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# Renewable energy in the heating sector in Austria with particular reference to the region of Upper Austria

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## HIGHLIGHTS

- ▸ Overview on Austrian heat sector and RES-H development.
- ▸ Growing RES-H market mainly due to regional promotion schemes.
- ▸ Austrian NREAP foresees only moderate growth of RES-H up to 2020.
- ▸ Targets and policies on the regional level might lead to stronger RES-H deployment.

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## ABSTRACT

The heating sector has been neglected in energy policies for quite some time, especially on the European level. Only recently, with the implementation of the European directive 2009/28/EC the sector has gained higher attention. The objective of this paper is to provide an overview of the heat market in Austria and of the current status and future prospects of renewable energy in the heat sector (RES-H) up to 2030. Despite the growing energy demand, the share of renewable energy in the total energy demand for space heating and hot water increased from about 20% in 1970 to about 34% in 2008. This is mainly due to ambitious RES-H support instruments and regional policy targets. For example, the government of the region of Upper Austria has implemented a target of 100% RES-H share in the space heating and hot water sector until the year 2030. However, the National Renewable Energy Action Plan for 2020 foresees only moderate growth rates for RES-H compared to recent market growth and scenarios in literature. Due to the ambitious targets and support schemes of regional governments it seems likely that RES-H deployment could growstronger than stated in the action plan.



## 1. Introduction

The heating sector and its potential to reduce greenhouse gas emissions, increase energy efficiency and employ a higher share of renewable energy has been neglected in energy policies for quite some time, especially on the European level. Only recently, with the implementation of the European directive 2009/28/EC on the promotion of the use of energy from renewable sources has a higher relevance attached to the heat sector. In Austria, the share of renewable energy sources for heating (RES-H) is relatively high compared to other European countries. Although the promotion schemes are somewhat fragmented between the nine Austrian regions, there are comprehensive programs in place, leading to significant progress of RES-H in some regions. Upper Austria is one of these outstanding regions, with ambitious RES-H support programs and a rapid growth of renewable heating deployment. Above all, the Upper Austrian government has set a target of 100% renewables in the space heating and hot water supply by the year 2030 (Dell, 2009).

Table 1 gives an overview of the structure of the final energy consumption in Austria in 2008. Transport (including off-road traction) accounts for the biggest share in the final energy

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**Table 1**
Structure of final energy consumption in Austria in the year 2008.
*Source*: Statistik Austria (2010a).

| Sectors | Consumption (PJ) | Structure (%) |
|---|---|---|
| Transport | 392.32 | 36.0 |
| Space heating and cooling, water heating | 315.05 | 28.9 |
| Steam production | 85.49 | 7.9 |
| Industry ovens | 159.99 | 14.7 |
| Lighting and computing | 28.33 | 2.6 |
| Stationary engines | 107.06 | 9.8 |
| Electrochemical purposes | 0.32 | 0.0 |
| Total | 1088.54 | 100.0 |

consumption, followed by the category "space heating, cooling and water heating". The share of cooling in this category is estimated at less than 1% (e.g. Kranzl et al., 2010a). High-temperature heat generation is subdivided into "steam production" (including process heat) and "industrial ovens". In total, low- and high-temperature heat generation and cooling account for more than 50% of the total energy consumption in Austria.

The greenhouse gas emissions related to heat generation and cooling amounted to about 36.2 million tons (Mt) $CO_{2e}$ in 2005, according to Haas et al. (2007). This is approximately 40% of the total national greenhouse gas emissions. Thereof, 22.4 Mt were related to space and water heating, 0.1 Mt to cooling, 4.6 Mt to steam production and 9.1 Mt to industry ovens.

The objective of this paper is to provide an overview of the heat market in Austria, of the current status and future prospects of RES-H. This includes the following aspects: (1) a description of the characteristics of the Austrian heat market, (2) an analysis of the development of RES-H technologies within the last years and decades, (3) a comprehensive documentation of the policy framework and support schemes for RES-H and (4) an outlook on possible further development paths of the heating sector as a whole and for different RES-H technologies.

This paper focuses on the space heating and hot water energy demand in residential buildings and buildings of the service sector. However, to some extent industrial and high-temperature heat supply is also taken into account. The RES-H technologies considered are (1) biomass heating systems (including small-scale wood log, wood chip and pellet boilers as well as medium to large scale heating plants and district heating systems), (2) heat pumps (air source and ground source heat pumps) and (3) solar thermal systems (hot water and combined space heating and hot water systems).

Several of these aspects are considered not only for the case of Austria, but also specifically for the region of Upper Austria. There are two reasons for this: first, many energy and environment related tasks fall into the responsibility of the regions ("Bundesländer"), especially where the building and the heating sectors are concerned. And second, the region of Upper Austria has an impressive record with regard to RES in the heating sector as well as very ambitious targets.

Upper Austria is one of the nine Austrian regions, located in the northern part of the country with a population of 1.4 million inhabitants. The region is highly industrialized, with heavy industry (steel and machinery) playing an important role. Furthermore, Upper Austria is home to a number of leading companies for renewable heating technologies (especially small-scale biomass boilers, solar collectors and heat pumps). From the year 2000 to 2009 RES-H energy consumption increased by about 38% from 40 PJ to almost 56 PJ. For the future deployment of "eco-heat", ambitious targets have been set. The definition of "eco-heat" in Upper Austria (Dell, 2010) includes RES-H and district heating. According to this definition, the share of "eco-heat" on total space heating and hot water energy consumption increased from less than 40% in 2003 to more than 45% in 2008. In new buildings, more than 85% of all heating systems are "eco-heating" systems (Dell, 2010). For future development, the ambitious energy strategy "Energy Future 2030" foresees 100% RES space heating (including hot water provision except process heat) (Dell, 2009).

With respect to the current state of the heat market as well as historical development of RES-H, this paper draws mainly on statistical data from Statistik Austria (2010a,b,c,d), Haneder and Furtner (2010), Biermayr et al. (2010) and Dell (2010). The future projections for RES-H in Austria have been collected from literature: Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (2006), Großmann et al. (2008), Haas et al. (2007), Müller et al. (2009), Haas et al. (2008), Kalt et al. (2010), Kratena and Wüger (2005), Ragwitz et al. (2004), Resch et al. (2009), Weiss and Biermayr (2008), Fink et al. (2009), Lutz (2007), a stakeholder process (described in more detail in Kranzl et al., 2009) as well as Austrian's national renewable energy action plan (NREAP) according to Directive 2009/28/EC submitted in mid-2010 (Bundesministerium für Wirtschaft, Familie und Jugend, 2010).

The literature provides a long list of papers dealing with the renewable heating sector in different regions. Among those are a number of studies dealing with certain sub-sectors or technologies, e.g. Singh et al. (2010), Leidl and Lubitz (2009), Biaou and Bernier (2008), Jablonski et al. (2008). The volume of academic literature dealing with national and regional renewable heating policies is much lower than those covering efficiency and retrofitting policy issues. Relevant examples are José et al. (2011), Bürger et al. (2008), Nast et al. (2006,2009). This paper adds to the part of those papers providing a descriptive discussion based on the documentation of empirical data of the sector and the policies. We combine this descriptive presentation of empirical data, policies and targets with a comparative analysis of scenarios for the future deployment of RES-H technologies in Austria. Based on the comparison of these elements we are able to draw conclusions regarding the level of ambition of existing policy targets for RES-H and its appropriateness in relation to potential and related cost. This should inform the discussion of overall policy of the support of RES-H in Austria.

The historic development and current situation of renewable energy in the Austrian heating sector are described in Section 2. Section 3 provides an overview of the policy background and support schemes for RES-H. The projections for the heat sector according to the studies mentioned above as well as prospects for different RES-H technologies are described in Section 4. This section also includes an overview of the RES-H targets set in the NREAP. Finally, this paper closes with conclusions regarding the importance of RES-H in the NREAP and an outlook and open questions regarding the role of policy targets and support instruments for further RES-H penetration (Section 5).

## 2. Historic development and current situation of RES-H

### 2.1. Structure of heat consumption

The structure of the final energy consumption broken down by energy source and sectors is shown in Fig. 1. "Space heating, cooling and water heating" comprises low-temperature heat generation and air conditioning in buildings. "Steam production" includes industrial and commercial heat generation and process heat and "industrial ovens" include industrial and commercial facilities, reaching from small bakery ovens to large blast furnaces. The fraction "stationary engines" includes the final energy

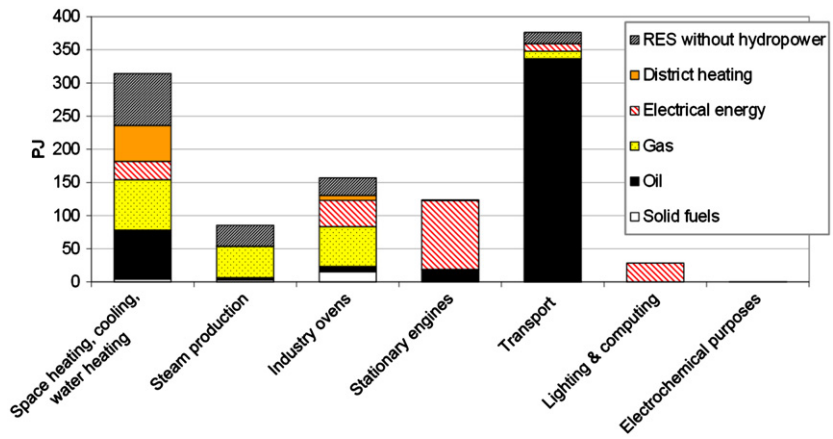


**Fig. 1.** Final energy consumption in Austria in 2009 broken down by energy sources and applications.
*Source:* Statistik Austria (2010a).

**Table 2**
Final energy consumption in the categories "low-temperature heat and cooling" and "high-temperature heat" broken down by energy sources in 2008.
*Source*: Statistik Austria (2010a).

| Energy sources | Low-temperature heat and cooling | | High-temperature heat | |
|---|---|---|---|---|
| | Consumption (PJ) | Structure (%) | Consumption (PJ) | Structure (%) |
| Solid fuels | 4 | 1 | 18 | 8 |
| Oil | 74 | 24 | 11 | 4 |
| Gas | 76 | 24 | 108 | 44 |
| Electrical energy | 28 | 9 | 40 | 16 |
| District heating | 54 | 17 | 8 | 3 |
| RES (excluding electricity from RES) | 78 | 25 | 58 | 24 |
| Total | 314 | 100 | 242 | 100 |

consumption of all kinds of engines which are not used for mobility, reaching from small engines in household appliances to large engines in industrial production processes. "Transport" comprises road transport as well as rail, air and marine traffic. Further categories are "lighting and computing" and "electrochemical purposes".

With regard to the energy sources used for heat generation, it is obvious that in both low- and high-temperature heat applications, a wider variety of energy sources is used than in the other categories, which are dominated by electrical energy or oil. Furthermore, the share of RES in heat generation is comparatively high, as can be seen in Table 2. Taking into account the renewable share of district heating (see Section 2.4), RES amounts to about one third of the total consumption of low-temperature heat and one quarter of high-temperature heat (with the share of RES in electricity generation not included). The main contribution comes from solid biomass in its different forms (wood logs, wood chips, pellets, wood residues, etc.).

### 2.2. Space heating and hot water supply

Fig. 2 shows the structure of the current stock of principal residences in Austria broken down by the year of construction and main heating systems installed. About half of the total stock has central heating systems installed and about one fifth is connected to district heating. The share of single stoves, gas and self-contained central heating systems is significantly higher in older buildings than in newer ones. More than 60% of all residential buildings which were constructed after 1970 have central heating systems installed and more than 20% have access to district heating.

During the last three decades the quality of thermal insulation of residences in Austria has improved significantly. Biermayr (1999) and Lang (2007) present data on space heating energy demands of typical single- and multi-family houses in Austria broken down by age structure. The data on representative single-family houses which were built before 1981 range from about 160 to more than 300 kWh/m$^2$ and those of multi-family houses from about 110 to 150 kWh/m$^2$. In contrast, the typical values of houses from the period 2002 to 2007 are about 50 kWh/m$^2$.

According to Amann (2008), the following annual rates of thermal renovation were achieved in the 1990s: Less than 1% in the field of privately owned houses and homestead apartments and about 2% in the field of municipal tenements. On average, the rates of thermal renovation were 1%. Current rates are estimated to be somewhat higher (1% and between 2% and 3%, respectively) due to corresponding policy measures for building renovation according to Kranzl et al. (2011).

However, with regard to the total energy demand for space heating, the effect of increasing thermal building quality was moderated by an increase of the average floor space. According to Statistik Austria (2010b), the average floor space of principal residences increased by more than 40% from 1990 to 2009. Hence, the final energy consumption of households for space heating and cooling remained relatively constant throughout this period.

Fig. 3 shows the development of the final energy consumption for space heating and hot water preparation since 1970. The data have been adjusted for deviation of heating degree days. The figure shows that the total energy consumption increased by almost 40% between 1970 and 2000. However, since the end of the 1990s final energy consumption remained more or less constant. From the perspective of increasing building stock this shows the impact of higher efficiency of new buildings and the thermal renovation measures. Natural gas has gained importance during the whole period whereas the consumption of other fossil energy carriers (first of all coal, but also heating oil) has been declining. The share of RES-H increased to more than 30% within the last few years.

### 2.3. High-temperature heat

High-temperature heat comprises the categories "steam production" and "industrial ovens". In 2008, these sectors accounted for 7.9% and 14.7% of the total final energy consumption in Austria

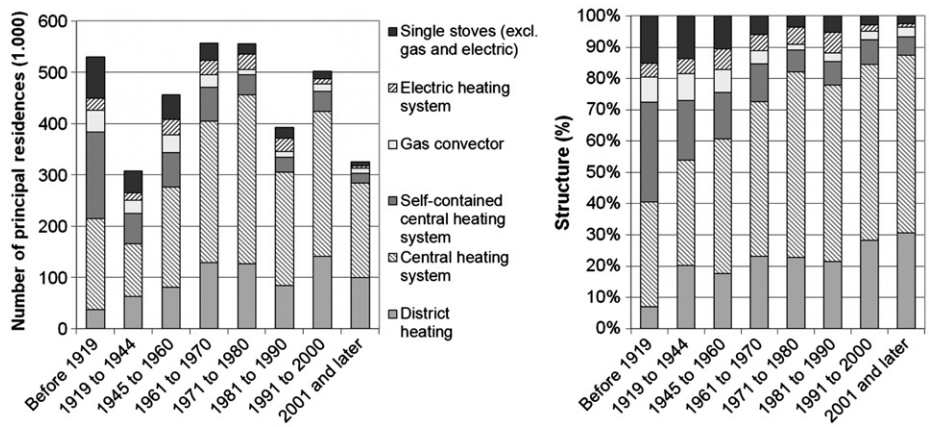


**Fig. 2.** Structure of principal residences broken down by year of construction and main heating system installed.
*Source:* Statistik Austria (2011).

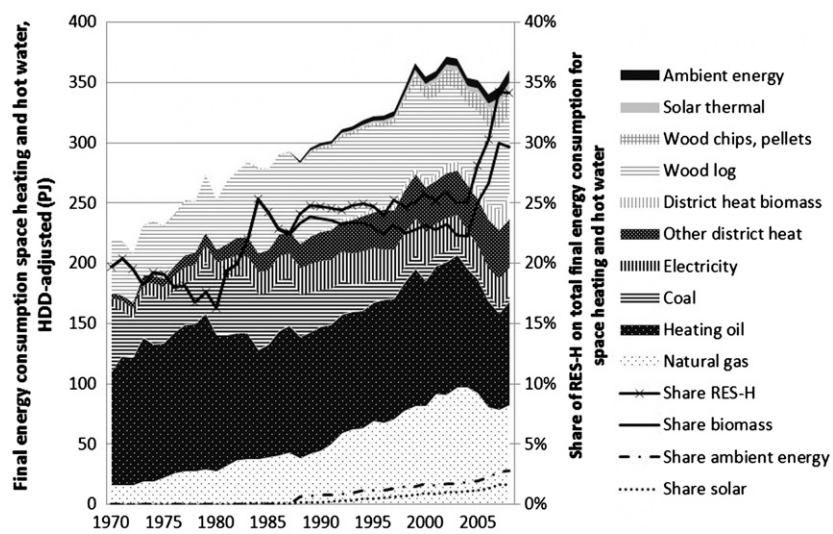


**Fig. 3.** Final energy consumption for space heating and cooling and RES-H share in Austria from 1990 to 2008 by energy carrier.
*Sources:* Statistik Austria (2010a), Biermayr et al. (2010), author's own calculations.

**Table 3**
Final energy consumption for steam production and industry ovens broken down by energy source in 2008.
*Source*: Statistik Austria (2010a).

| Energy sources | Steam production | | | Industry ovens | | |
|---|---|---|---|---|---|---|
| | Consumption (PJ) | Structure (%) | Relative change compared to 1993 (%) | Consumption (PJ) | Structure (%) | Relative change compared to 1993 (%) |
| Solid fuels | 3.12 | 4 | −18 | 15.31 | 10 | +25 |
| Oil | 2.92 | 3 | −77 | 7.98 | 5 | −53 |
| Gas | 47.44 | 55 | +77 | 63.22 | 39 | +38 |
| Wastes | 6.34 | 7 | +246 | 6.52 | 4 | +233 |
| Biomass | 25.11 | 29 | +30 | 15.78 | 10 | +84 |
| Other renewables | 0.00 | 0 | – | 3.88 | 2 | +265 |
| District heat | 0.16 | 0 | −78 | 7.84 | 5 | +104 |
| Electricity | 0.39 | 0 | +6 | 39.52 | 25 | +13 |
| Total | 85.49 | 100 | +31 | 160.05 | 100 | +28 |

(see Table 1). Steam production, which includes industrial process heat generation, is primarily based on natural gas (55%) and biomass (29%), as can be seen in Table 3. The main reason for the high share of biomass is the economically significant wood processing industries in Austria, which utilize vast amounts of wood wastes like bark, wood chips and black liquor (biogenic waste liquor from paper and pulp production) for energy recovery. In the category "industry ovens" the share of biomass is 10% and the shares of natural gas and electricity 39% and 25%, respectively. During the last 15 years (from 1993 to 2008), the energy consumption in these sectors increased by 31% (steam production) and 28% (industry ovens).

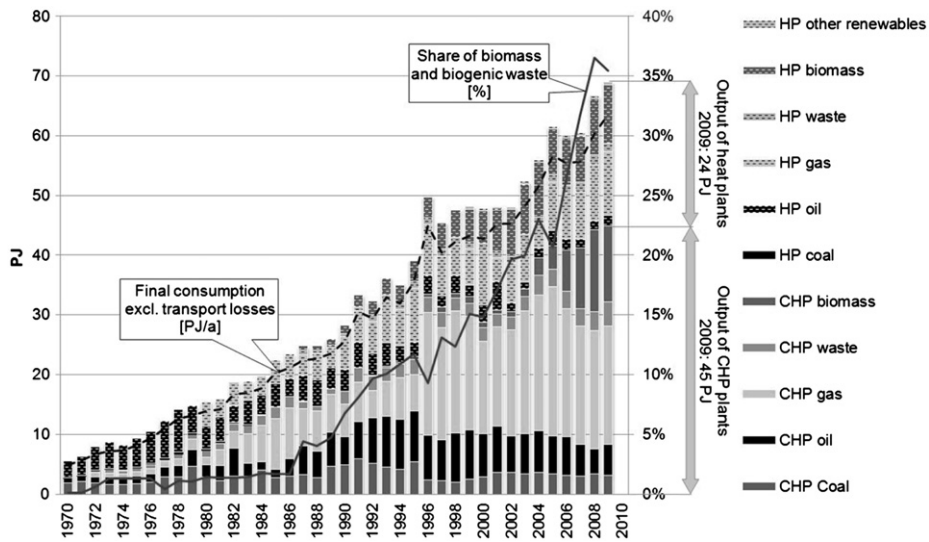


**Fig. 4.** Historic development of district heat supply from heating plants (HP) and combined heat and power plants (CHP) in Austria.
*Source:* Statistik Austria (2010d).

### 2.4. District heat

Since 1980 the share of dwellings supplied with district heat has increased from approximately 83,000 to 750,000 (2008), which corresponds to more than 20% of all dwellings in Austria. Among dwellings which were constructed after 2001, the share is even higher (27%). The shares in Austria's biggest cities are 36% in Vienna, 60% in Linz, 30% in Klagenfurt, 26% in Graz and 23% in Salzburg (FGW, 2010). In total, the length of district heating grids in Austria was approximately 4200 km in 2009, having doubled since 1995 (FGW, 2010).

Fig. 4 shows the structure of district heat supply in Austria, broken down by energy sources and plant types. The biggest contribution is made by gas-fired combined heat and power (CHP) plants, followed by biomass heat plants. In total, biomass and biogenic waste account for more than 35% of district heat delivered and other RES for 1%. The figure also illustrates that the increase of renewable heat in district heating from 2005 to 2008 was primarily due to a rapid growth of biomass CHP.

### 2.5. Solar thermal

The Austrian market for solar thermal collectors developed strongly over the two most recent decades. Since about 2005 the growth rates (new installed collector area) amounted to about 10% of the total installed collector area. Fig. 5 shows the development of annual installations and of the total installed collector area. The first systems were installed in the 1970s. The 1980s were characterized by dynamic progression of self-made solar thermal systems, which gave way to the commercial phase of market introduction through the 1990s.

According to these data, the mean annual growth of new installed collector area (defined as the ratio of RES-H installations in year $t$ to the installations in year $t$ minus 1) in the period from 1990 to 2009 and from 2000 to 2009 was 12% and 9%, respectively.

About one third of the number of newly installed systems is designed as auxiliary heating system mainly in existing buildings with the remainder installed in new buildings. In 2009 more than a quarter of the total installed collector area was located in the region of Upper Austria (26%), followed by Lower Austria (23%) and Styria (18%). Related to population, deployment was also highest in Upper Austria, with almost 70 $m^2$ per 1.000 inhabitants

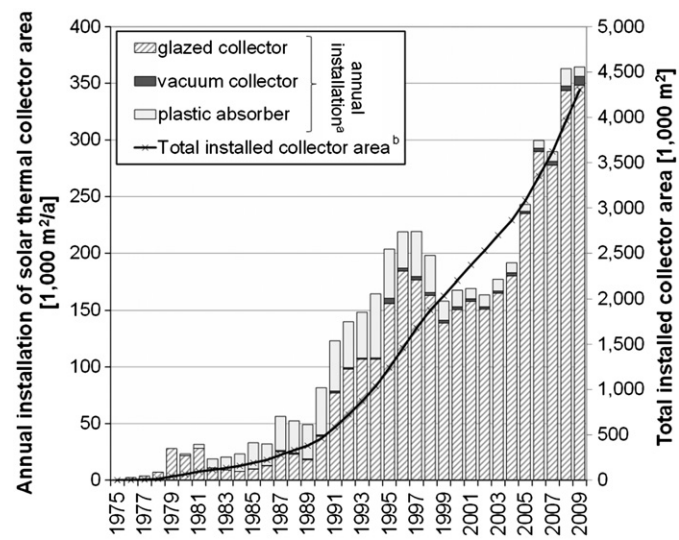


**Fig. 5.** Development of installed solar thermal collector area in Austria: (a) refers to left axis; (b) refers to right axis.
*Source:* Biermayr et al. (2010).

compared to the Austrian average of about 43 $m^2$ per 1.000 inhabitants.

In Upper Austria, the first solar target, set in 1993, was to reach an installed surface area of 300,000 $m^2$ solar thermal collectors by 2000, where the real deployment developed much faster (compare Fig. 6). By 2000, the energy strategy "Energy 21" set a further target of 1 million $m^2$ ($Mm^2$) solar thermal collectors by 2010 – equating to 0.7 $m^2$ per inhabitant.

By the end of 2009, 1.1 $Mm^2$ with an annual energy output of about 350 GWh were installed in Upper Austria. Fig. 6 shows the historic development and the 2010-target set in the year 2000. The real growth path turned out to be even steeper than the target from the year 2000.

In Upper Austria, the large majority of the solar thermal systems is installed in single-family homes and has a collector area of about 12 $m^2$. Apartment buildings, public and commercial sector buildings are also increasingly equipped with solar thermal installations. There are a few plants in Upper Austria which use

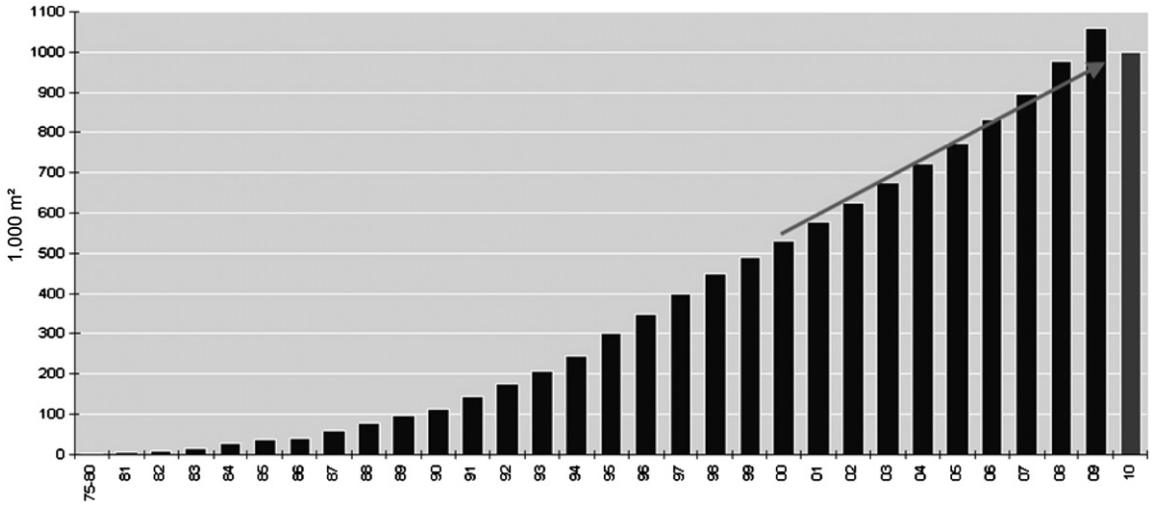


**Fig. 6.** Development of solar heating systems installed in Upper Austria from 1980 to 2009 (in 1000 $m^2$). The value for 2010 represents the policy target implemented in the year 2000.
*Source:* Dell (2010).

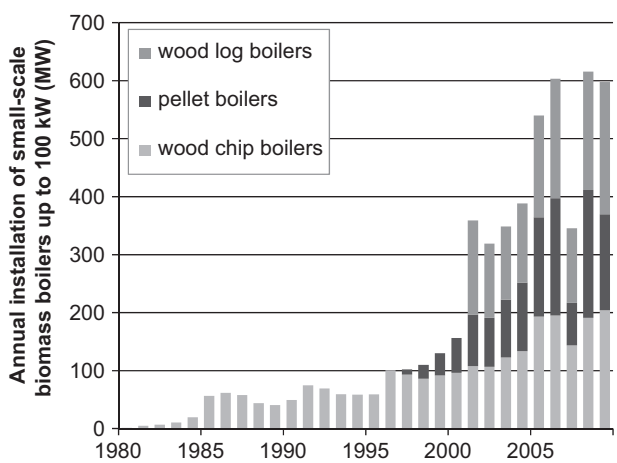


**Fig. 7.** Annual installation of small-scale biomass boilers up to 100 kW in Austria (data for wood log boilers are only available from 2001-2009).
*Source:* Haneder and Furtner (2010).

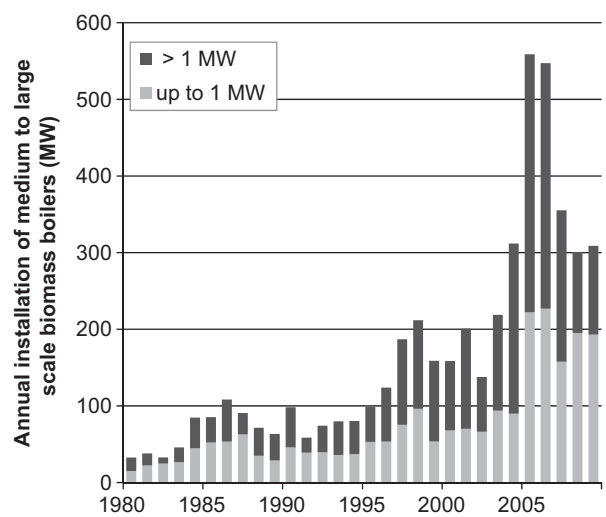


**Fig. 8.** Annual installation of medium to large-scale biomass plants in Austria.
*Source:* Haneder and Furtner (2010).

solar energy for cooling and a 212 kW-solar thermal system which is connected to a biomass district heating system (collector area: 300 $m^2$).

### 2.6. Biomass

Residential heating with wood log has a long tradition in Austria. Since the 1980s wood chip heating systems have become increasingly important and in the late 1990s the highly successful market introduction of pellet boilers started. Fig. 7 shows the development of annual installations of all pellet, wood log and wood chip boilers since 1980. (Stoves are not included and data for wood log boilers are only available from 2001 to 2009.) Sales figures for small-scale biomass boilers have increased rapidly during the last decade. Fig. 7 also shows that the year 2007 brought dramatic market developments, first of all for pellet boilers. The steep decline of sales figures was due to a significant price increase in pellets in 2006. However, as pellet prices dropped down to their original levels in mid-2007, the market recovered and an all-time high of 220 MW of pellet boilers was installed in 2008.

Biomass small scale heating systems had an average market growth between 2001 and 2009 (the period for which all types of new small scale biomass heating systems are covered) of 25%. However, the graph shows that this development was strongly fluctuating and characterized by significant discontinuities with strong negative growth in some years (in particular 2007, after the pellet price increase in 2006, e.g. documented in Bradley et al., 2009).

Fig. 8 shows the development of annual installations of biomass boilers with a capacity of more than 100 kW. (The capacities in this figure include boilers of heating plants as well as such of CHP plants.) A generally very positive trend is apparent, with a very rapid deployment in the years 2005 and 2006, primarily due to a boom in the field of CHP, triggered by the implementation of attractive feed-in tariffs within the Renewable Energy Act of 2002. The annual installation in the years 2005 and 2006 was more than 500 MW. More than 50% of the total capacity installed in 2007 were plants with a rated thermal power of more than 1 MW, about 20% were plants between 0.5 and 1 MW and about 25% plants in the range of 0.1–0.5 MW. After an amendment of the Renewable Energy Act in 2006 the rate of deployment of CHP plants as well as the capacity of large-scale boilers went down significantly.

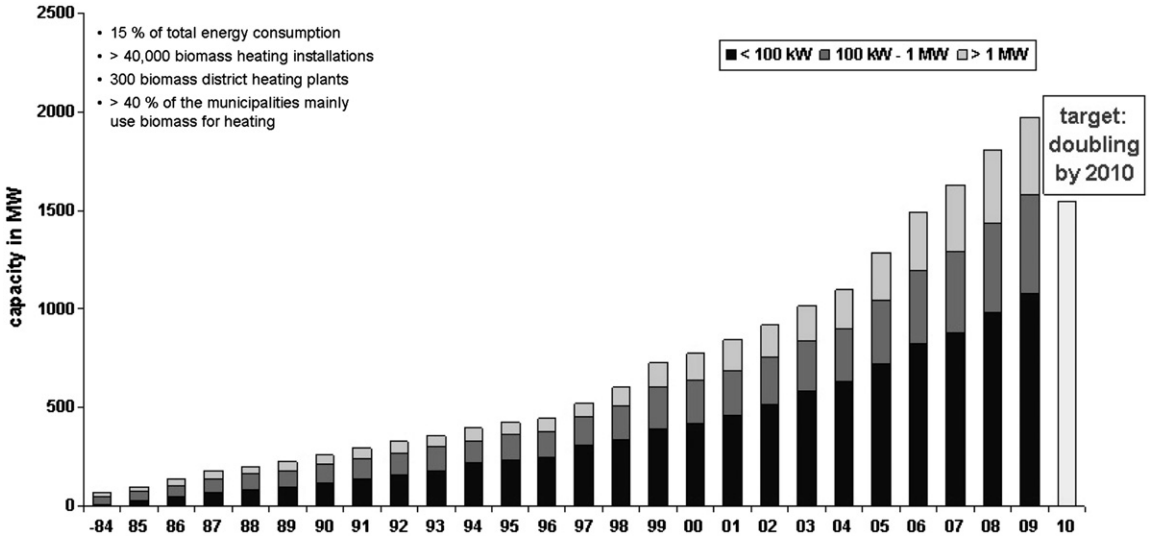


**Fig. 9.** Development of biomass boilers installed in Upper Austria.
*Source:* Dell (2010).

Biomass boilers between 100 kW and 1 MW had an average market growth in the periods of 1990–2009 and 2000–2009 of 11% and 12%, respectively.

Biomass heating has a long tradition in Upper Austria. Overall, biomass boilers contribute about 15% of total energy consumption in Upper Austria. In total, around 1.2 Mt of solid biomass (including saw residues) are used annually for biomass heating in automatic heating systems, producing 3.51 TWh of heat.

Automatic biomass heating systems, using wood pellets, wood chips and log wood have seen a continuous growth over the last 20 years, with the introduction of automatic wood pellet heating systems to the market in the late 1990s providing a strong boost. By the end of 2009, there were 38,000 automatic small scale systems in operation (18,000 of which were pellet boilers) in Upper Austria. The business model of biomass district heating systems (operated by farmer cooperatives) also contributed significantly to the market development. Fig. 9 shows the development of biomass boilers installed in Upper Austria. Again, the target set in the year 2000, to double the installed capacity until 2010, was over-fulfilled.

### 2.7. Heat pumps

Fig. 10 shows the historic development of heat pumps. In the 1980s the market was dominated by hot water systems, but the main market growth in recent years occurred in space heating systems. Air conditioning systems are only a small market niche. In 2009, more than 40% of installed heat pumps in Austria were aerothermal heat pumps.

If the development of heat pumps in Austria is compared with the oil price development (as has been done in Kranzl, 2007), a correlation with a time lag of about five years becomes obvious: The oil price peak in the 1970s and early 1980s resulted in a rapid growth of hot water heat pumps. However, in the late 1980s and 1990s, the number of heat pumps annually installed decreased significantly due to constantly low oil prices during this period. The last few years have again seen a rapid increase in the number of annual installations. Apart from the impact of recent oil price developments, recent growth rates were accompanied by policy instruments providing a further economic incentive (see Section 3).

The average annual market growth of heat pumps in the period from 1990 to 2009 and from 2000 to 2009 amounted to

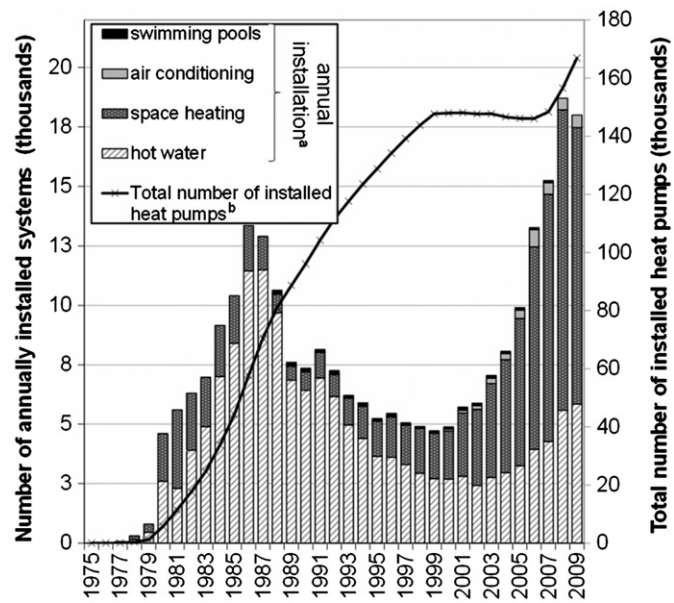


**Fig. 10.** Development of installed heat pumps in Austria: (a) refers to left axis; (b) refers to right axis.
*Source:* Knapek et al. (2005).

5% and 15%, respectively. The years 2006–2008 showed a considerable increase.

Biermayr et al. (2010) list several factors as main drivers for the market decline in 2009: (1) The economic crisis hit the heat pump sector due to the high share of heat pump installations in new buildings; a decline in building construction led to a corresponding drop in heat pump installations. (2) The Austrian heating oil industry started an attractive support program for heating oil boilers in 2009. This led to a market shift and a decrease of biomass boilers and heat pumps.

In Upper Austria, among the heat pumps presently installed, about 50% are for space heating and 50% are for domestic hot water production. In total, about 30,000 heat pumps are in operation. In 2009 the number of new heat pump installations in Upper Austria declined more significantly than in the whole country (Fig. 11).

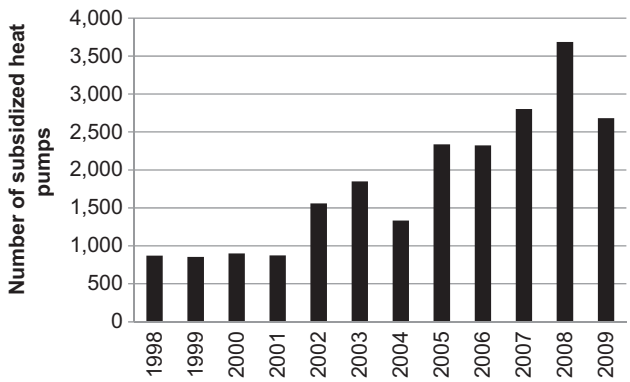


**Fig. 11.** Number of subsidized heat pumps in Upper Austria.
*Source:* Dell (2010).

## 3. Support schemes for RES-H

This section gives an overview on the policy framework supporting RES-H technologies. The section is structured according to the different types of support schemes:

Fiscal incentives (Section 3.1) include grants and tax incentives. Apart from these support schemes, the Austrian support for residential building construction and renovation ("Wohnbauförderung") plays a crucial role in supporting energy efficiency measures and renewable energy in the building sector, as public support for building construction and renovation is usually bound to the precondition of using RES-H. The fact that more than 90% of new buildings receive this support (Amann, 2009) underlines the impact of this precondition. This type of support scheme is documented in Section 3.2. Promotional activities are described in Section 3.3. Section 3.4 includes an overview of the specific situation of RES-H support schemes in Upper Austria.

### 3.1. Fiscal incentives

#### 3.1.1. Grants

Fiscal incentives for solar thermal systems, heat pumps and biomass heating systems for residential heating are primarily based on investment subsidies. Since they are within the authority of the regional governments, the support schemes vary from region to region. A direct comparison of the amounts of subsidies between the regions is not straightforward due to diverse conditions, methods of calculation, etc. National policies are focused on subsidies for large scale plants (e.g. biomass district heating, industrial plants).

*Subsidies for solar thermal systems*: Subsidies were first introduced by some regions during the 1980s and developed strongly during the 1990s (e.g. described in Stanzer et al., 2010). Roughly speaking, the level of investment subsidies for solar thermal systems varies from 20% to 50% of the total eligible investment costs (depending on the size of the installation, collector type, etc.). Typical subsidies are in the range of 600–1700 € for water heating systems and 1100–3500 € for combined water and space heating systems.

In Vienna, Lower Austria, Burgenland, Upper Austria, Carinthia and Tyrol the subsidies are defined as a share of the investment costs. Upper limits are usually calculated on the basis of a fixed amount plus an amount per $m^2$ collector area. For solar thermal space heating systems the upper limits are usually clearly higher than those for water heating systems. In Salzburg and Styria investment subsidies are calculated based on slightly different methods.

*Subsidies for biomass systems*: Investment subsidies for biomass heating systems are granted in every region but their amounts

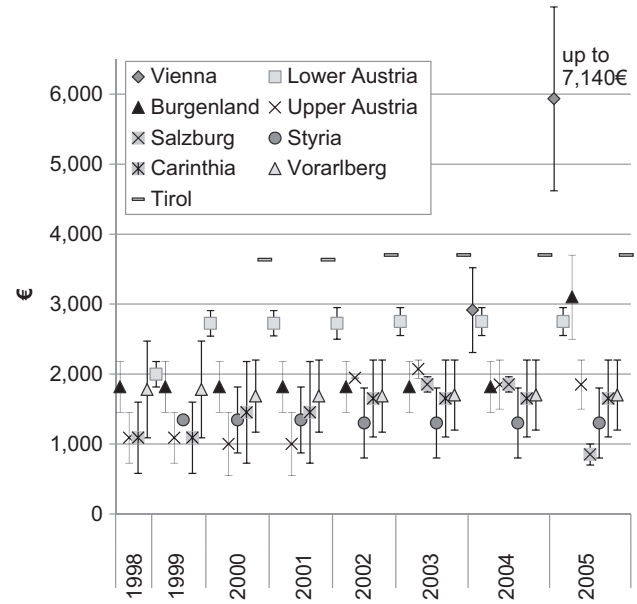


**Fig. 12.** Development of typical/maximum investment subsidies for biomass heating systems.
*Source:* Knapek et al. (2005).

and conditions are very diverse. In Lower and Upper Austria, Carinthia, Styria and Burgenland the subsidies account for 25–30% of the investment costs. In the other regions the amounts partly depend on parameters like the type of the heating system, emissions and other parameters. Fig. 12 illustrates the historic development of typical (for some regions maximum) subsidies for biomass heating systems from 1998 to 2005. Due to the different conditions a comparison is not straightforward. Nevertheless, the figure illustrates that from 1998 to 2005 subsidies were introduced, and then raised significantly, in all regions. (Due to the diversity of support schemes and different eligibility criteria a direct comparison between regions is not possible and actual amounts can vary widely. The ranges represent the deviation of the maximum/typical values, depending on boiler types, emissions and other criteria.)

*Subsidies for heat pumps*: Investment subsidies for heat pumps in Lower and Upper Austria, Burgenland and Tirol range from 15% to 30% of the total eligible investment costs. In some regions the amount of subsidies depends on whether the heat pump is used for water heating only or also for space heating. Moreover, several electricity utilities provide additional incentives for heat pumps like investment subsidies or/and reduced electricity tariffs. According to an agreement between the regions and the federal government on climate mitigation measures in the building sector (Art. 15a-Agreement, 2009), heat pumps have to fulfill minimum requirements with regard to performance to receive a subsidy. The agreement requires heat pumps to achieve a mean seasonal COP of 4 to qualify for financial support schemes, with a limited derogation for some systems with mean seasonal values between 3 and 4, contingent on meeting specific conditions.

#### 3.1.2. Tax incentives

Tax incentives for RES-H include value added tax differentiation, taxes on fossil fuels and income tax allowances.

*Value added tax*: Agricultural and forestry products are taxed with a reduced value added tax (VAT) of 10% instead of the regular VAT of 20%. Hence, the VAT on biomass fuels (log wood, wood chips, pellets, etc.) is 10% lower than on other fuels.

*Taxes on fossil fuels*: Apart from the reduced VAT for biomass, the use of renewable technologies is favoured by additional taxes on fossil fuels. According to the Austrian mineral oil tax regulation, the energy tax on heating oil is 98 € per 1.000 l (about 9.8 €/MWh) and the tax on other fossil fuel oils 60 € per 1.000 kg (about 5.07 €/MWh). The additional tax on natural gas is 6.6 ct per cubic meter (about 5.96 €/MWh).

*Income tax allowance*: Since 1979 the Austrian Income Tax Act defines energy savings measures as special expenses for which tax allowances may be reclaimed. These measures also include expenses for RES-H systems (heat pumps, solar thermal systems and bioenergy systems), DHW systems and energy efficiency measures. Special expenses can be deducted from the net taxable income (tax base). The significance of this instrument is rather limited compared to the investment subsidies described above (Lescot et al., 2009).

### 3.2. Compulsion based instruments and the support of residential building construction

Since the 1950s support schemes for residential building construction have been in place in all regions. Support schemes for building renovation have been implemented more recently. Originally, no energy specific standards were required for receiving these subsidies but within the last years adaptations have been made in several regions, defining thermal quality standards or renewable energy sources as precondition for public support (e.g. in Upper Austria support is only granted for houses with solar thermal or biomass heating systems). Due to the high importance of these support schemes for private home builders, the impact of these requirements is substantial (comparable to an obligation to use RES-H and energy efficient building construction, respectively).

Besides these activities and some side-measures which are compulsory (energy certificate of buildings, emission standards of biomass boilers, etc.) there are no obligations to use renewable energy in the building stock.

### 3.3. Promotional activities

Apart from the instruments mentioned above, a number of awareness campaigns and training programmes have been carried out by regional energy agencies as well as the federal government (e.g. the program "holz:wärme" for biomass and "solar:wärme" for solar heat within the framework program "klima:aktiv"). An example for a regional activity was the campaign "Spar mit Solar" which was carried out in Styria in 2008. Within this campaign, numerous free information events about solar heating were held.

Since 2000 the Austrian Biomass Association has been organizing regular job training courses for plumbers and chimney sweepers. These courses are partly financed by the Federal Ministry of Agriculture, Forestry, Environment and Water Management. Attending these courses qualifies professionals as "Biowärme-Installateur" ("bio-heat plumber") or "Biowärme-Rauchfangkehrer" ("bio-heat chimney sweepers"), which are legally protected terms.

### 3.4. Support schemes for RES-H in Upper Austria

Upper Austria has a long track record in supporting renewable heating, both with grants and with promotional activities, often carried out as integrated "policy packages". For example, two complementary instruments, the grant for solar thermal installations and free energy consulting for home owners have been in place since 1981 and 1991, respectively. The fact that such support schemes have been in place without interruptions is considered a crucial success factor, as stable funding and support conditions contribute to a well-developed RES-H market and continuous growth of the RES-H industry. Today, Upper Austrian companies are exporting their products to the whole of Europe and beyond.

In Upper Austria (as in the whole of Austria) the most important fiscal incentives in the heat sector are grants. There are grants in the form of direct subsidies for solar thermal, biomass (log wood, wood chips, wood pellets) and heat pumps.

Generally speaking, subsidies cover about 20–30% of the investment costs and are provided by the regional government. There is a distinction between small domestic buildings, apartment buildings, non-domestic buildings and the agricultural sector:

*Domestic buildings*: Table 4 gives an overview of investment grants for homeowners.

**Table 4**
Investment grants for homeowners in Upper Austria.

| Technology | Amount |
|---|---|
| Solar thermal collectors | – 1100 € plus 100 (flat plate collectors) resp. 140 € (vacuum collector) per $m^2$<br>– In total, max. 3800 €<br>– Solar keymark and heat meter required |
| Pellet and wood chip heating systems | – Up to 1700 € for new installations<br>– Up to 2200 € for switching from fossil fuels to biomass heating<br>– 500 € for renewal of biomass heating systems |
| Pellet stoves | – Only in low energy buildings and as the only heating system |
| Connection to district heating | – 700 €<br>– If more than 50% of the DH is produced by RES 1200 €<br>– 1100 € for switching from fossil fuels to district heating<br>– (1700 € if more than 50% of the DH is produced by RES) |
| Heat pumps | – 1000 € (COP min. 4) or 1700 € (COP min. 4.5)<br>– Heat meter, solar thermal or PV or green electricity required<br>– 1500 € for switching from fossil fuels to heat pumps<br>– (COP min. 4)<br>– 2200 € for switching from fossil fuels to heat pumps<br>– (COP min. 4.5)<br>– 500 € for renewal of heat pumps |

For apartment buildings, a different funding regime for RES-H exists. The soft loan programs, which support the construction and renovation of a large part of all buildings, provide greater support if solar and/or biomass systems are being installed. Additionally, a direct subsidy of 20 € per $m^2$ is granted if solar thermal and/or biomass systems are installed.

For non-domestic buildings a funding scheme supported by both the regional and national government (Ministry of Environment, operated by Kommunalkredit Austria, entitled "UFI", "Umweltförderung im Inland") exists. For biomass (including biomass district heating and biomass CHP), solar thermal and heat pumps, an investment subsidy of up to 30% is granted from the national level. In addition, up to 60% of the national subsidy (max. 15% of the investment costs) is provided by the regional administration.

Specific funding schemes also exist for the *agricultural sector*, including a special support program for biomass district heating plants of up to 4 MW and operated by farmers or farmers' cooperatives, which covers up to 40% of the investment costs. This is also financed from national and the regional funds, as well as European programs (agricultural funds).

On the regional level, there is also the specific "Biomassefonds". This is a revolving fund set up in 1993 with a budget of €3.6 million. This fund is used to provide soft loans which are intended to bridge the financing gap in the initial phase of a biomass district heat project.

Further funding instruments include:

- A *regional program for "Energy Contracting"*, the so-called "Energie-Contracting-Programm" (ECP), which supports the financing of such projects – meaning that a subsidy is granted to cover a part of the costs from financing the investment by the energy service company (in addition to technology specific investment subsidies). The program covers both energy efficiency investments and RES-H and provides up to 13.5% of the investment costs for RES-H contracting.
- A *regional research and development program* – implemented by the regional energy agency (O.Ö. Energiesparverband) – supports research and product development in the fields of energy efficiency and renewable energy sources. Companies offering RES-H products and services have profited from this program particularly, where it has helped to stimulate the development of a more competitive product portfolio.

## 4. Outlook for the Austrian RES-H sector

In this section different scenarios and prospects for the Austrian heating sector and in particular possible development paths and policy targets for RES-H technologies are discussed. Selected scenarios from the literature for the development of the RES-H sector as a whole and various RES-H technologies in particular are compared, and RES-H targets derived from stakeholder processes are discussed.

### 4.1. Scenarios for the development of RES-H technologies

Recently, several projects and studies have produced energy scenarios and in particular scenarios for the development of RES-H technologies in Austria. From the literature indicated in Section 1 we selected those with both the highest relevance for our paper and the strongest focus on the RES-H sector. Table 5 shows the sources and scenarios that have been selected:

A comparison of scenarios from literature always leads to some methodological problems and challenges, because different types of technologies, demand sectors, system boundaries, etc. are considered in each study. This needs to be taken into account in the discussion of the following graphs.

Due to the large number of available scenarios within the literature, it was necessary to make a choice and select specific scenarios from the sources indicated in Table 5. From those projects providing a broad range of scenarios, we selected more ambitious ones. A low-growth scenario in particular is covered by the WAM-scenario (with addition measures) in Müller et al. (2009). This source provides also a scenario with an even slightly lower RES-H growth (WM-scenario: with measures). However, it should be taken into account that the policy measures of the WAM-scenario were already in the preparation phase of real implementation at the time when the analyses were carried out. Overall, this leads to a scenario selection covering a range of moderate to ambitious RES-H development in Austria.

Further scenarios for the deployment of RES-H technologies are developed based on the simulation tool Invert. Results, detailed assumptions and methodological approaches are presented in Kranzl et al. (2010b, submitted).

Fig. 13 shows a comparison of literature results for scenarios on biomass heating in Austria. The wide deviation of the starting values in 2005 is mainly due to the fact that some of the scenarios include industrial heating processes and some do not. In particular, the scenario "RES-H 2030 accelerated, total" includes the industry sector, whereas the scenarios "RES-H 2030, accelerated, space heating" and "Heat 2020, WAM" consider only space and water heating. Moreover, the different starting values are to some extent due to different publication years of the studies and revisions of statistical data on biomass utilization during the last years. The scenario "Heat 2020, WAM" represents a scenario where only those measures which are currently in place or under policy discussion are included, and only up to 2020. Thus, no ambitious new policy instruments or incentives are included in this scenario. Moreover, a very low increase in energy prices has been assumed. Taking this into consideration, we can conclude that the more ambitious scenarios suggest a biomass final energy consumption for the low-temperature heating sector above 100 PJ in the year 2020.

The literature overview for solar thermal systems (Fig. 14) shows a very broad range of scenarios. There are two scenarios (which are actually from the same authors and institutions) showing a very steep increase in solar thermal utilization ("Solar roadmap" and "ESTIF, RDP"). According to these scenarios, the current solar thermal energy output of 5 PJ in 2009 (Biermayr et al., 2010) would increase to more than 35 PJ in 2020. The basic assumption here is that extensive R&D and corresponding technological progress takes place, in particular this is likely to mean the development of high-density efficient and economic thermal storage systems. Moreover, this is accompanied by favorable economic conditions.

The other scenarios are clearly more conservative, assuming lower technological progress and stronger barriers in the diffusion. They show an increase to 10–17 PJ in 2020 and 20–40 PJ in 2030. Unlike the scenarios for biomass, all solar thermal scenarios show a steep increase after 2020. This is due to the fact that biomass heating systems are already well established in certain market segments (especially single family houses in rural areas), but further diffusion into other market segments is hindered by different barriers and is considered unlikely. The "demand side potentials" of solar thermal systems, on the other hand, are far from exploited.

The heat pump scenarios (Fig. 15) again show a very broad range of projections. The core drivers for diverging results in these studies are different assumptions about optimal fields of application of this technology and the minimum COP which is required according to standards and regulations. The strict requirement

**Table 5**
Overview of selected RES-H scenarios from literature.

| Quote | Short description | RES-H sector covered | | |
|---|---|---|---|---|
| | | Biomass | Heat pumps | Solar-thermal |
| Haas et al. (2007) | In this project, a bottom-up model of the Austrian building stock was used to analyze the conditions under which a share of 100% RES is achievable in the Austrian heating sector until 2030. The most ambitious scenario, the "accelerated scenario" achieves a share of 80% RES in the Austrian heating sector until 2030. This scenario is called "RES-H 2030, accelerated" in the graphs below | X | X | X |
| Austrian Federal Ministry of agriculture, forestry, environment and water management (2006) | In 2006 a proposal for an Austrian biomass action plan has been developed by the Austrian Federal Ministry of Agriculture, Forestry, Environment and Water management This scenario is called "BAP 2006" in the graphs below | X | | |
| Müller et al. (2009) | This scenario is the most recent scenario of the Austrian heating sector of small scale consumers. It was developed as an input to the reporting for the monitoring mechanism of GHG-emissions to the European Commission. The scenario "with-additional-measure" ("WAM") was selected for this collection. This scenario includes measures that are currently discussed, but not yet adopted. The 2020-RES-target is not achieved in this scenario | X | X | X |
| Großmann et al. (2008) | This scenario ("SERI, DAM") is called "Denk an morgen" ("Think of tomorrow"). Thus, it is focused mainly on new, innovative and sustainable technologies. The scenario has been developed in a participatory stakeholder process | X | X | X |
| Haas et al. (2008) | In this project, a wide range of scenarios have been developed for different RES-technologies up to 2050, taking into account different support levels, energy price scenarios and $CO_2$-prices. The scenario taken into account here is the "alternative support scheme scenario" which represents a more ambitious development of RES technologies due to corresponding support schemes and economic side-conditions | X | X | X |
| Kalt et al. (2010) | In this paper, four different scenarios of the Austrian bioenergy sector up to 2050were developed, each in a low and a high energy price scenario: a no policy scenario, a "heat and power" scenario, a "balanced" policy scenario and a "transport" scenario. For this comparison the "heat and power – high price" scenario was selected | X | | |
| Weiss and Biermayr (2008) | Weiss and Biermayr (commissioned by ESTIF) developed ambitious scenarios for solar thermal collectors in different European countries. The most ambitious scenario ("RDP", "full research and development policy-scenario") is based on the assumption of extensive R&D and favorable economic conditions. The Austrian values are included in the following graphs as "ESTIF, RDP" | | | X |
| Fink et al. (2009) | The "Solar Roadmap" provides an ambitious scenario for the contribution of solar thermal energy to the low-temperature heat market up to 2030. Moreover, required policy measures and actions are identified | | | X |
| Lutz (2007) | The "Heat Pump Roadmap" provides an ambitious scenario for the contribution of heat pumps to the space heating and hot water as well as for the industry sector | | X | |

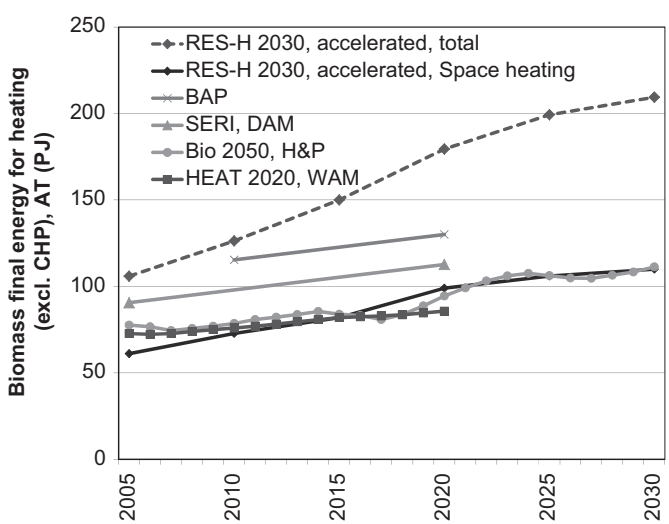


**Fig. 13.** Comparison of literature results for scenarios on biomass heating (excluding CHP) in Austria.

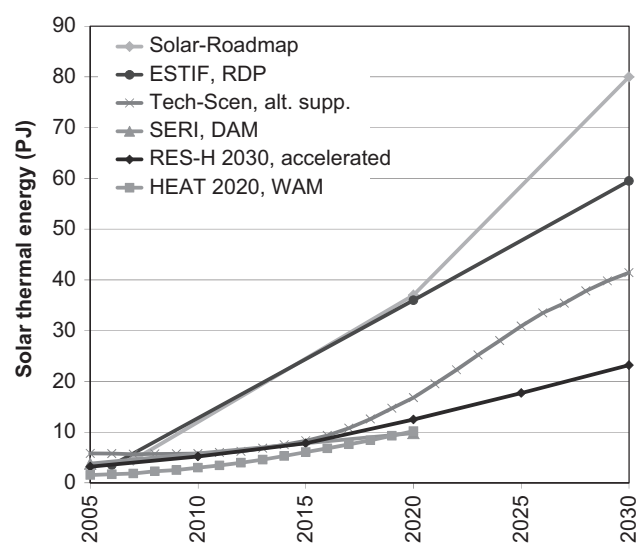


**Fig. 14.** Comparison of literature results for scenarios of solar thermal collectors in Austria.

that a high minimum COP should be achieved leads to the fact that only buildings with a high thermal quality will be equipped with heat pumps. This restriction reduces the market potential significantly, but in those buildings where heat pumps are applied, highly efficient operation can be assumed. This is not the case in the high-deployment scenarios, where heat pumps are also assumed to be installed in buildings with relatively low thermal qualities resulting in lower COP-values and corresponding higher electricity consumption in the heating sector.

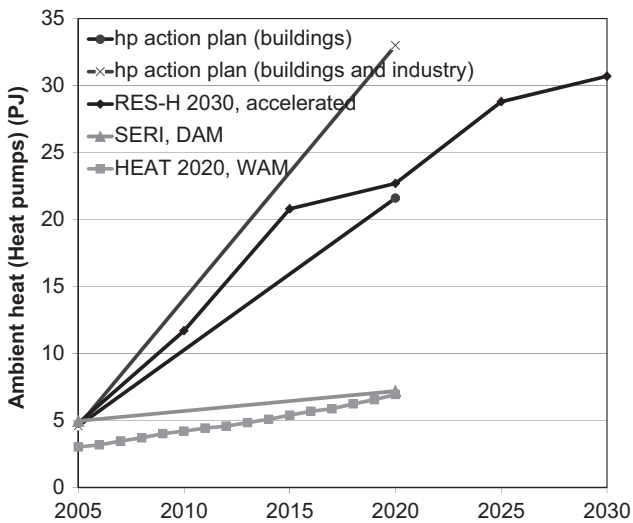


**Fig. 15.** Comparison of literature results for heat pumps (in terms of ambient energy) in Austria.

### 4.2. Energy policy targets

In this section energy policy targets for the Austrian RES-H sector are compared. First, RES-H targets derived in Kranzl et al. (2009) are discussed (Section 3.3.1). Consecutively, the RES-H targets according to the National Renewable Energy Action Plan (NREAP) submitted by the Austrian government in mid-2010 are documented (Section 3.3.2). Finally, RES-H targets implemented in Upper Austria are discussed (Section 3.3.3).

#### 4.2.1. RES-H targets derived in the project RES-H policy

In Kranzl et al. (2009), which is based on the 'RES-H Policy' project, ranges for policy targets were derived on the basis of the following steps:

- Literature analysis (see Section 4.1)
- Top-down analysis by breaking down existing scenarios from the model Green-X (Resch et al., 2009)
- Bottom-up approach for assessing the possible development of RES-H technologies in ambitious growth scenarios
- Based on these analyses and data, a stakeholder discussion process was carried out. For this purpose, a questionnaire was sent out to key policy and industry stakeholders. The results of this consultation were discussed in a workshop. This process resulted in target ranges for the different RES-H technologies for the years 2020 and 2030 (see Table 6).

The final energy demand for space heating and hot water in the residential and non-residential building sector according to different scenarios (Müller et al., 2010; Müller et al., 2009; Kranzl et al., 2009; Bundesministerium für Wirtschaft, Familie und Jugend, 2010) is expected to be in the range of 305–325 PJ in 2020 and 235–280 PJ in 2030. This would lead to a share of RES in this sector of about 40–50% (55%) and 55–65% ( > 75%) for 2020 and 2030, respectively (values in brackets correspond to maximum RES-target and minimum energy consumption values).

#### 4.2.2. RES-H targets in the Austrian NREAP

Table 7 shows the policy targets for renewable energy in the heating and cooling sector according to the NREAP (Bundesministerium für Wirtschaft, Familie und Jugend, 2010). The increase in renewable heat from 2005 to 2010 amounts to more than 19 PJ.

**Table 6**
Structure of final energy consumption in Austria in the year 2008.
*Source:* Kranzl et al. (2009).

| PJ | 2007 | 2020 | 2030 |
|---|---|---|---|
| *Solar thermal* | | | |
| Space heating and hot water | 5 | 15–20 | 30–45 |
| Industrial appliances | 0 | 2–4 | 3–7 |
| *Biomass* | | | |
| Space heating and hot water | | | |
| Pellets | 5 | 20–30 | 20–30 |
| Wood chips | 11 | 20–30 | 20–30 |
| Wood log | 65 | 45–60 | 30–55 |
| District heating[a] | 21.9 | 18–22 | 20–30 |
| Total space heating and hot water | 102.9 | 105–130 | 90–130 |
| Industrial appliances | 37 | 35–43 | 50–60 |
| Total biomass energy for heating | 126 | 140–173 | 140–190 |
| *Ambient energy – heat pumps* | | | |
| Space heating and hot water | 3 | 7–13 | 10–17 |
| Industrial appliances | 0 | 2–4 | 3–7 |
| *Total RES-H* | | | |
| Space heating and hot water | 97 | 127–163 | 130–192 |
| Industrial appliances | 37 | 39–51 | 56–74 |
| Total | 134 | 166–214 | 186–266 |

[a] The target ranges do not include waste heat from biomass CHP (due to the focus on RES-H and not on RES-E). However, from 2005 to 2008 this sector increased from 4.1 to 14.3 PJ. Thus, the historic values include waste heat from CHP, whereas the target values do not, which needs to be taken into consideration.

**Table 7**
Targets for RES-H/C according to the Austrian NREAP.
*Source:* Bundesministerium für Wirtschaft, Familie und Jugend (2010).

| (PJ) | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Geothermal | 0.8 | 0.8 | 1.1 | 1.7 |
| Solar thermal | 3.9 | 5.3 | 7.6 | 11.3 |
| Biomass | 127.0 | 143.0 | 145.0 | 151.0 |
| Solid | 126.7 | 142.4 | 144.3 | 150.3 |
| Biogas | 0.3 | 0.6 | 0.7 | 0.7 |
| Liquid biofuels | 0.0 | 0.0 | 0.0 | 0.0 |
| Heat pumps | 2.9 | 4.0 | 5.7 | 11.0 |
| Aerothermal | 0.0 | 1.6 | 2.3 | 4.4 |
| Geothermal | 0.0 | 0.4 | 0.6 | 1.1 |
| Hydrothermal | 0.0 | 2.0 | 2.8 | 5.5 |
| Renewables in heating and cooling | 134.0 | 153.1 | 159.4 | 175.0 |
| Biomass central (grid) | 14.4 | 27.1 | 27.6 | 29.4 |
| Biomass decentral | 112.6 | 115.9 | 117.4 | 121.6 |

From 2010 to 2020 an additional increase of 22 PJ is anticipated. Whereas more or less a constant growth from 2005 to 2020 is assumed for solar thermal and heat pumps, a significantly lower growth is assumed for biomass, which will have to make a major contribution to the target.

For the interpretation and understanding of the NREAP targets, the following aspects should be taken into account:

(1) A considerable share of the RES-H growth from 2005 to 2010 has been due to the increase of biomass CHP in the years 2006–2008 leading to a high additional output of waste heat from biomass CHP (compare Fig. 3). The NREAP does not assume that biomass CHP will continue to increase in the same way until 2020. In fact, the biomass district heating sector is assumed to grow by less than 10% for the whole period from 2010 to 2020.
(2) The negotiations around the overall RES target in the renewable energy directive (leading to a RES target of 34% in 2020 for Austria) were mainly based on data from the energy balance 2007 (Statistik Austria, 2007). For 2005 and 2006 it recorded 123 PJ and 127 PJ of final energy consumption being

met by renewable energy, respectively. The energy balance 2008 (Statistik Austria, 2008) for the years 2005, 2006 and 2007 showed 136 PJ, 151 PJ and 153 PJ of final energy consumption from renewable energy, respectively. According to the calculation method defined in the renewable energy directive, this amounted to a RES share of 28.8% in 2007. The energy balance 2010 gives a RES share of 30.1% for the year 2009. Thus, it emerged that the 34% target was no longer very ambitious. This led to the development of the "Energy strategy 2020" by the responsible ministries, via a broad discussion process. It included a RES target of 35.48% for 2020 (BMLFUW and BMWFJ, 2010). However, when it came to the NREAP the Austrian government was not willing to go beyond the 34% target, arguing that there was no reason for setting a more ambitious binding target (discussion workshop of NREAP target in June 2010 at the Austrian Ministry of economy, family and youth).

(3) With regard to the relative share of RES in the heat sector, a comparison based on absolute numbers is somewhat misleading. Due to growing efficiency and declining energy demand in the heat sector (which may be expected in the future as a result of thermal renovation, building codes, etc.), a constant amount of RES-H energy means an increasing share of buildings being heated with RES-H energy.

In Section 5 we will compare the NREAP RES-H targets with the historic market growth according to Sections 2.5–2.7. For this purpose, we calculated the market growth rate that would result from the NREAP targets. Market growth is defined as the ratio of RES-H installations in year *t* to the installations in year *t* minus 1. The installations in each year consist (1) of the net expansion of capacities in order to reach the RES-H generation according to the NREAP targets and (2) of the replacement of old RES-H systems after their lifetime's expiry. For the latter one we assumed a lifetime of 20 years and based the calculation on the time series of installations documented in Sections 2.5–2.7. For biomass heating, we focused on small scale systems, assuming that the growth of decentralized biomass heating systems suggested by the NREAP will be met by small scale applications only. Moreover, we assumed that the net expansion of biomass heating capacities occurs in the pellets and wood chip boiler sector, while the stock of wood log boilers remains constant.

Relating this result to the NREAP suggests for an average annual market growth from 2008 to 2020 for solar thermal of 7%, for heat pumps of 6% and for wood chips and pellets boilers $<100$ kW of 11% and 12%, respectively, which will be required to hit the NREAP targets. It should be noted that the replacement of old RES-H systems makes a significant contribution to the market.

#### 4.2.3. RES-H targets in the region of upper Austria

Based on an initiative of the regional government and the regional parliament, the "Energy Future 2030" process is currently being implemented. In 2007, within the frame of this process, four different scenarios were developed. In October 2007, the regional government adopted the most ambitious scenario, the "turning point scenario" as its official targets for 2030. The targets in this scenario include:

- 100% electricity from renewable energy sources
- no fossil fuels for space heating and hot water
- reduction of heat demand by 39%
- reduction of fossil transport fuel consumption by 41%
- reduction of GHG emissions by 65%

In 2007, within the frame of "Energy Future 2030", a scientific analysis of the RES and energy efficiency potentials was carried out (Haas and Kranzl, 2006). According to this analysis, biomass heating could be increased from 38 PJ to 60 PJ, using only wood resources from the region (see Table 8). A main uncertainty factor concerning this potential is the biomass consumption for electricity generation and other purposes (including material uses).

**Table 8**
Potentials for RES-H for 2030.
*Source*: Dell (2009).

| [PJ/a] | 2005 | Potentials 2030 |
|---|---|---|
| Biomass heat | 38 | 60 |
| Heat pumps | 1 | 2–3 |
| Solar thermal | 1 | 4 |

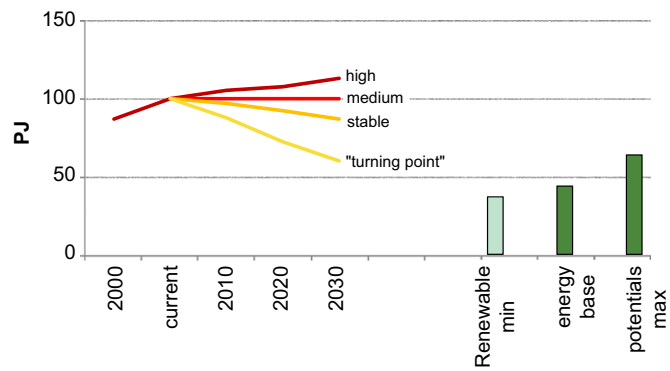


**Fig. 16.** Development of heat consumption, scenarios and renewable energy potentials for the sector space heating and hot water in Upper Austria 2000–2030 (PJ).
*Source:* Dell (2009).

Fig. 16 shows a comparison of the historic development of heat consumption, scenarios up to 2030 and potentials for the heating sector. The basic proposition of the "turning-point-scenario" which has been adopted by the regional government is that by 2030 demand in the heating sector (excluding industrial heat demand) can be met by 100% renewable energy.

## 5. Discussion and conclusions

### 5.1. NREAP RES-H targets in relation to scenarios and target ranges

The data and results presented in Section 4 allow for a comparison of the Austrian RES-H targets in the NREAP with scenarios from the literature and targets derived through a stakeholder process within the project RES-H Policy, as described in Section 4.2.1. A comparison of the NREAP target values for 2020 (Table 7) with the results of the stakeholder process (Table 6) and literature scenarios (Figs. 13–15) leads to the following conclusions:

For *solar thermal*, the NREAP-target (11.3 PJ) is below the target ranges derived in Kranzl et al. (2009) (17–24 PJ) and in the lower part of the range of literature scenarios (10–38 PJ) for the year 2020. The Austrian NREAP does not distinguish between solar thermal systems for space heating and hot water on the one hand and industrial appliances on the other. Currently, the share of solar thermal systems in industry is still very low (Biermayr et al., 2010). Therefore, projected deployment of solar thermal systems for industrial process applications can be regarded as having a higher degree of uncertainty than in the space heating sector. However, even if only the target range for the sector of space heating and hot water preparation (15–20 PJ) is taken into account, it would lead to the conclusion that the NREAP-targets are rather unambitious.

For *heat pumps*, the NREAP-target for 2020 (11 PJ) is in the lower part of both the target range according to the stakeholder process (9–17 PJ) and within the literature scenarios (7–33 PJ). Again, the application of heat pumps so far strongly focuses on the sector of space heating and hot water preparation, while the industry sector only plays a minor role (Biermayr et al., 2010). Considering only the space heating and hot water sector is taken into account (7–13 PJ), the NREAP target is in the upper-middle of the target range (Table 6). The technology split according to the NREAP-target shows a share of 40% aerothermal heat pumps in the year 2020; this is in line with current developments (see Section 2.7). However, it is not in line with the policy framework requiring minimum mean seasonal COP of 3–4 (see Section 3.1.1), which aerothermal heat pumps hardly achieve.

For *biomass* the NREAP-target (151 PJ) is also situated in the lower part of the target range (140–173 PJ), despite the latter not including figures for waste heat from biomass CHP (amounting to 14.3 PJ in 2008 according to Statistik Austria, 2010d). The selected literature scenarios (which also do not include heat from biomass CHP) cover a range of about 90–180 PJ in 2020.

*The overarching target for renewable heating and cooling* in the Austrian renewable energy action plan (175 PJ) is in the lower range of the target range derived by the (data-supported) stakeholder process (166–214 PJ). Also the comparison with the scenarios in the literature leads to the conclusion that the RES-H target within the NREAP does not reflect an ambitious development compared to the considered scenarios and analyses.

### 5.2. NREAP RES-H targets in relation to historic and recent growth rates

Sections 2.5–2.7 present the market development and growth rates of RES-H systems in the last years and decades. It was shown that considerable market growth took place in this period, although partly interrupted by strong discontinuities. The comparison of the growth of the sector according to the RES-H NREAP-targets with recent growth can lead to additional insight.

According to the data presented in Section 4.2.2, the average annual market growth rates of *solar thermal collectors* in the period from 1990 to 2009 and from 2000 to 2009 were 12% and 9%, respectively. The targeted annual growth rate from 2008 to 2020, according to the NREAP, is about 7%. Thus, the NREAP target corresponds to a decreasing market dynamic. A crucial open question in the assessment is when the current slowing down in solar thermal market growth will be turned into a more positive dynamic again.

For *heat pumps*, the average annual growth rates in the deployment of heat pumps (number of annually installed systems) in the period from 1990 to 2009 and from 2000 to 2009 amounted to 5% and 15%, respectively. The NREAP target would correspond to an annual growth of about 6%. Hence, compared to the market growth in the last decade the heat pump NREAP target represents a reduced market dynamic. However, as with solar thermal the ambitiousness of the 2020 target also depends on the duration of the currently stagnant market.

*Biomass small scale heating systems* (up to 100 kW) had an average market growth of 25% between 2001 and 2009 (the period for which all types of new small scale biomass heating systems are covered). However, the sector experienced quite strong fluctuations and discontinuities. For decentralized, small scale wood chips and pellets systems, achieving the NREAP-target would require annual market growth of 11% and 12%, respectively (2008–2020). Thus, on average the annual market growth rate would be less in the period up to 2020 than the recent historical rate.

Thus, we can come to the conclusion that for *all investigated RES-H technologies* the NREAP target would lead to a reduced market growth compared to mean growth rates of the last decade.

It has to be taken into account that past expansion rates are not necessarily indicative of future growth rates. In particular, increasing marginal costs of renewable energies and the exploitation of potentials could lead to declining growth. Therefore, we should combine the results of this section with those of Section 5.1, since most of the scenarios presented in Section 4.1 do take into account availability of potentials, diffusion restrictions, increasing marginal costs due to comprehensive modeling approaches. In fact, the conclusions from the findings in Section 5.1 and this section support each other.

### 5.3. Outlook and open questions

The combination of policy framework, economic side conditions, traditions and public perceptions has led to an increasing use of RES-H during the period 1990–2010. Section 3 has shown that there is a broad range of different policies supporting renewable heating in Austria. Financial support schemes (mainly based on regional subsidies) are one of the main pillars of this policy mix. Generally, the number of support schemes and their incentives for renewable heating has increased in recent years and this holds in particular for RES-H incentives in the frame of support for residential building construction. Further, there are indications that this supported the market growth of RES-H.

Regarding the technology mix of policy targets and eligibility criteria for public support, RES-H policies to some extent lack consistency. For example, in the case of heat pumps, policy targets regarding the share of aerothermal heat pumps (Table 7) are not consistent with the requirements regarding minimum COP (Section 3.1.1).

Based on historical data concerning the development of policies and the deployment of RES-H technologies, it is not possible to derive conclusions about the actual impact of different support schemes; other crucial aspects like fuel price developments, macroeconomic processes and crises, public awareness, impact of information campaigns, trainings, etc. would have to be included in the analysis. This was not in the scope of this paper. Examples for quantitative assessment of future impacts of RES-H policies are presented in other papers of this special issue.

The case of Austria shows that static definitions of RES targets might lead to the fact that uncertainty in statistical data and unexpected market developments turn the target into one with a low level of ambition, at least in parts of the RES sector. Thus, a crucial question which remains to be answered is: How could EU policy instruments and EU Member States policy instruments adapt to changing deployment, short term market developments (like the strong growth in recent years on the one hand and currently stagnant markets for RES-H on the other hand) and other dynamic parameters? And further: How to define directives in a way that provide incentives for ambitious policy target setting?

In contrast to the unambitious target for RES-H in the Austrian NREAP, which was defined at the federal level, regional policy targets and instruments tend to be quite ambitious, at least for some of the regions, e.g. Upper Austria. Currently, no reduction of regional RES-H promotion schemes as presented in Section 3 is on the horizon. Even though this might also become a question of the currently discussed cuts in public budget spending, the facts presented in this paper support the hypothesis that Austria might exceed the RES-H targets of its NREAP. This at least seems likely in case that the regional support policies and general favorable side conditions remain in place.

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