Woodpellets
in Europe

State of the Art • Technologies • Activities • Markets

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ABSTRACT

As part of the Thermie B project DIS2043/98-AT (DGXVII) „Industrial network on wood pellets – from the production to the marketing of a comfortable biomass fuel“, project partners from Sweden, Norway, Germany and Austria have been supporting and encourageing the market penetration of this relatively new biogenic energy source. Thanks to the varied composition of the project team, which included practitioners, researchers and consultants, and the exchange of information and collaboration with key national players, it was possible to deal with this wide-ranging theme in depth and to launch specific activities aimed at increasing the market share of pellet technology.

The term „pellet technology“ is used here and throughout the project in an extended sense to include all of the aspects that need to be taken into account in the marketing of this renewable energy source. It comprises the manufacture and development of pellets and heating systems, marketing, sales and service, and the various local conditions that apply. The topic also called for the integration of technical, economic, logistical and environmental aspects. The main geographical focuses were Sweden, Germany and Austria where the pellet markets are most highly developed, and Norway, which, because of its proximity to Sweden and the raw material potential, has considerable promise. These countries play a pioneering role in the pellet sector and provide stimulus for neighbouring countries.

The project had two complementary focuses:

1) An analysis of the state of the art in pellet technology (in the sense mentioned above) in the participating countries with particular reference to market potential, technical and non-technical obstacles and strategies for improving market penetration. The method included an evaluation of written documents, questionnaires (end users, heating system manufacturers, suppliers and pellet manufacturers), personal interviews and roundtable discussions with key players, and discussion within the project group. The study also has a brief review of the pellet market in the United States where the technology originated. The European situation differs markedly, however, particularly with regard to the greater weight of environmental arguments in marketing. For this reason no directly comparable conclusions could be drawn. The results are summarised in this publication. The findings can be transferred to other (EU) states – with adjustments for specific national aspects in some cases – and used to speed up the introduction of pellets by building on clearly formulated experience, avoiding known obstacles and encouraging positive influences. At the end of the publication is a list of manufacturers of heating systems and pellets in the countries concerned.

2) The second aspect of the project was the implementation and initiation of specific marketing activities and a pan-European exchange of experience. Project meetings took place in Sweden and Germany at which specific themes were discussed (pellet manufacture, pellet quality, logistics, heating and conveyor technology) and pelletising works and pellet heating systems visited. The highpoint of the international exchange of experience was the organisation of the First European Roundtable on Wood Pellets in Salzburg (Austria) in October 1999 with the participation of 200 experts from all over Europe. (The papers are assembled in a separate volume.) Apart from the conference there was also a poster session and exhibition (burners, stoves, analysis systems, dies).

Various activities aimed at greater market penetration have been initiated in the countries participating in the project. These activities included discussion and exchange of

experience with national experts, information events, roundtables, articles in trade magazines and speeches, consultancy for users and multipliers, the publication of information brochures and also an initiative to improve pellet quality and standardisation and motivation of the builders of co-operative dwellings to opt for pellet heating systems.

The extensive findings of the project are summed up below:

Wood pellets have enormous market potential as a biomass fuel although their current share of the heat energy market in general and the biomass fuel market is very small at present. The potential exists because of the availability of the raw material, the comparatively high energy density, the possibility of their use in automatic firing systems with a high level of user convenience and, not least – provided that certain energy policy conditions are fulfilled – their competitive price. For small systems in particular this opens up a new dimension in practical biomass heating, which, under certain circumstances, could represent a genuine alternative in this area to oil or electric heating.

The main technical challenge is the obtaining of high fuel quality (low dust component and no impurities or dangerous additives), efficient, highly reliable and user-friendly heating systems, gentle transport and storage techniques, the development and standardisation of charging systems, and rapidly available and professional service. Communications problems and competition between the different players make co-ordination difficult. In many cases the absence of an infrastructure (no chimneys, no water-based central heating systems) is a barrier to the installation of pellet heating. A poorly functioning or non-existent supply system (market) for fuel, heating systems and services could also discourage consumers from changing over to this heating system. Traditional heating customs and social influences are further possible hindrances. The main factor, however, is the economic one, where both fuel costs – now competitive in many European countries with non-renewable heating fuels – and the much higher investment costs are telling issues.

By and large, however, non-technical obstacles are likely to have a stronger impact on market development than technical barriers.

Strategies for further market penetration: Political support and direction remain indispensable if the carbon dioxide reduction targets formulated at a political level are to be achieved. Biomass (pellets) and the low-energy market can play an important role in this respect, which should be encouraged.

Greater co-ordination, co-operation and information are further important aspects of market penetration. The technical development of the system – heating systems, charging, transport and storage, pellet quality and the supply chain in general, and also quality assurance (certification and standards) – must be stepped up and made more professional The market infrastructure, regional marketing networks and standardisation of pellet supply and heating systems all need to be (further) developed. Marketing and advertising should be intensified and a definition of a brand image for wood pellets is also of importance.

The various activities and the commitment of the companies, consultants and institutions active in this market give hope that existing barriers can be overcome and that wood pellets as a new biomass fuel will flourish, increasing the proportion of biomass used for heating and strengthening regional economies at the same time.

1 PELLETS IN EUROPEAN COUNTRIES, USA AND CANADA

This article gives a brief description of the situation of wood pellets technology in some European countries, production capacity and pelletising companies, heating systems and manufacturers, specific features of the market, building structure, traditional heating and cost structures. Emphasis is on those countries where wood pellets use is most widespread and developed.

1.1 SWEDEN

1.1.1 Background

Biomass use

In 1996 the biomass accounted for 14.1% of gross inland consumption and 12.2% of the final energy demand [1]. More than 50% of bioenergy in Sweden is used in industry, mainly where it is a waste product.

Low-temperature heat is provided by single stoves (33%) and district heating plants (67%). The amount of heat supplied via district heating systems has been increasing threefold for the past five years.

13.3% of dwellings (4,349,000) are heated by biomass,

21.7% by oil, 1% by natural gas,

23.4% by electricity,

34.9% by district heating and

5.7% by other means.

The main energy source in district heating systems is biomass (42.3%). There is strong encouragement by the government to replace fossil energy by biomass. A problem to be solved are the houses built without a hot-water pipe system, because the switch from direct electric heating to biomass or district heat supply involves a considerable investment [2].

Swedish energy policy and energy legislation [3]

Sweden's current energy policy was formulated in an inter-party agreement, which resulted in the 1991 Energy Policy Act. The purpose of the agreement was to create the conditions for sustainable, long-term energy policy decisions with a view to safeguarding the availability of electricity and other energy at globally competitive prices. The timetable for

[1] European Union (1998): Annual Energy Review.
[2] AEBIOM (1997): Strategies for the Development of Biomass as an Energy-Carrier in Europe
[3] NUTEK (1997): Climate Report 1997, National Board for Industrial and Technical Development

the nuclear power phase-out and the pace at which the phase-out can proceed will depend on the effectiveness of energy-saving efforts, the availability of power from environmentally acceptable sources, and the need to keep prices internationally competitive.

The Climate Policy Act of 1993 further stipulated that Sweden should have stabilised its carbon dioxide emissions at the 1990 level by the year 2000, after which they should decrease.

Fiscal measures

In conjunction with the corporate and income tax reform in Sweden in 1990, VAT was imposed on energy. The rate is currently 25%. In 1991 a tax was introduced on carbon dioxide emissions of ECU 27.4 per tonne of carbon dioxide, and the energy taxes were reduced by 50% at the same time. That same year a sulphur tax was also introduced of ECU 3.3 per kg of sulphur emissions on coal and peat, and ECU 3.0 per cubic metre for every tenth of a percent by weight of sulphur content in oil. In 1992 a charge was introduced on nitrogen oxides from certain boilers and turbines. The charge is refunded as a function of the particular plant's energy production and emissions.

Further changes were made in the energy tax system in 1993 applying mainly to industry. In the old system, energy-intensive industries were able to obtain tax exemptions. In the new system the general energy tax on fuels and electricity was abolished for the entire industrial sector and the carbon dioxide tax was reduced to one quarter of the general level. For other users the energy tax remained at the same level and the carbon dioxide tax was raised from ECU 27.4 to ECU 35.1 per tonne of carbon dioxide.

A new law, the Energy Tax Act, has been in effect since January 1995. It includes a modified taxation procedure in accordance with the EU Mineral Oil Directive, which calls for an increase in certain taxes on fuels. To help finance Sweden's membership fee to the EU, the carbon dioxide tax was raised on 1 January 1996 to ECU 39.5 per tonne of carbon dioxide and the electricity tax by ECU 0.5 per MWh. The production tax on hydroelectric power plants was also raised.

On 1 September 1996 the energy tax on all fuels was raised along with a special tax on nuclear power. For fossil fuels the energy tax was increased by about 11%. For petrol and diesel the rise was about 3%, and for electricity between 15 and 35%, depending on the customer category. That same year, the Riksdag passed a resolution to change the taxation of hydroelectric power by replacing the current tax by a special property tax.

The government has also presented a proposal to double the carbon dioxide tax for industry and at the same time to introduce exemptions for energy-intensive sectors. The proposal has now been reviewed by the relevant EU bodies and entered into force on 1 July 1997.

Subsidies[4]

- Investment grants for certain energy investments such as CHP production based on biofuels, wind power and small-scale hydroelectric power. Beneficiaries are small electricity producers.
- Subsidies for converting buildings with electric heating to district heating. Beneficiaries are house owners with electric heating.
- Subsidies for municipal/local energy guidance.

[4] Altener Programme. Contract N° 4.1030/E/96-008: renewable energy source legislation, Final Report of the Ener-Iure Project

1.1.2 History

Wood pellet production planning in Sweden started in the late 1970s with the decision to build a pelletising plant in Mora. The plant started production in November 1982 and immediately ran into problems because costs were much higher than had been calculated.

At this time there was no experience in the production or combustion of wood pellets and no equipment for burning this kind of biofuel. Equipment was developed for converting oil boilers to pellet-fired boilers. In practically all cases, however, they were highly inefficient, not least because of the poor pellet quality. During this first year the raw material was usually bark. Pellets often had an ash content of 2.5% to 17%. The plant in Mora was closed 1986.

In 1984 a pellet plant was built in Vårgårda. The plant's last owner was the Volvo group. It was closed in 1989. In 1987 the first plant for pelletising dried material was built in Kil. It was designed for an output of 3,000 tonnes a year. This plant is still in operation and is the oldest commercial plant in Sweden.

In the early 1990s the Swedish government came up with a proposal for taxation of mineral fuel. Overnight it was no longer profitable to burn coal, oil or gas, and biofuels became the most profitable fuel. This marked a turning point and the use of wood pellets started to grow rapidly.

One reason for the rapid growth was that the pulp and paper industry was able to use raw materials other than spruce and pine from sawmills. Swedish particleboard production capacity decreased from 1,500,000 m³ in the late 1970s to 500,000 m³/year today. A lot of planing shavings are available as a result.

The main type of raw material is sawdust. There is only one pellet mill in which bark is pelletised.

1.1.3 Production, capacity and raw material

Production capacity is about 1,000,000 tonnes/year. According to information from industry the amount of raw material (white wood in the form of sawdust, planing shavings, chips) available for pelletising is about 1,000,000 tonnes a year. This means that new pelletising projects will need other types of raw material such as residues from forest thinning and harvesting (branches, crowns, damaged wood).

YEAR	approximate PRODUCTION CAPACITY in tonnes
1995	180,000
1996	200,000
1997	400,000
1998	600,000
1999	780,000
2000	1,000,000

Most of the recently built pellet plants, especially the bigger ones, have installed dryers to handle wet raw material. The ash content in the white wood is less than 0.5%. Ash content in the material with bark is over 2.5%.

One plant produces pellets from bark. Mönsterås is a large pulp and paper mill. Bark is a by-product from the logs debarked before pulp production. The amount of bark is so great that the plant today has a capacity of 50,000 tonnes a year. The other big consumer of the bark is the boiler, which produces steam, electricity and heat for the plant.

Total production and use of wood pellets in 1998
Between 570,000 and 600,000 tonnes of wood pellets were fired in 1998. Supply from Swedish producers is 470,000 tonnes (for a total installed production capacity of over 1,000,000 tonnes). Of this amount, 220,000 tonnes were delivered to a single customer (large-scale district heating plant) in the eastern part of Sweden. The remaining 250,000 tonnes were mostly delivered to medium-sized boilers.

Small consumers are still not using wood pellets to the extent foreseen.

Quality standards
In 1998 a standard for wood pellets was elaborated (see Chapter 2.3).

Import of wood pellets
In 1998 about 100,000 tonnes were imported to Sweden, mostly from Canada. Some also came from the Baltic states, Poland and the Netherlands. Obviously it is profitable to transport pellets from Canada to Sweden in big ships because of the low transportation costs.

1.1.4 Use of wood pellets

Pellets are used in Sweden by three main groups.

1. Large-scale central heating plants. Fuel in these big boilers is mostly dust for suspension firing. Pellets are used only for distribution and storage. Most burners have been converted from coal-dust firing. Some large plants that used to fire coal on travelling grate stokers have now converted to firing wood pellets.
2. Medium-sized boilers (0.5 to 4 MW) using a stoker retort and most kinds of step grate stokers
3. Small boilers and stoves (1.0 to 25 kW)

The dust burners developed for the first category can handle wood dust and operate very well. The firing systems that have been converted to wood pellet firing also operate very well.

In the second category no facilities have been developed specially for wood pellets. There is a very large market here for companies that can develop equipment for this very special kind of fuel.

In the third category the listed products (see Chapter 7) are currently being developed for wood-pellet firing. At the moment all of them continue to have minor problems and none can yet be fully recommended.

Combustion units in 1998

pellet burners (mostly replacing oil burners in an existing boiler):	9.000
boilers:	100
pellet stoves:	1.500

In 1998 about 40% of produced pellets were fired in a single large-scale heating plant. Most of the rest was fired in medium-sized boilers and stoves.

Energy consumption of heating systems in private houses

	firewood	oil	electric convectors	electric water-based heating	district heating	natural gas	total
number of households	400.000	562.000	514.000	241.000	144.000	20.,000	1.881.000
%	21,3	29,9	27,3	12,8	7,7	1.1	
TWh	12	14	14	7	3.6	0	36.727

1.1.5 Potential for different burning systems

Pellet stoves
Generally the market for pellet stoves in Sweden is considered to be extremely promising, not least because of the developments in the late 1960s and early 1970s. When the nuclear power plants were built it was very profitable to install direct electric heating systems in small houses. Today around 550,000 houses are equipped in this way.

Very often these houses have no chimney. The cost of building a new chimney is between EUR 900 and EUR 1,000. Today there is a special pellet-vent system available on the market, which was developed in USA for pellet stoves. Because of the very high efficiency in the burning system the temperature is quite low and controlled in the stove.

It would cost EUR 14,500 to EUR 17,000 to replace this heating system by a warm-water central heating system.

Pellet burners
The pellet burner is a combustion unit used for converting small oil-burning boilers to pellet burning. The burner costs between EUR 1,700 and EUR 2,000. An additional storage system is needed, which costs about the same amount as the burner. In principle all these boilers could be converted to pellet burning systems. The total number of convertible oil boilers is about 600,000.

Pellet boilers
This is a product for the same market as for the pellet burner above. The problem is that customers find this solution rather expensive and therefore choose the burner. There have been a number of problems because the combustion system does not fit with the existing boiler. Most of the boilers are built for burning oil. For bioenergy the boiler has to have a specially designed firing chamber and a tube suitable for burning wood.

Medium-sized boilers

Medium-sized boilers are boilers with 100 to 500 kW output including the burning system. There are some good boilers of this type on the market and a number of units have been developed specially for pellet firing.

Large boilers

There are a lot of large boilers available on the market. They have been in use on the Swedish market since the mid-1980s and function well.

Discussion

Since pellets have been on the market a number of small systems for firing pellets have been developed. The problem for manufacturers of this product is that they have not had the financial resources to develop a finished product before going on the market. All manufacturers are concerned to keep the price of their product as low as possible and many have run into major financial problems.

For medium-sized boilers the situation is much better. In this field manufacturers can achieve a better price for their product.

For large boilers the situation today is also very promising because manufacturers offer products that are good and include a control system for regulating the equipment down to 15% to 20% output.

1.1.6 Fuel prices

Today wood pellets are very cheap compared with oil and electricity.

Pellets are sold to major consumers for less than EUR 100/tonne = EUR 21.27/MWh
Pellet in 16 kg bags are on the market for EUR 156.50/tonne = EUR 33.28/MWh
Oil price for small consumers = EUR 446.90/m³ = EUR 45.60/MWh
Electricity for small consumer = EUR 83.80/MWh

In many cases by wood pellets can reduce heating costs by 50%.

1.1.7 Marketing and actors on the market

To increase the pellet market some of the bigger manufacturers (e.g. Södra) offer customers a complete heating centre and sell heat instead of fuel. The customer has to pay for the supplied kWh, which is measured by means of heat meter.

In August 1998 an oil company (Statoil) started a test for supplying wood pellets directly and through its existing network of petrol stations. Statoil started its own pellet plant in Norway in August 1999. Other oil companies are likely to follow suit and change their strategy from oil supply to energy supply.

SVEBIO Sweden has a well organised Biomass Association, SVEBIO, which is a member of AEBIOM.

Pellet Producers Association Pellet producers have decided to actively encourage the production and use of pellets through an organisation called **PelletIndustrins Riksförförbund** (PIR – pellet producers association), which was formed in February 1998. It is proposing to invest a considerable amount in the development of the industry itself and the market. It has already established co-operation agreements with universities, private research centres and other consultants. The association has one committee for technical matters and another committee for marketing.

The marketing committee is exerting pressure on market players to increase, develop and sell firing equipment and pellets. It also provides information for consumers, architects, constructors, heating engineers and other experts. It is responsible for marketing problems and co-operates with manufacturers of firing equipment with a view to elaborating a programme to persuade consumers of the benefits of wood pellets and to counter objections raised by small consumers with regard to storage, delivery and service.

The technical committee is responsible for all technical problems that the PIR considers necessary to work on and solve.

In its marketing activities PIR co-operates with the **Pelletsvärmegruppen** (pellet heating group), an association of firing equipment manufacturers.

Main marketing problems

Customer have to be informed and convinced that wood pellets are a good alternative fuel. At present they do not see the benefit of the wood pellet system.

There are many technical and non-technical problems connected with the use of pellets in small heating units, such as storage, delivery to the customer and service.

For units with more than 100 kW output these problems do not exist. A number of units of this size are in operation today and information is available about them.

1.1.8 Transport and delivery

The main package units are loose bulk and big bags. Purchases are usually made directly from the pellet manufacturers. In recent years the number of pellet dealers has risen rapidly. Pellets are usually delivered directly to consumers by bulk vehicles, but homeowners sometimes buy their pellets directly from the mill and organise transport themselves [5].

[5] Vinterbäck J., Roos A., 1999: Residential pellet heating in Austria, New England and Sweden. Swedish University of Agriculture, Uppsala

1.2 NORWAY

1.2.1 History and background

Within Europe Norway has a special place in terms of energy production and consumption.

At present around 50% of the total energy consumption is provided by electricity and practically all of this electricity is produced by hydroelectric power. This has resulted in one-sided infrastructural development and buildings equipped with direct electric heating rather than district heating or central heating systems. Logically the consumption of electricity in households is very high. On average about 70% of electricity in households is used for heating and warm water. Local and regional energy planning focuses solely on power distribution. Most of the hydroelectric power stations are in public ownership (partly state and county, but mostly local municipalities).

Further expansion of the hydroelectric power network is limited because of preservation and environmental protection considerations. The long growth period in electricity production has slowed down and almost ground to a stop. Since the 1990s a new trend has emerged: electricity consumption is increasing faster than production. Since 1997 there has been a growing gap between consumption and production of electricity, and electricity has to be imported from neighbouring countries to make up the balance.

Politicians and authorities agree that this shortage of nationally produced electricity is creating major socioeconomic and environmental problems and is not acceptable as a long-term solution.

Discussion has only recently started. The government called a group of experts and decision-makers to evaluate the situation and present proposals and strategies for the future. The result of this comprehensive study was presented last year (*Norges offentlige utredninger NOU 1990: 11. Energi- og kraftbalansen mot 2020*). But there is not yet any political agreement as to which scenario should be given priority and a clear orientation in energy policy is not yet visible.

1.2.2 General data on wood pellets

Pellet production on a large scale has only recently started. The total production of pellets in Norway in 1998 was about 10,000 tonnes. The estimate for 1999 was approximately 20,000 tonnes, of which 11,000 tonnes were planned for export to Sweden. The existing plants are producing far below their capacity because of lack of customers.

The production capacity for pellets in Norway is expected to rise in the next two years to 100,000 tonnes per year. This is more than ten times the current demand in Norway and illustrates the big gap between production capacity and consumption.

A number of pellet production projects were in planning but most have been stopped or postponed because of the difficult market situation or for other reasons. If selling markets in Norway do not increase in the next years, the existing pellet factories will have severe financial problems and the planned factories will have no market either.

<u>The key requirement with regard to pellets in Norway is to create a consumer market.</u>

Raw materials: The timber industry is very widespread in the country, especially in forest regions. In these areas by-products and production waste from industry supply plenty of raw material (sawdust) for production of pellets. These industries are mainly located in the central regions (Hedmark, Oppland, Akershus, Buskerud, Trøndelag). The coastal and very northern regions have much fewer raw materials.

An interesting experiment is under preparation in the municipality of Røros. In co-operation with another company and the municipality the local pellet factory has set up a test plant to collect timber from demolished buildings, crush it and produce pellets. Initial test results show that only very clean raw material (timber waste) should be used, otherwise the pellets produce too much slag when burnt. There is also a study in Troms investigating the possibility of pelletising birch wood waste from particleboard production.

Generally the potential supply of raw material for pellet production (sawdust) is much greater than the actual pellet production and it is estimated that there is enough raw material for expansion of production. So far no pellet producer has had problems with the availability of raw material.

Distribution, logistics, storage
There is not yet a nationwide distribution network covering all regions. Many regions are not well supplied, while regions near existing factories and intermediate traders have a reliable supply. Pellets are supplied by all existing factories and a number of other sales offices, normally the same companies that sell pellet burners or stoves.

Pellets are transported in both big bags and bulk. Smaller bags of 20 kg or less are not yet much in use, but several suppliers are starting distribution of small size bags now (Frya Bioenergi, Hydro Texaco, Norske skog/Statoil).

1.2.3 Heating systems and potential for pellet use

District heating is not very common in Norway. There are about 20 district heating networks of medium or bigger size. Only Trondheim and Oslo have a well established infrastructure for district heating. Scattered housing only partly explains this development. More importantly, district heating has never been given much priority in national and local energy policies. In recent years projects for district heating in medium-sized and small towns and villages have been initiated, mostly in connection with use of bioenergy and waste incineration. Due to very high investment costs and low subsidies from public authorities there is only limited chance that these project plans will be implemented in the near future.

Other heating systems are compiled in the table below.

Table 1-1: Existing heating systems in apartments in Norway (1990)

Total number of apartments	**1,769,000**	**Potential for pellets**	
Heating system	**Number**	**Suitability for pellet burners**	**Suitability for pellet stoves**
electric heating combined with stoves for solid fuel	619,000 (35.0%)	NO	YES
electric heating	418,000 (23.6%)	NO	YES (where chimney exists)
electric heating combined with stoves for solid fuel or liquid fuel	209,000 (11.8%)	NO	YES
central heating	171,000 (9.7%)	YES	NO
stoves for solid fuel	93,000 (5.3%)	NO	YES
stoves for liquid fuel	51,000 (2.9%)	NO	YES
central heating combined with one or several other heating sources	46,000 (2.6%)	YES	YES

(Source: Norges offentlige utredning Energi- og kraftbalansen mot 2020, p.95 and assessment of potential for use of pellets by Asplan Viak)

The figures reveal the unique characteristics of the housing sector:

- Only very few houses have central heating.
- A large majority (approx. 70%) have electric heating as the only or dominant heating system.
- It is quite common to have combined solutions (approx. 50%) with different energy sources, the combination of electric heating with stoves for firewood being the largest group (35%).
- The use of wood stoves, mainly as an additional heating source in combination with others, is very widespread (54%). It is estimated that there are 800,000 wood stoves in use in apartments.
- The majority (58.6%) have a combination of several heating sources.

Potential for pellet heating systems in the existing housing stock

- The potential for converting central heating from oil-fired to pellet-fired systems is limited because of the low percentage of central heating.
- The potential for introducing pellet stoves is very great. Theoretically all apartments with electric heating combined with stoves or only stoves could use pellets as an alternative or supplement without high investments or alterations to the building (56.9%). The apartments with electric heating that have a chimney can also be added to this group. That means around two thirds of all apartments would be suitable for use of pellet stoves without major changes and investment.
- Also from the point of consumer feeling, custom and the habit of using firewood in their houses, pellet stoves could have a good acceptance, combining technological innovation with a deep-rooted and widespread national heating tradition.

Heating technology and products (pellet burners and pellet stoves) are imported from other European countries or the USA. Pellet stoves are mainly imported from Sweden, Austria and the USA, pellet burners mainly from Sweden and Denmark. At present a Norwegian company is developing a combined pellet stove, where oil can also be fired (see „Heating Technology“).

1.2.4 Consumers and existing heating facilities

Thanks to enhanced awareness the interest in biomass fuel and especially wood pellets is increasing. However, real market penetration seems to be difficult.

The **biomass market** is characterised by the following aspects:

- Project plans for investment in district heating and local heating based on biomass fuel increased rapidly last year.
- In several regions new companies selling turn-key heating systems have emerged in the energy market. They offer contracted projects and services. These new companies are often a co-operation between forest owners and municipal energy companies.
- Three of the major oil companies (Statoil, Hydro Texaco, Shell) have established new branches or companies to handle the biomass market. The goal is to establish energy services based on biomass as a supplement to their conventional energy services.
- A substantial breakthrough in new biomass heating technologies is not in sight. Almost all companies face economic difficulties due to low energy prices (oil, electricity).

Major pellet consumers

Table 1-2: Existing pellet burners (>200 kW)

Name and place	Contact	Year of construction	Type and size of buildings	Capacity/ production
Sødorp ungdomskole, Vinstra (Oppland county)	Thormod Øfsteng, Gudbrandsdal Energi	1998	school	
Gymbygget, Røros (Sør-Trøndelag county)	Jakob Trøan Røros kommune	1998	sports hall	
Norges Landbrukshøyskole, Aas (Østfold county)		1997	university complex, 100,000 m²	3.6 MW 15 GWh/a
Magnor skole, Eidskog (Hedmark county)		1998	school	200 kW
Skotterud, Eidskog (Hedmark county)		1998	public buildings	
Tolga (Hedmark county)	Jon Vingelen	1998	public buildings	600 kW
Sæter gård-Politiets kurssenter, Kongsvinger (Hedmark county)	Erik Nilssen	1997	educational institution	200 kW
Eidsvåg skole, Salhus skole, Åstvedthallen, Bergen (Hordaland county)	Per Fr. Gjesdahl, Bergen kommune	1998	schools and sports hall	

Table 1-3: Planned projects with pellet burners for central heating (>200kW)

Name and place	Contact	Planned year of construction	Type and size of buildings	Capacity
Fylkeshuset, Hamar (Hedmark county)	Hamar region Energiverk	1999 local distibution net 2000 pellet burner	3 big public buildings	400 kW (800 kW)
Brumunddal skole, Brumunddal (Hedmark county)	Ringsaker kommune	2000	school	200 kW
Oppland Sentralsykehus Lillehammer (Oppland county)	Oppland fylkeskommune, Innkjøps- og eiendomsavdeling	2000 or 2001	hospital, 53,000 m²	2,000 or 2,500 kW (pellets 2,000 t per year)
Granheim lungesenter, Gausdal (Oppland county)	Oppland fylkeskommune	2000 or 2001	public health institution, 2,800 m²	

There are no figures for pellet burners (small 20-50 kW) in use for central heating, but in several districts there are farmhouses with a pellet burners of that size. The total number of pellet burners in the range between 20 and 50 kW in Norway is estimated around 30.
An estimate of the number of pellet stoves in Norway (1999) is shown in the following table:

Table 1-4: Estimated number of pellet stoves

County	Number of pellet stoves in use (estimate)
Oslo-akershus	5
Oppland	25
Hedmark	15
Hordaland	50
other counties south Norway	30
Sør-Trøndelag	5
other counties	10
SUM Norway	140

(Source: own enquiries in 1999 among suppliers)
(Note: approx. 10% of the figures above are pellet stoves for exhibition and demonstration by suppliers and traders and are not in permanent use in buildings).

Considering that every stove needs between 1 and 2 tonnes of pellets per year, the consumption of all pellet stoves at the moment is not more than 300 tonnes per year, which is very low compared to pellet production capacity.

1.2.5 Market situation and market penetration

In the last three years there has been a noticeable increase in the marketing of bioenergy-related products and services. The Norwegian Biomass Association (NoBio) is very active in spreading information on recent developments, projects and services. Some private companies have also posted information folders and websites on the Internet (e.g. Norsk Hydro-Bioenergi as, Gudbrandsdal Energi, Biobrensel Teknikk as, Vaksdal Biobrensel).

Small companies, which are often linked with forest landowners in the timber industry, are playing a pioneering role in this respect.

Pellet situation
Specific marketing of pellets is almost non-existent. There are some isolated marketing actions by different companies (pellet producers, energy suppliers, vendors of heating technology), but no general offensive and goal-directed marketing activities for pellets.

For any marketing strategy, however, it is important to realise that the market is not homogeneous but consists of different groups with different conditions and requirements, which must be addressed specifically:

- use of larger pellet burners for central heating of large buildings, building complexes or groups of buildings: this market is appealing for real estate administrators, public institutions, municipalities, industry, etc.
- the market for pellet stoves in single-family houses: although pellet stoves for single-family houses are already widely used in Sweden, in Norway only a few have been introduced and imported in the last three years.

Market potential
The market potential for pellet stoves is thought to be quite promising, however, for the following reasons:

- The housing sector in Norway is dominated by single-family houses, most of them with direct electric heating.
- Electric heating in housing has no long-term future because of an increasing need for electricity imports and an expected rise in prices, which are currently very low.
- Transformation of existing housing stock away from electric heating is difficult because of the poor infrastructure (lack of district heating and water-based heating systems in housing stock). Pellet stoves are an alternative to electric heating without the need to invest in water-based central heating systems.
- Pellet stoves are very similar to ordinary wood stoves in terms of handling, technique, image and visual appearance and would therefore fit in very well in a long and deeply rooted heating tradition.

1.2.6 Economy, cost structure, competitiveness

Pellet price in relation to oil and electricity

Electricity

The average price of electricity in 1997 was NOK 0.585/kWh for households (and NOK 0.365 for industry). Since the liberalisation of the market the price went down to an average of NOK 0.513/kWh in January 1999. On average the price of electricity went down 7% between July 1997 and July 1998 (source: Statistisk Sentralbyrå).

The various price components are shown in the following table.

Table 1-5: Price for electricity in households NOK/kWh, average for January 1999 (source Konkurransetilsynet, NVE)

Price	NOK/kWh	EUR/kWh
1. basic electricity price	0.1695	0.0208937
tax on electricity	0.0594	0.0073220
VAT	0.0527	0.0064961
2. net distribution	0.1890	0.0232974
VAT	0.0430	0.0053005
SUM	**0.5136**	0.0633097

Oil prices

Price for households in 1997 was EUR 0,459 (NOK 3.72)/litre, which gives a price of EUR 0,065 (NOK 0.528)/kWh (efficiency of oil burner is deducted) (source: Statistisk Sentralbyrå).
For larger quantities the prices are substantially lower and depend very much on negotiations between seller and buyer.

Price relation between electricity, oil and biomass

It is not possible to give exact generally valid figures, because the prices change, depending on region, type of project and time of the year.

However the following figures may be regarded as a rough average.

Average price per kWh (including all taxes, not including capital investment costs)

Electricity	NOK 0.45 – 0.50	EUR 0,055 – 0,062
Oil	NOK 0.30 – 0.40	EUR 0,037 – 0,049
Pellet	NOK 0.22 – 0.35	EUR 0,027 – 0,043

(source: own calculations based on current market prices)

Average price per kWh including all taxes and capital costs for investment)

Electricity (direct)	NOK 0.51	EUR 0,063
District heating	NOK 0.60	EUR 0,074
Central heating with combination of oil/electricity	NOK 0.81	EUR 0,100
Central heating with biomass fuel	NOK 0.86	EUR 0,106

(source: Ife, EnFo)

Subsidies

Since 1997 the government has started to subsidise projects on a large scale to increase the energy production of renewable energy (mainly biomass, but also others). The programme

is not only for biomass projects but also for heating pumps and use of industrial process heat. In 1999 it had a budget of NOK 77 million. The average subsidy is normally 20% of the investment costs, in a few cases up to 25%. The chances of receiving a subsidy at all are not very high, and only around 15% of all applications receive one. To avoid bad investments and too much dependence on public support it is the policy of NVE to support only those projects with a sound economic base. With the tough competition for other types of energy and difficult market situation it is not even certain that all of the subsidised projects will be implemented.

Statens miljøfond has a loan programme for environmentally oriented projects and Statens Landbruksbank has a fund of NOK 8 million to subsidise bioenergy projects, which is to be used in conjunction with the NVE-supported projects.

The present public subsidy programme is big enough to provide support for some demonstration projects but far too small to ensure broad market penetration of biomass in the energy sector. This is one of the reasons for the slow dissemination of bioenergy in Norway compared with Finland, Sweden, Denmark and Austria.

1.2.7 Obstruction to market penetration

Infrastructure and logistics

- The development of the national infrastructure, housing stock and equipment supply is too biased towards electric heating; there is very little district heating.
- Infrastructure and logistics for biomass supply are available only in a few localities and regions.
- The widely scattered housing structure does not favour district heating.

Market

- The market for heating with electricity/oil is very well organised and much better developed than the bioenergy market.
- New plans for electricity production (natural gas power stations) on a large scale are in preparation, but as the feasibility of the projects is uncertain, future developments in the energy market are very difficult to predict.
- There is an absence of public information and practical demonstrations in the bioenergy sector.
- The demand from consumers for pellets is still low.
- None of the traditional heating equipment suppliers (varmesenter) have pellet stoves and burners in their shops yet, and technical service is still limited.
- The activities and strategies of the commercial sector are too isolated: there is a lack of visibility, integration and profile as a „single“ sector.

Economy

- Energy prices for both oil and electricity are low, and have even gone down in the last twelve months.
- Subsidies are low as a percentage of investment costs and far too small to give results on a broader scale.

Culture, tradition and mentality

- Consumers and builders are used to choosing the „easy solution“ (electricity).
- The population is used to a supply of cheap electricity and an increase in electricity prices is a politically and socially sensitive issue.
- There is no great tradition or experience in the organisation of shared energy solutions (micro-networks, district heating)

1.2.8 Factors encouraging market penetration

- Raw material for pellet production is readily available.
- The neighbouring Swedish market could help establishment of the market in Norway.
- Energy prices are expected to rise in the long run.
- The use of wood in building heating is very widespread, and the cultural and technological leap to pellets is therefore not very great.
- The government has declared the conversion from electric heating to new renewable energy heating as a priority.
- Large oil/energy companies are investing in the pellet market and can help to develop a difficult market.
- Pellet stoves have an excellent chance of becoming „standard“ in old single-family houses.
- A combination of pellet stoves with underfloor heating might be a good solution for new residential buildings.

1.2.9 Market needs

- Better and more specific promotion of pellets product information at exhibitions and fairs, and in information campaigns
- One-stop shopping for consumers
- Systematic promotion of central heating and district heating on a national scale
- Introduction of pellet stoves and burners by stove suppliers and shops
- Establishment of professional pellet distribution network in all regions
- Provision of a more standardised solution for pellet storage in consumer’s houses
- Prototypes/demonstration projects in all municipalities and regions

1.2.10 Spreading of information to overcome barriers

The following measures could help to remove barriers:

- Special subsidy programme for purchase of pellet stoves
- Information and initiation of pilot projects in co-operative and public housing sector
- Promotion of bioenergy in new environmentally oriented housing schemes
- Organisation and co-ordination of commercial sector in regional networks, including better information policy
- Slow but steady and predictable change in energy tax policy in favour of new renewable energy/biomass

1.3 GERMANY

1.3.1 History and background

In Germany biomass accounted for 1.3% of gross inland consumption and 1.1% of the final energy demand in 1996[6]. Of all newly built dwellings in 1996 (213,230) 4.0% were heated by biomass, heat pumps, solar energy and district heat, 0.2% by coal, 24.7% by oil, 69.7% by natural gas and 1.5% by electricity[7].

German energy policy and energy law[8]
The energy sector is regulated by the state under the Energy Management Act [*Energiewirtschaftsgesetz*], which was amended in November 1997 and came into force in April 1998. The act is designed to ensure a supply of electricity and gas via supply lines that are as secure, inexpensive and environmentally compatible as possible. It replaced the Act for the Promotion of the Energy Industry of December 1935.

Federal, state and local authorities promote the use of renewable energy sources through various, sometimes short-term, poorly funded and frequently modified programmes. The main financial promotion measure at a national level is the Electricity Feed-In Act. However, the tariffs for the electricity fed into the grid are financed not from taxes but from the revenues of the energy supply utilities.

Fiscal measures[9]
In order to support the use and the market penetration of biofuel, the Law on Excise Tax on Oil and Oil Products does not include a specific passage on biofuels. This is widely considered as a tax exemption. The 1999 tax reform brought an increase of the excise tax on oil and oil products (oil: + 0.02 ECU/l; natural gas: + 0.0016 ECU/kWh) and a new energy tax on electricity (0.01 ECU/kWh).

Subsidies
Individual measures involving the use of renewable energy sources are funded from the federal budget. These measures do not, however, represent a general programme for introducing renewable energy sources onto the market. The following measures concerning biomass are supported:

- Installation and extension of biomass plants for steam production, heat production and combined heat and power generation >50 kW. Since 1999 smaller heating installations have also been supported by the government.
- Installation or extension of biogas plants for the use of agricultural waste products for energy.

[6] European Union (1998): Annual Energy Review
[7] Statistical Yearbook 1998 for the Federal Republic of Germany: Baugenehmigungen im Hochbau, Nach Art der Beheizung 1996
[8] Altener Programme. Contract N° 4.1030/E/96-008: Renewable Energy Source Legislation in Germany, Final Report of the Ener-Iure Project
[9] Altener Programme. Contract N° 4.1030/E/96-008: Renewable Energy Source Legislation in Germany, Final Report of the Ener-Iure Project

- The Agricultural Investment Support Programme subsidises investments for energy saving in the agricultural sector:
  - biomass plants
  - heat pumps
  - solar plants
  - shift of the heating system to economically sound energy sources.
- Subsidies for support of renewable raw materials

Subsidies for renewable energy source demonstration measures and for the use of renewable energy sources are available from the German states (*Länder*). Renewable energy source subsidy programmes depend on the availability of budgetary resources. Many programmes are still in force, but there are no more funds available. This is often a problem not only for the potential investor, but also for the small and medium-size enterprises active in the markets for renewable energies. Up to now there has been little co-ordination between the federal, state and local programmes.

1.3.2 Raw material and production capacity

The following table shows the forest area in the German *Länder*.

Table 1-6: Forest area in the German *Länder* in 1998

Land	forest land [hectare]	fuel wood / forest waste products	
		[1000m³/a	tons/a
Baden Württemberg	1,344,879	3,557	889,361
Bavaria	2,415,550	6,390	1,597,389
Berlin	15,522	34	8,479
Brandenburg	1,023,753	2,237	559,217
Bremen	752	2	411
Hamburg	3,390	7	1,852
Hesse	839,860	2,093	523,232
Lower Saxony	491,546	1,074	268,503
Mecklenburg-Vorpommern	984,020	2,150	537,513
North Rhine Westphalia	842,444	2,099	524,842
Rhineland Palatinate	804,553	2,005	501,236
Saarland	85,779	214	53,440
Saxony	485,441	1,067	266,748
Saxony Anhalt	433,559	947	236,828
Schleswig-Holstein	144,526	316	78,946
Thuringia	514,564	1,131	282,752
Germany total	**10,430,138**	**25,323**	**6,330,750**

Availability of raw materials in the *Länder*
About 30% of Germany is covered with woodland and the wood volume increases by about 60 million cubic metres per year. Of the total wood reserves in German forests an average of 40 million cubic metres is used annually, while about 20 million cubic metres per year are not yet used and remain in the forests. At least 20% of the average amount

used annually – 8 million cubic metres – could be made available for the production of wood pellets.

Realistically, however, only scrap wood, wood shavings and sawdust from the wood and timber industry (sawmills) and forest waste products would be available as raw material for pelletising.

The following table shows the potential of fuel wood in Germany in 1998 and is based on wood statistics and material-flow analyses (the experience of recent years and various statistics).

Table 1-7: Annual amount of wood useable as fuel in Germany in 1998

Sort of wood	**Amount [million m³]**
fuel wood from forests	4.5
scrap wood from sawmills and commercial timber	7.0
forest waste products	2.0
total	13.5

The estimated potential of fuel wood in Germany is about 20 million tonnes per year. By-products (waste) from sawmills useable for pellet production represent 29 to 34% of total processed wood.

German pellet production
Commercial wood pellet production has started in several locations in Germany in the last two years. Table 6-6 in Chapter 7 shows the manufacturers and some of the wood pellet vendors (February 2000)

Germany now has about six special manufacturers of wood pellets already producing (Baden-Württemberg: 2) and several plants are in planning. Biomass experts estimate that between 800,000 and 1,100,000 tonnes of raw material are available for pelletising.

If pellet demand increases in the future, scrap wood from the woodworking industry will be re-routed for pellet production. Whether scrap wood 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.

1.3.3 Use of wood pellets

Like production, the combustion of wood pellets is still in its early stages in Germany, but the interest in wood pellet heating systems is rapidly growing.

The use of pellets for heating is concentrated on the niche market of low-energy houses with an annual fuel consumption of around 1,500 kg per 100 m² living space. There is currently a demand for the development of heating units with very low energy requirements for energy-saving housing.

German furnace manufacturers have responded to the recent growth in the pellet market. Manufacturers producing pellet furnaces are shown in Table 6-7 in Chapter 6. However, most units are currently imported from Austria, Denmark and Sweden.

The technical development of small wood-burning stoves (2 to 8 kW) and boilers (8 to 25 kW) has progressed considerably in the last few years. The trend towards a convenient and environmentally sound heating system is growing and sponsored by a special government programme.

1.3.4 Fuel prices

The prices of wood pellets range from EUR 127.823 (250 DEM)/t (large units) up to EUR 201.517 (400 DEM)/t (small bags, low quantity). Compared to prices of agricultural goods these fuel prices are relatively high (e.g.: oats: EUR 92.033 (180 DEM)/t, wheat: EUR 127.823 (250) DEM/t, barley and others: EUR 97.145 (190 DEM)/t).

The following table shows different fuel costs in Germany.

Table 1-8: Total annual costs of fuel oil, gas, pellets and wood chips for a single house with 150 m² of heating area (20,000 kWh/a useable energy). (February 2000).

fuel	**pellets*)**	**gas**	**oil**	**wood chips**
unit	kg	m³	litre	Sm³ (formed m³)
costs [DEM/unit]	0.31 loose pellets	0.590	0.70	25.0
fuel quantity/year	3,390 kg	2,305 m³	2,350 l	30 Sm³
total cost/year [DEM]	1,391	1,359	1,645	750
total cost/year [EUR]	711,207	694,845	841,075	383,468
cost /kWh [DEM]	0.0695	0.0679	0.117	0.0375
cost /kWh [EUR]	0.0355	0.3471	0.5982	0.1917

*) current market prices are: small bags (15 kg): EUR0.178 (0.35 DEM)/kg,
big bag: EUR 0.158(0.31 DEM)/kg, loose pellets: (>3000 kg): 0.29 DEM/kg

1.3.5 Pellet distribution and subsidies in Baden-Württemberg

At present renewable energy sources account for 2.5% of the energy demand in Baden-Württemberg. Biomass represents about 0.3% of primary energy consumption. Most of the energy consumption in private houses is for space heating.

With a view to reducing primary energy consumption a special support programme for biomass has been set up as one of the key strategies in the policy of increasing the share of renewable energy sources in medium term to up to 12% of primary energy consumption. The government of Baden-Württemberg would like to increase the contribution of biomass to energy generation from 0.3% at present to 5% by 2010. To achieve this ambitious target it has subsidised the installation of biomass heating and combined heat and power generation. Furthermore, a new subsidy programme was started in 1999 to reduce heat losses and energy consumption in private buildings.

It has become abundantly clear that the lack of information is one of the main barriers to establishing an efficient pellet market. To counter this deficit the Energy Information Centre [*Landesgewerbeamt*] has developed a marketing concept which is currently being implemented. As special training programme is also being designed. The activities (survey, roundtable talks, discussions) carried out within the framework of this project (Thermie B) have already improved the information and awareness levels of many actors.

1.4 AUSTRIA

1.4.1 History and background

In Austria 47% of area is covered with forests and annual wood growth exceeds exploitation. Currently wood growth amounts to 27 to 31 million cubic metres per year, and exploitation is about two thirds of growth (20 million cubic metres). Also the forest area is also increasing by up to 7,000 ha per year[10]. In view of these natural conditions Austria is ideally placed for further use of wood fuels in the form of logs, wood chips or pellets.

Following figures are illustrating energy use and energy carriers.

Table 1-9: Energy source distribution [Energiestatistik 1995, Energiebericht der Bundesregierung 1996]

Total energy consumption	1183 PJ	
of which other energy sources	143 PJ	12.1%
of which hydroelectric power	173 PJ	14.6%

Table 1-10: Other energy sources in percent

firewood	67
waste lye	12
wood chips	6
bark	7
waste	2
heat pump	3
	total 97%
straw	0.7
solar thermal collectors	0.7
biogas + biological oil	1.2
wood and straw briquettes	0.7
geothermic energy	0.1
wind and solar electricity	0.0%
	together around 3%

In Austria, the heating of houses and supply of low-temperature heat are the main uses of biomass. A total of 16.3% of all dwellings (3,147,800) are heated mainly by biomass, 5.8% by coal, 27.4% by oil, 9.8% by electricity, 25.2% by natural gas, 12.4% by district heat and 3.1% by unknown fuel.

Since the beginning of the 1990s the number of houses heated by biomass has decreased significantly. Between 1994 and 1997 about 20,000 fewer buildings every year used

[10] www.proholz.at

biomass[11]. As most of these buildings are heated by old-fashioned wood boilers with very high emissions, it would be useful from an environmental point of view if these boilers were replaced. In most cases, however, these old wood boilers are being replaced by new oil or gas boilers. This trend is in line with the general development in heating systems in Austria towards more convenience, in other words a change from single stoves (for one room) to central and district heating and to grid distribution (natural gas and district heat)[12]. It also explains the increase in the number of modern biomass heating systems with high comfort (wood chip and pellet burners).

The number of apartments/houses heated with wood (-7%) and coal (-49%) is steadily decreasing, while gas (+33%), oil (+9%), electricity (+20%) and district heating (+59%) are on the increase[13].

Table 1-11: Changes in percentage of apartments/houses heated with a specific fuel

wood	-7%
coal	-49%
gas	+33%
oil	+9%
electricity	+20%
district heating	+59% only a small amount from renewable energy

In this situation wood pellets are seen as a new chance to increase the use of biomass fuels since they provide the heating convenience demanded for by customers.

In 1994, an Austrian wood briquette manufacturer imported wood pellets from Sweden and the Netherlands to test the market for wood pellet fuel together with an Austrian furnace manufacturer that also produced pellet stoves for export to the USA. The test was relatively successful and the briquette manufacturer decided to produce wood pellets too.

Initially, wood pellets were used only in stoves. Then, in a severe winter, biomass heating plants were not getting enough wood chips. This shortage was made good with pellets. This was the first time pellets had been used as fuel in biomass district heating. The prospects for their large-scale use in district heating systems is negligible, however, because they are not competitively priced in comparison with wood chips. Pellets burnt in biomass district heating plants are usually of inferior quality and are often the rejects from smaller heating systems.

[11] Österreichisches Statistisches Zentralamt (1998): Beheizung der Wohnungen 1997, Statistische Nachrichten 5/1998
[12] AEBIOM (1997): Strategies for the Development of Biomass as an Energy Carrier in Europe
[13] Energiestatistik 1995, Energiebericht der Österreichischen Bundesregierung, 1996

1.4.2 Background

Austrian energy policy and energy law

In order to ensure a sustainable energy supply that is as environmentally sound as possible but also to counteract the foreseeable exhaustion of the country's energy resources in good time, Austria started to promote the development of renewable energy sources early on. Apart from exploiting the existing energy-saving potential to the maximum, the federal government sees the best chance of meeting its carbon dioxide reduction target in the most comprehensive possible development of renewable energy sources, and particularly in an increased market penetration of biomass. According to estimates in the 1993 Energy Plan, an additional potential of 30 to 40 PJ could be mobilised if effective measures were implemented[14].

There is no uniform energy law in Austria. Energy is a classic example of an issue governed by a variety of laws. The conflict of federalism versus centralism plays an important part in the development and construction of Austrian energy legislation. Most of the distribution of tasks between the federal and provincial authorities is governed by formal Federal Constitutional Law.

Norms and emission standards

Austrian standards (so-called ÖNORMs) are not legal norms, but they establish a very important framework for the exploitation of renewable energy sources. They cover areas such as the determination of general guidelines.

In Austria, emission standards for biomass-fired systems for private houses are determined by the nine provinces and therefore vary, although there exists a lower threshold that no province may fall below. The lower threshold emission standards are shown in the following table.[15]

Table 1-12: Emission standards for biomass boilers in Austria

	CO (mg/MJ)	NO_x (mg/MJ)	HC (mg/MJ)	dust (mg/MJ)
manually operated	1,100	150	80	60
automatically operated	500	150	40	60

Fiscal measures

As a first step towards a carbon dioxide or energy tax, a tax on gas (ECU 0.0435/m³ + 20% VAT) and electricity (ECU 0.0073/kWh + 20% VAT) was introduced on 1 June 1996. This tax applies to small-scale as well as industrial users. Approximately 12% of the tax revenue is made available to the provinces for the implementation of energy-saving and environmental protection measures, including measures for the promotion of renewable energy sources.

The mineral oil tax for biodiesel is reduced (ECU 13.08 instead of ECU 282.70) and there is no tax on biodiesel used by agricultural co-operatives.

The Income Tax Act allows private investors to obtain tax credits for investments using renewable energies.

[14] E.V.A. - the Austrian Energy Agency (1998): Austria's energy policy with regard to renewable energy sources

[15] Vereinbarung gemäß Art. 15a B-VG über Schutzmaßnahmen betr. Kleinfeuerungen (23.11.94)

Subsidies
In Austria there is a huge variety of subsidy programmes to facilitate the marketing of renewable energy sources both at the federal and the provincial level, ranging from tax incentives to subsidies in sectors such as housing construction, agriculture and industry. The use of renewable energies (especially biomass heating) is subsidised in all provinces in combination with home-development schemes. Investors receive a higher level of subsidies if they integrate the use of renewable energies in their buildings. Besides the promotion of renewable energy sources within home-development schemes, there are additional subsidy programmes of limited duration. The federal programmes are aimed at the commercial, industrial and agricultural sector and are complemented by provincial programmes for the above-mentioned sectors. These programmes are probably the most important instrument in Austria for the promotion of the use of renewable energies.[16]

1.4.3 Wood pellet producers and production capacity

In Austria there are 12 companies producing wood pellets. Companies and production capacity and amount of sales is shown below.

Table 1-13: Pelletising companies, production capacity and actual production in 1999

Name and address of company	Region	Production capacity [tonnes]	Current production and sales [tonnes]
Umdasch	Lower Austria	5,000	5,000
Leitinger	Styria	20,000	8,000
Pfeiffer	Tyrol	37,000	5,000
Glechner	Upper Austria	15,000	8,000
Eberschwanger	Upper Austria	5,000	4,000
Labee	Tyrol	15,000	3,000
Pabst	Styria	5,000	1,000
Seppele	Carinthia	5,000	2,500
Krippl	Lower Austria	0,300	0,300
Loitzl	Styria	5,000	3,000
Kaufmann (solid wood)	Styria	5,000	1,000
Binder	Tyrol	1,000	0,500
Total		**118,300**	**41,300**

1.4.4 Raw material potential

On average 11.5 million cubic metres of wood are processed in Austrian sawmills per year. Wood waste (mainly sawdust) amounts to 3.5 million cubic metres, of which 2.0 million is used in the particleboard industry, leaving 1.0 million, together with 1.0 million cubic metres of bark for pelletising. An additional 0.5 million cubic metres of dry wood waste

[16] Altener Programme. Contract N° 4.1030/E/96-008: renewable energy source` legislation in Austria, Final Report of the Ener-Iure Project

comes from the timber industry and joiners. The theoretically retrievable potential is around 10 million cubic metres[17].

Between 600,000 and 1 million tonnes of raw material might be available for pelletising. Waste is also used for internal heating and drying purposes or for other production processes.

According to an estimate by the Austrian Pellet Association and Umdasch AG, the raw material potential for pelletising and the amount of pellets in the year of 2003 are as follows:

dry wood shavings	200,000 tonnes	
used already	100,000 tonnes	for briquette production
wet saw dust	600,000 tonnes	
in 1999	5,000 tonnes	for pellet production

An estimated 100,000 tonnes of pellets will be sold in 2003, compared with 41,000 tonnes at present.

Additionally there is a large amount of thinning waste from forests and small timber that is not used at present. At present, however, high labour costs and low fuel prices work against the economical exploitation of this potential.

1.4.5 Use of wood pellets and combustion units

Wood pellets are heated in stoves, boilers for central heating in single-family houses or in small district heating systems (micro-networks). The most important use is the firing of pellets in central heating systems in single- or two-family houses.

The use of pellets to fire central heating systems and stoves is expected to increase, especially in low-energy houses. Their use in district heating systems is of lesser importance since wood chips are cheaper and more readily available. Most pellets used in district heating systems are of poor quality (too much dust) and unusable in small combustion units. For very small district heating systems pellets could be of interest because they take up less space and pellet furnaces are better than wood chip heating and charging systems.

The following table shows the amount of wood pellets used in different heating systems.

Table 1-14: Combustion of wood pellets in different heating systems (1998)

Heating system	Amount of pellets [tonnes]
Stoves	4,000
Wood chip fired plants and smaller district heating systems	10,000
Pellet central heating systems (for single-family houses)	26,000

In the last few years the amount of wood pellets used in automatic heating systems has increased considerably. After a rapid rise in the number of small boilers in the early 1980s and the stagnation caused by very low oil prices, the rate of increase has remained steady

[17] Haas J., Hackstock, R., 1998: Brennstoffversorgung mit Biomassepellets. Untersuchung über die Voraussetzungen für einen verstärkten Einsatz von Biomassepellets in Holzzentralheizungen. Federal Ministry of Science and Transport, Vienna

with around 1,550 new installations a year. A significant increase occurred in 1996, followed by 2,452 new wood chip and pellet boilers in 1997 and 3,236 units in 1998. This development is due to the marked increase in automatic pellet heating systems[18].

Table 1-15: Number of pellet heating systems in Austria [as above]

year	stoves		central heating system					
	automatic		automatic and pellet tank		automatic feed and. pellet transport from storage bunker to boiler		total	
	number	total kW	number	total kW	number	total kW	number	total kW
1997	689	7,550	220	4,111	205	4,817	425	8,928
1998	353	3,023	503	8,750	820	15,389	1,323	24,139

1.4.6 Development of the pellet market

The following table shows the development of the wood pellet market and estimates the trend for the coming years on the basis of discussions with different people involved in wood pellet technology.

Table 1-16: Pellet market in Austria [in thousand tonnes]

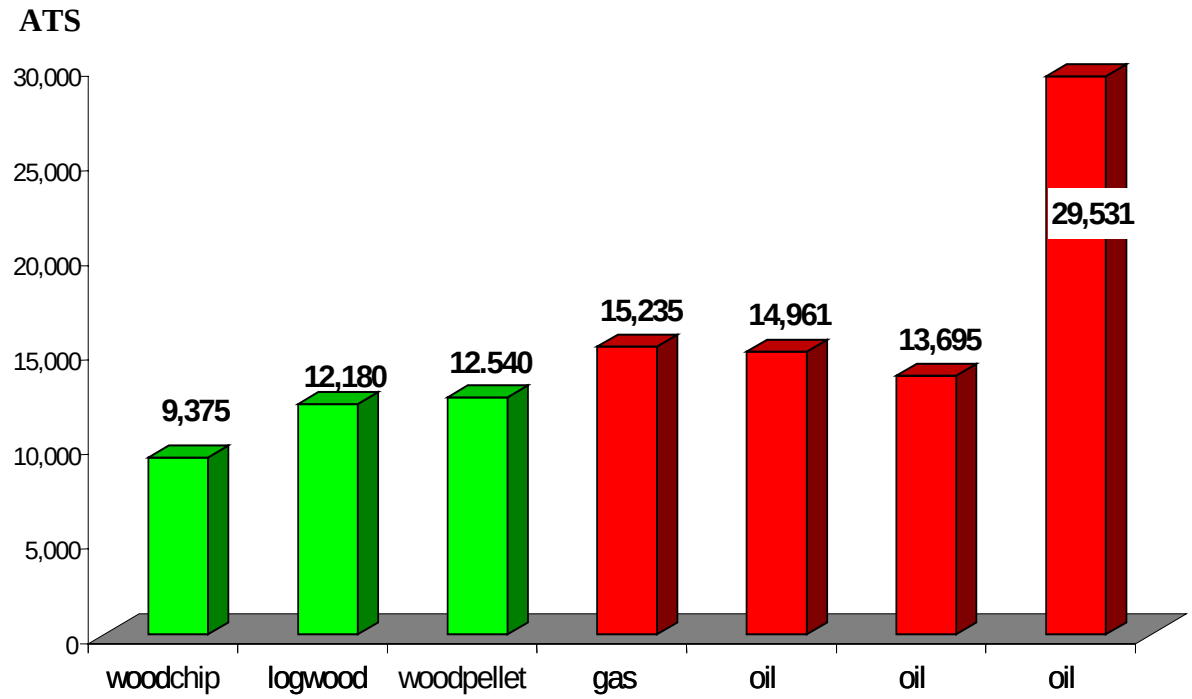
	1996	1997	1998	1999	2000	*) 2010
Production	15	20	30	35	45	200
Imports	-	-	1	1	5	20
Exports	1	1	2	2	5	20
For final use in Austria	14	19	29	34	45	200
-of which for small heating systems**)	13	18	28	33	44	190
-from which in heating plants ***)	1	1	1	1	1	10

*) estimate of the production development in the timeframe of the Commission White Paper
**) heating plants up to 100 kW
***) heating plants over 100 kW

[18] Jonas A, Haneder H, Landwirtschaftskammer NÖ, 1999: Zahlenmäßige Entwicklung der modernen Holz- und Rindenfeuerungen in Österreich)

1.4.7 Fuel prices

Figure 1-1: Annual fuel costs for 15 kW heating output without hot water supply (22,500 kWh usable energy, 1,500 full-load hours) according to Ö-Norm; adjusted for efficiency; including sales tax and delivery (December 1999)



	Softwood chips	hardwood	blown in	inclusive counter rent	inclusive delivery fee*	∅ 15 years	South Tirol
price/unit	250.-/Srm	700.-/rm	2,20 /kg	0,595/kWh	5,20 /l	4,75 /l	10,50 /l
fuel amount	38 Srm	17,4 rm	5,7 t	25.000 kWh	2.813 l	2.813 l	2.813 l

* delivery fee: ATS 336

Table 1-17: Current fuel costs/kWh in Austria (22,500 kWh usable energy, 1,500 full-load hours, fuel price per unit as shown in the table above)

	Average price per kWh [ATS]	Average price per kWh [EUR]
wood chips	0.417	0.0303
logs	0.541	0.0393
pellets	0.557	0.0405
gas	0.677	0.0492
fuel oil (recently)	0.665	0.0483
fuel oil average past 15 years)	0.609	0.0442
electricity (January 2000)	2.100	0.1526

In terms of energy content (calorific value) fuel wood pellets and oil are similar in price.

It is not so much fuel prices as the high investment costs for biomass and pellet furnaces that hinder market penetration in Austria.

1.5 THE WOOD PELLET FUEL INDUSTRY IN THE USA AND CANADA

1.5.1 History and background

The wood pellet fuel industry became established in the mid-1980s with the introduction of the residential wood pellet stove. This appliance was capable of reducing particulate emissions well below the new EPA requirements for wood stoves and of providing consumers with a new level of automation and convenience for heating with wood.

Sales of pellet stoves increased rapidly in the early 1990s, reaching a peak in 1994 and thereafter levelling off and declining somewhat with the competition of natural gas stoves. Pellet fuel sales followed the demand curve produced by residential pellet stoves. Residential use has accounted for approximately 95% of sales during this period, the balance being industrial use. Pellet fuel sales during the period 1993 to 1998 amounted to 500,000 to 600,000 tons per year.

Pellet fuel accounts for about 0.025% of residential space heat demand in the US.

1.5.2 Production of wood pellets

In 1984 there were two pellet plants operating in the Pacific Northwest of the US. The figure in Chapter 7 lists most of the operating wood pellet plants in North America today.

The majority of pellet plants are owned by small companies established specifically for that purpose. Large forest product companies (with two exceptions) have not generally participated in this business.

The raw material used is commonly sawdust. Shavings and chips are used to a lesser extent. The industry is a mix of stand-alone plants, whose only business is pellet production, and plants that are part of other wood-processing companies. The stand-alone firms buy their raw materials on the open market and tend to be larger producers. The add-on operations usually process only the residues generated by the company's wood-processing activities.

The wood pellet industry has a history of slow plant start-ups. Many plants have required six to eighteen months after starting to normalise operations. This long period of low production causes larger than expected financial losses and often totally drains working capital. The long start-up periods were due to a variety of factors including:

- variations in raw materials
- inadequate design and engineering
- use of worn-out or improperly sized equipment and
- inexperience on the part of management and production workers

There has been a noticeable improvement in start-up times in the past two years. This is probably due to firms doing their homework before entering the business, improved equipment, better overall plant design and installation by equipment/engineering firms, and the information and assistance provided by other pellet producers.

1.5.3 Production process and pellet plant equipment

Wood pelletising plants in the US and Canada come in all shapes and sizes. They range in **production rate** from 0.75 to 15 tons per hour (TPH). Differences are mostly based on amount and size of equipment, but species of wood is also a factor. Generally plants processing softwoods have a higher production rate per hour than similar sized machines processing hardwoods. For the years 1990 to 1992 industry experts estimated that hardwood pelletising productivity was 50% less than that of softwood. Significant gains were made thereafter and in 1994 it was generally believed that hardwood output per hour was about 25% less than softwood. Generally speaking the rate of production for softwoods on identical equipment is about 20 to 25% higher. When bark is included in the raw material, production also rises, but fuel quality will deteriorates.

For the sake of discussion, plants are divided here into three sizes: 1 TPH, 3 to 4 TPH, and 7 to 8 TPH. It is assumed that the raw material is either soft or hardwood, free of bark with an ash content of 0.8% or less. Most agricultural by-products are processed at approximately the same production rates, but at a much lower cost.

Drying equipment is a must when grinding and pelletising wet green wood. The drying system equipment and installation can be bypassed if dry wood (under 12% moisture) is used. In the plant diagram the dryer system is up front in the flow and is easy to connect or deactivated as required. Dry wood is fed directly to the primary or secondary grinder, depending on particle size received.

Grinding is normally done with either one or two systems. No grinder is needed if the incoming raw material is already 3,000 microns or smaller (1/8" particle size). Raw material of matchbook size and smaller can be reduced with a single hammer mill. Incoming raw material larger than matchbook size generally needs to be processed using two grinding systems. Occasionally very large raw material such as slab wood or pallets requires a separate initial breakdown machine such as a rotary grinder or low torque shredder.

1.5.4 Production costs

In order to compare plant costs between the different sizes, the following assumptions are made for all three plants:

- The raw material is green, mixed-species wood residue from sawmills.
- The mix consists of sawdust, ends, broken pieces and a small amount of sander dust.
- The systems all use dryers (cost to be deducted if dry wood is used).
- All systems are priced on an installed basis (all welding, motor control stations, wiring, sprinkler system, structural system and distribution systems are part of installed cost).
- Where used equipment is utilised, 50% is to be deducted from the cost of that piece of equipment piece. Installation costs are the same for new and used equipment.
- The basic building to house equipment is included, but not the warehouse. It is assumed that the dryer is located outside. The office is not included either.

Production cost of wood pellets depends on the size of plant and annual production levels. Using green sawdust residues (50% moisture), average direct production costs are approximately US $42/ton including electrical, drying, pelletising, labour and bagging in 40 lb bags. Including indirect costs, sawdust residue costs and maintenance costs the average range of total production cost per ton is $82 to $95.

Table 1-18: Wood pellet plant operating costs (USD per finished ton, 2000 lb)

DIRECT PRODUCTION COST:	USD
raw material	8 - 40
labour (includes supervisory and overhead)	8 - 12
electric power and motor fuel	6 - 10
bagging (includes pallets, bags)	13 - 17
dies and rollers	2 - 6
maintenance	6 - 9
dryer fuel	0 - 8
GENERAL ADMINISTRATIVE COST	USD
management and office	2 - 4
insurance	2 - 4
marketing	2 - 5
inventory and storage	2 - 6
debt service	6 - 15
AVERAGE RANGE OF TOTAL COSTS PER TON	82 - 95

Many established plants have total costs in the range of $82 to $95 per ton. This assumes raw material costs are in the range of $12 and $20 per ton. Raw material costs have been increasing rapidly in some areas, and there are indications that many plants will face significantly higher feed stock costs in the future.

As far as other operating costs are concerned, the industry presents a fairly normal profile in terms of operating efficiency. Generally, the larger plants have lower per ton costs for labour, maintenance and related direct production expenses. Some larger firms report, however, that the cost savings they gain by increasing output are often offset by the increased cost of reaching out further for raw materials to support the higher production.

Cost and longer term availability of feed stock are probably the most significant factors in determining the feasibility of a pellet plant.

1.5.5 Use of wood pellets and heating costs

About 95% of pellet sales are used for firing in residential buildings, most of them in pellet stoves. the Figures below show a comparison of heating cost based on different fuels.

Figure 1-2: Heating costs in the US

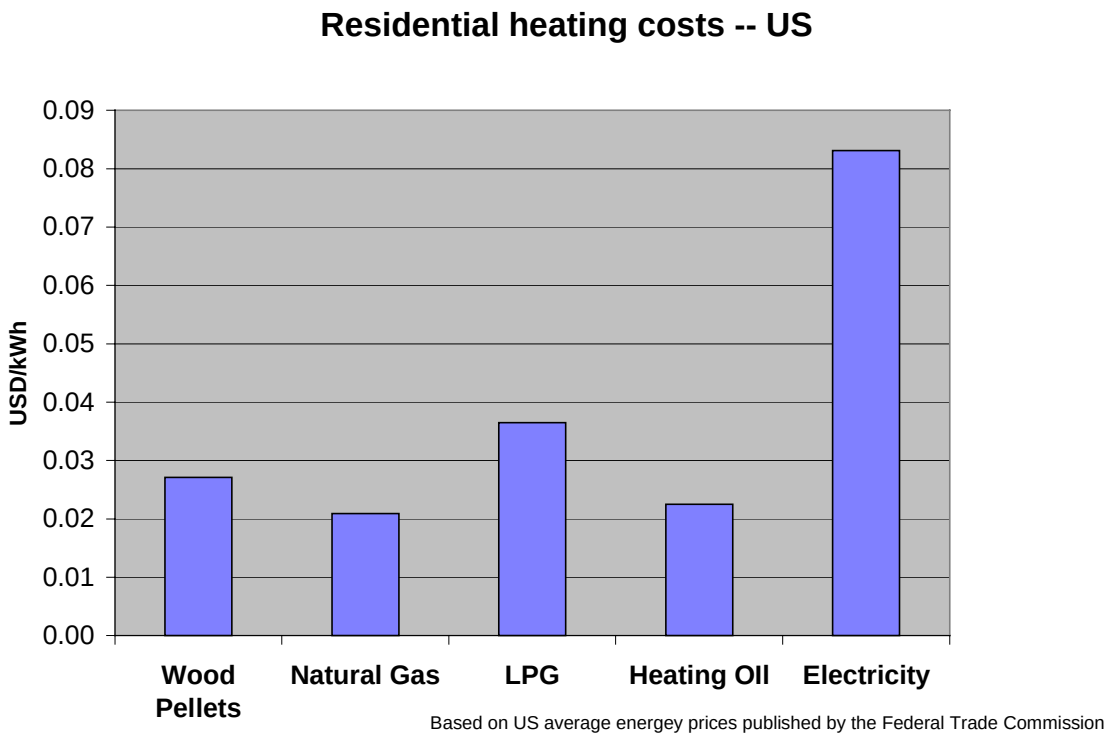


Table 1-19: Residential heat energy costs in US

Fuel	**Cost**	Equivalent cost in USD/MMBtu	**Cost ratio re pellets**	**Equivalent cost in USD/kWh**
Wood pellets	$135/ton	7.94	1.00	0.027
Natural gas	61.2¢/therm	6.12	0.77	0.021
LPG	$0.98/gal	10.69	1.35	0.036
Heating oil	$0.99/gal	6.60	0.83	0.023
Electricity	8.31¢/kWh	24.35	3.07	0.083

Based on US average energy prices published by the Federal Trade Commission 10 February 1997.

1.5.6 Distribution and marketing

Pellets are sold to the residential market in 40 lb bags by way of single-step distribution (retailers). The retailers are speciality hearth shops, home centres, hardware stores, grocery stores and farm stores. Consumers purchase pellets by the bag or by the ton (50 bags stacked on a pallet). A few retailers provide a home delivery service. There is no bulk delivery service to the consumer.

Residential prices of heating fuels are shown in the next figure, compared on a kWh basis. The average retail price of bagged wood pellets is assumed to be $135/ton.

Pellet sales survey – 1993-1999
Bagged fuel pellet sales in the 1998-99 heating season were approximately 681,000 tons. A total of 60 firms reported making pellets. (PFI data from US and Canada, data is collected on a regional basis).

The regional distribution of pellet sales for the past five years is shown on the chart below. It also contains the annual appliance sales as reported by the Hearth Products Association (HPA). Total pellet sales decreased by about 1.3% in the 1998-1999 season, whereas appliance sales decreased by 15%. For the season 1999-2000 a further dramatic decrease in appliance sales is anticipated due to the millennium expectation that electricity supply will not be guaranteed and that homeowners will not be able to heat their homes. A further reason for the decrease in appliance sales is the greater availability of natural gas, which induces consumers to change to fossil fuel because of the very low environmental protection mentality and awareness. The western US (Pacific and Mountain) continues to be the largest market, accounting for almost 50% of the total bagged fuel sales, and the Northeast continues to claim approximately 22% of the market.

Table 1-20: Pellet sales in US 1993 - 1999 [tons]

REGION YEAR	**1998-1999**	**1997-1998**	**1996-1997**	**1995-1996**	**1994-1995**	**1993-1994**
US Pacific	231,000	236,000	228,000	262,000	293,000	239,000
Mountain	120,000	108,000	108,000	123,000	120,000	130,000
Central	31,000	49,000	36,000	19,000	15,000	18,000
Great Lakes	27,000	22,000	45,000	36,000	24,000	26,000
Northeast	135,000	154,000	143,000	107,000	84,000	62,000
Southeast	58,000	49,000	49,000	39,000	34,000	21,000
Canada (Maritimes/Quebec)	42,000	40,000	38,000	33,000	16,000	10,000
Ontario/Saskatchewan/ Manitoba	21,000	19,000	18,000	19,000	16,000	10,000
Alberta/BC	16,000	13,000	17,000	16,000	8,000	7,000
TOTALS	**681,000**	**690,000**	**682,000**	**654,000**	**610,000**	**523,000**
Total pellet stove sales	**34,000 (US only)**	**40,000 (US only)**	**36,000 (US only)**	**47,500 (US + CAN)**	**76,150 (US + CAN)**	**70,000 (US + CAN)**

1.5.7 Expansion into Europe

Because of the decreasing appliance sales in US and Canada, most stove manufacturers try to export into Europe, without being aware of the very high quality, service and reliability expectations of European consumers. Unless US and Canadian products are specially tuned and modified for the European market, they will not pass the strong emission and efficiency tests required by European governments.

European importers of such products should be aware that the US and Canadian way of promoting such products in their home market is completely different to that commonly used in Europe and should check well in advance before importing such products whether CE certification is feasible.

1.5.8 Outlook for European manufacturers

Many small and medium-sized companies are very enthusiastic about manufacturing pellet fuelled stoves and central heating plants, but most of them do not have enough financial resources to research long enough to develop and guarantee trouble-free high-convenience products. Many manufacturers have to sell their products before development is complete in order to maintain the liquidity of the company. It is not uncommon for the final adjustment to take place in the homes of end users, which is to the disadvantage of this outstanding heating technology idea.

Almost all large and financially healthy companies in the central heating business throughout Europe have an eye on this new heating technology. It is expected that they will step into this business once the small and medium-sized companies have invested enough to guarantee a decent return on investment – to the disadvantage, of course, of the existing small and medium-sized pioneers. On the other hand this is the only possible way to gain access to adequate financial resources and a large sales territory. Both are necessary to guarantee highly developed mass production and to force product prices down to a level that is competitive with fossil fuel products.

Until this happens, the European Union and the national governments should strongly support the present companies with loan and support programmes and at the same time promote this new idea of CO_2-neutral heating. In no way should VAT be brought to the level of fossil fuels, as the fossil fuel lobby is currently trying to achieve in countries such as Austria.

1.5.9 Promotion of pellet fuel

Most pellet fuel and stove manufacturers promote wood pellets through retail dealers using print (newspaper), radio, and some television advertising. The national industrial associations – Pellet Fuels Institute (PFI) and Hearth Products Association (HPA) – distribute informational brochures and leaflets. The PFI conducts a consumer awareness campaign through the news media, funded by the manufacturer members. To boost the pellet industry further, the industry must continue the consumer awareness campaign and promote the industry's environmental benefits. Pellets are a renewable fuel and can be burned cleanly and efficiently.

2 PRODUCTION OF WOOD PELLETS

2.1 SHORT DISCRIPTION OF PRODUCTION TECHNOLOGIES

Generally the manufacture of wood pellets involves the following processes:

1.	hogging/grinding	The raw material is hogged to a small and uniform particle size.
2.	drying	The wood dust is dried to a moisture level of 8 to 10% using wood or natural gas as fuel in a rotary drum dryer.
3.	pelletising	The dry wood dust is extruded into pellets using conventional pellet mills, often with dry steam conditioning. No additives are normally used. The lignin in the wood acts as a binding agent as it softens during the pelletising process.
4.	cooling	The pellets are immediately air quenched to set up the lignin and thus stabilise the pellet.
5.	fines separation	Residual fines are separated and returned to the process.
6.	bagging/storing	The pellets are bagged automatically in bags or big bags or stored in a silo.

Biomass is usually processed to pellets and briquettes in a stationary plant, using piston or roller presses with perforated dies. The raw material used may be sawdust, shavings or chips. Various factors – the effect of raw material type, water content, degree of comminution and type of press die, for example – affect pelletising parameters such as the power and energy requirement, pellet quality or material throughput. The comminution and water content of the raw material can be seen as key parameters.

Binding materials also affect production rate, power requirement, pellet quality and costs. Tests have been run with different herbaceous crops, but extrapolation to wood material is not possible. As a result, the disadvantages of the additional costs cannot be made good through the advantages of lower power demand, higher throughput and improved pellet quality.

Special pelletising technology and experiences in the US are described in Chapters 1.5.2 to 1.5.4

2.1.1 Traditional technique

Pelletising consists basically of at least four steps. It must be remembered that most raw materials are wet and that the raw material available in future will also be wet.

The pelletising process comprises:

DRYING – MILLING – PELLETISING – COOLING

DRYING: The raw material cannot be pelletised with a moisture content of more than 17%. All existing dryers – drum dryer, steam dryer (direct or indirect) and hot air dryer – are in use.

MILLING: The raw material has to be milled to produce uniform material for feeding to the pellet mill. A hammer mill is normally used. The screen size depends on the diameter of the pellets to be produced. The hammer mill is normally powered by an electric motor. The energy is converted into heat, which is also used to extract further moisture from the raw material at this stage.

PELLETISING is carried out in a normal pellet mill. Loose material is fed into the pelletising cavity. Die rotation and roller pressure force the material through die, compressing it into pellets. Adjustable knives cut the pellets to the desired length. Pellet mills can be of the flat-die or vertical mounted ring die type. In the former case the die is mounted flat and remains stationary while the powered rollers rotate. With the ring die, it is the die that rotates. As the raw material comes into the gap between the die and roller the roller starts to rotate and presses the material through the holes in the die. As with the hammer mill, a certain amount of additional moisture is extracted with the pellet mill.

COOLING is a very important part in the process. When the pellet leaves the pellet mill it is very hot (normally 90 to 95°C). The pelletising process releases moisture, which has to be removed along with the heat. The cooling process helps to stabilise, harden and form the pellets.

FINES SEPARATION (optional). Residual fines are separated and returned to the process.

BAGGING/STORING (optional). The pellets are bagged automatically (small bags 25 kg, 40 lb, big bags) or stored in a silo.

Main **criteria for achieving high-quality pellets:**

- homogeneous raw material
- well conditioned raw material
- right die specification

Usual technical design and installation of a pellet plant:

dryer:	boiler rating for dryer, 1 MW/tonne dried moister (water)
milling:	15 kW/ton MILLED raw material.
pellet mill:	60 kW/tonne produced pellets
cooling:	fan with 5 kW/tonne cooled pellets

2.1.2 Steam explosion process

The largest pellet producer in Norway, Cambi Bioenergi Vestmarka, has developed an experimental pellet production plant that produces pellets of dark brown colour, which are much harder, have higher specific weight and less sensitivity to moisture and separation of fines. The technology is unique. By preconditioning the raw material to release the natural lignin in wood, pellets of higher quality are produced [19].

[19] For further information: Fastbränslepannor, Bengt Nilsson ABB, Glimmervägen 23, S-65350 Karlstad, Sweden.

The general process is described below:

The raw material (sawdust) is preconditioned by heating a steam-compression reactor. After a certain exposure time the pressure is reduced, causing the material to „explode". This process only works under certain defined conditions. After this procedure the wood comes out from the vessel in the form of wood fibre, which is very wet and brown in colour. The pelletised material is of extremely high quality (hard, durable, with few fines). This preconditioning process also doubles the pellet mill production capacity.

The plant in Norway is a prototype plant and has yet to be upgraded into a commercial plant. It was designed to investigate the influence of conditioning on the pelletising process. The results have been highly promising, with a 100% increase in the pellet mill capacity. The bulk density of the pellets is 850 kg/m³. The good results are attributable to the separation of the natural lignin and hence to an improvement in the binding and lubrication.

Unfortunately no further details or economic data are available at present.

2.1.3 ETS pelletising technology

The Italian company EcoTre System has developed a patented pelletising technology for industrial use. The aim of the development was to minimise energy consumption [20].

The process is completely new and marks a departure from traditional pellet manufacturing designs. Specific electric consumption ranges from 0.025 kWh/kg (i.e. 0.0113 kWh/lb) to 0.045 kWh/kg (i.e. 0.0204 kWh/lb) depending on the type of wood.

The mechanical design and logistics are also new. The pelletiser has two grooved dies and pellets are drawn from outside towards inside each dye.

The system operates without any additives to the material to be pelletised and the maximum operating temperature of the dies is 55 to 60°C, when the equipment reaches its maximum production capacity.

The low-temperature die operation offers several advantages: no fumes or vapours, direct pellet bagging without additional cooling devices; simplicity and lower investment costs.

With the new pellets extraction/dedusting system, the finished product can be bagged at a temperature very close to ambient temperature.

The pelletiser can handle material with 30 to 35% humidity, thereby doing away with the need for a dryer. It can also handle wood chips and shavings, which can be refined using a suitable mill.

All operation are automated and monitored on a control panel with a microprocessor, which automatically adapts the operating parameters to the characteristics of the material to be pelletised.

Clogging is easily removed by reverting the rotation of the dies without any further dismantling or other operations.

There are no special handling requirements before the material enters the pelletiser.

20 Emidio TOSI, EcoTre System s.r.l., Via delle Cantine 12, I-50040 Settimello (FI)

Depending from the type of wood sawdust, the bulk density of pellets (with 6 mm diameter and a 12 mm average length) can vary from 650 to 780 kg/m^3, while the specific weight can reach up to 1.5 kg/dm^3.

All specifications and characteristics comply with the strictest official European and American standards.

2.2 RAW MATERIALS AND POTENTIAL

The most common raw materials for manufacturing wood pellets are

- shavings
- sawdust.

Shavings generally accumulating in woodworking companies are dry, while sawdust from the forest and timber industry has a water content of up to 50%. Because of the differences in moisture content different preconditioning treatments are required before pelletising (depending on the pelletising technology).

Other raw materials for manufacturing fuel pellets include:
- bark
- wood chips (from forests or short rotation coppice)
- agricultural stalk crops (straw, grass)
- sorted household waste
- paper
- wood waste

In Växjö (Sweden), for example, one manufacturer produces 20,000 tonnes/year from sorted household waste. Paper has been pelletised on a relatively large scale in Sweden but it has not been profitable. Different raw materials require appropriate preconditioning and/or pelletising technology.

Pelletising other raw materials apart from wood is not of interest at present because in most European countries there is enough sawdust. The next step could be the use of wood chips from forest residues and later wood for conversion into energy from short rotation coppices.

Pellet manufacturing and combustion cannot be seen in isolation and the social framework – energy price, agriculture situation and labour costs – are important factors that can affect the profitability of pellet production.

The choice of raw material is also a question of marketing strategy. If wood pellets are to be introduced on the market as renewable and environmentally sound fuel, precautions measures should be taken to prevent „ecological dumping“.

2.3 PELLET QUALITY AND QUALITY STANDARDS

2.3.1 Quality aspects and standardisation

There are two basic criteria for judging biofuel quality: *chemical and compositional characteristics* and *physical characteristics*. The first group includes criteria such as the concentration of certain elements (Cl, N, S, K and heavy metals), the ash and water content, and the calorific value and ash melting behaviour. The physical characteristics listed in the second group describe the visual parameters and the type of processing that the biomass has undergone

Table 2-1 Quality characteristics of biofuels

Parameter	Effects
Chemical and compositional characteristics	
Water content	storability, calorific value, losses, self-ignition
Calorific value	fuel utilisation, plant design
Element content	
Cl	HCl, dioxin/furane emissions, corrosion in superheaters
N	NO_x, HCN and N_2O emissions
S	SO_x emissions
K	corrosion in superheaters, reduction of ash melting point
Mg, Ca, P	raising of ash melting point, effect on pollutant retention in ashes and use of ashes
Heavy metals	pollutant emissions, use or disposal of ashes
Ash content	particle emissions, costs for use or disposal of ashes
Ash softening behaviour	operational safety, level of pollutant emissions
Fungi spores	health risks during fuel handling
Physical characteristics	
Storage or bulk density	transport and storage expenditures, logistical planning
Unit density	combustion properties (specific heat conductivity, rate of gasification)
Particle size distribution	pourability, bridge-building tendency, operational safety during fuel conveying, drying properties, dust formation
Share of fines	bulk density, transportation losses, dust formation
Durability (for pellets, briquettes)	quality changes during transhipment, disintegration, fuel losses

During pelletisation it is mainly the physical characteristics of the fuel that are affected. Additionally, both the mean water content and the uniformity of the moisture distribution are drastically improved. Further changes in the chemical composition are unlikely, since the use of chemical or natural additives other than water is usually prohibited during the production of wood pellets.

The pellet quality cannot be defined without reference to heating technology, since different heating systems require different fuel qualities. For large heating plants durability of pellets and amount of fines is less important, whereas for use in pellet stoves the pellets must be extremely durable so that they do not produce too much dust in the storage bunker and do not cause technical problems in the feeding and combustion unit.

However, there are still a number of unanswered questions with regard to pellet quality parameters and production technology. The influence of chemical or biological wood parameters on the pelletising process and pellet quality (e.g. fibre content, different chemicals, growth conditions of wood) is unclear. In addition, a number of technical influences (temperature, pressure, die, etc.) influencing pelletising quality are not yet completely understood. For this reason the technical, chemical or physical factors influencing pellet quality during the pelletising process need to be further analysed.

2.3.2 Quality standards

European and US (PFI recommended) quality standards for fuel pellets are shown in the following table.

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 Sweden if binding agents are used amount and sort have to be declared.

The CEN (European Committee for Standardization) and national standardisation institutes are co-operating to prepare a European standard for biomass fuels. At present the working group is discussing the materials that may be as biomass and whether only wood and agricultural biomass or also peat and household waste should be included.

The table on the next page shows quality standards in different countries.

Table 2-2: Comparison of pellet standards of different countries

Specification	**Austria** ÖNORM M 7135		**Sweden** SS 18 71 20			**Germany** DIN 51731			**USA** Pellet Fuels Institute	
	compressed wood	compressed bark	group 1	group 2	group 3	5 length categories otherwise the same [cm]			standard grade	premium grade
dimensions	- pellets: 4 - 20 mm diameter max.100 mm long	- briquettes: 20-120 mm diameter max 400 mm long	max. length 4x diameter**)	max. length 5x diameter	max. length 6x diameter	HP1 HP2 HP3 HP4 HP5	>30 length 15-30 10-16 <10 <5	>10cm ∅ 6-10 3-7 1-4 0,4-1	6-7,5 mm ∅ < 3,6 cm	6-7,5 mm ∅ < 3,6 cm
bulk density			≥ 600 kg/m^3**)	≥ 500 kg/m^3	≥ 500 kg/m^3					>40 pounds/cubic ft. +) = 639kg/m^3
durability/fines in % <3mm*)**			≤ 0.8	≤ 1.5	≤ 1.5				<0,5% through a screen of 3mm	<0,5% through a screen of 3mm
unit density (US)	≥ 1.0 kg/dm³	≥ 1.0 kg/dm³				1-1.4 g/cm³				
water content	≤ 12%	≤ 18%	≤ 10%	≤ 10%	≤ 12%	<12%				
ash content	≤ 0.5%*)	≤ 6.0%*)	≤ 0.7%	≤ 1.5%	>1.5%	<1.5%			<3%	<1 %
total moisture content (at delivery)			≤ 10%	≤ 10%	≤ 12%					
(lower) calorific value	≥ 18.0 MJ/kg*)	≥ 18.0 MJ/kg*)	≥ 16.9MJ/kg ≥ 4.7 kWh/kg	≥ 16.9MJ/kg 4.7 kWh/kg	≥ 16.9MJ/kg 4.7 kWh/kg	17.5 - 19.5 MJ/kg ***)				
sulphur	≤ 0.04%*)	≤ 0.08%*)	≤ 0.08%	≤ 0.08%	to be indicated	<0.08				
nitrogen	≤ 0.3%*)	≤ 0.6%*)				<0.3				
chlorine	≤ 0.02%*)	≤ 0.04%*)	≤ 0.03%	≤ 0.03%	to be indicated	<0.03				
arsenic						<0.8 mg/kg				
cadmium						<0.5 mg/kg				
chromium						<8 mg/kg				
copper						<5 mg/kg				
mercury						<0.05 mg/kg				
lead						<10 mg/kg				
zinc						<100 mg/kg				
extractable organic halogens						<3 mg/kg				
impurities	made only of un-contaminated wood	made only of un-contaminated bark								
binding agents	forbidden	forbidden	amount and sort has to be declared							
ash melting point			initial temperature has to be declared							

*) relative to dry matter
**) in manufacturing warehouse
***) water and ash free; +) pound = 453.5 g cubic foot = 0,02832m^3 = 639kg/m^3; bulk weight: Srm = formed room metre

Austrian pellet standard(s)

There is a uniform standard for pellets and briquettes (ÖNORM 7135). Pellets or briquettes must be made only of pure wood, binding agents are not allowed. At present standardisation of durability and the mount of fines is under debate. A durability standard for pellets is currently being discussed and prepared. Durability will define the mechanical strength of pellets to withstand the production of fines during transport.

The Austrian Federal Ministry for the Environment has devised a special environment label for biomass fuels – briquettes and pellets (Umweltzeichen, UZ 38). Only raw material from natural wood is allowed (sawdust, shavings, etc.). Use of materials such as packaging, coatings, glues, chipboard or fibreboard residues is forbidden. Chemical parameters, testing methods and limit values are similar to those in ÖNORM 7135. At present no Austrian pellet manufacturer has applied for this label.

The Austrian Pellet Association has developed a special label (quality seal) for association members (pellet and furnace manufacturer, retailers). The label is a sign of high pellet, stove and boiler, and maintenance and delivery quality[21].

German pellet standard

A German DIN standard exists for wood pellets. The limit values and conditions for wood fuel pellets or briquettes are shown in the table (DIN 51731[22]).

Apart from the pellet or briquette shape the unit density and the chemical composition are defined.

Pellet quality, national standards in Norway

The Norwegian Society for Construction and Standardisation (NBS – Norges Bygging- og Standardiseringforbund, Oslo) is at present working on this question. A standard for pellets does not yet exist, but it is possible that the Swedish standard will also be introduced and used in Norway.

The quality can vary, depending on local production condition and raw material. Variety also depends on the different types of production (white pellets from conventional pellet mills and brown pellets from steam reactor process, which tend to be much harder and more durable).

US pellet standard

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

[21] http://www.pelletsverband.at

[22] DIN 51731 (1996): Test of solid fuels - compressed wood and compressed bark in natural state - pellets and briquettes - requirements and test specifications [in German], Deutsches Institut für Normung, Beuth Verlag, Berlin, 3 pages

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).

General discussion
An alignment of pellet standards and testing methods in all EU countries would be highly desirable. Standardisation of the amount of fines, the durability and mechanical strength of pellets and appropriate testing methods are the main questions needing to be solved.

The number of parameters should be limited to the essential ones, and over-regulation should be avoided.

Pellet quality cannot be defined without reference to heating technology, since different heating systems require different fuel qualities. For large heating plants durability of pellets and amount of fines is less important, whereas for use in pellet stoves the pellets must be extremely durable so that they do not produce too much dust in the storage bunker and do not cause technical problems in the feeding and combustion unit. At least two groups of pellet standards should be defined for different combustion purposes (large-scale and small combustion units).

Although bulk density is included in most national standards, there is a problem that bulk density is highly influenced by the amount of fines and dimension of pellets.

For small combustion units in particular a uniform pellet length is important, but it is difficult to standardise this parameter since the length changes during transport. Because of the design of the dies it is also difficult to control maximum pellet length during the production process.

To maintain a good product image („pure wood“) it must be ensured that the raw material is not of inferior quality and that it does not contain impurities. The question of binding agents must also be taken into account. In most standards binding agents are not allowed or at least have to be declared.

2.3.3 Binding agents or conditioning

Pellets should be highly durable without producing too much dust during transport and filling of storage bunkers. There are several ways in which this aim can be achieved:

- adding binding agents
- conditioning the raw material
- varying the pelletising process itself
- combinations of the above

In principle the need for binding agents to achieve high pellet quality should be carefully considered. Pelletising experts fail to agree on this point. Most of them say that it is not necessary and that high-quality pellets with few fines can be obtained by using an appropriate preconditioning process and pelletising technique. In practice recently several manufacturers have started to add 0.5% to 2% starch.

Possible **binding agents** include:
- starch
- molasses
- natural paraffin
- plant oil
- lignin sulphate
- synthetic agents

Such additives may be useful for other fuel resources such as herbaceous crops (straw, grain, elephant grass and hay). Under the German emission control legislation molasses as a residue from sugar production, natural paraffin or starch are permissible (1. BImschV §3 (4))[23].

These additives are commonly used in forage pelletising to improve the physical characteristics of the pellets. Apart from these desirable benefits, additives are also conceivable as a means of improving some chemical compositional characteristics. For example slag formation can be hindered by using kaolin or calcium and magnesium oxides.

Alterations to the pelletising technology – changing the thickness of dies, pressing time, pressing temperatures and pressure – can help to improve pellet quality without binding agents. Conditioning of raw material by steam explosion (see Chapter 2.1.2) is another way of obtaining high quality pellets, albeit an expensive one.

Considerable discussion on binding agents has also taken place in Sweden. Several products were tested before it was found that lignin produced the best results. Lignin is a natural wood constituent. Lignin sulphate is a by-product of pulp and paper production. The binding quality of lignin sulphate is good but it also increases the sulphur and ash content, which can cause problems with the firing equipment. Another problem is sulphur emissions. One of the arguments for bioenergy is that there are NO sulphur emissions. Spruce and pine bark has proved to be a good binding agent in practice.

2.4 ENERGY CONSUMPTION FOR PELLETISING AND DRYING

Pelletising machinery has a throughput of about 4 tonnes/hour of raw wood material. Conditioning of raw material (temperature, moisture, drying, crushing) also affects throughput.

Energy demand for wood pelletising (including conditioning) is 80 to 130 kWh/t. The actual amount depends on different production factors (lubricants, screening, crushing, die, etc.).

In general pellet manufactures say that around 1.5% - 2% of the energy content of the pellet is necessary for pelletising process (not including drying of raw material). Including the drying process with wet raw material (sawdust) 7 to 10% of the energy content of pellet is needed for pelletising. If wood chips are pelletised about 20% of the energy content would be required for the manufacturing process (including drying and crushing). These data refer

[23] BImSchG (1997): Bundes-Immissionsschutzgesetz. Feldhaus, G. und Hansel, H.D. (revised), C. F. Müller Verlag, Heidelberg, 11th edition, 646 pages

to investigations done by *Raggam & Bergmair* in 1996 [24] who state an energy content of wood (atro) of 5200 kWh / ton.

The problem with this analyses is that kWh-power (for the pelletising machinery) is mixed up with kWh-heat (energy content of wood), which is not allowable from the physical point of view. Moreover raw material for pelletizing is never absoluty dry, therefor real percentage of energy demand for pelletzing must be higher:

One ton of dry wood contains the energy equivalent of 1000 kWh-power or 4500 kWh-heat. Based on this physical fact the above mentioned percentage of energy demand for pelletising should be as follows:

- 8 to 13% of the energy content of the pellet is necessary for pelletising dry raw material
- 10 to 25% of the energy content of pellet is needed for pelletising including the drying process with wet raw material (sawdust)
- 18 to 35% of the energy content would be required for the manufacturing process for pelletising of wood chips (including drying and crushing)

In the USA the **production rate** varies from 0.75 to 15 tons per hour (TPH). Differences mostly result from the amount and size of equipment, but the species of wood is also a factor. Generally speaking softwoods are processed at a 20 to 25 percent higher rate of production on identical equipment. When bark is included in the raw material, production also rises but fuel quality deteriorates. For this discussion, plants are divided into three sizes: 1 TPH, 3 to 4 TPH, and 7 to 8 TPH.

[24] Raggam, A., Bergmair J., 1996: Gesamtenergieaufwand bei der Herstellung von Hackgut und Pellets. Forschungsinsitut für alternative Energienutzung und Biomasseverwertung. Im Auftrag der Regionalenergie Steiermark.

3 APPLICATIONS AND COMBUSTION TECHNOLOGY

3.1 USES OF WOOD PELLET HEATING SYSTEMS

Wood pellets for heating residential buildings
The technical development of small wood pellet boilers has progressed considerably during the last few years. Alongside biomass district heating systems, fully automatic wood chip burning boilers and wood pellet boilers can also be used in areas with high building density with the same convenience as conventional oil or gas heating systems.

The main uses of wood pellets for space heating are as follows:

a large-scale district heating systems
b medium-sized district heating systems
c small-scale district heating for residential buildings in high and medium density housing (micro-networks)
d central heating systems for single houses
e chimney ovens and stoves

Comments

a Large-scale district heating systems
This application is found primarily in Sweden because of:
- low pellet costs (pellet producers have a poor income situation)
- low to medium prices for fossil energy for industry (imported coal, heavy oil)
For large units there is high and critical competition from wood chips and straw. In Germany and Austria pellet combustion in large furnaces for industry and district heating is not likely because of the economical conditions there.

b Medium-sized district heating systems
The situation in Germany and Austria is the same as for large-scale district heating units. In Bavaria there is one demonstration unit running with 10 MW output in a hot air dryer. Pellets are in competition with chopped straw and wood chips.

c Small-scale district heating for residential buildings (micro-networks).
In areas with a poor wood chip and straw supply, wood and straw pellets are economically viable if the price of light fuel oil is higher then 0.80 DEM/l. This has been the case in Germany since January 2000. A technical and econimcal advantage is that wood pellets reduce the technical complexity of storage, pellet feed and conveyor units and herefor investment costs are lower.

d Central heating systems for individual houses
Where fuel oil prices are high wood pellets can compete with fossil energy. The smaller the unit, the bigger the advantage of pellet furnaces compared with logs and wood chip incineration. Many manufacturers of small wood chip furnaces for fine wood chips (less than 25 mm diameter) offer special pellet furnaces or adaptations of wood chip furnaces. This reduces the technical complexity of storage, pellet feed and conveyor units, since pellets have three times the density and flow more easily.

Wood owners prefer to use their own wood in log or wood chip combustion units. Only when they do not have enough wood of their own do they consider buying pellets. There are special pellet boilers, for the most part from Austrian and Bavarian manufacturers. Some types of combustion system are very promising.

e Chimney ovens and stoves

The first pellet stove from Frank Whitfield (inventor of pellet stoves) came to Europe in 1983. Some years later straw pellets started to be used as biofuel in Denmark in large central heating plants.

Stoves using solid biomass fuel with automatic charging can only run on pellets. Stoves for low heat output of 5 to 10 kW are required for energy-saving houses (mainly wood houses with good insulation). With increasing fuel oil prices there will be a tremendous demand for pellet stoves. In 1999 around 1,000 pellet stoves were sold in Germany, mainly imported units. A total of 300 units came from German production.

As pellets are of such good quality, all wood chip furnaces for small chips can use pellets as fuel. They are dry, small in diameter (6 to 8 mm) and length (10 to 30 mm), and herefore have a large reaction surface and hence a high gasification potential. They can be easily transported and dosed by screw or piston charging.

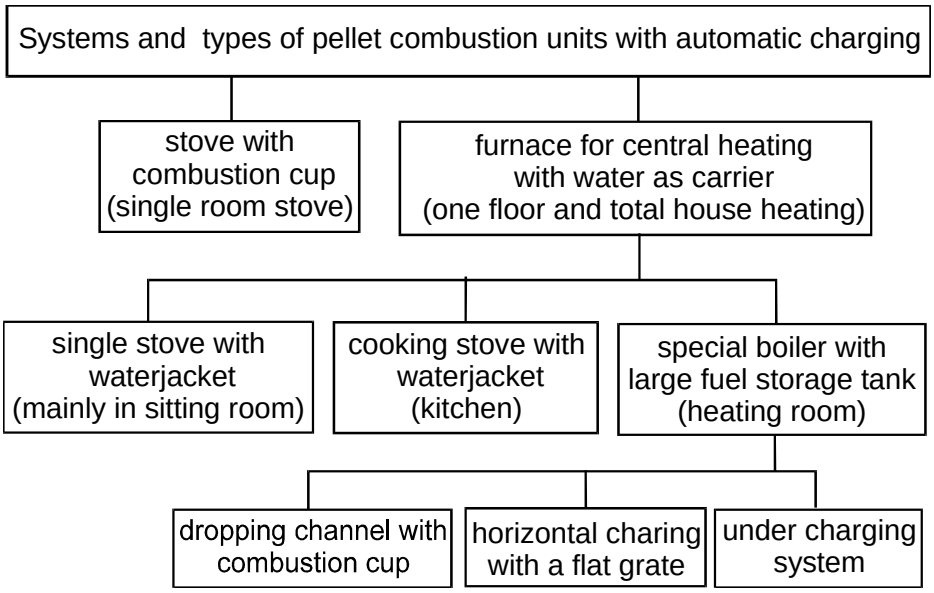
There are four **main types of heating systems suitable for pellets**. These heating systems use different combustion systems, from small combustion cups to movable grates in megawatt units.

- pellets stove (6 to 10 kW)
  water-based or non-water-based systems for apartments, single-family houses, especially low-energy houses
- small pellets boilers (7 to 20 kW) for central heating systems in single- or two-family houses
- medium-sized pellet boilers (20 to 50 kW) for multi-family houses, small district heating systems
- large-scale district heating

3.2 OVERVIEW OF HEATING TECHNOLOGY FOR DIFFERENT SYSTEMS

Many different stoves and boilers for pellet combustion have been developed in last 15 years in response to varying requirements with regard to form, heating value, ash content, particle size, conveying characteristics and heat application.

The following scheme shall give an overview:



The most commonly used combustion chambers with charging systems and heat exchangers are shown in figure 3-1 on the next page.

The first pellet stoves worked with a 25 kg pellet storage tank, an auger charging system, automatic firing control as a function of the heat requirement combined with exact setting of the combustion air. The dropping channel prevents back burning to the fuel store, even in the event of a power cut. These relatively cheap stoves, which cost between DEM 6,000 and DEM 9,000, can also be upgraded by installing water tubes as an additional heat exchanger connected to the central heating system. This costs a further DEM 2,000. In this case a subsidy of DEM 4,000 (120 DEM/kW) is possible.

The other pellet combustion units are similar to the wood chip furnaces for small wood chips. The fuel container is smaller because of the bulk weight of pellets, which is three times that of wood chips. The pellets can be charged easily because pellets flow like cereals. Conveying technology can be adapted from farm technology, thus reducing costs even further (mass production).

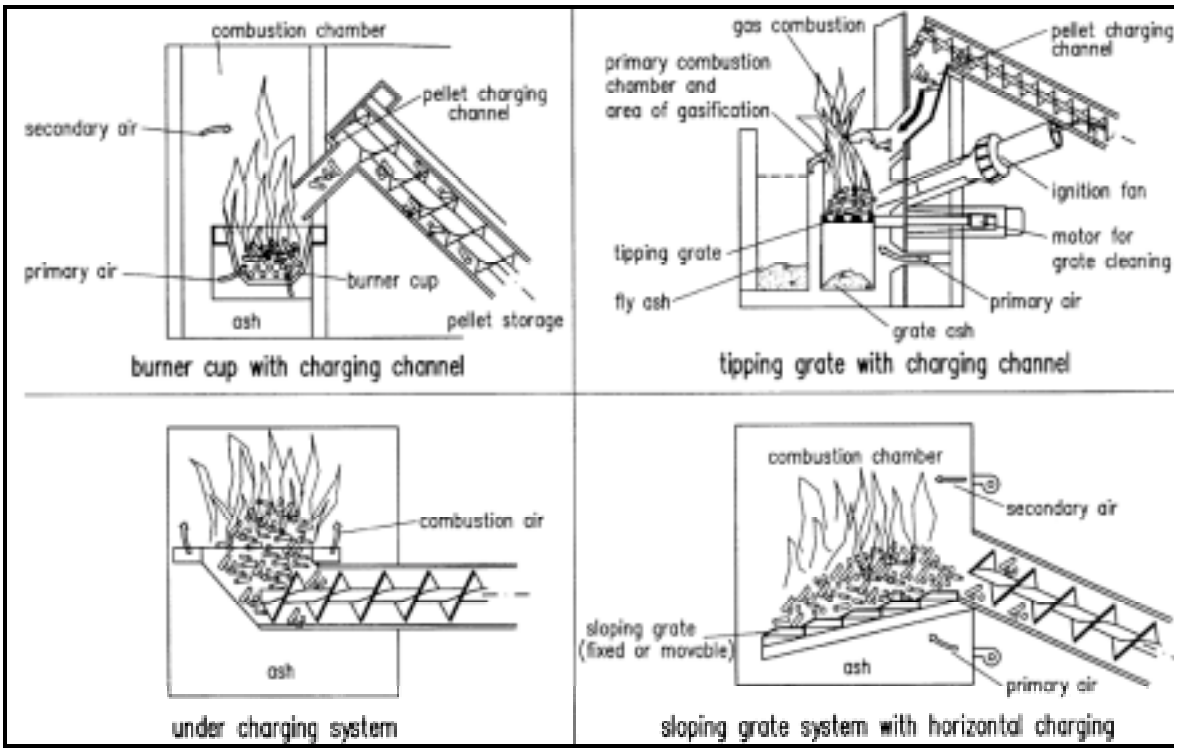


Figure 3-1: Most commonly used combustion chambers with charging systems and heat exchangers

3.3 COMBUSTION QUALITY

Trials with different stoves have been carried out to investigate the performance of different pellet qualities (particles, density). Small particles up to 5% did not affect the combustion quality. The CO content doubled from 50 to 100 mg/m³. The dust emission was the same with fuel with higher particle content.

An ash content of more than 1% causes functioning problems after six to eight hours. Automatic cleaning of the combustion zone is essential and some manufacturers have solved this problem very elegantly (tipping grate, movable grate, mechanical cleaning tools above the grate combined with a timer, under charging system).

High combustion quality with biomass fuel can be achieved much more easily with pellets and briquettes than with chopped or baled biomass. Trials have shown that CO values below 100 mg/m³ flue gas and ash content of less than 30 g/m³ are no problem with advanced stoves and boilers using pellets.

3.4 EMISSIONS OF WOOD PELLET FIRED BOILERS COMPARED TO OTHER WOOD FUELS

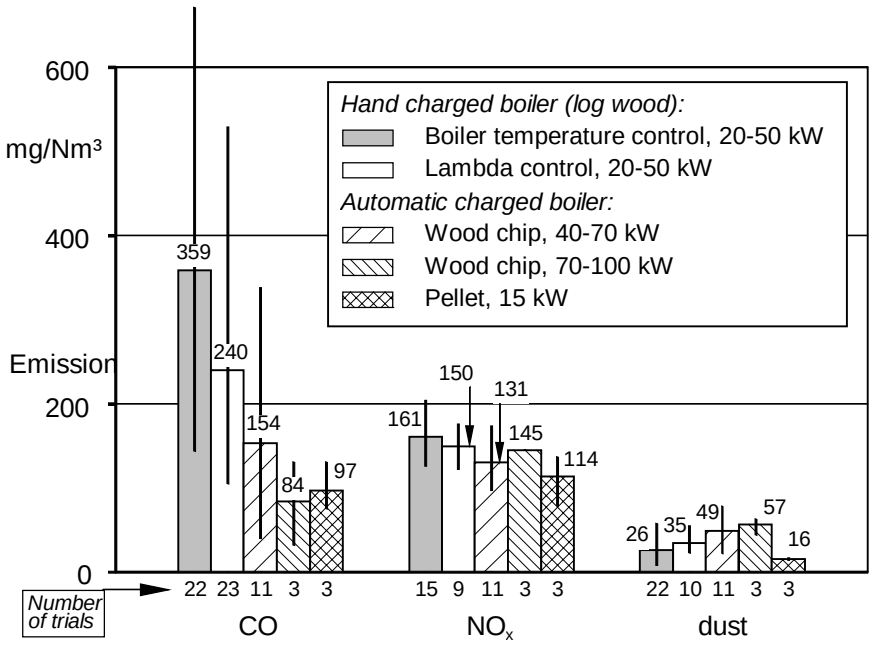
Several trials had been conducted by Landtechnik Weihenstephan using a 200 kW combustion unit with a water-cooled combustion bed and an ash pusher.

For special wood pellet boilers, where the combustion takes place in a combustion bowl and the combustion air typically comes in at the bottom and at the sides, the results are different to those for herbaceous fuels discussed earlier.

The existing emission results for pellet combustion confirm that their use in boilers can lead to significant improvements in dust and CO emissions, compared with other hand-charged log wood or even wood chip boilers.

Positive emission effects have also been found in comparative measurements with traditional stoves, where the use of pellets in an automatically charged chimney stove produced the best results among all systems tested.

Figure 3-2: Emissions from wood combustion with nominal heat power output [25]



Among the wood fuels, pelletised material always gave the best results in combustion trials. CO and dust emissions were usually around 10 to 25% of the legal limits.

[25] Hartmann, H.; Launhardt, T.; Schmid, H. (1998): Combination of Wood Fuel and Natural Gas in Domestic Heating Systems. - In: Biomass for Energy and Industry, Proceedings of the 10th European Conference and Technology Exhibition, Würzburg (Germany), 8-11 June 1998. Ed.: C.A.R.M.E.N e.V. Würzburg-Rimpar, pp. 1304-1307

4 LOGISTICS, TRANSPORT AND STORAGE

4.1 PELLET DISTRIBUTION SYSTEMS

Pellets are distributed by manufacturers and local retailers. Either pellet manufacturers have established a transport and distribution system on their own with direct sales to the end consumer or they work together with local fuel or forage retailers.

Manufacturers and retailers have been trying to establish comprehensive pellet supply networks, but there is still a lot of work to do because there are few regions with an efficient local pellet market.

Road transport of pellets over long distances (more than 200 to 300 km) is not very economical (high transport costs in relation to low product costs), so pellet manufacturers and suppliers try to establish local markets and co-operate with the local wood and timber industries.

Traditional fuel retailers are tending to phase out wood fuels in favour of fossil fuels. Today their main economic basis is oil products. So far only a few companies have engaged in transport and delivery of fuel pellets. One task for the future will be to motivate fuel retailers to supply wood pellets too.

Pellets are distributed in the following ways:

a) **Small bags** (15- 25 kg or 40 lb, sold and delivered on pallets of 800 kg or as single bags). This kind of package is appropriate for minimal pellet consumption, e.g. when pellet stoves are used only as auxiliary heating. Consumers buy the pellets in household goods stores, filling stations or agricultural supply stores and transport them to their homes on their own. The advantage of pellets sale in sacks is that the amount of fines in the fuel is very low provided that the sacks are handled properly and the pellets are protected against wetness. However, pellet prices in this package form are much higher than purchase of loose pellets.

b) **Big bags** (with 1 to 1.5 m³ content). Most manufacturers also offer pellets in this way. Big bags have to be moved by stacker track, tractor front-loader or crane, which is inconvenient, especially for transport to the end consumer, so this transport form is used mostly for transport of pellets to retailers.

c) **Bulk material** delivery in a tanker and pneumatic filling of storage bunker or silos is becoming the main pellet distribution form in Europe. Handling is similar to fuel oil delivery and meets the convenience requirements of customers and retailers alike. Loose pellet transport in tankers and pneumatic filling is becoming more professionally organised, but there are still several problems to be solved. Customers' storage bunkers are one of the crucial points in the delivery chain and their filling must be clean and practical. Several technologies with different air volumes and pneumatic pressures are to be tested. Filling couplings in the wall of the storage bunker have to be standardised (at present fire brigade type A couplings are the most common ones). Precautions have to be taken against dust production and crushing of pellets during filling procedure.

Several weighing systems are used to monitor the amount of pellets sold. The most common system is to weigh the tanker on a weigh bridge before and after filling of the tank chambers. This is time-consuming and customers do not have direct control over amount of pellets they have bought. A better system is an on-board weighing system installed in the tanker that immediately measures the amount of loaded or unloaded pellets. The problem is that investment costs for this system are higher.

Different logistic systems predominate in different countries and regions. In the United States sales in small bags are the most common (mostly fired in stoves). In Norway and Sweden sale in bags is also very common but the delivery in tankers is on the increase. In Austria pellets were originally sold packed and this is still the most common form for stoves. Tankers have also been used and these are now gaining in popularity. As central heating with pellets becomes more common the delivery of loose pellets is on the increase because fuel demand is much higher.

The logistics of wood pellets – distribution, transport and delivery and to some extent storage of pellets at customers' home – is one of the most sensitive areas in the marketing of wood pellets at the moment. Areas where improvements could be made include costs, quality and customer convenience.

Fuel is normally supplied by specialist suppliers (nowadays mostly dealing with fossil fuels) or feed retailers, most of which are small businesses. For a nationwide distribution system to be established, these businesses need to be motivated, involved and trained to handle pellets.

4.2 PELLET STORAGE

Storage at retailers

- closed halls
- silos
- fly roof

Storage in closed rooms and silos is the most common, and pellets are seldom stored outdoors under fly roofs. Pellets should be stored in closed halls or silos so as to protect against moisture and maintain quality.

Precautions should be taken against mixing pellets with other stored wood fuel (wood chips). If (even very few) wood chips are mixed with pellets severe problems may be experienced during pneumatic filling, conveying and combustion.

Storage at customers' homes

- bunkers
- silos

Depending on the amount of pellets, closed storage bunkers or silos are the most appropriate storage facilities. In Austria and Germany silos are quite scarce whereas in Sweden they are more common, especially with bigger combustion units and heating plants.

The ideal storage system will depend on the building preconditions.

Generally a silo is the best way to store fuel pellets (moisture protection, continuous sliding of the pellets towards the conveyer system, less dust production) but a silo might be taller than the local building regulations allow. It could also be installed outdoors, in which case aesthetic considerations come into play (e.g. integration of the silo into the building, panelling).

For single-family houses special storage bunkers in the cellar near the boiler room are the most common form of storage.

Storage bunkers in private houses have to comply with several requirements. The most important are:

- National or regional fire-protection regulations must be observed.
- Size of storage area: fuel quantity for at least one or one and a half heating periods should be storable. The extent to which a room can be filled depends on the shape of the room and the position of filling couplings (height).
- Inclining floor (45 degrees) can help to allow maximum and easy emptying of storage bunker as pellets continuously slide towards the conveyer system.
- Filling couplings and pipes should be made of metal (to prevent electrostatic charge).
- The door should be able to withstand the pressure of pellets.
- The room should be dry and insulated (with no condensed water on the outside walls).
- The whole room (including the door) should be sealed against dust.

For further information see footnotes 26 and 27.

4.3 DISTRIBUTION OF HEATING EQUIPMENT

Heating equipment is sold by heating engineers and directly by manufacturers. Pellet stoves could also be sold at building markets. The interest of heating engineers in biomass furnaces is developing very slowly.

The distribution channel and actors depend on the kind of heating equipment (stove, boiler, micro-network, heating plant).

- Stoves are distributed by traditional stove suppliers, household goods stores or agricultural suppliers or directly by manufacturers.
- Boilers are sold directly by boiler manufacturers or by heating engineers.
- Larger-scale heating units (micro-networks and heating plants) are planned and installed by specialist design offices together with boiler manufacturers.

[26] ÖKL Merkblatt : Einbau von Holzpelletfeuerungen in Wohnhäusern. Österr. Kuratorium für Landtechnik und Landentwicklung, Vienna, 1998
[27] Oberösterreichischer Energiesparverband: Biomass Tank. Linz, 1999

5 WOOD PELLET MARKET

During the years that wood pellets have been on the market, many people have taken the initiative to promote the use of pellets. Consumption of pellets has to be increased, however, if a balance between the installed production capacity and the raw material potential is to be achieved and fuel pellets as a form of renewable energy are to make a noteworthy contribution to the total heat energy consumption in Europe. Wood pellets have the potential to increase the amount of renewable energy sources in the low-temperature market.

This section describes the general situation of heat energy markets in Europe and then examines wood pellet markets and their potential in Germany (primarily Baden-Württemberg and Bavaria), Austria, Sweden and Norway based on the results of enquiries with the main players (pellet suppliers, boiler manufacturers, heating engineers and installers) and round-table talks organised in the course of the study.

There are several differences in national or regional low-temperature heat markets but also a good deal of agreement. For this reason the market analyses are presented together, with special local considerations being discussed afterwards (see also Chapter 1).

5.1 BACKGROUND – RENEWABLE ENERGY AND GREENHOUSE GAS EMISSIONS

In December 1997 in Kyoto the European Union and its Member States agreed on a Protocol committing them to an 8% reduction in greenhouse gas emissions compared with 1990 levels between 2008 and 2012. Recent data indicates, however, that carbon dioxide emissions are increasing again. New activities are therefore necessary to curb this upward trend in order to meet the commitment and to enhance the credibility of the European Union and its Member States in international negotiations.[28]

Carbon dioxide is the most important greenhouse gas and accounts for 75% of the emissions. In general, carbon dioxide emissions are a consequence of burning fossil fuels, be it gas, coal or oil.

There are three ways of reducing carbon dioxide emissions:

- reducing energy consumption through better energy efficiency or energy saving
- reducing the impact of fossil energy sources with high carbon content (coal, oil) and developing the use of energy sources with low carbon content (gas)
- substituting fossil energy by renewable energy sources

However, an increased conversion from oil and coal to gas could jeopardise supply security, since gas is increasingly imported from non-European countries. The EU's dependence on energy imports is already 50% and is expected to rise to 70% by 2020 if no action is taken.

[28] Preparing for Implementation of the Kyoto Protocol. Commission Communication to the Council and the Parliament. COM (1999) 230 Brussels, May 1999

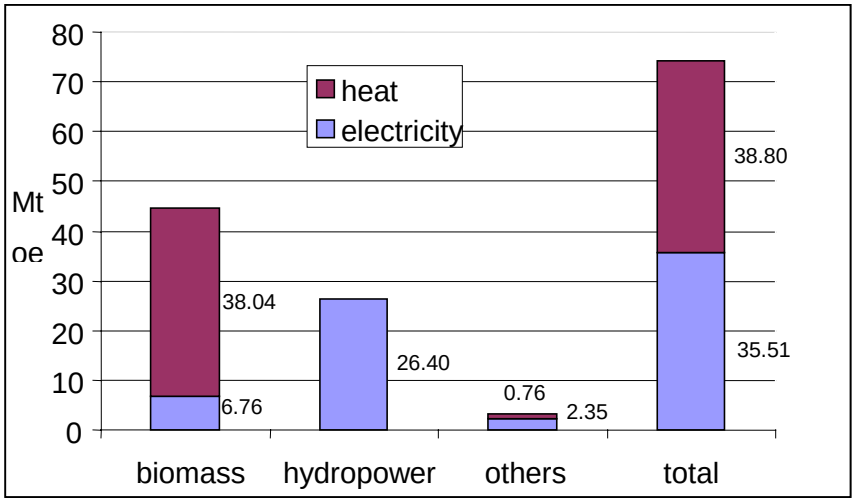
Therefore the main strategies are

* reduction of energy consumption and
* increased use of renewable energy sources (RES).

The different options for achieving the Kyoto target are touched on here but detailed discussion is beyond the scope of this paper.

- Electricity as heat supply – the inefficient option. To increase the overall efficiency of the energy system direct space heating by electricity should be reduced, especially in countries where power stations without co-generation prevail. This conclusion does not apply to heat pumps.
- The energy-saving potential. There is a big difference between the theoretical energy-saving potential and the economically meaningful energy-saving potential. Energy saving usually requires additional investments in the form of new appliances, better insulated houses, new cars, etc. As long as energy prices are low the money being saved by reducing energy consumption is more than offset in many cases by the additional cost of investment. Energy saving and better energy are important and they contribute to a slowdown in the increase of carbon dioxide emissions, but they will not contribute to a reduction of carbon dioxide emissions in absolute figures as long as energy is as cheap and energy taxes as low as they have been in the past years.
- The role of renewable energy sources. In the White Paper the Commission sets the ambitious but realistic goal of doubling the share of renewable energy sources from 6 to 12% by 2010[29, 30]. According to this White Paper the contribution of renewable energy sources to the current energy system is as follows:

Figure 5-1: Renewable energy sources in the European Union, 1995



The figure shows that there are two important forms of renewable energy sources – hydroelectric power and biomass.

The rapid introduction of renewable energy sources is likely to be the most important single measure to comply with the Kyoto Protocol. Biomass is the renewable energy source with the biggest potential for growth. The heat market is the most important

[29] Energy for the Future: Renewable Sources of Energy -White Paper for a Community Strategy and Action Plan. European Commission, Brussels,1997

[30] Position paper of AEBIOM on the White Paper on Renewable Energy Sources and AGENDA 2000, AEBIOM, Brussels, March 1998

market for rapid deployment of biomass. Without a rapid introduction of biomass into the heat market it will not be possible to comply with the Kyoto-Protocol[31].

5.2 LOW TEMPERATURE HEAT MARKET IN EUROPEAN COUNTRIES

The methods of heating differ from country to country, however, and influence consumers' willingness to change the heating systems used in their buildings or homes.

Table 5-1: Heating of buildings and homes in European states (in 1,000s) with different energy carriers, and newly built houses per year [32].

number of	A	B	Dk	FIN	F	UK	I	Nl	N	S
homes	3,123	3,746	2,.426	2,351	27,712	23,482	34,480	6,100	1,800	4,415
heated with										
coal	215	368	20	2	667	1,178	3,200	0	0	0
natural gas	778	1,403	262	28	8,913	17,587	14,500	5,856	0	42
oil	843	1,575	597	519	5,520	918	16,300	43	180	944
electricity	312	231	237	460	8,985	2,965	0	43	1,260	1,019
biomass	572	53	26	300	2,434	235	480	0	360	578
district heating	347	39	1,283	1,042	1,151	599	2	159	0	1,519
homes built/year	50	44	5	21	300		300	100	19.5	15

Nevertheless, countries can be grouped to a certain extent by type of heating:

District heat more than 30%
In Denmark, Finland and Sweden district heating reaches more than 30% of buildings and homes.

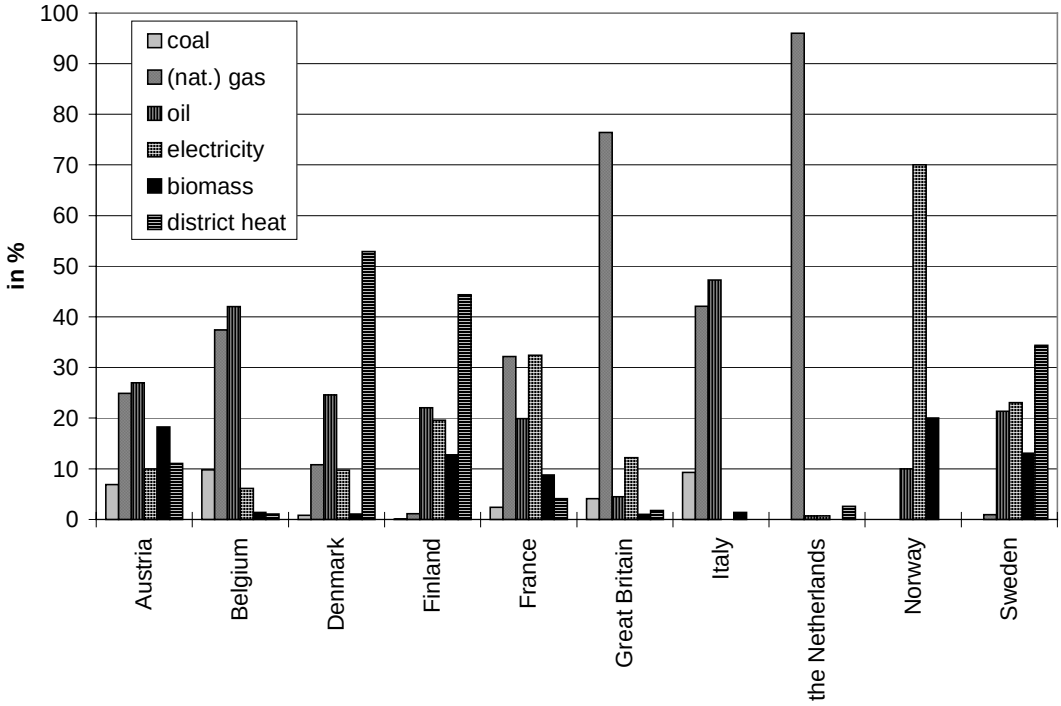
Natural gas more than 30%
In Belgium, France, Great Britain, Italy and the Netherlands, on the other hand, more than 30% of all homes are heated with natural gas. In the Netherlands natural gas heating accounts for 96% of all homes and in Great Britain for 75%.

Electricity more than 30%
Amazingly, electricity attains more than 30% of the market share in France and Norway. In Sweden as well 23% of all homes are heated with electricity. In most other countries electricity heating systems are account for less than 10%.

Wood and coal more than 20%
In Norway wood heating and in Austria wood and coal heating account for 20% or more of all homes.

[31] Altener contract 4.1030/E/07-001 „Strategy for the deployment of biomass as an energy carrier in Europe" Austrian Biomass Association, Vienna, 1997
[32] Altener contract 4.1030/E/07-001 „Strategy for the deployment of biomass as an energy carrier in Europe" Austrian Biomass Association, Vienna, 1997

Figure 5-2: Heating systems in European states, in percent.



In view of these big differences in the heating habits in Europe, an individual strategy for each country is required to achieve a rapid deployment of bioenergy in the low-temperature heat market.

5.2.1 Size of heat market

Obviously society needs different qualities of energy such as low-temperature heat for space heating and warm water, high-temperature heat in industrial production processes, mechanical energy for stationary power and mobile use and electrical energy for power, light and information technology. Electrical energy stays at the top of this quality pyramid, being an energy form that can be used to cover every energy need, whereas the energy in warm water can be used only for heating purposes.

Sorensen has analysed the end-use energy in Western Europe according to the energy quality needed (next table).

Table 5-2: End-use energy 1990 for different purposes[33]

Western Europe, Japan, Australia	watt/cap	%
low temperature heat (space heating, other forms)	370	43
medium and high temperature heat	90	10
refrigeration	20	2
stationary mechanical	130	15
electrical appliances	120	14
transportation	140	16
total	870	100

[33] Sorensen, B. Roskilde University Denmark, http://mmf.ruc.dk/energy/hobart/htm 1998

According to this analysis 53% of the final energy is used for heating purposes, 43% for low-temperature heat. This heat is produced by fossil fuels, renewable energy sources and electricity.

Heat is the most important energy form needed in the European Union since the heat market accounts for about 50% of the total energy market.

- Private households (domestic users) are the most important consumer group.
- Space heating and warm water within the domestic sector have the largest market share among the four user groups and three energy forms.
- 38% (groups 1 and 2) of the energy users produce goods whose competitiveness depends to a greater or lesser extent on energy prices.
- 62% of the energy is used by energy consumers for whom energy prices do not effect the competitiveness of the economy.

5.2.2 Cost structure of heat market

The following table shows a comparison of costs of entire heating systems based on different fuels as well as costs of kWh of heat gained from gas, oil, electricity, firewood or pellets.

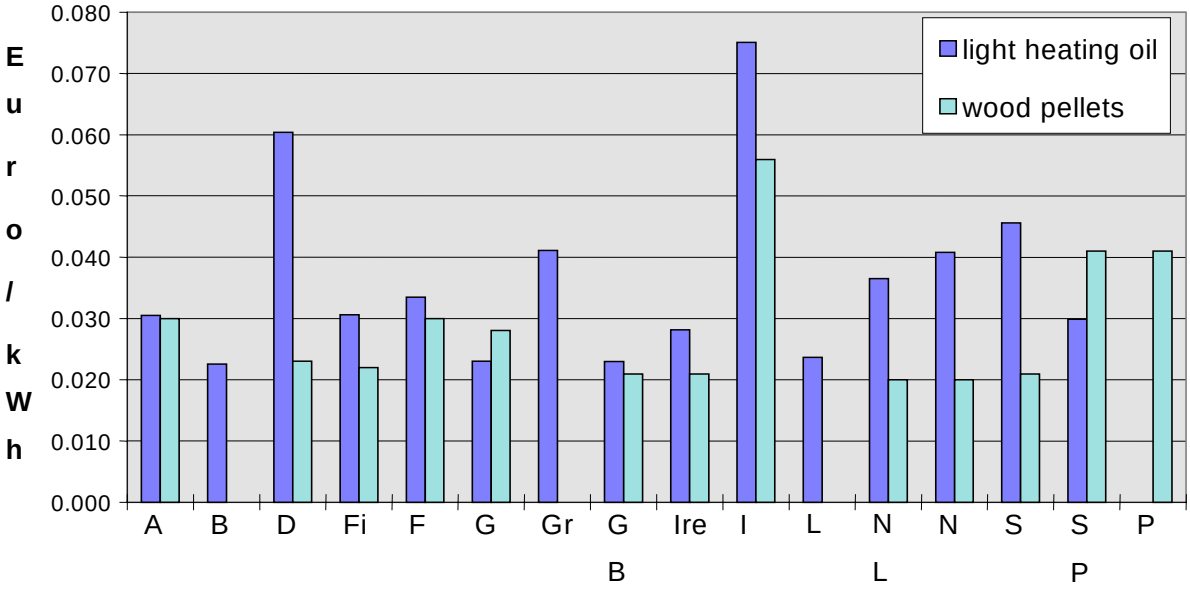
Pellets can be used in central heating systems in most European countries at costs comparable with light heating oil or at lower cost. Only in Germany (till the end of 1999) and Spain was light heating oil cheaper than pellets (see next table and figure). The data is taken from an enquiry about the price of wood pellets in the European countries.

Table 5-3: Prices of energy carriers in European countries (September 1999)

country	light heating oil	natural gas	electricity	wood pellets
	EUR/kWh			
Austria*	0.031	0.032	0.145	0.030
Belgium	0.023	0.031	0.195	
Denmark	0.060	0.050	0.175	0.023
Finland	0.031	0.013	0.095	0.022
France	0.034	0.039	0.152	0.030
Germany*	0.023	0.033	0.180	0.028
Great Britain	0.023	0.025	0.125	0.021
Greece	0.041		0.080	
Ireland	0.028	0.033	0.115	0.021
Italy	0.075	0.055	0.075	0.056
Luxembourg	0.024	0.022	0.151	
Netherlands	0.037	0.027	0.128	0.020
Norway	0.041		0.042	0.020
Portugal			0.138	0.041
Spain	0.030	0.040	0.149	0.041
Sweden	0.046		0.084	0.021

*) In Austria and Germany the price of fuel oil has since increased.

Figure 5-3: Prices of light heating oil and wood pellets in European countries (autumn 1999)



*) The price of fuel oil has since increased by 80% in Austria and 100% in Germany.

Taking into account investment costs

In Austria, for example, the price of pellets is slightly lower than that of oil. Taking into account the higher investment costs for heating furnace and investment subsidies the costs per kWh are 0.096 EUR/kWh for a pellet-heating system compared to 0.091 EUR/kWh for a fuel oil system.

Costs for pellet heating installations are expected to decrease as a result of technological improvements. This will make pellet heating competitive even without public support. Subsidies for pellet heating systems are available in Austria, Denmark (only in areas without district heating) and Germany. In Sweden subsidies are available if electric heating systems are replaced by district heat. In addition, it can be expected that the price of pellets will be more stable in the future than fossil fuels, because it is an indigenous fuel.

Yet, rapid market penetration of fuel pellets will occur only if there is a cost advantage of 20 to 30% compared with traditional fuels.

5.2.3 Cost calculation of energy from wood pellets - an example from Germany

In contrast to other countries such as Sweden (1.20 DEM/l), Denmark (1.10 DEM/l), Austria (0.80 DEM/l) and Italy (1.40 DEM/l) fuel oil prices for private use have been extremely low in Germany (0.40 to 0.50 DEM/l in the last 10 years. In December 1999 oil prices suddenly rose to 0.80 DEM/l (3,000 l basis) and in January 2000 to just under 0.90 DEM/l.

With oil costing over 0.80 DEM/l, wood pellet combustion starts to be economically efficient at 0.30 DEM/kg. Thus wood pellet combustion had no chance of competing with fuel oil before December 1999. Manufacturers of pellet stoves and pellet boilers now face a tremendous demand for their products. Some use surplus wood waste from wood processing. In Germany there are some 35 hot-air dryers for grass combined with pelletisers. Some have been adapted for wood waste instead of dry grass. Even drum dryers are used since pelletising is only possible if the milled material has a moisture content of 8 to 12%. Grass dryers have also been adapted to deliver pellets for 250 DEM/t. Normally 300 to 420 DEM/t has to be paid.

Some remarks about the costs for energy from wood pellets.
The main cost components are:

- fuel costs
- labour costs
- capital cost (interest and depreciation)

a) Pellets cost 0.25 to 0.42 DEM/kg, i.e. 0.05 to 0.08 DEM/kWh or 0.50 to 0.80 DEM/kg oil equivalent.
b) Labour costs are near zero, with only the cost for bag transport from the store to the stove.
c) Capital costs result from depreciation time (10 to 15 years). The money market influences the interest: equity carries about 5% interest, while loans cost 10% a year. Interest has to be calculated from the half the value of the new furnace.

The total capital cost varies from 9.2% to 15% per year.

If a complete pellet furnace with 15 kW rating costs DEM 15,000, the specific price may be calculated at 1,000 DEM/kW. The annual cost is between 92 DEM/kW•a and 150 DEM/kW•a.

To **calculate the capital costs for one kWh** annual costs should be divided by full-load hours per year, which might amount to 1,800 hours in central Germany.

92: 1,800 = 0.05 DEM/kWh
150: 1,800 = 0.08 DEM/kWh

Total costs (fuel and capital) in Germany are between 0.10 and 0.16 DEM/kWh.

Comparable total costs for oil with Germany's new oil price of 0.80 DEM/litre are in the region of 0.11 to 0.15 DEM/kWh. When oil cost 0.40 DEM/litre these costs were 0.07 to 0.11 DEM/kWh, thus explaining the lack of competition between wood to oil. The situation has changed since December 1999, although we do not know for how long.

5.3 MARKET CHARACTERISTICS AND REQUIREMENTS

In view of the circumstances mentioned above, the pellet market can function efficiently only if the appropriate fuel can be supplied on time with minimal costs and if convenient and low-emission heating installations are available at a competitive price.

In general, wood pellets are competitively priced compared with other energy sources. The degree to which they remain competitive depends on the prices of the different energy sources (oil, gas or electricity) and heat supply structure in the different countries. The various expectations and intentions of market players have to be considered and integrated if the fuel pellet market is to be further developed.

At present the situation is as follows:

- Wood pellets represent a promising option for the renewable fuel market.
- Consumers are showing a very high interest in this new fuel but there is still a lack of information, and specific (minor) problems are slowing down market penetration.
- The degree to which wood pellet heating can be developed depends to a large extent on the market situation with respect to other heat energy sources and on national heating habits and structures.

5.3.1 Market niches for fuel pellets

Market niches for pellets for low temperature heat may be found in:

- Small combustion units (stoves as additional heating system, central heating system, especially in low energy houses)
- Single- and multi family houses (boilers for central heating)
- District heating (micro-networks and large-scale heating plants)

The primary field of application varies from country to country depending on the national and regional forestry and woodworking industries, heating habits and culture. A survey of the European pellet market has to take all these applications into account. In Austria and Germany (as representatives of central and southern Europe) small combustion units (stoves, low-temperature houses, central heating systems for single-family houses) predominate. In northern Europe most pellets are fired in medium and large-scaled heating plants, but the use of pellets in small combustion units is also becoming more common and is the focus of marketing activities aimed at replacing very widespread electric heating systems.

5.3.2 Properties of fuel pellets

Pellets are a refined biofuel. Over the past 15 years they have been developed into an environmentally friendly and convenient alternative to fossil fuels suitable both for private households and for district heating plants.

Advantages of pellets

- refined product
- dry and easy to store
- permit environmentally friendly combustion
- permit automatic combustion
- made from domestic renewable raw materials
- high energy density to facilitate transport and storage
- ideal for closed cycle renewable energy systems
- economical alternative on both a small and large scale
- high energy density permitting transport to areas with high energy requirements
- creates jobs

Disadvantages of pellets

- somewhat more labour-intensive for the private homeowner than heating with gas, oil or electricity
- fuel supply, transport and combustion are not (yet) as reliable as gas, oil and electricity

Development

Pellets could become an important alternative to fossil fuels, which together with electricity dominate the residential heating market today. For pellets to become one of the major fuels in Europe the technology must be further developed throughout the entire fuel chain from forest to consumer and back to the forest. European collaboration on energy projects to develop pellets as fuel would be welcome. If existing market penetration barriers can be overcome, this fuel has very good prospects.

5.3.3 Survey of market situation

The following description of the pellet market is based on discussions with key players.

The intentions of different market players vary and are sometimes conflicting. Nevertheless the pellet market is developing quite well in some European countries as wood pellets have a number of advantages making them attractive for the forestry, wood and timber industry, heating furnace manufacturers and last but not least for customers.

A new economic sector involving wood pellets is currently developing in key countries (Sweden, Austria, Denmark, south Germany).

The **potential** for pellet-based heating systems in single- and multi-family buildings is quite good. In many rural regions of Europe single and multi-family housing density is

moderate (500 to 900 buildings per square kilometre). This might be sufficiently large for district heating or gas grids. But recently district heating systems (especially for biomass) have faced economic problems caused by inefficient grid usage due to low housing density. This will result in a cutback in the construction of biomass district heating plants in these areas. Additionally, many new houses are low-energy houses with a very low heat energy demand, which makes district heating even more uneconomical. This sector of single-family houses (dwellings for one or two families) and multi-family buildings is therefore of special interest for individual heating systems based on wood pellets (stove, central heating, micro-network). In terms of convenience and price pellets can usually compete with fossil fuels. Once the specific barriers to their more widespread use are overcome pellets could give biomass fuel a new opening on the low-temperature heat market.

Raw material for wood pellet manufacturing exists in most European countries, especially those with abundant forest land. The cultivation of plants with energy potential (e.g. short rotation coppices) may be an option for the future.

Customers are very interested in this environmentally sound fuel but there is still a lack of information. For consumers there are three main advantages of fuel pellets: the environment argument, convenience and price. For many small consumers environmental arguments have become very important, but the heating system also has to be convenient and not too expensive compared with other heating systems and fuels. Until now small consumers have been pioneers, so to speak. If further customers – not only these pioneers – are to be attracted, the price of the fuel and the heating installation will become more important. For the other consumer group, namely district heating plants, fuel price is a central purchasing criterion.

It is clear that the **lack of information (**to installers, retailers, consumers) is still one of the main barriers to the establishment of a successful pellet market. In several regions (e.g. Baden Württemberg) a marketing concept with special tools (leaflets, training) has been developed and is currently being implemented with a view to increasing the information and awareness levels of installers, pellet producers, pellet suppliers and customers (homeowners).

Modern fully automatic wood pellet burning systems offer an alternative to conventional oil or gas fired heating systems. **Problems** to date have usually been caused by incorrect handling and mistakes in operation, which can be easily solved once they have been identified.

5.4 INTENTIONS OF DIFFERENT MARKET PLAYERS

The different market players – forest owners, woodworking and timber companies, and the end consumer – pursue different objectives:

- Forest owners and the woodworking and timber industry are interested in achieving high added value for residues.
- Pellet manufacturers want to run their production facilities profitably.
- Pellet manufacturers, suppliers and retailers want to sell a reliable quantity of the fuel at a stable price.
- Pellet suppliers and retailers strive for capacity utilisation and for efficient transport of wood fuel while complying with environmental and safety regulations.
- Suppliers and retailers would like to smooth out differences between supply and demand through controlled sale and purchase of the fuel.
- Consumers are looking for a guaranteed and dependable fuel supply.
- Consumers require an environmentally sound fuel of consistent quality available at a low price.
- Consumers require lower investment costs for pellet heating installations.
- Pellet boiler manufacturers hoping to stay in competition with other fuels face high technology development costs and have to sell their products at a cost-covering price.
- Fossil fuel and furnace suppliers are wary of losing their share of the market.
- Environmental protectionist (politicians, administration, NGOs) are interested in further market penetration of renewable energy sources through the introduction of fuel pellets.

5.5 BARRIERS TO MARKET PENETRATION

5.5.1 Technical barriers

There are several bottlenecks where technical barriers are slowing down market penetration.

Production of wood pellets is becoming more and more professional. There are several innovative companies on the market engaged in the development of pelletising technology with a view to manufacturing high-quality pellets. Nevertheless there remain some problems regarding the durability and consistent quality of pellets. Production of high-quality pellets capable of withstanding mechanical abrasion during transport and storing manipulations is still the main challenge for pellet manufacturers. High-quality pellets are particularly important for residential markets with their small combustion units, not least as inferior quality pellets (too many fines) cause problems in charging systems and combustion units.

Transport
Usually loose pellets are transported from the manufacturer to the retailer's storage and then to the customer in tankers. Unloading and filling of storage silos or bunkers cause strong mechanical abrasion to pellets, which can result in large amounts of dust. Transport in tankers and pneumatic loading and unloading is best for bulk goods and was first used for transport of forage or grain, which are more compact than pellets. For pellets made of sawdust (single particles) high air pressure, air flow and velocity of pellets during pneumatic filling of storage containers or bunkers may crush the pellets and result in large amounts of fines. The development of more gentle loading and unloading technologies could help to solve the dust problem with pellet fuels.

Drivers of pellet tankers need specialised know-how concerning air pressure, air volume and material and correct handling, for example.

Few tankers are equipped with onboard weighing systems (especially in Austria and Germany, less so in Sweden). Without these onboard weighing systems a weigh bridge has to be used with each individual order in a separate tank chamber and re-weighing of surplus pellets, if too many have been ordered, for example. Moreover customers have no real control over the quantity of delivered pellets.

Storage: Non-professional installation of storage bunkers, inefficient sealing and incorrectly fitted filling couplings may cause problems through too much dust during filling. Dust may also be caused by inefficient filtering of the outgoing air by a dust collector during the pressurised filling of the storage bunker.

Charging system: The technical requirements for extraction of pellets from a storage container and feeding of the combustion unit are significantly lower than those for wood chips. Pellets flow more freely and can therefore be easily transported and dosed not only

by screw or piston charging, but also with a pneumatic extractor. Pellet combustion requires a stabile fuel supply and charging system with special conveyor elements. These elements are not yet fully developed and there are still some technical problems, in some cases also because of incorrect installation or handling.

Combustion units: The design of efficient pellet burning units calls for considerable development and testing. Because many of the companies working in the field of heating furnace production are small, they are sometimes forced by economic constraints to launch a product too early. Problems have been reported with the conveying system, combustion unit, regulation or noise (this latter particularly in Norway).

Service and maintenance: The after-sales service of some furnace manufacturers or installers is inefficient and not available at short notice. Problems of this nature have been reported in particular by operators of very small district heating systems (micro-networks) and private households.

These technical problems will have to be solved if pellets are to gain a further foothold in the market, but companies are already working hard at solutions. In the present situation it would appear that co-operation between different companies active on the pellet market and the co-ordination of isolated activities are the main challenges to be dealt with if the market penetration of wood pellets is to continue to progress.

5.5.2 Non-technical barriers

Lack of information
Although a number of activities have already been organised, there is still a lack of knowledge, information and confidence concerning this new biomass fuel and heating system. The potential of biomass fuels is not well enough known and there are not enough practical demonstration projects. Biomass heating is still associated with manual charging systems using logs, which are not regarded as practical or convenient.

This lack of information concerns not only private consumers but also politicians, local administrations, heating engineers, fuel merchants, architects and building designers. As a result key players prefer „safe“ and established heating solutions using gas, fuel oil or electricity. It is clear that the lack of information remains one of the main barriers to the establishment of a successful pellet market.

Information through brochures and publications has a limited effect. Most homeowners who already heat with pellets obtained their information at trade fairs and from friends. Visits to existing projects and personal contacts would be an effective way of convincing potential customers and other key players.

Communication problems
In spite of the co-operation between different market players, there are still communication problems between installers and furnace manufacturers, installers and electricians, furnace manufacturers and pellet manufacturers, pellet manufacturers and retailers, retailers and heating engineers, and local authorities and building constructors, for example. Pellet technology (from production to marketing) is a complex topic calling for adaptation and harmonisation. These communication problems result in a lack of technical harmonisation,

e.g. equipping of storage bunkers or charging systems, operating instructions or maintenance advice. Divergent information from different companies or organisations confuses customers, increases the likelihood of error and results in higher costs.

Many market players have already recognised this problem and taken steps to remedy it.

Infrastructure

At present the infrastructure and markets for electric, fuel oil or gas heating systems are very well developed whereas the infrastructure and logistics for biomass or pellet heating is developed only in a few localities and regions.

In some countries (Norway, and to some extent Sweden) the national heating infrastructure and equipment supply is developed one-sidedly in favour of electrical heating. The existing houses lack water pipes for central heating and most of them are equipped only for electric heating.

The existing building structure plays a leading role in the decision to change the heating system. If buildings have no chimney because they are heated with electricity or district heat or if they do not yet have a water-based system, a change in the heating system would involve high investment costs and a considerable amount of conversion work. This generally discourages homeowners or building associations from installing an individual heating system based on wood pellets.

Pellet stoves are a good solution where there is no water-based heating system. If there is no chimney, however, an individual biomass-fired heating system cannot be realistically installed.

The greatest difficulty appears to exist with the replacement of gas heating systems by modern wood systems, which is almost impossible without large subsidies. In countries with a high proportion of natural gas heating in houses (Belgium, UK, Italy, Netherlands) the possibility of changing to biomass is very limited.

Traditional stove suppliers do not yet have pellet stoves in their range. Many installers are not aware or convinced of the advantages of pellet heating and do not offer the system to their customers. For customers it is still difficult to obtain correct information and support from local practitioners (heating engineers, fuel merchants, builders).

Very few regions (in Austria and some parts of Sweden) have a pellet marketing system in which the fuel, suitable heating appliances and the required installation and service facilities are available within easy local access.

Heating traditions and social influences

The heating traditions in different regions, the regional mentality and culture also influence the choice of the heating system.

In rural areas inhabitants are familiar with heating with biomass. Households that until now have used traditional wood or coal systems are in many cases willing to switch to a modern wood heating system using logs, wood chips or pellets. But if the heating system has to be changed people generally opt for the more convenient oil heating systems, since automatic pellet heating is still not very well known. This decision is also influenced by social changes, such as the increase in two-earner families, with the result that there is nobody at home to charge the boiler.

In several countries – Norway, for example – consumers and builders are used to electric heating. As the price for electricity has been being very low for many years, people are accustomed to it and do not give much thought to other systems. Electric heating systems are the norm. The consumption of cheap electricity is a deeply-rooted habit (in Norway) and increases in electricity or mineral oil prices are a sensitive political and social issue.

Education, awareness of the environmental context and an environmental conscience by customers also influence the choice of heating system.

Economy

Last but not least economy plays an important role with regard to the market penetration of renewable energy sources. Economic aspects influence decisions by all market players (from forestry to the end user).

For the end user the fuel price exerts an important influence on the choice of heating system. As long as non-renewable fuels were very cheap, oil and gas heating systems were preferred. In many countries recently fuel oil prices have gone up so that pellets have become more competitive as a fuel. In Germany, for example, the price of fuel oil doubled within a short time. This has been followed by an immediate increase in the interest of customers in biomass and especially in pellets.

But it is not only fuel costs that count. Investment costs for the heating, charging and storing installations are a decisive factor as well. For pellets these investment costs can be twice as high as those for oil heating systems. These higher investment costs for pellet heating slow down market penetration.

In some countries (Austria and Germany) there are good subsidies that can usefully make good differences in investment costs. In other countries (Norway) subsidies as a percentage of investment costs are too low to have a widespread effect.

In summary non-technical barriers appear to influence the market penetration of pellets more than technical barriers.

5.6 FACTORS LIKELY TO ENCOURAGE GREATER MARKET PENETRATION

Raw material
There is plenty of raw material for pellet production in a number of regions of Europe. Forest exploitation can be sustainably expanded. The forestry and wood and timber industry and to some extent farmers can all expect a positive economic effect if new markets for biomass energy products are developed.

Fuel price
In most European countries pellet fuel prices are the same as those for other heat energy resources. In the long run it is expected that energy prices for oil and electricity will go up, while the price of biomass will stagnate or even go down.

Subsidies
Subsidies for biomass and pellet heating equipment are a useful temporary solution to stimulate market penetration and make good differences in investment costs.

Space requirement
Pellet heating systems require less storage space than traditional biomass heating systems for single houses (logs or wood chips).

Convenience
In principle pellet heating systems operate fully automatically and provide almost the same heating convenience as other heating systems. In Scandinavia, for example, pellet stoves have an excellent chance of becoming „standard“ in single-family houses, since they are very much in line with consumers' needs, while keeping up the tradition of wood stoves and also creating an atmosphere on account of the visible fire.

Environmental aspects
Fuel pellets are made of pure wood and are fully renewable. The raw material is mostly provided from local forests and not very much transportation is needed. Pellets produce very low emissions when fired and there is a positive impact on greenhouse gas emissions.

Political will
In most European countries and in the European Union (White Paper) there are political agreements to promote renewable energies. This is a positive working base that needs greater practical implementation. Several countries have already passed laws or other regulations to promote biomass fuels (including pellets) and other countries are likely to follow suit.

Examples of established markets
There are already well established pellet markets (Sweden, Austria) to set an example.

In many countries (especially in rural areas) the use of wood for space heating is very widespread, and the mental and technological leap to pellets is therefore not so great.

Commitment of powerful economic groups
Especially in Scandinavia large oil companies are investing in the pellet market and can help promotion in a difficult market situation.

5.7 STRATEGIES FOR MARKET PENETRATION OF WOOD PELLETS

Political support and direction
Support for industrial market penetration activities by politicians and the government is very important. The political framework can promote or hinder the competitiveness of renewable fuels (e.g. taxes for fossil fuels, wage policy and labour costs, subsidies). Industrial market players would like to increase the acceptance of wood pellet fuel but they need the support of a political structure.

In view of the relative importance of biomass compared with other renewable energy carriers and the significance of the low-temperature heat market, it is clear that a successful biomass promotion programme will go a long way to ensuring that the aims of the White Paper and the Kyoto Agreement do not remain merely on paper. The strategies for reducing carbon dioxide emissions call not only for a reduction in energy consumption but also for the use of renewable energy sources, where the heat market plays the major role.

In the European Union biomass will make inroads into the low-temperature heat market only if fossil fuels are subject to high energy taxes of around ?200 per 1000 litres of heating oil equivalent. In countries where such taxes do not exist as an incentive to switch to biomass fuels, investment subsidies could be provided.

Experiences in several countries demonstrate that the taxation of fossil fuels and electricity and tax exemption for renewable energy sources are key factors in the development of non-fossil energy sources. In Member States with high taxes on fossil fuels and electricity heating systems are developing towards the goals of the Kyoto Agreement.

Bold policies can lower barriers whereas the absence of political support can make those barriers insuperable.

Intensifying and co-ordinating information
The main task in the current situation is to provide information to all relevant target groups. As has already been stated and shown in this study the market barriers are not technological but rather in the form of inadequate information and awareness by installers, heating engineers, pellet producers, pellet suppliers, boiler manufacturers, consumers and government authorities.

Information also includes practical demonstrations, site visits and trade fairs, which are very useful tools for market penetration.

Technical development and professional approach
Boilers, pellets and the supply chain itself all need to be developed. Existing technical problems in the field of combustion, charging, transport or storing of pellets have to be solved. Professional competence is needed so that the systems available on the market work properly.

The technical development of pellet boilers should focus on fully automatic boilers, high efficiency, low emissions and adaptation to existing heating systems.

A professional approach includes regular service and maintenance by qualified companies.

Quality assurance, certification and standardisation
The introduction of wood pellets as a proprietary product guaranteeing a constant good quality of the fuel calls for standardisation and certification on a European level.

For pellet boilers standardised quality labels and certification valid throughout the EU are also needed to guarantee the quality of heating furnaces available on the market and provide consumers with products meeting their expectations.

Market infrastructure
In order to introduce a working and stable market for wood pellets and to establish large-scale utilisation of pellets a wood pellet fuel and boiler supply structure on a local, regional, national and international level needs to be set up.

Regional networks of suppliers and heating engineers and regional pellet distribution networks are necessary. Pellet stoves and boilers have to be introduced into the existing network of stove suppliers and shops. The supply structure for wood pellets can be based on the experience gained in pilot projects More standardised solutions for pellet heating and supply and storage should also be provided.

Wood exploitation
In many European regions there is plenty of wood that is not being used.

Competitiveness and prices
At present pellet fuel is competitive compared with other fuels. This is not the case with pellet boilers, however. In spite of the high development costs pellet boilers have to become cheaper. Financial support by the government should be provided as long as necessary.

Advertising and marketing
Fuel pellets should become a proprietary product „wood pellet“, a special trademark guaranteeing constantly good quality, environmental soundness and high heating comfort.

Better promotion of pellet heating system is needed alongside professional distribution and advertising strategies.

More practical information and demonstration projects are needed. Leaflets and product sheets on pellets and pellet boilers, conferences, exhibitions, fairs are also important.

Collaboration with other market players (building associations, service stations) will help progress. Pilot projects initiated together with co-operative housing associations and the promotion of pellets for new housing schemes will help market penetration.

Individual programmes and pilot projects are needed with account taken of the different conditions prevailing in each country.

Concentrate activities on a few aspects

While keeping in mind the general situation it might be useful to concentrate on a few very specific problems when promoting fuel pellets. Different regions or countries have different problems. Market penetration activities will be more effective if they focus on the specific regional situation.

In Norway, for example, this focus could be achieved through co-operation with local housing co-operatives. In Germany and Austria it is central heating boilers and stoves for low-energy houses. In Sweden it could be stoves on the one hand and heating plants on the other. It is the general policy of the government and authorities to avoid direct electric heating in new buildings, and pellet stoves are a very attractive alternative.

Newly built houses represent a special market segment for pellets. Single-family and environmentally oriented houses could provide an excellent market.

6 LIST OF ADDRESSES

Table 6-1: Pellet mills in the Nordic countries

WOOD PELLET PRODUCER

Place	***Owner***	***Contact***	***Phone***	***Notice***	***Prod tonnes/y***
Sweden					
Luleå	Bioenergi i Luleå	Torgny Sellberg	0920 -255025		90,000
Bureå	Bure Pellets	Börje Andersson	0910 - 40023		8,000
Skellefteå	Skellefteå Kraft	Lars Olov Andersson	0910 - 772500		130,000
Överklinten	MBAB	Martin Bäckman	0934 - 40200		25,000
Härnösand	Bioenergi i Norr	Bo Sandin	0611 - 15085		80,000
Edsbyn	PI Energi	Gunilla Embertsen	0271 - 27300		45,000
Ljusne	Mellanskog Bränsle	Claes Rosengren	026 - 134632		15,000
Främlingshem	Mebio	C - G Sjölander	026 - 36050		40,000
Valbo	Mellanskog Bränslen	Claes Rosengren	026 - 134632		40,000
Norberg	Svensk Brikettenergi	Håkan Nilsson	036 - 147820		40,000
Orsa	Mellanskog Bränsle	Claes Rosengren	026 - 134632		40,000
Katrineholm	Forssjö Bruk	Per Stenegard	0150 - 73400		22,000
Frykenpellets	Vänerbränslen	Bengt Alm	054 - 101917		15,000
Säffle	Vänerbygdens Pellets	Per Olsson	0533 - 10191		20,000
Ulricehamn	Södra Träpulver	Tomas Isaksson	0321 - 15190		50,000
Vaggeryd	SÅBI	Åke Andersson	036 - 198600		50,000
Mönsterås	Södra Skogsenergi	Mauritz Nilsson	035 - 108970	bark	50,000
Österbymo	SÅBI	Åke Andersson	036 - 198600		55,000
Borensberg	Bobergs Valltork	Torsten Kinnefors	0141 - 70064		30,000
Malmö	Skånska Lantmännen	Jan Fältman	04022 5517	straw	20,000
Östervåla	Våla Bioenergi	Lennart Persson	0292 - 40023		5,000
Vinslöv	Sv Brikettenergi	Håkan Nilsson	036 - 147820		15,000
Norway					
Vestmarka	Cambi Bioenergi	Björn Huse			30,000
Brumunddal	N Skog/Statoil	JE Ingvaldsen/Geir S	start Aug 99		15,000
Finland					
Finncambi	Cambi Bioenergi	Stefan Skaata			15,000
	Biowatti	Marti Savolainen	start 99		
Denmark					
H P - Pellets	(50% köpt av KFK)				
Naessund	Spanvall				
Veijen	Spanvall				
DLB	Esbjerg				
	Fyn				
			Denmark total		150,000
Baltic					
Törva	Hansa Granul				
Talsi	Svensk Brikettenergi				

Table 6-2: Producers of pellet stoves and boilers for pellet-burning, available in Sweden or Nordic countries

Name	Made in	Representative in Sweden	Price, EUR	
Pellet stoves				
Austroflam Integra	Austria	Jötul	3,340	
Enviro Fire	Canada	Convent Energi	2,010	
Eco Logica	Italy	Narvells	2,910	
Quadra Fire	USA	Ezy Energi AB	2,570	
Whitield Quest Plus	USA	Kennedygruppen AB	2,540	
Eco Tec Tyr	Sweden	Eco Tec	2,900	
WodkeTopline	Germany	SBS Janfire AB	4,760	
Wodke Smart	Germany	SBS Janfire AB	3,200	
S:t Croix Lövhult	USA	Albinpannan AB	2,670	
S:t Croix Töre	USA	Albinpannan AB	2,110	
S:t Croix Kalix	USA	Albinpannan AB	2,330	
Thelin (Kentucky)	USA	Convent Energi	2,230	
PellX (pelletstove)	Sweden	Scand Pellets AB	2,180	
Waterford Erin	Ireland	Narvells AB	3,320	
Jamestown	USA	Svenska Gräs AB	1,890	
Grenfire	Denmark	Grenfire ApS		
Specification for pellet stoves above taken from BIOENERGI no 6 1998				
Pellet burners				
PellX	Sweden	Scand Pellet AB	1,790	P
Janfire	Sweden	SBS Åmål	1,990	P
EcoTec	Sweden	Ecotechnology AB	1,890	P
Ivabo villa S	Sweden	Ivabo	2,000	
Ivabo villa XL	Sweden	Ivabo	2,780	P
Bio Warm	Sweden	El Team	1,790	
Biopell	Sweden	Albinpannan	1,820	P
Cello	Sweden	Iton HB	2,010	
PellEco 2000	Sweden	TräEnergi Teknik	2,240	
Pelda 21	Sweden	Nils Gunnar Norman	2,180	
EP - brännaren	Sweden	Altbergs Plåt	2,100	P
Tekno Term	Sweden	Tekno Term Energy	2,000	
Torsbyugnen	Sweden	Torsbyugnen	1,780	
Villamatic	Denmark	Värme och Miljö AB	2,790	
Roslagsbrännaren	Sweden	BWA Energi	1,670	
Eldoradobrännaren	Sweden	JWT Development	2,800	
Säätötuli stoker	Awede	Nymans försäljning		
Specification for pellet burner is according to the specification in the magazine BIOENERGY no. 5 1998. Above burners are <25 kW. Some producer have burners available for >25 kW				
Pellet boilers				
Combifire	Sweden	Vedsol AB		
Multi-Heat	Denmark	HS Perifal	4,470	
Passat Compact	Denmark	Thermia Värme AB		
Specification for boilers like pellet burner above				
P = Certified according to the Swedish recommendation for small pellet burning equipment.				

Table 6-3: Pelletising companies in Austria, production capacity and actual production in 1999

Name and address of company	Region	Production capacity [tonnes]	Current production and sales [tonnes]
Umdasch	Lower Austria	5,000	5,000
Leitinger	Styria	20,000	8,000
Pfeiffer	Tyrol	37,000	5,000
Glechner	Upper Austria	15,000	8,000
Eberschwanger	Upper Austria	5,000	4,000
Labee	Tyrol	15,000	3,000
Pabst	Styria	5,000	1,000
Seppele	Carinthia	5,000	2,500
Krippl	Lower Austria	300	300
Loitzl	Styria	5,000	3,000
Kaufmann (solid wood)	Styria	5,000	1,000
Binder	Tyrol	1,000	500
Total		**118,300**	**41,300**

Table 6-4: Austrian manufacturers of biomass furnaces [Ref.: List of the Austrian Biomass Agency, Ökoenergie May 1998]

Name of company	Address	Telephone number
Josef Binder	A-8570 Voitsberg	03142 - 22544
Biogen	A-5084 Großgmain	06247 - 7259
Anton Eder	A-5733 Bramberg	06566 - 7366
Ing. Friedrich Enickl	A- 4407 Dietach-Steyr	07252 - 38267
Heribert Erhart	A-8504 Preding	03185 - 2311
Fischer	A- 4722 Peuerbach	07276 - 2441
Fröhling	A- 4710 Grieskirchen	07248 - 6060
Ernst Gerlinger Bioheiztechnik	A- 4391 Waldhausen	07418 - 230
Hager Energietechnik	A- 2170 Poysdorf	02552 - 2110
Hargassner	A- 4952 Weng/Innkreis	07723 - 5274
Harreither	A- 3334 Gaflenz	07446 - 6660
Hechtl Landmaschinen	A- 8561 Söding	03137 - 2339
Heizomat Energiesysteme	A- 4810 Gmunden	07612 - 737600
Herz Feuerungstechnik	A- 8272 Sebersdorf	03333 - 2411
Hoval	A-4614 Marchtrenk	07243 - 550-0
ID Energiesysteme	A- 9971 Matrei	04875 - 6172
Jäger Technik	A- 8141 Unterpremstätten	03136 - 549060
Köb & Schäfer KG	A- 6922 Wolfurt	05574 - 6770
Kohlbach	A-9400 Wolfsberg	04352 - 21570
Kr Ing. Ernst Kurri	A-2700 Wr. Neustadt	02622 - 23865
KWB	A-8321 St. Margarethen an der Raab	03115 - 6116 -0
Lohberger	A-5230 Mattighofen	07742 - 52110
Mawera	A-6971 Hard	05574 - 74301-0
Meva	A-5431 Kuchl	06244 - 6056
Michelitsch	A-8551 Wies	03468 - 230
Oekofen	A-4132 Lembach	07286 - 7450
Perhofer	A-8190 Birkfeld	03174 - 3705
JPA Pöllhuber Fördertechnik	A-4845 Rutzenmoos	07672 - 28530
Pöllinger	A-3385 Gerersdorf	02749 - 8684
Polytechnik Klima-Luft-Wärmeanlagen	A-2564 Weissenbach	02672 - 890
Prüller	A-4463 Großraming	07254 - 7325
August Rath jun.	A-1015 Vienna	01- 5134426

Reinisch	A-8045 Graz	0316 - 972297
Rendl	A- 5020 Salzburg	0662 - 433034
Rika	A-4569 Micheldorf	07582 - 686
Sommerauer & Lindner	A- 5120 St. Pantaleon	06277 - 7804
Sonnenkraft Vertriebs GmbH	A- 4655 Vorchdorf	07614 - 6006
TM - Feuerungsanlagen	A- 8271 Waltersdorf	0333 - 2155
Thermostrom Energietechnik	A-4407 Steyr	07252 - 38271
Urbas	A-9199 Völkermarkt	04232 - 2521
Vaillant	A-1231 Vienna	01 - 863600
Vanicek	A-8230 Hartberg	03332 - 6021
Wagner	A-8152 Stallhofen	03142 - 21207
Windhager Zentralheizung	A-5201 Seekirchen	06212 - 2341
Wuck/Biothermal	A-8793 Trofaiach	03847 - 2243

Table 6-5: Manufacturers and sales representatives offering pellet furnaces in Germany

Manufacturer/sales representative	**Furnace type**	**Nominal heat power** output [kW]	**Suitable fuel type**				
			wood			straw, etc.	
			logs	wood chips	pellets	chopped fuel	pellets
Austroflamm Gfereth 101, A-4631 Krenglbach Tel.: 0043 7249/464430 fax 46636	chimney stove (automatic charging, with water heat exchanger) pellet boilers	6-11 15			× ×		
Biogen Heiztechnik GmbH Plainburgerstr. 503, A-5084 Großgmain Tel.: 0043 6247/72 59 fax: 8796	boiler integrated furnace	15-120		×	×	×	×
Biotech GmbH - siehe Fa. Lambelet	pellet boilers	15			×		
Compello/ Sonnenkraft GmbH Reitfeld 6, 93086 Wörth a.d. D. Tel.: 0982/90103 fax: 90105	chimney stove (automatic charging, with water heat exchanger) pellet boilers	9 15			× ×		
Georg Fischer GmbH & Co. Bruck-Waasen 7, A-4722 Peuerbach Tel.: 0043 7276/2441-0 fax: 3031	pellet boilers				×		
Fröling, Heizkessel- und Behälterbau GmbH Industriestr. 12, A-4710 Grieskirchen Tel.: 0043 72 48/606 fax: 62 387	pellet boilers prefurnace boiler integrated furnace	18 15-120 20-1000		× × ×	×		
Ernst Gerlinger Froschau 79, A-4391 Waldhausen Tel.: 0043 7418/230 fax: 2304	pellet boilers, boiler integrated furnace	45-88		×	×		
Gutekunst Wangener Str. 100, 88212 Ravensburg Tel.: 0751/36661-0	pellet boilers				×		
Hargassner, Holzverbrennungsanlagen Gunderding 8, A-4952 Weng Tel.: 0043 7723/5274 fax: 52745	boiler integrated furnace	15-140		×	×		
Herz-Feuerungstechnik, A-8272 Sebersdorf Vertrieb: Harald Wichmann Lessingstr. 21, 87439 Kempten Tel.: 0831/14 24 fax: 14924	pellet boilers boiler integrated furnace	15 25-170		×	×		
Hestia GmbH Kappelstraße 12, 86510 Ried b. Mering Tel.: 08208/1264 fax: 1514	pellet boilers	25-50		×	×		
Heizomat-Gerätebau GmbH Maicha 21, 91710 Gunzenhausen Tel.: 09836/9797-0 fax: 979797	boiler integrated furnace	14.5-800		×	×		

Kanad. Holzgranulatofen - see Fa. Lambelet	chimney stove (automatic charging, with water heat exchanger)	7			×		
KWB/ Fraidl GmbH. Lindenstr. 16, 86643 Rennertshofen/Ammerfeld Tel.:09094/1467 fax.: 902266	pellet boilers boiler integrated furnace	10-20 25-100		 ×	× ×		
Fa. Lambelet Salzwerkstr. 8-10, 79639 Grenzach-Wyhlen Tel.: 07624/91590 fax: 4136	pellet boilers chimney stove (automatic charging with water heat exchanger)	15 7			× ×		
Lohberger Postfach 90, A-5230 Mattighofen Tel.: 0043 7742/52 11-0 fax: 521110	pellet boilers boiler integrated furnace	15 20-80		× ×	×		
Ökofen GmbH Mühlgasse 9, A-4132 Lembach i.M. Tel.: 0043 7286/7450 fax: 7809	pellet boilers boiler integrated furnace	10-30 20-70		 ×	× ×		
Ökotherm/ Fellner GmbH Träglhof 2, 92242 Hirschau Tel.: 09608/9200 49 fax.: 920011	boiler integrated furnace	20-140		×	×	×	×
Passat Energi GmbH Morgenstern 16, 24870 Ellingstedt Tel.: 04627/189500 fax: 189501	pellet boilers boiler integrated furnace	10-23 23-180		 ×	× ×		
Pfeifer Biomassetechnik Mittelösch 12, 88213 Ravensburg Tel.: 0751/36661-0 fax: 794143	pellet boilers boiler integrated furnace	15-25 50-300		 ×	× ×		
Perhofer Biomat GmbH & Co KG Waisenegg 115, A-8190 Birkfeld Tel.: 0043 3174/3705 fax: 37058	pellet boilers prefurnace boiler integrated furnace	22 35-70 15-70		 × ×	×		
Rendl Heizkessel und Stahlbau GmbH Friedrich-List-Straße 84, 81377 München Tel.: 089/718555 fax: 7145436	pellet boilers boiler integrated furnace	13 20-200		 ×	× ×		
RIKA Müllerviertel, A-4563 Micheldorf Tel.: 0043 7582/686-0 fax: 68643	chimney stove (automatic charging, with water heat exchanger) pellet boilers	9 15			× ×		
Sommerauer & Lindner/ Vertrieb: Reinhardt Energietechnik GmbH Galgenberg 1, 94474 Vilshofen Tel.: 08541/910831 fax.: 910832	pellet boilers boiler integrated furnace	14 30-50		× ×	× ×		
Whitfield Entwicklungs- und Vertrieb GmbH Auf Kasal 59, A-6820 Frasanz Tel.: 0043 5522/52836 fax: 54111	chimney stove (automatic charging, with water heat exchanger)	8			×		
Ingfried Wodtke GmbH Rittweg 55-57, 72070 Tübingen Tel.: 07071/70030 fax: 700350	chimney stove elements chimney stoves tiled stove elements pellet chimney stove (automatic)	8-11 7-9 6-10 6-8	× × ×		 ×		

Table 6-6: Wood pellet suppliers and producers in Germany

Company/Address	Remark
Baywa Lagerhäuser	wood pellet distributor
Allspan Durmersheimer Straße 24, 76185 Karlsruhe Tel.: 0721/56580-0, fax: 0721/56580-55 Augsburger Straße 2, 86459 Gessertshausen Tel.: 08238/7941	producer and wood pellet distributor wood pellet distributor
BHSR Energie- und Umwelttechnik Industriestr. 1, 32699 Extertal-Silixen Tel.: 05751/44 35, fax: 05751/44500	wood pellet distributor

Binder Feuerungstechnik Kappelstr. 12, 86510 Ried b. Mering Tel.: 08208/1264, fax: 08208/1514	wood pellet distributor
Biomassehof Allgäu GmbH Rathausstraße 3, 87452 Altusried Tel.: 08373/7691, fax: 08373/7612	wood pellet distributor (delivery by silo-truck possible)
Biomassehof Schongau-Altenstadt Leitersberg 2a, 86971 Peiting Tel.: 08861/9111-0	producer and wood pellet distributor
Endreß Metall- und Anlagenbau Postfach 1141, 91533 Rottenburg-Vorbach Tel.: 09861/3294, fax: 09861/86746	wood pellet distributor
Fallert, Klaus 77767 Appenweiler	producer and wood pellet distributor
Fari, Fernando Feldstr. 35a, 64319 Pfungstadt Tel.: 06157/2274, fax: 06157/88978	wood pellet distributor
Fichtwaldtrocknung Hillmersdorfer Straße 5, 02936 Proßmarke Tel.: 035364/257, fax: 08234/8851	producer of wood pellets
Flachs + Stroh Naturstofftechnik GmbH Haunstettner Straße 1, 86399 Bobingen Tel.: 08234/3021, fax: 08234/8851	producer and wood pellet distributor
GEKA - Kneifel Wärmetechnik Dieselstr. 8, 76227 Karlsruhe Tel.: 0721/405021-24	wood pellet distributor
Hölter ATB Beisenstr. 39-41, 45964 Gladbeck Tel.: 02043/401218, fax: 02043/401213	wood pellet distributor
Walter **Huber** GmbH Fuggerstr. 30, 84561 Mehring/Öd Tel.: 08677/64628, fax: 08677/65707	wood pellet distributor
LIN-KA-Vølund - Jens Holland Flarup Hollesenstr. 34, 24768 Rendsburg Tel.: 04331/789551, fax: 04331/789554	wood pellet distributor
Prohadi GmbH Klein Dübener Str., 02959 Groß Düben Tel.: 035773/70621, fax: 035773/70621	producer and distributor of wood and straw pellets
Pfeifer Biomassetechnik Mittelösch 12, 88213 Ravensburg Tel.: 0751/783838, fax: 0751/794143	wood pellet distributor
Rettenmaier & Söhne Holzmühle 13, 73494 Rosenberg Tel.: 07967/152203, fax: 07967/152222	producer and wood pellet distributor
Scharr KG Liebknechtstr. 50, 70565 Stuttgart (Vaihigen) Tel.: 0711/786823-0, fax: 0711/7868369	wood pellet distributor
Schellinger & Co, Mühlenwerke Schießplatzstraße 1, 88250 Weingarten Tel.: 0751/56094-0, fax: 0751/56094-49	producer and wood pellet distributor (delivery by silo-truck possible)
Solar Projekt Energiesysteme Am Bläsiberg 13, 88250 Weingarten Tel.: 0751/5603330, fax: 0751/5603377	wood pellet distributor
Walter **Steyer** GmbH Botnanger Str. 31, 70193 Stuttgart Tel.: 0711/6573440, fax: 0711/6572457	wood pellet distributor
Trocknungsgenossenschaft Weißenburg Weiboltshauser Straße 6, 91792 Ellingen Telefon: 099141/3480	wood pellet producer

Trocknungsgegemeinschaft Calau Senftenberger Straße 6, 03201 Calau Telefon: 03541/2751	wood pellet producer
Trocknungsgenossenschaft Golzow Genschmarer Straße 20, 15328 Golzow Telefon: 033472/232, fax: 033472/232	wood pellet producer
Wodtke GmbH Rittweg 55-57, 72070 Tübingen Tel.: 07071/7003-0, fax: 07071/7003-50	wood pellet distributor
ZE Holzsysteme Vertriebsgesellschaft Hocheckstr. 32, 83075 Bad Feilnbach Tel.: 08066/9191, fax: 08066/9193	wood pellet distributor

Table 6-7: Pellets factories in Norway existing (1 -4) and scheduled to start up (5,6) in the next few years

Name and place	Contact/telephone	Start of production	Actual annual production in to (average)	Production capacity in to
1) Vi Tre as, Røros (Sør-Trøndelag county)	Gisle Ødegaard +47-724 12855	1992	700	3,000
2) Cambi Bioenergi Vestmarka as, Eidskog (Hedmark county)	Bjørn Huse +47-628 39188	1997	15,000	30,000
3) Vaksdal Biobrensel as, Dalekvam (Hordaland county)	Arnfinn Trøen +47-565 98920	1998	500	12,000
4) Norske Skog, Brumunddal (Hemark county)	Jan Erik Ingvaldsen +47-623 46683	Sept. 1999	flexible, depending on market	8,000 (capacity own raw material)
5) Frya Bioenergi as, Hundorp (Oppland county)	Roald Nilssen +47-612 97300	end of 1999	5,000	30,000
6) Troms skogeierforening, Sørreisa (Troms county)	Kurt Jessen Johannson	not yet known	not yet known	not yet known

Table 6-8: Pellet suppliers in Norway

Company, location, county, telephone	pellet stoves	pellet burners for central heating (small)	pellet burners for central heating (large)	distribution and sale of pellets
Bioenergi as, Oslo +47-221 24040			×	×
ALVAS, Alternativ Varme as, Rygge, Østfold +47-692 60100		×		
Vi Tre as, Røros, Sør-Trøndelag +47-724 12855	×			×
Møre Biobrensel as, Halsanaustan, Hordaland +47-715 56363	×			×
Frya Bioenergi as, Hundorp, Oppland +47-612 97300	×			×
Hydro Texaco Energi, Oslo/Bekkestua +47-221 24000	×			×
Vaksdal Biobrensel as, Dalekvam, Hordaland +47-565 98920	×			×
Biobrensel Teknikk as, Hemnes, Østfold +47-638 58870	×	×		×
Norske Skog/ Statoil, Brumunddal, Hedmark +47-623 46683				×
Cambi Bioenergi, Vestmarka, Hedmark +47-628 39188				×

Additionally there are several suppliers and companies dealing with heating plants and technology for wood chips. Most of them would be ready to expand to the pellet market as soon as there was demand.

Table 6-9: Pellet producers in the US; fuel pellet plants currently in operation - (PFI members)

	City	State	Phone	Contact	Content*
EAST					
Allegheny Pellet Corp.	Youngsville	PA	(814) 563-4358	Ron Leaksky	A
Associated Harvest Co.	Lafargeville	NY	(315) 658-2926	Glenn Waldroff	A
Catamount Pellet Fuel Corp.	Adams	MA	(413) 743-8212	Averill Cook	A
Dry Creek Products	Arcade	NY	(716) 492-2990	Barbara Shine	A
Juaniata Wood Pellets, Inc.	Mifflintown	PA	(717) 436-5484	David Deamer	
Hamer Pellet Fuel Company	Kenova	WV	(304) 453-6381	J.P. Hamer II	A
New England Wood Pellet Co.	Jaffrey	NH	(603) 532-5723	Steve Walker	A
Renewable Energies, Inc.	Slatyfork	WV	(304) 572-5722	Stephanie Rose	A
Wood Pellets, Inc.	Summerhill	PA	(814) 495-9335	Donna Nolan	A
SOUTH					
Cansorb Industries	Cleveland	NC	(704) 278-9603	Bill Kraigsley	
Fiber Resources, Inc.	Pine Bluff	AR	(870) 535-1759	J.R. Weaver	A
MIDWEST					
Koetter & Smith	Borden	IN	(812) 923-5111	Bill Miller	A
Lignetics of Missouri	Doniphan	MO	(800) 286-5943	Elton Bates	
Marth Wood Shaving Supply	Marathon	WI	(715) 842-9200	Jerry Natzke	A
Pennington Seed Inc.	Greenfield	MO	(417) 637-5978	Keith Hankins	A
Pope & Talbot - Hartland Wood Pellets	Spearsfish	SD	(800) 940-6037	Everett Follette	A
Raney Resources And Recycling	Drayton	ND	(701) 454-6340	David Raney	
Valley Forest Resources	Marcell	MN	(218) 832-3600	Floyd Hovartier	B
Westway Trading Corporation	Mapleton	ND	(701) 282-5010	Jeff Olson	C
WEST					
Advanced Wood Resources	Brownsville	OR	(541) 466-5115	Dan Knight	A
C.D. Pellet Company	Omak	WA	(509) 826-2059	Cherie Peterson	A
CNZ Corporation	Sheridan	WY	(307) 672-9797	Orrin Connell	A
Forest Energy Corporation	Show Low	AZ	(800) 246-3192	Rob Davis	A
Lignetics OF Idaho	Sandpoint	ID	(208) 263-0564	Ken Tucker	A
Manke Lumber Company	Tacoma	WA	(253) 572-6252	Milt Farvour	A
North Idaho Energy Logs	Moyie Springs	ID	(208) 267-5311	Jim Fairchild	A
Rocky Mountain Forest Prod.	Laramie	WY	(307) 745-8924	Butch Keadle	A
Simmons Densifield Fuels, Inc	Yakima	WA	(509) 453-6008	Ron Simmons	A
Valley Ventures DBA Envirolets	Caldwell	ID	(208) 454-0509	Rick Youngblood	
West Oregon Wood Products	Columbia City	OR	(503) 397-6707	Christopher Sharron	A
CANADA					
Advanced Wood Technology	Fredericton	NB	(506) 451-7788	Glen Warman	A
Alberta Dehydrating Company	Renfrew	ON	(613) 432-3614	Allan Lindsay	A
Cubex, Inc.	Papineauville	PQ	(819) 427-5105	Germain Bissonnette	A, B
Energex	Lac-Magantic	PQ	(819) 583-4313	Sandy McCloud	A, B
Lakewood Industries	Ear Falls	ON	(807) 222-3616	Richard Robinson	
Lang's Deny, Ltd.	Palmerston	ON	(519) 343-3353	Ken Martin	A, B
N.S. Bauman Ltd.	Wailenstein	ON	(519) 669-5447	Willard Bauman	A, B
Pellet Flame	Prince George	BC	(250) 963-7220	John Swann	A
Pinnacle Pellet	Quesnel	BC	(250) 747-1714	Rob or Jim	A
Princeton Co-Generation Corp.	Princeton	BC	(604) 272-9212	Dean Johnston	A
Shaw Resources	Shubenacadie	NS	(902) 883-2220	Greg Gillespie	
Valbor Industries	Blainville	PQ	(800) 567-1919	Mark Drisdelle	A

* ash content: A = less than 1%, B = less than 3%, C = over 3%
Last updated: 17 September 1998