HPP Annex 43

Country Report: AUSTRIA

International Energy Agency

AUSTRIAN INSTITUTE OF TECHNOLOGY

TU Graz

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December 2016

Content

1 Heating, Cooling and DHW market developments

Chapter 1 provides information on the national market for space heating, domestic hot water production and cooling including data on the current heating and cooling supply of residential and non-residential buildings, market trends regarding different heating and cooling technologies with a special focus on renewable technologies such as heat pump technologies, biomass and solar thermal systems. Finally, the results of a research project regarding the projected development of the heating and cooling market in Austria by 2050 respectively 2080 are presented.

1.1 Current market for space heating, DHW (and cooling)

1.1.1 Residential market

Currently approx. 50% of the Austrian residential stock is centrally heated, 24% of dwellings are connected to district heating networks. The heating systems installed depend on both, age and type of dwellings. The older the building, the higher is the share of gas and self-contained central heating systems. 75% of all buildings with one or two flats have central heating systems in place; 51% of buildings with more than 20 dwellings are connected to district heating networks.

With a share of about 48%, fossil fuels are still the predominant energy carrier for residential heating in Austria. Renewables, biogenic fuels and district heating are constantly gaining on importance; gas consumption remains relatively stable at around 23%, whereas the consumption values for coal and heating oil are declining. Wood and wooden products such as wood pellets are the most popular energy carriers for residential heating with a share of approx. 33%. Domestic hot water (DHW) is currently mainly provided by means of electricity; followed by natural gas (22%) and solar thermal and heat pump systems (12.5%). Statistical information on residential cooling is not available.

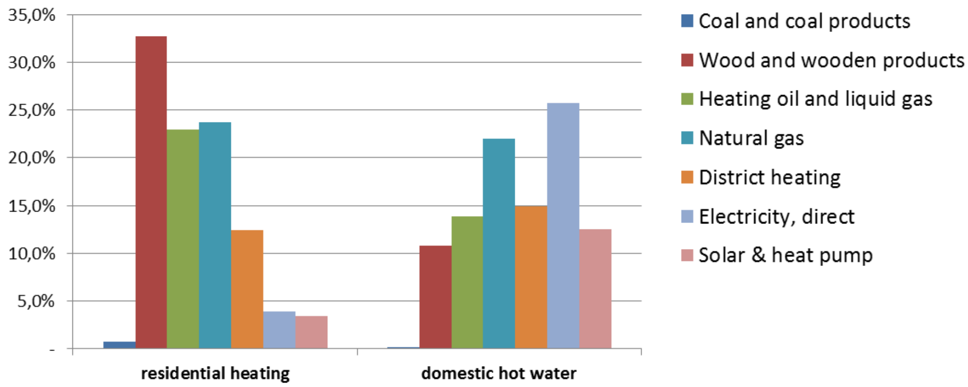


Figure 1: Energy carriers for space heating and domestic hot water in Austria in 2011/2012 (Statistik Austria 2013)

The distribution of households connected to a natural gas grid varies considerably on a regional level. In the eastern provinces nearly 60% of households are connected to natural gas, this share is only 9% in Southern Austria, and 22% in the western provinces (see figure 1).

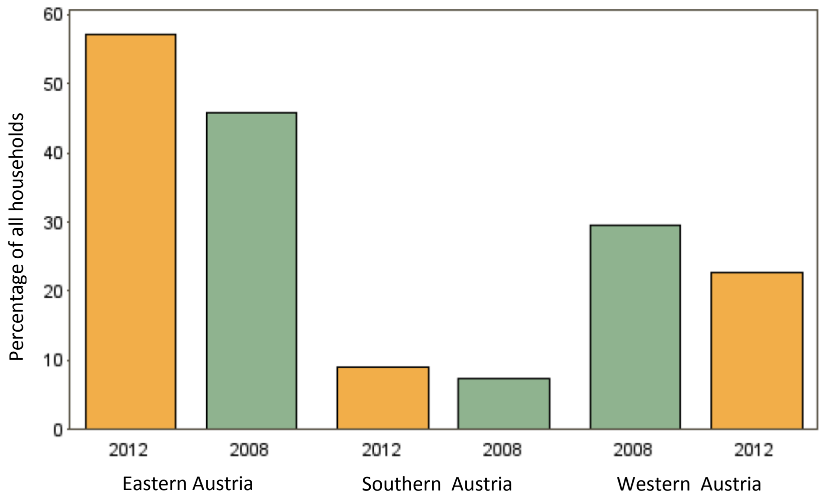


Figure 2: Gas connections of households in Austria (Statistik Austria 2013)

In winter 2012 the average daily gas consumption of a single household added up to 7m³; slightly more than in the winter 2008 where it reached 6.7m³. (Strom- und Gastagebuch 2012)

In 2014, 43.300 gas-driven heating units were sold. That is nearly every second new heating system installed. Electrically driven heat pumps follow on second place. (Forum Gas Wasser Wärme 4/2015). The most popular gas fired heating systems are gas boilers. Gas condensing boilers are still rare. The majority of heating systems (56%) are combined with the DHW system all year round. 28% of households have separate systems for heating and DHW; 16% have a combined system in winter and a separate one for heating and DHW in summer. The latter is to be found especially in single family and duplex houses (AEA 2013).

1.1.2 Non-residential market

Around 53% of the useful energy for heating and air-conditioning for private and public buildings is provided via district heating and cooling networks; 20% of useful energy derives from natural gas; 13% from direct electricity. In contrast to production buildings where natural gas (43%), wood and wooden products (24%) are the main energy carriers, see subsequent figure. (Statistik Austria, 2013)

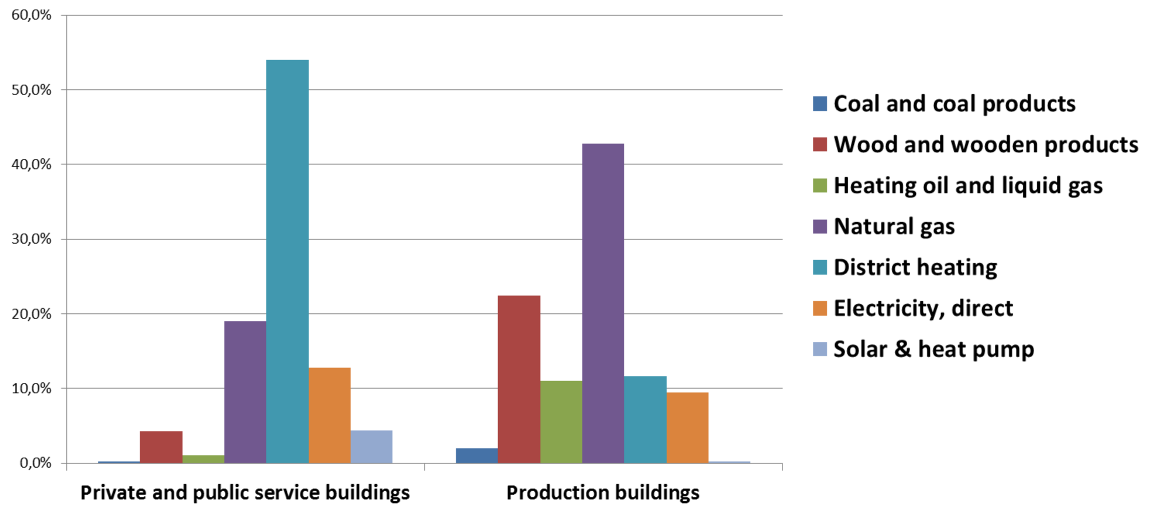


Figure 3: Energy carriers for space heating and air-conditioning in private and public buildings as well as production buildings in Austria in 2011/2012 (Statistik Austria 2013)

1.2 Market trends of Heat Pump Technologies

Assuming a technical lifetime of 20 years, there are currently about 223.000 heat pumps in operation in Austria. In 2014, the majority of them is used in residential buildings for heating and DHW (around 63%), 34% are implemented for hot water production only and the rest is used for ventilation or de-humidification. The share of heat pumps for DHW only in the stock of heat pumps is continuously decreasing since the beginning of 2000, whereas the one for heat pumps for heating purposes is increasing (see Figure 4). Most heat pumps installed are electrically driven compression heat pump systems (Biermayr 2015). **The market diffusion of Fuel driven sorption heat pumps (FSHP) in residential buildings is in a very early market stage with no official market figures available.**

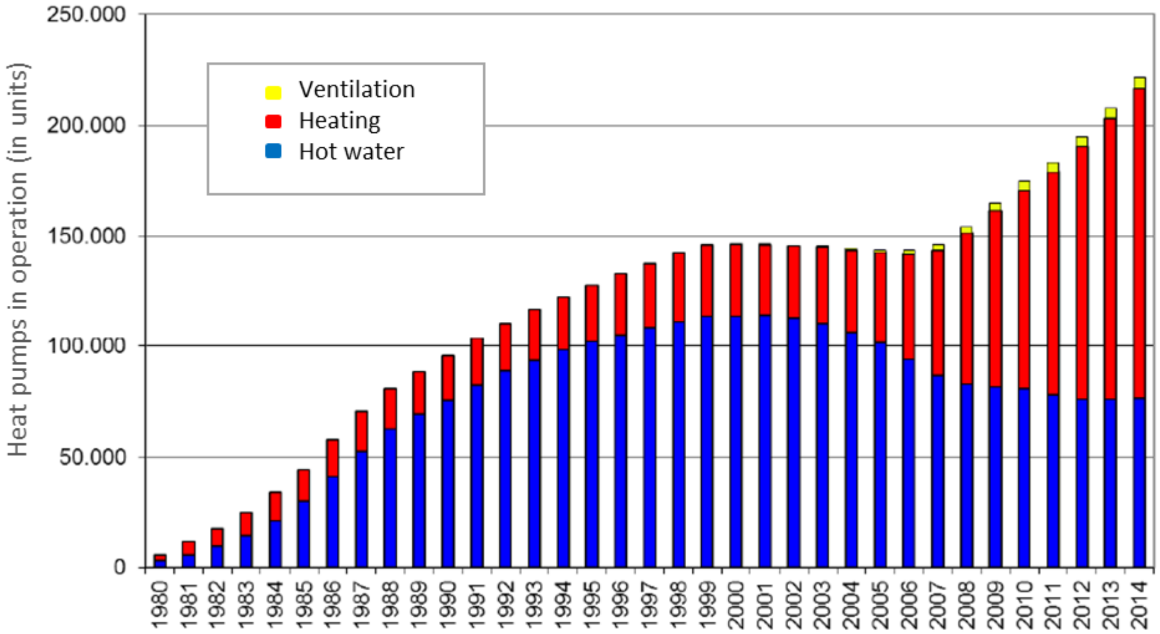


Figure 4: Cumulated stock of heat pumps in Austria (Biermayr 2015)

The sharp increase of the market diffusion of heat pumps for heating purposes started at the beginning of the 2000s (see Figure 5) and was accompanied by an improved energy-efficiency of the residential buildings and a growing demand for low-energy houses (Biermayr 2014).

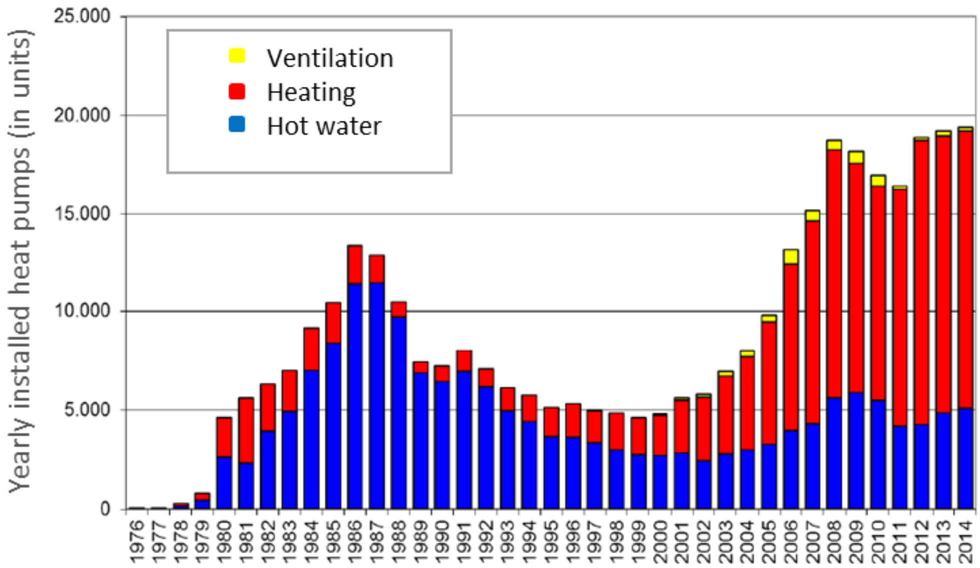


Figure 5: Market share of the yearly installed heat pumps in Austria (Biermayr 2015)

Nowadays, the most popular heat source is air. Especially air-to-water heat pumps experienced strong growth rates since the year 2004 and have a market share of 62.8% in 2014. Currently, one of two heat pumps newly installed is an air-to-water heat pump system. Brine-to-water heat pumps follow on the second place with a market share of 25%, water-to-water heat pump systems are ranked third with 5,4%. DX-heat pumps, the most popular heat source system in the 1990ties, continuously lost in importance and are of little significance in 2015 with a market share of 5,5% (Biermayr 2015).

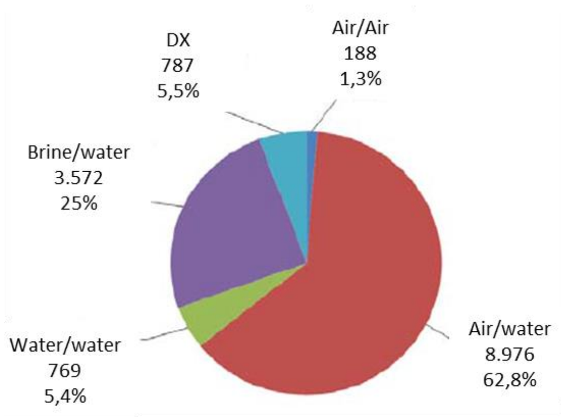


Figure 6: Development of heat sources: market share in 2014 (Biermayr 2014)

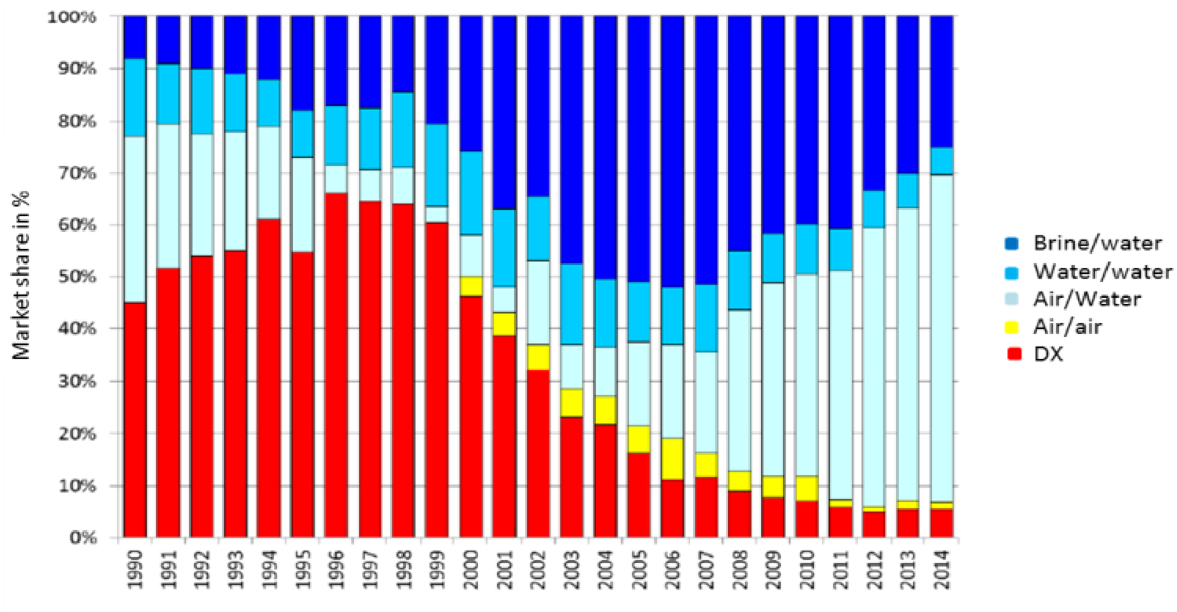


Figure 7: Market share of sources for heat pumps in Austria (Biermayr 2015)

The trend towards air-to-water heat pumps in Austria started in the year 2004 and is unbroken. It is assumed that it will continue in the upcoming years due to the various advantages of the technology (Biermayr et al. 2014).

As far as air-conditioning and cooling of residential buildings is concerned, there is already some demand in selected customer segments. Although the cooling demand in Austria can be currently met by passive measures it is expected that due to global warming, more heat-emitting electric appliances inside the buildings and a rising need for comfort, this market is expected to be a promising one for the future (Biermayr et al. 2014). According to Weiss and Biermayr (2009) the energy consumption for air conditioning in the residential sector in Austria will add up to 0.26 TWh in 2020, 0.57 TWh in 2030 and 0.83 TWh in 2050.

1.3 Market trends of other heating technologies

1.3.1 Biomass

The utilization of solid biomass has a long tradition in Austria and is a very important factor within the RES sector. The consumption of final energy from sold biofuels increased from 142 PJ for 2007 to 179 PJ for 2013. In 2014, the consumption of solid biofuels decreased to 150 PJ due to relatively high average temperatures. (Biermayr et al. 2015)

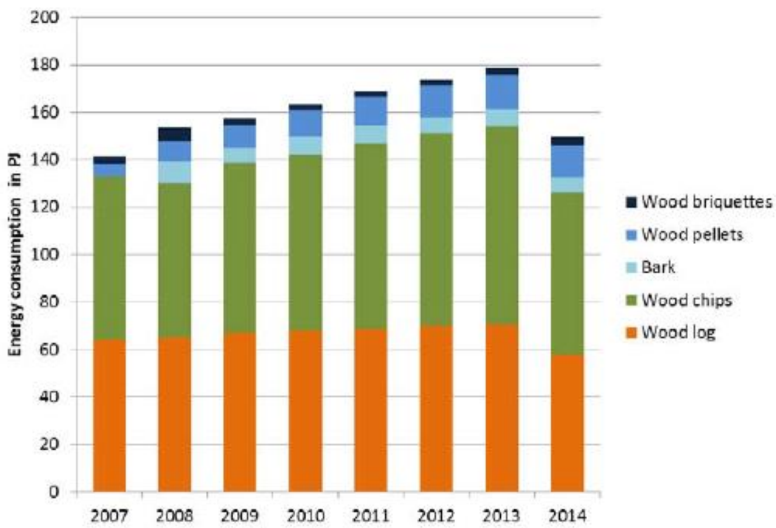


Figure 8: Market development of different biomass fuel types from 2007 to 2013 in Austria (Biermayr et al. 2015)

The success of bioenergy highly depends on the availability of suitable biomasses in sufficient volumes and at competitive prices. Thereby short rotation forestry with willow and poplar planting is seen as highly potential for the future extension of the biomass base. Additionally the upgrading of residues, co-products and waste from agriculture to solid biofuels and the upgrading from other biogenic waste fractions to solid biofuels will be in the focus for the upcoming years. In 2014, 6,266 pellet boilers, 3,820 wood log boilers and 2,658 wood chip boilers were sold on the Austrian market. Furthermore, 2,399 pellet stoves, 6,710 cooking stoves and 11,692 wood log stoves were sold. Figure 8 shows the market development of biomass boilers in Austria from 1994 to 2014. (Biermayr et al. 2015)

1.3.2 Solar thermal

Although the Austrian solar heat market is still facing difficult times, with sales declining for the fifth consecutive year, it remains one of the most important European markets, being the second largest market per capita in continental Europe and on the third position (Europe) respectively 7th rank (worldwide) in terms of total installed capacity. One of the main reasons to explain this decline is the attraction that solar photovoltaic and heat pump investment represent for consumers. Actually the main market of the heating resources moves bit by bit from new buildings to renovation whereby the actually small renovation instalments will become a major influencing factor in the future. (ESTIF, 2014 and Biermayr et al. 2015).

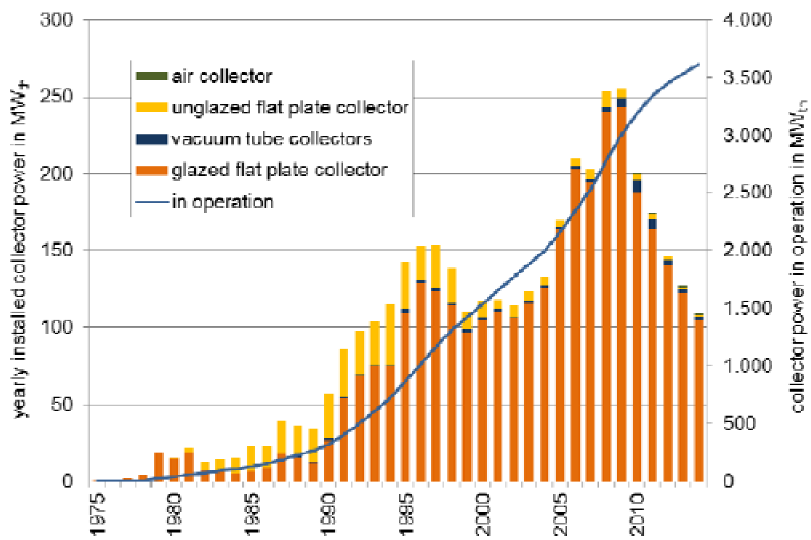


Figure 9: Market development of solar thermal collectors in Austria (AEE INTEC 2015)

In 2014, a solar thermal collector area of 155.170m² was installed, which corresponds to an installed capacity of 108.6 MW_{th}. By the end of 2014, 42% of the installed solar thermal collectors are used for DHW production in single family houses, 39% for DHW and space heating in single and multi-family houses, 11% provide heat for swimming pools, 6% are installed for DHW at large consumers whereas 2% of the installed collector are providing heat for district heating and cooling or industrial processes. (Biermayr et al, 2015).

The-2014 newly installed solar thermal collectors were sold to the following groups: 59% to single family houses, followed by multi-family houses (32%), hotels and leisure facilities (4%) and trade & industry (3%). In 33% of the cases, the solar thermal system was installed in the context of a newly built house, 38% of the sales were generated with solar thermal installations in refurbished buildings, 29% of the installed solar collectors were an individual measure in an old building. In most cases (55%) the solar heating system will provide both, DHW and space heating. By the end of the year 2014 5.5 million m^2 of solar thermal collectors are in operation. This corresponds to an installed thermal capacity of 3.882 MWth. (Biermayr et al, 2015).

1.4 Future heating and cooling market

According to the research project PRESENCE[1] which aimed amongst others to show the impact of climate change under a range of reasonable and relevant policy framework conditions, increased

[1] PRESENCE – Power through Resilience of Energy Systems: Energy Crises, Trends and Climate Change, Vienna University of Technology, Contact person: Lukas Kranzl

building refurbishments and energy efficient new buildings will lead to a significant reduction of the total energy demand for heating and cooling. Comparing different scenarios[2], the Austrian annual final energy demand for heating and cooling in 2050 is expected to be between 55 and 70 TWh which corresponds to a reduction of 25% (grey and green scenario) to 40% (blue scenario) compared to current levels. It is anticipated that the cooling demand will increase by 60 to 100% compared to constant climate conditions while the energy needs for heating will decrease by 20 to 25% (Kranzl, 2014).

The following bar chart shows the projected development of the Austrian final energy demand and its coverage by different energy sources for two possible climate scenarios: for a constant climate change, and for a climate change scenario based on the average values of three climate region models (CRMs) till 2080 (Kranzl, 2014). As shown in the following figure, it is expected that the share of fossil energy carriers will decrease by 60% (grey scenario) to 80% (blue scenario) within the next four decades (Kranzl, 2014).

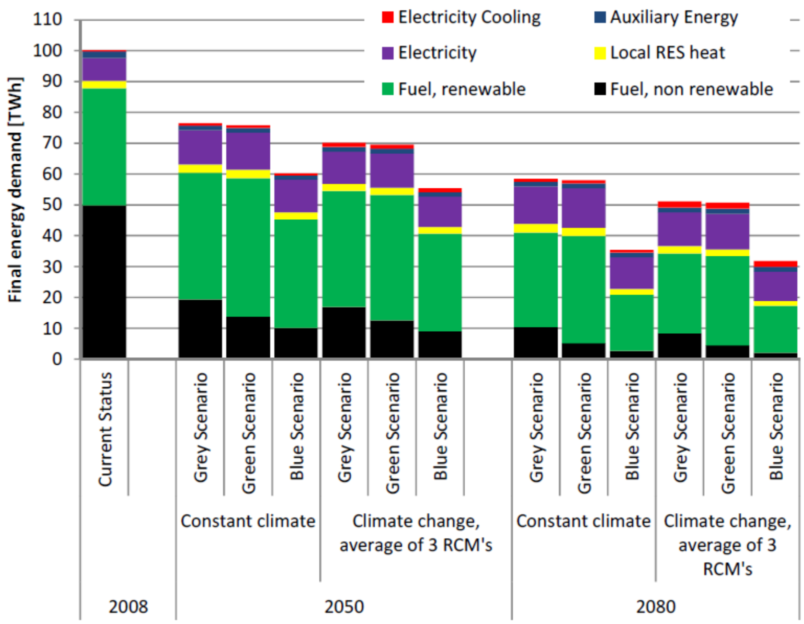


Figure 10: Development of final energy demand for heating and cooling (Kranzl, 2014)

[2] grey scenario: business-as-usual with no particular focus on renewable energy sources (RES) or additional effort on high quality building retrofitting programs; green scenario: special focus on renewable energy sources; blue scenario: special focus on RES as well as on energy efficient refurbishment of buildings

2 Relevant national legislation and subsidy/incentive programs

In chapter two, relevant Austrian legislation concerning the design, production and safety requirements of FSHP is presented. In addition an overview on the national public and industries' subsidies and incentives is given.

2.1 Legislation applicable to FSHP appliances

2.1.1 Austrian Standards

OENORM EN 378 Refrigerating systems and heat pumps - Safety and environmental requirements

-This European Standard specifies the requirements relating to safety of persons and property (but not goods in storage) and the local and global environment for: a) stationary and mobile refrigerating systems of all sizes, including heat pumps; b) secondary cooling or heating systems; c) location of these refrigerating systems.

- OENORM EN 378-1 (2012-07-01) Part 1: Basic requirements, definitions, classification and selection criteria
- OENORM EN 378-2 (2012-07-01) Part 2: Design, construction, testing, marking and documentation
- OENORM EN 378-3 (2012-07-01) Part 3: Installation site and personal protection
- OENORM EN 378-4 (2012-07-01) Part 4: Operation, maintenance, repair and recovery

OENORM EN 12309 (1999-10-01) Gas-fired absorption and adsorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70 kW

Appliances covered by EN 12309 include one or a combination of the following:

- gas-fired sorption chiller;
- gas-fired sorption chiller/heater;
- gas-fired sorption heat pump.

EN 12309 applies to appliances only when used for space heating or cooling or refrigeration with or without heat recovery. Appliances can be monovalent, bivalent or hybrid types. EN 12309 applies to appliances having flue gas systems of type B and C (according to CEN/TR 1749) and to appliances designed for outdoor installations. EN 12309 applies to appliances that can be single ducted or double ducted. EN 12309 only applies to appliances having

- integral burners under the control of fully automatic burner control systems,
- closed system refrigerant circuits in which the refrigerant does not come into direct contact with the water or air to be cooled or heated,
- mechanical means to assist transportation of the combustion air and/or the flue gas.

The above appliances can have one or more primary or secondary functions (i.e. heat recovery – see definitions in prEN 12309-1:2012) and EN 12309 applies to all such functions providing that the function concerned is dependent on circulation of fluid (refrigerant and/or solution) within the absorption, adsorption or refrigerant circuit(s). EN 12309 is applicable to appliances that are intended to be type tested. Requirements for appliances that are not type tested would need to be subject to further consideration. In the case of packaged units (consisting of several parts), EN 12309 applies only to those designed and supplied as a complete package. EN 12309 does not apply to air conditioners. The appliances having their condenser cooled by air and by the evaporation of external additional water are not covered by EN 12309. Installations used for heating and/or cooling of industrial processes are not within the scope of the standard.

- OENORM EN 12309-1 (1999-10-01) Part 1: Safety

- OENORM EN 12309-2 (2000-04-01) Part 2: Rational use of energy

Note that a revised version of the OENORM EN 12309 “Gas-fired absorption and adsorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70 kW” Part 1-2 will be available soon. The current (2014-10-29) draft versions of the revised normative documents are:

- OENORM prEN 12309-1 (2012-09-01) Part 1: Terms and definitions”

- OENORM prEN 12309-2 (2013-06-15) Part 2: Safety”

- OENORM prEN 12309-3 (2012-09-01) Part 3: Test conditions”

- OENORM prEN 12309-4 (2012-08-15) Part 4: Test methods”

- OENORM prEN 12309-5 (2012-09-01) “Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70 kW - Part 5: Requirements”

- OENORM prEN 12309-6 (2012-09-01) Part 6: Calculation of seasonal performances”

- OENORM prEN 12309-7 (2012-09-01) Part 7: Specific provisions for hybrid appliances”

OENORM EN 13313 (2011-05-01) “Refrigerating systems and heat pumps - Competence of personnel“

This European Standard defines the activities related to refrigerating circuits and the associated competence profiles and establishes procedures for assessing the competence of persons who carry out these activities.

OENORM EN 14276-1 (2011-05-15) “Pressure equipment for refrigerating systems and heat pumps”

This European Standard specifies the requirements for material, design, manufacturing, testing and documentation for stationary pressure vessels intended for use in refrigerating systems and heat pumps. These systems are referenced in this standard as refrigerating systems as defined in EN 378-1. This European Standard applies to vessels including welded or brazed attachments up to and including the nozzle flanges, screwed, welded or brazed connectors or to the edge to be welded or brazed at the first circumferential joint connecting piping or other elements. This European Standard applies to pressure vessels with an internal pressure down to 1 bar, to account for the evacuation of the vessel prior to charging with refrigerant. This European Standard applies to both the mechanical loading conditions and thermal conditions as defined in EN 13445-3 associated with refrigerating systems. It applies to pressure vessels subject to the maximum allowable temperatures for which nominal design stresses for materials are derived using EN 13445-2 and EN 13445-3 or as specified in this standard. In addition vessels designed to this standard should have a maximum design temperature not exceeding 200 °C and a maximum design pressure not exceeding 64 bars. Outside of these limits, it is important that EN 13445 be used for the design, construction and inspection of the vessel. Under these circumstances it is important that the unique nature of refrigerating plant, as indicated in the introduction to this standard, also be taken into account. It is important that pressure vessels used in refrigerating systems and heat pumps of category less than II as defined in Annex H comply with other relevant clauses of EN 378-2 for vessels. This European Standard applies to pressure vessels where the main pressure bearing parts are manufactured from metallic ductile materials as defined in Clause 4 and Annex I of this standard.

- OENORM EN 14276-1 (2011-05-15) Part 1: Vessels - General requirements”
- OENORM EN 14276-2 (2011-04-15) Part 2: Piping - General requirements”

OENORM EN 15316-4-2 (2012-01-15) “Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies”

This European Standard covers heat pumps for space heating, heat pump water heaters (HPWH) and heat pumps with combined space heating and domestic hot water production in alternate or simultaneous operation, where the same heat pump delivers the heat to cover the space heating and domestic hot water heat requirement.

- OENORM EN 15316-4-2 (2012-01-15) Part 4-2: Space heating generation systems, heat pump systems”

OENORM EN 15450 (2008-01-11) “Heating systems in buildings - Design of heat pump heating systems”

This European Standard specifies design criteria for heating systems in buildings using heat pumps alone or in combination with other heat generators. Heat pump systems considered include water - water, brine - water, refrigerant - water (direct expansion systems), air - air and air - water systems driven by electricity or gas. This European Standard takes into account the heating requirements of attached systems (e.g. domestic hot water, process heat) in the design of heat supply, but does not cover the design of these systems. This European Standard covers only the aspects dealing with the heat pump, the interface with the heat distribution system and heat emission system (e.g. buffering system), the control of the whole system and the aspects dealing with energy source of the system.

OENORM EN 12953 (2012-04-15) “Shell boilers”

This European Standard applies to shell boilers with volumes in excess of 2 litres for the generation of steam and/or hot water at an allowable pressure greater than 0,5 bar and with a temperature in excess of 110 °C. The purpose of this European Standard is to ensure that the hazards associated with the operation of shell boilers are reduced to a minimum and that adequate protection is provided to contain the hazards that still prevail when the shell boiler is put into service. This protection will be achieved by the proper application of the design, manufacturing, testing and inspection methods and techniques incorporated in the various parts of this European Standard. Where appropriate, adequate warning of residual hazards and the potential for misuse are given in the training and operating instructions and local to the equipment concerned (see EN 12953-7 and EN 12953-8).

OENORM EN 10213 (2008-03-01) “Steel castings for pressure purposes”

EN 10213 applies to steel castings for pressure containing parts. It includes materials which are used for the manufacture of components, for pressure equipment. EN 10213 relates to castings characterised by their chemical composition and mechanical properties. It applies where castings are joined by welding by the founder. EN 10213 does not apply in cases where castings are welded to wrought products (plates, tubes, forgings), or by non founders.

OENORM EN 10216 (2014-12-01) "Seamless steel tubes for pressure purposes - Technical delivery conditions"

This European Standard specifies the technical delivery conditions in two test categories for seamless tubes of circular cross section made of austenitic (including creep resisting steel) and austenitic-ferritic stainless steel which are intended for pressure and corrosion resisting purposes at room temperature, at low temperatures or at elevated temperatures.

OENORM EN 60335 (2015-08-01) "Household and similar electrical appliances - Safety"

This European Standard deals with the safety of electric appliances.

2.1.2 Framework for FSHP products

The main normative document for fuel driven heat pumps in Austria is the OENORM EN 12309 (Gas-fired absorption and adsorption air-conditioning and/or heat pump appliances with a net heat input not exceeding 70kW).

OENORM EN 12309 consists of two parts in the current version and is related to safety and rational use of energy when operating thermally driven heat pumps. A more detailed draft version consisting of seven parts is already available and will replace the older version soon.

The VBG 20 (1997) "Unfallverhütungsvorschriften – UVV Kälteanlagen, Wärmepumpen und Kühleinrichtungen" is also used in Austria.

Information on the design of thermally driven heat pumps is presented in OENORM EN15316-4-2 (Method for calculation of system energy requirements and system efficiencies) and OENORM EN15450 (Heating systems in buildings (Design of heat pumps heating systems).

2.1.3 Heat pumps in building performance codes

Heat pumps are also covered in the Austrian building performance code OENORM H 5056 (2010 01 01) "Energy performance of buildings - Energy use for heating". This normative document is valid for the calculation of the heating load of the buildings and referred to the electrical driven heat pumps with heat duties up to 400 kW.

According to it, all heat pumps are divided into following groups:

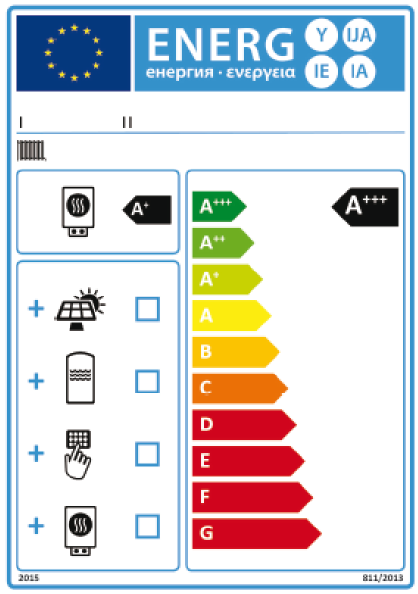
- Regarding to the heat source and the heat sink: air/water; soil/water and water/water.
- Regarding to the operation procedure: monovalent operation; bivalent-alternative operation and bivalent-parallel operation.

Currently, FSHPs are not considered in the OENORM H 5056.

2.2 Quality and other labels for FSHP, national and international

2.2.1 Quality labels in Austria

Energylabel



The Directive on Energy labeling, which provides labeling of products to raise consumer awareness, was implemented on the 26th of September 2015, by the European Union. Manufacturers need to provide heaters (space heating and hot water) with a so-called product label to inform the consumer about the primary energy efficiency of the product. (Note that the primary energy factors for different energy sources are summarized in Table 3 on page 36) In addition, the installer is responsible for showing the primary energy efficiency of composite systems in the form of a package label (see an example in the picture to the right). When there is a heating system consisting of several components (e.g. heat pump, solar panels, storage, temperature controller), a package label for the entire system is calculated taking into account the efficiency of each device.

EU Ecolabel

The aim is to enable EU citizens to live well, within the planet's ecological limits, in an innovative, circular economy, where biodiversity is protected, valued and restored and environment-related health risks are minimized in ways to enhance our society's resilience, and where growth has been decoupled from resource use. The EU Ecolabel is a voluntary scheme, which means that producers, importers and retailers can choose to apply for the label for their products. Since 2007 it is also available for heat pumps. It can be awarded to electrically driven, gas driven or gas absorption heat pumps with the purpose of space heating or the opposite process space cooling, with a maximum heating capacity of 100 kW. Heat pumps exclusively providing hot water for sanitary use, and those only extracting heat from a building are excluded. At the moment (October 2015) there is no heat pump awarded in Austria.

EHPA – Quality label

The EHPA Quality Label is a label that shows the end-consumer a quality compression heat pump unit or model range on the market. The heat pumps that receive the label need to undergo tests according to the international standard EN14511 and EN16147. These tests are executed by EN17025 accredited test institutes.

Currently (2015), the EHPA quality label is not available for FSHP.

European Quality Label for Heat Pumps

ehpa

2.3 Legislation regarding usage of heat sources (e.g. ground water, waste heat, refrigerants, environmental targets)

Water act - WRG 1959

For the thermal use of groundwater and ground a legal process according to the water act is required under certain conditions.

The responsible water authority for the water act authorization procedure is generally the Municipal Department 58 in Vienna. However, if the system for thermal use of the ground and groundwater is part of business facilities (according to the Code of Trade and Commerce 1994), the resident district municipal authority or district authority (Bezirkshauptmannschaft) is the responsible water authority. (RIS, 2015)

Code of Trade and Commerce 1994 - GewO 1994, BGBl. 194/1994 i. d. g. F.

If the system for thermal use of the ground and groundwater is part of business facilities (according to the Code of Trade and Commerce 1994), the industrial facilities regulations have to be obeyed. The resident district municipal authority or district authority (Bezirkshauptmannschaft) is the responsible water authority. (RIS, 2015)

Environmental Impact Assessment Act 2000 - UVP-G 2000, BGBl. 697/1999 i. d. g. F.

If the installation and operation of a system for thermal use of the ground and groundwater is foreseen in the course of an Environmental Impact Assessment (UVP) also this part of the whole system has to be observed according to the UVP Act. The resident district municipal authority or district authority (Bezirkshauptmannschaft) is the responsible authority. (RIS, 2015)

ÖWAV-RB 207 – Heat pumps – thermal use of the groundwater and the ground – heating and cooling, 2009

This rule sheet of the Austrian Water and Wastewater Association (ÖWAV) refers to the thermal use of the ground (unconsolidated and consolidated rocks) and groundwater whereby the use of highly tempered and mineralized deep groundwater is excluded. The thermal use of surface water is not subject to this rule sheet. (Austrian Standards, 2015)

VDI 4640-2, May 2015 (draft) – thermal use of the ground – ground coupled heat pump systems

In this guideline the designing and installing of the following applications are considered:
Heat pump systems (HP systems) with use of groundwater through wells, HP systems with use of the ground by geothermal collectors and geothermal probes and HP systems with direct evaporation. Additional heat source systems such as energy piles, parts of buildings with ground contact, tunnels as heat exchanger, compact geothermal collectors and storage probes are also addressed in this directive.

Guidelines for acoustics of air / water heat pumps

This guide provides recommendations and instructions for correct installation of air / water heat pumps in order to limit the noise pollution in the area to a minimum. (Austrian Heat Pump Association, 2014)

2.4 Safety, maintenance, installation issues with focus on FSHP

Detailed information on safety issues for the FSHP can be found in the standards described in section 2.1.1.

2.5 Subsidies and incentives for different heating & cooling technologies with focus on FSHP

In general, subsidies and incentives for heating and cooling technologies in Austria are provided on municipal (local), provincial (regional) and federal (central) level. Furthermore some energy providers are supporting the purchase of heat pump technologies via direct grants or favourable tariffs.

2.5.1 Public subsidies and incentives

The incentive on local level is mostly provided in form of a small direct, non-refundable investment grant, and is mainly supplied in addition to regional funding. On a regional level, small-scale renewable heating and cooling systems for the use in privately owned residential buildings are supported within the framework of the public housing subsidy schemes of the different provinces. Within these programmes, biomass and solar thermal systems as well as heat pumps are funded. Most provinces explicitly fund ground- and air-source heat pump systems when they are combined with PV or solar thermal (Land NÖ 2014) (Land OÖ 2014).

Only the province of Vienna supports also gas-fired ad- and absorption heat pump systems in terraced houses or small houses in allot settlements (Stadt Wien 2014).

On federal level, there are no subsidies for small scale heating and cooling technologies for private homes, with one exception: the replacement of fossil fired boilers, electric night or direct storage heaters with newly installed pellets and wood chips central heating systems (Kommunalkredit Public Consulting 2014).

When it comes to heating (and cooling) commercial and industrial applications or office buildings, subsidies in form of direct, non-refundable, investment grant are available for heat pumps, solar thermal (Kommunalkredit Public Consulting 2014) and biomass heating systems in the framework of the UFI ("Umweltförderungsprogramm") of the Kommunalkredit Public Consulting.

The scheme "heat pumps for companies" (Kommunalkredit Public Consulting 2014) distinguishes between heat pumps <400kW$_{th}$ and > 400kW$_{th}$ and focuses on electrically driven heat pumps for hot water production and / or heating. Electrically driven heat pumps for cooling only, are not eligible for funding. The investment grant may add up to a maximum of 30% of the eligible costs which comprise the costs for the renewable heating system and its integration, but not the expenses for the heat distribution system within the building. Gas-fired heat pumps are explicitly not eligible for funding under this scheme.

Thermally driven ad- and absorption heat pumps are supported within the context of the scheme "air conditioning and cooling" when driven by waste heat, renewables or district heat. The investment grant may add up to a maximum of 35% of the eligible costs (Kommunalkredit Public Consulting 2014).

Heat pumps are furthermore promoted in context with the scheme “energy saving measures for companies (Kommunalkredit Public Consulting 2014) and the scheme “waste heat extraction” (Kommunalkredit Public Consulting 2014). In both cases, the non-refundable investment grant may add up to a maximum of 30% of the eligible costs.

2.5.2 Industry subsidies and incentives

Some energy suppliers such as e.g. Salzburg AG (Salzburg AG 2014) support the introduction of heat pumps with a non-refundable, one-off payment up to EUR 3.000. The eco-power provider ENAMO (Enamo 2014) and Linz AG (Linz AG 2014) offer support in form of yearly bonuses of EUR 50,-- deducted from the energy bill for a period of 5 years (in total EUR 250). The only company explicitly supporting gas-fired heat pumps with a non-refundable investment grant is the Tyrolean TIGAS. For heat pumps up to 15kW EUR 600,-- are provided; for larger systems the grant is calculated as EUR 40 per kW with a maximum grant of EUR 6.000,-- per metering point.

Summing up, the promotion of FSHP in Austria is scarce. Only the province of Vienna and the Tyrolean company TIGAS (Tigas 2014) explicitly promote gas-fired heat pump systems for residential houses.

2.6 FSHP in the Austrian NREAP

The “National Renewable Energy Action Plan 2010 for Austria (NREAP-AT)” developed under Directive 2009/28/EC of the European Parliament and of the Council foresees various measures for the promotion of renewable heating and cooling technologies in general and heat pumps in particular, but does not specify which type of heat pumps – thermally or electrically – driven heat pumps should be the subject of promotion (WIFO 2010).

3 Heat sources

Chapter 3 provides background information on potential heat sources in Austria including the climatic conditions, ground water temperature, availability and temperature of industrial waste heat. Furthermore information is given on the situation of the Austrian district heating and solar thermal market.

3.1 Climate in Austria

Austria's climate is basically influenced by four climate zones (see **Figure 11**):

- Alpine climate: short cool and humid summer, long and snowy winter
- Central European climate: cool humid summer, temperate and humid winter
- Pannonic climate: hot and dry summer, temperate and dry winter
- Illyric climate: hot sticky summer, cold winter

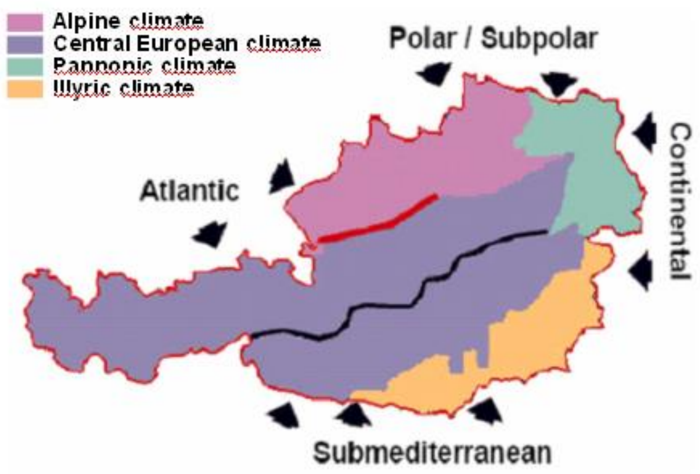


Figure 11: Climate Zones in Austria (Christanell 2007)

Due to its geographical location, the yearly average temperatures and average solar global radiation differ considerably on a regional level as shown in Figure 12 and Figure 13. The yearly average ambient air temperature varies from -8°C in the Southern Alps up to +12°C in the very east of the country. The average solar irradiation ranges from 1100 kWh/m2 in the north-eastern parts of Austria to more than 1400 kWh/m2 in the south-western areas. This impacts the boundary conditions for the design of heating and cooling systems to a large extent.

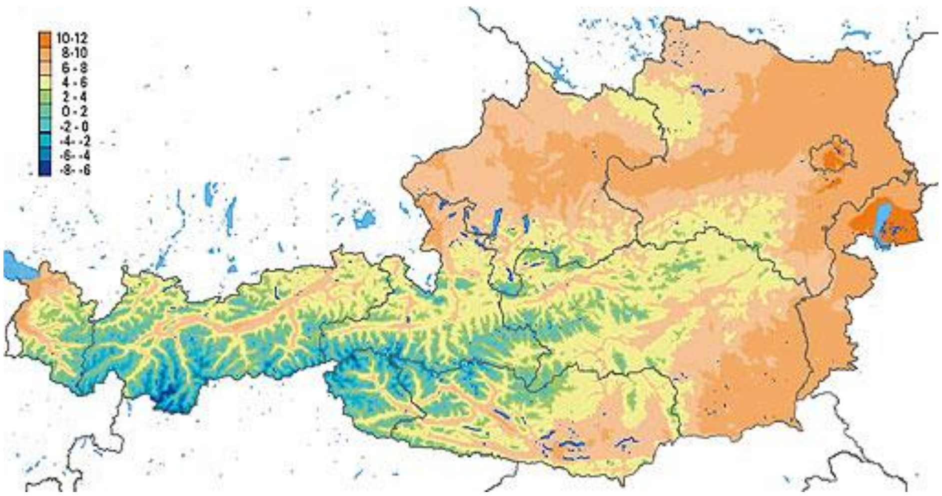


Figure 12: Yearly average temperatures (Leitgeb and English 2006)

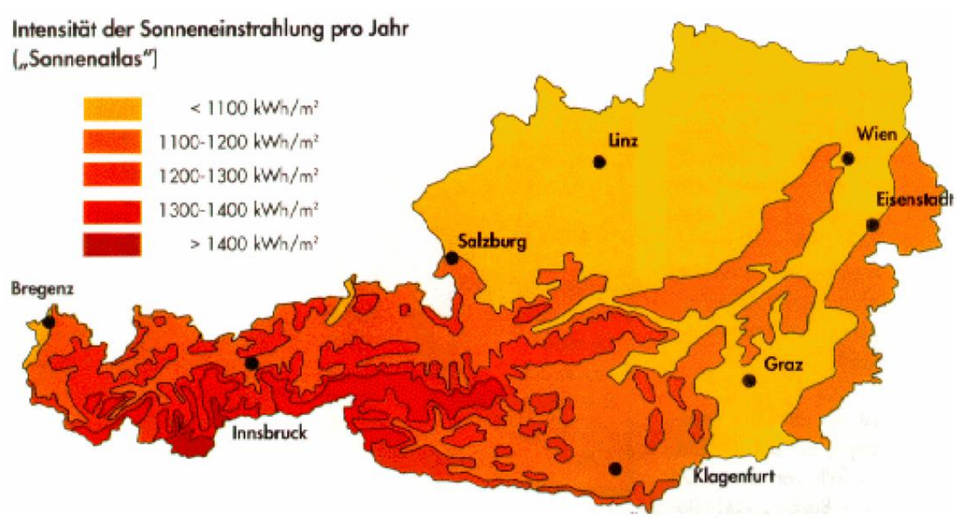


Figure 13: Yearly average global solar radiation (Leitgeb and English 2006)

Heating degree days (HDD12/20) and heating days (HD12) are given in Table 1 for four Austrian cities in the corresponding climate zones.

Table 1: Heating degree days and heating days for four Austrian cities representing four typical climate zones

City	Climate zone	HDD12/20	HD12
Innsbruck	Alpine	3704	220
Linz	Central European	3527	214
Vienna	Pannonic	3319	204
Klagenfurt	Illyric	3935	222

3.2 Ground water temperature

The ground water temperature in Austria is between 10 and 14°C. An analysis of various bodies of ground water showed a temperature rise of 0.7°C on average (bandwidth: 0.4°C to 1.3°C) between the years 1997 and 2009 (UBA, 2011).

3.3 Availability and temperatures of waste heat, alternative usage of waste heat

The potential of industrial waste heat in Austria is sufficient to supply approximately 70.000 households in a direct way and another 75.000 households via district heating networks with flow temperatures of 50 to 70 °C. Most of the industrial waste heat potential - approx. ¾ or 5.300 GWh/y - is available at temperature levels between 20 and 35°C, and is produced in/near cities with existing district heating networks. The largest waste heat potentials originate within the metal, paper, glass, stone and earth sector with a geographical focus on Upper Austria, Styria, Lower Austria and Tyrol (KPC 2013).

3.4 District heating in Austria

In Austria, district heating systems are mainly used in urban areas with high heat densities for supplying heat to large-volume buildings. Additionally, there are a number of smaller biomass based rural district heating networks, some of them supported by solar energy. By 2012, 806.000 dwellings (=22%) are connected to district heating networks. For buildings with more than 20 apartments, 48% were connected to the grid. Private households, agricultural businesses (36%) as well as public and private service operators (50%) are the main consumers of district heating. As mentioned above, district heating networks are popular in urban areas. (FGW 2014) 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 2011).

The Austrian district heating systems are primarily fired on "recycled heat", that is surplus heat from electricity production (CHP), waste-to-energy plants, and industrial processes (48%); gas accounts for roughly 40%. Within the last 5 years, the share of heat produced by CHP was fluctuating; in 2012 it was 63.7%. The further expansion and compression of District Heating and Cooling - networks is politically supported especially in context with urban energy efficiency measures (EnergieStrategie Österreich 2010). The national DHC-network currently covers a length of 4.600 km (0.5 km/1.000 inhabitants); an average increase of 92km per year is planned by the network operators within the period 2013 to 2022. The Austrian market for district cooling is still small (74 GWh in 2010), but is expected to triple by 2017 due to an increasing demand of cold especially in urban areas (FGW, 2014).

3.5 Solar Heating in Austria

See chapter 1.3.2.

4 Building stock and user profiles in residential applications

Chapter 4 provides an overview of the Austrian building stock, its ownership structure, construction period, heating systems and energy sources for both domestic hot water production and heating.

4.1 Building stock and ownership structure

In 2011, 2.2 million buildings (+7.1% compared to 2001) and 4.4 million dwellings (+15% compared to 2001) were counted in Austria (Statistik Austria 2014). In 2013, the micro census resulted in a number of 3.7 million main residence dwellings in Austria (Statistik Austria 2014). The majority of the buildings (approx. 82%) are one or two family houses, with almost all of them (approx. 93%) are privately owned (see Table 2).

Table 2: Overview of building type and ownership structure in Austria in 2011 (Statistik Austria 2014)

		Owner			
	Total	Physical persons	Local authority	Non-profit housing associations	Other non-physical
Total	2 191 280	1 944 590	87 128	71 822	87 740
Residential buildings with 1 or 2 dwellings	1 790 332	1 668 105	19 669	21 231	18 124
Residential buildings with 3 to 10 dwellings	185 773	149 739	29 438	49 421	18 252
Collective residential buildings	4 815	1 421	1 881	241	1 272
Non-residential buildings total	212 486	125 325	36 140	929	50 092
Office	35 420	-	-	-	-
Hotel	37 468	-	-	-	-
Retail or wholesaler	36 334	-	-	-	-
Traffic / communication	3 951	-	-	-	-
Industry, storage or vehicle workshop	71 940	-	-	-	-
Culture, Leasure, Education	26 482	-	-	-	-

The average useful floor area per dwelling in Austria is 89.8 m^2 in 2011 with an average of 4.2 rooms per dwelling (2011). In single-family houses, the average dwelling has 5.6 rooms and a floor area of 127.3 m^2. These figures decrease to 4.6 rooms and 99.8 m2 in buildings with two dwellings and to 3.4 rooms and 70.6 m^2 in dwellings in apartment buildings. Dwellings in buildings that are primarily used for purposes other than residential are equivalent to dwellings in two-family houses in terms of their size (Statistik Austria 2013).

About 83% of the overall dwelling stock was built before 1990 and will therefore be subject to thermal renovation in the upcoming years.

Figure 14: Construction period of the dwellings in Austria in absolute values (Statistik Austria 2013)

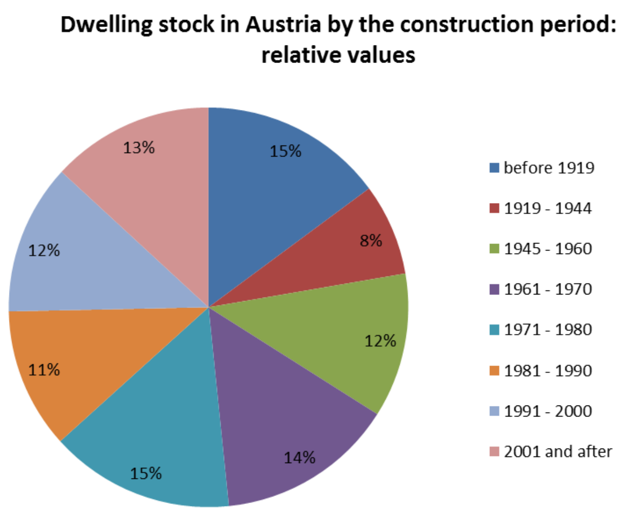


Figure 15: Construction period of the dwellings in Austria in relative values (Statistik Austria 2013)

The average rate of renovation between the years 2000 and 2010 is reportedly 1% per year, with differences on a regional level but also in regard to the building's owners. Buildings owned by non-profit organizations or local authorities show renovation rates above 1%, but do not reach the target of 3% p.a. (IIBW, 2013).

4.2 Specific energy consumption for residential heating and air-conditioning

The average useful energy consumption of the Austrian households for residential heating and air-conditioning in 2012 is 159 kWh/(m^{2}a). As indicated by the following figure, the specific energy consumption in kWh/(m²a) of the households is continuously declining since 1990. In 2012, the Austrian households were consuming 70.5 % of the energy for heating and air-conditioning compared to the reference year 1990.

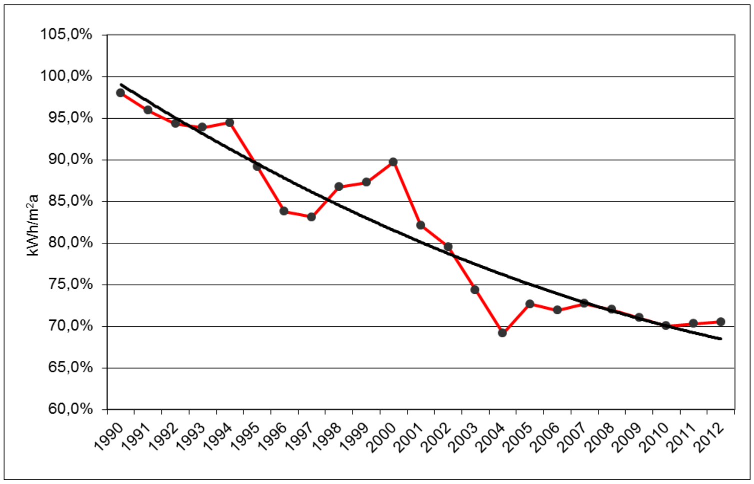
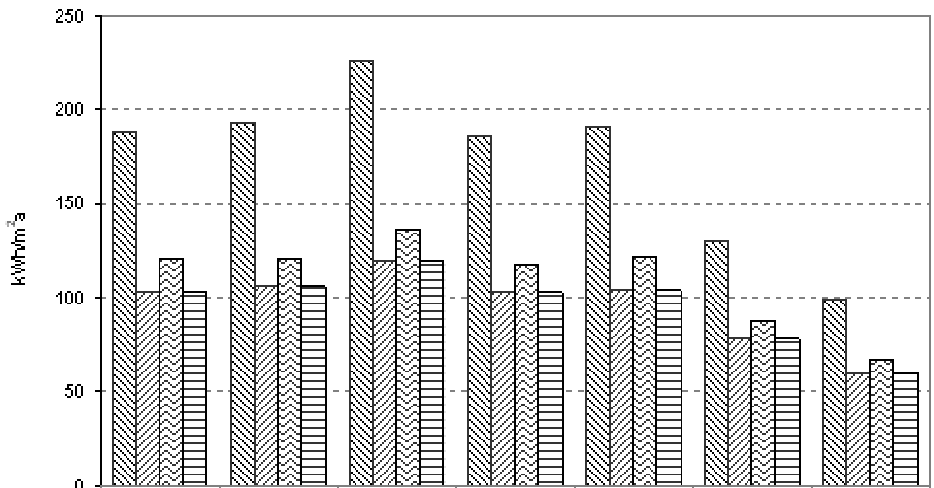


Figure 16: Relative development of the energy consumption for heating and air-conditioning in Austrian dwellings from 1990 (reference year) till 2012. An energy consumption of 100% is equivalent to 226 kWh/m^{2}a (Statistik Austria 2014)

The heating load is very much dependent on the year of construction and possible thermal refurbishment of the building envelope. As shown in Figure 17, buildings with one dwelling built in Austria before 1945 have a specific useful energy demand for space heating of about 190 kWh/m²a. For dwellings built between 1945 and 1960 this value rises to 230 kWh/m²a as this period was the time of fast and cheap production of living space after the Second World War. Since then the specific energy demand of buildings steadily decreased, partly due to the first oil price shock in the end of the 1970s. This development was enabled by the availability of more effective insulation materials and advanced window technology, supported by a growing environmental concern. For buildings built after 1991 the useful heating demand is in the range of 100 kWh/m²a, which is already less than half of the values of the period from 1945 to 1960. The annual heating demand of houses from the period 2002 to 2007 is about 50 kWh/m^{2}a.

For multifamily buildings the value was already 60 to 70 kWh/m²a in 1991. With building codes and subsidy schemes values of about 50-60 kWh/m²a for single (and two) dwelling buildings and 40-50 kWh/(m²a) for multi dwelling buildings are achieved. Houses built according to the passive house concept show that the space heating demand can be decreased to 15 kWh/m²a. The requirements to reach such small heating demands are an optimal thermal insulation of the building envelope and effective mechanical ventilation using air heat recovery. Thus, the energy demand of new buildings decreased drastically in the last 50 years (Statistik Austria 2008).



	before 1919	1919-1945	1945-1960	1961-1970	1971-1980	1981-1990	after 1990
SDB	188	193	226	186	191	130	99
MDB - B	103	106	120	103	104	78	60
MDB - S	121	121	136	118	122	88	67
NRB	103	106	120	103	104	78	60

Figure 17: Specific annual energy use for heating in kWh/ (m2a) of single (SDB) and multi-dwelling (MDB; -B=large, -S=small) buildings, as well as non-residential buildings (NRB) by the construction period (Statistik Austria 2008)

4.3 Heating systems and energy sources for DHW

Approx. 50% of the current dwelling stock in Austria is centrally heated and 24% is equipped with access to district heating networks (see Figure 17).

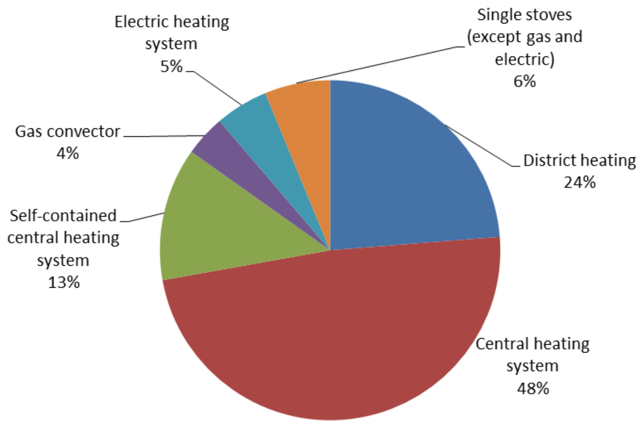


Figure 18: Structure of heating systems in Austrian dwellings in 2013 (Statistik Austria 2014)

The heating system installed depends on both, the age and type of dwelling. The share of gas and self-contained central heating systems and single stoves is significantly higher in older buildings, whereas central heating systems and access to district heating systems became popular from the 1970ties onwards (see Figure 19).

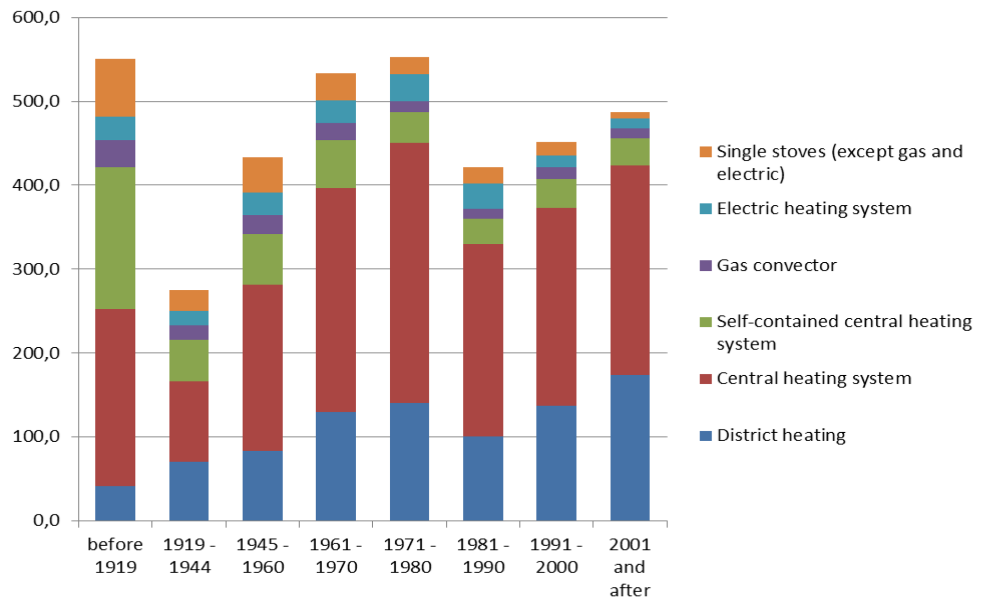


Figure 19: Structure of heating systems in Austrian dwellings in 2013 broken down by age of the dwelling (Statistik Austria 2014)

75% of all buildings with one or two dwellings have central heating systems installed; whereas 51% of buildings with more than 20 dwellings are equipped with access to district heating networks (see Figure 20).

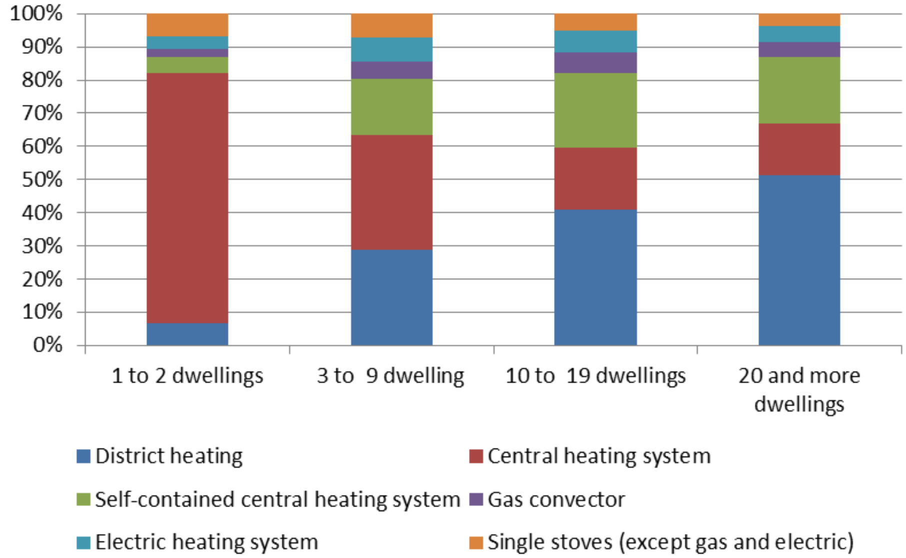


Figure 20: Structure of heating systems in Austrian dwellings in 2013 broken down at dwelling type (Statistik Austria 2014)

Fossil fuels are still the predominant source of energy for heating dwellings in Austria, although renewables are gaining importance. Natural gas, oil and coal are used in nearly half of the dwellings. Renewables - biomass (20%), solar (1%) and heat pump systems (2%) - are covering about 23% of the heating demand. (Statistik Austria 2013). The following figure gives an overview of the used energy source for space heating in Austrian dwellings in 2011/2012 (see Figure 21 and Figure 22).

The average consumption of hot water in Austria is around 35 liters per person and day or 84 liters per household and day. About 50% of the dwellings derive sanitary hot water from their heating units. Approx. 42% use electric storage water heaters with more than 30 liters of capacity as their primary hot water source. Finally, some 37% of the dwellings have a secondary water heater which normally provides only one room with hot sanitary water. About 85% of these are electric storage; further 14% are instantaneous electric systems (Kemna 2007).

It can be concluded from the above, that the energy source for sanitary hot water production in the dwellings which have combined heating and hot water systems roughly corresponds to the distribution shown in Figure 22. In the dwellings with dedicated water heaters, electric storage boilers are predominant.

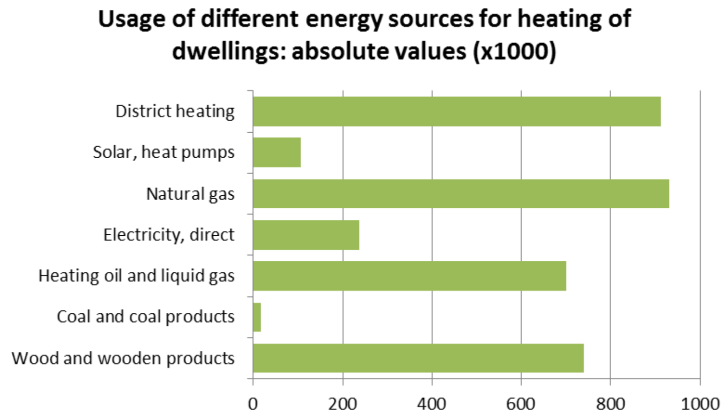


Figure 21: Structure of energy sources for space heating in Austria in 2011/2012, in absolute values (Statistik Austria 2013)

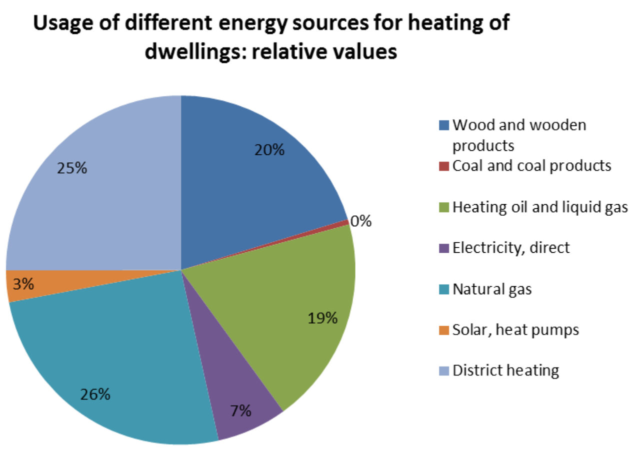


Figure 22: Structure of energy sources for space heating in Austria in 2011/2012, in relative values (Statistik Austria 2013)

Results of a survey in the context of the IEE (Intelligent Energy Europe) project MOVIDA[3] show that houses built between 1949 and 1975 often use boilers which are between 15 and 30 years old. Only 13% of the inspected boilers are less than 15 years old. The majority of the boilers are used for both heating and hot water production; only 20% are simply used for heating. 57% of the boilers were over-dimensioned, while only 43% had the right boiler capacity (Landesenergieverein Steiermark 2013).

[3] MOVing from Inspection to Domestic Advice by service companies, www.movida-project.eu

4.4 Number of new residential and non-residential buildings

The construction activity in the residential sector in the years 2005 to 2013 comprise on average 50.000 new dwellings per year with 80% of them situated in newly built houses. As shown in the following figure, the share of newly built 1 and 2 dwellings decreased within the last years from 38% in 2005 to 32% in 2012, whereas the one of >3 dwellings per buildings (DpB) increased to 45% (see Figure 23 and Figure 24).

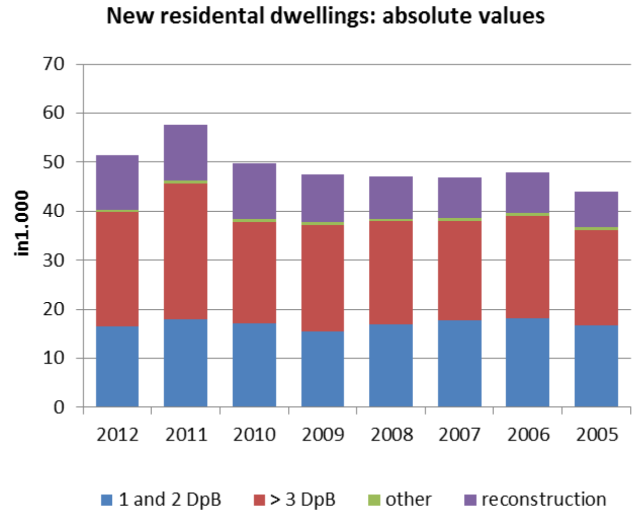


Figure 23: Construction activity in the residential sector. Dwellings built by type of the building: DpB – dwellings per building, in absolute values (Statisik Austria 2014)

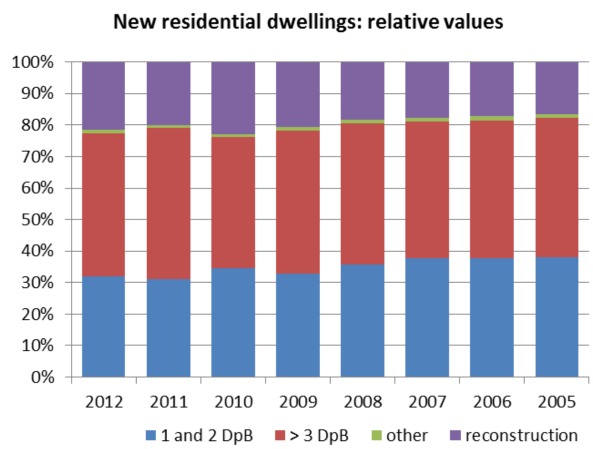


Figure 24: Construction activity in the residential sector. Dwellings built by type of the building: DpB – dwellings per building, in relative values (Statisik Austria 2014)

In the years 2005 to 2013, 1850 other buildings than residential ones were built on average per year. In 2013, industry and storage buildings represent nearly half of the new non-residential buildings in Austria (see Figure 25).

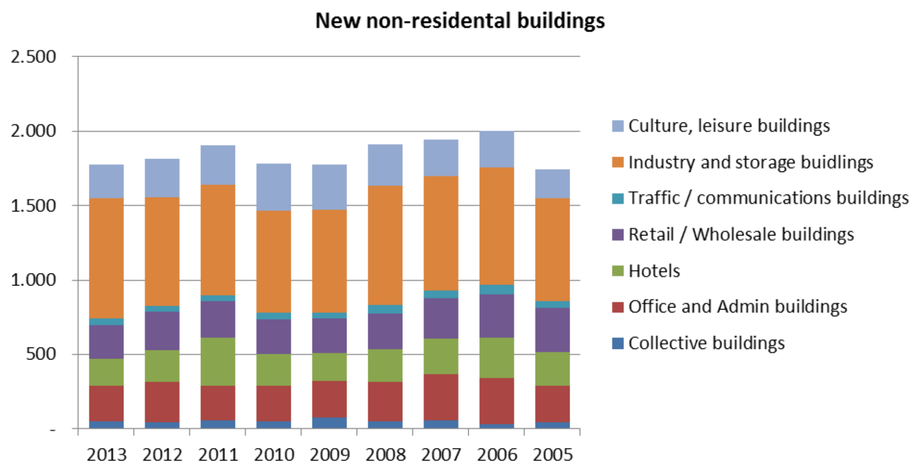


Figure 25: Construction activity in the non-residential sector (Statisik Austria 2014)

5 Energy quality

Chapter 6 provides information on primary energy factors for different types of energy carriers, the development of energy prices for industry and households, as well as their single components.

5.1 Primary energy factors for different types of energy carriers

The primary energy factors for the various energy carriers are stipulated in different guidelines and standards for the construction / refurbishment of buildings. The following table gives an overview.

Table 3: Primary energy factors for different energy carriers (AEA 2013), (Austrian Standards 2008), (OIB 2015)

	Guideline 6 (OIB 2015)	ÖNORM EN 15603:2008-07 (Austrian Standards 2008)	(AEA 2012)
Black coal	1.46	1.19	1.07
Brown coal	1.46	1.40	1.07
Heating oil (heavy)	1.23	1.35	1.13
Heating oil (light)	1.23	1.35	1.14
Natural gas	1.17	1.36	1.18
Liquid natural gas			1.10
Wooden pellets	1.08	1.09	1.08
Firewood	1.08	1.09	1.04
Electricity-Mix Austria	1.91		
District heat from heating plant (renewable)	1.60		
District heat from heating plant (non-renewable)	1.52		
District heat from highly efficient CHP	0.94		

5.2 Energy prices

In general, Austrian households have to pay nearly twice the price for electricity and gas than businesses and industry. As depicted in the following graphs, the average electricity price including all taxes and levies for industry decreased from 2009 to 2013 from 11.1 to 10.6 cent/kWh (-4.2%), whereas the electricity price for households was rising continuously from 18.4 cent/kWh in 2009 to

20.48 cent/kWh (+11,3%) in 2013. When it comes to gas, both end users have experienced rising prices from 2009 to 2013. While the average gas price for businesses/industrial companies increased from 3.12 to 3.68 cent/kWh (+17.8%) in 2013, the gas prices for households went up from 6.4 cent/kWh in 2009 to 7 cent/kWh (+9.3%) in 2013.

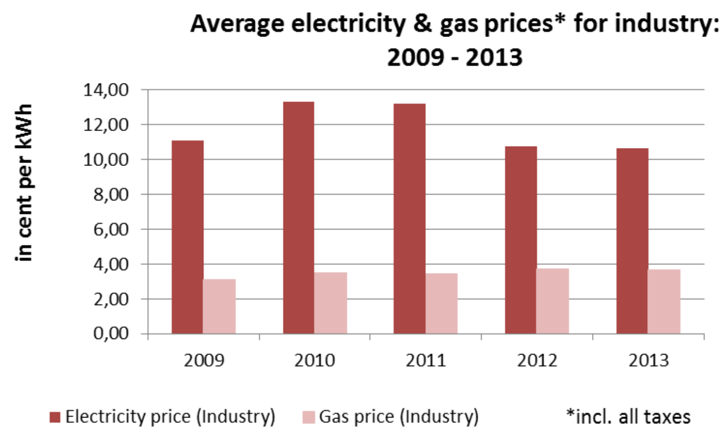


Figure 26: Average electricity & gas prices for industry (Statistik Austria 2015)

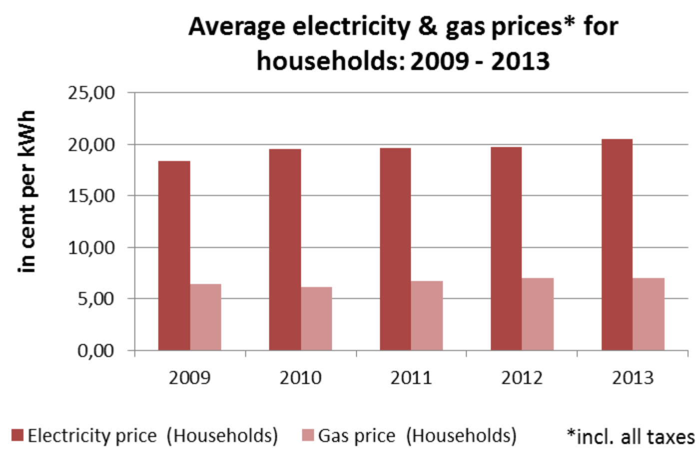


Figure 27: Average electricity & gas prices for households (Statistik Austria 2015)

Electricity and gas prices contain following components: energy price, various taxes such as e.g. green-power-subsidies, community levies, etc. and the grid tariff. As far as businesses and industry are concerned, energy prices for gas and electricity are subject to individual negotiations, whereas the grid tariffs are regulated by the national regulation commission e-Control Austria (www.e-control.at). Taxes are collected on different levels, from the state, to the provinces and municipalities.

5.2.1 Energy prices for industry

The industrial prices for electricity and gas vary. They depend on the annual consumption, the negation skills of the businesses, as well as on the grid tariffs and taxes. The following graphs show the components of the current prices for electricity and gas for a company in Vienna with a yearly consumption of 30.000 kWh electric energy respectively 100.000 kWh gas in detail (E-Control 2015).

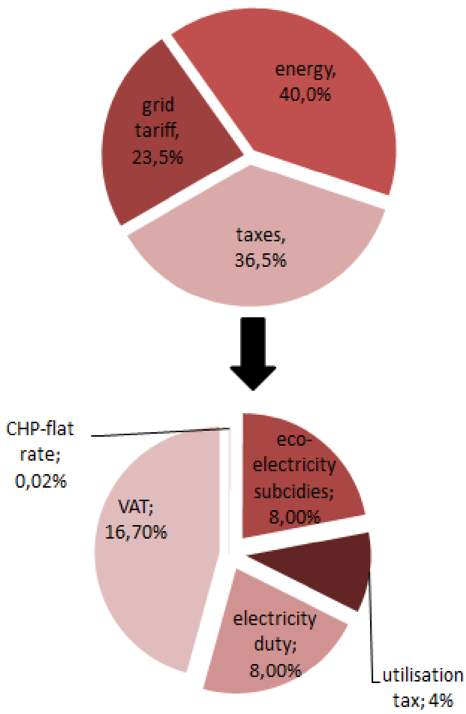


Figure 28: Components of industrial electricity price, yearly consumption: 30.000 kWh, Vienna (06/2015) (E-Control 2015)

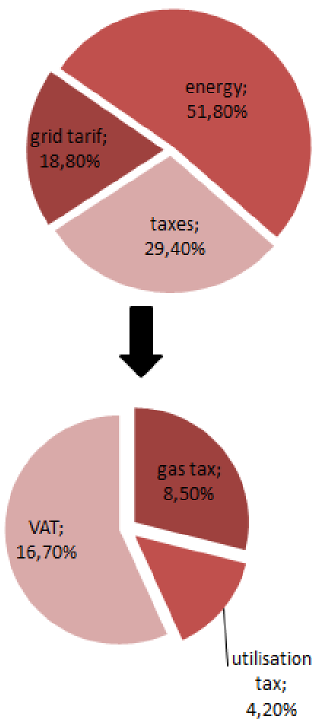


Figure 29: Components of industrial gas price, yearly consumption: 100.000 kWh, Vienna (06/2015) (E-Control 2015)

<u>Components of the electricity price</u>

- **Electricity duty**: This component adds up to 1.5 cent per kWh. Every energy delivery is subject to it, with the exception of energy deliveries to energy utilities.
- **Eco-electricity subsidies**: It is yearly set by regulation.
- **Eco-electricity flat rate**: This flat rate is an annual fixed amount per metering point. It is staggered by network levels.
- **Utilisation tax**: This component is obliged by some municipalities for the use of public land e.g. for electricity grids.

Components of the gas price

- **Gas tax**: It adds up to 6.6 cent per Nm^3.
- **Utilization tax:** In some municipalities this component has to be paid for the use of public land as for example in the case of supply lines for natural gas. The regulation takes place by state laws and comes up to maximal 6 % of the revenues which are earned by the company using natural gas lines on public land.

5.2.2 Energy prices for households

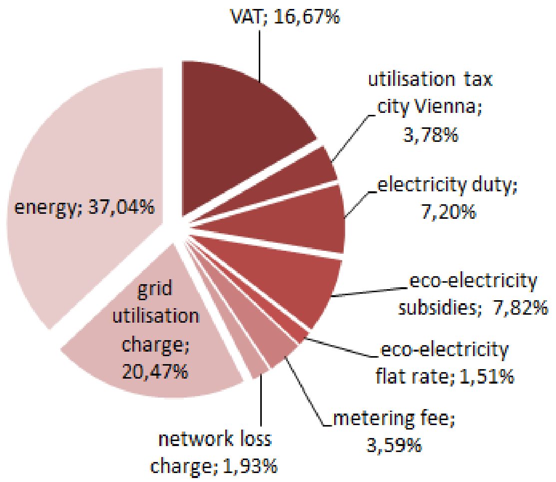


Figure 30: Components of electricity price for households, yearly consumption: 3.500 kWh, Vienna, local supplier (2012) (E-Control 2015)

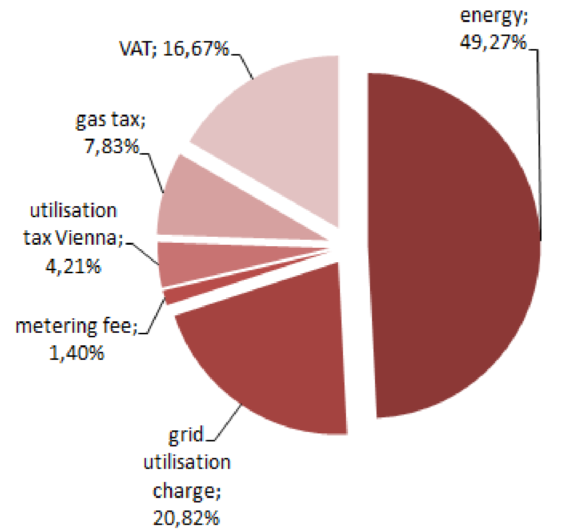


Figure 31: Components of gas price for households, yearly consumption: 15.000 kWh, grid area: Vienna, cheapest provider (2012) (E-Control 2015)

Main components of the households' electricity price

- **Energy duty**: This duty adds up to 1.5 cent per kWh.
- **Grid Utilization tax**: This component is obliged by some municipalities for the use of public land for example for electricity grids.
- **Green-electricity subsidies:** Every consumer has to pay this for supporting renewable energies.

Main Components of the households' gas price

- **Gas tax**: It adds up to 6.6 cent per Nm^3.
- **Utilization tax:** This component is obliged by some municipalities for the use of public land for example for electricity grids.

6 FSHP Manufacturers and products

Chapter 7 contains a description of manufacturers and technical details of gas driven heat pump systems. It covers both, products already available on the market, and such which are still under development respectively shortly before market introduction. Furthermore four national research projects (three ongoing and one lately completed) are presented.

6.1 Manufacturers and products available on the Austrian market

6.1.1 Robur

Robur is an Italian manufacturer of gas driven absorption heat pumps and chillers, which sells its products in whole Europe. The company's portfolio comprises ground (E3 GS), water (E3 WS), and air source (E3 A) absorption heat pumps with maximum heat outputs of around 35-40 kW as well as a reversible air source heat pump for both heating and cooling (E3 AR). There are two versions of the air and ground source heat pump available, one optimized for high temperature heat supply systems (HT) and one for low temperature heat supply systems (LT). The chosen process for all offered heat pumps is a modified GAX (Generator-Absorber-Heat-Exchange) cycle with an internally cooled dephlegmator.

Figure 32 shows a schematic of the air source heat pump E3 A. It is noteworthy that the absorber is divided into two separate parts, one being cooled by the rich solution (GAX) and one by the heating water. The latter and the condenser are combined in a single device and consequently both are cooled by heating water with the same return and flow temperature. Evaporation takes place by cooling ambient air and is supported by a fan. Technical details of the two versions (LT/HT) of the appliance are summarized inTable 4.

The manufacturer states the GUE, which is defined as the ratio of the overall heating capacity and the burner capacity for different operating points in order to specify the efficiency. Operating points are specified by two letters and two numbers, with the first letter and number referring to the external source fluid and the second letter and number describing the external sink circuit. Letters denote the type of the respective fluid (A=air, B=brine, W=water), while numbers stand for the evaporator inlet temperature (in °C) in case of the source and the flow temperature in case of the sink. Accordingly, the operating point A7W50, for instance, refers to an air source heat pump with a dry-bulb temperature of the surrounding air of 7 °C and a heating water flow temperature of 50 °C

A schematic of the ground and water source heat pump is depicted in Figure 33.

The process is basically the same as the one of the air source version; however the evaporator is passed through by brine and water respectively, instead of air. Technical details of both the ground source and the water source can be found in Table 5 and Table 6 respectively.

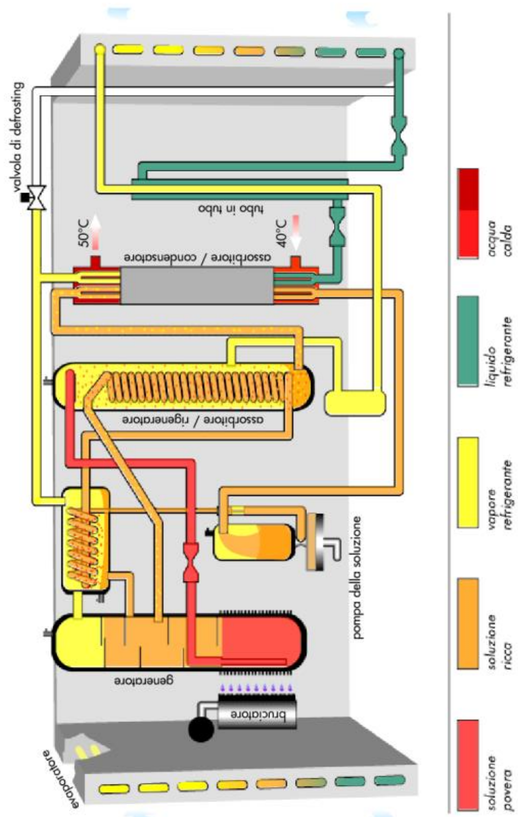


Figure 32: Schematic of the Robur E3 A (Robur GmbH 2014)

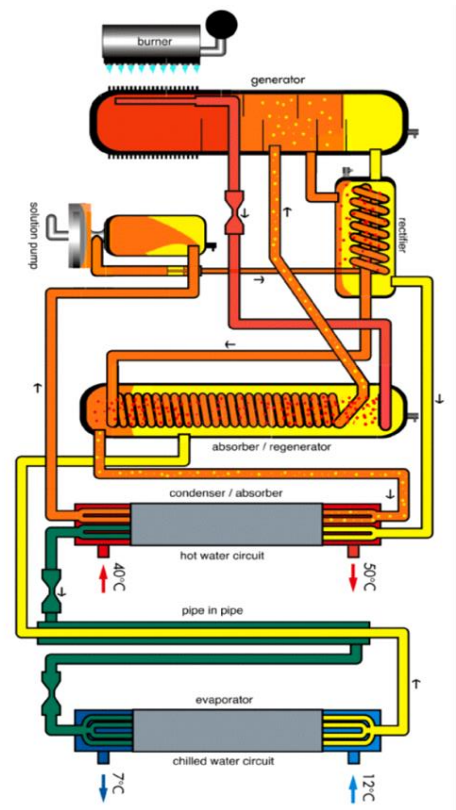


Figure 33: Schematic of the Robur E3 GS/WS (Ainardi and Guerra 2008)

Table 4: Technical details of the Robur E3 A (Robur GmbH 2014)

		E3 A LT	E3 A HT
Type		Absorption	
Working pair		Ammonia/water	
Application		Heating	
Heat source		Air	
Control		Modulating	
Operating point A7W50	GUE [%]	151	152
	Maximum heat output [kW]	34,9	35,4
Operating point A7W35	GUE [%]	165	-
	Maximum heat output [kW]	38,4	-
Operating point A7W65	GUE [%]	-	119
	Maximum heat output [kW]	-	27,5
Operating point A-7W50	GUE [%]	-	125
	Maximum heat output [kW]	-	31,5
Maximum flow temperature [°C]	Central heating	55	65
	Domestic hot water	70	

Table 5: Technical details of the Robur E3 GS (Robur GmbH 2014)

		E3 GS LT	E3 GS HT
Type		Absorption	
Working pairs		Ammonia/waters	
Application		Heating	
Heat sources		Brine	
Control		Modulating	
Operating point B0W50	GUE (%)	150	149
	Maximum heat output (kW)	37,7	37,6
Operating point B0W35	GUE (%)	170	-
	Maximum heat output (kW)	42,6	-
Operating point B0W65	GUE (%)	-	125
	Maximum heat output (kW)	-	31,5
Maximum flow temperature (°C)	Central heating	55	65
	Domestic hot water	70	

Table 6: Technical details of the Robur E3 WS (Robur GmbH 2014)

		E3 WS
Type		Absorption
Working pairs		Ammonia/waters
Application		Heating
Heat sources		Brine
Control		Modulating
Operating point W10W50	GUE (%)	166
	Maximum heat output (kW)	41,6
Operating point W10W65	GUE (%)	143
	Maximum heat output (kW)	35,8
Maximum flow temperature (°C)	Central heating	65
	Domestic hot water	70

In order to allow for reversible operation with an air source heat pump the function of the heat exchangers have to be switched. While in heating mode the ambient air is used as heat source, in cooling mode it serves as heat sink. Accordingly the heat exchanger being in contact with the ambient air has to act as evaporator in the first case and as condenser/absorber in the second case. On the other hand the heat exchanger, which is the condenser/absorber during heating, becomes the evaporator during cooling. This is realized by a complex switching valve, see Figure 34.

Table 7 lists specifications of the reversible heat pump. Note that the GUE for cooling – in contrast to the GUE for heating – is defined as the ratio of the evaporator capacity (cooling output) and the gas capacity.

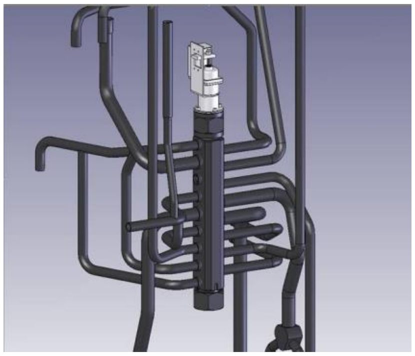


Figure 34: Switching valve for reversible operation (Ainardi and Guerra 2008)

Table 7: Technical details of the Robur E3 AR at the operating points A7W50 for heating and W7A35 for cooling (Robur GmbH 2014)

		E3 AR
Type		Absorption
Working pairs		Ammonia/waters
Application		Heating/cooling (reversible)
Heat source/sink		Air
Control		Modulating
Heating	GUE (%)	140
	Maximum heat output (kW)	35,3
	Maximum flow temperature (°C)	60
Cooling	GUE (%)	67
	Maximum cooling output (kW)	16,9

6.1.2 Oertli

Oertli, a company with Swiss roots which is now located in Moeglingen, Germany, sells gas driven absorption heat pumps that are based on the above described Robur devices. Oertli and corresponding Robur identifiers can be found in Table 8.

Table 8: Gas driven absorption heat pumps offered by Oertli (Oertli-Rohleder Wärmetechnik GmbH 2014) and corresponding Robur names

Oertli	Robur	Technical details
GAWP 35 LW LT	E3 A LT	see Table 4
GAWP 35 LW HT	E3 A HT	see Table 4
GAWP 40 SW LT	E3 GS LT	see Table 5
GAWP 40 SW HT	E3 GS HT	see Table 5

Complementary to those heat pumps Oertli offers different products for the realization of bivalent heat supply systems (optionally including cascades of heat pumps and/or peak boilers). Amongst those are different condensing boilers (GMR 5000, GSR 230), storage tanks that are designed especially for the use in combination with heat pumps (PS 500 WP, PS 802 WP), and a system controller (OE-tronic 4). Figure 35 shows the hydraulic diagram of such a heat supply system, consisting of two gas driven air source heat pumps, two peak boilers, a storage tank (buffer), a DHW storage, and 4 heating circuits. One of the heat pumps acts as lead heating device. In case it cannot deliver enough heat to achieve the desired temperature in the buffer tank after a defined time, the second heat pump and the two peak boilers consecutively kick in.

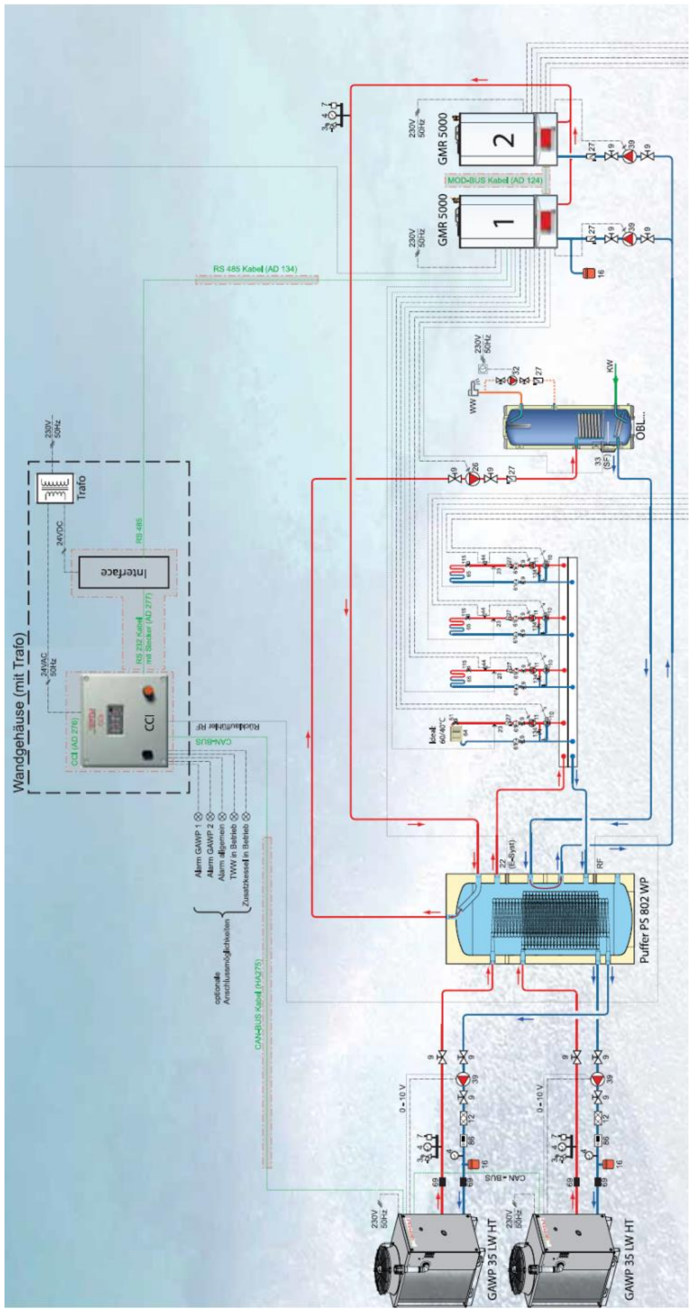


Figure 35: Bivalent heat supply system with Oertli components

(Oertli-Rohleder Wärmetechnik GmbH 2014)

6.1.3 Vaillant

Vaillant, a German heating equipment manufacturer, offers two versions of a gas driven adsorption heat pump for heat outputs between 1,5 and 10 kW (zeoTHERM VAS 106/4) and between 1,5 and 15 kW (zeoTHERM VAS 156/4) respectively. The "working pair" is water/zeolite and solar heat is used as heat source. A schematic including the adsorption and desorption phase is shown in Figure 36. Technical details can be found in

Table **9**: The efficiency is specified by means of the annual coefficient of performance according to VDI guideline 4650-2 for a heat supply system with nominal temperatures of 35 °C (flow) and 28 °C (return), respectively.

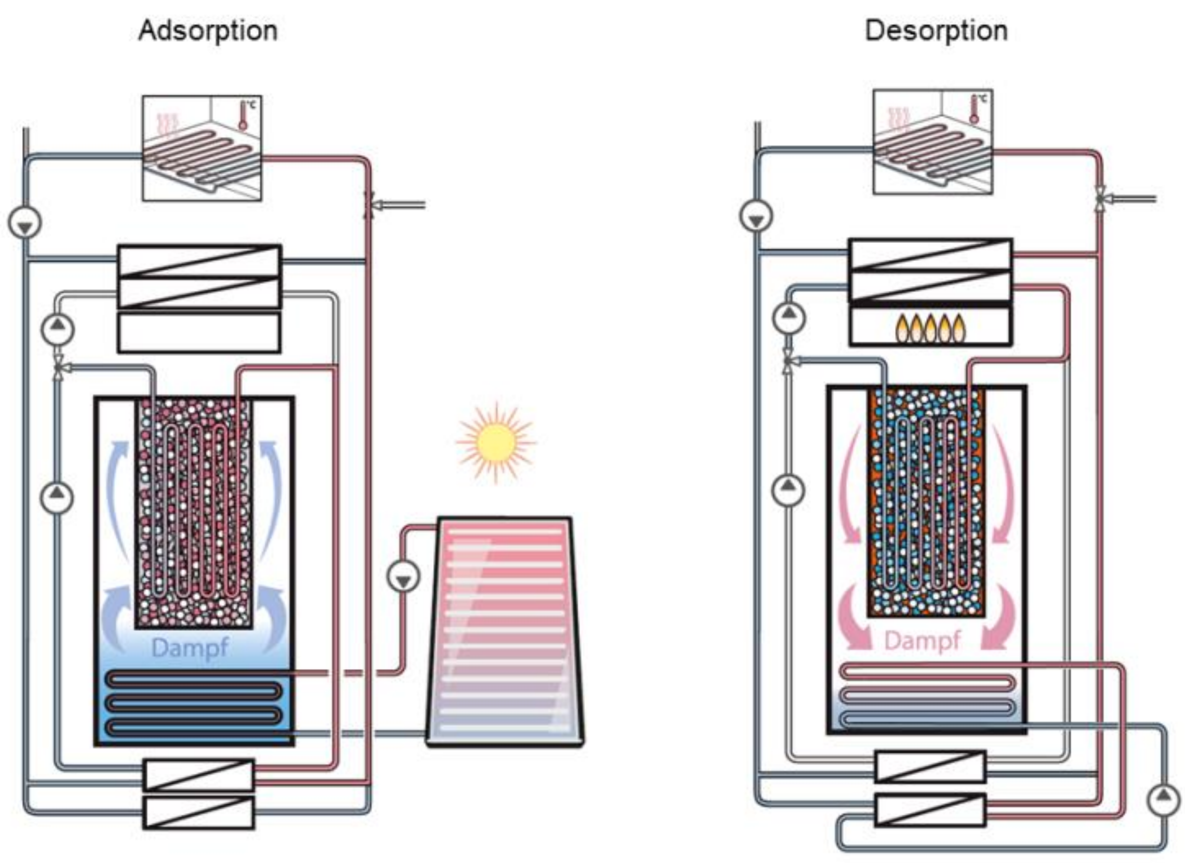


Figure 36: Schematic of the Vaillant zeoTHERM (Vaillant GmbH 2014)

Table 9: Technical details of the Vaillant zeoTHERM (Vaillant GmbH 2014)

	zeoTHERM VAS 106/4	zeoTHERM VAS 156/4
Type	Adsorption	
Working pair	Water/zeolite	
Application	Heating	
Heat source	Brine (solar)	
Control	Modulating	
Minimum heat output (kW)	1,5	1,5
Maximum heat output (kW)	10	15
Annual coefficient of performance (VDI 4650-2, 35/28°C (%)	135	131
Maximum flow temperature (°C)	75	

The heat pump is embedded in a hybrid heat supply system, consisting of the adsorption heat pump, solar collectors, a storage tank for domestic hot water, and a solar station, see Figure 37. The installed heating system is shown schematically in Figure 38. Depending on the temperatures in the solar collectors and in the storage tank, solar heat can be used to charge the storage tank, directly for space heating, or as heat source of the heat pump. The latter (heat pump) mode is active if the temperature in the solar collector is too low for direct solar heating or charging of the storage. An integrated gas burner delivers the driving heat during desorption phase. It can also be used for direct heating by means of natural gas in case the collector temperature is too low for heat pump operation or if the heat pump is not able to meet the total heat demand.

Figure 37: Components of the overall heat supply system (left to right: zeolite gas heat pump, solar storage, solar station, solar collectors) (Vaillant GmbH 2014)

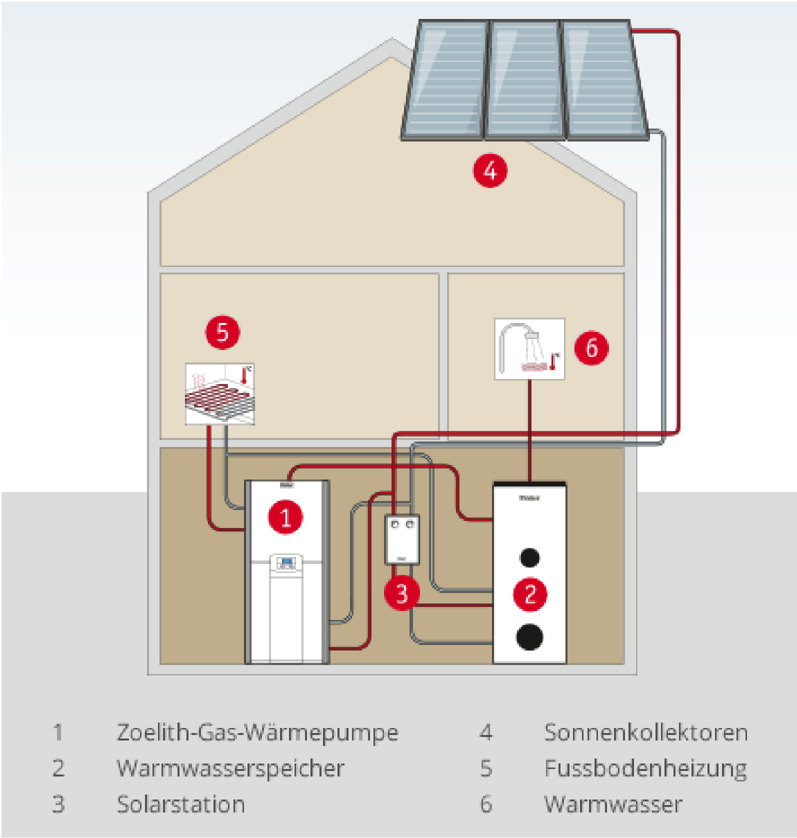


Figure 38: Installed overall heating system (Gravag Erdgas AG 2014)

6.2 Appliances in development

6.2.1 E-Sorp/Heliotherm

Although there are small-scale adsorption heat pumps on the market (Vaillant zeoTherm, Viessmann Vitosorp), no absorption heat pump with a nominal heat output below ca. 35 kW is available up to now.

The Austrian based company E-Sorp is currently developing such an appliance, see Figure 37. E-Sorp, a 100% subsidiary of Heliotherm GmbH, is exclusively responsible for research and development, while Heliotherm takes over distribution.

Technical details are listed in Table 10. A pre-series unit, designed as GAX cycle, showed a GUE of 174 % at the operating point B10W35 in laboratory measurements. The appliance shall be suitable to both new buildings and retrofit applications. In order to increase the maximum flow temperature which might be necessary in the retrofit case), a boiler mode is implemented. A possible integration of the appliance into a heating system including one heating circuit, two buffer tanks, and a solar panel, is shown in Figure 39. Planned future steps include certifications (CE marking, TÜV, etc.), efficiency measurements by external testing institutes, field tests, and optimization of the control system.

Figure 36: Pre-series unit of the E-Sorp/Heliotherm appliance (Strohmaier 2014)

Table 10: Technical details of the E-Sorp/Heliotherm appliance in development (E-Sorp GmbH 2014)

Type	Absorption
Application	Heating/cooling
Hat source	Brine/air/water
Control	Modulating
Minimum heat output (kW)	5
Maximum heat output (kW)	18
GUE (pre-series unit, operating point B10W35) (%)	174
Maximum flow temperature (boiler mode) (°C)	70

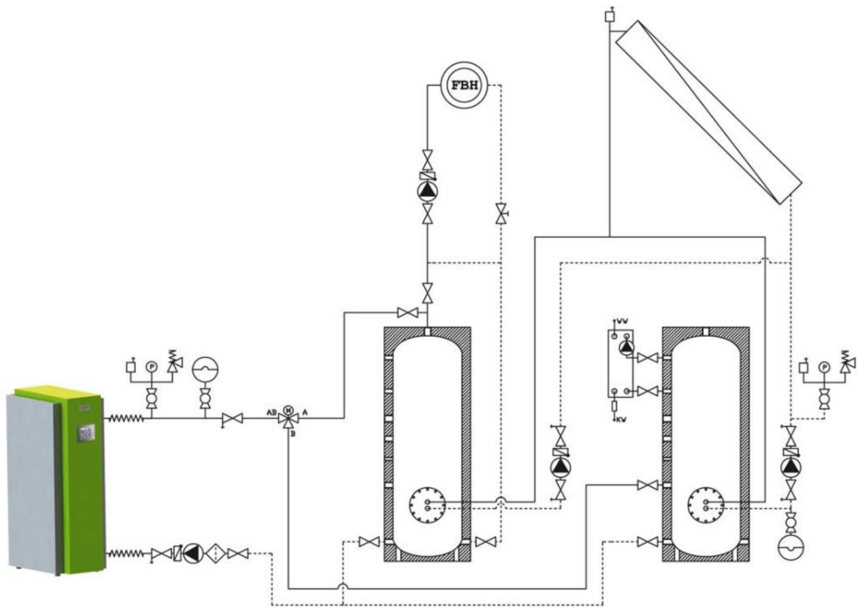


Figure 39: Possible integration into a heating system (Strohmaier 2014)

6.3 Research activities

Research concerning sorption heat pump technology is conducted at two Austrian research institutes, the Austrian Institute of Technology (AIT) and the Institute of Thermal Engineering (IWT) at the Graz University of Technology.

Examples of ongoing and lately completed national research projects at those two institutes are listed below.

- NexGen: Gas absorption heat pump of the next generation (AIT, TU Graz)
- ThermoPump: Thermally driven solution Pump (TU Graz)
- DoublePump: New concept of a thermally driven solution pump suitable for small-capacity ammonia/water-absorption heat pumping systems (TU Graz)
- IEA HPP Annex 34: Thermal decomposition and corrosion in NH3/H2O heat pumps (TU Graz)
- SOptA: Optimization of NH3/H2O heat pumps by means of simulation (TU Graz)

In the following, the research projects mentioned are described in detail.

6.3.1 NexGen

The cooperative research project, conducted by AIT, the IWT, and the Austrian SME E-Sorp GmbH, aims at evaluating different GAX implementations for small-scale absorption heat pumps with respect to their efficiency. Additionally control strategies for such an appliance shall be developed.

Based on simulations of possible GAX cycles, the concepts promising the most interesting potential to improve the system's efficiency are identified. Subsequently selected concepts are built as laboratory prototypes in order to validate the simulation assumptions and collect experimental data (see Figure 40). Finally a prototype including a control system shall be constructed offering the possibility to test the appliance's performance related to its efficiency and control behavior.

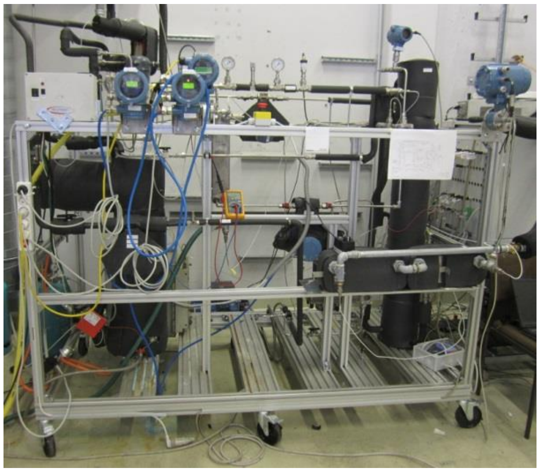


Figure 40: A combined generator-absorber set-up to verify the simulations in the NexGen Project.

6.3.2 ThermoPump

The goal of this project, which is a cooperation of the IWT and the two Austrian companies Pink GmbH and Heliotherm GmbH, is the development of a thermally driven solution pump as an alternative to the nowadays common electrical solution pump in absorption heat pumps. Possible advantages of such a concept are lower operating costs and independency from the electrical net on the one hand side and a more robust pump due to the absence of power transmission devices (such as a shaft) on the other hand side (Zotter 2011).

The following figure shows a thermally driven solution pump integrated in an absorption cycle. A portion of the refrigerant bypasses the refrigeration circuit (condenser, refrigerant throttle, and evaporator), but is expanded in the thermo pump instead. In doing so, energy, which is used to increase the rich solution's pressure, is released. As this refrigerant does not contribute to the evaporator capacity, the efficiency of the heat pump is reduced. On the other hand the use of electrical energy, which is more valuable from an energetic point of view and also more expensive than heat, can be avoided.

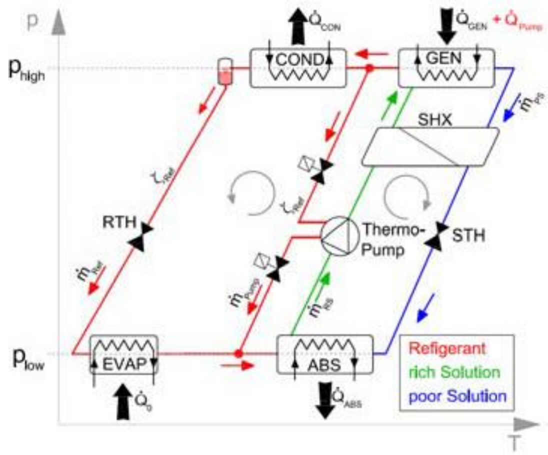


Figure 41: Thermally driven solution pump as part of the absorption cycle (Zotter and Rieberer 2013)

6.3.3 DoublePump

This ongoing project is a follow-up project of ThermoPump (see section 6.3.2) and is carried out by the project partners Pink GmbH, E-Sorp GmbH, and IWT. A new dual-flow concept of a thermally driven solution pump was developed and a prototype will be built, see Figure 42. The prototype is going to be installed into a commercial absorption chiller (Pink Chiller P19) instead of the existing electrically driven solution pump. The system will be tested regarding delivery rate of rich solution and efficiency of the absorption chiller. Furthermore an adequate control strategy will be developed, implemented, and optimized.

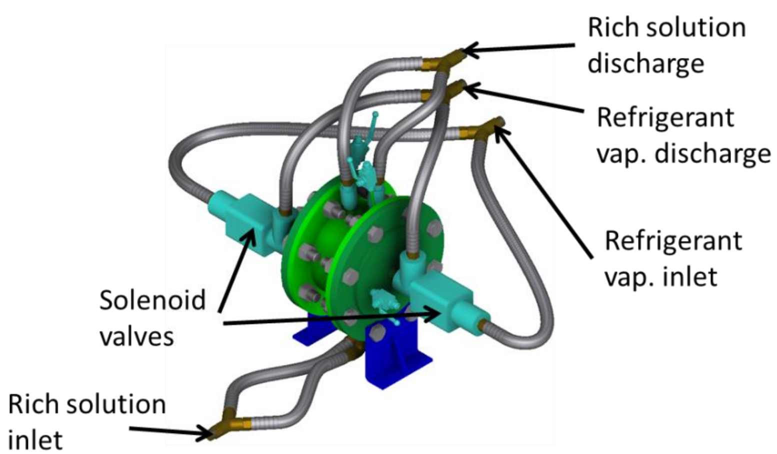


Figure 42: CAD model of the DoublePump prototype (Arnitz and Zauner, 2015)

This new dual-flow concept promises a nearly steady mass flow rate of the rich solution, a compact design, and a minimized effect of the thermally driven solution pump on the absorption system's efficiency.

6.3.4 IEA HPP Annex 34

This project was executed within the framework of IEA HPP Annex 34. For detailed information see the according report (Rieberer 2013). The scope was an experimental examination of the formation of inert gases in ammonia-water absorption heat pumps by both corrosion and decomposition of ammonia. The goal was to quantify the formed inert gases depending on temperature as well as used materials, surface treatment, inhibitors, and water quality.

For that purpose, a test rig was built (see Figure 43) in which the desorption and absorption process of NH3/H2O mixtures are reproduced under similar conditions as in absorption heat pumps. Different materials can be positioned in the solution and the desorbed (generator) temperature can be controlled by means of an electric heater, so that tests concerning corrosion and decomposition behavior can be performed. Additionally 16 autoclaves were produced using 4 different materials and 4 different surface treatment procedures, filled with NH3/H2O solution, and placed in an oven at a defined temperature for a certain time, see Figure 44.

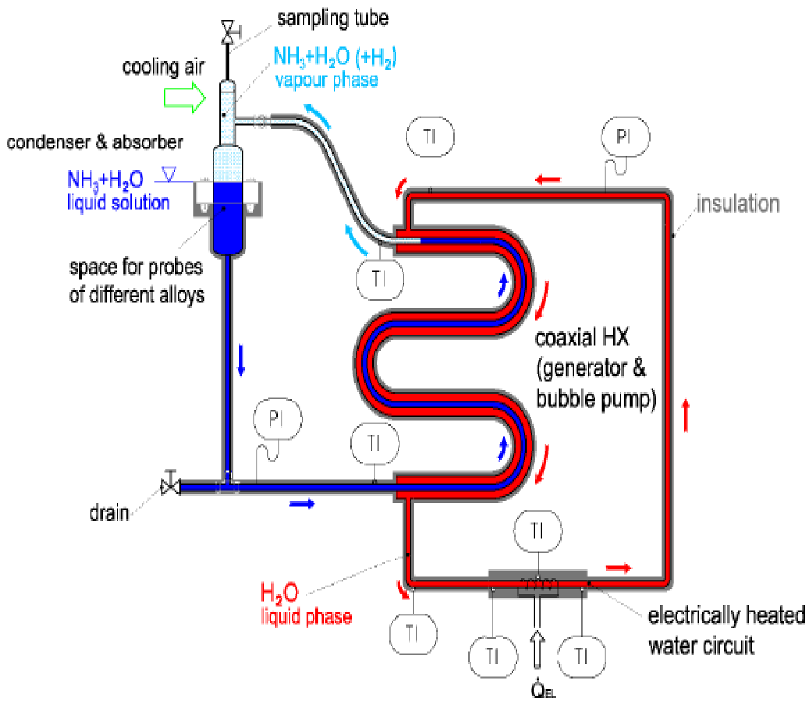


Figure 43: Schematic of the decomposition test rig (Rieberer 2013)

Figure 44: Autoclaves in the oven (Rieberer 2013)

Probes from the gas phase in the test rig and the autoclaves were taken, gaseous NH_3 contained in the probe was washed out, and eventually the probe was analyzed with a gas chromatograph. As hydrogen is formed by both corrosion and decomposition while nitrogen is only formed by decomposition, the origin of the inert gases can be determined quantitatively considering the according reaction equations.

The following observations were made:

- No significant amounts of nitrogen were measured up to 290°C. Hence no relevant decomposition takes place at those temperatures and the present hydrogen was formed exclusively by corrosion.
- Considerable less amounts of hydrogen were measured when using carbon steel instead of stainless steel.

- The production of hydrogen was high at the beginning of the tests and dropped significantly over the course of time.
- The water quality seems to have no effect on the formation of inert gases.
- Two chrome free inhibitors were tested and both showed a slightly positive influence on the avoidance of inert gases.

6.3.5 SOptA

This project is a cooperation between the German company Bosch Thermotechnology GmbH and the IWT. Scope of the project is the analysis and optimization of a small-scale (18 kW heating capacity) gas absorption heat pump prototype (see Figure 45). A serial device for the domestic market (planned market introduction: 2016) based on that prototype can be seen in Figure 46.

Figure 45: Laboratory prototype

Figure 46: Planned commercial version: Buderus Logatherm GWPS192-18 i (Buderus 2015)

The project aims at a reduced size and/or an increased efficiency of the system. To achieve those goals, the prototype is initially characterized by means of experiments. Subsequently a simulation model of the overall cycle is developed based on the measurement results. Using that model, parametric studies focusing on the desorber are performed in order to identify components with significant potential regarding a reduction of size and an increase of the efficiency. To obtain higher resolved simulation results, detailed simulation models of the identified components are set up and finally a 3D-CFD analysis of the heat and mass transfer in a selected component is performed. Proposals for an optimized configuration of the desorber shall be derived from the measurement and simulation results.

7 Typical system configurations

7.1 General

E-Sorp is currently the only Austrian company in the field of gas heat pumps for space heating. This firm develops a natural gas driven small-scale NH_3/H_2O absorption heat pump for both air and ground as heat source (see Section 6). In the following two different configurations of NH_3/H_2O absorption heat pumps are compared with each other for different heating systems, climatic zones in Austria, and building types by means of numerical methods. A simulation model of the E-Sorp appliance was set up and validated against experimental data from laboratory measurements. A model of an alternative cycle configuration was derived from that model and both models were used for annual simulations.

7.2 Typical system configurations for different applications

Internal heat recovery is crucial for the efficiency of absorption heat pumps. Typical concepts include a solution heat exchanger and Generator-Absorber-Heat-EXchange (GAX) designs (compare Herold 1996) with the latter being implemented in the E-Sorp appliance. A schematic of the overall E-Sorp cycle can be seen in section 6. This cycle design will be referred to as “GAX-design”.

The appliance was modelled with the software Engineering Equation Solver (EES, 2015) , which solves mass, species, and energy balances of all components considering following assumptions:

- Saturated states at the outlets of the desorber (liquid solution at state point 8, vapor at state point 11)
- Constant subcooling at the condenser (state point 12) and absorber outlets (state point 2)
- Refrigerant heat exchanger (RHX) and evaporator (EVA) are modelled by means of heat exchanger effectivenesses that are a function of the refrigerant’s mass flow rate
- Rectifier (REC) is modelled by 4 theoretical mixing trays

The simulation model was validated against laboratory measurements with the E-Sorp appliance and the GUEhs at most operating points were predicted within a 5 % error margin (Wechsler and Rieberer, 2015).

Figure 48 shows a similar cycle, which is equipped with a solution heat exchanger instead of the GAX-absorber. A corresponding model was derived from the model of the E-Sorp appliance by introducing following additional assumptions:

- Adiabatic mixing in the mixing tank upstream the absorber (MIX)

- Solution heat exchanger (SHX) effectiveness: 0.8

This configuration is labelled “SHX-design” in the following.

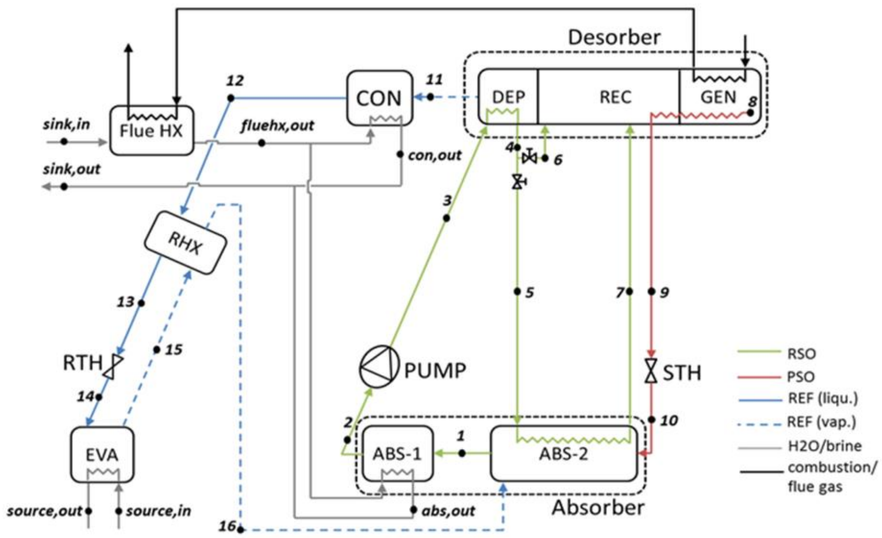


Figure 47: Schematic of the E-Sorp appliance (GAX-design)

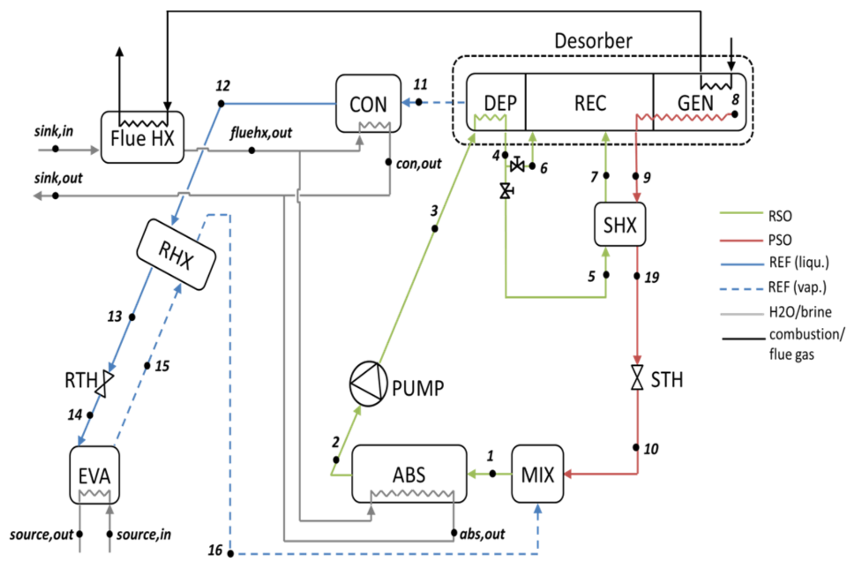


Figure 48: Schematic of a gas absorption heat pump cycle with solution heat exchanger (SHX-design)

Both cycles have been compared with each other by means of annual simulations. Climatic data from three different locations in Austria (Eisenstadt, Graz, and Innsbruck), which represent different Austrian climatic zones (see Figure 11) from Meteonorm (2016) have been used. An overview of the standard outside temperatures (i.e. the lowest ambient temperature that occurs during the year according to the climatic data) of those locations can be found in Table 11.

Table 11: Standard outside temperatures of the considered locations for the annual simulations

Eisenstadt	-13 °C
Graz	-12 °C
Innsbruck	-13 °C

Heating systems with design flow temperatures of 35 and 55 °C have been considered. The required sink outlet temperatures (flow temperatures) have been computed as a function of the outside temperatures by using a linear heating curve with following end points: the maximum flow temperature (design flow temperature, either 35 or 55 °C) at the standard outside temperature (according to Table 11) and a flow temperature of 25 °C at an outside temperature of 20 °C. A constant temperature difference of 5 K between sink out- and inlet was assumed. The heat pumps were considered to be equipped with an outdoor unit and a secondary brine circuit and the source inlet temperatures were considered to be 3 K below the outside temperatures. The temperature difference between source in- and outlet was set to a constant value of 3 K. The heating load as a function of the outside temperature was taken from reference building models (127.3 m^2) with heating loads of 45, 60, and 100 kWh/(m^2a) (SFH45, SFH60, and SFH100) for reference climatic conditions of Zurich (Heimrath and Haller, 2007).

In the following the influence of the heating system's design flow temperature, the location, and the building type on the SGUEh is shown exemplarily by means of three scenarios. The design flow temperature of the heating system has the most significant effect on the SGUEh. In Figure 49 the SGUEhs of the two cycle designs are depicted for the building SFH60 located in Graz and two different design flow temperatures (35 and 55 °C). As expected, GAX-design is clearly superior when the heating system operates with relatively low temperatures due to relatively small temperature lifts, while the difference between both cycle designs diminishes when the design flow temperature is higher.

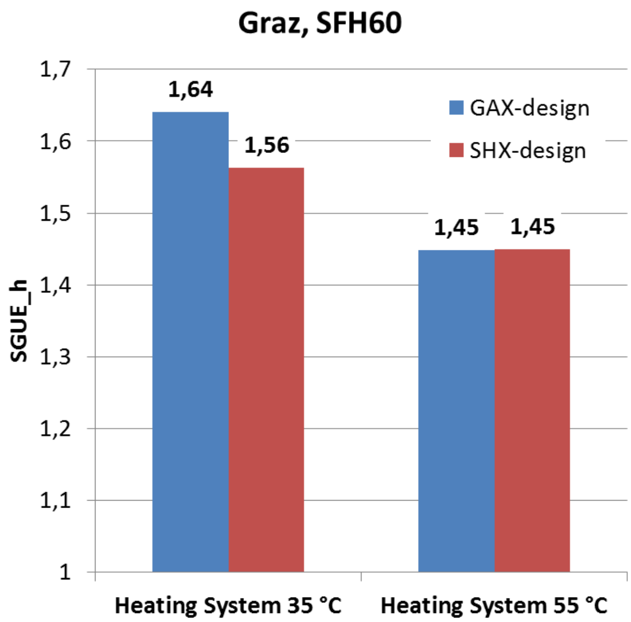


Figure 49: Influence of the design flow temperature on the SGUEh

Figure 50 shows the SGUEh for a given building (SFH60) and heating system (design flow temperature 35 °C) for the three considered locations. There are minor differences, which are due to small differences in the outside temperatures. Graz has an average outside temperature of 3.4 °C, Innsbruck of 3.1 °C, and Eisenstadt of 5.1 °C (time weighted averages over heating period). As can be seen, the SGUEh increases with increasing average outside temperatures. A comparison of the SGUEh for different building types and a given location (Innsbruck) and heating system (design flow temperature 35 °C) can be seen in Figure 51. Again the differences are only marginal and can be attributed to small differences in the average flow temperatures (30.1, 30.0, and 29.6 °C for SFH45, SFH60, and SFH100, respectively). Those differences in the averaged flow temperatures are caused by non-linearities in the correlation between ambient temperature and heating load of the building models. This leads to a different weight of given flow temperatures in different building models when it comes to the weighted averaging of the flow temperatures.

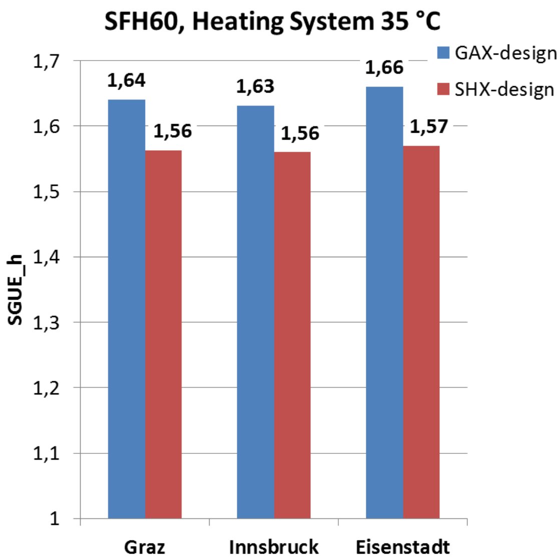


Figure 50: Influence of the location on the SGUEh

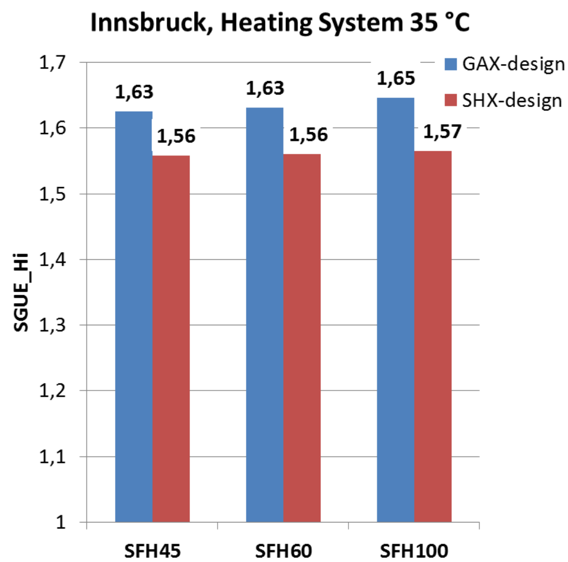


Figure 51: Influence of the building type on the SGUEh

The saving potentials of the two gas heat pump variants were evaluated in reference to a condensing boiler, whose efficiency was modelled in a straightforward way as a function of the sink inlet temperature (return temperature).

$$\eta = -0.0022 \cdot t_{return} + 1.103$$

In case of the low temperature heating system (35 °C) ca. 36-37 % (depending on the location and the building type) of fuel can be saved compared to a condensing boiler, when a gas heat pump with GAX-design is used. This is equivalent to an annual saving of ca. EUR 295 or ca. 855 kg CO_2 in case of the building type SFH100. Note that the heating demand of this building is relatively low, especially compared to buildings that are typically interesting for retrofit applications. Higher heating demands naturally lead to higher saving potentials in absolute figures.

With SHX-design in combination with a low temperature heating system, the fuel saving potential is still around 33 %. In case of the high temperature heating system (55 °C) the saving potential is ca. 30 % for both heat pump designs.

8 Chances and barriers for FSHP

Chapter 9 presents chances and barriers for fossil-fired heat pumps in the Austrian market. A survey was conducted to gather insides on the topic of gas-driven (absorption) heat pumps by market participants such as heat pump manufacturers, installers/planners of such heating systems and potential users. In total, 135 persons participated in the survey. In the following, the main results of the interviews are presented[4]:

- Austrian heat pump manufacturer: interview within the framework of the AITs heat-pump manufacturers' day on 09.10.2014, 11 respondents
- Installers/planners of heat pumps systems
    a) Interviews with installers/planners taking part in four AIT courses for certificated heat pump installers/planner from 10.01.2014 to 31.03.2015, 23 respondents
    b) Online survey conducted from 16.03.2015 to 14.04.2015 via the online portal SoSci (www.soscisurvey.de), the link to the survey was sent to 724 national installers and planners by email, 52 respondents, response rate therefore 7%
- Potential users: personal interviews by AIT employees from 10.01.2015 to 30.03.2015, 49 respondents, 69% of the interviewed potential users live in an urban area with more than 50.000 inhabitants, 8% in the urban area with less than 50.000 inhabitants) and 23% in rural areas

[4] A detailed evaluation of the surveys can be found in the Appendix in chapter 11.2

8.1 Awareness level

As shown by Figure 52 and Figure 53, gas driven heat pump is not a well-known technology in Austria, neither with potential users, nor with installers and planners. Only one in four users have heard of gas driven heat pumps; with installers and planners it is roughly every second one.

The most known heat pump manufacturers are Vaillant and Viessmann followed by E-Sorp and Robur. In addition, Sanyo, Buderus, Bosch and Heliotherm have been named.

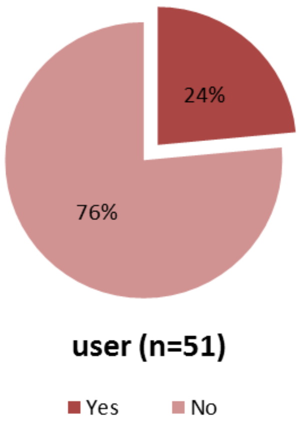


Figure 52: Do you know gas sorption heat pumps?

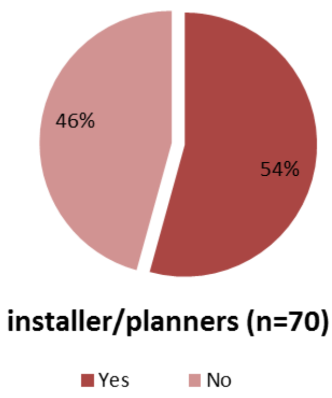
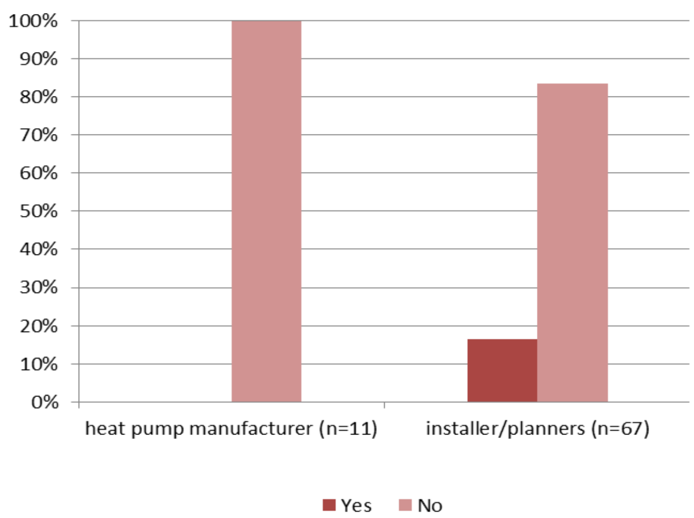


Figure 53: Do you know gas sorption heat pumps?



As clearly illustrated in Figure 54, gas driven heat pumps are not offered by any interviewed heat pump manufacturer; only very few of the installer/planners interviewed have them in their product range. The interview also showed that only ten percent of the installer/planners asked have installed gas driven heat pumps so far. Similar numbers were devoted by asking users if they already have heat pumps in use or know somebody who uses them. Thus it can be concluded that gas driven heat pumps have a very low awareness level within all relevant stakeholders in Austria.

Figure 54: Does your product range include gas driven heat pumps?

8.2 Market entry barriers

Low investment costs and a short payback period are not the most important decision factors concerning the acquisition of a new heating system. Figure 56 illustrates that more than 50 % of the users would accept a payback period of up to ten years. This means that users are willing to spend a larger amount of money on renewable technologies that amortizes after a longer period of time in return of low running expenses in the future. As depicted in Figure 55, comfort and other factors are of great significance for the buying decision. The most "other factors" mentioned include "ease of operation", "ease of maintenance", "durability" as well as "operating safety".

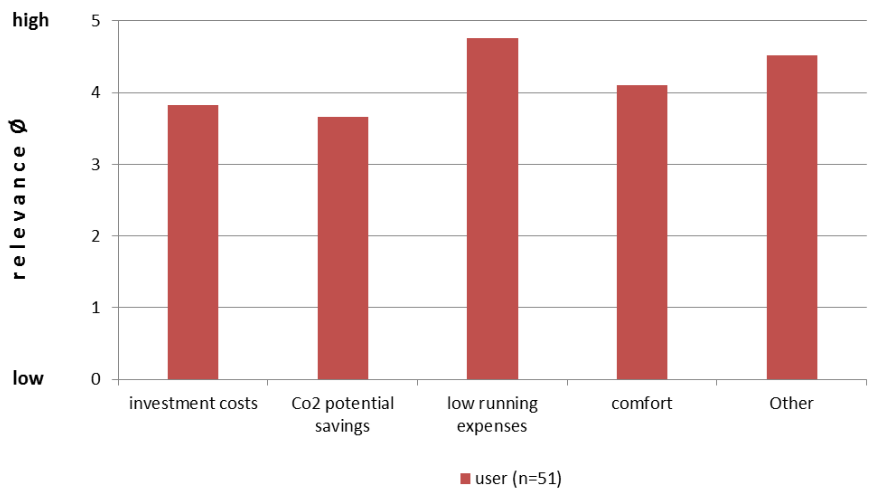


Figure 55: What is determining your buying decision on heating systems?

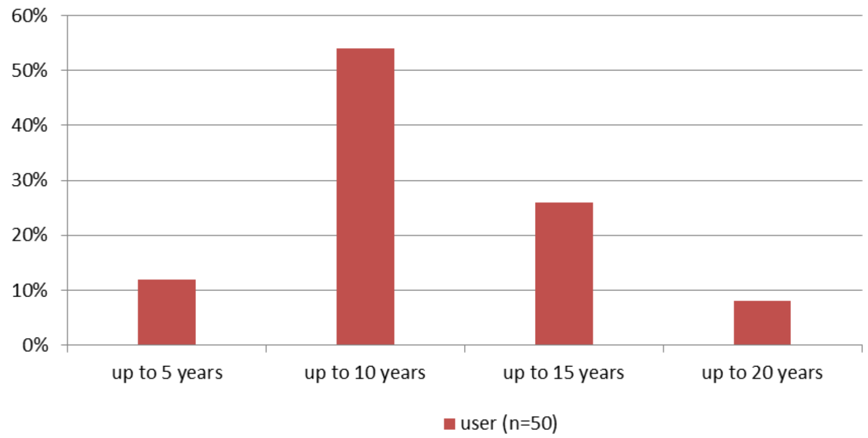


Figure 56: Which payback period is acceptable when buying an ecologically friendly heating system such as gas driven heat pumps?

By asking heat pump manufacturers and installer/planner for the market entry barriers for this technology up to a capacity of 50kW in Austria, they were in agreement that the technology is hardly known by users and as mentioned at the beginning this consistent with the result that more than three quarters of the users do not know gas driven heat pumps. However, as it can be seen on Figure 57, for heat pump manufacturers the biggest market entry barrier is the cost factor which means on the one hand that the technology's investment costs are still too high and on the other hand gas driven heat pumps are too expensive to operate. Comparing the results of heat pump manufacturers and installer/planners, it is evident that installer/planners give less weight to the different market entry barriers than heat pump manufacturers.

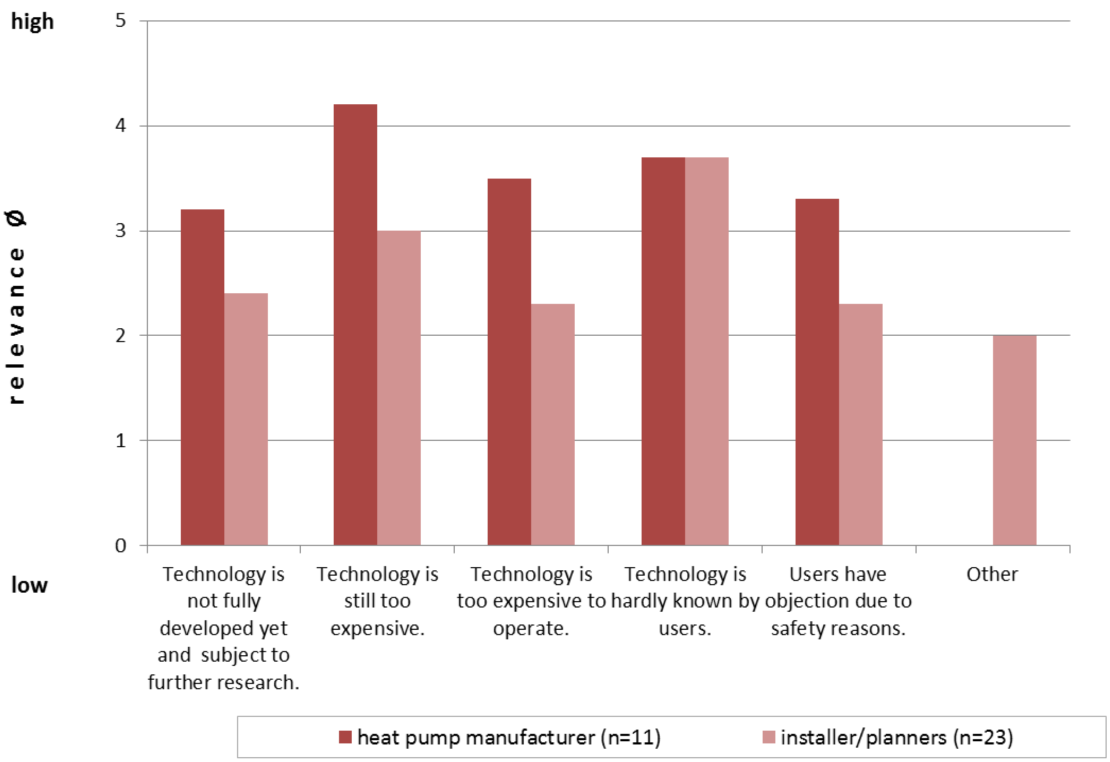


Figure 57: What are the market entry barriers for this technology up to a capacity of 50 kW in Austria?

8.3 Market potential and future applications

The interpretation concerning market potential resulted positive numbers as only one out of four would not take purchasing a gas driven heat pump into consideration. The high number of "Don't know" answers colored light pink on Figure 58 could be traced back to the lack of knowledge on the technology of gas driven heat pumps of many of the users. According to the result of the question where they would assemble a gas driven heat pump it came out that more than 60 % would consider both – a newly built house as well as a refurbished house. The rest mostly chose the refurbished house. Misgivings in the operation of a gas driven heat pump are seen in the aspects safety, availability of gas, CO_2 emissions and in the price setting.

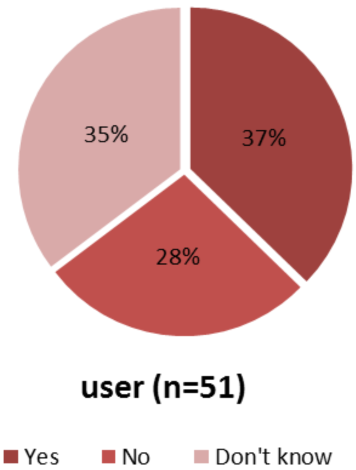


Figure 58: If you need a heating system would you consider purchasing a gas driven heat pump if it is operated similar to a gas condensing unit?

Figure 59 shows where heat pump manufacturer and installer/planners could see future markets for gas driven heat pumps. While in the view of the heat pump manufacturers the smaller industrial applications would present the best market, installer/planners would equally focus on refurbished one family or double family houses, refurbished multi-family houses and smaller industrial applications. Thus connecting both opinions smaller industrial applications would be the best market and newly built one family or double-family houses have been seen as the market with the fewest sales potential by both asked groups. Moreover hotels and refurbished places with gas connections have been listed by heat pump manufacturers. Furthermore the most potential gas-powered heat pump, meant by three of four heat pump manufacturers, is the gas-adsorption heat pump.

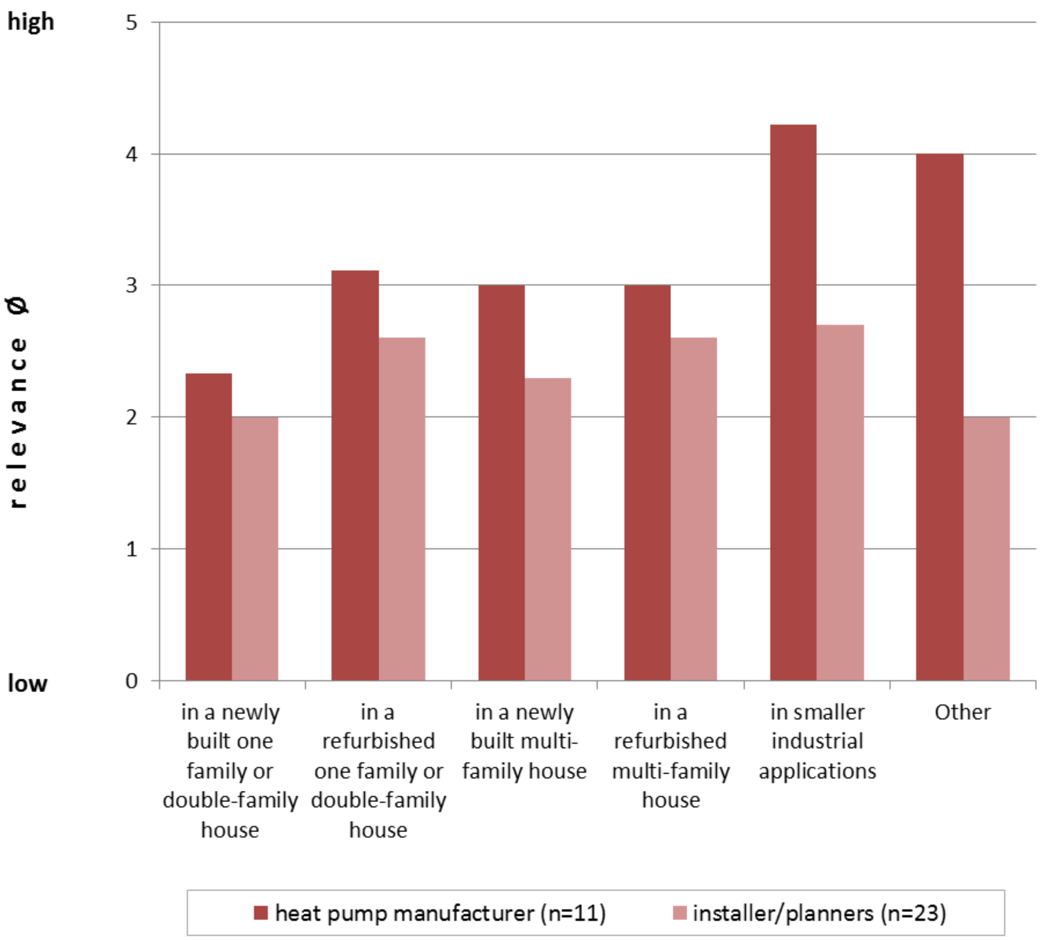


Figure 59: Where do you see future sale markets for heat pumps?

8.4 Measures for bringing technology to the market

As the above-mentioned facts show that both user and installer/planners do not know much about gas driven heat pumps increasing the brand awareness by information campaigns seems to be the best measure for introducing the technology successfully to the market. Comparing the results in Figure 60, this plan can be strengthened as heat pump manufacturers as well as installers/planners are of the same opinion that information campaigns and therefore an increased brand awareness would speed up the market entry. In addition, heat pump manufacturers see higher public subsidies as equally important.

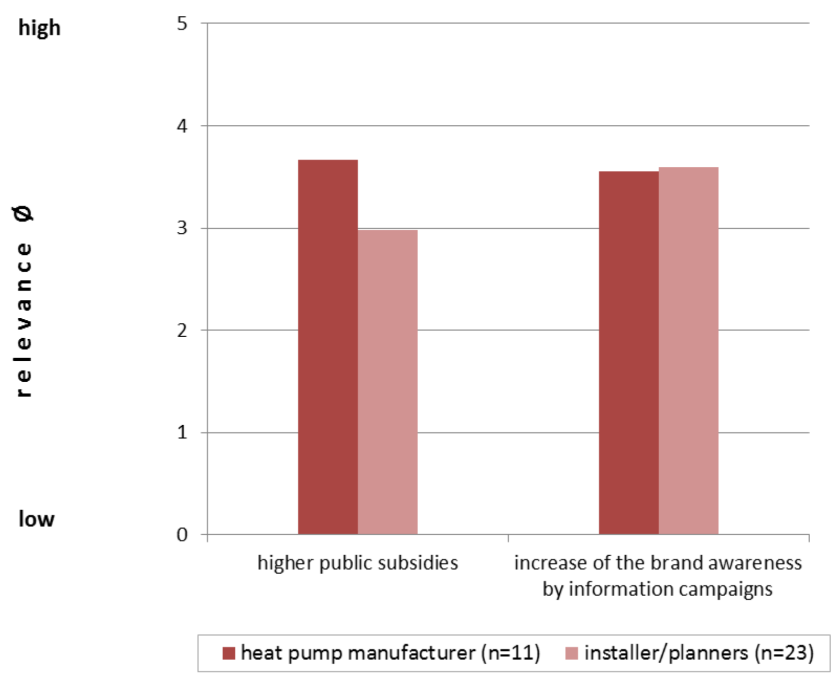


Figure 60: What are the main measures to speed up the market entry/diffusion of this technology?

Note, that another barrier for the market entrance is the usage of the term COP for electrical driven heat pumps as well as for FDSHPs. Contrary to the COPs for FDSHPs which are related to the thermal energy of the heat sink, the COP of electrical driven heat pumps is related to the electric energy. Hence, the COP of the electrical heat pumps is about 2 to 3 times higher than for FDSHPs although the primary energy consumption is nearly the same in both systems. Therefore a performance measure related to the primary energy consumption should be preferred in the future to enhance the chances for a market entrance.

Based on the results from Chapter 8, a catalogue of measures supporting the market introduction and diffusion of fuel-driven heat pumps was developed within the Austrian consortium in 2016. The proposed actions aim at increasing the awareness level of the technology, which proved to be very low. In addition, the measures were directed towards reducing the acquisition and operating expenses of heat pump systems.

1) Actions to improve the level of awareness of fuel-driven heat pumps

The **informational instruments** identified comprise:

Action		Target Group
M1	Integration of the topic in the AIT heat pump courses for “certified heat pump installers” respect. “certified heat pump planners”	Installers and planners of heat pump systems
M2	Information event respectively information campaign by relevant interest representatives such as e.g. trade association of gas and heat supplying companies	Installers and planners of heat pump systems End users
M3	Dissemination of Best-Practices in industry newspapers such as e.g. österreichische Installateur, KI-Kälte Luft Klimatechnik, TGA Fachplaner, etc.	Installers and planners of heat pump systems
M4	Information and training of funding agencies in federal provinces and energy agencies in particular regarding operating mode, advantages, potential of fuel-driven sorption heat pumps and their differences compared to compression heat pumps (GUE instead of COP, etc.) as well as gas condensing units	Funding experts from national federal provinces Energy agencies

2) Actions to reduce acquisition and operational expenses

The actions to reduce **acquisition costs** comprise**:**

Action		Target groups
M5	Consideration of fuel-driven heat pumps in the funding programmes of the federal provinces focusing on the use in refurbished houses in areas with an existing gas infrastructure	End users
M6	Incentives such as a non-repayable grant by utilities when purchasing a heat pump (see TIGAS[5])	End users

[5] http://www.tigas.at/index.php/produkte/erdgas/foerderungen

The actions to reduce **operation costs** comprise**:**

Action		Target groups
M7	Incentive-Programs of the utilities such as e.g. yearly bonus payment by utilities as offered in earlier years bei Linz AG	End users

The catalogue of measures was sent to 24 national energy, housing and funding experts in the federal provinces asking the following bundle of questions:

1. Do you know the technology of fuel-driven heat pumps? If yes, shall they be supported financially?
2. Are the measures developed reasonable for supporting the technology? Are reasonable measures missing?
3. Do you have suggestions for further market supporting instruments?
4. Do you have further feedback for us or do you want to discuss the topic in more detail?

In the following, the results of the 4 answers received (equals 17% of the contacted experts) are summarized. The persons participating are experts from the following provinces: Upper Austria, Salzburg, Vorarlberg and Styria.

Amongst the experts, fuel-driven heat pumps are well-known. In the whole, the measures developed by the research team are considered suitable to overcome resp. reduce existing market barriers. Different opinions exist towards the eligibility of public funding in this context. Whereas experts from Upper Austria and Styria are categorically exclude public funds for fuel-driven heat pumps due to their fossil character, experts from Vorarlberg and Salzburg judge that topic more differentiated. Although Vorarlberg does not offer currently public funding for that kind of heat pumps, grants might be feasible for retrofitted buildings, especially for larger buildings e.g. hotels as there are few energy-efficient alternatives for that kind of application.

Best practice examples are seen as very important, as the range of application is not well known. In addition, one expert recommended informing resp. training the decision makers of funding agencies regarding the advantages, potentials, ecological consequences as well as cost-efficiency of fuel-driven heat pumps. Of relevance in this context is the question if primary energy savings will be in the focus of attention in future or if it is “only” about phasing out fossils. If the second case applies, fuel-driven heat pumps have little potential as the production of biogas also leads to cost and resource problems.

9 Conclusion

About 83% of the overall dwelling stock in Austria was built before 1990. Furthermore, about 26% of the dwellings in Austria use natural gas as energy source for heating. Therefore, the FSHP have a good chance on the Austrian market for thermal renovation in the upcoming years.

Although there is already a potential market for fuel driven sorption heat pumps in Austria, especially in the areas with gas infrastructure, the technology is not very common at the moment. One of the main reasons is that the technology is rather unknown by potential users and only partly known by installers and planners. Furthermore there are only few companies offering fuel driven heat pump systems on the Austrian market. Hence, it will be important to provide the national stakeholders with reliable information on the technology.

However, the poor efficiency of the widespread condensing boiler technology compared to the fuel driven sorption heat pump technology (FSHPs reach about 120 to 160% of the efficiency of a condensing boiler) leads to the conclusion, that the FSHPs are able to replace the condensing boilers in the near future. One further indication, that FSHPs are the “Next generation condensing boilers” is that many companies, originally coming from the boiler market, like Vaillant, Viessmann, Buderus, etc. are currently developing their own FSHP-systems.

Due to the increasing interest of major companies on the FSHP-technology, the price situation on the market will relax, since the competition is increasing. This was already observed when Viessmann brought their Zeolith-adsorption heat pump into the German market in 2015. Therefore, a further market entrance barrier, the price, as identified in the surveys in the present work, will be addressed in the next years.

Whether the technology will prove successful on the market will further depend on the ratio between the local gas price and the local electric energy price. Therefore a forecast is difficult to make.

Although, different kinds of FSHPs have already entered series production, many improvements could be achieved by answering the right scientific questions. For example is the TU Graz currently working on a FSHP which works without an electric driven solution pump, one of the most critical and most electric energy consuming parts in the machine. This was achieved by substituting the mechanical pump with a thermally driven pump, which utilizes a partial flow of the high pressure refrigerant from the desorber outlet in order to pump rich solution from the absorber outlet to the high pressure level.

Summing up one can say that the FSHP is able to replace the condensing boiler, in the near future. Nevertheless there are still improvements possible to the FSHP on the current market.

10 Appendix

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10.2 Detailed Evaluation of the survey

10.2.1 Heat pump manufacturer

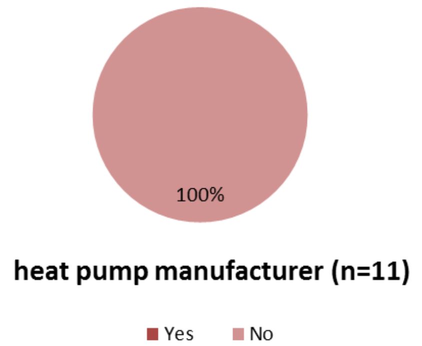

Figure 61: Does your product range includes gas driven heat pumps?

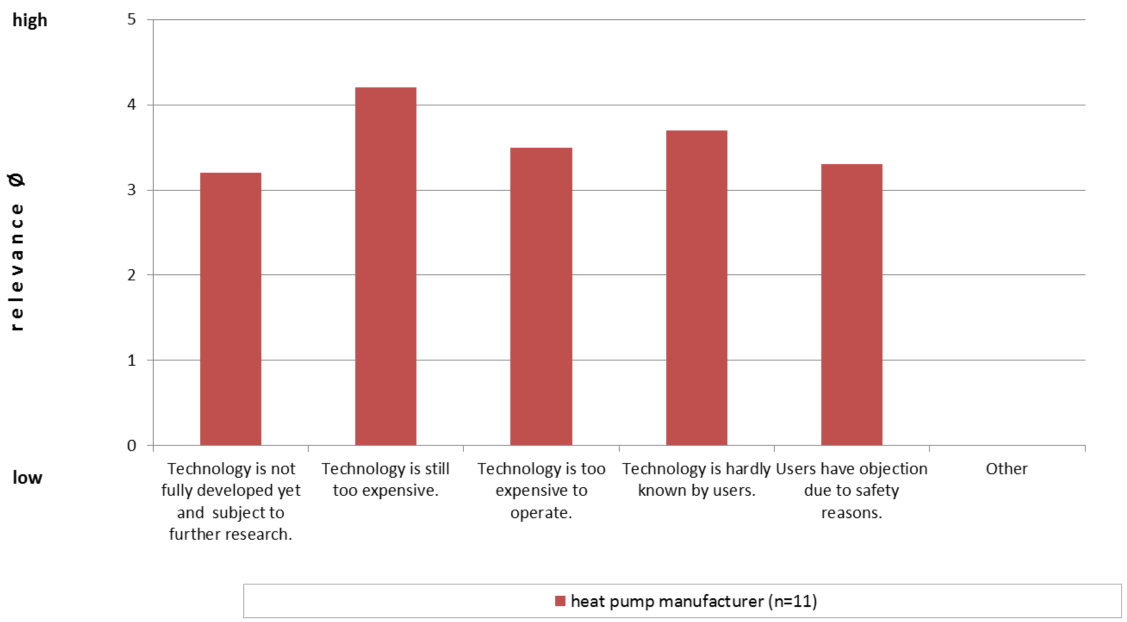

Figure 62: What are the market entry barriers for this technology up to a capacity of 50kW in Austria?

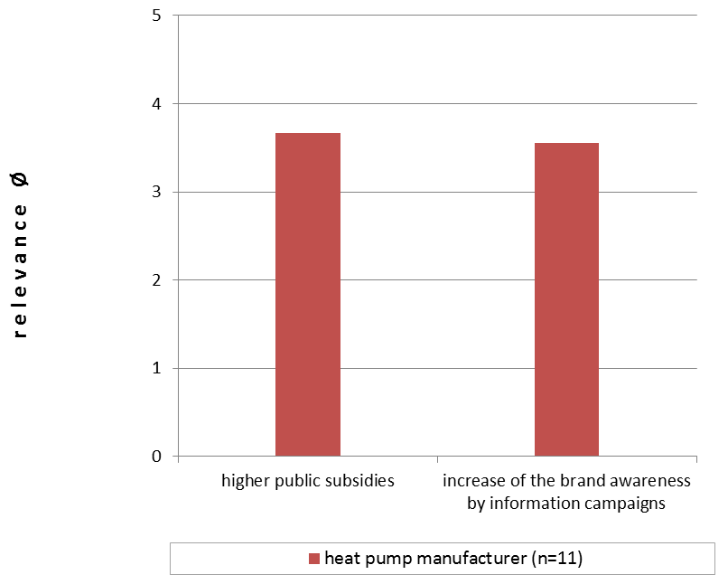

Figure 63: What are the main measures to speed up the market entry/diffusion of this technology?

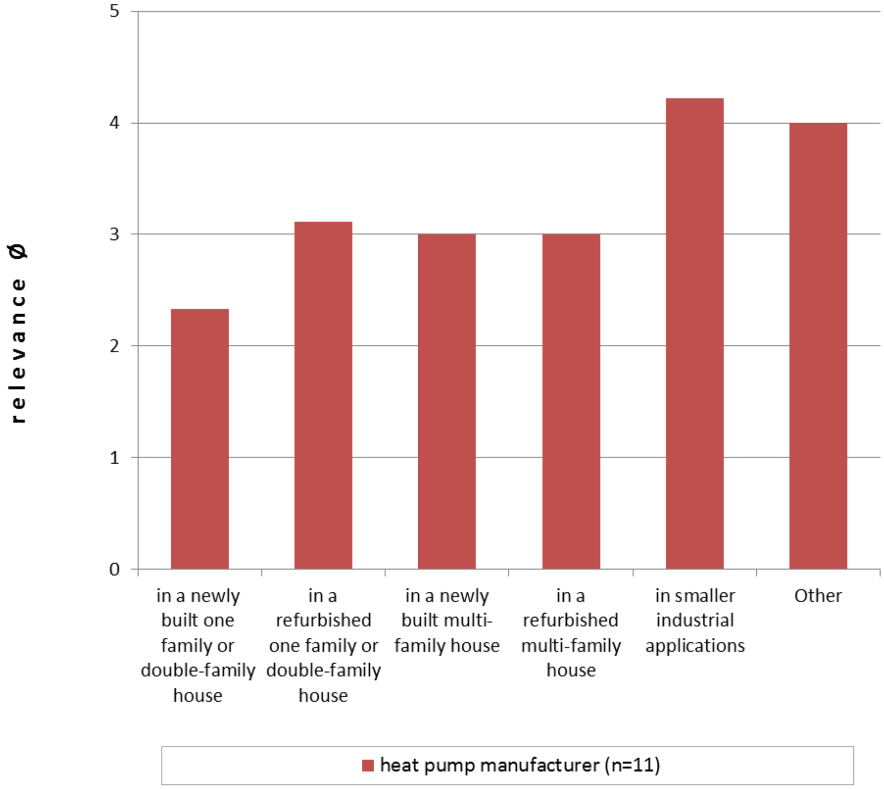

Figure 64: Where do you see future sales markets for heat pumps?

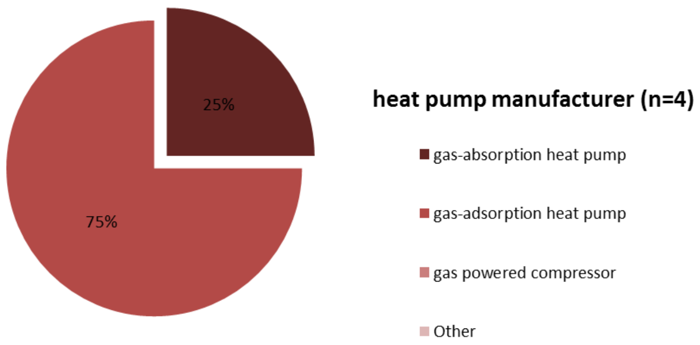

Figure 65: Which of the gas driven heat pump technologies has the best market potential in your point of view?

10.2.2 Installer/Planner

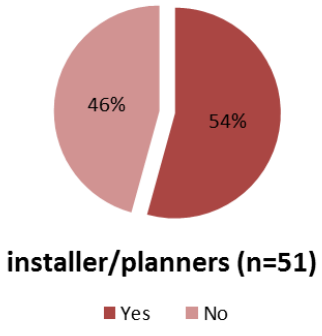

Figure 66: Do you know gas sorption heat pumps?

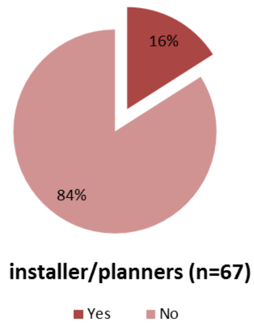

Figure 67: Does your product range include gas driven heat pumps?

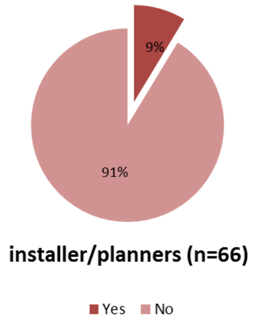

Figure 68: Have you already installed gas driven heat pumps?

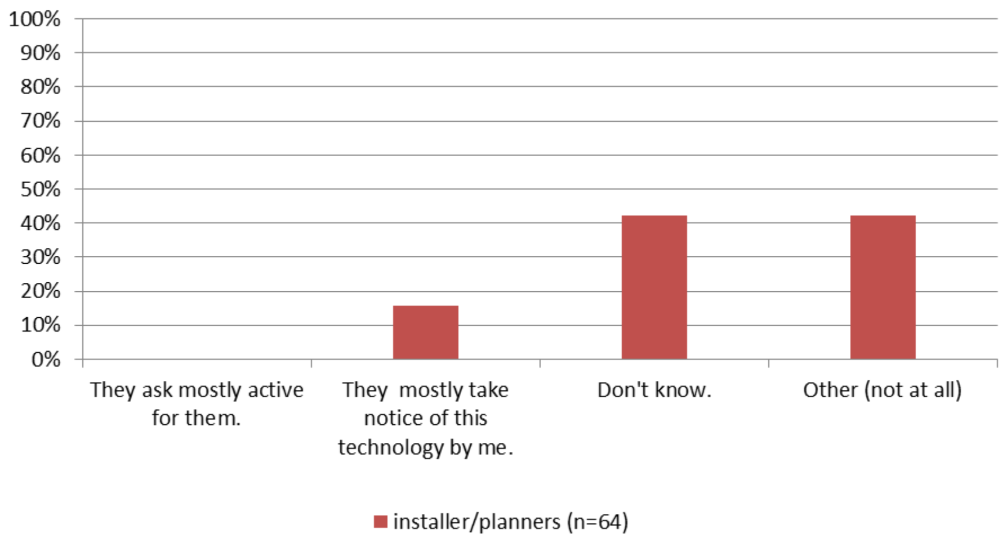

Figure 69: How well are your customers informed about gas driven heat pumps?

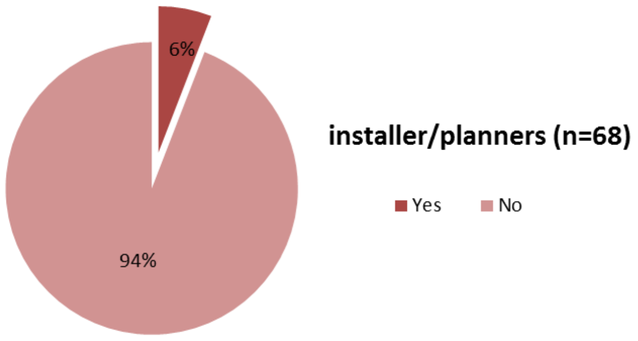

Figure 70: Do you know Austrian standards for gas driven heat pumps?

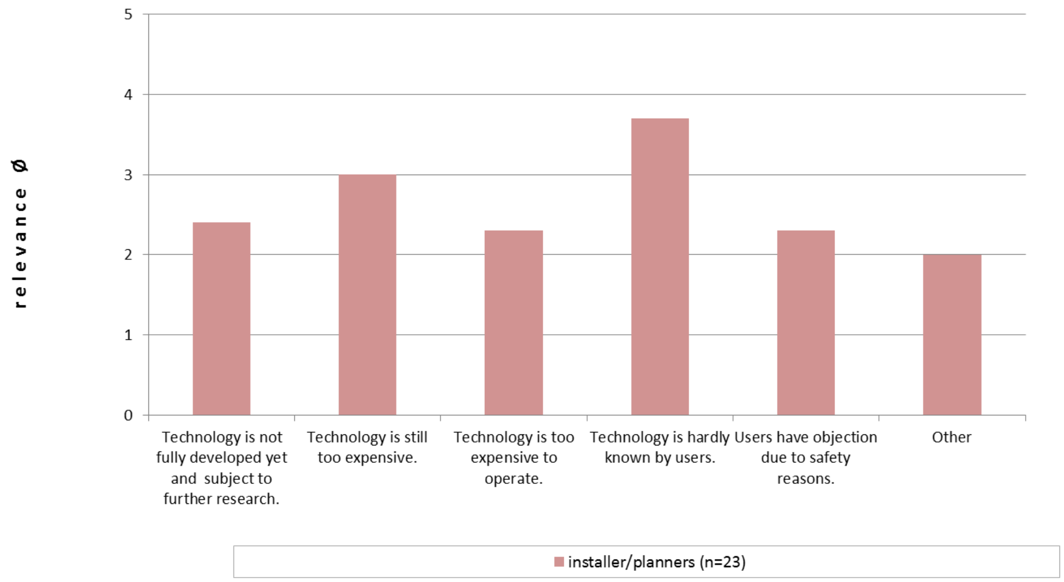

Figure 71: What are the market entry barriers for this technology up to a capacity of 50kW in Austria?

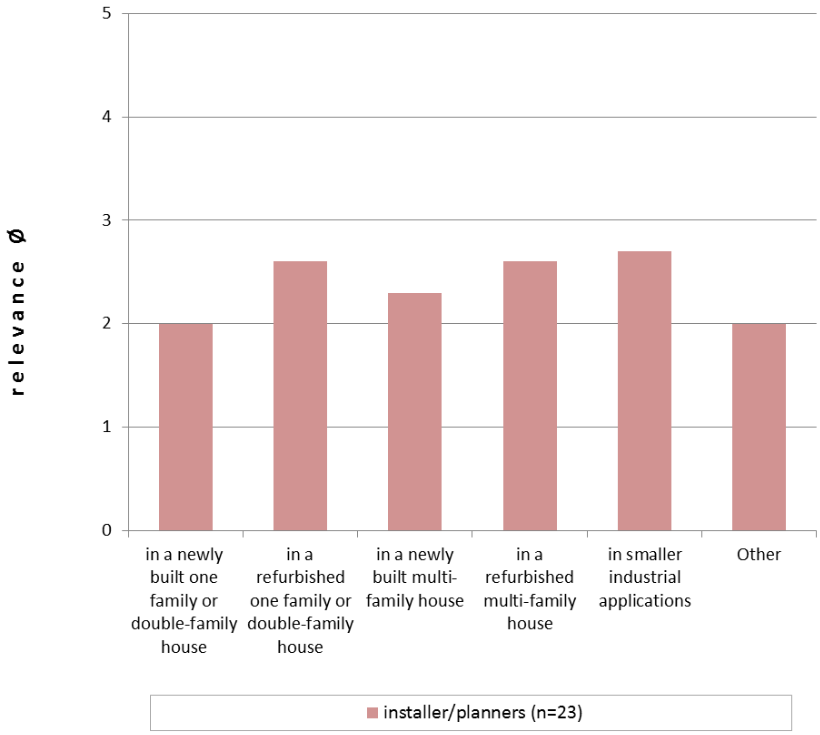

Figure 72: Where do you see future sales markets for heat pumps?

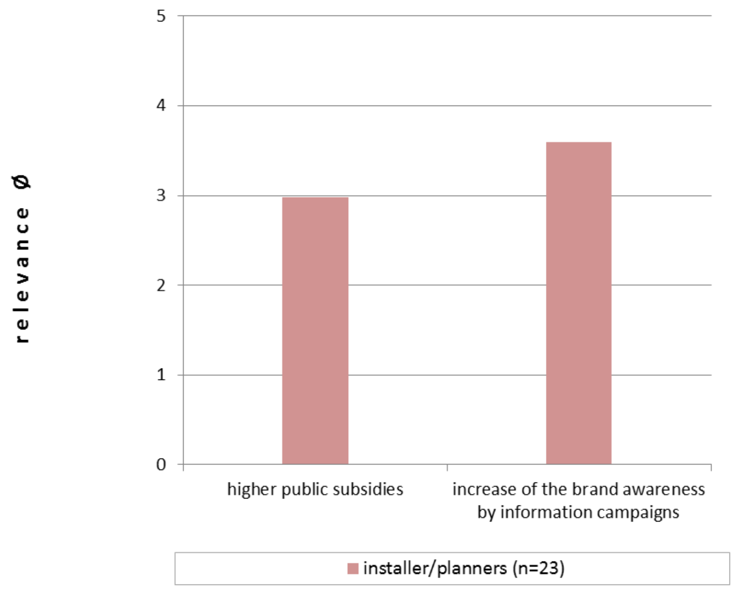

Figure 73: What are the main measures to speed up the market entry/diffusion of this technology?

10.2.3 User

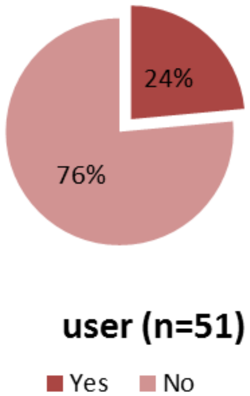

Figure 74: Do you know gas sorption heat pumps?

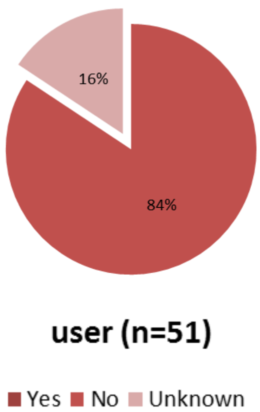

Figure 75: Do you already have gas driven heat pumps in use or do you know somebody who is using them?

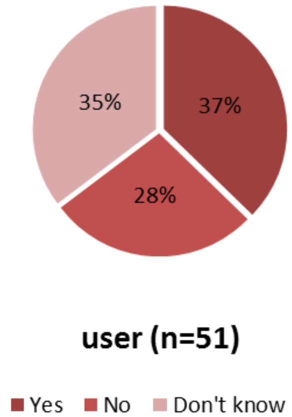

Figure 76: If you need a heating system would you consider purchasing a gas driven heat pump, if it is operated similar to a gas

condensing unit?

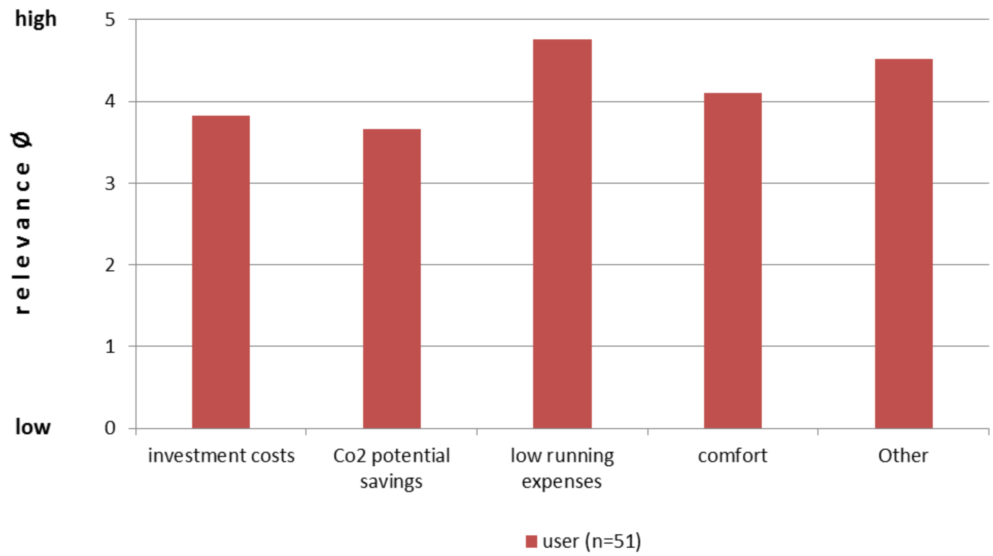

Figure 77: What is determining you buying decision on heating systems?

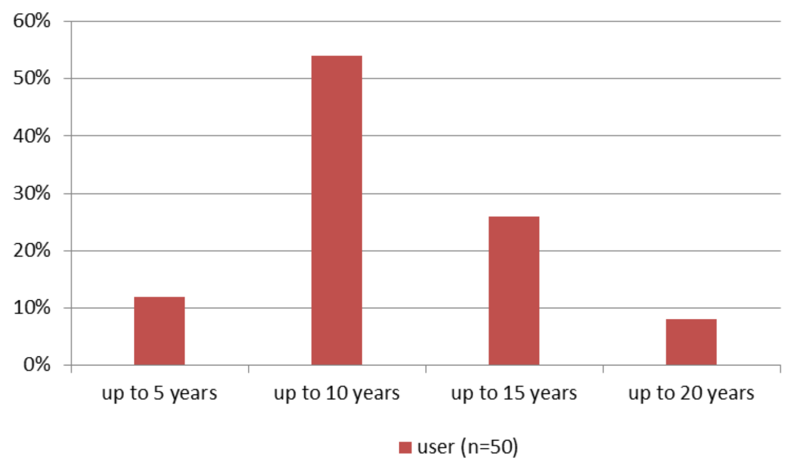

Figure 78: Which payback period is barely acceptable for you when buying an ecologically friendly heating system such as gas driven heat pumps?

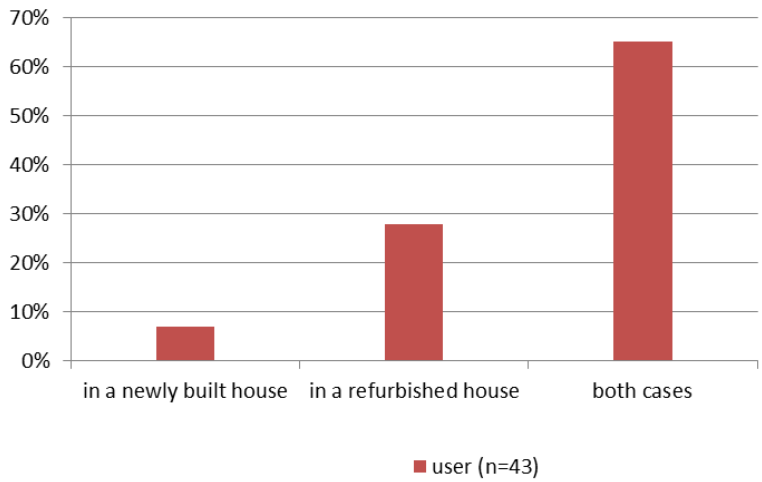

Figure 79: Where would you use a gas driven heat pump?

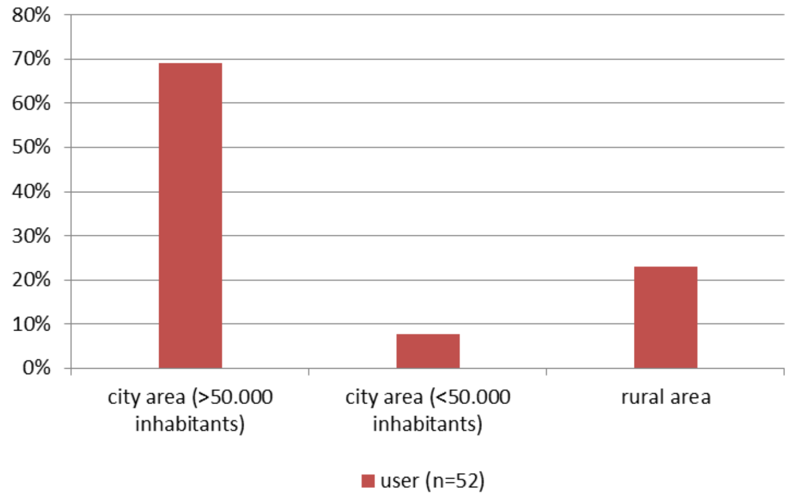

Figure 80: Where do you live?

10.3 Questionnaires

In order to guarantee that the filesize of the electronic version of the Country Report does not exceed 20 MB, the Questionnaires are not included in the electronic version.