IIIEE Theses 2008:19

What's the matter with the Wood Pellet Markets in Europe?

An Investigation of Pellet Markets in Sweden, Austria and Germany

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Thesis for the fulfilment of the
Master of Science in Environmental Management and Policy
Lund, Sweden, September 2008

iiiee

Published in 2006 by IIIEE, Lund University, P.O. Box 196, S-221 00 LUND, Sweden,
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ISSN 1401-9191

Acknowledgements

Firstly, I would like to thank my family who has always supported my ideas and plans, and is surely already wondering what is coming next.

Special gratitude to my supervisors Philip Peck and Kes McCormick, who provided me with the opportunity to participate in conferences and workshops during my research phase that definitely enriched the content and findings of my thesis. Moreover, your suggestions, comments and guidance, especially during the last days of my thesis, have been very meaningful to me.

At the DBFZ in Germany, I would like to thank Janet Witt for her contribution to the thesis and her encouragement to give me insights into the matter of "wood pellets". Also a big thank-you to my other colleagues in room 015 who made the months of thesis writing so enjoyable.

Thanks to all the interviewees and respondents in particular to Sebastian Kilburg and Martin Junginger who were ready to answer all upcoming questions during the whole thesis writing and provided manifold insights.

And now to you EMPs and MESPOMs. It has been a great year together! We shared lots of things starting from tasty falafels and cooking events, to 'long' nights in the nations and at the tute, to playing innebandy and finally ending in the experience of writing a Master's thesis. Thank you that you all have been around.

Abstract

Increasing the share of renewable energy for covering our energy demand is central to the energy policy of the European Union. Despite the acknowledged importance, renewable energy has not yet reached the favoured wide-spread utilisation throughout Europe. Wood pellets, cylindrical sticks of 10 to 30 mm length mainly made from wood processing residues, are a renewable, cost-competitive, local and convenient energy solution for heating and hot water supply in domestic buildings. Under the application of an innovation system approach, the European pellet market for small-scale pellet applications has been analysed concerning its barriers to diffusion. Despite the potential of the energy carrier pellets to contribute to a more sustainable energy supply, instabilities on the pellet market could be observed in the past. In order to identify the causes for the problems of the European pellet market, the institutional legislation around pellets, the market formation, the price development and consumer acceptance have been heart of the study.

In the analysis, the three European pellet markets of Sweden, Austria and Germany have been considered. The aim of this thesis is to identify key barriers to the diffusion of the European pellet market from where measures can be derived to overcome these obstacles. Thereby, appropriate policy instruments are viewed as vital measures in order to remove the presented barriers. Finally, this knowledge is used to define how favourable conditions for a widely spread commercialization of wood pellet applications can be ensured. The generic conditions for an effective small-scale pellet market are grouped according to political (the legislation), economic (supply, demand, price) and social (consumer perception and local factors) aspects. The outcome of the thesis reveals that wood pellets for domestic use are part of the solution to move towards a more sustainable energy supply. However, appropriate policy measures need to be taken in order realise their potential.

Keywords: Innovation system; pellet heating system; Sweden; Austria; Germany

Executive Summary

Renewable energy has been recognized and accepted as a vital component in the process of securing our energy supply, combating climate change and decreasing energy import dependency. The European Union (EU) has acknowledged the significance of renewable energy with its recently published document "**Renewable Energy Road Map**" released in January 2007 (COM(2006) 848 final). A target of 20% renewable energy in the total primary energy consumption in Europe by 2020 has been set. Currently at 7.5% the share must more than double in the short time frame of a decade. To ensure this goal the potential of accessible and efficient renewable energy sources has to be stimulated and made available.

One renewable energy technology fulfilling the mentioned criteria as availability and efficiency are wood pellets. Wood pellets are a solid biomass energy source primarily made of wood residues such as sawdust and shavings. They can be utilised both at a small-scale (private households) and large-scale (CHP, power plants) for heating as well as electricity generation, respectively. The thesis focuses on the domestic use of pellets for heating purposes. This area is of particular interest since pellets have beneficial properties such as easy handling and storage, and a clean and efficient combustion in automatic pellet stoves or boilers, which make them a convenient source for the heat and hot water demand in detached houses (Illsley et al., 2007). However, the domestic wood pellet market in Europe has encountered problems, slowing the diffusion and keeping the market share rather low.

Some important challenges affecting pellet markets are supply and demand instabilities, price fluctuations and large price differences among national markets in the EU. In order to identify the causes for these problems an analytical framework based on a **systems approach** has been chosen. In this context, the introduction and diffusion of technologies is viewed as an interaction between actors under a certain set up of institutions (Jacobsson & Johnson, 2000). The advantage of considering the diffusion of technology under a systems approach is that an analysis of feedback mechanisms can be incorporated. The main elements of the system are **actors**, **institutions** and **networks** and only their effective formation will allow a successful diffusion of a technology. Applying this approach on the wood pellets market, the actors – suppliers, consumers and the government, the institutional and legislative frameworks and the parameter price and their setting have been identified as problematic spots that hinder the dissemination of pellet applications.

For the analysis of the pellet market, three national markets in Europe have been selected. The countries include Sweden, Germany and Austria, which have the longest history in wood pellet applications and are the largest markets in respect to pellet heating systems installed and pellets produced and consumed in Europe. In this thesis, these markets have been reviewed with respect to their energy policy and the market formation covering supply, demand, pricing and consumer perception. Results of the analysis revealed that for example:

- legislation for renewable energy is in place;
- the first generation of policy measures for promoting wood pellets have been implemented, especially through financial incentives;
- the design of these measures is still inadequate and other policy instruments that are recognised to have important facilitating impacts (regulation and education) are hardly used;

- direct and indirect subsidies for and inadequate taxation of conventional energy remain on the market, thus disadvantaging renewable systems;

- the initial investment costs for pellet heating systems remain higher relative to alternatives;

- a Europe-wide quality standard for wood pellets has not yet been achieved; and

- awareness and acceptance among consumers is still at low levels.

Pursuant to the above causal factors, a number of key barriers and barrier categories were derived. As a supportive analytical model for identifying barriers to the pellet market diffusion, a framework on barriers to renewable energy penetration has been used. This framework allows identifying barriers based on single barrier elements. In the context of the study, the barrier elements correspond to the causal factors presented above.

The barriers identified ranged from the lack of awareness and information, the favourable treatment to conventional energy, a small market size, the lack of regulatory framework and standards to the lack of consumer acceptance.

For a wide-spread dissemination of pellet applications it is crucial to overcome these key barriers. Along with barrier identification the framework also provides recommendations for appropriate measures to overcome such barriers. Policy instruments are seen as vital measures in removing barriers. A set of policy measures is presented below:

- application of regulations requiring the use of biomass for heating;

- removal of direct and indirect subsidies for incumbent energy sources;

- ensuring consistent legislative instruments; and

- wide-spread use of information and awareness campaigns.

Finally, barriers and measures were used for deriving overall beneficial conditions for an effective pellet market stimulating its diffusion.

The results illustrate that political intervention remains necessary for making use of the untapped potential of wood pellets. Policy measures will assist in overcoming "teething" troubles of this developing market and in establishing stable market structures.

Table of Contents

List of Figures

List of Tables

1 Introduction and Background

1.1 Renewable energy sources

Renewable energy (RE) is gradually gaining importance for meeting our present energy demand. The share of renewables in the energy mix of the European Union increased from about 4.5% in 1990 to 8.5% in 2007 (Commission, DG TREN, 2008). Reasons and triggers for this development are manifold. The first vital consideration of promoting renewable energy sources as energy carrier came with the oil crisis in 1973 (Jacobsson & Johnson, 2000) and the energy crisis 1978/79. The crises had far reaching negative macroeconomic effects and revealed the dependency on this fossil fuel, chiefly due to its deposits in a limited number of countries in the world. Accordingly, the European Union's (EU-27) current dependency on energy imports accounts for more than 50% (Year: 2006) (Commission, DG TREN, 2008). The nuclear power plant disaster of Chernobyl in 1986 revealed the great security problems related to nuclear energy another incumbent energy source, and raised the debate on the existing risk of accidents with unpredictable consequences for a whole society. Besides, there is the unsolved question of the permanent nuclear waste disposal. Recently, discussions about global warming which has been internationally addressed on the United Nations conference in Rio de Janeiro 1992 and is caused by augmented CO_2 emissions with significant energy-related carbon dioxide emissions in particular during fossil fuel combustion (United Nations (UN), 1997) enjoy strong political and public attention. Furthermore, the limited availability of fossil fuels (Commission COM(2006)105 final); and a new energy crisis with again skyrocketing crude oil prices since spring 2008 with a peak of 143 USD per barrel in July 2008 (Handelsblatt, 2008) encouraged alternative[1] energies utilization even more. The events have induced a rethinking of the energy policies at the national, the European Union as well as the global level. It is evident that there is a need for a fundamental change for satisfying our energy demand and to combat the negative aspects of conventional energy sources and hence guarantee a sustainable way of energy supply. The major motivations for a shift to alternative energy sources are summarized below:

- Secure future energy supply (availability and affordability)
- Decrease dependency on raw oil (imports)
- Reduce CO_2 emissions
- Sustainability
- Guarantee health and safety
- Increase local value creation

1.2 Renewable energy policies

The European Union responded to this development and acknowledged the importance of renewable energies as an energy carrier with the White Paper for a Community Strategy "Energy for the future: renewable sources for energy" in 1997 (COM(97)599 final). In the

[1] The term 'alternative' energy is used as a direct synonym for 'renewable' energy in the study on hand.

document an increase of the share of renewables in the EU's total energy consumption from 6% to 12 % by 2010 has been set. This new attention to renewable energy sources (RES) resulted in the latest publication of the Commission on renewables (the Renewable Energy Road Map) with compulsory and more specific targets for renewable energy development in the RES field (COM(2006) 848). The document was released as part of the integrated energy and climate change package and defines the goal to cover 20% of the EU's total energy demand - electricity, heating and cooling and transport - with renewable energy by 2020 (in 2007: 8.5%). For the implementation of this target a directive for the promotion of renewables has been proposed in January 2008 where individual targets for each Member State for reaching the overall goal of 20% were determined.

To meet this ambitious goal, a mix of different renewable energy sources - solar, wind, biomass, geothermal and hydro power - is required in order to cover this essential share of energy demand. So far, none of the renewable energy sources has the capacity to contribute to a high degree to the energy mix, often also due to technological immatureness, a low efficiency factor and an unrealized cost competitiveness with incumbent energies. There are however renewable energy technologies such as hydro power, wind power and biomass which hold the potential of satisfying a considerable part of our energy demand due to the emergence of reliable and economically viable technologies. This is vital to the effect that a future broader mix of various energy sources with regenerative energy which have a lower impact on the environment, less safety risks, future supply security and more equality of energy resources will help to prevent encountering problems from conventional energy sources that have been faced in the past.

The area with the highest share of energy consumption in the EU but least consideration from a renewables perspective is heating and cooling. About 50% of the total energy demand comes from this sector. The Commission has recognized renewable energy can play a vital role in supplying energy in that area and replace a share of incumbent[2] energy sources like heating oil and natural gas (Commission Communication COM(2006) 848 final). In publications by energy associations and organisations[3] it has been argued that despite the significance of this sector, little in terms of political support for renewable energy for heating (RES-H) has been done. On the European Union level both renewable energy for electricity (RES-E) (Directive 2001/77/EC) and renewable energy for transport fuels (Directive 2003/30/EC) have received independent consideration ensuing in directives to this point.

1.3 Biomass

Biomass makes by far the largest contribution among renewables with almost 70% to the total energy consumption in the EU and approximately 95%[4] to the heating sector. Biomass is plant and animal matter. It has a substantial energy content absorbed from solar radiation during the photosynthesis process and afterwards stored in the organic material. This energy can be recovered through different conversion methods as thermochemical conversion (direct combustion, gasification and pyrolysis), physical-chemical conversion (extraction) and biochemical conversion (fermentation and digestion), and then deployed as resource for heating, electricity generation and transport fuels (OECD/IEA, 2007). The conversion processes lead either directly to energy generation as in the case of direct combustion of solid

[2] Incumbent is used interchangeable with conventional

[3] OECD/IEA, 2007; AEBIOM 2007

[4] Commission Communication COM(2004)366 final

biomass or to the production of a secondary fuel source as biodiesel, biogas etc. which are then combusted for energy generation. Thus, based on the conversion processes and related application, it can distinguished between solid fuels (solid biomass), gaseous fuels (biogas) and liquid fuels (biodiesel, bioethanol).

The size of the biomass sector and the availability of already mature technologies for the conversion of biomass into useful energy plus easily accessible feedstock make it a very important and attractive renewable energy source in order to meet the set target of 20% renewables in the energy mix by 2020. Mature technologies and still unused input material stocks[5] are beneficial prerequisites allowing a reliable and cost competitive supply with energy. The EU acknowledged the significance of biomass with the introduction of a Biomass Action Plan in 2005. The plan shall secure the emergence and supply of energy from biomass.

Among biomass utilization, direct combustion of solid biomass has still the greatest exploitation. In 2005, almost 90% of bioenergy generated within the European Union (EU-25) came from solid biomass. The remaining 7% and 4% were contributed by biogas and biofuels (bioethanol, biodiesel)[6], respectively (Commission, 2008a). Solid biomass can be categorized in vegetal as woody biomass (wood and wood waste) and non-woody biomass (agricultural residues), and in animal biomass (Commission, 2008a). The paper will focus on woody biomass which is still the most prominent solid biomass with about 70% (EurObserv'ER, 2007). Wood and wood residues are utilized both for electricity generation from combined heat and power (CHP) and from co-firing in power plants, and applied for industrial and residential heating (Commission Communication COM(2004)366 final). One revived and upgraded form of utilizing woody biomass for energy generation is wood pellets. This fuel and its diffusion is the object of this thesis. Therefore, the next paragraphs will give an introduction to the fuel's characteristics and capacity as energy source.

1.4 Pellets as a part of the solution

Pellets are cylindrical sticks of 10 to 30 mm length mainly made from wood processing residues as shavings or sawdust originating from sawmills or other secondary wood processing industry. They are applied in small- and large-scale applications for heating purposes but also for electricity generation. Hence, it has to be distinguished between so-called premium pellets for domestic use and industrial pellets burned in power plants and CHP. Pellet markets have firstly emerged in Europe about 20 years ago (Institute for Energy and Environment, 2008). In particular, the area of small-scale applications for domestic heating offers an untapped potential for a stronger utilization of wood pellets for heating and hot water supply and thus the replacement of established sources as heating oil, natural gas and also electricity (European Biomass Association (AEBIOM), 2007).

This was not at least backed by the advantages of wood pellets as a fuel. Pellets hold the possibility of an immediate applicability since an efficient[7], clean[8] and automatic combustion technology is in place, which makes it commercially viable. Moreover, pellets can be used in

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[5] An availability of biomass for energy generation (electricity, heating, fuels) is estimated to 150 Mtoe within the EU-15. In 2001, 56 Mtoe of biomass has been utilized in the EU-15. (Commission Communication COM(2004)366 final).

[6] The classification of solid biomass, biogas and biofuels follows the definition of the EU (Commission, 2008a). However, biofuels can also be seen as any fuel derived from biomass (TheBioenergySite, 2008).

[7] The efficiency of a pellet boiler is about 90%, some boilers already reach up to 95% (European Biomass Association (AEBIOM), 2007).

[8] Low air emissions of particulate matter, NOx, CO_2

large and small scale installations emphasising its universal applicability. The fuel is made from by-products of the wood processing industry, which is a familiar and indigenous input material. The fuel's easy handling and suitability for storage as well as the option of a relatively easy conversion of existing oil heaters to a pellet heating system prove to be particularly advantageous in the small-scale sector. Concerning its economic viability, the fuel price for pellets is currently significantly lower than for conventional energy sources as heating oil, gas or electricity which outweighs the still higher acquisition costs (European Biomass Association (AEBIOM), 2008). These characteristics make pellets such an interesting renewable source as a part of the solution for achieving the set target of 20% renewables by 2020.

1.4.1 Market penetration

Despite the promising preconditions and political attention to RES, pellets have experienced insufficient growth so far. The market penetration is still little throughout Europe compared to their potential and other fuels. For example, in Sweden, the leading pellet market in Europe, the share of pellets for heating and hot water supply in private households amounts only to 4.5% (Statistics Sweden (SCB), 2007), despite Sweden's bioenergy friendly and fossil fuel antagonistic policy making for two decades.

Problems related to the pellet market and considered possible causes for this trend are linked to the price structure and price development of wood pellets as well as the supply and demand formation on the market (Junginger, Hoeldrich, et al., 2008). Pellet markets in Europe are characterized by instabilities in supply and demand resulting both in surplus and scarcity of pellet supply, what in turn affects the price stability (Commission, 2007), (Junginger, Hoeldrich, et al., 2008). Past observations of the pellet markets in Europe include price fluctuations with a change in the pellet price of up to 45% within a few months. Next to fluctuations, high price differences between European pellet markets with a factor up to two exist (Junginger, Hoeldrich, et al., 2008). These factors affect the degree of the market penetration of wood pellets.

1.4.2 Wood pellets as energy carrier

Wood pellets are made from woody biomass primarily untreated by-products of the wood-processing industry as sawdust and shavings. Other feedstock like straw and agricultural residues as well as mixed matter is emerging as promising raw materials for agropellets (European Biomass Association (AEBIOM), 2007). The residues are grinded and formed to small sticks under high mechanical pressure. The pelletizing process takes place without any additives[9] and the residues hold together based on the wood's lignin and resin. In case the residues are too wet, a drying process has to be placed at the beginning of the production to reach a lower moisture content of ≈10% (Peksa-Blanchard, Dolzan, et al., 2007).

For the production of wood pellets from dry matter the energy consumption amounts to approximately 3% of the pellets' energy content. This takes into account all the production processes, to make wood pellets from the source material, and the delivery. In contrast, the energy consumption of domestic heating oil is 12%, of natural gas 10% and of liquefied petroleum gas 14.5% on equal terms (C.A.R.M.E.N e.V., 2002).

Wood pellets can be applied in stoves (<10 kW), in small- (8-100 kW) and medium-scale (100kW-1MW) boilers and large-scale (power plants) systems for heating and power

[9] If required, natural bonding agents (as starch) are used

production purposes. The smaller the heating installations the higher are the quality requirements for the pellets due to the technology characteristics. Austria, Germany and Sweden have national product standards for pellets in domestic usage. The standards regulate the size, composition and other properties as heating value and density. A Europe-wide standard for pellets for small-scale application is on its way currently prepared by the European Committee for Standardization (CEN) and presumably in place from 2009. In general applies that a pellet's diameter is between 6 and 10 mm and the length 5 times the diameter (Peksa-Blanchard, Dolzan, et al., 2007). Typically, wood pellets have a diameter of about 6 mm for residential use and 8 mm for industrial application in Germany and Austria. In Sweden the dimension is 8 mm for both small- and large-scale applications (AEAT, 2003). In respect to the specification and quality requirements of small-scale pellet heating systems, a Europe-wide standard EN 303-5 is already in place since 1999. All three countries apply this standard at the national level (Fiedler, 2004).

The caloric value of 1 kg wood pellets is ≈ 5 kWh_{th}. In contrast, heating oil has twice the heating value. Hence, 2 kilogram of wood pellets corresponds to the energy content of 1 litre domestic heating oil. During the heating period a single family house consumes on average 4-6 tons of pellets depending on the building standard, the absolute square footage and the outside temperature level (reference Germany and Austria). (European Biomass Association (AEBIOM), 2007).

The comfort of an automatically fed pellet heating system is comparable to a heating oil system. The storage is usually filled with wood pellets once a year which is sufficient to meet the heat demand during one heating period. Due to the low ash content of the pellets and the efficient combustion process, the ash has to be removed only about three times during a heating period. (Pilz et al., 2004).

Following up the general discussion of advantages of renewable energy sources above, specific advantages applicable to pellets are presented here. Advantages in comparison to other energy sources both conventional as well as regenerative are (European Biomass Association (AEBIOM), 2007), (European Renewable Energy Council, 2007), (OECD/IEA, 2007):

- Decreased fossil fuel import dependency
- Carbon neutral fuel[10]
- Reduced risk of environmental pollution
- Lower energy costs than fossil fuels (facilitated by high oil and gas prices)
- Small- and large-scale applications
- Storage possibility (especially in contrast to other regenerative energies)
- Availability (not dependent on weather situations or subject to seasonal influences as solar energy and wind power) ⇨ gives security for investors
- High energetic content compared to other wood energy sources

[10] Considering the combustion process and not the whole life cycle.

- Convenient application with automatic heating systems (comparable to heating oil systems)

- Regional raw material production and usage

1.5 Research objective

As presented above the wood pellets market is facing instabilities in supply and demand as well as the price which hinders its development. In this research the current trend of the renewable energy source 'wood pellets' as a fuel for small-scale applications in the European market since its emergence in the 1990s is presented. The intention is to reveal the state of development based on the formation of a market. As such, an objective is to determine which measures have been successful or have hindered facilitating the access of wood pellets to the energy market. This assists in identifying barriers to the pellet market, from where measures can be derived to overcome these obstacles. Finally, it is intended that this knowledge is used to define how conditions favourable for a widely spread commercialization of wood pellet applications can be ensured.

This study uses these observations as a starting point in order to address the following research question:

- What are the factors facilitating the development of an effective wood pellet market for small-scale applications?

Under consideration of the following sub-questions:

- What are the causes for the instabilities within the wood pellet market both on a national level in the cases of Sweden, Germany, and Austria and at the EU level?

- What are the barriers to the wood pellet market development and respective measures to overcome those?

1.6 Thesis outline

In chapter 1 of this thesis, the context for renewable energy sources was discussed as well as the main policies promoting such sources in the EU. The role of biomass in the energy mix was introduced and background information on pellets was briefly presented.

In chapter 2 the methodology applied for this research is introduced. This includes information on the data collection, the theoretical background and analytical framework as well as the scope and limitations to the study.

Chapter 3 gives an outline on the energy situation in the European Union plus the case countries Sweden, Austria and Germany. The energy mix and key figures to the energy market like energy intensity, CO_2 emissions and energy import dependency are described.

Chapter 4 is the heart of the report covering the analysis of the European Union energy policy for renewable energy sources as well as the energy policy and pellet market structure at a national level. The national legislation analysis concludes with a comparison and summary of the countries' energy policy in terms of implemented policy instruments. In the pellet market

analysis for Sweden, Austria and Germany it is divided into the sections supply and demand, price figures on the pellet market and consumer perception.

The final chapter 5 comprises a discussion of barriers to the wood pellet market based on the findings of the analysis section. Moreover, recommendations for overcoming those barriers resulting in a set of favourable conditions for the diffusion of the renewable energy technology (RET) pellets are presented.

The thesis concludes with a summary of the most important findings and provides an outlook for further research.

2 Methodology

The thesis has been supported by the German Biomass Research Centre (DBFZ) in Leipzig, Germany. The centre deals with the economic, environmental, technological feasibility and availability of biomass utilization for energy generation. Pellets represent one of the institute's research areas on solid biomass. Questions related to pellet markets, combustion processes and pellets standardisation are core research themes. Mrs. Janet Witt, who is researching the German and EU pellet markets and a project manager at the DBFZ has supported and contributed to the study during the entire research period.

For the research of the pellet market in Europe, three countries - Sweden, Germany and Austria - have been chosen as examples of European pellet markets. Due to the young age of the pellet market, the description and analysis of the pellet markets in Sweden, Austria, and Germany and at the European level is based on the review of current literature, expert interviews and information attained from conference participations at some of the latest meetings on bioenergy and pellets. Most of the information is gathered from literature sources, conference proceedings and presentations. This is completed by personal interviews with experts in the field of bioenergy and wood pellets. Expert interviews are seen as vital for the analysis in order to understand the "big" picture of the different pellet markets (Painuly, 2001).

The analysis is twofold. On the one hand the causes for the small market penetration of the pellet technology are examined and on the other hand the barriers and corresponding measures for overcoming these problems need to be identified. For the analysis of the wood pellet market's problems a framework studying the diffusion of renewable energy technologies (RETs) is adapted as the foundation. The authors Jacobsson and Johnson (2000) identify the diffusion of RETs as a "transformation of the energy system into one which incorporates a larger share of renewable energy technology."(Jacobsson & Johnson, 2000). To achieve a larger share, the authors perceive that "[t]here are still significant obstacles to be overcome" and "[i]n order to clarify these obstacles, it is necessary to develop an analytical framework for analysing the process of transformation."(Jacobsson & Johnson, 2000).

The framework by Jacobsson and Johnson (2000) assists in identifying problematic spots and related barriers to the establishment of a stable[11] pellet market. For categorizing barriers and hence finding measures to overcome those obstacles a framework presented by J. Painuly (2001), senior energy planner at the UNEP Risø Centre on Energy, Climate and Sustainable Development (URC), Roskilde, Denmark, is used. Painuly (2001) shows traits of the renewable energy market from where conclusions on a certain type of barrier and its elements can be drawn. The paper provides a very detailed list of elements which will assist in identifying the presence and type of barriers to the pellet market presented in the discussion section. Besides, Painuly (2001) outlines measures for overcoming the barriers.

2.1 Scope and Boundaries

The scope of this paper is the description and analysis of the current status and the development of the wood pellet markets in Sweden, Austria, and Germany and at the European level. The three countries have been chosen as case studies since their pellet markets have been affected by the described problems. Moreover, they are leading markets

[11] Considering expansion as the consequence of a stable market which results in a higher share in the energy market

and have a long tradition in biomass and experience in wood pellet applications. This allows better insights into the problems but also identifies successful measures for the diffusion of wood pellet applications.

Within the wood pellet market the focus of the study is on small-scale applications. This scope has been chosen because of the facts that wood pellets have a great potential for a fast and easy diffusion in the domestic sector due to their advantageous attributes (as described above). Besides, pellets suit the specifications of the heating market with rather decentralized structures employing local solutions for heating and hot water supply of buildings. It has to be noted that for a general introduction of the markets in Sweden, Germany and Austria the pellet market is introduced as a whole, in order to understand the possible extent of small-scale applications.

The goal of the research is the identification of barriers and promoting aspects to the pellet market formation resulting in the preparation of general conditions for an efficient pellet market.

The research is restricted to pellets made from wood and focuses on their application in small-scale installations for heating purposes. Wood pellets are the most widely spread and commercial pellet type. Thus, when referring to the term pellets throughout the text, wood pellets are considered.

2.2 Theoretical foundation and analytical framework

Prior to the presenting the major elements of the analytical framework for studying the problems and barriers of the pellet market, the framework foundations are commented upon.

2.2.1 Description of the framework

The first important aspect of the framework utilised here is its systems approach for innovation (Jacobsson & Johnson, 2000). As defined by Edquist (1999) a systematic view "recognizes the potentially complex interdependencies and possibilities for multiple kinds of interactions between the various elements of the innovations process" (Edquist & Hommen, 1999) and thus "can prove useful to study how technology co-evolves with institutions and organisations in order to account for the complex interactions between actors." (Edquist & McKelvey, 2000). The systems perspective acknowledges the interactions of elements as influencing factors in the development of a technology and thus during the process of innovation. Therefore, the approach helps to prevent the analyst from ignoring feedback paths within technological change and relations between factors that decide on success or failure of the establishment of a new technology (Edquist & Hommen, 1999). Systems of innovation has been described by various authors as Freeman (1987), Lundvall (1992), Patel and Pavitt (1994), Metcalfe (1995) and assessed as meaningful by recognized organizations as the OECD[12]. In contrast, a linear approach has the thinking "that "science leads to technology and technology satisfies market needs"" (Edquist & Hommen, 1999). This approach does not take into account feedback and thus ignores learning processes which are essential for the successful introduction and establishment of a new technology.

Furthermore, the framework aims to combine different views on the process of technology diffusion. It considers relative prices as a basis for the decision in favour of a technology,

[12] OECD, 1997, National Innovation Systems

entrepreneurship as a trigger for diffusion, and the influence of a system on its actors' 'choice of technology (Jacobsson & Johnson, 2000).

Based on these considerations, a framework has been derived within this work with the central component of a technological system which is "built around specific technologies" (Jacobsson & Johnson, 2000); aligned to the aim of the analysis' objective the diffusion of a new technology. A technological system and its elements are determined as a "**network(s) of agents** interacting in a specific technology area under a particular **institutional infrastructure** to generate, diffuse, and utilize technology." (Jacobsson & Johnson, 2000). Therefore, the main elements of a technological system are held to be actors, networks and institutions.

A successful diffusion of a new technology is hence determined by the effective interactions and a new set up of the three elements. This implies, that there are actors with the knowledge about the new technology, new networks connecting these actors plus new/changed institutions in favour of the technology in place (Jacobsson & Johnson, 2000). Applying this concept on the wood pellet market it is the goal to analyse these elements – actors, networks and institutions – within the pellet market in respect to their formation but also in which manner and how successfully they affect one another.

Before the actors, networks and institutions are described in the context of the wood pellet market, general definitions are given.

Actor: one who takes part that is a piece of the system (TheFreeDictionary, 2008a). With the act of participation interest in an area is expressed.

Network: an interconnecting group or system (TheFreeDictionary, 2008b), that is a group of actors and their relationships.

Institutions can be seen in various perspectives and many definitions are to be found. However, all definitions have in common that an institution is something overarching, generally accepted and provides guidance for behaviour. Hence, a very general definition is an "organization; custom; convention; law or activity which is accepted in a society" (TOEIC Vocabulary, 2008). For the purpose of this framework a definition by Douglass North (1991), a recognized economist with research in the field of institutional economics, is used.

Institutions: "are the humanly devised constraints that structure political, economic and social interaction. They consist of both informal constraints (sanctions, taboos, customs, traditions, and codes of conduct), and formal rules (constitutions, laws, property rights)." (North, 1991).

2.2.2 Application of the framework on the wood pellet market

Putting this concept into the context of the pellet market, the **actors** are the industry, including raw material suppliers, wood pellet and equipment producers; the consumers as private households; the government supporting this energy source[13]; NGOs; bioenergy and trade associations; and experts/academia researching in wood pellets and their applications are to be mentioned. These stakeholders are connected and exchange knowledge via networks.

[13] As expressed in the White Paper for a Community Strategy by the Commission in 1997 "greater access to upgraded fuels such as chips and pellets and a more intensive exploitation of appropriate forest, wood and paper industry residues" (Commission Communication COM(97)599 final)

Networks can be seen as a degree of connectivity of actors but also as entities promoting connectivity and information flows among actors. For example, how well are wood pellet suppliers connected to their customers as well as to their suppliers of sawdust (user-producer network) (Jacobsson & Johnson, 2000). A driving force for information exchange in the wood pellet market is trade and bioenergy/pellet industry associations. They publish studies on the wood pellet market, provide information, connect various stakeholders via membership, and organize conferences/workshops as platform for knowledge exchange and establishing contacts.

As shown above, **institutions** are of a formal and informal nature. Within the pellet market informal traits are the tradition and culture of firing with wood and the recognition of pellets as an efficient fuel. Formal aspects are legislation for biomass where pellets are part of consideration, the educational system and the capital market around pellets. (Jacobsson & Johnson, 2000).

As the illustration shows a sufficient amount of actors are present in the wood pellet market. A new network has been set up and new legislation has been introduced on European pellet markets. Still the wood pellet technology has not diffused according to its potential. Hence, this leads to the assumption that the system in its current formation does not yet function to its potential and some elements, although in place, are unstable.

Therefore, elements of the system among actors, networks and institutions need to be singled out and analysed according to the given problems of the pellet market (see section 1.4.1).

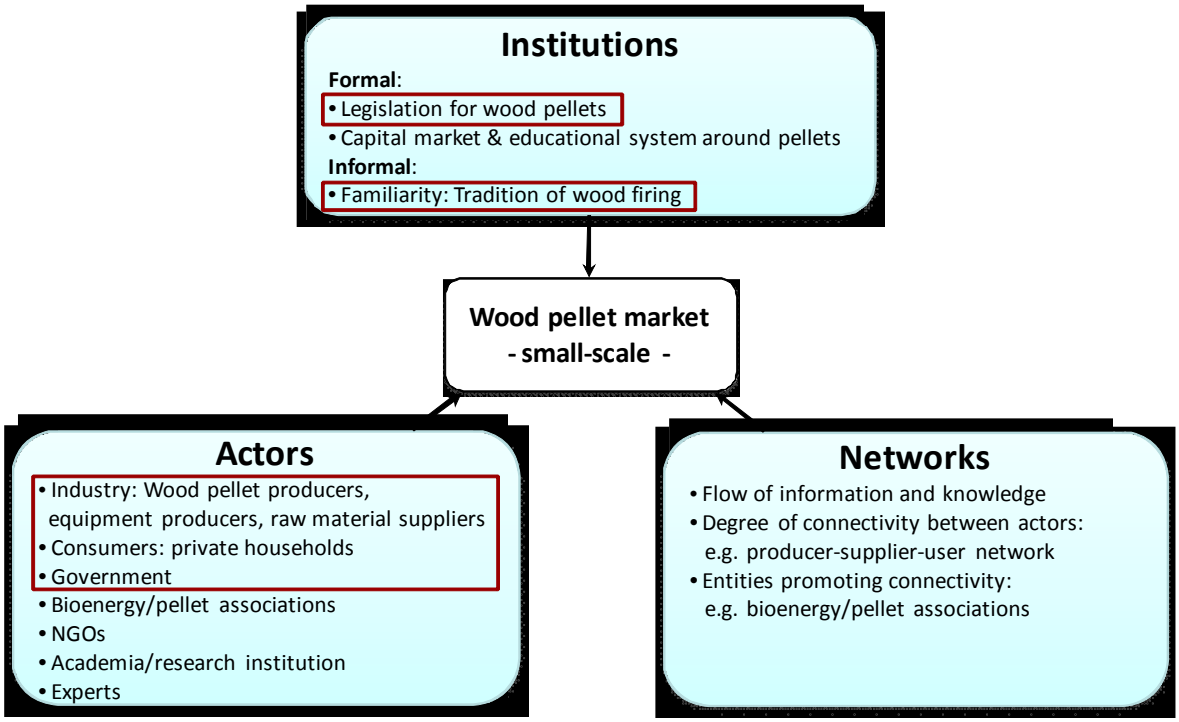
Among the actors the analysis starts from the users and suppliers where problems have occurred in 'expressing' demand and supply on the market place. This in turn affects the price development of wood pellets, a significant parameter of the market. The price for wood pellets in comparison to other fuels reflects their cost competitiveness. If pellets are cost competitive they will have access "to larger segments in the market" (Jacobsson & Johnson, 2000). Therewith the success on the market depends on the price which will be examined as a market factor.

Furthermore, attention will be given to the institutions of legislation and tradition. It is believed, based on preliminary considerations of the pellet market by the author, that legislation is not formed as required for the diffusion of a pellet market. Therefore, the legislative framework and its supporting elements for wood pellets need to be revised and analysed. In general, an important role of institutions in effecting technological change and influencing the diffusion of a technology has been assigned in the literature (Edquist & Johnson, 1997), (Lundvall, 1992), (Freeman, 1995). Particular attention was given to the legislature and cultural elements among institutions.

For example, an analysis considering existing policy measures and their effect on RES in the heating and cooling sector by the IEA has revealed that "well designed supporting policies have been highly effective in obtaining market expansion of REHC technologies" and thus it has been argued that "particularly where good renewable energy resources are available, governments should take strong action with respect to policy development that supports both the increased deployment of commercially available and cost competitive renewable energy technologies for heating and cooling (REHC) and the further development of those at the early-market stage." (OECD/IEA, 2007). This has also been mentioned in connection with biomass and thus applies to the pellet market as well.

In terms of culture the success of a technology depends on the degree of acceptance by the stakeholders for example by the consumer side. Acceptance is for example determined by the familiarity with the technology and its consideration as "suitable". This concept is reflected in the theory of legitimacy. Authors of Aldrich and Fiol (1994), and Jacobsson and Bergek (2004) have dealt with the lack of legitimacy as a barrier for the introduction of a new technology. Thereby, two types of legitimation have to be distinguished: cognitive – "the spread of knowledge about a new venture" and sociopolitical – "the process by which key stakeholders, […], accept a venture as appropriate and right" (Aldrich & Fiol, 1994). The study will focus on the cognitive component of the legitimacy theory since the amount of stakeholders already involved and the taken policy measures imply that the wood pellet technology can be regarded as suitable. However, the level of awareness concerning the wood pellet fuel and technology needs to be evaluated.

Figure 1 Analytical framework applied to the pellet market and highlighted areas of analysis



Analytical Framework based on: Jacobsson & Johnson
The diffusion of renewable energy technology: an analytical framework and key issues for research

2.2.3 Research process

In the context of the given problems of the wood pellet market, that is price fluctuations and differences, and instabilities in supply and demand; the actors, consumers and wood pellet producers and their interplay on the market, is considered essential and is central to the analysis.

Accordingly, the structure of the analysis is established as follows:

First details on the energy policy in Sweden, Austria, Germany and the European Union are presented. Thereby, information on legislation promoting both the utilization of renewable energy, including bioenergy and wood pellets, and of conventional fuels has been gathered. The motivation for adopting this approach is given below.

On the one hand next to policy instruments particularly promoting wood pellets as energy source the policy setting is important for its successful diffusion. The whole policy setting around renewable energy sources as an initial driving force for the development of RETs must be considered. Thus, the illustration of the policy development in the renewables field especially at the EU level as the overarching institution gives an insight into what type of instruments have been applied so far and with what success. For the analysis on the national level it is distinguished between the overarching RE policy and legislation for RES-E and RES-H. Wood pellets are mainly applied for heating and can contribute here the most to higher renewable energy utilization[14]. Furthermore, focus in RE policy was first given to the electricity sector and hence it lays the foundation for further legislations also in the RES-H area.

On the other hand it is vital to describe instruments favouring incumbent energy sources since they are affecting the successful implementation of alternative energies (Jacobsson & Johnson, 2000). In this case, subsidies providing a financial competitive advantage to conventional energy sources and the lack of appropriate taxation reflecting the external effects of fossil fuels are object of the analysis.

The information on various legislation is attained from publications of national energy and environmental agencies, textbooks on energy policy and from communications and directives at the EU level.

After examination of the legislative side of the wood pellet sector, the market is looked upon, involving supply and demand and the price development of pellets. This also involves comparison to conventional fuels. The relation of producers and consumers on the single markets is studied based on supply figures as production and production capacity and demand figures as the consumption, characterizing the size and potential of a market. In regards to prices, wood pellet prices for each of the cases are collected and contrasted to one another as well as to the price development of conventional energy sources.

Data is collected via publications of bioenergy and wood pellet associations as well as from interviews with experts in their respective countries. Associations publish information on the price and market development on a monthly basis. Important associations for bioenergy within the EU and on the national markets are: the Austrian biomass association (proPellets), the Swedish bioenergy association (SVEBIO), Swedish pellet industry association (PiR), German energy pellet association (DEPV), the central network for marketing and development of agricultural resources in Germany (C.A.R.M.E.N. e.V.) and the European biomass association (AEBIOM).

2.3 Literature review

For the literature review current literature from scientific journals and textbooks on the energy market and renewable energy technologies is reviewed. Furthermore, publications by bioenergy and pellet associations on the pellet market situation are considered. An important reference for information on the European and national pellet markets is the so-called PELLETS@LAS, a project funded by the Intelligent Energy Europe programme of the EU. There, project partners from countries within the EU like national associations engaged in the bioenergy field bring together data on price, production, production capacity, consumption

[14] It has to be mentioned that there is potential application for electricity generation, too, but this is not object of the thesis

and quality of pellets. This information is published via a web-based platform where the market data can be accessed.

2.4 Conferences

As part of the research two conferences on bioenergy were attended. In May 2008 the World Bioenergy Conference in Jönköping, Sweden (from May 27th to May 29th) took place and on 26 June 2008 a discussion workshop with the title "European pellets roadmap up to 2020" was organized in Brussels, Belgium. At the conferences, topics as the "Status of pellet market in Europe – status 2008; target for 2020"; "What is needed to develop the market in a satisfactory way up to the year 2020?"; "Recommendations for policies at national level: cases Germany and Sweden"; and "The PELLETS@LAS project – Mapping the European pellet markets" were covered. The content of the presentations, discussions and documents are incorporated in the analysis. In particular, the pellet road map for Europe describes problems of the pellet market and thus addresses the research objective and questions of the study on hand.

2.5 Interviews

During the conferences and research period, interviews with experts working and publishing in the wood pellet field were conducted. Experts have been chosen as a survey group in order to attain an overview of the pellet market and its inner relations and connections. Expert interviews were conducted with persons holding particular knowledge on the Swedish, Austrian, German and European pellet market.

The interviews addressed items such as the general market and price development, determining factors of the pellet price and problems for the pellet diffusion.

During the World Bioenergy Conference in Jönköping, Sweden (May 27th to May 29th 2008) personal interviews with representatives engaged in the wood pellets industry in Germany, Sweden and at the EU-level were carried out.

Moreover, further interviews have been conducted with representatives of the wood pellet market in the respective countries via email or telephone during the study. The interviewees are listed in the appendix.

2.6 Limitations

Limitations to the study are given by the nature of the pellet market and the design of the methodology.

The pellet market is young and still not well structured. These characteristics are particularly reflected by the scarce availability of public data and the missing preparation of data for statistical purposes in the single countries and EU-wide. There are no official statistics on each of the market items - production, production capacity, consumption and price - in place. Consequently, the presented information on one topic is often gathered from several sources, mainly bioenergy and pellet associations, and therefore happens to be incomplete and conflicting from source to source.

Further constraints in the data collection exist due to regional differences of the wood pellet markets in Sweden, Germany and Austria. For example, there are variations concerning the

preparation of data among the national associations. Hence, the published prices for wood pellets refer to different sizes of packaging and delivery terms. These aspects affect the comparability between the countries in terms of pellet market data.

In the literature and articles sometimes no adequate distinction is made whether pellets for small-scale or large-scale applications are considered. However, pellets differ in composition, quality and thus price due to the intended use. Therefore, data applied in the market and price analysis can be imprecise although it has been the endeavour to consequently give remarks when referring to industrial or residential use.

In the methodology a specific respondent group for interviews has been chosen. This approach places a limitation on a detailed illustration of the pellet market, in contrast to interviewing each stakeholder group of the pellet market. However, it has been the intention to receive an overall picture of the pellet market and a better understanding of certain market elements as the price, corresponding to the given problem.

3 Energy profiles

3.1.1 Germany

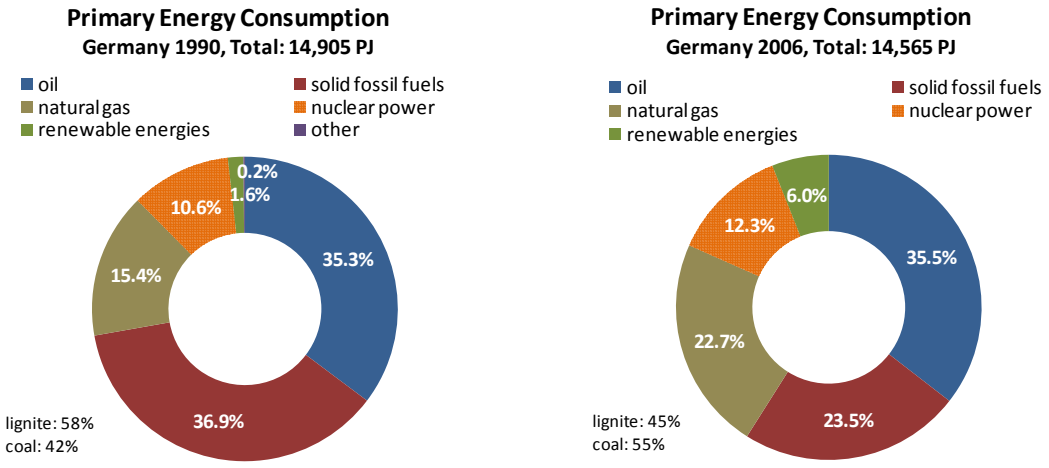
Germany is the largest economy in Europe with a Gross National Income (GNI) of 3,197,029 Mio. US Dollars (World Bank, 2008) and is often referred to along with France as the engine of the European Union in terms of progress and encouraging reforms (Roger, 2000). Germany has the largest primary energy consumption (13,842 PJ in 2007) among the EU27 states and shows a high energy import dependency of oil products, natural gas as well as solid fuels like coal. Energy imports were 47% of the total primary energy consumption in 1990 and increased to 62% in the year 2006 (Commission, DG TREN, 2008). This is due to the declining extraction of domestic solid fuels as lignite and coal which have been important domestic energy source for a long time. Germany utilizes a great mix of energy sources.

Table 1 Energy Key Figures, Germany, 1990-2006

Energy Key Figures[15]	1990	2000	2006
Energy intensity (toe/M€)	205	165	160
Energy per capita (kgoe/cap)	4,489	4,151	4,237
Import dependency (%)	46.4	59.9	61.3
CO_2 emissions (Mt)	1,052	908	910
CO_2 intensity (tCO_2/toe)	2.95	2.66	2.61

Source: DG TREN, 2008

Figure 2 Primary Energy Consumption, Germany 1990 and 2006



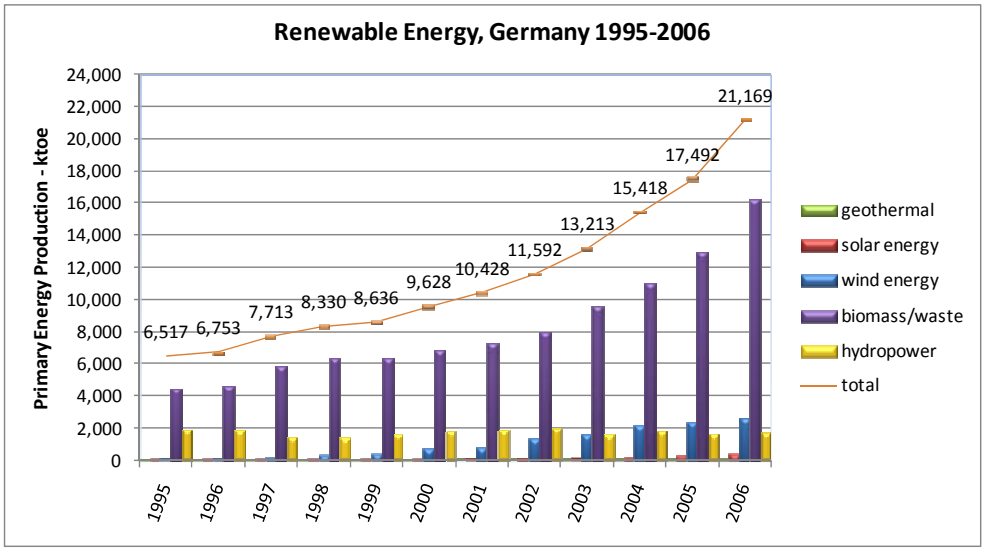
Source: Eurostat, 2008

[15] Abbreviations: toe = ton of oil equivalent, kgoe = kilogram of oil equivalent, cap = capita

Since 1990, the energy efficiency has improved and the total consumption decreased from 14,905 PJ to 13,842 PJ in 2007 (BMWi, 2008). Renewable energy utilization experienced a notably growth of more than 100% between 2000 (403 PJ) and 2006 (884 PJ).

Germany is leading in renewable energy utilization with a consumption of 884 PJ from a total of 5,407 PJ within EU 27 in 2006. The major renewables are biomass and wind energy (Status: 2006). Germany has a leading position in solar energy generation Europe-wide. Solar energy produced in Germany presents almost half of the total production of EU27 (Commission, DG TREN, 2008), albeit solar energy contributes only to a smaller share to the total renewables mix.

Figure 3 Renewable Energy, Germany 1995-2006



Source: Eurostat, 2008

3.1.2 Austria

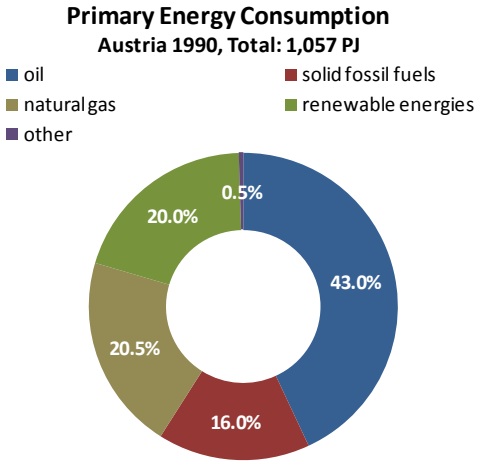
The Alpine Republic of Austria has a GNI of 355,088 Mio. US Dollars (World Bank, 2008) and is ranked among the first thirty countries worldwide in 2007. One important and energy-intensive industry of the country is pulp and paper. Like Germany, Austria is importing the majority of its energy sources with about 72%. Domestic sources are hydro power and energy from biomass. A peculiarity of Austrian's energy mix is the absence of nuclear power as energy supply. Austria belongs to a smaller group of developed countries in the EU – as Italy, Denmark, and Luxembourg – not using nuclear power as energy resource (Commission, DG TREN, 2008).

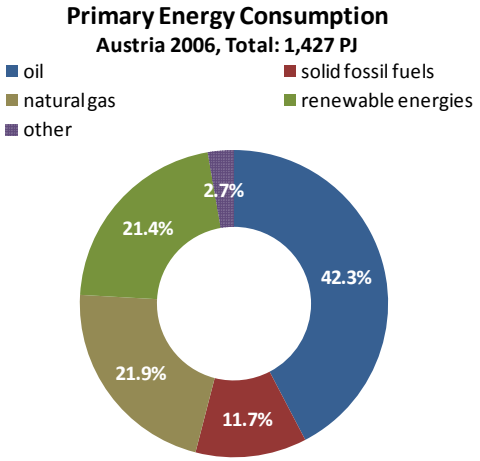
Table 2 Energy Key Figures, Austria, 1990-2006

Energy Key Figures[16]	1990	2000	2006
Energy Intensity (toe/M€)	154	138	146
Energy per capita (kgoe/cap)	3,289	3,624	4,116
Import dependency (%)	68.5	65.8	72.9
CO_2 emissions (Mt)	63	68	79
CO_2 intensity (tCO_2/toe)	2.49	2.33	2.32

Source: DG TREN, 2008

Figure 4 Primary Energy Consumption, Austria 1990 and 2006





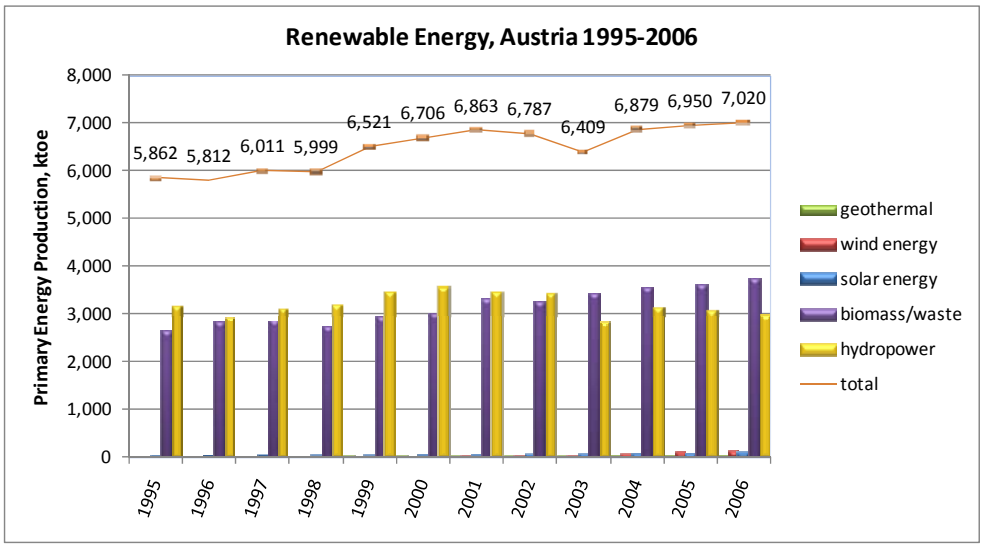
Source: Eurostat, 2008

Energy consumption raised steadily in the last 15 years about 35% which entailed higher CO_2 emissions. The share of renewable energy is high with a contribution of more than 20% to the energy mix.

[16] Abbreviations: toe = ton of oil equivalent, kgoe = kilogram of oil equivalent, cap = capita

Among the renewable energy sources biomass and hydro power are dominating in Austria, other RES are emerging and are quite well developed comparing to EU27 states. Besides, Austria lies in the upper half concerning the total renewables utilization for energy generation in the EU (Commission, DG TREN, 2008). However, it has been an overall moderate growth in RE deployment since 1990 with 211 PJ to 305 PJ in 2006 (+45%).

Figure 5 Renewable Energy, Austria 1995-2006



Source: Eurostat, 2008

3.1.3 Sweden

Sweden in terms of area is the sixth largest country in Europe, with a strong economy (GNI 421,342 Mio. US Dollars (World Bank, 2008)) and well developed welfare system. Due to the climate conditions and the domestic energy-intensive industries as pulp and paper, wood processing and chemical, Sweden ranks among the top five countries with the highest energy consumption per capita ratio within the EU (Commission, DG TREN, 2008).

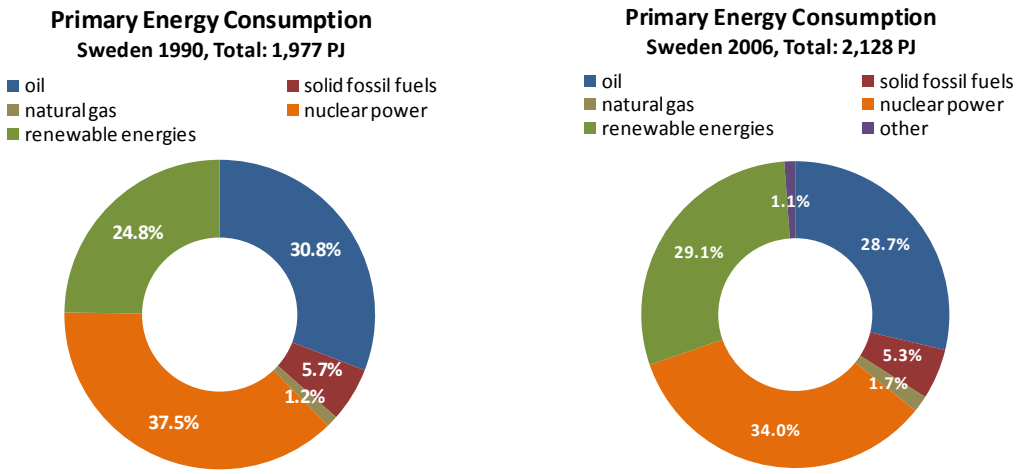
Table 3 Energy Key Figures, Sweden, 1990-2006

Energy Key Figures[17]	1990	2000	2006
Energy Intensity (toe/M€)	216	180	162
Energy per capita (kgoe/cap)	5,516	5,399	5,597
Import dependency (%)	37.7	39.2	37.4
CO_2 emissions (Mt)	60	60	61
CO_2 intensity (tCO_2/toe)	1.27	1.26	1.19

Source: DG TREN, 2008

[17] Abbreviations: toe = ton of oil equivalent, kgoe = kilogram of oil equivalent, cap = capita

Figure 6 Primary Energy Consumption, Sweden 1990 and 2006

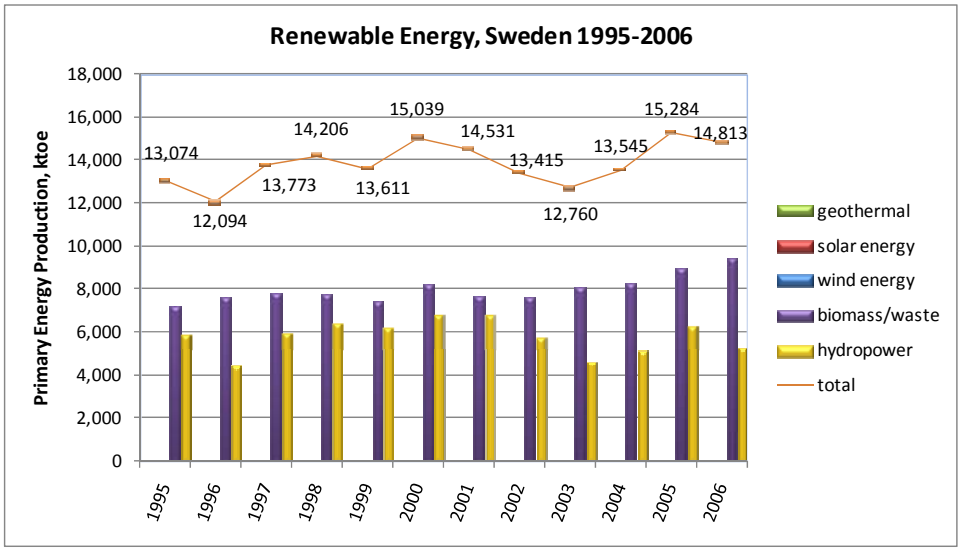


Source: Eurostat, 2008

In contrast to Austria and Germany, Sweden is much less dependent on energy imports. This is based on the high portion of nuclear power and renewable energy in the primary energy mix (together more than 60%).

Sweden has the third largest total RE consumption of 14,813 PJ after Germany and France within the EU. Considering the significant lower yearly energy demand, renewables make up a share of 29% in the total energy consumption. This is the largest share throughout the EU27. Sweden is leading in hydro power utilization EU-wide, shows a large application of biomass and has an emerging wind power industry. Geothermal and solar energy sources are hardly applied also owing to country-specific climate conditions (Commission, DG TREN, 2008).

Figure 7 Renewable Energy, Sweden 1995-2006



Source: Eurostat, 2008

3.1.4 Summary

All key figures of Sweden, Austria, and Germany are summarized and compared to the EU27 energy statistics of 2006 in the table below.

Table 4 Energy key figures 2006 at a glance: Germany, Sweden, Austria and EU27

Energy Key Figures[18], 2006	Germany	Sweden	Austria	EU27
Primary energy consumption (Mtoe)	349.03	50.83	34.09	**1,825.18**
Renewables primary energy production (Mtoe)	21.17	14.81	7.02	**127.42**
Biomass (Mtoe)	16.18	9.42	3.74	**89.03**
Energy intensity (toe/M€)	160	162	146	**177**
Energy per capita (kgoe/cap)	4,237	5,597	4,116	**3,695**
Import dependency (%)	61.3	37.4	72.9	**53.8**
CO_2 emissions (Mt)	910	61	79	**4559**
CO_2 intensity (tCO_2/toe)	2.61	1.19	2.32	**2.5**

Source: DG TREN, 2008

[18] Abbreviations: toe = ton of oil equivalent, kgoe = kilogram of oil equivalent, cap = capita

4 Description and analysis of the pellet markets – Sweden, Austria, Germany & EU

4.1 Legislation

The analysis of policy instruments influencing the diffusion of wood pellet applications will begin with an overview on the development of renewable energy legislation in the EU, wherein significant aspects for the diffusion of the solid biomass and wood pellet sectors are underlined. This is followed by a reflection on national energy policy covering renewable energy policy and the instruments supporting incumbent energy sources especially subsidies and inadequate taxation, which are viewed as constraints to the diffusion of renewables in Sweden, Germany and Austria.

The chapter is concluded with a comparison and summary of the various policy instruments utilised on national level. The framework developed by Vedung et al. (1998), and applied by the OECD/IEA (2007) in the document "Renewables for heating and cooling, untapped potential", will be used for the comparison and summary of the instruments. According to the framework, policy instruments are grouped into financial and fiscal incentives ("carrots"), regulations and standards ("sticks"), and information/educationally programmes ("sermons") (Vedung et al., 1998).

This overall approach aims to identify where policies for renewable energy sources and pellets stand right now and where the gaps lie that need to be addressed.

Review of energy policy in the respective countries and the European Union is based on textbooks, publications of energy and environment agencies and legal documents of the EU as white and green papers, communications and directives.

4.1.1 European Union

In the last decade the European Union has given new impetus through white papers, green papers and directives aiming at an increased employment of renewable energy sources for heating, electricity generation and as transport fuels (Commission, 2008b). The vital policies are the White Paper on Energy Policy (Com(95) 682 Final) – recognizing renewables as the "sustainable energy source" of the future and the need of their further development; the White Paper on Renewable Energies (COM(97) 599) – giving a Community Strategy and Action Plan with the target of doubling the share of renewables in the total energy consumption to 12% by 2010; and the Green Paper on Security of Energy Supply in 2000 underpinning RES's important role in meeting our energy demand. For the implementation of the 'new' energy policy, directives and promotion programmes aiming at the deployment of renewables are utilised (Commission, DG TREN, 2002). The cornerstones of the EU energy policy affecting the development of RES and solid biomass in particular as energy source are presented in a chronological order below.

In September 2001, the **Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market** came into effect. A directive has been considered as necessary since the share of renewables in the electricity generation is still too small and slowly growing given the ambitious targets to satisfy 22% of the demand for electricity from renewables by 2010. According to the directive the member states are obliged to reach set national targets for the contribution of renewables to the

electricity generation. The directive was to be adopted by 27th October 2003 (Directive 2001/77/EC). This decree forms the framework for using biomass for the generation of electricity (Commission Communication COM(2005)628 final).

A **Council Directive for the taxation of energy products and electricity** was concluded on the 27 October 2003. The directive sets minimum rates for the taxation of energy products, when applied for heating or as fuel, and the taxation of electricity. The term energy products subject to taxation by this directive covers oil products, coal (hard and lignite), and natural gas (Council Directive 2003/96/EC). Fuel wood including pellets has been exempted from scope of taxation under this directive (Council Directive 2003/96/EC). Hence, the directive forms an approach to better reflect the real costs (external costs) related to fossil fuels and thus to improve the competitiveness of renewables for energy generation. The Member States had to implement the decree by 31 December 2006.

On February 11th 2004 the **Directive on the promotion of cogeneration** entered into force. This decree is directed at a widespread use of cogeneration and a coordination of the various promotion instruments for combined heat and power cycle, in place within the European Union (Directive 2004/8/EC). The directive is insofar of importance for the biomass sector since CHP is a potential area of biomass application (Commission Communication COM(2005)628 final). The transposition of the directive has to follow before the 21 February 2006.

A very supportive EU document for energy from biomass is the **EU Biomass Action Plan (BAP)** published in December 2005. It asks for the harmonization of the biomass policy within the Union in order to increase the contribution of biomass to heating, electricity and transport fuels. One tool of the BAP is the establishment of national Biomass Action Plans (nBAPs). The national Biomass Action Plans identify the current status of biomass utilization, the future potential availability and respective subsidy programmes in order to make stronger use of this energy resource. (Commission Communication COM(2005)628 final). Focus is also on the "development of markets for pellets and chips" (Commission Communication COM(2006)302 final, 2006). The target of the BAP is to increase energy biomass utilization from 69 Mtoe in 2003 to 195 Mtoe by 2020. In line with the biomass action plan, the EU Forestry Strategy (COM(2005) 84 final) and the related **EU Forest Action Plan** (COM(2006) 302 final) should give a stimulus to the forestry through a Europe-wide policy to manage and utilise the potential of bioenergy from wood.

The currently guiding policy for renewable energy within the EU is the so-called "**Renewable Energy Road Map**" released in January 2007 (COM(2006) 848 final). The act sets the mandatory target for renewable energy to contribute with 20% to the total energy mix in the EU until 2020 which supports cutting CO_2 emissions. The road map includes strategies for RES utilization for electricity generation, heating and cooling, and as biofuels. In March 2007 the European Council set legally binding targets for reaching a 20% share of renewable energies and for a decrease of CO_2 emissions of 20% by 2020. This resulted in the '**20 20 by 2020 Europe's climate change opportunity**' (COM(2008) 30 final). For reaching the target the '**Directive on the promotion of the use of energy from renewable sources**' has been proposed in January 2008 determining individual targets for energy from renewables for each Member State (COM(2008) 19 final).

However, among EU legislations for renewable energy, a specific Directive on the promotion of heating produced from renewable energy sources is not in place, yet. Despite the fact that 48% of the energy consumption is used for heating and only 20% for electricity and 32% for transportation within the EU (European Renewable Energy Council, 2007); the heating sector

has not gained adequate attention so far. A directive on RES-H has been assessed and repeatedly mentioned as necessary for a better utilization of the existing potential of renewables and especially biomass (Commission Communication COM(2004)366 final). Apparently, the preparation of a RES-H directive is accompanied by difficulties due to the different 'nature' of renewables as energy input for heating than for electricity or fuels. The heating sector is more decentralized and complex than electricity generation from alternative energies. (Commission, 2008b). A larger variety of renewable energy sources with respective technologies is applied in a rather distributed energy system. Due to the decentralized nature of the heating sector, a directive would also directly address target groups as the final consumer. There, legislation has to be cautiously in order to avoid negative effects as a too high burden on the single consumer. Thus, the directive for RES-H cannot necessarily follow the structure of the directives for electricity and biofuels. It has been recognized that is has to be moved away from an 'overall' target setting policy outline to "specific initiatives" like targets for technologies or information/education instruments for consumers and suppliers (Commission, 2008b), (Commission Communication COM(2004)366 final). A directive for heating from renewables would certainly stimulate the pellet market for small-scale applications. Up to now, the **Directive on the energy performance of buildings** (2002/91/EC) includes elements supporting the RES-H deployment in buildings but it is not explicitly regulating heating from biomass (European Renewable Energy Council, 2005).

Research programmes for the development and dissemination of renewable energy sources are the Framework Programmes and the Intelligent Energy – Europe Programme. Under the 7th Framework Programme (2007-2013), problems related to the utilization of biomass for electricity generation and biomass technologies are addressed. The Intelligent Energy – Europe Programme provides funding for different projects in the renewable energy field. Relevant for the wood pellet expansion are the PELLETS@LAS project (running from 20007-2009) for the promotion of a transparent European pellet market and pellet trade, and the PROPELLETS project (duration 2005-2007) for the promotion of European pellet heating systems (Commission, 2008c).

4.1.2 Germany

Germany has a federal state structure with limited legislative power at the federal state level. Decisions on the general energy policy are made at the federal level, however federal states are able to shape some energy goals on their own. For example, it could be observed that federal states have established their own promotion programmes for supporting renewable energy next to the nationwide valid programmes (Reiche, 2002).

Germany has created overarching policies for both the promotion of renewable energy for electricity generation and heating. The introduction of the act for supporting RES-E dates back in the early 1990s. Germany has been the forerunner in implementing fixed purchase prices for electricity from renewables – a feed-in tariff system. An important revision of the law followed in 2000 with the Renewable Energies Act (EEG). This act has proven to be extremely successful showing an increase of renewables contribution from 6% in 2000 to 12% by 2006 (BMU, 2007a). On the heating sector, Germany has just recently passed a "Renewable Energies Heat Act" with the goal of a RES-H increase to 14% by 2020. The law imposes the obligation of covering a share of the heat and hot water demand in newly built houses (from 2009) by renewable energy sources.

Important decisions shaping the energy policy are the government's decision for a nuclear phase-out by 2022 and the stop of subsidy payments to the coal industry by 2018.

4.1.2.1 Promotion of renewable energy sources for electricity (RES-E)

The support of renewable energy for electricity generation can look back on a long history. In January 1991 the "Act on the Sale of the Electricity to the Grid" (Stromeinspeisungsgesetz - StrEG) came into effect. A feed-in law that obliges energy suppliers to source electricity primarily from producers of renewable energy and to compensate them at a fixed price which is high enough to allow an efficient operation of the installations (Act on the Sale of the Electricity to the Grid, 1990). The law had been amended in 1998 and finally substituted by the "Renewable Energies Act" (Erneuerbare-Energien-Gesetz - EEG) in 2000. The main innovations of the new EEG have been the introduction of a guaranteed compensation for the next 20 years, a differentiated tariff system for the various renewable energy sources and a degressive promotion for new facilities (decreasing compensations on a yearly base) (Renewable Energies Act, 2000). These changes provided security for investors as well as gave incentives for innovations and improvements of the efficiency in the renewables sector. This stimulated strongly the electricity generation from renewable energy. The overall goal of the EEG is an increase of the share in the power generation from currently 13% (Status: 2007) to 30% by 2020 (BMU, 2007b).

A further important step within the EEG was the amendment of 2004 with better tariffs for electricity generation from biomass (the basic compensation is at a higher rate than the current rate of 2000 after the annual degression) and a stronger focus on small-scale applications and electricity from renewable raw materials (too dominating utilization of biological waste so far) (Renewable Energies Act, 2004).

In June 2008, the Bundestag passed the 3rd amendment of the EEG which enters into force in 2009. Again small-scale biomass applications are particularly promoted with a higher compensation per kWh at unchanged tariffs for the other categories. An overview of the changes for the compensation for biomass since the introduction of the EEG in 2000 until 2009 is given below. In the table only the payment categories for new installations and potential for biomass and thus pellets applications are presented. The first category is the basic

compensation for electricity from biomass. However, the amount can increase due to specific conditions, shown in the following lines. The degression rate refers to the year of starting operations.

Table 5 Development Renewable Energies Act in Germany, Biomass, 2000-2009

Biomass – relevant pellet use & new installations	According to EEG 2000 (Renewable Energies Act, 2000)	According to EEG 2004 (Renewable Energies Act, 2004)	According to EEG 2009 (BMU, 2007b)
Level of Compensation (minimum rate)	10.23 €ct/kWh up to 500 kW 9.21 €ct/kWh up to 5 MW 8.70 €ct/kWh up to 20 MW (1 % annual degression on basic compensation; duration: 20 years)	11.50 €ct/kWh up to 150 kW 9.90 €ct/kWh up to 500 kW 8.90 €ct/kWh up to 5 MW 8.40 €ct/kWh up to 20 MW (1.5 % annual degression on basic compensation; duration: 20 years)	11.67[19] €ct/kWh up to 150 kW 9.18 €ct/kWh up to 500 kW 8.25 €ct/kWh up to 5 MW 7.79 €ct/kWh up to 20 MW (1 % annual degression on basic compensation and bonus; duration: 20 years)
Level of Compensation - Biomass: only renewable raw materials[20] -	———————	17.50 €ct/kWh up to 150 kW 15.90 €ct/kWh up to 500 kW 12.90 €ct/kWh up to 5 MW	17.67 €ct/kWh up to 150 kW 15.18 €ct/kWh up to 500 kW 12.25 €ct/kWh up to 5 MW
Level of Compensation - electricity from CHP	———————	13.50 €ct/kWh up to 150 kW 11.90 €ct/kWh up to 500 kW 10.90 €ct/kWh up to 5 MW 10.40 €ct/kWh up to 20 MW	14.67[21] €ct/kWh up to 150 kW 12.18 €ct/kWh up to 500 kW 11.25 €ct/kWh up to 5 MW 10.79 €ct/kWh up to 20 MW

The amount of electricity generated from biomass since the adoption of the EEG has increased from 4.1 billion kWh in 2000 to 18 billion kWh in 2006 (BMU, 2007b). The goal is a rise to 42 billion kWh by 2020, what makes biomass the second largest green electricity provider after wind power (BMU, 2008a). However, the application of pellets for electricity generation in power plants is few and far between in Germany. Wood pellets are dominantly produced for residential use of better quality and at a premium price.

In June 2001, the ordinance on generation of electricity from biomass (Biomasseverordnung) came into effect defining which materials are to be considered as biomass for the compensation payment under the Renewable Energy Sources Act (EEG). Moreover, it regulates what kind of methods are to be applied for electricity generation and which related environmental standards are to be met (BMU, 2005). However, for the promotion of the wood pellet market the regulation has no influence yet due to the fact that pellets are not competitive enough in comparison to other fuels.

[19] Valid for both new and existing installations

[20] Only biomass from plants and its compnents coming from agriculture, forestry or gardening (shifting the focus from biological waste and waste wood to renewable raw materials)

[21] Valid for both new and existing installations

4.1.2.2 Promotion of renewable energy sources for heating (RES-H)

In June 2008 the "Erneuerbare-Energien-WärmeGesetz" – the Renewable Energies Heat Act – has been passed and will be effective from 2009. It is the equivalent to the EEG for the promotion of renewables in the heat sector. The law was passed under the integrated climate and energy programme of the German government with the objective to increase the share of renewable energy for heating and hot water supply from 6% to 14% by 2020. It has been introduced comparatively late to the EEG of 2000, albeit more than twice the amount of energy is consumed for heating than for electricity generation in Germany (Year: 2005) (International Energy Agency (IEA), n.d.). The law regulates that a share of the heat and hot water demand of buildings has to be covered by renewable energy. The duty applies to all house owners private, commercial and state of newly erected buildings (building application from 2009 onwards). Considering the definition of the term 'share' for heat coming from renewables under this act, the level is connected to the type of renewable source used. For example, when applying a biomass heating system or heating pump respectively, to meet the obligation more than 50% of the heat demand has to be covered by these sources. Solar heating has to contribute with a smaller share of 15% (BMU, 2007c). Since a heating system running on renewable energy sources is linked to higher investment cost, financial assistance is provided through the Market Incentive Programme (Marktanreizprogramm – MAP). The MAP is explained in more detail under 4.1.2.3. Renewable energy sources that receive particular attention under this act and thus are centre for reaching the goal of 20% are biomass, solar and geothermal energy. Biomass energy in the form of wood pellet, biogas or bio oil heating systems is considered. Therefore, this law can significantly contribute to the development of the wood pellet market since biomass is one of the main acknowledged substitutes for conventional energy sources under this law.[22]

In order to disseminate renewable energy for heating in old buildings, the market incentive programme provides funding when changing the old heating system to a new one based on renewables. However, there is no obligation for existing buildings under the Renewable Energies Heat Act (BMU, 2008b).

4.1.2.3 Promotion of pellets

In September 1999, the Market Incentive Programme (Marktanreizprogramm – MAP) was introduced at the federal level, which particularly promotes renewable energy for heating. There, private households and small to medium-sized companies receive government grants for the installation of smaller facilities and soft loans (lower interest and longer duration) for larger ones when investing in renewable energy for heat generation. The government allocated a budget of 100 Mio. € at the beginning of the programme in 1999. A budget of 350 million Euros is available for this programme in 2008. For the period 2009-2012 an increase to a yearly budget of 500 million Euros will be provided (BMU, 2008c).

Over time the subsidy programme had been amended repeatedly concerning the type of RE application considered under the scheme as well as the subsidy level (OECD/IEA, 2007). The latest amendment in the course of the integrated climate and energy programme of January 2008 adopted a benefit scheme. Hence, a premium is paid when installing particular efficient renewable energy systems or when combining renewable energy sources (e.g. installation of a

[22] It has to be noted that there is the possibility to take other measures instead of installing alternative heating systems (if not feasible or reasonable) in order to fulfill the obligation. For example, insulation of the building at least 15% above the level regulated by law or to obtain 50% of the heat of cogeneration. It has to be observed, to which extent these compensating measures are apopted influencing the amount of new renewable energy heating systems

pellet heating and solar panels) (German Energy Pellet Association (DEPV), 2008). Funding can be received via the Federal Office of Economics and Export Control (BAFA) and the reconstruction loan corporation (KfW) a public agency.

According to BAFA the basic funding for pellet combusting installations amounts to 36 € per kW of heat output. However, there is a minimum assured subsidy rate for the different pellet systems independent from the actual set up capacity. The funding under BAFA within the MAP is shown in the table below. (Federal Office of Economics and Export Control (BAFA), 2008), (Central network for marketing and development of agricultural resources (C.A.R.M.E.N. e.V.), 2008).

Table 6 Promotion of small-scale pellet heating systems in Germany, 2008

Automatic loading pellet heating systems	Funding	Minimum Level of Funding
wood pellet stove (air-formed 8 kW – 100 kW)	36 Euro/kW	min. 1,000 Euro
wood pellet boiler (5 kW – 100 kW)	36 Euro/kW	min. 2,000 Euro
wood pellet boiler (5 kW – 100 kW plus newly fitted buffer storage with a capacity of at least 30 l/kW)	36 Euro/kW	min. 2,500 Euro

Source: BAFA

In the case of medium- and large-scale installations heated with solid biomass investors can receive a repayment subsidy of 20 € per kW of heat output for the construction or extension of a facility through the KfW (Reconstruction loan corporation (KfW), 2007).

In addition to the repayment subsidy, the reconstruction loan corporation offers soft loans for financing the purchase of a biomass heating system. The loans mainly directed to private persons and small- and medium-sized enterprises have a lower interest and offer flexibility in the repayment. (Reconstruction loan corporation (KfW), 2007).

Table 7 Promotion of medium- to large-scale pellet heating systems in Germany, 2008

Automatic loading installations, > 100 kW	Level of Funding
Biomass installations	20 €/kW, max. 50,000 Euro
Biomass installations plus local heating network construction/extension	24 €/kW, max. 60,000 Euro

Source: KfW

For securing the pellet quality and thus meeting the requirement for a failure-free operation of pellet heating systems, Germany has a national pellet product standard called DIN 51731. The standard regulates specifications as the size, composition, ash and water content, heating value and density. DIN 51731 is a certified standard which is reflected in a label on the packaging. (Pilz et al., 2004). Also for the pellet heating system (up to 300 kW heat output) a certified standard is in place, DIN EN 303-5. It states requirements for the construction, material used etc.. A certified standard grants more confidence to the consumer in the pellet technology.

4.1.2.4 Energy subsidies for conventional energy sources

In Germany, the coal industry receives direct monetary subsidies from the government. In 2007 the grant amounted to 2.5 billion Euros what is a considerable reduction comparing with the amount of 4.7 billion Euros provided in 1998 (Federal Ministry of Economics and Technology (BMWi), n.d.). The subsidy aims at the competitiveness of the expensive German hard coal with imports and thus to maintain this industrial sector (protectionism).

Under the social democratic-green coalition between 1998 and 2005 a change in the energy policy took place. It has been decided to slowly reduce the subsidies resulting in a final phase-out. The extraction of coal in Germany is not reasonable under economic aspects. This resulted in a resolution of the federal government and the federal states North Rhine-Westphalia and Saarland (the main areas of hard coal mining in Germany) in February 2007, to end the subsidies for hard coal by 2018. The stop of subsidy payments means the end for hard coal production in Germany. The remaining demand for hard coal (after 2018) will be satisfied through imports (BMWi, 2008). The time for phasing out subsidies on hard coal production in Germany is scheduled very late and governmental funds are spent for another 10 years on an industry sector without future. These financial resources could be applied for research and development of other energy sources and their dissemination.

Next to the hard coal industry nuclear energy has been promoted by direct subsidies till recently. Grants from the public authorities have been provided for research and development until 2002 (Jäger & Weis, 2004). Thus, between 1974 and 2007 the state provided funds of 24 billion Euros for the nuclear research and development as nuclear fusion, nuclear reactor safety, and solution of final storage etc. (BMU, 2007d). Under the new aims of the energy policy of social democratic-green coalition a phase-out of nuclear power utilization was targeted. It resulted in an agreement between the government and the utilities in 2001, with the goal to restrict the use of nuclear for power generation power until 2022 (BMWi, n.d.). Despite, the stop of direct subsidies, indirect subsidies as tax-free provisions for the disposal and no taxation on nuclear fuel are still in place. Moreover, costs for the German state arise related to transportation of nuclear waste and the destruction of nuclear facilities (EUROSOLAR, 2006).

4.1.2.5 Taxation of energy products

An ecological taxation had been introduced in April 1999. Under this ecological tax reform an electricity tax and mineral oil tax have been adopted. The electricity tax is addressed to all electricity products except from electricity from renewable energy. The mineral oil tax is directed to fossil fuels – as gasoline, heating oil, natural gas, coal. In the period from 1999 to 2003 the mineral oil tax was increased repeatedly. However, there are some tax reliefs due to intended purpose and type of organization. When fossil fuels are used for heating purposes and/or electricity generation they are subject to a tax relief. The same applies to the manufacturing industry with a lower taxation. This does not provide incentive enough to both consider and reconsider renewable energy heating systems at the point of investment. Besides, the taxation for coal per kWh is very little in comparison to the other fossil fuels (0.33 €/GJ = 0.12 €ct/kWh). In case of consumption as heating fuel in private households or for electricity generation it is even tax-free (Energy Taxation Law, 2006). An overview of the two important fossil fuels used for heating in Germany in comparison to pellets, both under full taxation and reduced taxation, is given below (Energy Taxation Law, 2006):

Table 8 Energy taxation in Germany, 2006

Type of energy source	Value-added tax	Energy tax - Full taxation	Energy tax - Tax relief for heating purposes
Heating oil (industry)[23]	19%	0.13 €/kg (1.18 €ct/kWh)	0.025 €/kg (0.22 €ct/kWh)
Light heating oil (private households)[24]	19%	0.4704 €/l (4.70 €ct kWh)	0.061 €/l (0.61 €ct kWh)[25]
Natural gas	19%	13.90 €/MWh[26] (1.39 €ct/kWh)	5.50 €/MWh (0.55 €ct kWh)
Wood pellets	7%	————	————

A smaller share of the tax income about 1% (of 18 billion Euros tax revenues in 2005) (Federal Ministry of Finance, 2005) is utilised as funding for renewable energy development in particular as means for the market incentive programme. In the last few years the ecological tax reform has been further developed into an ecological finance reform which covers boarder areas than purely taxation as e.g. the removal of the direct subsidies for hard coal and change of the motor vehicle tax (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), 2006).

Wood pellets are exempted from environmental taxes and levied at a reduced rate of 7% value added tax in comparison to natural gas or heating oil on which the regular tax rate of 19% is charged.

4.1.2.6 Other

Germany has not outlined a national Biomass Action Plan yet. It is still in the preparation phase (Kautto & Peck, 2008). However, a set up BAP is vital for assessing a country's biomass potential and thus to take appropriate action to utilise it.

Concerning the proposed EU directive on the promotion of the use of energy from renewable sources, Germany has to meet a national target of 18% of renewable energy sources in the final energy consumption in 2020, compared to 5.1% in 2005 (Commission Proposal COM(2008)19 final).

[23] Assumption: Heating value 11 kWh/kg
[24] Assumption: Heating value 10 kWh/l
[25] From 2009: 0.076 €/l = 0.76 €ct/kWh
[26] Increase to 31.80 Euros/MWh after 2018

4.1.3 Austria

As Germany, Austria has a federal state structure. Hence, energy programmes are decided on federal, state and local level. The main difference to Germany is the greater decisive power of the federal states on the energy policy which is also still applied. For example, the level of subsidies for investments in pellet heating installations is set on the federal state level and hence differs significantly among the federal states. This leads to an uneven development and diffusion of renewable energy utilization throughout the country (Reiche, 2002). However, it has to be noted that some federal states have implemented very successful programmes with convincing results.

In respect of legislation in the renewable energy area, the instrument feed-in tariffs has been introduced for the promotion of electricity from renewable energy sources on the federal level. Such an overarching policy for the support of RES-H is not in place. Promotion of renewables for heating is rather affected by programmes of the single federal states. (Reiche, 2002). Due to this condition it has been spared to review single supporting programmes as separate section but to include relevant ones for pellets in the section 'promotion of pellets'.

For financially supporting investments in renewable energy the 'Österreichische Kommunalkredit', a special commercial bank, gives soft loans and subsidies similar to the KfW in Germany. It includes funding for biomass e.g. investments in district heating schemes based on biomass (Kommunalkredit Public Consulting (KPC), n.d.). Further programmes subsidised by the Kommunalkredit as klima:aktiv and the climate and energy fund are described in more detail below.

4.1.3.1 Promotion of renewable energy sources for electricity (RES-E)

The first policy that dealt with the promotion of RES was the "Elektrizitätswirtschafts- und -organisationsgesetz (ElWOG)" (Electricity industry and organisation) law passed in 1998. The actual task of the law was to foster the liberalization of the electricity market and thus to implement the EU directive on common rules for the internal market in electricity (96/92/EC) (Electricity industry and organisation law, 1998). One of the goals of this act was the increase of the share of renewables for electricity generation. It regulated that each electricity distributor had to provide a certain amount of green power whereas the producer of green electricity gets paid a minimum price (Reiche, 2002). Stimulating renewable energy utilization for electricity was only one of several objectives of the ElWOG. This part became more separated under the "Ökostromgesetz" (Green Electricity Act) passed in August 2002 (BGBI. I Nr.149 2002) - a feed-in law promoting the utilization of renewable energy for energy generation. The concept of the feed-in law in Austria is similar to the one in Germany: minimum prices and mandatory utilization of electricity from renewables. Major differences are shorter periods for guaranteed subsidy payments (between 10 and 15 years, depending on the type of energy source and commissioning date), no integrated degression rate and a fixed amount of funding per renewables category (Austrian Energy Agency, 2006a).

In July 2006 the 1st amendment of the Green Electricity Act (BGBI. I Nr.105 2006) and in June 2008 the 2nd amendment (BGBI. I Nr.44 2008) were passed. Crucial changes apart from increased tariffs were longer periods of guaranteed prices (for biomass installations 15 years) and more flexibility in the subsidies – the option to increase the yearly budget was adopted and the handling of allocating the total subsidy amount among the different renewable energy sources has been removed. The reform shall facilitate achieving a share of electricity from RE of 15% by 2015 (Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW), 2008), (Austrian Energy Agency, 2006a). The specific goal for

biomass established by the amendments of the law is the installation of 100MW biomass with an additional electricity generation of 600 GWh (Green Electricity Amendment 2008). The tariffs for 2008 are alike the ones of 2006.

Table 9 Development of the Green Electricity Act in Austria, Biomass, 2002-2006

Solid biomass e.g. wood chips	**According to Green Electricity Act 2002** (Austrian Energy Agency, 2006a)	**According to Green Electricity Act 2006** (Austrian Energy Agency, 2006b)	
Level of compensation		Contract signed 2006	Contract signed 2007
	16.00 €ct/kWh up to 2 MW	15.70 €ct/kWh up to 2 MW	15.65 €ct/kWh up to 2 MW
	15.00 €ct/kWh up to 5 MW	15.00 €ct/kWh up to 5 MW	14.95 €ct/kWh up to 5 MW
	13.00 €ct/kWh up to 10 MW	13.40 €ct/kWh up to 10 MW	13.30 €ct/kWh up to 10 MW
	10.20 €ct/kWh > 10 MW	11.30 €ct/kWh > 10 MW	11.10 €ct/kWh > 10 MW
	6.50 €ct/kWh mixed combustion	6.40 €ct/kWh mixed combustion	6.30 €ct/kWh mixed combustion
	(duration 10 years)	(duration 15 years)	(duration 15 years)

Source: Austrian energy agency 2006, E-control 2008

A further important regulation of the ElWOG is the duty for electricity companies to break down the type of energy sources for power generation utilised on the customer's bill (Reiche, 2002).

4.1.3.2 Promotion of pellets

In 2004 Klima:aktiv an initiative of the Lebensministerium and part of the Austrian climate strategy was launched. A programme that promotes the utilization of renewable energy sources and aims at decreasing CO_2 emissions. It runs until 2012 and is funded by the Lebensministerium. Two programmes in the area of renewable energy are of importance for the pellet market development: "Holzwärme" which gives incentives for house owners to install biomass heating systems and "Energieholz" which supports to develop unused wood potentials in Austria (klima:aktiv, 2008). Within this programme events are organized to give information regarding the installation of pellet heating systems, the advantages of pellets and available subsidy programmes on federal and federal state level. Furthermore, research and development projects are funded for identifying the prospective wood residues in Austria.

A subsidy directly aiming at wood pellet heating systems is a grant for investing in a new installation or switching to one. However, the amount is determined by each of the nine federal states. The different rates are presented in table 10 (Status: 2008) (Austrian Biomass Association, 2008a).

Table 10 Investment grants for automatic pellet heating systems in Austria (maximum subsidy rate per federal state)

Federal state	Level of subsidy (in €)
Vienna	7,000
Lower Austria	2,950
Tyrol	2,800
Upper Austria	2,640
Burgenland	2,500
Carinthia	2,400
Vorarlberg	2,200
Salzburg	2,000
Styria	1,400

Source: Austrian biomass association, 2008

Moreover, there is a climate and energy fund law (Klima- und Energiefondsgesetz (KLI.EN)) of the federal government in place since July 2007. The law promotes energy efficiency and utilization of renewable energy (Climate and Energy Fund Act, 2007). One programme of the fund particularly promoting pellet heating systems is called "Förderaktion Holz". Effective from the 1st of April 2008, investors of newly installed or converted wood heating systems will receive next to the existing subsidies of the federal states (Länder) as shown in table 10 an additional subsidy of 800 Euros. This programme runs until the end of 2008 and aims at a further diffusion of pellet heating systems across the country (Austrian Biomass Association, 2008b).

Austria has a national pellet product standard called ÖNORM M 7135. It has a similar structure in terms of the type of parameters addressed as in the German counterpart DIN 51731, however the level of the single parameters differ. (Pilz et al., 2004) Pellet heating systems (up to 300 kW heat output) are certified by ÖNORM EN 303-5.

4.1.3.3 Taxation of energy products

In 1995 a tax on oil products was introduced based on the 'Mineralölsteuergesetz' (mineral oil tax act). As under the German energy taxation law fiscal distinctions according to the purpose are made. For 1 kg of oil for heating or electricity generation purposes 6 €ct are charged, otherwise 37.5 €ct/l (24. Federal law, 2007).

The introduction of an energy tax on gas and electricity followed in the subsequent year within the "Elekrtizitätsabgabegesetz and Erdgasabgabegesetz" (electricity taxation act/ natural gas taxation act). The levy for electricity amounts to 1.5 €ct/kWh and for natural gas to 6.6 €ct/m^3 (plus 20% value added tax) (Federal Ministry of Finance (BMF), 2006). However, the tax does not exclude electricity from renewables. The only exemptions were on biomass and biodiesel due to their significance to substitute oil (Reiche, 2002). Next to oil, electricity, and natural gas a levy on coal was established in 2003 (Kohleabgabegesetz – coal taxation act). For 1 kg of coal a tax of 5 €ct has to be paid.

The value added tax on wood pellets amounts to 10% in Austria. In contrast, heating oil, natural gas and electricity are taxed at the standard rate of 20%.

4.1.3.4 Other

Austria is in the preparation phase of a national Biomass Action Plan. So far a draft with an overview of the biomass potential in Austria, an outlook for the biomass development until 2010 and 2020, and proposals how to produce additional biomass for energy purposes has been elaborated. In the report the highest growth rate is anticipated for wood pellets for heat production. There an increase of 280% by 2010 and 640% by 2020 compared to the base year 2004 is expected (BMLFUW, 2006)[27].

Under the proposed EU directive on the promotion of the use of energy from renewable sources, Austria has to meet a national target of 34% of renewable energy sources in the final energy consumption by 2020, compared to 20.3% in 2005 (Commission Proposal COM(2008)19 final).

[27] Fuel requirement pellets for heating: 4.3 PJ 2004, 12.0 PJ, 27.5 PJ 2020

4.1.4 Sweden

Sweden is somewhat different from Germany and Austria in its (renewable) energy policy. The main supportive policies for renewable energy in Sweden are financial subsidies, energy and carbon dioxide taxes on fossil fuels and green certificates for the promotion of electricity from renewables, a market-based economic instrument. In Austria and Germany feed-in tariffs for electricity from renewables and a lower ecological taxation on conventional energy (mainly due to a lacking carbon dioxide tax in the two countries) are applied. Similarities exist in the decision on phasing-out nuclear power as energy source. Like Germany, Sweden has programmes on phasing out all nuclear power plants for electricity generation. As early as 1980, the government confirmed after a referendum the end of nuclear energy by the year 2010. This date had been repealed in 1997 and in 2002 the government and the energy industry had agreed on the nuclear power phase-out in 2017 (Reiche, 2002). The recent government has not taken further steps in closing additional nuclear power plants so far. The issue is that nuclear power plays an important role in particular in the electricity generation. Almost a half of the electricity is supplied by nuclear power plants (46%) and the other half is generated from hydro power (46%). A minor fraction comes from renewables (6%) and fossil fuels (2%) (Year: 2005) (IEA, 2008). Thus, a total phase-out would cause extreme difficulties for a secure and low-carbon energy supply. A substitution by more hydropower is not viable due to an already extensive usage and resolved stop of its expansion. A likely substitution by oil would make a compliance with the CO_2 emissions target under the Kyoto protocol difficult to achieve (IEA, 2007a). Therefore, this decision will definitely provide opportunities for the development of renewables as alternative energy sources. However, it is questionable if renewable energy can substitute the nuclear power share by 2017 what jeopardizes the final shut down of nuclear power plants.

Next to the decision on nuclear power, Sweden anticipates the phase out of oil and electricity usage for heating purposes in residential and commercial areas. Instead the government focuses more on alternative energy sources to heat among which pellet, solar and biofuel heating have been mentioned (Swedish Energy Agency, 2006).

4.1.3.5 Promotion of renewable energy sources for electricity (RES-E)

For stimulating electricity generation from RES Sweden has introduced an electricity certificate system in May 2003. It is a quota system where each electricity supplier has to provide a certain amount of the annual electricity sales from renewables. The overall quota is set by the government and the amount of so-called green certificates obtained through RE electricity purchasing[28] is determined by the sales figures of a supplier. One certificate refers to 1 MWh of green electricity. For non-fulfilment of the quota, a fine is to be paid per missing certificate. As in the case of the feed-in tariff system the added costs reflected in a higher price are borne by the consumer (Swedish Energy Agency, 2008a). The goal is to increase RE electricity production from the 2002-level of 70 TWh[29] to 80 TWh in 2010 and 86 TWh in 2016. So far, electricity from renewables has increased by 6.76 TWh since the introduction of the system (Status: 2007) in contrast to the anticipation of 8.96 TWh. In the years 2003 to 2007 the most certificates have been issued by far for biofuels including by-products from

[28] 1 electricity certificate for 1 MWh produced electricity.

[29] Almost 90% of the 70 TWh come from hydro power and only 6.5 TWh from other renewable energy sources. Under the electricity certificate scheme hydro power is excluded from RES definition. Hence, the increase of 17 TWh has to mainly from sources making up a small share by 2002.

forestry industry (Swedish Energy Agency, 2008b). Industrial wood pellets are utilized in CHP and power plants for electricity generation.

4.1.3.6 Promotion of renewable energy sources for heating (RES-H)

The Swedish government has established a so-called conversion grant in 2006, supporting investments into renewable heating systems like biomass, CHP, district heating and solar energy. The purpose was to bring a shift from the widespread use of heating oil and electricity for residential heating. The timeframe for the programme was set for 5 years until the end of 2010 (OECD/IEA, 2007). The conversion grant incentivised investments into alternative energy sources. It stimulated the small-scale pellet market resulting in an increased number of pellet boiler sales, pellet production and pellet boiler producers on the Swedish market between 2006 and 2008 (Höglund, 2008). However, its budget was already consumed by October 2007. This led to a drop in investments for renewable heating and hence, negatively affected the renewable energy market (Höglund, 2008).

4.1.3.7 Promotion of pellets

Among the programmes stimulating wood pellet utilization in Sweden, it has to be differentiated between pellets applications in power/CHP plants and residence. Already beginning 1990s, subsidies for the investment in biomass utilization in CHP plants have been granted. This support was running from 1991 until end of 2002 with an interruption between 1996 and 1998. For setting up a biomass firing plant or converting an existing one 25% of the investment costs have been refunded (OECD/IEA, 2007).

For small-scale applications the Swedish government stimulates investments under the Local Investment Programme (LIP) into sustainable projects since 1996. In particular 'renewable energy projects' have led to investments into biomass heating systems among which a number of local pellet heating systems have been installed. The LIP was substituted by the Climate Investment Programme (KlimP) in 2002. There, grants in the area of energy use in homes/commercial premises (e.g. converting oil heating into pellet heating) and energy production/distribution (e.g. local heating systems with pellets) have promoted a diffused use of pellets for heating (Swedish Environmental Protection Agency, 2007).

A further promoting tool for wood pellets for residential use was in place in the years 2004 to 2006. There, the house builder received a tax deduction when installing a heating system based on biomass like wood pellets, wood chips or agricultural crops. The tax deduction amounted to 30% of the total installation costs for the heating system including the boiler, buffer storage etc. (AEBIOM, 2006).

The Swedish pellet product standard SS 187120 guarantees the quality of pellets for household usage. As the German and Austrian standard it addresses alike types of parameters, however the levels of the single parameters differ. Sweden applies the European standard for small-scale pellet heating systems (up to 300 kW heat output) (Fiedler, 2004).

4.1.3.8 Taxation of energy products

The first considerations of policies promoting renewable energy for the energy supply came with the Energy Policy Bill (1991) and Sustainable Energy Supply Bill (1997). The goal was a sustainable energy supply e.g. to substitute fossil fuels by renewables for heating and electricity. To achieve this shift in the energy system an Energy Research Programme was initiated. Next to it, ecological taxation and prices were chosen as steering instruments to

transpose this policy (OECD/IEA, 2000). Due to this decision, a complex taxation system concerning energy products emerged. Thus, environmental taxes, as an energy tax, carbon dioxide tax, electricity tax, sulphur tax and nitrogen oxide tax on fossil fuels and electricity (consumption) have been introduced. Bioenergy including pellets is exempted from the taxes (Reiche, 2002). The tax structure is as follows: Energy tax is charged on electricity and all fossil fuels, the carbon dioxide tax is charged on all fossil fuels and the sulphur tax is charged on all fossil fuels and peat. The tax levels of 2007 for two important energy sources in Sweden, heating oil and electricity, are shown in table 11 (Ministry of Finance, 2007). The tax on heating oil is indicated per m^3 and on electricity per kWh consumed. In brackets the corresponding value is given in Euros. On top of the energy tax, comes the value added tax of 25% on energy consumption.

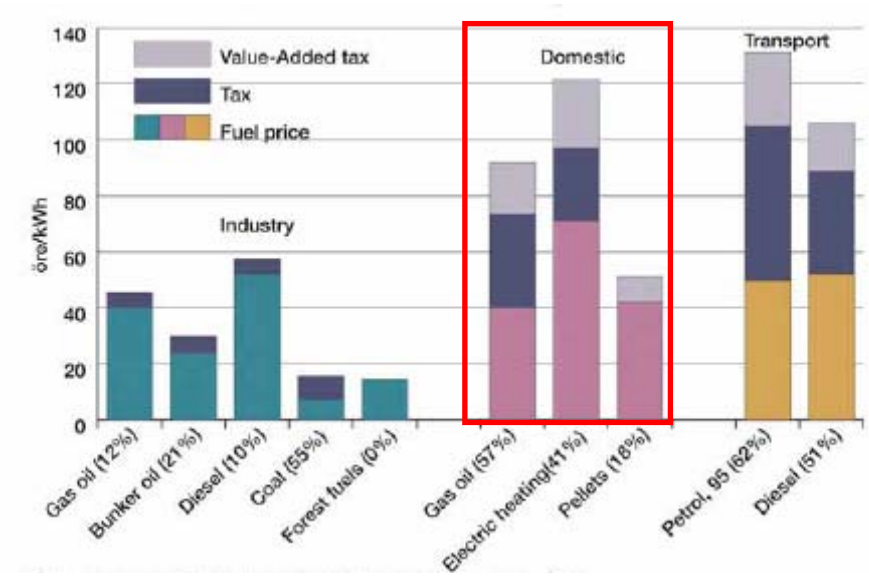
Table 11 Energy taxation of heating oil and electricity in Sweden, 2007

Energy product	Total energy tax in Skr (in Euro)
Residential heating oil (per m^3)	3,647 (396.41)
Electricity (per kWh)	
- Households in Northern Sweden	0.178 (0.019)
- Households in rest of Sweden	0.270 (0.029)
- Industry, agriculture	0.005 (0.0005)

Source: Ministry of Finance, 2007

The effects of the ecological taxation are illustrated in figure 8. Due to the energy tax and the value-added tax, the total share of taxes of the price for gas oil amounts to 57% per kWh and for electric heating to 41% per kWh. In contrast, taxes on pellets make up 18% of the total price per kWh since they are not subject to the energy tax but charged the value-added tax. (Status: year 2006) (Swedish Energy Agency, 2008c). This taxation system made wood pellets attractive as an alternative to oil for heating in residential buildings.

Figure 8 Total energy prices for various user categories in Sweden, 2006



Source: Swedish Energy Agency, 2008 (Swedish Energy Agency, 2008c). (The percentage in brackets stands for the share of taxes of the total price for the respective fuel)

A survey by Statistics Sweden (SCB) revealed that in 2006 only about 8% of the private households (one- and two dwelling buildings) in Sweden used oil for heating and hot water, with a further declining tendency. The main energy source is electricity with more than 50%[30] followed by biofuels (25%) and district heating (11%). Applied biofuels are firewood, wood chips and wood pellets. The share of pellet heating systems among biofuels amounts to 18% and the total consumption to 4.5% (Statistics Sweden (SCB), 2007)[31]

Thus, it can be stated that the use of energy taxes encouraged an increased deployment of bioenergy while at the same time heating oil utilization declined. Taxation revealed to be an effective tool to develop renewable energy sources (biofuels) as substitutes for oil in domestic heating and hot water supply in Sweden.

4.1.3.9 Other

Sweden has not started to prepare a national biomass action plan, yet. But as mentioned by Kautto and Peck, especially in the case of Sweden and its traditional closeness to biomass as energy source, it does not imply that Sweden is not active in the field of bioenergy dissemination (Kautto & Peck, 2008).

Under the proposed EU directive on the promotion of the use of energy from renewable sources Sweden has a national overall target for the share of energy from renewables in the final consumption of 49% in 2020 from 29.6% in 2005 (Commission Proposal COM(2008)19 final).

4.1.4 Summary

All countries primarily prefer fiscal and financial incentive schemes as policy instruments. Promotion programmes with grants and soft loans as well as ecological taxation are the most applied tools for supporting renewable energy.

The national energy policy of Germany and Austria has similar structures and objectives for the promotion of renewable energy per se as well as wood pellets. Similar policy measures are not least due to a similar structure of the wood pellets market (small-scale applications) as well as the historic and cultural closeness of the two countries. Germany and Austria have currently specific programmes promoting biomass and wood pellets as seen with the market incentive programme (MAP) in Germany or the campaign "Förderaktion Holz" and the preparation phase of establishing a national biomass action plan in Austria. The promotion concerns the higher investment costs for a pellet heating system and thus reduces the initial financial burden. Higher investment costs are often viewed as barrier for consumers to decide for pellets as alternative.

Sweden focuses its attention on taxation by imposing energy and carbon taxes on fuels from which biofuels are exempted (OECD/IEA, 2007). The instruments for promoting wood pellet applications are investment grants for both large- and small-scale applications. This reflects the same policy approach as in Austria and Germany.

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[30] Including electricity heating only, combination of electricity with other fuels, electricty consumed for the use of heat pumps

[31] It has to be noted that the survey exclusively considered one- and two-dwelling houses. By including apartment houses the distribution will change to the effect that the share of district heating is much larger.

Overall it could be noticed that the instruments of regulation and information/education are rather applied sporadically in order to stimulate investments in wood pellet boilers. Solely in Germany a regulation for RES application for heating has been introduced.

In Germany, Austria and Sweden information campaigns have been initiated on a federal state level. The German state North Rhine-Westphalia had launched a campaign called "Aktion Holzpellets" in 2003 and the federal state Upper Austria started a pellets campaign in 2008. Both programmes aim at information dissemination highlighting the advantages of wood pellets utilization as fuel (Egger, 2008). At the beginning of 2007 a first nationwide initiative "Pro Pellets" was established in Germany to promote the fuel wood pellets as energy of the future (Initiative Pro Pellets, 2008), however without big success. Next to a lacking wide-spread use of marketing and information campaigns as policy instruments, specially-tailored subsidy programmes for supporting wood pellets are not sufficiently in place. Germany had introduced programmes for the sole promotion of either solar or geothermal energy (e.g. 1,000 roofs programme or solarthermics 2000 programme for photovoltaic). However, nothing comparable has been established for wood pellets so far.

Table 12 Summary policy instruments in Sweden, Austria and Germany for renewable and conventional energy sources[32]

Policy instrument		**Germany**	**Austria**	**Sweden**
Financial instruments	Capital grants	Investment grants: Market Incentive Programme (MAP)	Investment grants: Förderaktion Holz (On federal state level there are individual investment grants programmes)	Conversion grants, investment grants
	Operation grants	Feed-in tariffs[33] (Renewable Energies Act)	Feed-in tariffs (Green Electricity Law)	Green certificates[34]
	Subsidies for conventional energy sources	Direct funding of coal, R&D programmes for nuclear power	R&D programmes for nuclear power [35]	R&D programmes for nuclear power
	Tax reductions and exemptions	Biomass is exempted from energy tax, reduced VAT rate on pellets	Biomass is exempted from energy tax, reduced VAT rate on pellets	Biomass is exempted from energy and carbon tax
	Tax deductions	———	———	Tax deduction on installing a biomass heating system
	Taxation of conventional	Ecological taxation	Ecological taxation	Ecological taxation including a carbon

[32] Evaluation follows the calssification in Renewables for Heating and Cooling: untapped potential, IEA/OECD, 2007

[33] Feed-in tariffs can also be viewed as regulation since they oblige local grid operators to purchase electricity from RES. On the other side feed-in tariffs give an incentive for the electricty production from RES due to a guaranteed minimum purchase prices.

[34] Green certificates also have mandatory elements. It can not only be seen as financial instrument per se and thus can be assigned to regulatory instruments as well.

[35] Despite that Austria does not utilise nuclear power it spends R&D funds on nuclear energy (Jäger & Weis, 2004)

	energy sources			dioxide tax
Regulatory instruments	Building regulation	Renewable Energies Heat Act	_____	_____
	Standards	National specification standard for pellets and EU standard for pellet heating system	National specification standard for pellets and EU standard for pellet heating system	National specification standard for pellets and EU standard for pellet heating system
Education instruments	Information	Information campaigns	Information campaigns	Information campaigns
Specifics		National coal industry	No use of nuclear energy; high share of hydro power (electricity) and biomass (heating) among renewables and total energy consumption	High share of hydro power (electricity) and biomass (heating) among renewables and total energy consumption

4.2 Market

Most pellets markets in Europe are still immature but fast growing, and differ from country to country. The markets with the longest history are Sweden and Denmark (both established about two decades ago) followed by Austria in the mid 1990s and later Germany formed in 2000 and a new big market Italy, to mention the main ones (Wild, 2008). In 2006, the total amount of pellets produced in Europe amounted to circa 6.3 million tons what is 75% of the worldwide production (8.3 Mt) (Rakos, 2008). The major European pellets production comes from Sweden, Germany, Austria, the Baltic States, Finland, and Denmark.

Within Europe three different types of consumer markets have developed over time: Markets where pellets are either mainly used for heat production (in Germany, Austria, and Italy), or power generation (in the Netherlands, Belgium and the United Kingdom), or both electricity and heat generation (Sweden and Denmark) (Wild, 2008).

In Germany and Austria pellets are mainly used in small- and medium-scale applications (pellet stoves and boilers). In contrast, Sweden employs wood pellets chiefly in large-scale appliances as power plants and CHP next to medium- and small-scale use e.g. for heating public facilities and single family houses.

The main actors of the pellets industry are the pellets producers, stove and boiler manufacturers, trade and producers of components. Currently, more than 60 boiler and stove manufacturers (European Biomass Association (AEBIOM), 2007) and 285[36] pellet producers (Bioenergy International, 2007) are on the European market. The following pellets market analysis of the considered markets will be based on the amounts of pellets produced, the pellets production capacity and the amount of installed pellets heating systems and related pellets consumption and the trading structure. Thereby an overview of the present market development is provided. In addition an outlook of the markets is given.

[36] Considering larger plants with mainly more than 10,000 tons yearly pellet output

Flows of pellet trade have been established in Europe during the last years. Trading of pellets primarily takes place within regional clusters. For instance, Austria exports mainly pellets to Germany and Italy and receives some smaller amounts from Czech Republic and Slovakia. The trading partners are bordering countries. Besides, it can be noticed that a few countries are only producers of wood pellets like Czech Republic, Slovakia or the Baltic States. Sweden, Germany and Austria are both producers and consumers. The convenient characteristics of pellets – easy to handle and store, and high energy content per kg in contrast to other woody biomass fuels– can facilitate its further commerce (EUBIONET II, 2007).

Figure 9 Main trading flows of pellets in Europe

Source: EUBIONET II, 2007

The problem related to the European trade of pellets is a lack of transparency and predictability. Pellets are traded via OTC trade (Over-the-counter) (Wild, 2008). The characteristic of an OTC trade is a direct exchange of the goods between two parties. Thus, a "place" of exchange is missing where different suppliers and consumers meet. This causes non transparent market structures concerning pellet prices and available quantities and capacities. Therefore, experts highly recommend moving from an OTC trade of pellets to a commodity trade which would significantly increase the transparency of the market (Wild, 2008).

4.2.1 Supply and demand

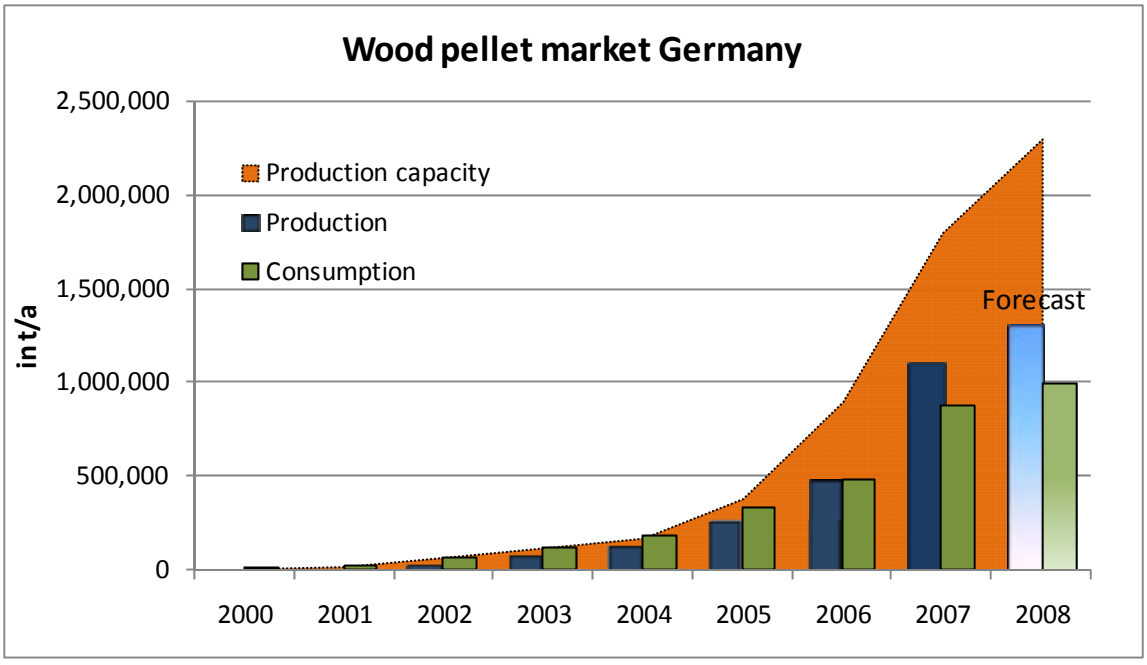
4.2.1.1 Germany

The German pellet market is fast developing with a significant growth potential. In the last years the market for pellet boilers and stoves for small- and medium-scale applications experienced a rapid increase. Factors as promotion programmes and the increasing oil and gas prices gave incentives for house owners to install wood pellet heating systems. In particular, it is expected that the recently passed Renewable Energies Heat Act effective from 2009 will give new impetus for a reinforced utilization of pellets on the small-scale market

The production and production capacity of wood pellets is not as high as in Sweden, however an increase is anticipated with new facilities under construction. At the moment, 60 production plants are located in Germany (DEPV, 2008) with a production of 0.9-1.2 million tons and a production capacity of 1.8 million tons in 2007. In comparison, in 2006, just 32 pellet producers were located in Germany (Peksa-Blanchard, Dolzan, et al., 2007) with a capacity of 900,000 tonnes. Only in 2006, the amount produced and demanded broke even. Before the pellet market was dependent on imports. In 2000 the production could only cover 20% of the demand and already by 2007 the production volume was 25% above the national consumption. (PELLETS@LAS, 2008).

In 2006, the provided budget for the promotion programme MAP was fully consumed by midyear[37]. The consequence was a rapid decline in pellet stoves and boiler sales (see figure 11). In the following year, the budget was about 20% higher (European Biomass Association (AEBIOM), 2007) however the demand was still damped owing to the circumstances of the previous year (Peksa-Blanchard, Dolzan, et al., 2007). As the pellet heating systems market experienced an increase in sales by 60% both in 2005 and 2006, the sales figures of 2007 just showed an increase of 20%. For 2008 a further growth of 20-30% is expected. (European Biomass Association (AEBIOM), 2007). Figure 10 shows the development of the parameters production, production capacity and consumption between 2000 and 2008. In figure 11 the corresponding development in the number of small-scale pellet heating systems in Germany is illustrated, both on a yearly base and cumulative.

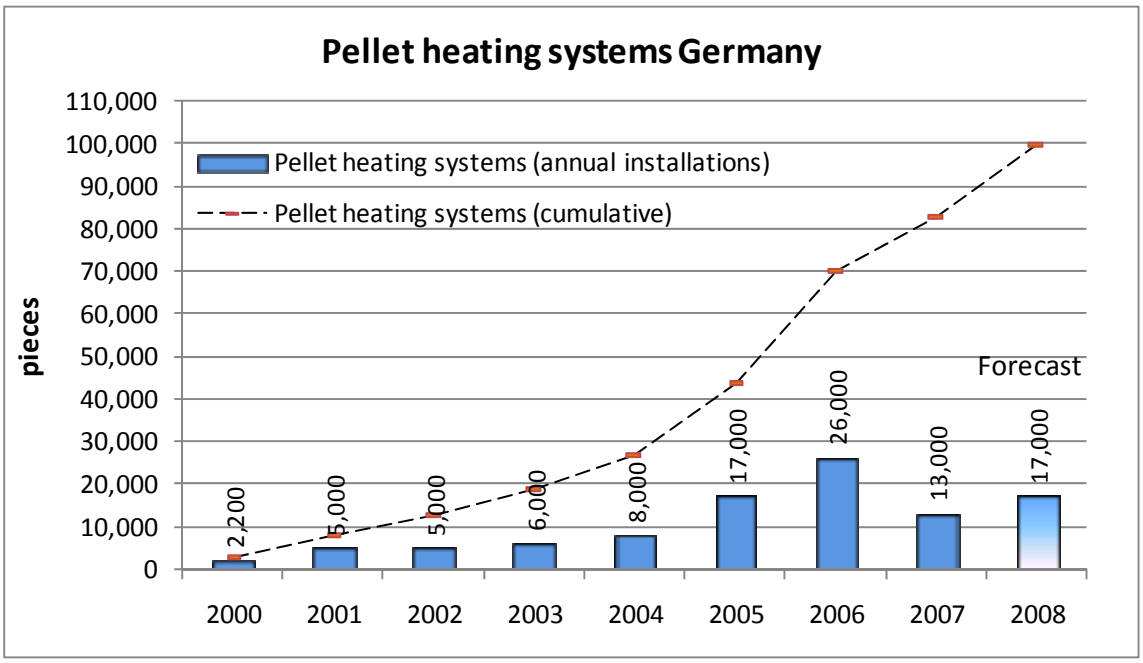
Figure 10 Wood pellet market development small-scale in Germany, 2000-2008



[37] The effects of the MAP are described in more detail in section 4.2.3.5.

Source: DEPV 2008, PELLETS@LAS 2008

Figure 11 Development of pellet heating systems (small-scale applications) in Germany, 2000-2008



Source: DEPV, 2008

4.2.1.2 Austria

Austria has a long tradition in the forest industry and hence wood has been a common heating fuel ever since. This premise eased the introduction of wood pellets as heating fuel into the market in the mid 1990s. Like in Germany, wood pellets are predominately applied in residential heating.

In 2007, 31[38] pellets producers (Bioenergy International, 2007) with a production capacity of 790,000 tons were located in Austria. Within a year the capacity increased by 14% to 900,000 tons. The number of set up pellet boilers rose from 425 in 1997 to already more than 10.000 of yearly installations in 2006, totalling to 47.000 pieces.

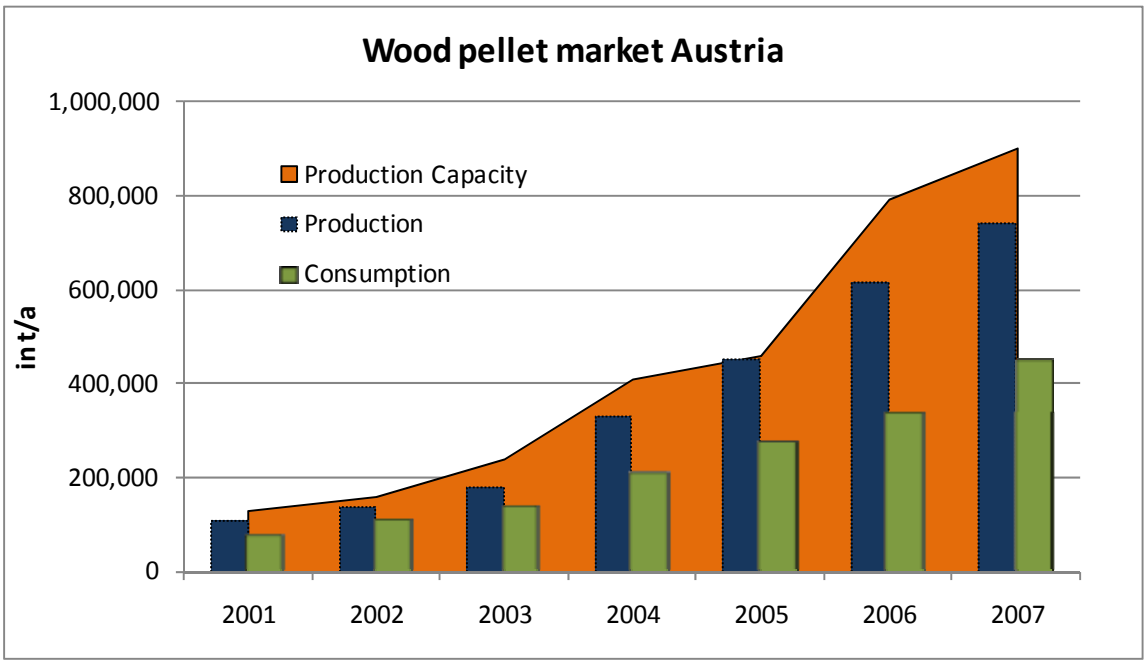
Austria has a higher production output than actually demanded. In the beginning of 2000 the level was 30% above the quantity demanded and by 2006 it was even 80% more pellets production than consumption. Thus, Austria is a net exporting country for pellets. Italy and Germany are the two main receiving countries.

Furthermore, Austria is leading in production and innovation of automatic pellet heating systems for small-scale applications in Europe (EurObserv'ER, 2007). In order to foster this leading position the Austrian government promotes Research & Development projects (IEA, 2007b).

[38] Considering larger plants with mainly more than 10,000 tons of yearly pellet output

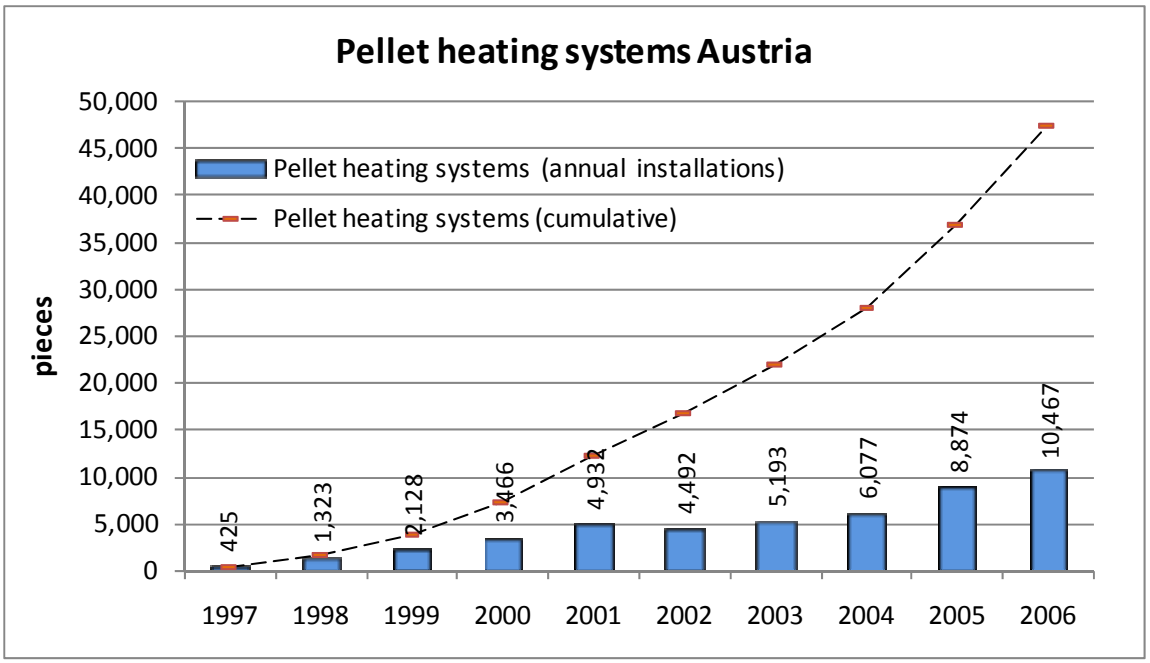
Figures on the wood pellet market development in Austria between 2001 and 2007 are presented below.

Figure 12 Wood pellet market development small-scale in Austria, 2000-2007



Source: PELLETS@LAS, 2008

Figure 13 Development of pellet heating systems (small-scale applications) in Austria, 1997-2006



Source: Energieklima, 2007

4.2.1.3 Sweden

Sweden was the first pellet market in Europe, starting to develop in the early 1980s. The emergence of a sound pellets industry was facilitated by the new Swedish energy policy with the introduced energy and carbon taxes on fossil fuels as well as the rising oil price. Thus, bioenergy and with it wood pellets became an alternative fuel both for large-scale and small-scale applications (Peksa-Blanchard, Dolzan, et al., 2007). At first, large-scale pellet applications established and shaped the pellet market in Sweden. Wood pellets were largely applied in power plants and district heating systems. And still, 60% of the pellets are supplied to large-scale users (Pelletsindustrin (PiR), 2008). Later small- and medium-scale applications evolved and are catching up (Höglund, 2008). This trend is also fostered by the raised carbon tax on heating oil as well as investment subsidy programmes tailored to the small-scale market.

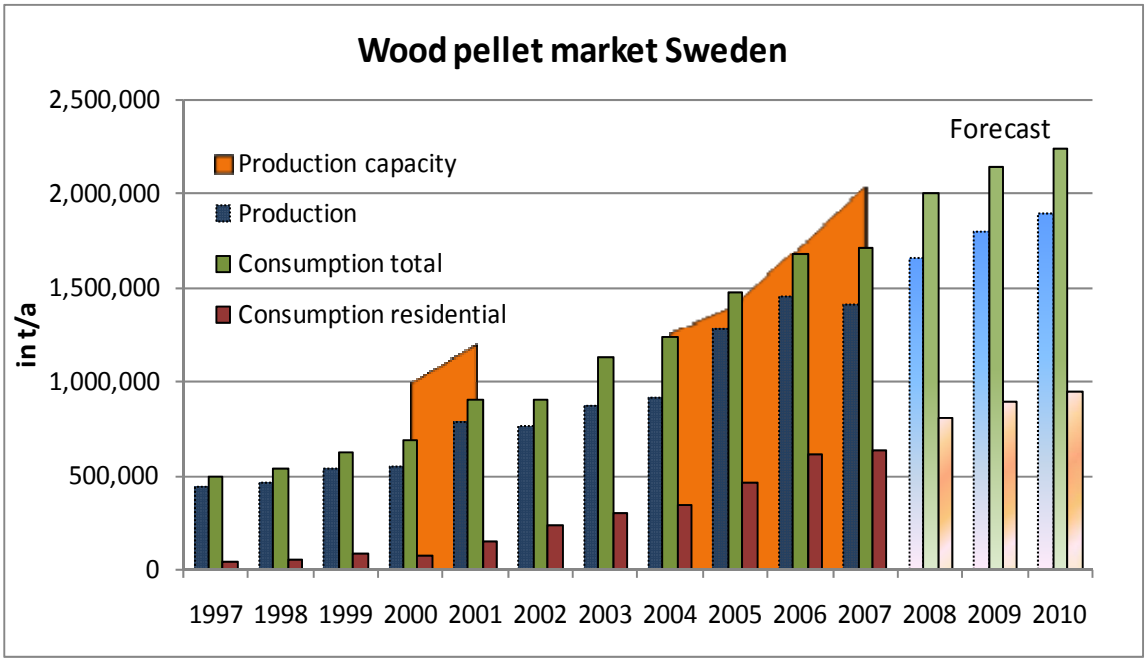
In 2007, 44[39] pellet producers were established in Sweden (Bioenergy International, 2007) with a production of 1,400,000 tons of pellets at a production capacity of 2,032,050 tons. The consumption throughout Sweden was in total (power plants and residential) 1,715,000 tons. Therewith, Sweden is both the largest pellets producer as well as consumer in Europe. Also in the small-scale sector alone (stoves and boilers < 100 kW), Sweden is the leading market concerning the number of facilities in place and related consumption. However, the total demand cannot be satisfied by its own means and Sweden receives imports from Canada as well as from Poland, the Baltic States and the Netherlands (Peksa-Blanchard, Dolzan, et al., 2007).

The future growth of the Swedish pellets market in terms of small-scale applications is guided by mainly substituting electrical heating and heating oil. A common practice was so far the replacement of heating oil installations with pellet systems. This has been successfully pursued in the last years and the number of Swedish private households heated by oil could be reduced. Thus, the substitution potential of conventional heating systems by pellets ones in the residential lies stronger in electric heating substitution or new installations. (Mahapatra & Gustavsson, 2008).

As in Germany, it happened that the stoppage of an investment subsidy contributed to a decrease in pellet boiler sales. The Swedish government granted financial support when converting a conventional system to a renewable system starting from 2006 until October 2007. The temporally restricted subsidy resulted also in a decreasing demand for pellet heating systems: in 2006: 32,000 units sold, and in 2007: only 6,000 units sold (Höglund, 2008).

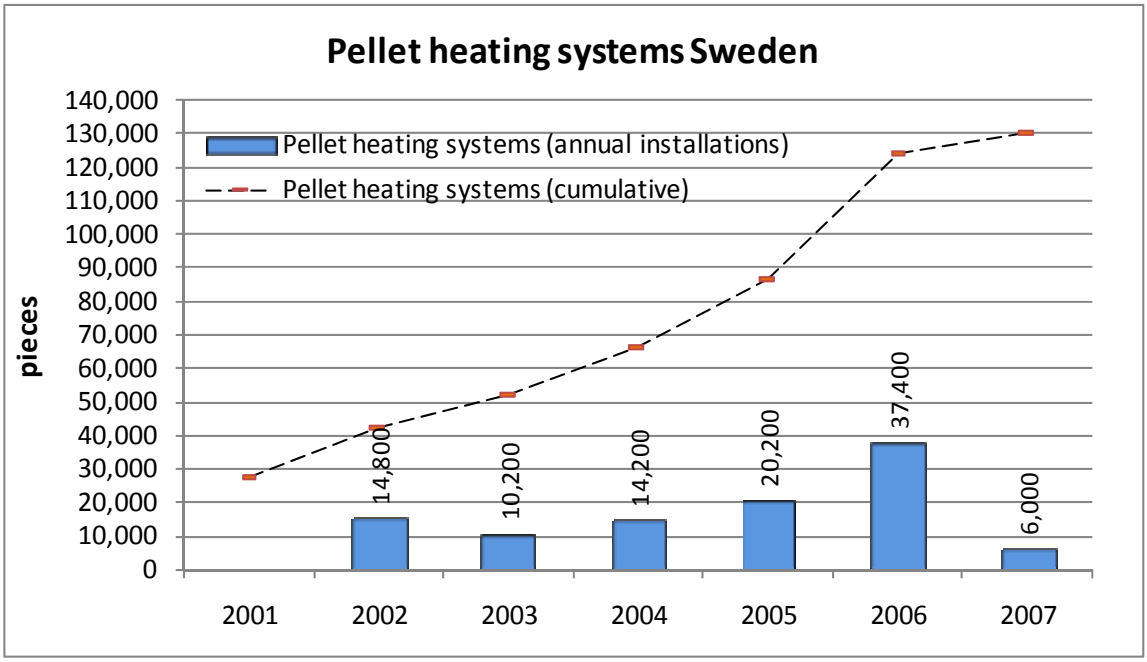
[39] Considering larger plants with mainly more than 10,000 tons of yearly pellet output

Figure 14 Wood pellet market development large- and small-scale in Sweden, 1997-2010



Source: Pelletsindustrin 2008, PELLETS@LAS 2008

Figure 15 Development of pellet heating systems (small-scale applications) in Sweden, 2001-2007



Source: PELLETS@LAS, 2008

4.2.1.4 Excursus: Sawdust availability in Europe and worldwide

A further important aspect of the development of the market and the price is the resources of raw materials used in the wood pellet production – sawdust, residues of the wood processing industry and sawmills. Two surveys estimating the sawdust availability have been considered.

One study of the sawdust availability in an important region for pellets production in Europe – the Baltic Sea area[40] – has been done by Johansson (2007). There, the total production potential is estimated to 11 Mt wood pellets if all sawdust is used for pellets. Currently, the production amounts to 3 Mt at a production capacity of 4.5 Mt (status: 2006) (Johansson, 2007). This shows that the there is security of supply for the coming years. In particular Germany and Russia[41] show a high potential of sawdust utilization. In contrast, the Swedish market already consumes a great share of its sawdust resources. However, other important European markets with sawdust availabilities and pellet markets as Austria and France have not been included in the survey. Besides, a consideration of full sawdust exploitation for pellets production is not realistic. A high demand comes e.g. from the furniture industry, too. Hence, on the long run limits to the European supply of wood pellets could arise due to emerging demand from new and existing markets to some extent without own required production capacities. Besides, no market in Europe has reached saturation so far and hence will ask for more future supply.

Thus, markets outside of Europe with large resources of woody industrial by-products but without a direct use as feedstock for other industries will become important future suppliers of the European pellet market. Countries with a potential to supply sawdust for wood pellet production are among others Brazil, Russia and Canada or also China (Peksa-Blanchard, Dolzan, et al., 2007).

Another study, focusing on the worldwide sawdust availability, identified a sawdust potential only for wood pellets production of 13 Mt (Peksa-Blanchard, Dolzan, et al., 2007).

Limited possible supply of sawdust by increasing expected demand will force up the wood pellets prices. Already now in countries like Denmark and Sweden prices for sawdust are higher than in others due to a greater utilization of sawdust for pellet production and other fields of application (fibreboard, particle board etc.) in comparison to its availability. The result is competition for this material what leads to higher prices. For example among established markets, the market price for sawdust is two to four times higher in Sweden and Denmark than in contrast to Germany and Austria with significantly lower prices. (EUBIONET II, 2007).

The two studies show that it can be assumed that about 50-60% of the available sawdust for the pellet production is already used. But these analyses do not include other presently used feedstock like shavings, promising future 'raw' materials as agricultural waste (straw, bagasse, husks) and the prospect of undeveloped markets (European Biomass Association (AEBIOM), 2007).

4.2.2 Consumer perspective

This part will discuss the awareness and acceptance of wood pellet heating systems on the market from a consumer perspective. As touched upon in the methodology introduction the degree of cognitive legitimation that is how well known the wood pellet technology is among the actors is considered. From the consumer's perspective it implies how familiar and knowledgeable the consumers are in using a technology. (Aldrich & Fiol, 1994). Two studies on the small-scale heating system market in Sweden and Germany have been taken into consideration.

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[40] Including the countries: Sweden, Finland, Denmark, Norway, Latvia, Estonia, Lithuania, Germany, Poland, Russia

[41] Considering North-West Russia

The Swedish research analyses the diffusion patterns of innovative residential heating systems in Sweden based on questionnaires directed to homeowners in the years 2004 and 2007. The intention was to identify motivations for homeowners to decide for an innovative heating system as heat pumps or pellet boilers and related to it "the variation in diffusion patterns" (Mahapatra & Gustavsson, 2008). Next to the initial need for a new heating system and socioeconomic factors as income and age, the attitude of a homeowner towards a certain heating system is seen as a trigger shaping the decision in favour of a heating type. The authors identified performance, economic, environmental and technical aspects, level of comfort, availability of fuel, and information collection as factors influencing the decision (Mahapatra & Gustavsson, 2008). In respect to pellet heating systems compared to other systems as oil, heat pumps, electric heaters and district heating the surveys brought the following results: pellet boilers were perceived as reasonable in fuel costs and investment costs[42], but there were disadvantageous aspects like least functional reliability and automation, lack of security in fuel supply, little environmental benignity and the time needed for information collection (Mahapatra & Gustavsson, 2008). In all categories district heating was rated as best and oil heating as worst. Pellet heating systems were ranked in the lower half among the considered heating systems. In terms of awareness specifics of pellet heating systems are least known among the consumers in contrast to all other heating systems of the study (Mahapatra & Gustavsson, 2008). Summarizing, pellet heating system polled badly in contrast to other systems from a consumer's perspective. Of course, some aspects as information collection still seen as a drawback in pellets are justifiable since it is not as established as for instance electric heating. However, it is apparent that this overall low ranking of pellets was also influenced by inadequate knowledge on this technology. For example, there was little awareness that fully automatic pellet heating systems are available which can compete with the convenience factor of other heating systems.

The German research is in connection with the evaluation of the market incentive programme (introduced and described in chapter 4.1.2.3.) and its development in promoting RETs for heating. Every one to two years a report on the status of the programme and its effects on the diffusion of RETs on the heating market is published. Among households deciding for a biomass heating system within the scope of this programme, the largest rate could be observed in the Southern part of Germany with 64% (BMU, 2004). This has been explained with the stronger familiarity with the fuel wood since the Southern part is characterized by large forested areas and application of wood heating is still common at least as supplementary heating[43]. Such a wood heating culture and tradition eases the spread of a new heating technology based on woody biomass. Hence, there is a correlation between familiarity and acceptance as fuel input. (BMU, 2004)

The two cases revealed that on the one hand adequate information on the pellet's technology and its specifications is vital for the acknowledgement of wood pellets as reliable and sufficient full. On the other hand the familiarity with wood fuels facilitates the acceptance of wood pellets as heating fuel. Hence, knowledge and acquaintance lead to a higher degree of legitimacy supporting a greater diffusion of pellets.

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[42] As described before, in Sweden it has been common practice to convert the heating oil system into a pellet system (mostly not automatically feeding) what is cheaper than installing new automatic pellet system. Thus, investment costs were not ranked as a negative aspect.

[43] Other factors as increasing prices for heating oil and a poorly developed natural gas system were also supporting this development

4.2.3 Price

The price analysis will focus on the price development of the pellet fuel. Besides, its cost competitiveness will be compared to the fuel prices and heating system prices for conventional fuels.

The market price for wood pellets depends on the production costs as the raw material, stages of production, personnel, etc.; the delivery costs as well as the margin and added taxes (VAT). Among production costs it has been identified that the highest cost fraction is allocated to the raw material with more than one third followed by the drying process (if required), the personnel and then the actual pelletizing. A further important cost driver is the throughput and related operating hours per plant (C.A.R.M.E.N e.V., 2002).

The total price of pellets (incl. VAT) for small-scale applications differs from country to country in Europe. A range of 130 to 267 €/t (Feb. 2008) could be observed what is a difference of more than 100%. (Junginger, Hoeldrich, et al., 2008).

The **raw material prices** have a significant impact on the price differences. As shown above prices for the input material sawdust vary from country to country. Combined with the high share of raw material costs among the production costs, it is a very important cost driver and fluctuations/differences are directly reflected in the pellet production costs.

Considering the **margin** experts participating in the PELLETS@LAS project stated that "pellet markets so far are **regional** influenced by **supply and demand**" (Junginger, Hoeldrich, et al., 2008), what results in a local pricing policy. Countries with higher demand than local supply are in the upper price range, countries with higher local production are in the medium price range and net producer countries have the lowest prices. Choosing Sweden as an example with the second highest pellets price in Europe (248 €/t, Feb. 2008), the price level could be explained as follows: there is more demand than local supply in the country. The scarcity allows producers to ask for a higher price. In contrast, Austria has surplus production and thus producers depend on selling their output. Furthermore, in Sweden the majority are large-scale users providing a basic demand. The remaining output can be sold at a price which is accepted by the market (Kilburg, 2008).

Next to varying raw material prices and margins **different levels of VAT** contribute to the price gap on the national pellet markets in Europe. The VAT rate for wood pellets ranges between 5 to 25% in Europe (Junginger, Hoeldrich, et al., 2008). For example, in Sweden the VAT rate for pellets is 25%, the standard rate, compared to Germany with a reduced tax rate of 7%. Looking at the effect on the total pellet price, as example the pellet prices of May 2008 are drawn on. Excluding the value added tax pellets in Sweden cost 202 €/t (252 €/t incl. VAT) and in Germany 176 €/t (188 €/t incl. VAT). Thus, in Sweden 20% of the total pellet price are for taxes comparing to Germany with about 6%. Therefore, VAT rates give scope for the wood pellet price.

The VAT rates for wood pellets compared to other energy sources in Austria, Sweden and Germany are shown below (Commission, DG TREN, 2008), (EUBIONET II, 2007).

Table 13 VAT rates for different energy sources in Austria, Sweden and Germany

Country	VAT rate (%) (basic rate)	VAT rate electricity (%)	VAT rate natural gas (%)	VAT rate heating oil (%)	VAT rate wood pellets (%)
Germany	19	19	19	19	7
Austria	20	20	20	20	10
Sweden	25	25	25	25	25

Source: Commission, DG TREN, 2008; EUIONET II, 2007

Next to considerable price differences between national pellet markets in Europe, price fluctuations have affected the pellet markets. A very prominent example was the pellet price increase up to 45% in some countries in Europe as Italy, Germany and Austria in 2006 because of a rapidly rising demand for pellets. The reason was a sudden demand boost for pellets in Italy due to a large number of newly installed pellet heating systems[44]. However, by that time there was no well established national supply of wood pellets in Italy. The result was an import of wood pellets mainly from Austria and Germany as trading partners[45] what induced a scarcity of supply which in turn caused the prices to skyrocket. Prices for wood pellets increased for example in Austria from 184 €/t in March 2006 to 267 €/t in November 2006 (Junginger, Hoeldrich, et al., 2008). This event deterred investment in pellet heating systems and the demand dropped in the affected countries. At the same time producers, naturally favouring higher prices, responded with higher production quantities in the second half of 2006 (Wild, 2008). This trend coupled with a rather warm winter 2006/2007 led to excess supply and consequently to a price deterioration. By April 2007, the prices reached the level of the previous year (Junginger, Hoeldrich, et al., 2008). This example reflected the still instable supply and demand situation of the young pellet market. Certainly, such an event impairs the consumer's trust in wood pellets as reliable fuel and a market needs to recover. Experts consider the year 2008 as recovery of the pellet market.

The factors that have been listed so far affect the development of wood pellet prices directly. However, there are also other significant aspects causing a price change but indirectly. The price levels of fossil fuels and other incumbent energy sources[46] influence the economic viability of wood pellets. Here, comparatively low pellet prices play a vital role in the further application's dissemination and thus to raise the demand for pellets.

Next to fuel prices, acquisition costs and other running expenses also make a major contribution to the consumer's decision in favour of pellets. Initial investment costs for different heating systems are not included in the price discussion. The focus is on the fuel price. However, in the form of an excursus the cost factors for a wood pellet, gas and oil heating system are presented in section 4.2.3.2, using the example of the German market.

Besides the already mentioned factors, other aspects can influence the pellet price as the raw material (sawdust) availability, weather conditions and seasons (Junginger, 2008). For example,

[44] Drivers for this positive development of the Italian pellets market are the introduction of a mineral oil tax, increased gas prices and good supply from Austria (European Biomass Association (AEBIOM), 2007).

[45] Also in Austria and Germany demand for pellets increased during 2006, what additonally affected the supply.

[46] Beside the trend of conventional energies, the progress of other alternative energies has an impact on the wood pellet market. Here, heat pumps can be seen as the primary competitor for heating systems in private houses. Solar energy is also further evolving, but the still great costs per kWh of generated energy have constraint its diffusion as source for heating so far. Under the given research scope the analysis will not cover the effect of other renewable energy sources. But certainly, this area plays a part in the degree of dissemination of pellet heating systems and thus is to be considered prospectively.

if there is a scarcity in the sawdust supply expected prices will go up. Or a milder winter decreases the demand for pellets what leads to a fall in prices. Moreover, the application of financial instruments as the taxation of fossil fuels or subsidies for pellet heating systems gives incentive to switch to pellets and raise the demand. The factors that can have an impact on the wood pellet price level directly and indirectly, respectively, are summarized below:

Table 14 Direct and indirect factors of the pellet price

Direct factors	Indirect factors
Supply (production and production capacity) and demand of pellets	Weather conditions, seasons (change in demand)
VAT rate and tax exemptions	Subsidies for pellet heating systems, environmental taxation of fossil fuels (change in demand)
Production costs: price for raw material, economies of scale; logistics	Raw material (sawdust) availability (change in supply); price level of fossil fuels affecting logistics costs
Margin	Price level of other fuels (change in demand)

These direct and indirect effects as well as their impacts on the development of the pellet prices are analysed and illustrated for each of the countries in the following chapter. For the price analysis of the three markets the national wood pellet price developments are compared to the fuel prices of the market-leading and competing energy sources, that is heating oil, natural gas and electricity. The period under consideration is January 2000 until August 2008.

4.2.3.1 Germany

Data for the analysis of the pellet price development for loose pellets in residential use on the German market has been gathered from C.A.R.M.E.N. e.V. for the years 2002 to 2008. C.A.R.M.E.N. e.V. provides monthly prices based on information from pellets suppliers. For price calculations, C.A.R.M.E.N. e.V. refers to a purchase quantity of 5 t delivered within a radius of 50 km and including VAT as well as related costs like blowing allowance and weighing. Previous price data starting from 2000 could not be obtained because no data has been recorded by that time. Experts mention a price of 180 to 185 €/t for the years 2000 and 2001 (Kilburg, 2008).

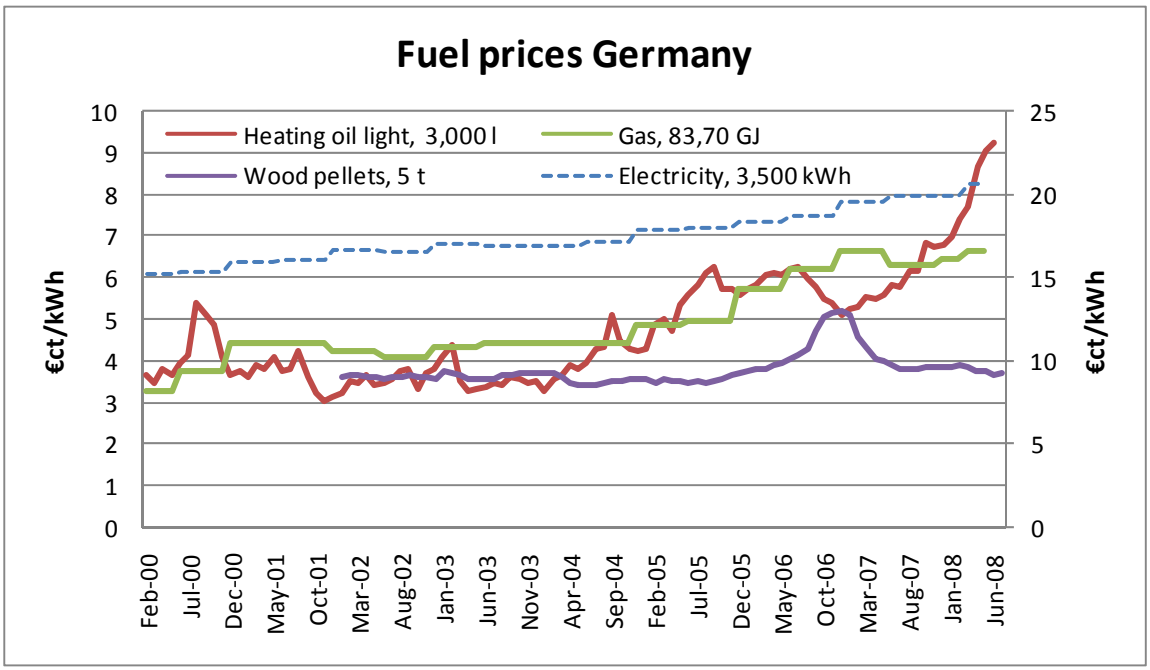
In Germany, the pellets prices have been fairly steady with price levels of 170 to 190 €/t from 2000 to 2005. The small variations are seasonally with higher prices in winter time and lower prices in summer (Kilburg, 2008). However, in spring 2006 prices started to rise with a peak price of 260 €/t in December 2006. Within one year the price increased by 40% (the reason for this development was described above). The prices settled down on the December 2005 level by May 2007. Since then prices have been stable with marginal seasonal fluctuations.

The price level of wood pellets in comparison to conventional fuels has been crucial for a successful market introduction and dissemination in Germany. In 2000 the price for heating oil raised more than 60% between January (32.9 €/100 l) and October (51.3 €/100 l). After a recovery in 2001/02, the heating oil price increased again in the second half of 2004 with no turning point but a rising tendency. From July 2004 (39.8 €/100 l) to July 2008 (92.5 €/100 l) the price for heating oil has more than doubled in Germany.

Graph 16 shows the price development of the fuel wood pellet in comparison to heating oil, gas and electricity as competing energy sources in €ct/kWh. 2003/04 pellet and heating oil

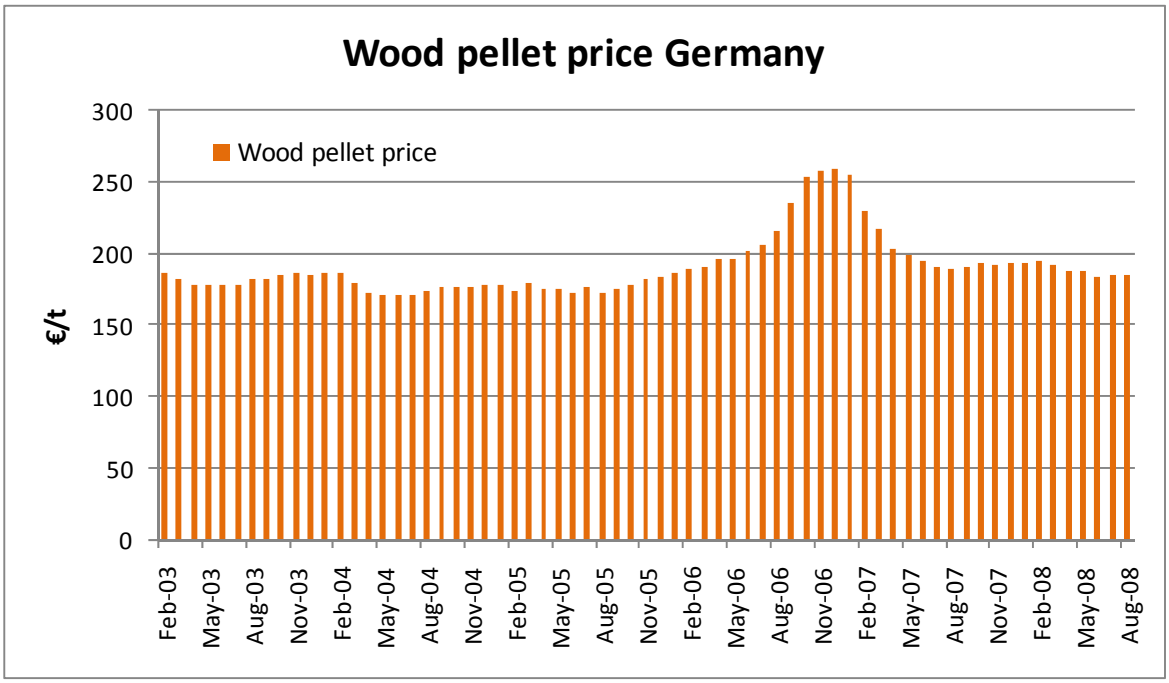
have been closely together but in 2005 the costs for heating oil took off and since then the gap got constantly wider.

Figure 16 Fuel price development in Germany, 2000-2008, incl. taxes[47]



Source: MWV, Statistisches Bundesamt, C.A.R.M.E.N. e.V. (www.carmen-ev.de), 2008

Figure 17 Wood pellet price development in Germany, 2003-2008, incl. taxes



[47] The consumer price for heating oil comprises of the following items: product price, mineral oil tax, VAT and contribution margin (including transportation, storage, administration and distribution costs) (Association of the German Petroleum Industry (MWV), 2008).

Source: C.A.R.M.E.N. e.V. (www.carmen-ev.de), 2008

4.2.3.2 Excursus: Influence of investment costs on the market development

Next to the pellet prices also the costs for installation and maintenance need to be considered to see the full financial impact in comparison to other energy sources. As example, the fuel and initial costs of both conventional and alternative energies are compared. In the table below, fuel costs as well as overall costs for the total heat supply for a newly built single-family house (150 m²/10kW heating demand) in Germany during a year are presented (reference year: 2006). Total costs include next to fuel costs, investments costs for the heating system[48], maintenance, insurance etc., and considers the governmental funding for RE.

Energy source	Fuel costs in Euro/year, incl. VAT	Total costs in Euro/year, incl. VAT
	August 2006	
Firewood	526	2,012
Heat pump	578	2,472
Wood pellets	679[49]	2,589
Heating oil	1,159	2,888
Liquefied petroleum gas	1,214	2,625
Natural gas	1,324	2,864
Electric heating	2,656	3,531

Source: Eltrop, IER, University of Stuttgart, August 2006 (Eltrop, 2006)

The overview shows, that pellets are already competitive compared to conventional energy sources as heating oil and gas. This is achieved by significantly lower fuel costs during a year. Among the total costs for the different energy sources the greatest price difference lies in the initial costs for the boiler. A pellet boiler (6,900 €) is twice as expensive as a gas (3,100 €) or oil one (3,700 €). Long-term the price for a pellet boiler is expected to decrease. The reason is lower production costs due to increasing production quantities of pellet boilers and the linked economy of scale effect. By 2008, the price for a pellet boiler went down to 6,000 € (Eltrop, 2008). A further decisive factor for the economic viability of pellet heating systems is at the moment governmental subsidies. In 2006, automatic pellet installations have been promoted under the German MAP programme with a minimum rate of 1,088 € (figure 22) helping to lower the investment costs. The minimum subsidy rate has been raised to 2,000 € for 2008 (BAFA, 2008) further closing the gap to conventional heating systems concerning initial investments.

4.2.3.3 Austria

Pellet prices were obtained from the Austrian association "proPellets" for the period January 2005 to July 2008. The prices include VAT and other costs as transportation, and refer to an order quantity of 6 t loose pellets for household use. Data is collected once a month from most of the pellet retailers in Austria. Price information before that period was quarterly available at the European Pellet Centre platform, the preceding project of the PELLETS@LAS, starting from July 2003. Before 2003 no data could be obtained.

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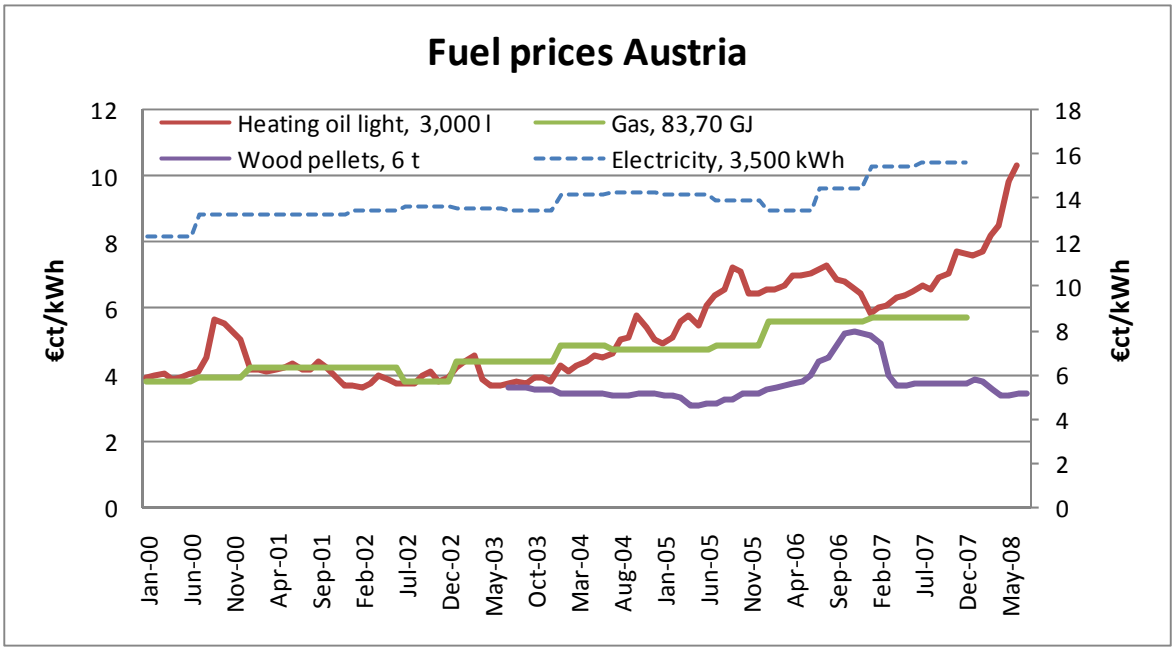
[48] An automatically fed heating system is considered. Pellet heating systems without an automatic feed in cost less.

[49] The fuel costs for wood pellets are calculated as follows: Net price for wood pellets in August 2006 200 €/t, with an annual demand (single-family house) of roughly 3 t plus the VAT of 7%

The wood pellet price development in Austria is very similar to the one in Germany both concerning the level and the trend. Austria has also experienced a strong increase in 2006/07 with a peak of 267 €/t in November 2006. Currently, prices are stable at an average of 180 €/t per month. Heating oil and gas prices have also alike levels to the German market during the period under review. Only electricity is lower priced by 4 €ct/kWh what is primarily based on higher overall taxes on electricity in Germany.

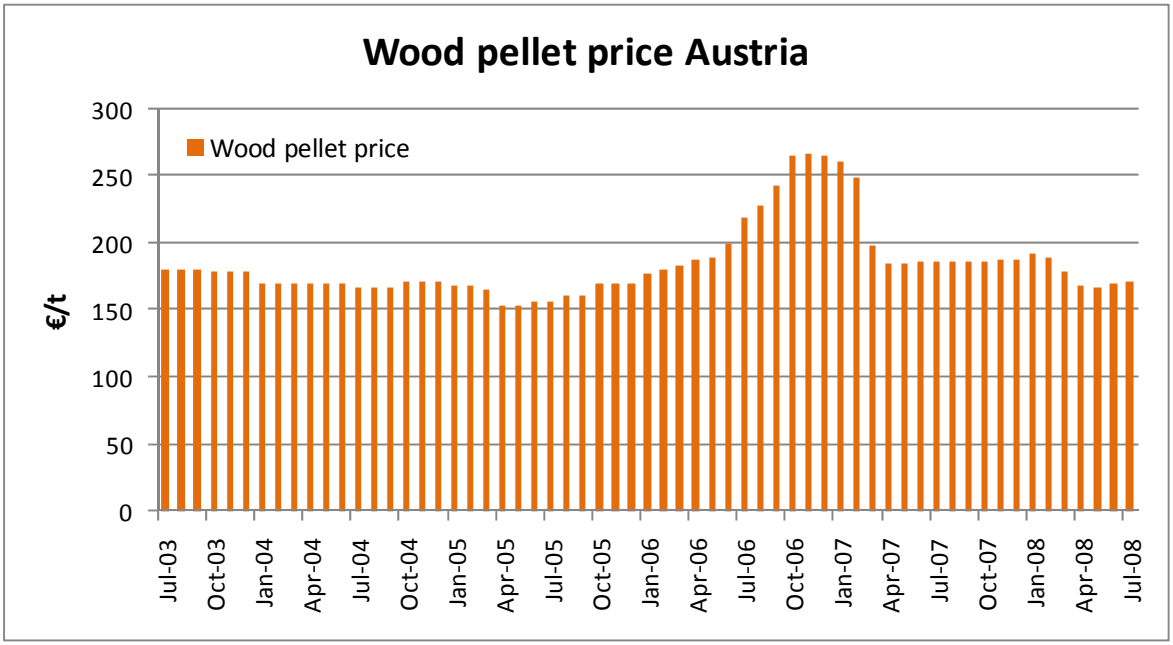
Graph 18 shows the price development of wood pellets in comparison to heating oil, gas and electricity as competing energy sources in €ct/kWh in Austria.

Figure 18 Fuel price development in Austria, 2000-2008, incl. taxes



Source: Oil bulletin, Statistisches Bundesamt, proPellets 2008

Figure 19 Wood pellet price development in Austria, 2003-2008, incl. taxes



Source: proPellets, 2008

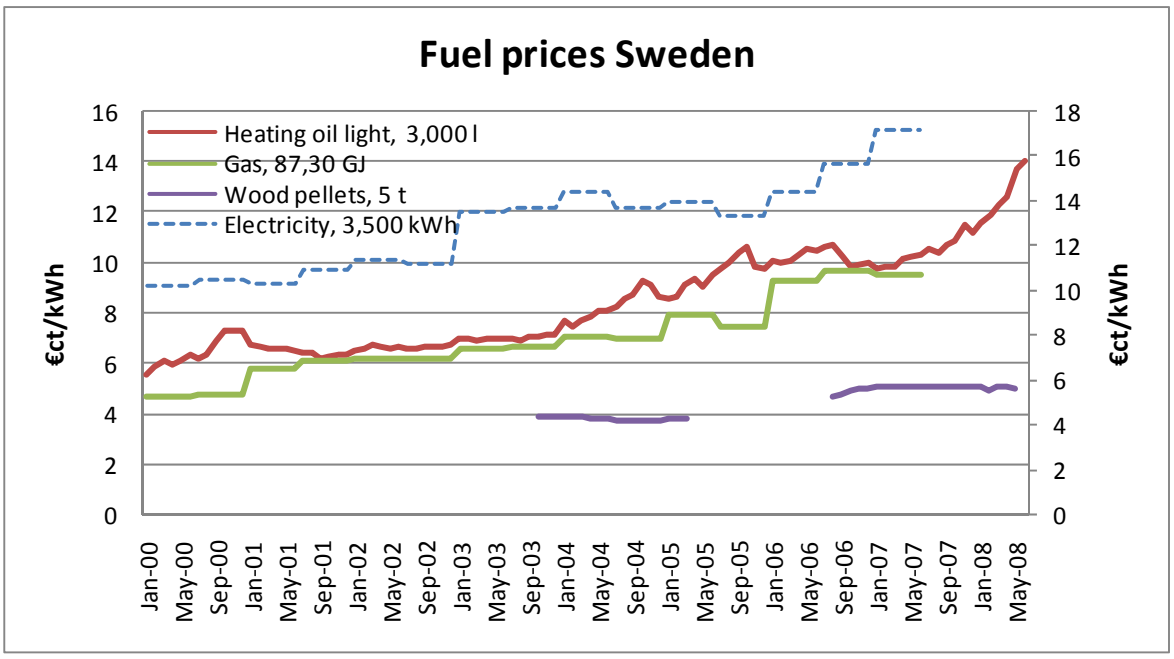
4.2.3.4 Sweden

The Swedish pellets association PiR publishes market prices of wood pellets every month. PiR receives information from all their members as well as from the majority of non-members. For the period August 2006 to May 2008 data is derived from this source. Average prices of one ton wood pellets refer to an order quantity of 5 t and include VAT and all costs related to delivery. Earlier price data is taken from the European Pellet Centre platform commencing with October 2003 until March 2005. Between 2005 and 2006 and before 2003 data has been missing.

In the period 2003 to 2005 prices have been steady and comparable to the Austrian and German levels with 189 €/t. But since 2006, wood pellet prices are significantly above the prices of the last years with 252 €/t on average. Reasons for this development can be found e.g. in an increased price for sawdust. Furthermore, the data for the pellet prices is incomplete. From early 2005 to mid 2006 no prices could be obtained.

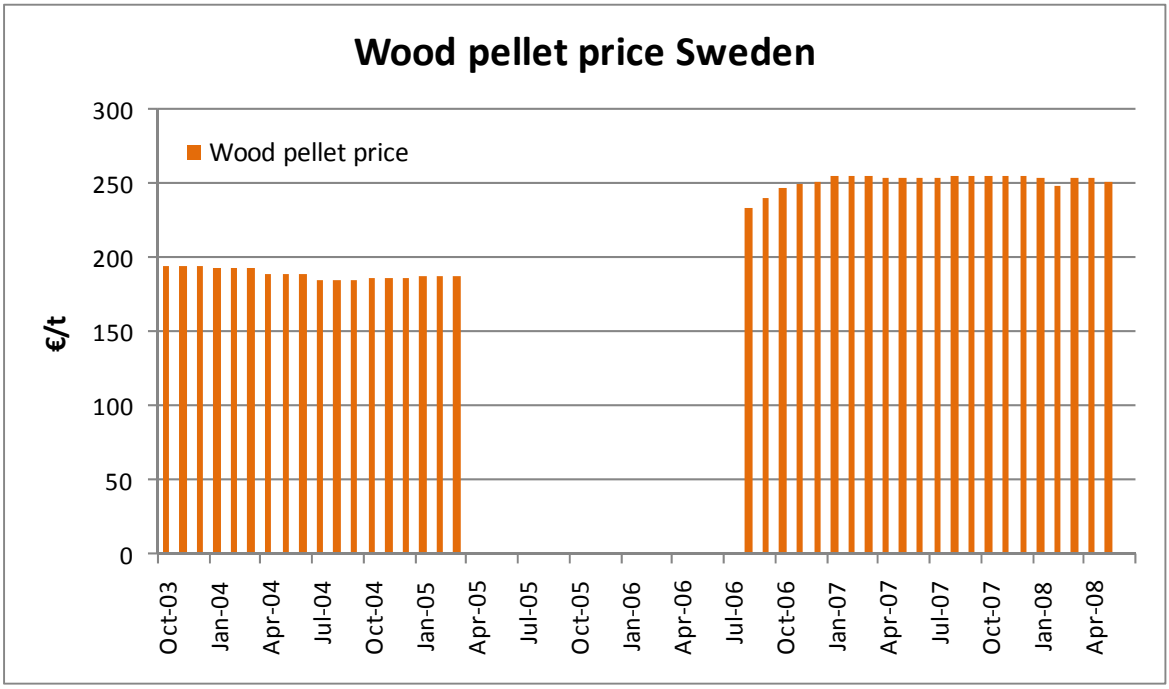
Prices for heating oil and gas are considerably higher than in Austria and Germany. One reason is the greater value added tax in Sweden. However, the determining factors are the energy tax level and the additional CO_2 tax on oil products. Thus, the indirect taxes amount to 385.77 € on 1,000 l heating oil. In contrast, in Austria taxes are 109.42 € and in Germany 61.35 € per 1,000 l (status: June 2008) (Commission, 2008d). Of course, high prices for fossil fuels are beneficial for the application of alternative energies. However, due to overall higher wood pellet prices in Sweden than in Austria and Germany the price ratio fossil fuels/wood pellets are alike.

Figure 20 Fuel price development in Sweden, 2000-2008, incl. taxes



Source: Oil bulletin, Statistisches Bundesamt, Pelletsindustrin, 2008

Figure 21 Wood pellet price development in Sweden, 2003-2008, incl. taxes



Source: Pelletsindustrin, 2008

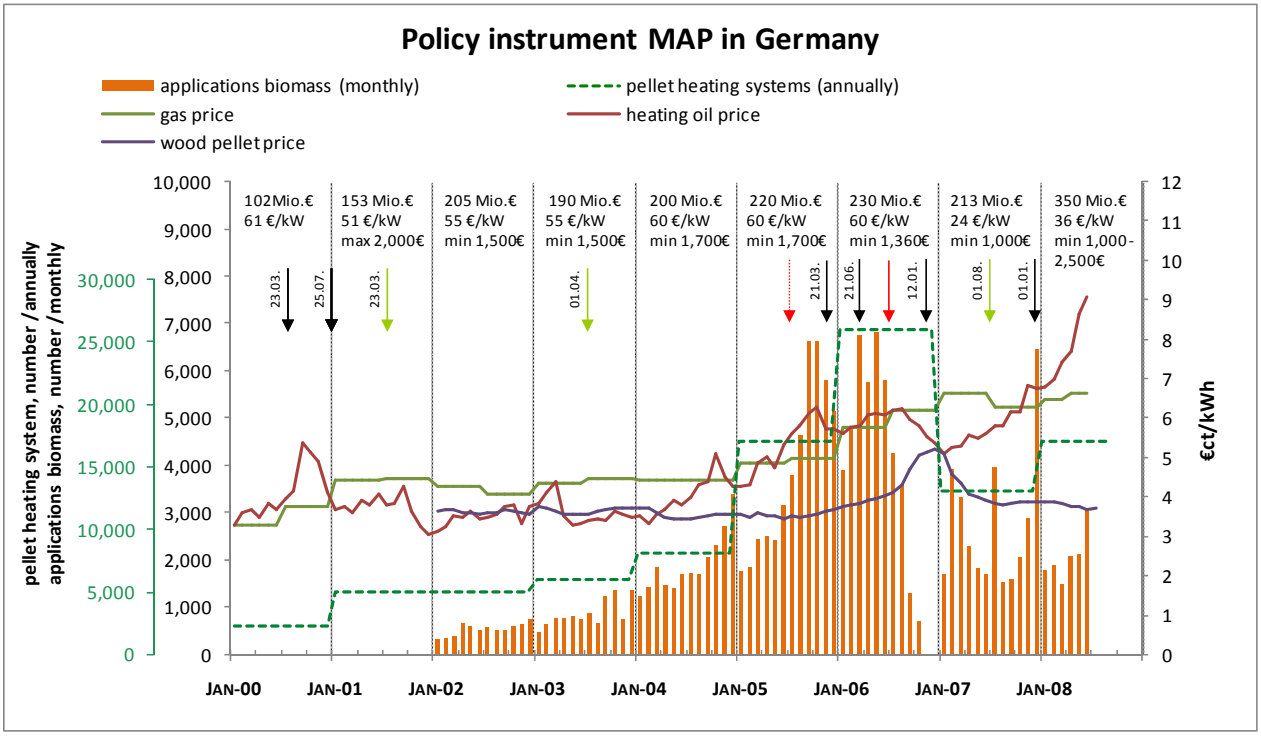
4.2.3.5 Excursus: Influence of incentive programmes on the market development

For the illustration of the relation between the implementation of a policy instrument and the pellet market development, the example of the market incentive programme (MAP) in Germany is chosen. To identify the impact of this programme on the market, its history and main attributes are compared with the pellet market development from 2000 to 2008 in graph 22. The BAFA publishes every 1 to 2 years the results and changes of the MAP. There, monthly numbers of applications handed in to receive investment grants for biomass heating systems are published. Application submissions have been selected as reference since they reveal variations in consumer behaviour due to amendments of the programme.[50] Numbers solely on pellet heating systems have only been collected since 2004. Thus, the overall number for small-scale biomass applications (<100 kWh) is applied as benchmark allowing a comparison to the previous years. Generally, it can be said that more than half of the applications refer to pellet installations each year (BMU, 2006) (BMU, 2007e).

The development of the MAP is characterized by changes in the promotion requirements and allocated federal budget as well as by unfavourable events like the depletion of the budget before the end of the defined period. In graph 22, the MAP budget for each period, the level of funding per biomass installation (black arrows = decrease with the respective date; green arrows = increase with the respective date) and the depletion of the period's budget (red arrows) are shown.

[50] Besides, the majority of the total number of installed pellet heating systems was promoted by the MAP. Hence, the number of applications is representative for the newly set up installations during the period under review. (BMU, 2004).

Figure 22 Policy instrument market incentive programme (MAP) in Germany, 2000-2008



Source: MWV (2008), Statistisches Bundesamt (2008), C.A.R.M.E.N. e.V. (www.carmen-ev.de) (2008), BMU (2006), ZWS (2008)

Key events since 2002, explaining changes in the number of applications, are listed below:

2002:

- In March 2002, the ceiling for funding was lifted and a minimum guaranteed subsidy rate was introduced.

2005:

- In October 2005 the budget was depleted resulting in a stop of funding.

2006:

- In August 2006 the budget was depleted resulting in a stop of funding. Consequently, the number of applications dropped. However, it has to be noted that during the second half of 2006 pellet fuel prices skyrocket, what also had an impact on a lower demand for pellet heating systems.

- On the 21-03-2006 and 21-06-2006 the promotion rates were reduced.

2007:

- Lower promotion rate per kW and lower minimum promotion than in the previous years.

- Possibility to hand in the application once again for facilities which could not be considered in 2006 due to exhausted funds (valid until 31st of July) Until end of July most of the applications came from the previous year.

- Increase of the promotion rate to 36 €/kW in August 2007.[51]

2008:

- Higher and more differentiated rates for pellet heating systems (stove vs. boiler).

The graph points out that the depletion of the budget and changes in the promotion conditions have a significant impact on the number of newly set up pellet facilities assuming a positive correlation between the number of applications and the number of pellet systems installed. For instance, in August 2006 it has been announced that the provided budget was exhausted. The immediate reaction was a serious drop in applications in September until December. Of course, consumers made use of the opportunity to hand in the application during the next funding period. But still, 2007 started cautiously despite the new MAP budget of 213 Mio. €. Also during the following months the amount did not balance the drop of the previous year. This implies that the depletion irritated the consumers and evoked modest investment behaviour.

With regards to changes in the promotion rate, it can be noticed that the consumer immediately reacts to improved and worsened conditions, respectively, with his/her investment behaviour. In March 2002 and August 2007 both the promotion rate as well as the minimum subsidy level has been increased. In the coming months the number of applications submitted went up significantly.

Furthermore, between December and January a drop can be seen each year. The uncertainty if the New Year brings a lowering of the budget and the promotion rate leads to proportionally more applications in December and less in January. Another aspect influencing the success or failure of a policy instrument next to its own measures is the development of other energy sources. In the figure a relation between the heating oil price level and the number of pellet installations is recognizable over time.

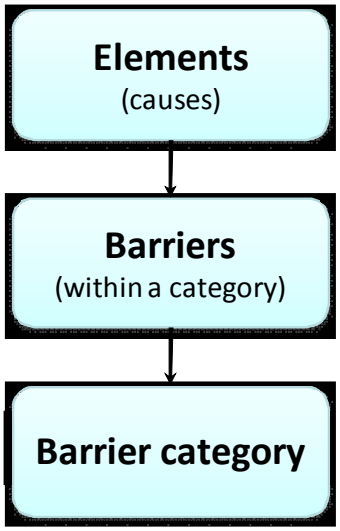
[51] http://www.solarserver.de/geld.html

5 Discussion

5.1 Identification of barriers to the pellet market

For identifying the barriers to the pellet market the analytical framework of Painuly (2001) is applied. The author rests his categorizing of barriers on the research and discussion on barriers constraining the adoption and diffusion of renewable energy on different publications as by Martinot and McDoom (1999), the second assessment report of the IPCC (1995), Gutermuth (1998) and the World Bank (1997). In this light, the paper "Promoting energy efficiency and renewable energy: GEF climate change projects and impacts" by Martinot and McDoom contains a set of generic barriers relevant for both energy efficiency and renewable energy and in particular to renewable energy aggregated from different projects and research on diffusion of RE. Obstacles such as lack of information, transaction costs, high front-end capital costs, perceived technology performance, institutional set-up, lack of legal framework, lack of technical skills etc., to name a few, are discussed (Martinot & McDoom, 1999).

Figure 23 Barrier levels



For ascertaining the presence and type of barriers, the approach of Painuly (2001) involved consideration of barriers at different levels in the system. He distinguishes between 'categories of barriers' on the top level, followed by 'barriers within a category' and the third level 'elements of these barriers'. By applying a bottom-up approach barriers can be identified based on the barrier elements. The presence of these elements can be understood as causes for the existence of barriers (Painuly, 2001).

Thus, derived from the information of the pellet market and the illustrated problems in the analysis section, the type of barrier can be better understood.

Painuly (2001) compiled a comprehensive list with major barrier categories and corresponding barriers. The following barrier categories have been involved in the framework:

- Market failure/imperfection;
- Market distortion;
- Economic and financial,
- Institutional,
- Technical,
- Social, cultural and behavioural,
- And other barriers

In the table below the recognized barrier elements as results of the analysis section and thus causes for encountered problems of the pellet market and respective barriers/barrier category are presented. A whole overview of the framework can be found in the appendix.

Table 15 Barrier categories, barriers and barrier elements of the pellet market

Barrier category	Barriers	Barrier elements (Causes)
Market failure/imperfection	Lack of information and awareness	Lack/low level of awareness, inadequate information on product, technology, costs, benefits & potential of the RET, O&M[52] costs, etc.: *Consumers are not knowledgeable enough on the technology. Lower fuel costs and with it running costs of pellets which balances the high investment costs over the system's lifetime are not emphasised enough.*
	High transaction costs	Related to gathering and processing information, red tape: *Consumers indicated that access to information is seen as problematic. Surveys revealed that customers were not aware where to look for information and the contact point did not provide sufficient information.*
	Missing market infrastructure	Lack of product visibility: *Surveys have shown that consumers were little aware of pellets and their characteristics.*
Market Distortions	Favour (such as subsidies) to conventional energy	Conventional energy is subsidised, consumers pay below marginal cost, average cost pricing is done, and low taxes compared to RETs. *Conventional energy sources receive direct financial subsidies (coal in Germany) or in the form of capital for R&D (nuclear power).*
	Taxes on RETs	RET production is taxed unfavourably, other direct/indirect taxes on RETs. *Wood pellets are taxed at the full VAT rate (Sweden).*
	Non-consideration of externalities	Negatives externalities (pollution, damage from this) from conventional energy not considered in pricing, positive impacts of RETs not valued, free rider problem with positive externalities. *Energy taxes on fossil and electricity are still too little, not addressing externalities to their full extent, a carbon tax has been introduced directed to externalities (Sweden)*

[52] Operation & Maintenance

Barrier category	**Barriers**	**Barrier elements (Causes)**
Economic and Financial	Economically not viable	High cost of product (initial investment) making it uncompetitive, resource (material, labour, capital) costs are higher than expected, high implementation/adaptation costs, competition for resources. *Initial investment costs for a pellet heating system are still higher than for a conventional one (oil, gas).*
	Market size small	Potential not realised. *Little market penetration despite beneficial preconditions*
Institutional	Lack of institutions/mechanisms to disseminate information	Lack of mechanisms to generate and disseminate information, lack of capacity in existing institutions, *Information dissemination and awareness raising too slow and fragmentary*
	Lack of a legal/regulatory framework	Ineffective regulatory body, regulations inadequate to promote RETs. *Despite the so far implemented legislations promoting pellets (mainly financial instruments) diffusion is marginal and slow. This implies that policies might be inadequate (the mix) or insufficient*
	Problems in realising financial incentives	Complicated procedure, red tape *Application procedures for receiving might be (are) too complex (this could be observed within the German programme MAP)*
	Lack of involvement of stakeholders in decision making	Stakeholders dispersed, difficult communication, fear of opposition. *Industry associations for pellets (bioenergy) still have little involvement and power in policy making*
	Clash of interests	RETs competing with conventional energy, threat to utility dominance, threat to utility profit, powerful lobbies for conventional energy, decoupling of investor–consumer interests. *Wood pellet applications directly compete with oil, gas, electricity at the domestic level plus these conventional sources have powerful lobbies in place. The input material sawdust is also input to other important industries as fibre board.*
Technical	Lack of standard and codes and certification	Lack of institution/initiative to fix standards, lack of capacity, lack of facilities for testing/certification. *A European quality standard for pellets is not in place, yet. A lack of capacity and initiative to agree on common aspects of the standards could be reasons.*

Barrier category	Barriers	Barrier elements (Causes)
	Lack of skilled personnel/training facilities	Lack of experts to train, lack of training facilities. *It could be observed that installers, engineers, architects etc. are not possess adequate knowledge of pellet heating systems and do not offer it as alternative heating system*
	Lack of O&M facilities	Lack of skilled personnel, lack of capacity. *Corresponding to the point above*
	Product not reliable	Missing or inadequate standards *A European standard for pellets is not in place, yet.*
Social, Cultural and Behavioural	Lack of consumer acceptance of the product	Unknown product, products lacks appeal, resistance to change, cultural reasons, and inadequate information. *Acceptance of wood pellets as equal heating fuel not existing, yet. A lack of wood/forestry culture can hinder the diffusion of pellets.*
	Lack of social acceptance for some RETs	Lack of social acceptance for some RETs, preference for traditional energy *A well developed gas network but also the familiarity to gas, oil and electricity as present heating sources constrain pellets. Moreover, e.g. refilling the pellet storage can be seen as drawback in contrast to gas and electricity.*
Other Barriers	Uncertain governmental policies	Uncertainty in policies, un-supportive policies, red tape, lack of policies to integrate RET products with the global market *Stop and go measures among policy instruments could be observed which negatively affected the pellet market*
	High risk perception for RETs	Uncertain new technology, irreversibility of investment and a lack of flexibility of plant and machinery for other usage. *Unfamiliarity with the pellet technology. Some machinery is only applicable for the pelletizing process.*

5.2 Identification of measures to overcome the barriers

After the barriers have been identified and categorized, appropriate and possible measures to overcome these barriers need to be shown. In the framework of Painuly (2001) measures are compared with policy instruments as the driving force for removing obstacles to the dissemination of RETs. This viewpoint is also supported by Jacobsson and Johnson (2000) who gave considerations for overcoming barriers steered by policy measures. Hence, appropriate policy instruments are viewed as vital in order to remove the presented barriers.

In the following overview, the barrier categories relevant for the pellet market are linked to policy instruments and actions that can be taken by governments for overcoming the difficulties of the market.

Table 16 Measures to overcome the barriers to the pellet market

Barrier category	Barrier	Measure
Market failure/imperfection	Lack of information and awareness	*Information and awareness campaigns on pellet technology and its benefits*
	High transaction costs	*Information and awareness campaigns targeting the consumer, training directed the contact points and supporting the networking between consumer and producer/supplier*
	Missing market infrastructure	*Information and awareness campaigns*
Market Distortions	Favour (such as subsidies) to conventional energy	*Phasing out of direct and indirect subsidies, e.g. nuclear power is supported with tax-free provisions or no taxation on the nuclear fuel. This keeps the costs for the generated energy low, reflecting in lower price levels for electricity (still widely used for heating purposes). Besides, energy/carbon taxation reflecting their social costs is to be introduced.*
	Taxes on RETs	*Tax reductions (reduced VAT), exemptions from energy/carbon tax for biomass and deductions (of the investment from the taxable capital)*
	Non-consideration of externalities	*Introduction of energy and carbon taxes with a rate fully compensating their social costs*
Economic and Financial	Economically not viable	*Capital subsidies for the installation of a pellet heating system to be fully competitive, provide soft loans and strengthened R&D efforts in order to reduce acquisition costs quicker*
	Market size small	*Stimulate consumption through financial instruments and if necessary regulations in order to increase 'guaranteed' demand allowing larger production rates with economies of scale*
Institutional	Lack of institutions/mechanisms to disseminate information	*Supporting the set up of 'bridging' institutions to increase connectivity between actors*
	Lack of a legal/regulatory framework	*Implement more policies directly tailored to the promotion of pellets in residential use and renewables in the heating sector and regulations to achieve a higher use of wood pellets*
	Problems in realising financial incentives	*Ease the application procedure for funding and guarantee its realisation through the possibility of a budget increase*

Barrier category	**Barrier**	**Measure**
	Lack of involvement of stakeholders in decision making	*Include and consult bioenergy, pellet and other industry associations in the process of policy making*
	Clash of interests	*Strengthen connectivity among actors hence they can organise better. Provide R&D on other input materials to avoid competition.*
Technical	Lack of standard and codes and certification	*Introduce overall specification standard for pellets in Europe by creating the ground for exchange of experts and commission projects for researching on the best compromise of existing national standards. Introduce certified quality standard for pellets.*
	Lack of skilled personnel/training facilities	*Funding of training and establish educational opportunities*
	Lack of O&M facilities	*Corresponding to the point above*
	Product not reliable	*Facilitate the establishment of a common and certified standard; create trust through demonstration*
Social, Cultural and Behavioural	Lack of consumer acceptance of the product	*Information and awareness campaigns on pellet technology and its benefits*
	Lack of social acceptance for some RETs	*Information and awareness campaigns on pellets and wood fuels, but also on its environmental, social and economic benefits in contrast to conventional energy sources; government procurement to facilitate social acceptance*
Other Barriers	Uncertain governmental policies	*Avoid stop and go measures for investment subsidies, remove cap of yearly budget in order to allow an increase, make use of the policy instrument regulations to give more predictability*
	High risk perception for RETs	*Training and brochures; provision of security to investors that it is a technology with future e.g. by creating demand through investment grants or regulations or introducing standards*

The analysis shows that the pellet market lacks particular attention to an increased application of educational measures in the form of information campaigns and training. Information campaigns aim at raising awareness among consumers and eliminating prejudice towards the fuel pellets, whereas training is directed to suppliers, installers, engineers, architects etc. to offer this heating system as an alternative as well as plus to give professional advice to the customer.

Another aspect which became apparent is the absence of continuity of financial incentives as in the case of capital grants reflected in "stop-and-go" measures and budget caps with no option for an increase in the capital. This causes uncertainties among consumers leading to fluctuations in the number of installed heating systems and thus to a difficult foreseeable demand.

Furthermore, little use of regulations and standards was found. However, considering the still limited utilisation of pellets despite their advantageous properties as a fuel, regulations are viewed as an effective instrument to achieve a higher market penetration and with it a required amount of consumers, also referred to as "minimum critical mass" (OECD/IEA, 2007), for stabilising the market.

5.3 Conditions for an effective pellet market

The content and findings of chapters 5.1 and 5.2 are used as foundation for the development of generic conditions for an effective small-scale pellet market. For a better overview, the measures are grouped according to political, economic and social aspects. The **political** sphere reflects the legislative side, the **economic** sphere the market (supply, demand, price) and the **social** sphere the consumer perception as well as local factors.

Political:

Among policy instruments it is sought to distinguish between the type of policy instrument (financial incentives, regulation, and education) to be applied and the respective characteristics the policy instruments have to posses in order to be effective in the dissemination of pellets for small-scale heating applications. Concerning the policy instruments it is not only important to introduce measures addressing pellets alone but also conventional energy sources due to their leading position and still favourable policy treatment.

- Type:

  Directed to wood pellets:

  Financial Instruments:

  - tax exemptions for wood pellets from ecological, energy, carbon taxes, supports competitiveness due to lower running expenses;
  - tax reduction in the form of a reduced VAT rate on wood pellets, supports the overall competitiveness due to lower running expenses;
  - tax deduction facilitating to bear the higher investment costs of pellet heating systems;
  - investment grants facilitating to bear the higher investment costs of pellet heating systems;
  - soft loans: facilitates to bear the higher investment costs of pellet heating systems; and
  - government procurement by purchasing pellet heating systems for covering the heat and hot water demand of public buildings, increases demand for pellets and makes the fuel more popular and trustful.

Information and Education Instruments:

- consumer side
    - marketing campaigns, brochures: explaining the functionality of pellets heating systems to achieve more confidence and familiarity with its operation among consumers and to change the mindset categorising wood-based energy sources as insufficient or obsolete;
    - Educational programmes: inform on the global warming matter and how the use of renewable energies can help combating this development; and
- installer/supplier side: certified training programmes for installers and civil engineers on pellet heating systems per se and their functionality. Hence, they offer pellets as alternative heating solution and inform on its specifications. A medium dissemination of technology knowledge.

Regulatory Instruments:

- building regulations: the requirement to use renewable energies to cover the heat consumption leads to a greater demand in RE technologies. Larger production quantities translate into economies of scale (lower costs)and improved quality; and
- standards: certified standards for pellets and the heating system. The standards should be uniform throughout Europe. This eases wider dissemination and guarantees quality of pellet heating systems translating into a reliable technology.

<u>Directed to conventional energy sources:</u>

Financial Instruments:

- established and adequate energy taxation for heating oil, gas and electricity;
- established and adequate carbon taxation reflecting externalities of fossil fuels; and
- removed favourable policy treatment.

Information and Education Instruments:

- brochures: explaining the benefits of wood pellets over heating oil, gas and electricity from a social, environmental and economic perspective; and
- programmes at educational institutions: inform on the global warming matter and its link to fossil fuel utilisation.

➢ Characteristics:

- long-term: secure stable development and give predictability of policy measures for actors as investors, consumers, suppliers;

- option to increase the yearly set budget of investment programmes: This avoids a temporary decline in the demand which results in fluctuations in demand;

- defined target of the policy: measurability of desired outcome, indication for the market; and

- specific design: supporting small-scale heating market and targeted at individual consumer or supplier.

Social/local:

Next to appropriate legislative measures, country[53] and societial traits are significant for the formation of an effective pellet market. Beneficial traits are:

- forest occurrence;

- raw material availability e.g. a strong wood processing industry;

- raw material accessibility as reliable import flows;

- acquaintance with wood as fuel;

- awareness of pellet technology;

- acknowledgement of pellets as sufficient fuel; and

- well developed infrastructure for supply.

Economic:

With the term economic sphere it is referred to the market set up and the way the different parameters; including supply and demand, and the price, interact with one another. Examples are:

- trade of pellets via a commodity market removes price differences among markets;

- a market with trade and information exchange on market figures and technology: removes price differences among markets and facilitates quality and progress in pellet heating equipment;

- test und technical development for utilising other input materials next to wood residues what stabilises the price development;

- a uniform and certified quality standard for pellets and pellet heating systems; and

- central statistics on market and price figures determining the market status and its future potential and hence supports effective policy making.

[53] Here, it is referred to a country since pellet markets are rather restricted to a country. However, when talking about a unified European pellet market it is better to speak of an area or zone.

6 Conclusions

In this chapter the main conclusions of the thesis are presented. First the general findings of the analysis are illustrated covering the causes for the instabilities of the pellet market which translate into barriers to the diffusion of the technology. Following, the key barriers and possible measures to overcome those obstacles are pointed out. Finally, the question which factors facilitate the development of an effective wood pellet market for small-scale applications is taken up. The section finishes with recommendations for further research based on the content and results of the study.

6.1 General findings

The analysis has revealed that the pellet market in Europe is still in its developing stage. The three pellet markets – Sweden, Germany and Austria – chosen with regard to their long history and size as well as experience in small-scale pellet applications in Europe show the following features in respect to their energy policy, the market formation covering supply, demand, pricing and the consumer perception:

- legislation for renewable energy is in place;
- the first generation of policy measures for promoting wood pellets have been implemented, especially through financial incentives;
- the design of these measures is still inadequate and other policy instruments that are recognised to have important facilitating impacts (regulation and education) are hardly used;
- direct and indirect subsidies for and inadequate taxation of conventional energy remain on the market, thus disadvantaging renewable systems;
- the initial investment costs for pellet heating systems[54] remain high relative to alternatives;
- a Europe-wide quality standard for wood pellets has not yet been achieved;
- a Europe-wide trade could not establish so far, trade of pellets rather takes place in clusters;
- referring to the preceding point, pellets are not traded via commodity markets making the pellet market not transparent in terms of quantities and prices;
- enormous price differences between European pellet markets exist;
- the primary input material sawdust is also an important raw material to other industries and thus can become subject to competition; and
- awareness and acceptance among consumers is still at low levels.

[54] Considering automatically fed pellet heating systems

These features were translated into barriers by applying a framework. The outcome was key barriers to the small-scale pellet market in Europe. They are described together with possible measures to overcome them in the next section.

6.2 Barriers and promoting measures

The barriers to the wide-spread utilisation of the pellets technology in Europe are of different nature. They include lack of awareness and information, favourable treatment to conventional energies, small market size, lack of regulatory framework and standards to lack of consumer acceptance. Hence, a variety of measures needs to be applied in order to remove these barriers.

The measures that are viewed as key for overcoming the existing barriers are listed below. It has been a focus on policy measures which are considered as a main tool for stabilising the market formation:

- widespread use of information and awareness campaigns;
- removal of direct and indirect subsidies for incumbent energy sources;
- ensuring consistent legislative instruments; and
- application of regulations requiring the use of biomass for heating.

The identification of measures revealed that guiding instruments as information and training programmes are vital in facilitating an interest and demand for heating systems based on wood pellets. It has been observed that in many cases insufficient knowledge and prejudice towards a wood based fuel led to non-consideration of this technology. For realising the demand financial and fiscal instruments are advantageous since they can remove economic drawbacks of the technology as high initial costs. However, for "assuring" the goal of a wide-spread use of renewable energy sources in a foreseeable period, as it was communicated by the EU through the target of 20% of renewable by 2020, the use of regulatory instruments is beneficial. A regulation as a building code forces a behaviour of the consumer in order to achieve the desired outcome.

Based on the above discussion the question of what are the factors facilitating the development of an effective wood pellet market for small-scale applications is addressed. In order to establish a self-sustaining pellet market, the following policy measures need to be directed to this sector:

- awareness and acceptance rising among consumers as well as installers and engineers;
- investment grants and soft loans facilitating to bear the higher investment costs of pellet heating systems;
- tax exemptions for pellets from ecological taxation;
- building regulations requiring the use renewable energy to cover the heat consumption; and
- certified and uniform standards for pellets and the heating system.

Next to policy instruments directed to the pellet market, measures directed to the incumbent energy sources (e.g. ecological taxation) as well as the economic (trade, pricing) and social (familiarity with wood fuels) situation of a market are important.

6.3 Further research and application

Based on the information and findings of this paper further research should be dedicated to identifying the best sequence of policy measures to be taken for overcoming barriers. This will support an optimal usage of the measures.

Moreover, other pellet markets with predominantly small-scale pellet applications in Europe as for example France and Italy should be drawn on to support the findings for the European pellet market based on the cases Sweden, Austria and Germany.

Furthermore, stakeholder opinion should be obtained on the identified barriers and measures of the thesis, in order to improve their setting based on the feedback (Painuly, 2001).

Besides, the developed generic conditions for an effective pellet market can be used as starting point for new pellet markets in order to facilitate their effective emergence and avoid the occurrence of the observed problems and obstacles.

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Abbreviations

AEBIOM - European biomass association

BAP – Biomass Action Plan

nBAP – national Biomass Action Plan

Bafa - Federal Office of Economics and Export Control (Germany)

BMLFUW - Federal Ministry of Agriculture, Forestry, Environment and Water Management (Austria)

BMU – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)

C.A.R.M.E.N. e.V. - Central network for marketing and development of agricultural resources (Germany)

CEN – European Committee for Standardization

CHP – Combined Heat and Power

CO_2 – Carbone dioxide

DEPV - German Energy Pellet Association

DG TREN – Directorate-General Energy and Transport

DIN – German Institute for Standardisation

EC – European Commission

EEG – Renewable Energies Act

ElWOG - Electricity industry and organisation law (Austria)

Eubionet – European bioenergy network

IEA – International Energy Agency

IPCC – Intergovernmental Panel on Climate Change

KfW - Reconstruction loan corporation (Germany)

Kgoe – Kilogram of oil equivalent

Mtoe – Million tonnes of oil equivalent

OECD – Organisation for Economic Cooperation and Development

OPEC – Organisation for Economic Cooperation and Development

ÖNORM – Austrian Standards Institute

RES – Renewable Energy Sources

RES-E - Renewable Energy Sources for Electricity generation

RES-H - Renewable Energy Sources for Heating

RET – Renewable Energy Technology

PiR – Pellet industry association (Sweden)

SVEBIO – Swedish bioenergy association

Toe – Ton of oil equivalent

UN – United Nations

Appendix

Interviews during the World Bioenergy Conference in Jönköping, Sweden (May 27th to May 29th 2008)

Interviewee	Country	Position
Dr. Martin Junginger	The Netherlands	Assistant professor, Copernicus Institute, University of Utrecht, IEA Bioenergy Task 40, PELLETS@LAS project
Sebastian Kilburg	Germany	Project manager, section: solid biomass – pellets, C.A.R.M.E.N. e.V., Straubing
Peter Wichers	Sweden	Lantmännen Agroenergi, Huskvarna
Jonas Höglund	Sweden	Section: pellets and biofuels, Swedish Bioenergy Association (SVEBIO), Stockholm; Swedish Pellet Industry Association (PiR)
Mia Nordström	Sweden	Management consultant, Vattenfall Power Consultant AB, Stockholm

Interviews during the study

Interviewee	Country	Position
Sebastian Kilburg	Germany	Project manager, section: solid biomass – pellets, C.A.R.M.E.N. e.V., Straubing
Jonas Höglund	Sweden	Section: pellets and biofuels, Swedish Bioenergy Association (SVEBIO), Stockholm; Swedish Pellet Industry Association (PiR)

Barrier category, barriers & barrier elements

Barrier category	**Barriers**	**Barrier elements**
Market Failure/imperfection	Highly controlled energy sector	Governmental monopoly of energy sector, private sector entry restricted, monopoly of energy supplier and/ or distributor, electricity generation, transmission and distribution controlled, lack of private sector investment.
	Lack of information and awareness	Lack/low level of awareness, inadequate information on product, technology, costs, benefits & potential of the RET, O&M costs, financing sources etc. Lack of agencies, or agencies ill equipped to provide information. Also, feedback mechanism may be missing or inadequate. Lack of knowledge/access to RET resource assessment data, implementation requirements.
	Restricted access to technology	Technology not freely available in the market, technology developer not willing to transfer technology, problems in import of technology/equipment due to restrictive policies/taxes etc.
	Lack of competition	Regulations prohibiting entry in the energy sector, unwieldy requirements for entry, governmental monopoly, barriers created by existing suppliers.
	High transaction costs	Related to gathering and processing information, procedures and delays, technology acquisition, implementation etc., poor infrastructure, red tape, costs underestimated in economic analysis.
	Missing market infrastructure	Missing or under-developed supply channels, logistic problems, lack of product visibility, lack of availability, difficult procurement (by consumers), inconvenient product location etc., lack of liberalisation in energy sector, mismanaged energy sector.
	High investment requirements	Economies of scale only at high investment level.
Market Distortions	Favour (such as subsidies) to conventional energy	Conventional energy is subsidised, consumers pay below marginal cost, average cost pricing is done, and low taxes compared to RETs.
	Taxes on RETs	RET production is taxed unfavourably, high import duties on equipment, other

		direct/indirect taxes on RETs.
	Non-consideration of externalities	Negatives externalities (pollution, damage from this) from conventional energy not considered in pricing, positive impacts of RETs not valued, free rider problem with positive externalities.
	Trade barriers	Tariff and non-tariff barriers on import/export of RETs.
Economic and Financial	Economically not viable	High cost of product (say energy produced) making it uncompetitive, resource (material, labour, capital) costs are higher than expected, high implementation/adaptation costs, high user costs, inadequate resource base, competition for resources.
	High discount rates	Equipment manufacturers/RE producers/consumers have high discount rate, risk/uncertainty is perceived as high.
	High payback period	Low rate of return, inadequate incentives, high tax on profits
	Market size small	Market potential small, limited/difficult access to international market, market barriers within the country, potential not realised, proper assessment of RET market not done.
	High cost of capital	High interest rates, scarcity of capital, governmental policies on cost of capital, lack of access to cheap capital, risk perception by financial institutions, macro-economic parameters such as inflation rate, demand for credit etc.
	Lack of access to capital	Distorted capital markets, governmental policies, poor creditworthiness, and poor regulations.
	Lack of access to credit to consumers	Under-developed credit market, poor worthiness, poor consumers recovery regulations.
	High up-front capital costs for investors	High-risk perception, lack of financing instruments/institutions.
	Lack of financial institutions to support RETs, lack of instruments	Under-developed capital markets, restricted entry to capital markets, unfavourable regulations.
Institutional	Lack of institutions/mechanisms to disseminate information	Lack of institutions/mechanisms to generate and disseminate information, lack of interest/capacity in existing

		institutions, lack of institutions to promote and enhance market (say international market), need for specialised agencies at planning level, operational level (ESCOs), lack of a regulatory body in the energy sector.
	Lack of a legal/regulatory framework	Missing or ineffective regulatory body, regulations inadequate to promote RETs, unfavourable regulations for RETs (restrictions related to aesthetic, safety and other considerations), lack of implementation of regulations, unwieldy regulations.
	Problems in realising financial incentives	Complicated procedure, red tape, corruption.
	Unstable macro-economic environment	High inflation rate, unstable polity, high price fluctuations, balance of payment problems, unstable currency, uncertain exchange rates, lack of coherent economic policies, uncertain economic growth.
	Lack of involvement of stakeholders in decision making	Stakeholders' consultation culture missing, stakeholders dispersed, difficult communication, fear of opposition.
	Clash of interests	RETs competing with conventional energy, threat to utility dominance, threat to utility profit, powerful lobbies against RETs, threat of transfer of control over energy, powerful lobbies for conventional energy, decoupling of investor–consumer interests (investor does not save and consumer cannot invest; e.g. SWH, tenant may not).
	Lack of R&D culture	R&D facilities missing, lack of capacity for R&D, lack of appreciation of R&D role in technology adaptation.
	Lack of private sector participation	Governmental policies, lack of capacity, better opportunities, restrictive regulations.
	Lack of professional institutions	Absence of professional/manufacturers' associations, ineffective consumer bodies, indifferent bureaucracy, lack of feedback to policy makers to promote RETs.
Technical	Lack of standard and codes and certification	Lack of institution/initiative to fix standards, lack of capacity, lack of facilities for testing/certification.
	Lack of skilled personnel/training facilities	Lack of experts to train, lack of training facilities, inadequate efforts.

	Lack of O&M facilities	Lack of skilled personnel, lack of capacity.
	Lack of entrepreneurs	Relatively low profitability, unwieldy/restrictive regulations.
	System constraints	Capacity limitation with current grid system, integration problems (for example, for intermittent nature of electricity from RETs with the grid), lack of skill.
	Product not reliable	Bad quality, lax quality control, missing or inadequate standards, bad work ethics, resource quality problems.
Social, Cultural and Behavioural	Lack of consumer acceptance of the product	Unknown product, aesthetic considerations, products lacks appeal, resistance to change, cultural reasons, high discount rates of consumers (due to risk and existing norm for PBP), inadequate information.
	Lack of social acceptance for some RETs	Lack of social acceptance for some RETs, technology seen as alien and of no use, lack of local participation, preference for traditional energy
Other Barriers	Uncertain governmental policies	Uncertainty in policies, un-supportive policies, inadequately equipped governmental agency, red tape, lack of governmental faith in RETs, lack of policies to integrate RET products with the global market, inadequately equipped governmental agency to handle the product
	Environmental	Ecological aspects (example water requirements for biomass production), local pollution (example, noise, visual impact in the case of wind energy), competition for resources (example, for land in the case of biomass production).
	High risk perception for RETs	Uncertain new technology, uncertain benefits, high investment risks, irreversibility of investment and a lack of flexibility of plant and machinery for other usage.
	Lack of infrastructure	Problems related to availability of infrastructure such as roads, connectivity to grid, communications, other logistics