechanical wood processing

Forest biomass is the major raw material of the forest industry and has an important role as a source of bioenergy. It has been estimated that there are 3 870 Mha of forest worldwide. Forest covers 30% of the earth's land area, of which about 95% are natural forests and 5% are plantations. Tropical and subtropical forests comprise 61% of the world's forests, while temperate and boreal forests account for 38%. The average area of forest and wooded land per inhabitant varies regionally. The area varies between 6.6 ha in Oceania, 0.2 ha in Asia and 1.4 ha in Europe. The world's total above ground biomass in forests is 420 000 Mt. The worldwide average above-ground woody biomass is 109 tonnes/ha. Brazil (114 000 Mt), Russia (47 000 Mt) and USA (24 000 Mt) have the largest biomass resources in their forests. The location of forest resources indicates that the potential for wood utilisation varies from country to country (Figure nr 42) (FAO, 2003).

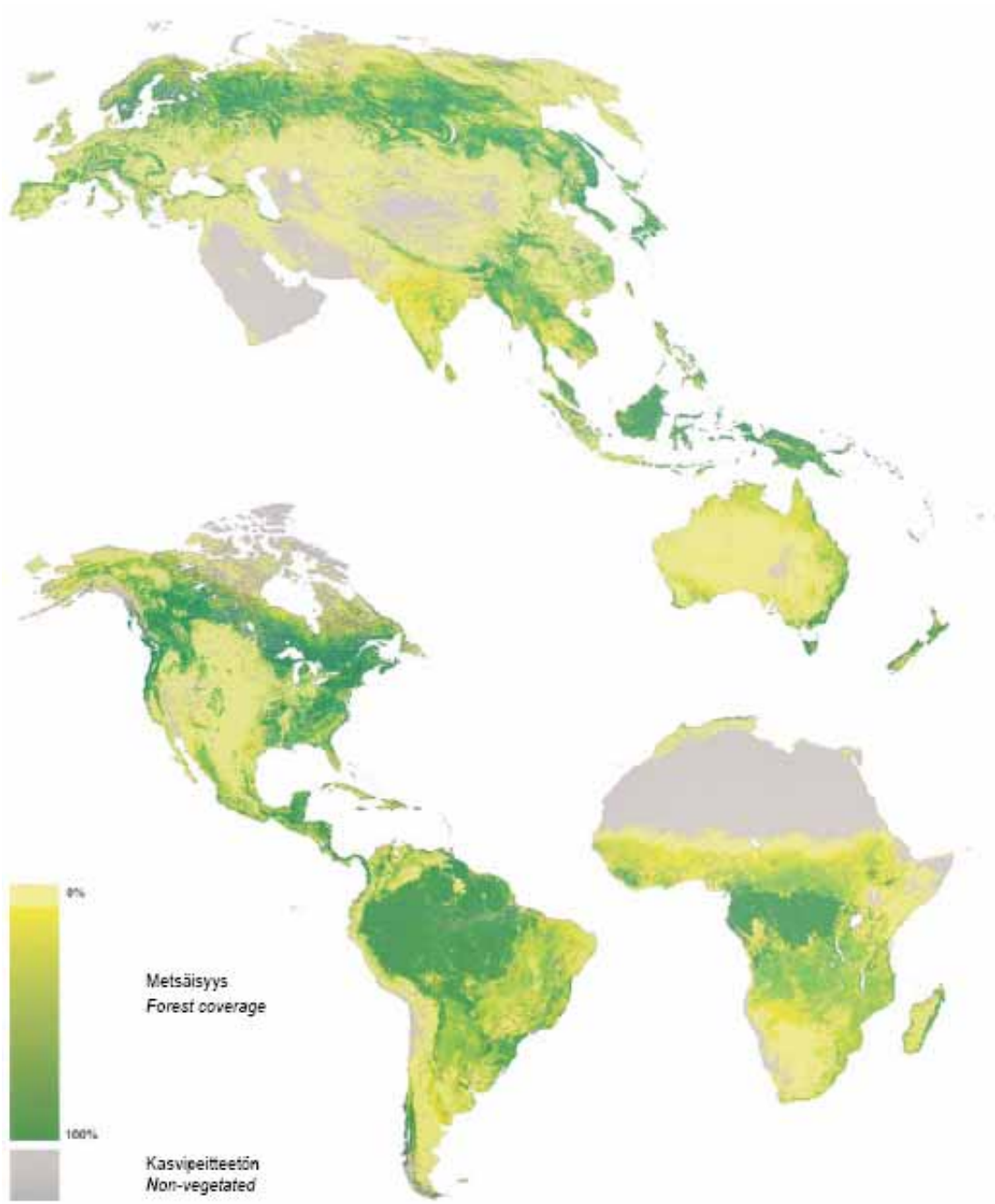


Figure nr 42. Global forests cover, % (Source: Finnish Forest Research Institute, 2005).

The current rate of the utilisation of forest resources varies between the world regions. Deforestation, poor forest management and overuse of wood resources are serious problems in several areas, but on the other hand, in many parts of the word the sustainable utilisation of forest resources can be increased. Estimates by FAO show that the global production of industrial round wood and wood fuel reached a total of 3 350 Mm3 in 2000 (FAO, 2003). As much as 53% of this was wood fuel and about 90% of wood fuel is currently produced and consumed in developing countries (IEA, 2004). In the statistics of FAO, industrial round wood is classified into three different groups – saw logs

and vaneer logs, pulpwood, and other industrial round wood. In 2004, the total consumption of industrial round wood was as follows[4] (FAOSTAT, 2006):

- Saw logs and vaneer logs 992 Mm3
- Pulpwood 505 Mm3
- Other industrial round wood 146 Mm3
- In total 1 643 Mm3

Logs are mainly used as raw material in the manufacturing of sawn timber and plywood, whereas smaller diameter pulp wood is consumed in wood pulp production. For pellet manufacturing from sawdust, sawmills are the major sources of raw material. Furthermore, plywood mills generate sawdust and similar fractions as by-products that are potential raw material of pellets. A review of the production of logs, sawn timber and plywood gives a preliminary view on global sawdust resources from the forest industry (Tables 8 and 9). North & Central America and Europe are the largest consumers of logs and producers of sawn timber, and the USA, Canada and Russia are the largest producers of sawn timber.

Continent	Production of industrial round wood [Mm³]	Production of logs [Mm³]	Production of sawn timber [Mm³]	Production of plywood [Mm³]
Africa	70	27	9	0.7
Asia	229	150	72	38.5
Europe	504	284	138	6.9
North & Central America	628	425	159	17.5
Oceania	48	24	9	0.7
South America	164	83	35	3.8
World	1,643	992	422	68.1

Table nr 8. World production of industrial round wood, logs, saw timber and plywood by continents in 2004. (Source: FAOSTAT, 2006)

[4] Figures do not include bark.

Production of logs [Mm³]		Production of sawn timber [Mm³]		Production of plywood [Mm³]	
1.	248.0 USA	1.	USA 93.1	1.	China 21.0
2.	167.1 Canada	2.	Canada 61.0	2.	USA 14.8
3.	Russia 67.9	3.	Russia 21.4	3.	Malaysia 5.0
4.	Brazil 54.9	4.	Brazil 21.2	4.	Indonesia 4.5
5.	China 52.2	5.	Germany 19.5	5.	Japan 3.1
6.	Sweden 35.4	6.	India 17.5	6.	Brazil 2.9
7.	Germany 32.2	7.	Sweden 16.9	7.	Canada 2.3
8.	Indonesia 26.0	8.	Japan 13.6	8.	Russia 2.2
9.	Finland 24.3	9.	Finland 13.5	9.	India 1.9
10.	Malaysia 22.0	10.	China 11.3	10.	Finland 1.4
11.	France 19.9	11.	Austria 11.1	11.	Taiwan 0.8
12.	India 18.4	12.	France 9.8	12.	South-Korea 0.8
13.	Chile 15.9	13.	Chile 8.0	13.	Chile 0.5
14.	Poland 13.0	14.	Turkey 6.2	14.	Italy 0.5
15.	Australia 12.2	15.	Malaysia 5.6	15.	France 0.4

Table nr 9. World top 15 countries in the production of logs, sawn timber and plywood in 2004. (Source: FAOSTAT, 2006)

Figure nr 43 presents the trend of world's consumption of logs and production of sawn timber and plywood in 1985-2004. There have not been remarkable changes during the reviewed period in the production of sawn timber and plywood. Considering the sawn timber production at country level between 1990 and 2004 the most remarkable increases in the annual production have realised in Canada (10.5 Mm³), India (9.6 Mm³), China (4.9 Mm³) and Germany (3.2 Mm³). On the other hand, in some of the largest countries in sawn timber production the annual production has declined from 1990 to 2004, examples are Japan (- 3.5 Mm³) and Brazil (-1.9 Mm³).

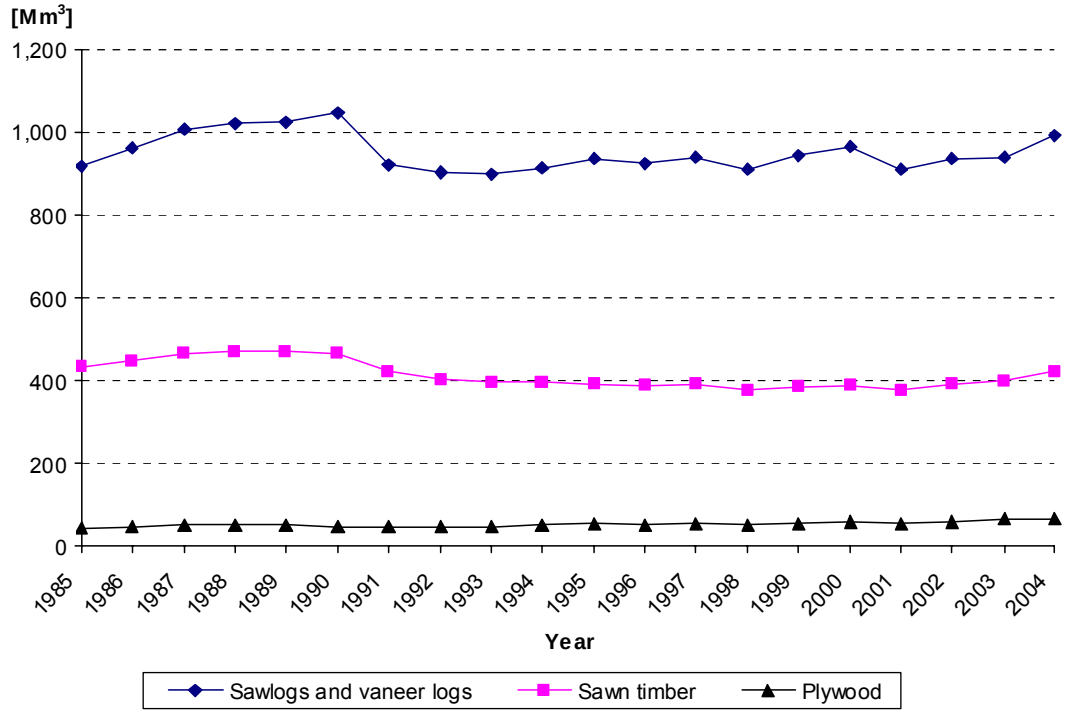


Figure nr 43. The consumption of logs and the production of sawn timber and plywood in 1985-2004. The volumes of round wood are without bark. (Source: FAOSTAT, 2006)

Particle board and fibreboard mills utilise byproducts from sawmills and plywood mills as raw material. The world's largest producers of particle board and fibreboard are depicted in Table nr 10.

Production of particle board [Mm³]			Production of fibreboard [Mm³]		
1.	USA	21.8	1.	China, Mainland	15.3
2.	Canada	11.3	2.	USA	7.5
3.	Germany	10.6	3.	Germany	5.1
4.	China, Mainland	6.4	4.	Canada	2.1
5.	France	4.4	5.	Poland	1.9
6.	Poland	4.1	6.	Korea, Republic of	1.6
7.	Italy	3.7	7.	France	1.3
8.	Russian Federation	3.6	8.	Spain	1.3
9.	Spain	3.2	9.	Malaysia	1.2
10.	Turkey	2.7	10.	Russian Federation	1.2
11.	United Kingdom	2.7	11.	Italy	1.1
12.	Austria	2.4	12.	Turkey	1.0
13.	Belgium	2.2	13.	Brazil	1.0
14.	Brazil	1.8	14.	Japan	0.9
15.	Japan	1.2	15.	New Zealand	0.9
	World	97.5		World	52.9

Table nr 10. World TOP 15 countries in the production of particle board and fibreboard. (Source: FAOSTAT, 2006)

7.2 Use of wood as raw material and energy in forest industry

In addition to round wood, some of the by-products – pulp chips and sawdust – are important raw materials for the forest industry[5]. The raw material use of these by-products improves the efficiency of wood conversion into products. On average, 40-60% of round wood can be converted into forest products in the forest industry – the rest is remaining by-products such as black liquor, bark, sawdust and chips that have no feasible raw material use within the forest industry. The conversion efficiency varies between the production processes of different products, and also the level of technology applied and the integration of the production processes affect the conversion efficiency. Mechanical wood processing can convert wooden raw material into products more efficiently than chemical pulp making, for instance.

7.2.1 Solid forest industry's by-products

The majority of the solid by-product fuels in the forest industry consist of bark. The bark content of round wood is 10-22% of the total volume of unbarked wood, depending on tree size and species (FAO, 1990). There is no proper market for bark as a raw material within the forest industry.

Sawmilling produces large quantities of by-products, which are well suitable raw material for other processes within the industry. Pulp chips equal pulpwood as a raw material in pulp making and are the most important by-product of sawmills in many regions. E.g. in Finland, the sales of pulp chips to pulp mills improves the economic situation of sawmills because pulp mills pay a higher price for pulp chips than energy producers. The other by-product that pulp mills can use as raw material is sawdust, but its quality as raw material is lower compared with pulpwood. Instead, sawdust is an important raw material for particle board and fibreboard mills. Plywood mills produce bark, peeler cores, sawdust, veneer chippings, panel trim and sander dust as by-products. From these, sawdust and sander dust can easily be exploited in wood pellet manufacturing. The market situation of forest industry by-products varies strongly between regions.

Figure nr 44 presents the material and energy balances of a typical Scandinavian sawmill per one cubic metre of dried sawn timber. Usually, a part of the by-products (bark and sawdust) is utilised in heat production for timber drying at sawmills, and the excess is sold as fuel to other heating and power plants or pellet production. In many cases, a sawmill is located on the same site with paper and pulp mills, forming a forest industry integrate which allows the efficient utilisation of raw material. In such cases, sawmill by-product fuels are utilised inside the integrate for heat and power production.

[5] Recovered fibres (recycled paper products) have become an important raw material for the forest industry. However, they are not considered in this study. In 2004, the total production of recycled paper in the world was 159 Mt (FAOSTAT 2006).

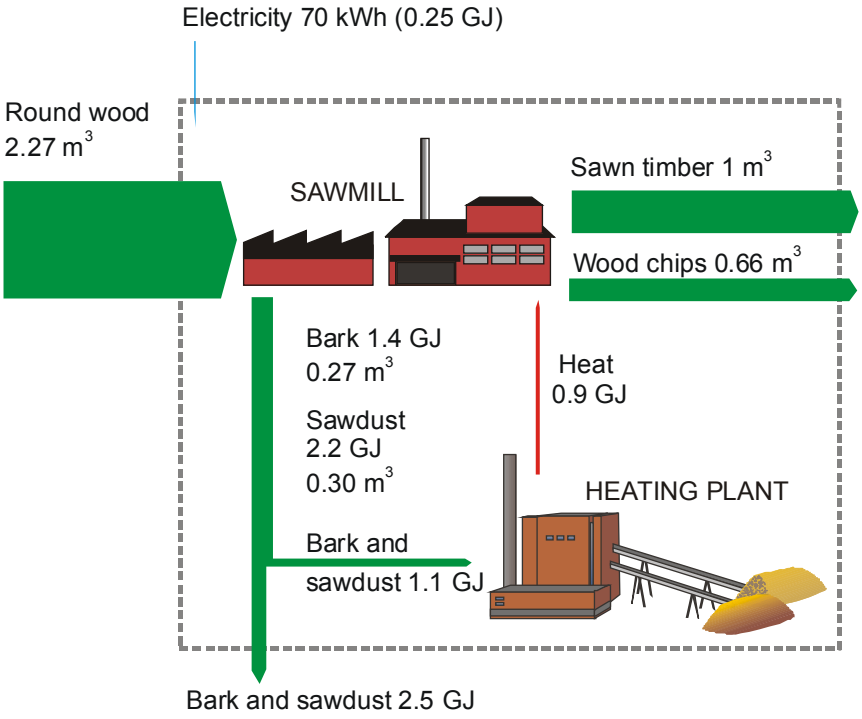


Figure nr 44. Material and energy balances of a typical sawmill for 1 m³ of dried sawn timber. (Source: Heinimö and Jäppinen, 2005)

7.2.2 Liquid forest industry's by-products (black liquor)

Black liquor is the most important by-product in energy production at forest industry mills. Energy production from black liquor is a solid part of the chemical pulping process. The wood material consists of two primary components: cellulose and lignin, approximately half and half. Lignin is a kind of glue that holds wood fibres together. In the chemical pulping process, a chipped wood material is cooked in a lye solution, which dissolves the lignin and leaves behind the cellulose. The cooking solution consists of cooking chemicals, and the lignin is burned in a recovery boiler for gathering the cooking chemicals and for utilising the energy of the dissolved wood material.

7.2.3 By-products in energy production

Generally, forest biomass has been a marginal source of energy in industrial applications, but in some countries with a large forest industry sector, such as Sweden, Finland and Austria, forest biomass has remarkable importance. In Finland, for instance, renewable energy sources cover approximately 25% of the total primary energy consumption, and over 80% of renewable energy is derived from wood. Nearly 80% of wood energy is generated from the processing residues of the forest industry (Statistics Finland, 2005). Figure nr 45 illustrates wood streams in the Finnish forest industry as an example. In the

year 2004, the Finnish forest industry was able to convert approximately 60% of the total raw wood consumption into products.

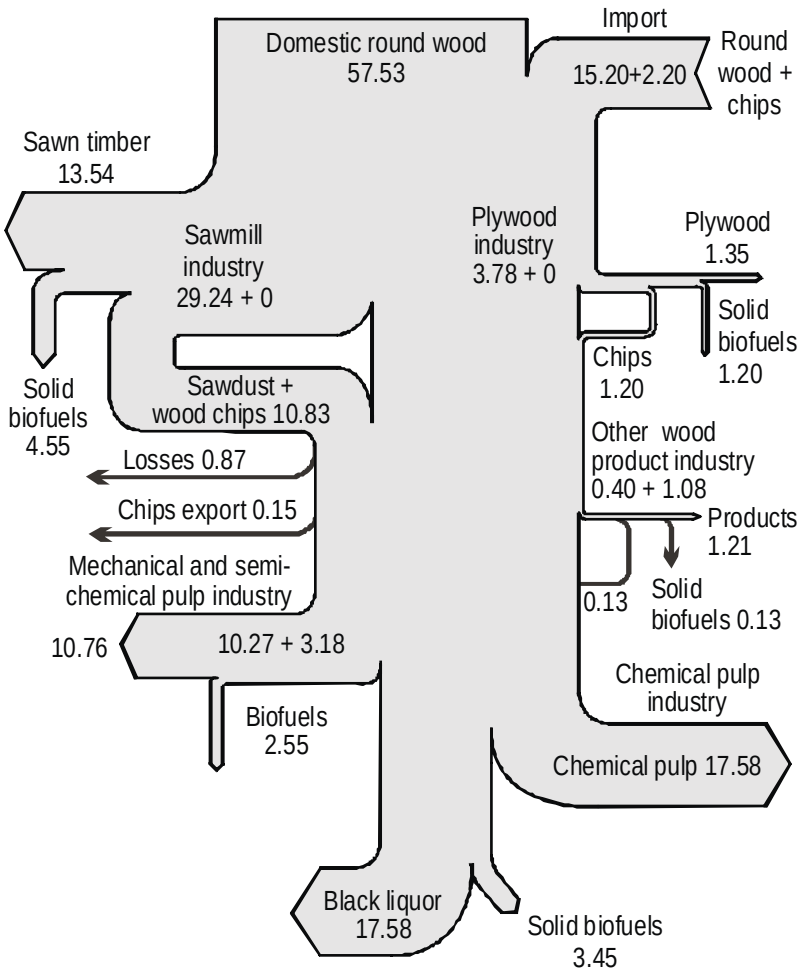


Figure nr 45. Wood streams in the Finnish forest industry in 2004,Mm³. Round wood includes bark, million m³. Particle board and fibreboard mills were included in the other wood products industry. (Source: Heinimö, 2006).

Worldwide, and especially in industrialised countries, the by-products of the forest industry are one of the major sources of bioenergy. A preliminary calculation showed the total volume of by-products of the forest industry to be 700-1 100 Mm3/a (equalling 5.3-8.0 EJ[6]). In comparison, the total use of bioenergy in industrialised countries was estimated at 15 EJ in 2002 by IEA (IEA, 2004).

[6] The initial data and assumptions of the calculation were: the conversion factor of round wood into by-products 40-60%, the total use of industrial round wood 1 600 Mm^3/a (excluding bark), average bark content 12%, average calorific value of wood 7.2 MJ/m^3.

7.3 Forestry/timber residues – Brazilian case

7.3.1 Raw material for pellet production

According to FAO (2007), Latin American countries have produced/used in 2004 about 237 million cubic meters (Mm³) of wood fuel, 169 Mm³ of industrial roundwood and 37 Mm³ of sawnwood. Data from Mexico are included in the North American group. Argentina, Brazil and Chile, according to the same source, have produced about 150 Mm³ (88.5%) of industrial roundwood and 31 Mm³ (82.7%) of sawnwood. On that amount of wood, several parameters may be applied for timber and field residues calculations. Results presented in the section 6.2 for example, account for 2004 the net amount of 18.6 Mm³ for Brazil. Following this approach, a Brazilian exercise is described below.

7.3.2 Brazilian assessment: methodology and results

Values of wood slashes from planted forests and saw mill residues were obtained taking into account: source of wood (place and species); final uses (pulp/paper, timber, steel); sustainability aspects (social, legal, environmental), and individual growth trends. It is important to mention that the need for nutrient cycling was considered in this report.
Calculations of residues able to be used were made through compilation of a series of data (inputs) obtained as listed in Table nr 11, from which were obtained the present amount of residues (outputs) in million of cubic meters (Mm³) and in million tonnes (Mt). Results were obtained using the Equation 1 below:

Equation nr 1: Quantity of forestry field/timber residues in volume (Source: Dolzan & Walter, 2005)

$$QRv = (VTc \cdot io)\,[((ibr + ibk)\,if\text{-}1\,) + (\,it \cdot ism \cdot 10\text{-}4)]$$

In which: QRv = Quantity of Residue in volume (Mm³); VTc = Volume Total consumed by the sub-sector (Mm³); io = index of participation for each forestry origin (%); ibr = index of participation of branches on the total field biomass (%); ibk = index of participation of barks on the total field biomass (%); it = index of participation of the trunks on the total field biomass (%); ism = index of participation of saw mill residues obtained during the logs mechanical process (%).

Description	Particip.	Demand	Growth	Wood	Residues (2004) b			Total Res (2004)	
	(%) a	(Mm3) a	(%)	Logs	Branchs	Barks	Saw	(Mm3)	(Mt)
Sub-sector			a				Mill c	(Eq.1)	d
1. Pulp and Paper		**45**	5.0				4	**10.6**	**9.0**
Pinus	36%		3.0	65	8	12		**5.0**	**4.2**
Eucaliptus	64%		6.5	81.5	7.6	8.2		**5.6**	**4.7**
2. Charcoal		**45**	0.0					**11.5**	**9.8**
Eucaliptus	74%		2.5	81.5	7.6	8.2		**6.5**	**5.5**
Native Forest	26%		7.5	41	7.6 e	10		**5.0**	**4.3**
3. Sawn wood		**65**						**76.6**	**65.1**
Pinus	27%		5.0	65	8	12	31.5	**9.0**	**7.6**
Eucaliptus	4%		5.0	81.5	7.6	8.2	35.3	**1.3**	**1.1**
Native Forest	69%		3.0	41	45	10	33,5	**66.3**	**56.4**
4. Plywood		**7**	5.0					**6.9**	**5.9**
Pinus	50%		5.0	65	8	12	29.5	**1.7**	**1.5**
Native Forest	50%		5,0	41	45	10	31.5	**5.1**	**4.4**
5. Wood Panels		**10**	10.0					**4.2**	**3.5**
Pinus	70%		0.0	65	8	12	19	**3.0**	**2.6**
Eucaliptus	30%		16.5	81.5	7.6	8.2	22.8	**1.1**	**1.0**
6. Industrial uses		**45**							
Demand Sub-total		**217**							
7. Non-industrial uses g		**103**							
Residential - energy		**33**							
Others - com+agr		**9**							
Others - wood constr		**61**							
Demand - Total Amount		**320**	**Residues - Total Amount**					**109.7**	**93.2**

Notes and Sources:

a) Values from Bracelpa, SDS, SBS, IBGE e ABIMCI in BRDE [2] and updated to 2004

b) Wood and residues: percentual values for pinus in White & Plaskett [12], eucalipto in Vital et al. [13], and native forest in Caldeira et al. [14]

c) Sawmill residues: Couto et al. [8]

d) Green state density: 0,85 t/m3

e) Charcoal forestry residues considered partially; branch percentual reduced from 42% to 7,6%, simulating fraction of diametre >0,2m and < 0,1m which do not go to the oven

f) Industrial Uses : residues not considered

g) Other non-industrial uses also not considered

Table nr 11: Wood demand values (Mm³) by products, by sector, and their related production of residues as a percentage of participation in volume and weight in Brazil for 2004 (source: Dolzan & Walter, 2005)Latin America case study

7.3.3 Brazilian figures: discussion

Results related to the forestry sector, such as annual planted and harvested areas, demand and supply, were projected from 2004 up to 2020. The annual gross/production found for 2004 of 320 Mm³ is coherent with FAO (2007) and IBGE (2006) figures of about 295 Mm³ for the same year. Non-formal agricultural and domestic production/uses seem to be the reason for differences.

Results along the time were compared each other, as well as the potential of forestry residues. The likely potential for field and saw mill residues seemed to be enough to displace industrial firewood as well as other energetic uses, such as residential, agricultural, commercial, and also to generate surplus. For gross supply it was estimated a forestry residue potential of 93.2 Mt for 2004, and 272.8 Mt for 2020. For the worst situation, a surplus of 17.4 Mt (0.15 EJ) for

2004; this value corresponds to 20.5 Mm³, that is in line with 18.6 Mm³, presented in the session 6.2. Projections found for 2020 were 172.6 Mt (1.45 EJ) for the best situation. Figure nr 46 below shows an intermediate scenario for bio-energy from wood residues.

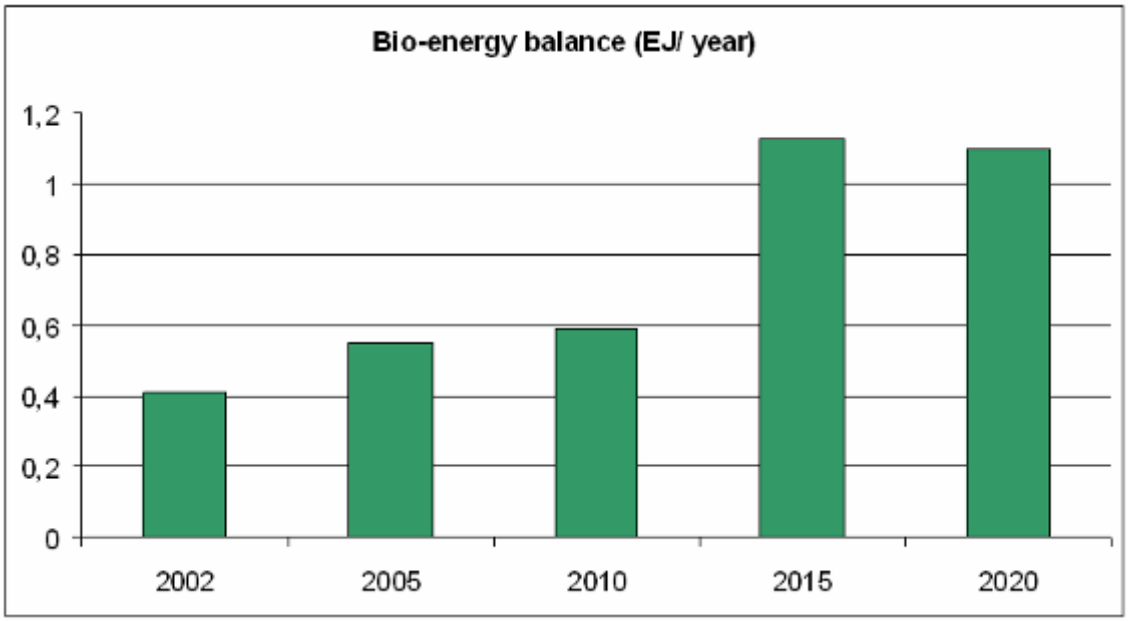


Figure nr 46: Production of energy from forestry (field/timber) residues considering an average supply/demand scenario in Brazil for 2004 (Source: Dolzan & Walter 2005)

8 Evaluation of the global raw-material potential for wood pellets from sawdust

8.1 Modelling the wood streams of forest industry at country level

An Excel based spreadsheet model was composed to investigate the wood streams of the forest industry at the country level and to identify the countries that have the largest sawdust resources for energy purposes. The main idea of the model is to evaluate the excess volumes of the forest industry's solid by-products, taking the raw material use of by-products in the forest industry into account. The model uses country-specific data on the production of industrial round wood and forest products and the trade of raw wood as the initial data. In this case, the data was obtained from the forestry data base of FAO. The conversion factors of bark free wood into forest products and by-products were sourced from literature (FAO, 1990). The structure of the model and the conversion factors applied are depicted below (Figure nr 47). The model uses universal conversion factors over the world regions and countries.

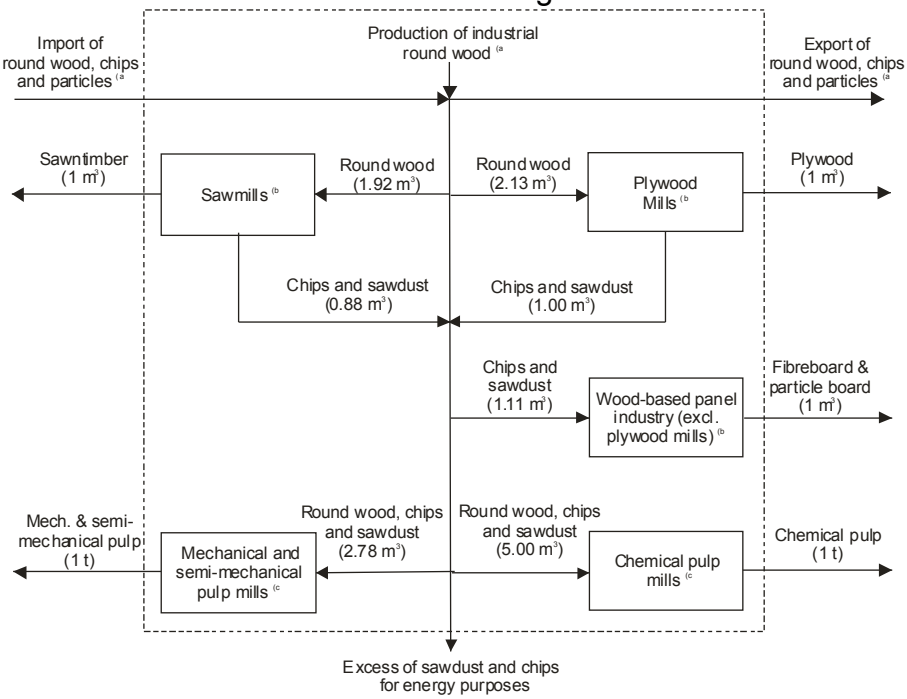


Figure nr 47. Illustration of the wood stream model and its main parameters. All wood streams presented are without bark.

[a Net consumption of raw wood was calculated as follows: Production of industrial round wood – production of other industrial round wood – export of industrial round wood + import of industrial round wood- export of chips + import of chips

[b Conversion factors were from (FAO, 1990).

[c The pulp yield form wood were assumed to be 50% for chemical pulp and 90% for mechanical and semi-mechanical pulps. 1 ton of pulp was assumed to equal 2.5 m³ wood.

By means of the model, the total global volume of by-products (excluding bark) from sawmills and plywood mills was estimated at 400 Mm3/a. Approximately 70% of the total volume consists of wood chips that can be used regarding its quality as raw material in pulp manufacturing. The total volume of sawdust from sawn timber production was estimated at 120-130 Mm3, which equals 50-60 Mt of wood pellets[7]. However, the prevailing use of by-products should be taken into account in the consideration of the availability of by-products for energy purposes. The countries with the largest production of sawn timber have not automatically the best availability or the largest excess of sawdust or other by-products.

8.2 Sawdust excess from forest industry

The largest producers of by-products are presented in Figure nr 48. The USA is by far the largest producer of by-products from mechanical wood processing and it produces over one fifth of the by-products under review.

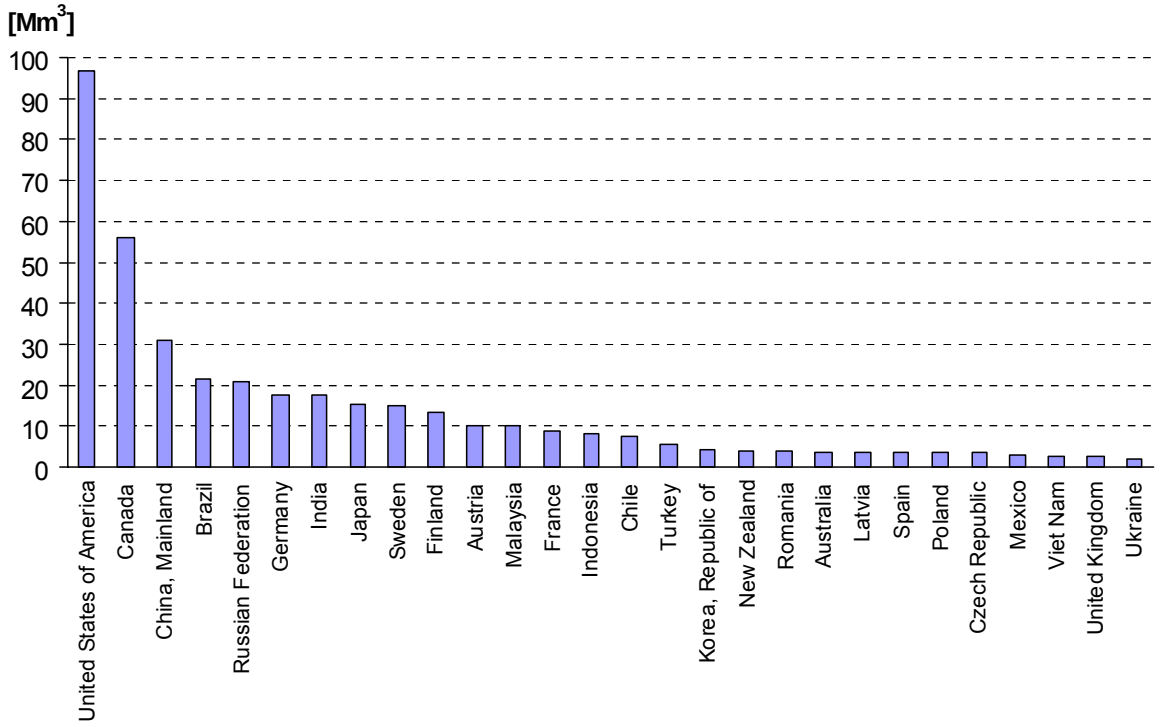


Figure nr 48. The largest producers of by-products from sawmills and plywood mills. Bark is excluded from the volumes. The global total volume is 440 Mm³.

In the next phase, the demand for raw the material of particle board and fibreboard mills was subtracted from the total volume of by-products (Figure nr 49). The USA, Canada and Germany are the largest producers of particle board, and China, the USA and Germany are the leading countries in the production of fibreboard (Table 10). The calculations showed that the demand for raw material of the particle board and fibreboard industry exceeds the

[7] The density of the wood matter of pellets was assumed at 450 kg/m^3.

theoretical volume of by-products in Spain, the UK and Poland. The potential reasons for that could be the import of raw materials of the wood panel industry or that the actual conversion of wood into products at sawmills and plywood mills is less efficient than the model assumed.

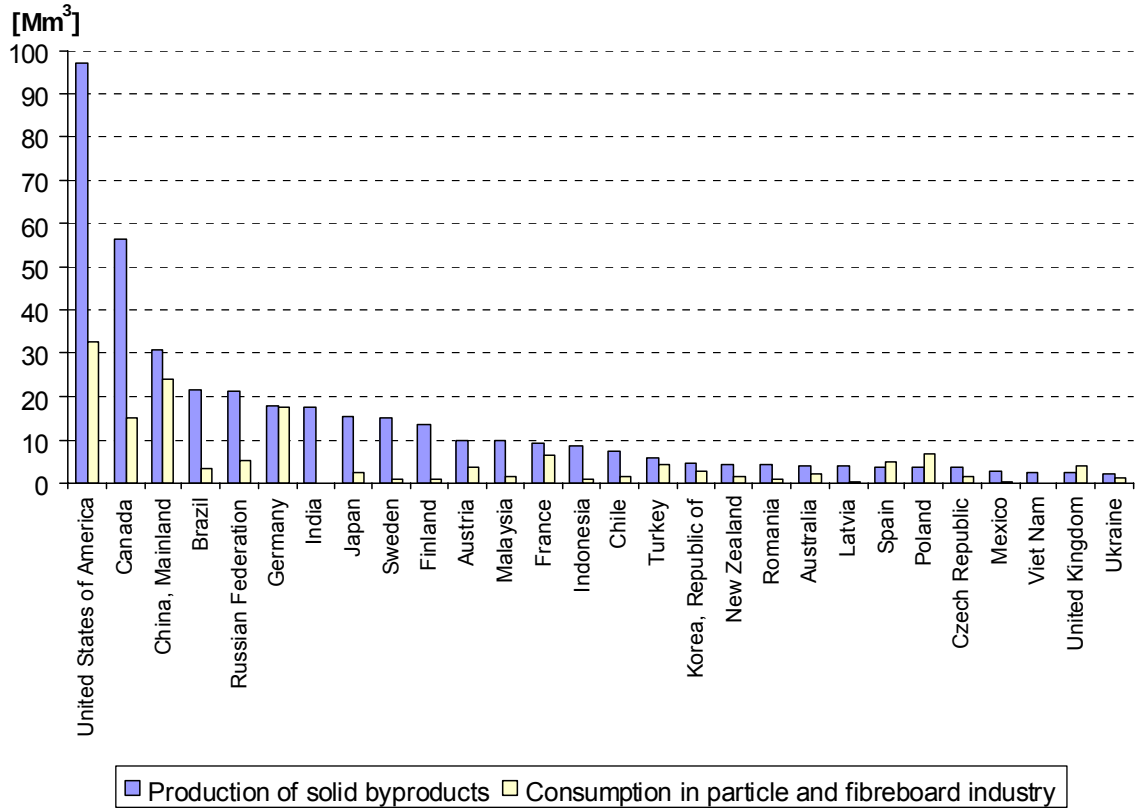


Figure nr 49. Comparison of the production of solid by-products in sawmill and plywood industry and the demand for raw material in particle board and fibreboard industry.

As mentioned previously, a total of about 70% of bark free by-products from sawmills and plywood mills are suitable raw material for pulp manufacturing. Figure nr 50 shows the theoretical excess of by-products in various countries after the by-products have been allocated over the forest industry according to the calculated demand. The countries are presented in the figure according to the theoretical surplus of solid by-products. The USA, Canada, Finland, Sweden, Japan, Brazil and Russia are the world's largest producers of wood pulp, and in these countries, the pulp industry is the most important user of by-products from mechanical wood processing, but from the previously mentioned countries Brazil, Russia and Canada seem to produce an excess of by-products that could be utilised for other purposes.

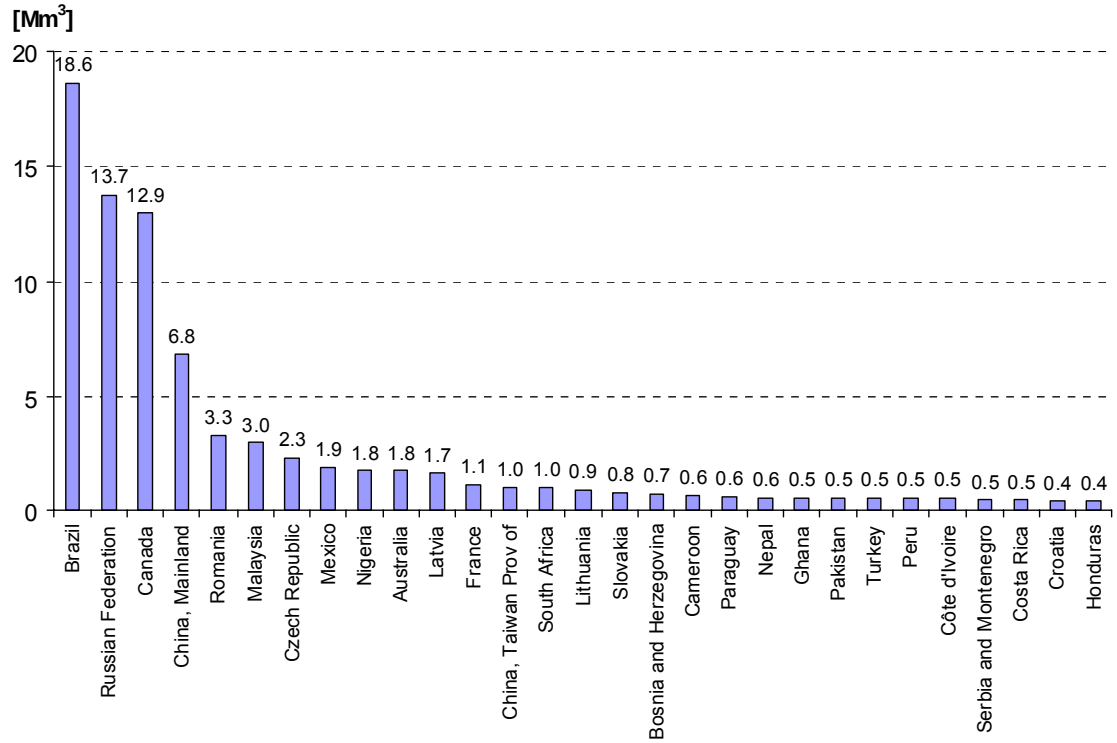


Figure nr 50. The countries having the largest theoretical excess of solid by-products from mechanical wood processing industry when the calculative raw material demand within the forest industry was subtracted from the total volume of by-products.

When interpreting the results, one should bear in mind that the calculations have been made by means of a model using universal conversion factors for wood into forest products and by-products. Furthermore, the present situation of the local utilisation of by-products was excluded from the scope of this study. Basically, the areas with sawmills but no local demand for by-products as a raw material or as a fuel are the most favourable for constructing new wood pellet production capacity, and feasible options for wood pellet production can also be found in countries that are not mentioned in Figure nr 50. Furthermore, several other factors, such as the market of biofuels and logistics, have an effect on the feasibility of utilising by-products for pellet production. It is clear that country specific studies will be needed for getting more comprehensive figures about the commercial possibilities of wood pellet production.

9 Discussion and Conclusions

Feedstock for energy, pulp and paper or other applications. In chapter 8 on the global raw-material potential for wood pellets from sawdust, both the gross theoretical potential of sawdust was presented, as was the 'net potential' after the fibre demand for raw material in particle board and fibreboard industry was subtracted. While even this net potential shows significant volumes of available sawdust (especially in Brazil, Canada and Russia), it should be clear that this does not imply that the particle board and fibreboard industry always will get priority over the feedstock. Already nowadays, in many regions, sawdust commands a higher price for energy application, and thus also parts of the gross potential may well be utilized for energy purposes. On the other hand, we do remark that various other factors also determine the net market potential, e.g. the logistics, investment climate for new pellet plants and local policy support.

Data and market information. Wood pellets markets are in an exponential growth. However, due to the emerging nature of that industry, information on the production, consumption and trade remain very fragmented. As there is no international standard method for collecting market information data, and no standard form is used by wood pellets industries to report their production, the information frequently varies from source to source. Therefore some inconsistencies may appear and comparisons exercises even though very valuable must be done with a great care. The data presented in this report includes wood pellets production, consumption, standards, prices, raw material for pellets production. Furthermore, some brief information on emerging markets is given with indication of their potential to contribute to the global wood pellet market.

Finally, statistics on trade of pellets for most of the countries investigated do not exist. This problem is currently investigated further by IEA Bioenergy Task 40, and also applies to other bioenergy carriers. In this report, where possible, the approximate numbers are given and indicated. In the remaining cases, only the origin of import or the target countries of export could be indicated.

Recommendations for further research

- *Concrete policy initiatives driving demand.* As a resource assessment, this study mainly analyzed "raw material push" issues, but also drivers in various countries pulling demand have been discussed. We note that for a detailed demand analysis, various levels of policy drivers can be distinguished such as 1) "policy statements", (2) institutions development, and (3) concrete incentive measures, incl. budget allocations. The USA, Canada, UK, most new EU members and Japan could be seen as examples of cases where the policy statements have not been accompanied by (swift) mechanism for implementation, creating disappointment, planning vacuum, lost opportunities, etc. A further investigation which concrete incentive measure currently drive pellet demand is recommended for the future
- *Other raw materials.* In this review, the raw material supply was limited to residues from the forest industry (saw dust, shavings, etc.). However,

wood pellets can of course be manufactured from all types of woody material, including round wood and trees. In fact, several market actors have announced that they will build several new pellet plants, which will base their production on these latter sources, as they are expected to be more secure, and in some case even cheaper than sawdust. Moreover, the global raw material base will be wider. Increasingly, market parties (especially large-scale users) are experimenting with pellets using straw, coffee husks, wheat husks and other agricultural residues as feedstock for pellets. Thus, we conclude that the resources assessed in this study are likely an underestimation of all technically available feedstocks. A further investigation into the suitability and availability of these other feedstocks is recommended.

Conclusions

Worldwide, wood pellets markets display an exponential growth. Wood pellet markets are opening up in many countries, such as currently in Canada and Eastern Europe, and it can be expected that this will continue in new markets. The sawdust availability study shows large potentials in e.g. Brazil and Russia. Areas with sawmills but no local demand for by-products (as a raw-material or as fuel) can offer interesting opportunities for constructing new wood pellet production capacity, though local logistics, investment climate and support policies also play vital roles in mobilizing new markets.

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11 Annex

New Agro-pellets Technology

By Dr. Giuliano Grassi

There is a general consensus that the deployment of bio-energy on a global scale will bring many significant energy-security environmental, socio-economic benefits. Biomass is a sleeping giant, however as far as the vast potential offered by cellulosic biomass conversion and utilisation is concerned, variation in the entire production system for biofuels supply (feedstocks production, pre-treatment, conversion, utilisation) will have to take into account the differences in local available resources potential, priority needs and economies, country by country. The new "**Agro-pellets technology**" is a basic pre-treatment technology, for stabilisation of humid biomasses to eliminate its bio-degradation and for increasing its specific energy content. Taking into account its innovative performances, its high energy efficiency and relative low cost**, this new technology is opening wide (short-medium term) perspectives for large-scale modern exploitation of all types of cellulosic biomasses** (agro-forestry residues, organic wastes, energy crops) and for all sectorial energy markets (heat, power, transport) and some basic chemicals markets (Bio-H2, Bio-methanol etc.).

To understand the importance of this new technology and its impact on future modern bioenergy activities the following fundamental related issues must be considered :

- **How large is the future biomass potential that could benefit from this technology?**
  EU potential: ~ 600 MTOE/y
  World potential: 5,600 MTOE/y

- **Why humid biomasses need to be dried?**
  At harvesting most of biomasses have a moisture content of ~ 50% and are thus submitted to biological degradation with G.H.G. emissions. Processing humid biomass into Agro-pellets, its specific energy content is increased from ~ 2,000 Kcal/kg to ~ 4,000 Kcal/kg (consuming ~ 600 Kcal/kg).

- **Why biomass needs to be compacted?**
  Loose biomass has a low volumetric density (~ 150 Kg/m^3). Agro-pellets, having a bulk density of ~ 0.7 t/m^3, reduce drastically the transport, storage, logistics costs, especially for large scale supply.

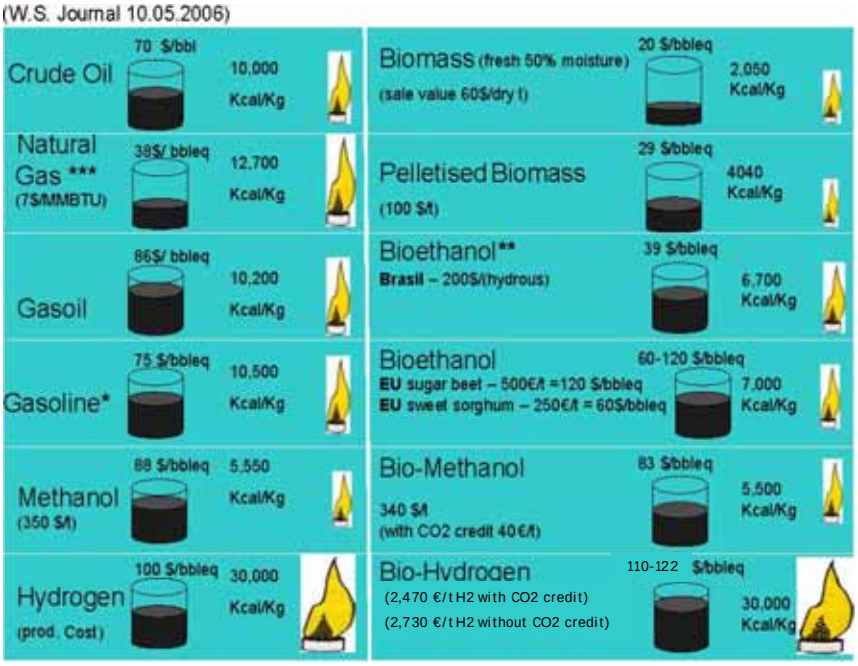
- **Why the supply of biomass to a processing/utilisation plant must have homogeneous chemical-physical characteristics?**
  This is a basic condition for stable operation of a plant. Because the new technology is able to manufacture Agro-pellets from any mixture of biomasses, the possibility to homogenising the final product and to arrange the elemental composition of A-P (by biomass blending) make easier the correct functioning of a conversion/utilisation plant. In particular to limit the chlorine, alkali-metals content.

In table here below the most peculiar characteristics are summarised:

CHARACTERISTICS OF THE NEW AGRO-PELLETS TECHNOLOGY	
I.	Capacity Range: 1-2-3-4-5-7-10 t/hr;
II.	Plant Area (for equipment, 3 days storage, operation): • for 1 t/hr unit: ~ 500 m^2 • for 5 t/hr unit: ~ 1500 m^2 • for 10 t/hr unit: ~ 2500-3000 m^2
III.	Total weight of the pelletizer: • for 1 t/hr unit: ~ 7.5 ton • for 5 t/hr unit: ~ 20 ton (15 t mono-black + 5 t separated equipment). Special lifting system needed for 15 t. For a 5 t/hr plant, a total number of 10 trucks are required, with an average transportation cost of ~ 1 €/t x km in the EU.
IV.	Biomass Pre-treatment: chipping machine + grinding unit to reduce the particles size to ~ 1 mm^3 are enclosed.
V.	Life of the plant (expected): ≥ 10 years. The recovery of the investment is covered by an operating period of 4 - 5 years.
VI.	Plant Guarantee: 2 years (EC certification is now available.
VII.	Dies Maintenance. With present utilised material (special steel) the average continuous time operation of dials is 4 ÷ 6 months, depending of the feedstock. This dies replacement can be considered as a consumable for the processing with an incidence of ~ 2.7 €/t pellets produced. In future, new high erosion resistant materials could be adopted, to reduce the substitution rate.
VIII.	Total Maintenance Cost: ~ 4% of the pelletisation investment per year.
IX.	Delivery Time: ~ 6 months for the largest units;
X.	Components Replacement, Services and Assistance: can be provided within 24 hr in case of urgency.
XI.	10 days of training for local plant operators is considered sufficient.

From the following Figure it can be verified which types of Biofuels in the EU can now compete with world-price conventional fuels. It appears thus that agro-pellets can penetrate the large heat production market, the green power market (in particular by co-firing), the gasoline/gasoil markets by bioethanol produced from sweet-sorghum approaching the competitiveness level of Brazilian bioethanol from sugar-cane. Biohydrogen and Biomethanol-coproduction could compete just now with CO2-credits with that one derived from Natural Gas.

Hydrocarbons Quotation **Biofuels production cost**



***** The industrial cost of Gasoline in the EU is 0,55 $/l and 0,584 €/li for Gas-oil. **1 bbleg = 0.135 TOE**

** Hydrous Bioethanol in Brazil is now (March 2006) traded at ~500$/$m^3$. At world level trading is ~650 $/ m^3 but the Brazilian Government keeps the price of anhydrous ethanol at the pump (blending) below 490 $/ m^3. The actual hydrous ETOH production cost is ~8$/GJ.

***One bbl (oil equivalent) of Natural Gas=166,6 Nm^3 (0.71 Kg/ Nm^3).

This new “Agro-pellets” technology may produce a global and large impact on policy issues.

POLICY ISSUES
• **increased security in energy supply** in a very long term : ~ 600 MTOE/y for the EU and ~ 5.6 billion TOE/y (world-wide); • **Agro-forestry activities** (diversified production) and promotion of a new process of rural development (supplementary income for a large number of farmers and for the huge market of biomass resources); • **Socio-economy and employment** (new, diversified, numerous jobs, especially in rural areas for the younger generation (≤ 500 d. t biomass per year/one job); • **General environment** (CO2 - SO2) mitigation, and decreased of pollution in congested urban areas by the use of biofuels; • Possibilities to process all type of biomasses and **mixtures** (without the need of binding compounds) thus offering the way also to **change the micro-element composition** of Agro-pellets to reduce (in combustion) corrosion particular emissions and the cost for their control (i.e. S, Cl, N, K, Na, ashes); • The **penetration of all sectorial energy markets** (heat, power, transport); Carbon credits will accelerate their deployments • Enlarged/increased **industrial competitiveness** (especially of SME, major actors of decentralised energy production); • **International cooperation** (transfer of technology, joint-venture, international trade infrastructure, international standards for Agro-pellets and for different markets, focalised common R&D and demonstration projects, education and training programmes, carbon-trading, clean development mechanical, etc.);

- **Many related policies issues** (environmental premium, energy supply planning, impact on agriculture, socio-economic, finances, international trading, education, etc.);
- **Support measures** (carbon-credits, social-credits, green-certificates, support of investment, etc.).