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Competitiveness of the heating and cooling industry and services

Part 1 of the Study on the competitiveness of the renewable energy sector

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European Commission
B-1049 Brussels

Main Authors: Malene S Jespersen, Ivo Georgiev, Sára D. Jaganjacová (COWI)

COWI

Centre for European Policy Studies

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List of abbreviations

AEBIOM	European Biomass Association
Bioenergy Europe	Formerly AEBIOM
CAPEX	Investment costs
CEO	Chief Executive Officer
CHP	Combined Heat and Power
DG ENER	Directorate-General for Energy
EBA	European Biogas Association
EC	European Commission
EGEC	European Geothermal Energy Council
EHPA	European Heat Pump Association
ELENA	European Local Energy Assistance
Solar Heat Europe/ESTIF	European Solar Thermal Industry Federation
FTE	Full Time Equivalents
ISDE	Sustainable energy investment subsidy scheme
LCOE	Levelized Cost of Energy
MS	Member State
MW	Megawatts
MWh	Megawatt Hour
NECPs	Draft National Energy and Climate Plans
NREAP	National Renewable Energy Action Plans
OPEX	Operating Expenditure
O&M	Operations and Maintenance
R&D&I	Research & Development and Innovation
RES Directive	Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources
RED II	Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (recast)
RES	Renewable Energy Source
RES H&C	Renewable Heating & Cooling
TSE	Turun Seudun Energiantuotanto Oy

Abstract

This report constitutes the first part of a larger Study on the “Competitiveness of the Renewable Energy Sector”, conducted by COWI and CEPS for the Directorate-General for Energy (DG ENER) of the European Commission (EC). It analyses the competitiveness of renewable energy technologies within the heating and cooling industry. The study has focused on four segments constituting 93% of the European renewable heating and cooling industry: biogas, biomass, heat pumps and solar-thermal. The current stay of play within each technological segment is presented, including their impacts on the EU economy in terms of job creation and turnover based on the latest available data. The competitiveness is assessed through the application of Porter's Five Competitive Forces model based on data analysis and structured interviews. Four case studies have been conducted to examine the impact of local conditions in different European Union (EU) Member States (MS). Finally, the report includes an overview of the 2030 plans of the EU Member States including their heating and cooling targets and supporting policies, based on the draft National Energy and Climate Plans (NECPs).

Executive summary

This report summarises the key findings from a study on the competitiveness of renewables in the heating and cooling industry. Heating and cooling represent around half of the final energy consumption of the Union and is a key sector in accelerating the decarbonisation of the energy system.

The study was launched by the European Commission and conducted in the period November 2017 to June 2019. The study was implemented by COWI together with CEPS and has been conducted in parallel with another study on private companies' sourcing of renewable energy. Both studies have been implemented under the same contract, but results are reported in two separate publications.

The main objective of this study is to answer the questions: 1) How do renewable H&C technologies compete in the H&C sector? and 2) What is the impact of the heating and cooling sector to the EU economy?

This study focuses on four specific renewable energy sources (RES) technologies in the heating and cooling industry: biomass, biogas, heat-pumps and solar-thermal. From a methodological standpoint, the study was developed along two strands: a desk study part, particularly statistical data to provide the contextual background against which to understand the competitiveness issues of renewable energy in heating and cooling, and a part focusing on in-depth consultations with key stakeholders. The consultations include a questionnaire and is underpinned by the Porter's Five Competitive Forces model. Moreover, they are complemented by four case studies (one on each heating and cooling technology) and in the form of interviews with four pan-European heating and cooling technology associations. Furthermore, milestone meetings were held with an Advisory Board consisting of these associations and chaired by DG ENER. These meetings have provided an important tool for validation and discussion of key observations with the joint participation of all concerned associations[1].

The renewable energy sector has a significant contribution to the EU economy. The EU's RE sector employed around 1.4 million Full Time Equivalents (FTEs) considering direct and indirect employment[2] with a turnover of approximately EUR 154.7 billion, in 2017. A rough estimate indicates that nearly half of those jobs (45%, 650 800 FTEs) are within the heating and cooling industry (considering biomass, biogas, heat pumps and solar-thermal segments). The combined turnover of those four technologies is EUR 67.2 billion and EUR 82.3 billion when biofuels and geothermal sectors are included. Increasing the share of renewable energy sources used in heating and cooling could have a positive impact on the EU economy and simultaneously on its citizens and environment.

[1] The merit of this study lies in its reliance on concrete and experience-based information. This information has been provided by publicly available data, respective organisations and collected through the conduct of case studies. The key analytical elements of Porter's five forces model have underpinned this data collection to ensure comparability and consistency across segments. While this approach covers the largest share of the heating and cooling sector, it is not fully representative of the heating and cooling sector. For example, there are RES technologies that are not considered, e.g. geothermal and bioliquids. The focus is largely on renewables, and to a lesser extend fossil fuels.

[2] Direct employment includes equipment manufacturing, plant construction, engineering and management, operation and maintenance and supply and exploitation. Indirect employment, on the other hand, includes secondary activities, i.e. transport and other services. Although the figures are not disaggregated (e.g. numbers of direct and indirect jobs), it is worth noting that employment figures are related to the installed capacity of a technology in a given year, i.e. not capturing sudden fluctuations, as there could be periods when there is less new capacity installed resulting in a drop in FTEs.

The increase in renewable energy consumption also has an impact on fossil fuels use. In 2016 and 2017 the use of renewables in heating and cooling sector contributed to 33% of the total avoided fossil fuels. The impact in terms of jobs varies across Member States.[3]

This assessment indicates that the industrial competitiveness of renewables in the heating and cooling industry needs to be improved. A competitive RES alternative to fossil-based solutions in heating and cooling is a prerequisite for Member States to support the EU in reaching its binding overall renewable energy target for 2030 of at least 32%, as well as their individual heating and cooling targets set in the draft National Energy and Climate Plans.

The first issue that impedes on the competitiveness of renewables is costs. Three out of four key renewable heating and cooling (RES H&C) technologies do not appear cost competitive under current market conditions (in terms of LCOE and CAPEX, without public support), when compared to the alternative average energy carrier price in the EU[4]. Heat from solid biomass is the most cost competitive renewable option. The availability of district heating infrastructure can make centralised RES H&C solutions competitive, for example within the solar-thermal segment. On the other hand, biogas companies are competing mainly on national markets and current market conditions make them dependent on support schemes. Additionally, even with low operating costs, heat pumps are not cost competitive in the absence of support schemes due to their high upfront investment costs. Similarly, the solar-thermal segment is competitive when support schemes are available to cover part of the upfront investment costs.

There are number of key factors that impede on the cost competitiveness of RES in the heating and cooling sector:

- **The lack of a carbon price**. While carbon emissions imply a societal cost, there is not a price tag associated with this cost on the market, and this renders fossil fuels-based solutions relatively cheaper than they would otherwise be.

- **High investment costs**. The fact that RES H&C technologies demand relatively high up-front investment costs is often seen as a barrier for investment. These high upfront financing requirements can constitute a major barrier, even though solar thermal and heat pumps offer low operation costs.

- **Competitive rivalry.** This study indicates that competitive rivalry is limited in certain local areas, e.g. for biogas, solar-thermal and heat pumps. This limited competitive rivalry implies that there is a risk that the cost reduction supported may not be fully passed on to the buyers / energy consumers.

Another important factor that impedes on the industrial competitiveness is a substitution barrier:

- **Imperfect knowledge.** For RES H&C technologies to be fully competitive vis-á-vis fossil-based technologies, the market should possess the same level of knowledge regarding the costs and benefits of the different alternatives. For

[3] EurObserv'ER has assessed eighteen EU countries: Austria, Belgium, the Czech Republic, Germany, Spain, France, Italy, the Netherlands, Denmark, Finland, Greece, Ireland, Luxembourg, Poland, Portugal, Romania, Sweden and United Kingdom. The results refer to direct jobs only and cover the effects of RES development on operation and maintenance (O&M) and fuel production activities in the fossil sectors.

[4] The benchmark average energy carrier price is for large consumers EUR 34/MWh in the EU, according to the EurObserv'ER data and the State of Renewable energies in Europe 2018 report.

example, installers play a key role in providing advice and guidance. However, installers tend to be inclined to favour the solutions that suit their skills and that they are familiar with. A lack of awareness of the existence of relevant RES H&C technologies on the side of buyers and project owners may further reinforce this.

At EU and national level there are measures, actions and policies in place to support the deployment of RES in heating and cooling and improve their industrial competitiveness. Measures differ across Member States, reflecting specific priorities, contexts and opportunities. Whilst the flexibility and freedom of action is important to maintain, a more competitive market for RES in heating and cooling could be promoted throughout the EU and at MS level through alignment and sharing of best practices. A more competitive renewable heating and cooling market will lead to an increased competitive rivalry with more suppliers, a wider variety of products/services and more flexibility for consumers to switch towards a renewables service provider at low cost. As a result, the EU's heating and cooling consumers will have more powers to dictate terms on the market.

The following areas of intervention could increase the industrial competitiveness of RES H&C:

- **Easing administrative costs and barriers** - the more aligned procedures and requirements are, for example regarding technical requirements, certification and licencing, the easier it is to enter other markets and increase competition. These barriers have to be addressed through the provisions within the recast of the Renewable Energy Directive (RED II), which requires Member States to set up national contact points that would guide applicants throughout the entire administrative permit application and permit granting process (e.g. by means of a manual of procedures), and to time limits for the duration of the permitting process for small- and large-scale solutions.

  Addressing administrative cost and barriers will reduce the costs of delivering RES H&C solutions and thereby make those technologies more competitive in three ways. First, the removal of barriers will lead to entry into the market of new actors with better, more cost-effective solutions, and to consumers being able to select from a wider list of possible suppliers. Second, administrative costs and barriers have led to some extent to protected markets and the removal of such indirect market protection strengthens the competition in the H&C sector and can make it more attractive for new actors and technology suppliers to increase presence in the EU market. Third, the reduction of administrative costs will lead to more cost-competitive RES H&C solutions onto market if the cost reductions are carried on to consumer prices.

- **Recognising the important role that installers have** - when providing advice and guidance on technology choices. Installers need to have the skills, knowledge and awareness to treat and consider RES H&C technologies on par with other technologies. As per RED II, MS must ensure that installers undergo a training which leads to certification in the following technologies - biomass stove and boiler, heat pumps, shallow geothermal systems and solar photovoltaic and solar thermal.

  Enhancing the skills and knowledge of installers and thereby removing a possible inclination towards the well-known solutions (all other things equal) will increase the extent to which actual substitution opportunities are recognised, considered and selected. Thus, a possible decision-bias towards fossil-based solutions will be reduced and the competitive position of RES compared to fossil-based solutions improved.

- **Supporting energy consumers** – in identifying the right technology choice possibly combined with implementation assistance. RED II provides for enhanced consumer rights regarding the information they receive on the performance of a given technology (e.g. heating and cooling system) and regarding their right to disconnect or terminate their contract.

  Supporting consumers will help to close possible information gaps, remove information biases and scepticism that relate to implementation uncertainties, or elements that may have disfavoured RES solutions. Thereby, the competitiveness of RES compared to the known fossil-based alternatives is improved. Further, such objective and informed support can help to improve the negotiation power of consumers and thereby ensure fair prices and cost-effective solutions. Such support may strengthen the consumers ability to drive down prices in cases where they currently suffer from insufficient knowledge.

- **Developing efficient support schemes** – to improve the competitiveness of RES H&C also considering support favouring fossil fuels and / or allocated only to RES electricity (not H&C).

  Support schemes can improve the cost-competitiveness of RES H&C and compensate for the lack of a full carbon price in the H&C sector. They can strengthen the competitiveness of RES vis-à-vis fossil fuels and could also help RES H&C to compete on similar terms as RES electricity. If the objective of the support scheme is to increase the use of RES H&C, the cost competitiveness to heating consumers' needs to be improved. Support can assist in this as it can drive prices down.

  Consumer price is a key factor to stimulate consumer demand and thereby the competition of H&C production. However, competition among suppliers within RES H&C is not yet fully developed. Attracting more suppliers and new entrants will increase the competitive rivalry which can drive consumer prices down. In this context, co-production of RES electricity and H&C is an important factor in establishing the sound business case for suppliers (as for example for biogas, as detailed in the case studies).

In addition, in the existing building stock **there are potentials for refurbishments that involve the introduction of RES H&C technologies** replacing old fossil-based solutions. Incentives to promote such choices can help to accelerate the use of, and demand for RES technologies.

Furthermore, there are market conditions that can weaken or promote the competitiveness and therefore the pace at which RES are deployed in the heating and cooling sector. For example, the structural lock-in of technology choices is a challenge. It implies that the 'window of opportunity' for technology shifts is rare and short. Technologies have a life time that spans 15-20 years, and installations may even be in operation after the expiry of the technical life time. This implies that a specific technology choice has a rather long time-horizon. Further, it is not uncommon that replacements occur when there is a break-down and thus not necessarily as part of a planned cycle. Hence consumer information, installer training and campaigns promoting the planned replacement of older heating systems is relevant.

Lastly, district heating and cooling infrastructures present an opportunity for centralised solutions benefiting from the economies of scale, thus improved efficiency and lower operational cost.

1. Introduction

This report constitutes the first part of a larger study on the "Competitiveness of the Renewable Energy Sector", conducted by COWI and CEPS for DG ENER of the European Commission. It focuses on the competitiveness of renewable energy technologies within the heating and cooling industry. More specifically, it assesses the competitiveness of the industry by focusing on biogas, biomass, heat pumps and solar-thermal segments relying on desk research, data analysis, consultation activities and four case studies illustrating local conditions in different EU Member States.

The Porter's Five Forces model has underpinned much of the analysis.

Text Box 1: Overview of Porter's Competitive Five Forces Model

Porter's five competitive forces model has underpinned the assessment by investigating:

1. **What is the strength of competition in the EU's H&C industry?** *The Competitive Rivalry Force illustrates the strength of competition in the H&C industry. It analyses the number and strength of competitors within the H&C sector, including: How many rivals are there? Who are they, and how does the quality of their products and services compare? Intense rivalry can limit profits and lead to price cutting, increased advertising expenditures, or increased spending on service/product improvements and innovation.*

2. **What is the extent to which different H&C products and services can be substituted?** *The Threat of Substitution force demonstrates the extent to which different products and services can be substitutes. It analyses the likelihood of customers finding a different way of obtaining H&C services and products. A substitution that is easy and cheap to make can weaken competitiveness and threaten profitability*.

3. **What is the strength of customers to drive down H&C prices?** *The Buyer's Power force illustrates the strength of customers to drive down H&C prices. It analyses how easy it is for customers to drive H&C prices down. How many buyers are there, and how big are their orders? How much would it cost them to switch a product and service to those of a rival? Are buyers strong enough to dictate terms?*

4. **What is the ability of suppliers to drive up the prices of H&C inputs?** *The Supplier's Power Force demonstrates the ability of suppliers to drive up the prices of H&C inputs. Similarly, as with buyers, this force suggests how easy it is for H&C suppliers to increase their prices? How many potential suppliers are there? How unique is the product or service that they provide, and how expensive would it be to switch from one supplier to another?*

5. **What is the ease with which new competitors can enter the EU H&C market?** *The Threat of New Entry force illustrates the ease with which new competitors can enter the H&C market. It suggests how easy is it to get a foothold in the RES H&C industry or market as an EU stakeholder? How much would it cost, and how tightly is the H&C sector regulated?*

Data to inform the analysis have been collected from industry associations at EU level and through four specific case studies illustrating national/local factors impacting the deployment of specific technologies. Further, the analysis has been supported by immediately available quantitative data from publicly available sources and provided by the associations.

The study has consulted with an Advisory Group consisting of representatives of European heating and cooling associations[5]. The implementation of the study has been followed by a Steering Committee established by the Commission.

Against this background, the report is structured as follows:

- Chapter 2 provides evidence on the competitiveness of the EU renewable energy sector within heating and cooling, focusing on the segments of biomass, biogas, heat pumps and solar-thermal.
- Chapter 3 outlines the impacts in the EU from renewables in heating and cooling, in terms of employment (direct and indirect jobs), as well as turnover (in million euros) per EU Member State.
- Chapter 4 puts forward policy recommendations to foster the deployment of renewable heating and cooling technologies in the EU.

The Final Report is complemented by two Annexes:

- Annex A (composed of four separate documents, from A.1 to A.4) presents four case studies of renewable energy heating and cooling technologies.
- Annex B provides an overview of the 2030 targets and policies of the EU Member States in the context of heating and cooling (based on their draft NECPs).

1.1 Background

In recent years the renewable energy sector has experienced rapid growth. Technological improvements, market competition and economies of scale continue to enable the lowering of the levelized cost of energy of renewables. Cost reductions improve the competitiveness[6] of renewable technologies relative to fossil fuel-based alternatives.

The European Union has built global leadership in the renewable energy sector with its policies.[7] Over the last decades the EU has managed to promote renewable energy and energy efficiency to decouple greenhouse gas emissions from economic growth thus demonstrating that decarbonisation and growth can go hand in hand.[8] Moreover, strengthening the EU's industrial competitiveness is a key for the future of Europe's economy. The recently adopted Industrial Policy Strategy aims to help European industries become the world leader in digitalisation, innovation and decarbonisation. Hence, the clean energy transition plays a key role in boosting Europe's competitiveness in building a strong industrial base in the EU. The renewable energy sector also has the

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[5] The Advisory Group consists of the European Biomass Association (AEBIOM, nowadays Bioenergy Europe), the European Biogas Association (EBA), the European Heat Pump Association (EHPA), European Solar Thermal Industry Federation and the European Geothermal Energy Council (EGEC).
[6] Competitiveness of the H&C sector is defined as the ability of the RES H&C sector to sustainably produce and sell technologies and services on a given market (inside or outside the EU) in a way that buyers prefer these against such offered by competitors. RES H&C technologies and services sales are growing at a higher rate than the total H&C market and of competitors (in a growing market), while maintaining an adequate return.
[7] https://ec.europa.eu/energy/sites/ener/files/documents/cop21-brochure-web.pdf
[8] https://www.governmenteuropa.eu/clean-energy-innovation-dg-energy/85648/

potential to stimulate employment in the EU through creation of new job opportunities - the sector accounts for more than 1.4 million jobs across the EU.[9]

Against this background, the EU Clean Energy Industrial Forum was created by the European Commission in 2017 and held its first meeting in January 2018[10]. The objective of the Forum is to consolidate the industrial base for renewables in the EU, identify new actions and initiatives for key sectors and develop recommendations on how to strengthen the EU value chain for renewable energy technologies. The Forum is part of the framework established to support the 'Clean energy for all Europeans' package and consists of numbers of CEOs/leaders from institutions and companies across the value chain of Europe's renewable energy industry. The Forum is supported by a Task Force which developed a set of proposals and recommendations. Furthermore, the recent proposal by the European Commission for a climate neutral economy by 2050 would provide the European industry with a strong long-term home market and thereby with a competitive advantage to maintain and strengthen Europe's global leadership in the renewable energy sector.[11]

Representing around half of the final energy consumption of the Union, the heating and cooling sector is a key sector in accelerating the decarbonisation of the energy system. Under current legislation of the Renewable Energy Directive (RED), EU Member States have to promote renewable heating and cooling technologies, and develop National Renewable Energy Action Plans (NREAPs) up to 2020 in which they commit to increase the final energy consumption from renewable energy sources by deploying heating and cooling technologies. Based on these plans, those technologies include solid biomass expected to cover (72,3%), heat pumps (11,04%), solar-thermal (5,77%), biogas (4,05%) and others such as bio-liquids (4,47%) and geothermal (2,37%)[12]. The information indicates an average 2030 target for heating and cooling of 36%. Regarding the individual sectors, the renewable energy share in heating and cooling (and also in electricity) has been above the levels defined by Member States in their NREAPs. Overall, the numbers suggest that the EU is on track to reach its 2020 target.[13] In 2017, renewable energy accounted for 19.5 % of the total energy used for heating and cooling in the European Union. In comparison, this share was just 10.4 % in 2004. Increases in industrial sectors, services and households contributed to this growth. Aerothermal, geothermal and hydrothermal heat energy captured by heat pumps was also taken into account if reported by countries[14].

However, the absence of a harmonised strategy at Union level, the lack of internalisation of external costs and the fragmentation of heating and cooling markets have, to date, led to relatively slow progress in the sector. For the period from 2021 onwards, the recast of the Renewable Energy Directive strengthens the provisions that promote renewable heating and cooling options. Under this new directive (RED II), Member States must carry out an assessment of their potential of energy from renewable sources and the use of waste heat and cold in the heating and cooling sector, in particular to promote energy

[9] COM(2019) 175 final Fourth report on the State of the Energy Union, https://ec.europa.eu/transparency/regdoc/rep/1/2019/EN/COM-2019-175-F1-EN-MAIN-PART-1.PDF

[10] http://www.solarpowereurope.org/european-commission-launches-clean-energy-industrial-forum-to-boost-solar-jobs-and-investment-in-europe/

[11] https://ec.europa.eu/info/news/climate-neutral-economy-will-give-european-renewable-energy-industry-global-competitive-advantage-2019-mar-18_en

[12] Those first four technologies cover over 93% of the contribution to the 2020 target and were selected for more in-depth analysis under this study NREAPs: https://visualise.jrc.ec.europa.eu/t/NREAPs/views/RES_HC_download/RES-HC_download?:embed=y&:loadOrderID=0&:display_count=no&:showVizHome=no

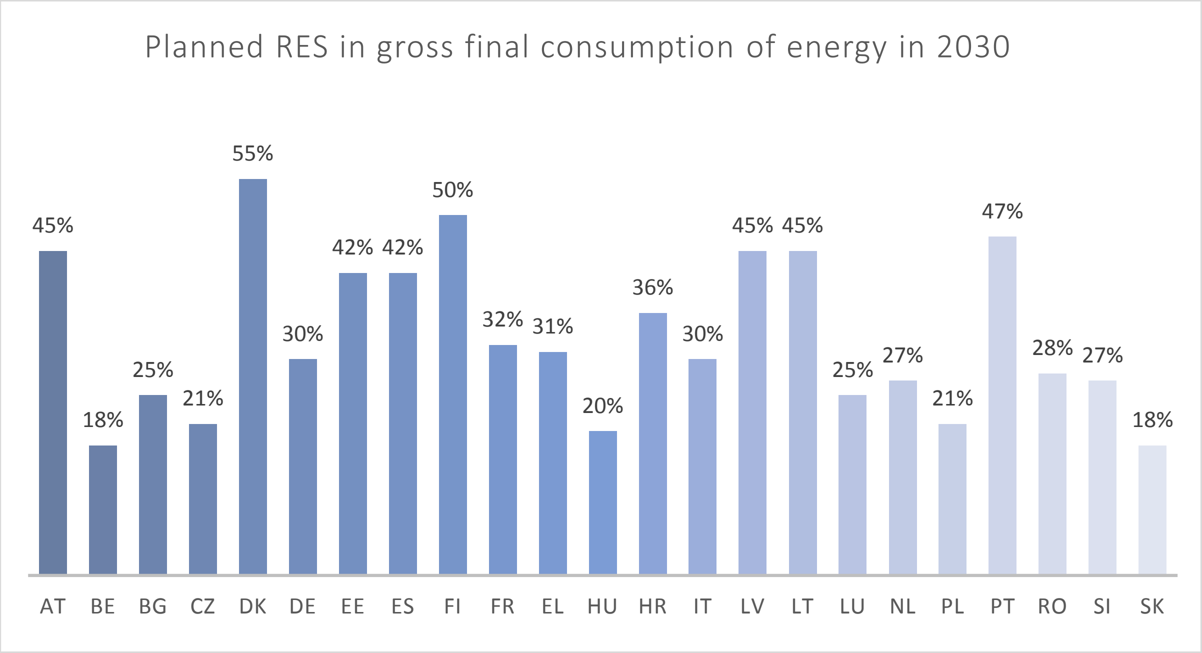
[13] European Commission: RES 4th progress report, 2019

[14] https://ec.europa.eu/info/news/energy-heating-cooling-renewable-sources-2019-mar-04_en

from renewable sources in heating and cooling installations and promote competitive and efficient district heating and cooling. Member States shall also endeavour to increase the share of renewable energy in that sector by an indicative 1,3 percentage points per year from 2020 to 2030.

Furthermore, the Member States are required to develop integrated National Energy and Climate Plans (NECPs) for the period 2021-2030, which cover the five dimensions of the Energy Union and explicitly requests plans for renewable heating and cooling. The EU Member States were obliged to submit a draft NECP by the end of 2018. The Commission monitors the progress of the EU, as part of the annual State of the Energy Union report[15]. The figure below illustrates the 2030 RES targets[16] of the EU Members States based on their draft NECPs. From the countries which submitted such targets, Denmark and Finland lead the way with over 50% of planned renewable energy in their final consumption. Austria, Estonia, Spain, Latvia, Lithuania and Portugal also indicate targets above 40% renewables by 2030.

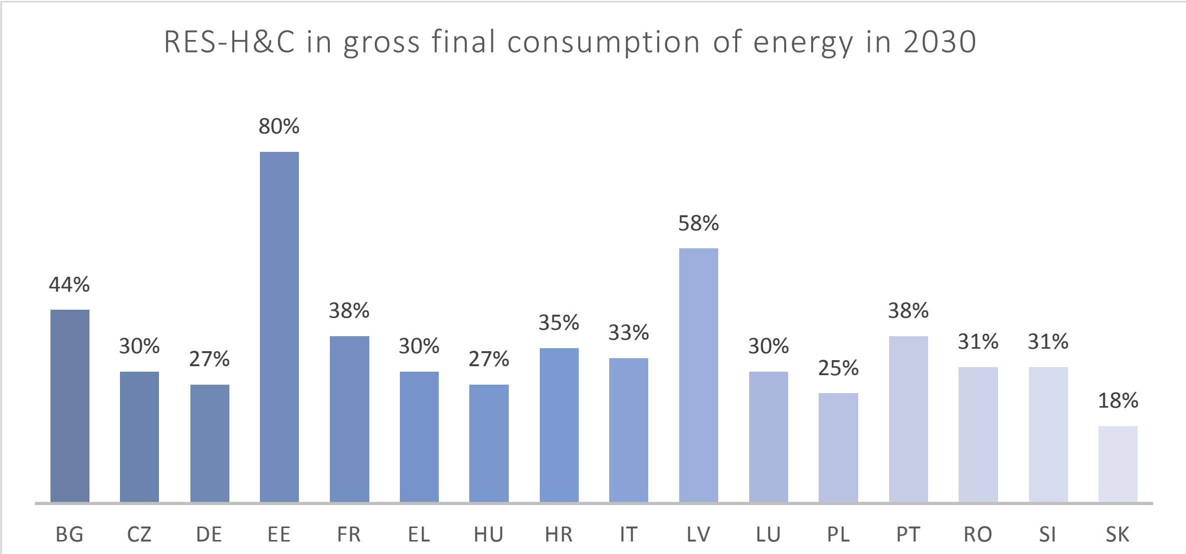
Figure 1: Planned RES in gross final consumption of energy in 2030



Source: Draft NECPs[17]

[15] https://ec.europa.eu/commission/publications/4th-state-energy-union_en
[16] The RES targets cover electricity, heating and transport
[17] Missing MS data for Cyprus, Ireland, Malta, Sweden and United Kingdom. The lower target from provided range was included in the chart for Austria.

Figure 2: Planned RES-H&C targets from gross final consumption of energy in 2030 across MS



Source: Draft NECPs[18]

16 Member States have included 2030 RES H&C targets in their draft NECPs[19], including policies and measures to support the transition to renewable heating and cooling. These include for example the modernisation of CHP plants, renovation of heat networks, development and/or modernisation of the district heating infrastructure.

From our review of the NECPs, it appears that awareness and promotion of renewable energy is rising across all the Member States. For example, in France there are awareness campaigns to promote the use of biomass, solar heating and heat pumps. Furthermore, the use of renewable systems in the heating and cooling industry is promoted via auctions, feed-in tariffs, aid schemes and grants. Numerous support schemes to promote the use of renewable energy for households have been launched or are planned to be launched. These schemes could be, for instance, new support mechanisms for electricity and heating from high efficiency cogeneration, solar water heaters, promotion of the use of waste heat and cold.

Furthermore, the EU Member States are promoting the use of renewable energies by implementing financial incentive schemes. Financial instruments and aid from state and EU funds play an important role in contributing to the country's RES targets. Among the most common incentives within heating and cooling are for instance funds and aid for boiler replacements, heat pumps and solar heating. These incentives can also be tax deductions and energy taxes to encourage more people to use green solutions. For example, the use of heat pumps (Denmark), forest chips (Finland) or solar heating (France). In some Member States, mandatory share/amount of renewable energy is required in new buildings and newly renovated buildings.

[18] Austria, Belgium, Cyprus, Denmark, Estonia, Finland, Ireland, Lithuania, Malta, Netherlands, Sweden, UK are remaining 12 Member States for which data on 2030 targets are not available yet.
[19] With France having target only for heating.

2. Competitiveness of renewables in the European heating and cooling industry

This chapter provides evidence on the competitiveness of the EU renewable energy sector within heating and cooling, focusing on the segments of biomass, biogas, heat pumps and solar-thermal. It discusses indicators impacting the competitiveness, such as the Levelized Cost of Energy (LCOE), Capital Expenditure (CAPEX), the energy carrier price, as well as opportunities for technology upgrades at the end of the technology lifetime and the impacts of the availability of district heating infrastructure. It further describes the current state-of-play of each segment in Europe. It considers the context of the industry and assesses the technology segment’s competitiveness when compared to the average energy carrier price for heating. The section also provides an overview of key observations from each of the four case studies (Annex A).

Prior to going into the specific technologies, this chapter elaborates on three themes that cut across individual technologies and which have an impact on the penetration of RES into heating and cooling: the cost levels, the role of district heating and the risk of technology lock-in.

Under current market conditions, three out of four RES H&C technologies do not appear cost competitive (in terms of LCOE and CAPEX, without public support), when compared to the alternative energy carrier price in the EU.

To assess the economic competitiveness of RES H&C technologies, it is necessary to derive the costs of a system (accounting for its characteristics such as technology, quality, size, location, etc.) and compare them to the cost of an alternative. That can be challenging on an aggregated EU level as in some Member States a RES H&C technology can be competitive, but in others the same technology may not. Differences in factors that determine the costs are for example location (e.g. heat from solar energy can be generated cheaper in Southern Europe than in Northern Europe) and operational aspects. In addition, the financing characteristics, the energy yield, as well as the energy carrier prices across the EU impact competitiveness [20].

The LCOE[21] is an approach for assessing the economic competitiveness [22]. It is applied for both electricity and H&C production. The method computes the average cost of energy over the lifetime of a plant/installation taking into consideration main cost components, such as investment, operations and maintenance (O&M), fuel, and decommissioning. The amount of fuel needed to produce heat is calculated separately based on its conversion efficiencies. In that way, the LCOE remains constant throughout the lifetime of the system and can be compared to the cost of the alternative (e.g. the energy carrier price), indicating the competitiveness of the specific technology.

[20] The State of Renewable energies in Europe 2018, EurObserv’ER

[21] The levelized cost of energy (LCOE) refers to the cost estimate of renewable energy production. It enables reporting the cost information of different renewable energy technologies in all Member States in a comparable manner.

[22] The renewable energy technology LCOE analysis requires a significant amount of data and assumptions, such as the capital expenditures, operational expenditures, fuel costs, economic life, annual energy production auxiliary energy requirements and fuel conversion efficiency. Thus, the figures presented are indicative. According to EurObserv'ER, the energy carrier costs presented in this report are based on statistical sources (Eurostat, European Commission) and own calculations. For heating technologies, the reference fuels (a Member State specific mix) are exposed to an assumed reference thermal energy conversion efficiency of 90% (capital and operational expenses are currently neglected in this approach). Heat prices are excluding taxes and levies and based on large consumers. They are calculated based on the country-specific average fuel mix. Where data were missing, average EU-data have been used.

In the context of RES H&C, the reference average energy carrier price for large consumers is EUR 34/MWh in the EU, according to the EurObserv'ER data and the State of Renewable energies in Europe 2018 report [23]. This price is lower than the LCOE of biogas and individual/residential heat pumps and solar-thermal systems, but in the LCOE range for heat produced from solid biomass[24]. As a result, only heat from solid biomass appears a cost-competitive RES H&C technology.

When adding fossil fuels alternatives into the assessment, none of the four RES H&C technologies appear cost-competitive. For reference, the average retail gas prices for industrial consumers reached 22 EUR/MWh in 2017, which is lower than the LCOE of any RES H&C alternative[25]. The gas prices for EU households which are significantly higher (approximately 60 EUR/MWh in 2017) can make solid biomass cost-competitive.

The investment costs required to make the renewable energy upgrades often represent a major barrier in the residential sector, followed by structural changes involved and the need of approval by neighbours. In the non-residential sector, the high investment cost barrier is the most significant [26]. Furthermore, from a private-economic perspective, heat pumps have both a higher LCOE and higher CAPEX than the alternative natural gas boiler system[27]. However, from a socio-economic perspective, heat pumps can be a competitive technology, especially if heating and cooling are considered together.

The availability of district heating infrastructure can improve the competitiveness of centralised solutions such large-scale renewable heating and cooling technologies, for example within the solar-thermal segment. Some RES H&C technologies such as solar-thermal can be much cheaper at scale but require a district heating grid for the distribution. However, the district heating infrastructure is not necessarily financially feasible to construct. For inner-city area district heating, the initial investment cost (distribution grid per consumer and home installation) is estimated to be around EUR 3 900[28].

Compared to this, the cost of a decentralized heating solution such as a gas boiler dimensioned for equivalent comfort, typically has an initial investment cost of about EUR 5 000. In case the building is not connected to a gas grid, an additional EUR 2 000 gas grid connection could be added on top of the boiler cost. The district heating is financially feasible for communities with heat densities that are comparable to inner and outer cities areas, especially if local waste heat from industry or a power plant is available.

Replacements with the same fossil-fuel based systems is easier and cheaper to implement and can create structural lock-in effects. Heating and cooling systems last typically 15-20 years. At the end of their lifecycle there is a time opportunity to upgrade a fossil-fuel based system with a renewable alternative. Sometimes an

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[23] The energy carrier price ranges between 23-63 EUR/MWh across the EU. This range does not include taxes and levies and is applicable for large consumer types according to EurObserv'ER. The impact of taxation on natural gas prices is 26% on household bills (compared to 40% for electricity) and only 10% of large industrial gas consumers. https://ec.europa.eu/transparency/regdoc/rep/10102/2019/EN/SWD-2019-1-F1-EN-MAIN-PART-1.PDF

[24] According to the State of Renewable Energies in Europe 2018 Report and EurObserv'ER data, the LCOE for heating from solid biomass ranges between EUR 32-38 per MWh. For heating from residential heat pumps, it ranges between EUR 133-157 per MWh and for heating from residential solar water heaters between EUR 199-277 per MWh. However, other studies by the RHC-Platform and IEA refer to solar thermal heat costs starting as low as EUR 30 per MWh for domestic hot water in Southern Europe. The LCOE of biogas is in the range of EUR 153-173 MWh (for electricity, as no EU data was available for heating only).

[25] Eurostat

[26] Front European Report on end user decision making factors for HC systems

[27] Sensitivity analysis indicates that heat pumps' CAPEX would need to fall by more than 50% to make them cost-competitive (Technical and economic feasibility of sustainable heating and cooling supply options in European municipalities)

[28] https://www.witpress.com/Secure/elibrary/papers/ESUS13/ESUS13009FU1.pdf

emergency replacement is necessary, and the easy solution is often to add (or replace) gas boilers, instead of identifying a renewable alternative which may be more expensive or take longer to implement. This emergency replacement can have a "lock in" effect in fossil-fuel based systems. Such a lock-in could be avoided if a renewable energy solution is purchased and identified in advance, which can be implemented without delay in case an emergency replacement is needed.

2.1 Assessment of the biomass technology segment

2.1.1 Current state of play

The gross final energy consumption of the bioenergy sector in Europe has experienced an average annual growth rate of almost 5% between 2000 and 2015 and a similar trend is expected up to 2020, according to Bioenergy Europe. The biomass heat segment represents the largest share of the bioenergy sector (about 75% of the gross final energy consumption). The heat segment has experienced the highest growth rate so far, when compared with biomass for electricity and transport. Most of the consumption of biomass for heating is concentrated in the residential sector (above 50%). Solid biomass fuels (mostly wood based) represent 91% of the biomass fuel used for heat.

The wood-based biomass sector for residential uses is highly fragmented and mainly composed of SMEs. It includes two segments: i) producers of biomass heating systems (e.g. stoves and boilers); and ii) producers of solid biomass (e.g. woodchips and pellets). The number of players operating in the EU is large. For instance, only in France over 2,500 companies were producing and distributing solid biomass in 2018. In the EU, Bioenergy Europe estimates that over 10,000 companies operate in the sector.

The number of market operators has been increasing, especially after the enactment of the Renewable Energy Directive and the introduction of public schemes supporting the transition to renewable heating and cooling. However, the following trends can be envisaged: i) the biomass heating system segment will most likely undergo a consolidation phase, due to stricter regulatory requirements (e.g. eco-design, air emission rules) that will increase production costs and displace producers of low quality equipment; ii) more efficient heating systems will require less fuel to generate the same amount of heat, thus reducing per capita demand of solid biomass; iii) new national targets for renewable heating and cooling set out in Article 23.1 of the revised Renewable Energy Directive will foster demand for both heating systems and solid biomass.

However, there are a number of barriers impinging on the growth rate of the biomass sector for residential uses. Those include: i) relatively high investment costs required to install biomass heating systems (this includes administrative costs linked to permitting for e.g. chimneys); ii) need for space to stock the biomass iii) public schemes supporting traditional energy solutions such as condensing gas boilers; and iv) lack of harmonisation of emission testing methods and of standards for the eco-design of biomass heating systems. In addition, public acceptance is a barrier, as households are increasingly concerned about deforestation and are not sure whether the production of wood-based biomass is environmentally sustainable.

2.1.2 Competitiveness of the biomass industry

Woody biomass heating systems for residential uses generally complement other systems. This means that on the one hand, competition with other heat systems is limited; on the other hand, consumers can easily reduce their biomass consumption and increase consumption of other heat sources based on price signals (e.g. increase in price of wood- based fuel or decrease in price of gas and electricity).

The main competitors of the biomass sector for residential uses include heat pumps, gas-based heating systems and electricity-based heating systems. Woody biomass heat has the following main advantages: i) low operating costs ii) independence (no need to be connected to the power grid or natural gas grid); iii) cosiness (it generates high-temperature heat); iv) limited environmental impact (low CO_2 emissions when compared to fossil fuel alternatives). In terms of energy efficiency, new biomass technologies can ensure up to 90% of energy conversion efficiency. However, on average the energy efficiency is approximately 60 to 70%, as open fire places are rather inefficient.

The buyers of wood-based biomass for residential uses have no power to drive down the prices of solid fuel or heating systems. The market demand is very fragmented, mainly made up of households based in rural areas. By contrast, in those regions where biomass district heating is popular (e.g. some Central Eastern European Member States), some buyers have relatively more power as they purchase heating systems via public tenders and may negotiate quantity discount for wood-based fuel.

The ability of biomass suppliers to drive up prices is low for two main reasons. First, the suppliers are mainly SMEs (most of them are micro-enterprises), which have limited power and compete. Second, biomass heating systems for residential uses often complement other types of heating systems (e.g. gas heated systems); hence, consumers can decide to reduce their consumption of woody biomass and switch to different heating sources in case of a spike in the biomass price.

Raw materials and components used for biomass heating systems are not highly specialised. Suppliers of such inputs generally do not have a significant market power. Also, suppliers of raw materials (e.g. forest management operators, forest-based industry) for wood based solid fuel have limited market power, as they just sell by-products that would otherwise largely generate disposal costs. However, at the local level, they may have some market power for two reasons. First, by-products used to produce wood-based biomass have a very low value-to-weight ratio and cannot travel long distances; hence producers of solid fuel depend on local supply of such by-products. Second, producers of wood-based biomass compete with each other and/or with producers of paper to purchase by-products from forest management operators and forest-based industries. This explains why they pay a positive price for raw materials that otherwise would just generate disposal costs.

2.1.3 Case study

The competitiveness of the biomass resource for heat production is further described in a case study on biomass at CHP plant in Naantali, Finland (Annex A). A summary of the case study is presented in the Text Box below.

Text Box 2: Case study: Biomass at CHP plant in Naantali, Finland

TSE aims to use regional and other sustainable sources of energy, while pursuing carbon-neutrality in the longer-term. The €240 million investment helps biomass and other fuels to supply heat to over 200,000 people in the Turku region. The heat is distributed via approximately 15 km of district heat transfer pipe. About 600 GWh of biofuel is imported by sea (one shipment per week) from the Baltic sea region (originating from Russia and Belarus). On average, 60 truckloads of biomass are transported to the Naantali power plant each day. The expected technical life of the CHP plant is several decades. The layout and structures of the plant allow for future development needs and changing the ration of fuels used (e.g. increase of biomass to 100%). For 2019, the target of TSE is to run 70% on biomass and invest in flue gas condenser that will increase the production of district heat by 60 MW.

Biomass is a competitive energy source in Finland compared to other alternatives (e.g. coal also without subsidy).

Competitiveness factor		Description
Positive	Government policy	The use of coal in energy production will be prohibited by law in 2029
Positive	Government support for investment	Subsidies are linked to the CO_2 emissions price, which is currently high, and thus biomass fuels receive a low Government subsidy, however it is still competitive.
Positive	Investment costs	The district heating market is liberalized, and price level is set to be competitive with best-alternatives for end-customers.
Neutral	Heat generation costs	Heat production price is set based on own production costs or based on voluntarily negotiated long-term heat supply agreements with 3rd parties. Biomass is cheaper than coal in Finland and, at the current price levels of emission allowances, peat is competitive compared to coal.
Negative	Feed-in tariffs	The Governmental support paid to forest chip electricity in 2015 amounted to EUR 33 million, and it has made amendments to energy taxation and operating aid for forest chip electricity.

2.2 Assessment of the biogas technology segment

2.2.1 Current state-of-play

Biogas heat production has increased significantly in recent years by an average annual 17% in the period from 2012 to 2016 (from 351.1 ktoe to 694.8 ktoe)[29]. For comparison, biogas counted for a modest share of 1% in 2005. Most biogas production takes place in Europe and US. Globally, some 4% of bioheat is produced from biogas. In Europe, about half of the biogas consumption is used for heat. The leading countries in Europe (in terms of heat production from biogas) are Germany, Italy and Denmark.

The number of biogas plants in Europe almost tripled from 2009 to 2016 reaching a total of 17,662. Some 62% of those are in Germany. The dominant technology is anaerobic digestion fed by organic feedstocks. Proximity to feedstock is a key factor to minimise transportation costs. Many plants are designed for electricity production, and thus heat generated through the electricity production is often and largely wasted. Increasing the utilisation of the produced heat demands additional investments particularly to provide for the distribution of the produced heat to consumers. Biogas benefits from existing gas boilers and the main capital costs relate to the distribution.

2.2.2 Competitiveness of the biogas industry

The market is fragmented with many smaller specialised companies and different component suppliers. In Europe, there are 388 biogas companies of which some 10% are

[29] Heat only plants and CHP plants: The State of Renewable Energies in Europe, Edition 2017, EurObserv'ER report https://www.eurobserv-er.org/17th-annual-overview-barometer/

technology manufacturers and the remaining are for example component providers, project developers and planners. Today's dominance of Germany in biogas production demonstrates the high potential in other parts of Europe. Promoting and accelerating the European production of biogas could thus help to further strengthen the position of the European industry; within Europe and globally. A growing EU market is a strong facilitator of the built-up of a globally competitive biogas sector (technology providers, component providers etc.). The biogas value chain today is localised (especially upstream[30]) and most actors are active in their domestic markets mainly. The reason for this is mostly administrative (e.g. permitting processes) and local conditions such as language barriers and proximity to the feedstock. Component and technology providers seek to access the international markets.

EU policy frameworks including particularly RED II and the national biogas targets are key drivers in promoting a growing biogas production in Europe. The competitiveness of biogas electricity is supported by feed-in tariffs and other support schemes[31]. However, the incentives for using biogas heat are less widespread, resulting in only around 10% of the biogas heat production being used.[32] Biogas heat production is confronted with high capital requirements and with strong competition from the lower price of natural gas. Electric heaters and electric heat pumps are other relevant competing alternatives.

High capital requirements can to some extent be met by financial support schemes, at national and EU level that need however to be carefully implemented. Another key factor is to have an ensured outlet and hence a predictable income stream from the heat production to finance first and foremost the capital costs incurred, but also the operational costs. The key threat in this regard lies in the capital requirements that challenge the price competitiveness of biogas heat, and price of the feedstock.

To deliver the necessary income streams, and thereby also providing other positive features of large-scale biogas heat production (e.g. contribution to climate change mitigation and circular economy), the plants can be developed jointly by natural persons, including local farmers such as the owner of the areal, the owner of the arable land, the owner of the pig farm. Such joint developments provide market volume and increases bargaining power in negotiating purchase contracts prior to undertaking the investment.

2.2.3 Case study

The competitiveness of the biogas as a resource for heat production is further described in a case study: Biogas Plant in Trebon, Czech Republic (Annex A). A summary of the case study is presented in the Text Box below.

Text Box 3: Case study: Biogas Plant in Trebon, Czech Republic

The biogas plant in Trebon (CZ) is an agricultural biogas plant that was constructed at a cost of EUR 4.5 million, 25% of which having been funded through ERDF. Feed is mainly maize silage from local farmers and grass silage from the nearby floodplains. Capacity is 12,000 m³/day of biogas. The biogas is transported from the biogas plant to the CHP through a 4.4 km pipeline constructed for the purpose. The electricity is sold to the grid at feed-in tariffs (fixed and with a guaranteed duration of 20 years). A small fraction of the biogas is distributed via a small CHP that produces electricity for the grid and heat for use by the biogas plant in fermentation.

The plant supplies heat to a municipal spa facility and an apartment blocks by a CHP with a capacity of

[30] There are examples where the produced biogas is being transported and sold in another country (e.g. produced in Denmark and transported and consumed in Sweden)

[31] That sometimes however suffer from the lack of EU coordination. An example is the current national schemes in Denmark and Norway where Denmark supports the biogas production, and Sweden supports the consumption.

[32] According to the European Biogas Association

855 KWel and 840 KWth. The utilisation of the biogas heat is about 55%-60%, resulting in a heat supply of between 4.2 and 5.5 GWh. The heat is sold to consumers at a price 10%-20% below the market price for natural gas heat.

Competitiveness factor		Description
Positive	Feed-in tariffs	Feed in tariff for electricity was essential for opting for the investment in the plant
	Secured demand	A contract with the heat buyers entered before construction at a price below the natural gas market price. The electricity was sold to grid at a feed in tariff.
	Secured supply	The project is based on local supplies of feedstock and is owned by locals with a vested interest in it (land, feedstock). In addition, the local community accepted the construction of the plant.
Neutral	Investment support	Investment: 25% (Programme under European Reginal Development Fund) but it is speculated that developers and installers took the support into account when pricing their services. Further, the strict deadlines involved in the support gave little opportunity to shift suppliers in the process.
Negative	Feed-in tariffs	The support only applied to electricity (the scheme was changed in 2016)

The project contributes to achievement of national RE targets (7,200 MWh of electricity and 500 MWh of heat) and to security of supply. It also contributes to climate change mitigation (CO_2 savings of about 9,400 t/year) and to improvement of air quality.

2.3 Assessment of the heat pumps technology segment

2.3.1 Current state of play

There is an increasing uptake of heat pumps in Europe[33]. From 2016 to 2017 sales rose by 4.4%. The largest markets are the southern European countries where the heat pumps are primarily used to deliver cooling. Italy, Spain and France together count for almost 80% of the sales. From 2014 to 2017, sales in the EU have increased by almost 40%[34]. Turnover generated in 2017 in Europe was EUR 7.1 billion.

The (housing) construction market is the biggest market. New buildings are well insulated and thus suitable for heat pumps. However, there are increasing prospects in the housing renovation market, which accounts for 80% of the building stock. Today's heat pumps can supply higher temperatures thus better meeting the energy needs of the older housing stock. In Europe there are 177 heat pump companies accounting for 70% of the global number of companies. Air-to-air heat pumps are most commonly used, followed by air-to-water heat pumps.

The dominant share of the worlds heat pump companies is based in Europe. Heat pump technologies are replicable assuming that basic contextual conditions are met. On the one hand, this enables European companies to expand outside of their home and European market, but on the other hand, it also means that entry barriers may be low for non-European companies. In terms of consumer prices, the operating costs of heat pumps are among the lowest in the heating and cooling sector. However, upfront investment costs are high resulting in pay-back times of up to 20 years.

[33] https://www.eurobserv-er.org/heat-pumps-barometer-2018/
[34] https://www.researchandmarkets.com/research/92hl4n/european_heat?w=4

2.3.2 Competitiveness of the heat pumps industry

Natural gas boilers are the main competitor of heat pumps, as they carry lower up-front investment costs. Additionally, biomass technologies, gas and electric heaters and air conditioners are other competitors in the residential sector.

Currently, heat pumps in Europe are marketed a high value product', and a few companies dominate a large share of the market which enables them to exercise some competitive power on price and conditions vis-à-vis installers. Buyers or consumers have little power as they are typically small actors – individuals or building companies. In the long term, the market may mature and make it more difficult for companies to exercise the same power. More suppliers are expected to enter the market and the small buyers would constitute an ever-smaller share of the market.

The key factors that limit the deployment of heat pumps into the European heating and cooling sector relate to finance, convenience and awareness. Operation costs are low, but upfront investment costs are high. Further, the installation process takes longer as is more complex than e.g. of natural gas and might involve more inconvenience during installation. There is also an issue of convenience and skills. Installers are less familiar with the installation of heat pumps and might tend to favour the technologies for which they possess the skills, such as natural gas, and be less inclined to propose alternatives such as heat pumps, feel less capable of installing them or of providing advice.

2.3.3 Case study

The competitiveness of heat pumps as a resource for heat and cooling production is further described in a Case study: Air-to-water heat pumps in residential zero-energy renovation, Arnhem, the Netherlands (Annex A).

Text Box 4: Case study: Air-to-water heat pumps in residential zero-energy renovation, Arnhem, the Netherlands

In a residential area, 96 small houses in 12 blocks were converted into zero-energy buildings. The houses were built in the 1950s and are the home to 400 people in total. The three key elements of the renovation were: insulation, PV panels on rooftops to generate electricity and medium-sized heat pumps (air to water) to provide space heating and domestic hot water. The cost of the entire energy renovation was EUR 75,000 per house with a pay-back period of 40 years. The cost of the energy modules was in the range of EUR 10,000-12,000. Once installed, the operation and maintenance costs are low and comparable to that associated with natural gas. The full renovation of the buildings into zero-energy houses delivers a CO_2 emissions saving in the order of 283,000 k/y. In addition, tenants benefit from improved living conditions through improved ventilation and protection against outdoor noise.

Competitiveness factors		Description
Positive	Government policy	A long-term target and commitment to disconnect all houses from the national gas network by 2050
	Government support for investments	The Dutch 'Sustainable Energy Investment Subsidy Scheme' (ISDE) provides grants to support households' and businesses' investments in renewable heating and cooling.
	Social housing: regulation on setting of rent	Regulation provides social housing companies that transform old buildings into zero-energy buildings with the opportunity to increase the rent by an 'Energy Performance Fee' that reflects the value of some of the energy savings resulting from the transformation to 'zero-energy buildings'.
Neutral	Pay-back period depends on contextual conditions	The lower the difference between the outside temperature and the water temperature that is required to provide for heating and hot water in buildings, the better is the performance of the air-to-water heat pump.
Negative	Investment costs	Investment costs are high and pay-back period long in the absence of support schemes. Support schemes are thus imperative to accelerate the use of heat pumps, overcome barriers (installers' convenience, shortage of skilled installers, and the weak price competitiveness of heat pumps) and to ensure that it becomes a possibility for the public at large, and not only for a wealthy segment.
	Convenience and skills constraints (installers)	Installers rely on the gas heating technologies that they are already familiar with. Heat pumps installers are in short supply at present.

2.4 Assessment of the solar-thermal technology segment

2.4.1 Current state-of-play

Official statistics on the number of players operating in the solar-thermal industry are missing. However, based on data provided by Solar Heat Europe/ESTIF, a recent survey identified 470 collector manufacturers worldwide (figures for China not included); among them 163 were European. The solar-thermal industry includes three main segments: i) solar heat for buildings (both water and space heating); ii) solar district heating; and iii) solar heat for industrial processes. The first segment (which currently accounts for about 90% of the market) is in the process of consolidation because of a number of mergers and acquisitions. By contrast, new players (including start-ups) are entering the other two segments and proposing new applications and solutions.

The installed capacity has been growing between 2015 and 2017 from 34,332 MW to 35,985 MW (5%). The yearly growth rate is affected by national policies: for instance, changes in the Danish legislation led to a major slowdown in MW installed in 2017. In 2018 however, Denmark remained the leading EU country for large-scale solar thermal systems for district heating, with 54% of the worldwide collector area installed (except for parabolic trough collectors). As for the number of installed solar thermal systems in

2018 in the EU, six were in Denmark (66 800 m²), six in Germany (9 380 m²) and two in Austria (3 010 m²).[35]

In 2016, the turnover of the solar-thermal sector reached EUR 2.2 billion and for 2017 worldwide turnover is estimated at EUR 15.2 billion.[36]

Solar-thermal systems can be combined with other heating and cooling technologies and the variability of the solar source is mitigated using thermal storage. On average, these systems can provide 30-40% of the annual energy required for space heating and 80-90% of the energy needed for water heating.

According to Solar Heat Europe/ESTIF, the following main barriers impinge on the growth rate of the sector:

i) lack of awareness (as the technology is sometimes confused with solar PV);

ii) burdensome authorisation process at the local level to install new capacity;

iii) lack of skilled installers as well as informed urban planners and qualified architects;

iv) distribution channels dominated by installers who may prefer installing traditional systems;

v) inadequate implementation of EU rules by Member States (e.g. Articles 13 and 14 of the Renewable Energy Directive);

vi) limited support schemes for heating and cooling;

vii) high upfront investment costs;

viii) limited access to capital;

ix) subsidies to fossil fuels and non-renewable technologies;

x) regulated prices for conventional fuels;

xi) lock-in to traditional technologies, especially when systems are replaced without adequate planning; and

xii) need to further explore the full potential of the technology via R&D&I activities.

The production of solar-thermal systems relies on three main raw materials: copper (pipes and absorbers), aluminium (frame and absorbers) and flat glass (transparent cover). Copper and aluminium are traded globally, and prices are set in commodity markets. Therefore, while the price of such materials may affect the final price of solar-thermal collectors, single producers of copper and aluminium have limited room to affect the supply-side market prices. Manufacturers of solar-thermal systems may substitute aluminium with copper for absorbers based on changes in the price of such materials. When it comes to flat glass, no supplier has enough market power to substantially affect the price of this component, especially if one considers that Chinese producers are also entering this supply side of the market and contribute to lowering the prices.

The technological barriers to entry in the solar-thermal sector are limited. A new manufacturer can opt for assembling solar-thermal collectors by buying components (e.g. absorbers) from other companies in the market. Based on the growth of their business

[35] International Energy Agency (2019), IEA Solar Heating & Cooling Programme, May 2019, Global Market Development and Trends in 2018, https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2019.pdf

[36] International Energy Agency (2019), IEA Solar Heating & Cooling Programme, May 2019, Global Market Development and Trends in 2018, https://www.iea-shc.org/Data/Sites/1/publications/Solar-Heat-Worldwide-2019.pdf

and learning curves, they can decide to internalise the production of such components at a later stage. Barriers to exit are also low. Some companies with high brand value and access to distribution channels (especially installers) represent an interesting target for mergers and acquisitions. In addition, production assets used by manufacturers of solar-thermal systems are not highly specialised (the most specific tools are the laser or ultrasonic welding machines for absorbers) and can be either purchased by other operators in the same market (consolidation) or by operators in other markets.

2.4.2 Competitiveness of the solar-thermal industry

No manufacturer controls a substantial share of the market. The largest manufacturer worldwide is a Chinese company producing about 1.4 GW of collectors per year (the overall size of the global market is about 36.5 GW). In the EU market, the situation is not much different, as the largest manufacturer produces about 350 MW per year (even if having capacity to double such production) and the size of the EU market is about 1.8 GW.

The competitive advantage of solar-thermal relies on the following factors: i) low OPEX (no fuel needed); ii) stable prices (energy costs mainly depend on CAPEX and performance); iii) low carbon footprints and contribution to the circular economy; iv) systems sold in the EU are mostly produced in the EU and the European technology is at the forefront of the innovation worldwide; v) high temperatures for water heating and industries, e.g. when compared to heat pumps; vi) high energy density (land area required), e.g. when compared to biomass and biogas; vii) no CO_2 or fine particle emissions, e.g. when compared to gas heating systems; viii) scalability, from small units for domestic hot water to solar district heating plants. Solar-thermal systems also compete with solar photovoltaic, insofar as space to install collectors on roofs is limited. Solar-thermal becomes more attractive when operating costs for other systems (e.g. gas heated boilers) tend to grow (e.g. increase in natural gas prices).

Overall, the performance of solar-thermal systems compared to other technologies in terms of costs depends on the type of system and energy demand (i.e. the temperature level). The use of solar-thermal for combined systems (domestic hot water and space heating) is more common in Central and Northern Europe.

Domestic buyers have generally no power to drive down the prices of solar-thermal systems, as the demand-side market is very fragmented. There is some competition between installers, which can drive down the price, if households choose between different heating and cooling technologies. By contrast, industrial users and, even more, buyers of district heating plants have some power as they purchase such systems via calls for tenders/procurement processes accounting for both quality and price. This leads to competition among solar-thermal system providers and, to some extent, among different renewable technologies. No buyer is responsible for a substantial share of the demand for solar-thermal systems.

2.4.3 Case study

The competitiveness of solar-thermal as a resource for heat distribution via the district heating grid is further described in a Case study: Solar district heating in Silkeborg, Denmark (Annex A).

Text Box 5: Case study: Solar district heating in Silkeborg, Denmark

The solar-thermal plant supplies approximately 20% of Silkeborg's annual district heating demand via the district heating network. In sunny days, the plant has supplied as much as 100% of the heating demand. Surplus heat is stored in tanks for later use. The solar-heating plant has a minimum lifetime of 25 years and its heat production covers the total annual heat consumption of 4 400 households (from a total of 22 000 connected to the district heating network). The plant consists of 12 436 solar collectors, covering a size of 156 694 m². On a sunny summer day, there are 2.7 million liters of water per hour circulating through the system, which is connected to the district heating network via 1.2 kilometer of pipes.

The solar-thermal technology upgrades ensure a stable development in the district heating price for the local communities that are connected, as they support Silkeborg Supply in becoming less dependent on the price fluctuations of traditional energy sources, such as natural gas. Specifically, the increased income to the utility from the solar-thermal plant mean that no increase of the heating price to the final consumers will be necessary, as the fuel costs savings offset the depreciation of the project. In addition to the benefits from fuels cost savings, there are reduced operational costs, environmental costs and CO_2 costs.

Competitiveness factor		Description
Positive	Governmental and municipal policies	Municipal target for carbon neutrality by 2030.
	Governmental support for investments	Legislative incentive (energy savings allow for funding via the national Energy Savings Agreement).
	Heat generation costs and predictability	Low OPEX (no fuel needed) and the heat production price is more predictable and unaffected by natural gas price fluctuations.
Neutral	Investment costs	The government support has covered expenses in the order of 5-10% of the capital costs (via a supplement to the revenue cap after the first year of operation), necessary to achieve the energy savings.
	Infrastructure requirement	Solar district heating is financially feasible, when there is already district heating infrastructure in place.
Negative	Performance depends on geography	The performance of solar-thermal systems compared to other technologies in terms of Levelized Cost of Energy depends on the type of system and energy demand (i.e. the temperature level). The countries where solar-thermal technologies perform best are the Southern European Member States, especially when it comes to domestic hot water systems.
	Land acquisition time and costs	The acquisition of the land for the construction of the plant and all the solar collectors can be challenging, as it is owned by private owners.

3. Impacts on the EU economy

This chapter presents the impacts on the EU from renewables in heating and cooling, in terms of employment (direct and indirect jobs), as well as turnover (in million euros) at an overall EU level and per Member State.

The energy sector employs over two million people in Europe, with more than half of those in the renewable energy sector.[37] The EU RES sector employed around 1.4 million full time equivalents (FTEs) considering direct and indirect employment with a turnover of approximately EUR 154.7 billion in 2017[38] [39]. The employment data refers to gross employment, not considering developments in non-renewable energy sectors or reduced expenditure in other sectors. Direct employment includes RES equipment manufacturing, RES plant construction, engineering and management, operation and maintenance, biomass supply and exploitation. Indirect employment refers to secondary activities, such as transport and other services.

A rough estimate indicates that nearly half of the RES jobs (45%, 650 800 FTEs) are within the heating and cooling industry (biomass, biogas, heat pumps and

[37] Study by Energy Watch Group and LUT University: Transition to 100% Renewable Energy in Europe (2018), http://energywatchgroup.org/wp-content/uploads/2018/12/EWG-LUT_Full-Study_Energy-Transition-Europe.pdf
[38] Considering data for wind, solar PV, solar thermal, biomass, biogas, heat pumps, geothermal, biofuels, hydro, waste
[39] EurObserv'ER, 2018

solar-thermal segments).[40] When including the geothermal sector and biofuels into the calculations, the number is considerably higher and reaching up to 892 100 FTEs in the EU. The biomass industry generates most of the jobs among all RES technology segments. Its share represents 25% of the employment in the whole RES sector and 56% from the four technologies within the scope of this study. Heat pumps provide 191 700 FTEs, ranking fourth among all the technologies and second among the 4 technologies. From the Member States point of view, Germany ranks highest in terms of renewable energy employment with 290 700 FTEs in 2017. Spain, France, United Kingdom and Italy rank among the top five players with combined FTEs of 861 500 jobs representing 60% of all the Member States.

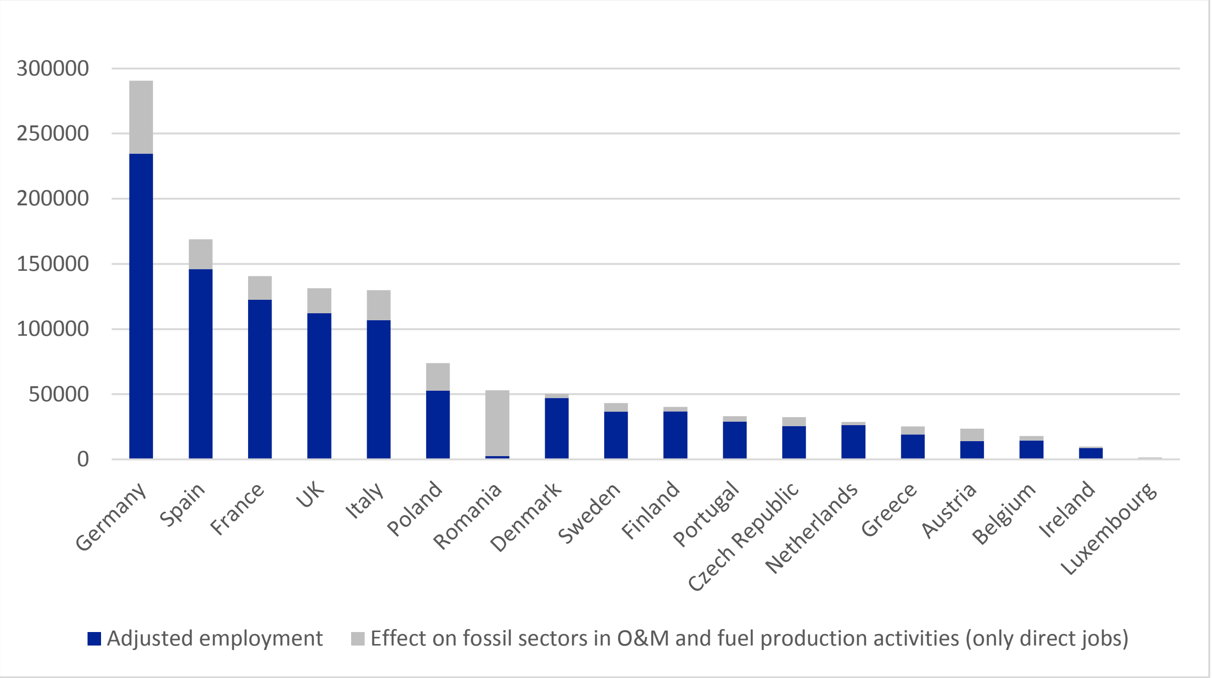
The combined turnover of the four heating and cooling technologies covered in this report[41] is EUR 67.2 billion and EUR 82.3 billion when biofuels and geothermal sectors are included.[42] The four technologies account for 43% of the total turnover of all RE technologies. Despite the fact that biogas and heat pumps have the most rapid annual growth rates, it is still biomass-based technologies that remain dominant in the market[43]. Biomass represents 22% of the total turnover of 10 technologies and 51% of the four technologies analysed in this study. Heat Pumps are right behind with a 34% share of all four sectors. In 2017, 15 Member States maintained or increased their industrial turnover whereas the other 13 Member States[44] saw a decline of EUR 9.7 billion in total.[45]

The share of energy from renewable sources in the EU heating and cooling sector was 19.5% in 2017[46.] Further integration of renewable energy sources into this sector could have great effects on the EU economy and simultaneously on its citizens and environment. The increase in renewable energy consumption also has an impact on fossil fuels use, in 2016 and 2017 the use of renewables in heating and cooling sector contributed to 33% of the total avoided fossil fuels.[47] As illustrated in

Figure 3, the impact on the fossil fuels sector varies across Member State. This is affected by the type of deployed renewable technology and by the composition of the fossil fuels sector in each Member State.

[40] It must be noted that some share of the jobs and turnover from the biomass and biogas estimates can be accounted to electricity production, thus not necessarily used for heating and cooling purposes.
[41] Solar Thermal, Biogas, Heat Pumps and Solid Biomass.
[42] EurObserv'ER online database, 2019
[43] EEA, Renewable energy in Europe 2017
[44] Austria, Bulgaria, Croatia, Estonia, France, Italy, Latvia, Lithuania, Luxembourg, the Netherlands, Poland, Slovenia and Sweden
[45] EurObserv'ER, 2018
[46] Eurostat, 2019
[47] EurObserv'ER, 2018

Figure 3: RES development effect on fossil sectors for 18 EU countries (2017 figures)[48]



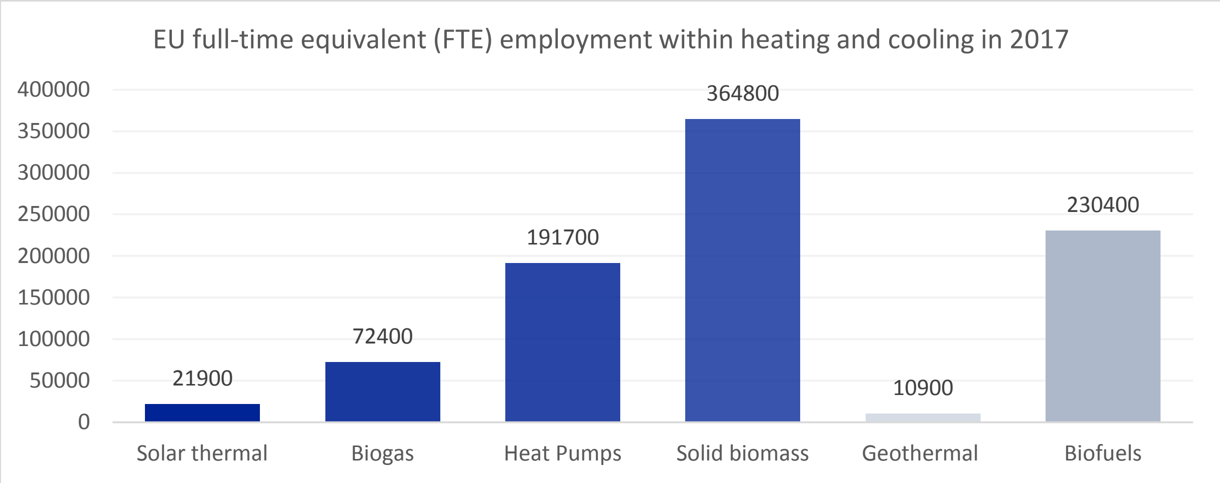
Source: EuroObserv'ER online database

Furthermore, the renewable heating and cooling sector could have a large contribution to accelerate the decarbonisation of the European energy system and therefore, the transition to renewable heating and cooling can boost EU's competitiveness[49].

A breakdown of the number of jobs and turnover per technology segment in 2017 is presented in the figures below.

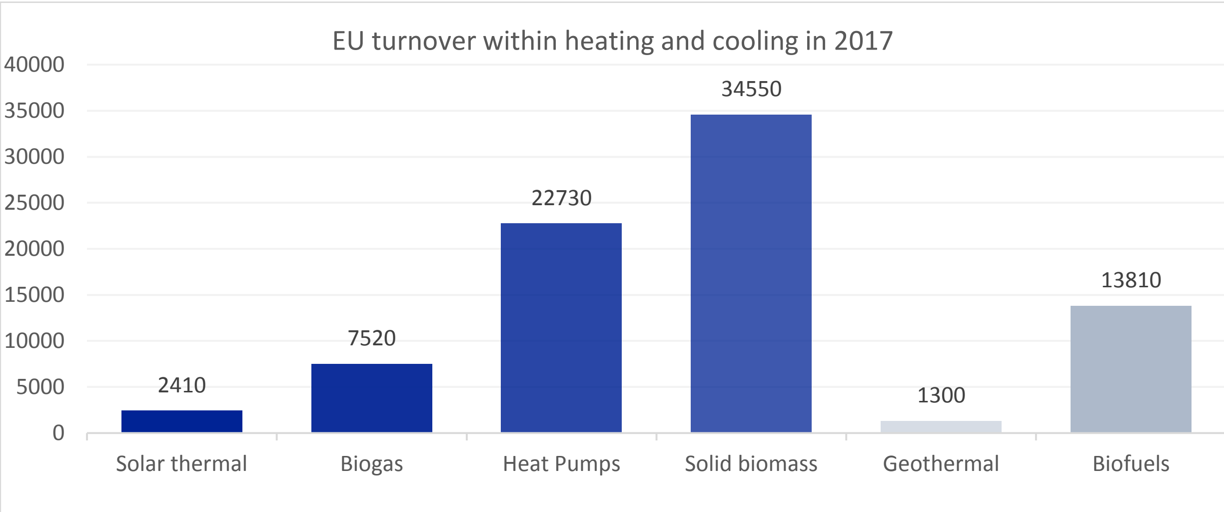
[48] Only eighteen EU countries have been evaluated: Austria, Belgium, the Czech Republic, Germany, Spain, France, Italy, the Netherlands, Denmark, Finland, Greece, Ireland, Luxembourg, Poland, Portugal, Romania, Sweden and United Kingdom. The results refer to direct jobs only and cover the effects of RES development on operation and maintenance (O&M) and fuel production activities in the fossil sectors.
[49] Reducing carbon dioxide emissions in line with the Paris Agreement could boost GDP. IRENA

Figure 4: Employment in the EU (direct and indirect jobs) in 2017



Source: EuroObserv'ER online database

Figure 5: Turnover in the EU in 2017 in million EUR (2017)

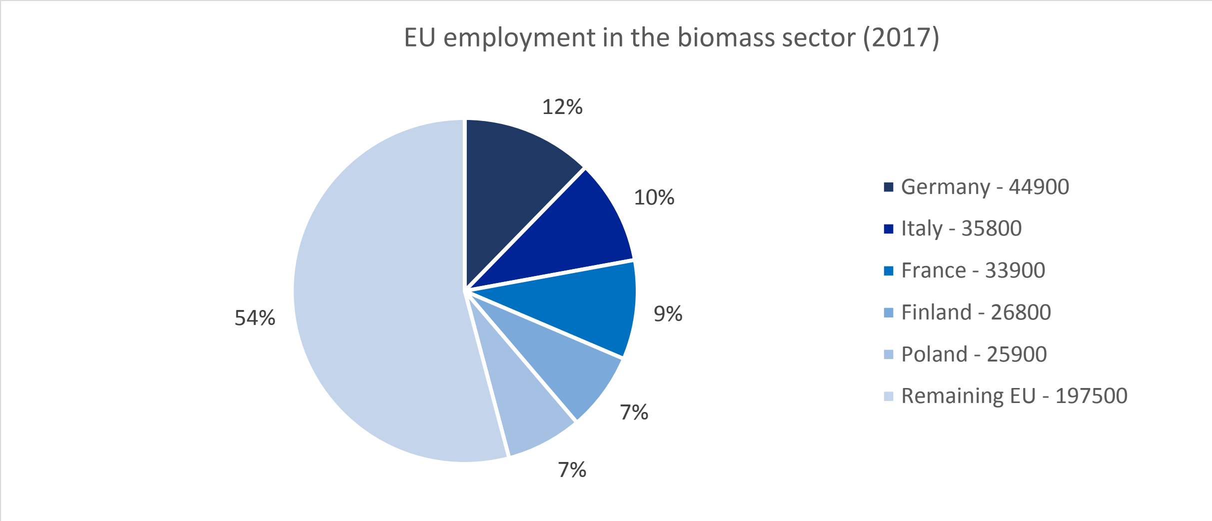


Source: EuroObserv'ER online database

3.1 Employment and turnover in the biomass technology segment

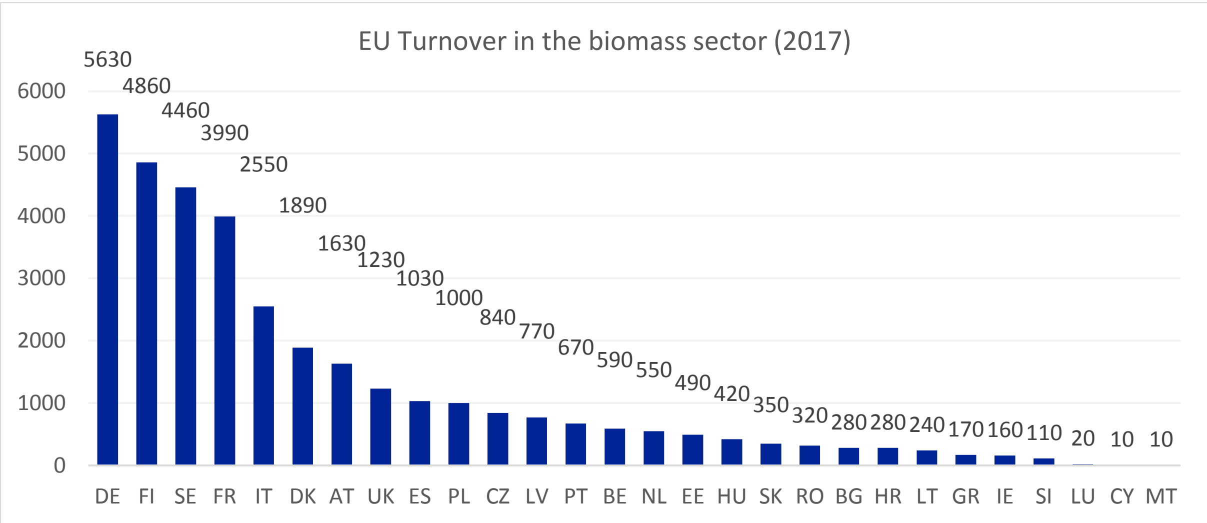
The biomass segment is dominant in most Member States. The labour market accounts for more than 364 800 jobs, with Germany, Italy, France, Finland and Poland as the largest employers in the EU. As the biomass sector is expanding, the turnover has increased between 2016 and 2017, reaching €34.5 billion.

Figure 6: Employment in the EU Biomass sector in % and actual numbers in 2017



Source: EurObserv'ER online database

Figure 7: Turnover in the EU Biomass sector in € million (2017)



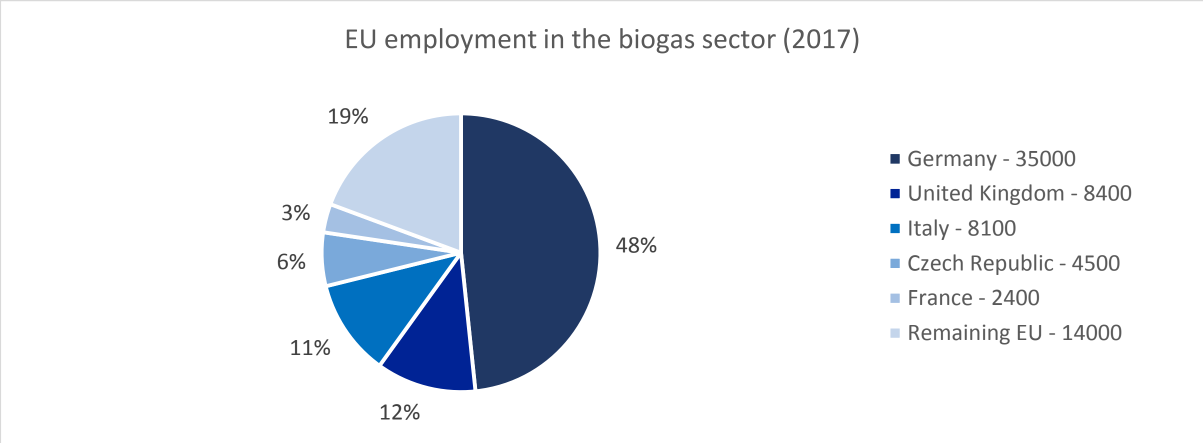
Source: EurObserv'ER online database

3.2 Employment and turnover in the biogas technology segment

The biogas segment employment accounts for 72 400 FTEs. Germany, as the biggest EU employer in the biogas sector, accounts for 48% of the total employment. Together with the United Kingdom, Italy, the Czech Republic and France, these Member States account for 80% of the total employment in the EU biogas sector. The estimated total turnover is

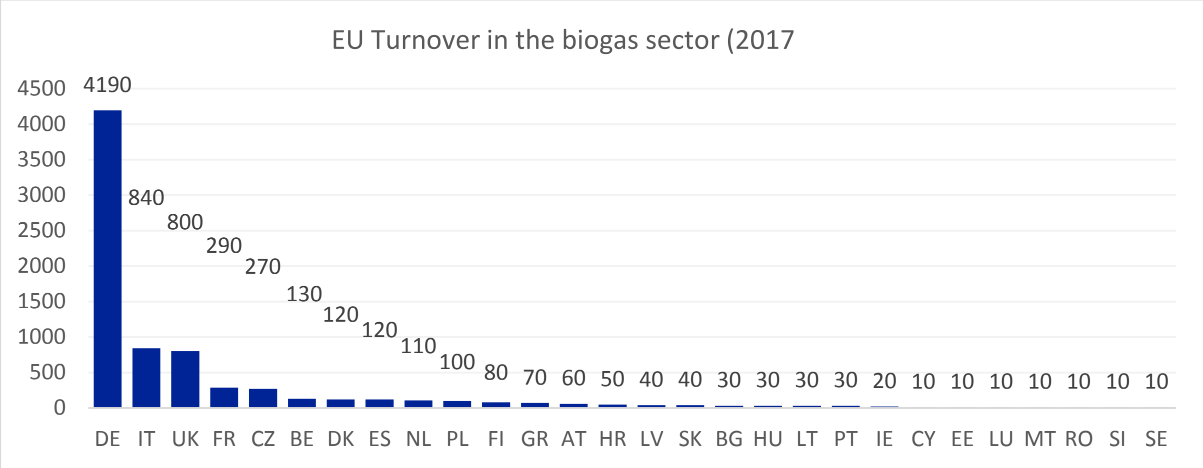
€7.5 billion. The sector turnover has experienced a downward trend in recent years which could be caused by a slowdown in investment in new plants.

Figure 8: Employment in the EU Biogas sector in % and actual numbers in 2017



Source: EurObserv'ER online database

Figure 9: Turnover in the EU Biogas sector in € million (2017)

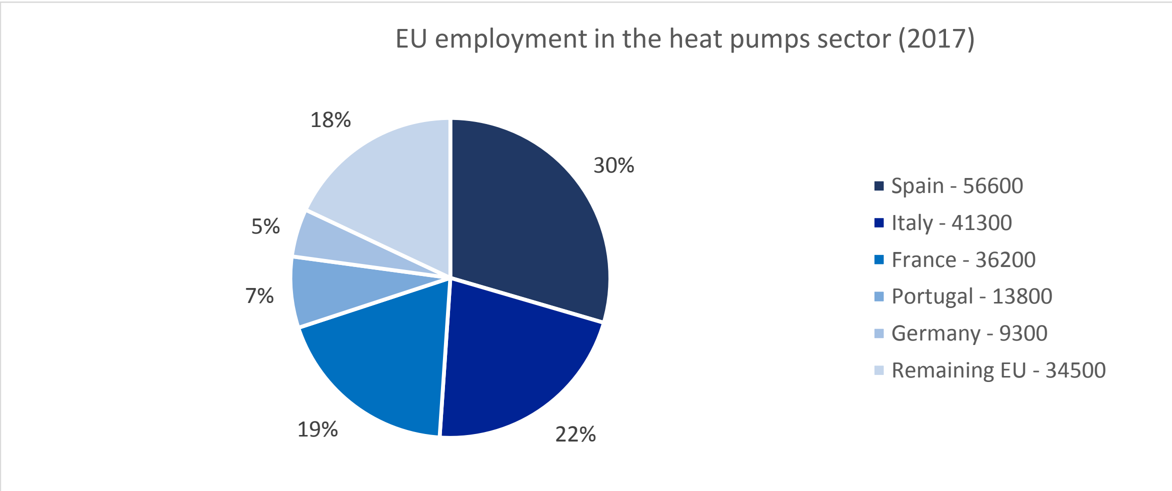


Source: EurObserv'ER online database, 2019

3.3 Employment and turnover in the heat pumps technology segment

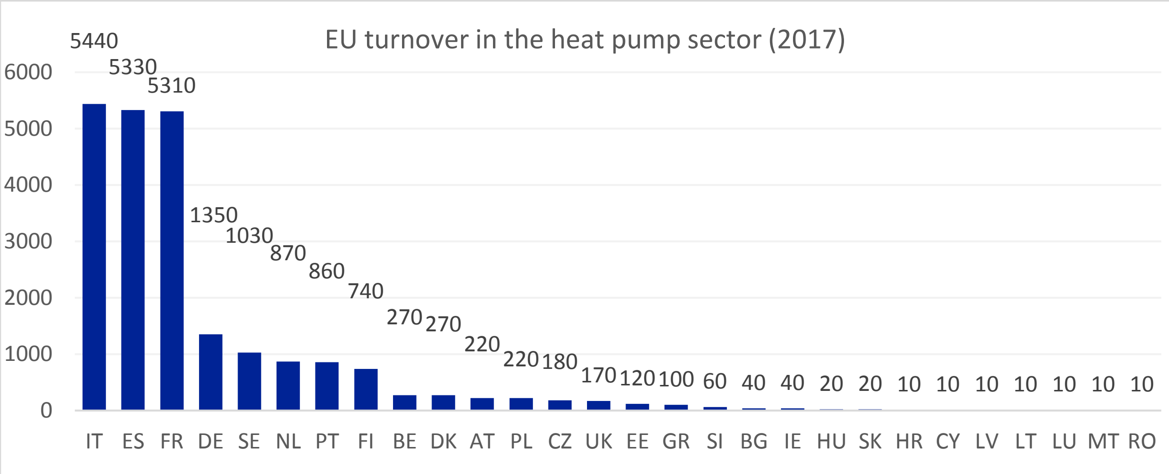
In 2017 heat pumps employment was 191 700 FTEs, with a turnover of € 22.73 billion. With 56 600 FTEs, Spain outranked Italy, the frontrunner of this sector. Together with France, Portugal and Germany, these 5 countries have the highest employment figures, accounting for 82% of the total EU FTEs in the heat pumps sector.

Figure 10: Employment in the EU heat pumps sector in % and actual numbers in 2017



Source: EurObserv'ER online database

Figure 11: Turnover in the EU Heat pumps sector in € million (2017)

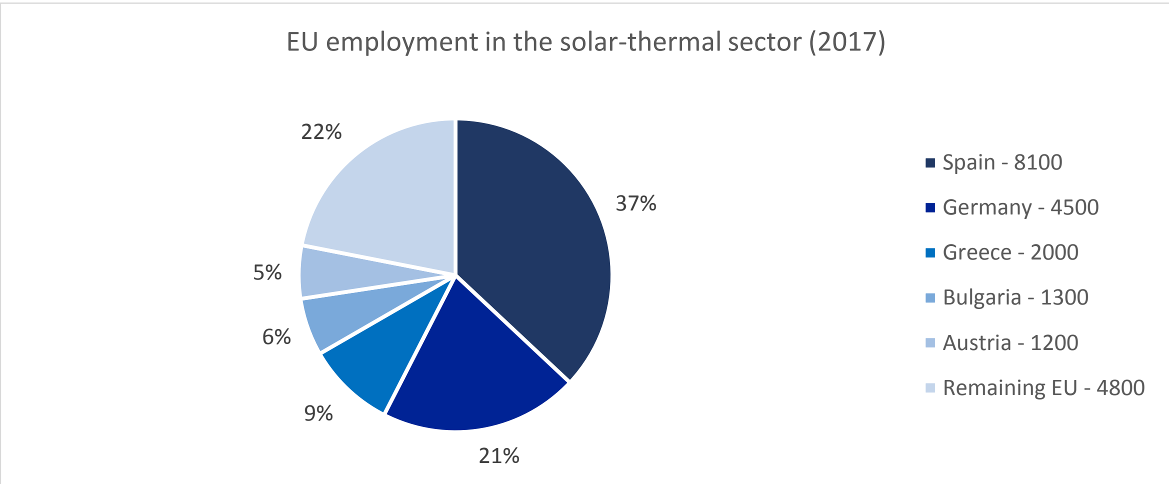


Source: EurObserv'ER online database

3.4 Employment and turnover in the solar-thermal technology segment

In the European Union around 21 900 people were employed in direct and indirect jobs in 2017. The five countries with the highest numbers of employees were Spain, Germany, Greece, Bulgaria and Austria. In contrast, in 14 Member States only around 100 people are employed in the solar-thermal sector, namely in Belgium, Cyprus, Estonia, Finland, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Romania, Slovakia, Slovenia and Sweden[50]. Turnover was € 2,4 billion with Spain, Germany, Austria, France and Greece ranking in the top five.

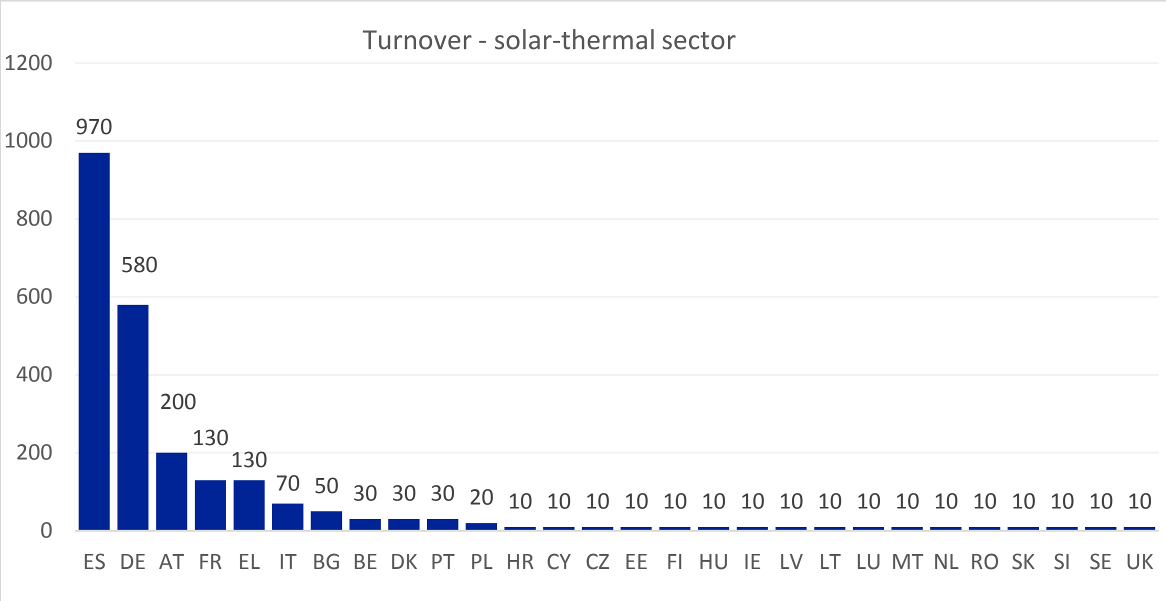
Figure 12: Employment in the EU solar-thermal sector in % and actual numbers in 2017



Source: EurObserv'ER online database, 2019

[50] EurObserv'ER report: The state of renewable energies in Europe 2018

Figure 13: Turnover in the EU solar-thermal sector in € million (2017)



Source: EurObserv'ER online database, 2019

4 Conclusions and the way forward

Solid biomass appears the most cost competitive renewable energy technology for heat production. Considering that the level of LCOE makes biomass heat rather competitive relative to other fuels, there is no need for financial support to increase the heat production for this resource for the time being. The main competitors for biomass heating systems are geothermal and ambient air heat pumps, gas-based heating systems and electricity-based heating systems. The intensity of the competitive rivalry appears strong in the biomass segment when compared to other renewable energy alternatives within the heating and cooling segment. As a result, large number of competitors could provide similar products and services leaving biomass companies with less power to increase future sales and/or profits. The biomass supply side is fragmented and dominated by SMEs.

The main driver for increased competitiveness is the recast of the Renewable Energy Directive (including new national targets for Article 23(1)). Its mere targets promote an expansion of the EU RES H&C market which in itself makes it a more attractive market to be in or enter. Further, through its provisions on national contact points the access to local markets for outside actors may be improved. This in turn will allow consumers with a wider slate of suppliers to choose from thus stimulating price competition and paving the way for the most effective and efficient solutions. Also, it contains obligations regarding theoretical training of installers. RED II now also calls for national contact points which is a potentially important means by which to ease access to domestic or local markets for outside players thereby increasing the competition in such markets to the benefit of suppliers and consumers. The more the local markets are open to outside players, the higher is the competition likely to be. This in turn will reduce possible 'over-normal' profits and benefit suppliers of technologies that are cost-competitive.

Public schemes supporting the transition to renewable heating and cooling would increase competitiveness because they will compensate for the lack of carbon prices when compared to fossil-fuels. This will stimulate competition for RES H&C and demand for the most energy efficient and cost-competitive solutions. Stricter regulatory requirements (e.g. eco-design, air emission rules) would increase fuel efficiency and could displace producers of low-quality equipment, which will provide consumers with better quality solutions in the long term.

Biogas companies are competing mainly on national markets and current market conditions make them dependent on support schemes. The level of difficulty for entering national markets varies from medium to very difficult across the EU Member States. The main factors influencing the level of difficulty are infrastructure, administrative barriers (length and complexity of permitting procedures) and lack of awareness among municipalities. In addition, the competitiveness of biogas heating is strongly dependent on the conditions for bio-based electricity.

Increased competitiveness and therefore a stronger utilisation of the biogas potential would require support schemes to promote the distribution and use of the heat that is produced at the biogas plants. Key actions in this direction include: 1) developing models for securing the income streams resulting from the production of heat. This could include for example: models and best practice examples of purchase contracts and how to set up the (groups of) project owners; possibly substituting the biogas heat consumption thereby providing for a societal premium in return for the contributions provided to climate change mitigation, waste management and air pollution reduction; rethinking the business case of biogas plants taking into consideration the utilisation of both electricity and heat, not only the electricity; 2) ensuring that capital costs do not become the critical constraint. This could include: financial support schemes for critical infrastructure elements; provision of support (guidance, models etc.) for establishing projects and ownership structures consumer contracts and feasibility studies.

Even with low operating costs, heat pumps are not competitive in the absence of support schemes due to their high upfront investment costs. Specific initiatives could help to promote their deployment further, and thereby also to help the EU heat pump industry in defending and strengthening its global position. Those initiatives include: 1) developing support schemes to ensure that investment decisions are taken on a level playing field compared to fossil fuel alternatives, and possibly combined with access to favourable financing of the relatively high up-front investment costs; 2) promoting the consideration of heat pump solutions in building refurbishments (along with other RES solutions) through legislative measures and/or through financial support schemes to make heat pumps more attractive to consumers; 3) ensuring that skills, awareness and convenience do not constrain the choice of heat pumps as a possible solution, e.g. through actively promoting such activities in ERDF and ESF programmes (Regional Development Fund and Social Fund).

The solar-thermal segment is competitive when support schemes are available to cover part of the upfront investment costs. There are significant differences between centralized (e.g. solar district heating) and decentralised (residential rooftop solar heating) solutions. The main competitors of solar-thermal are natural gas boilers. Key advantages include low OPEX, stable prices and high temperature for water heating (e.g. when compared to heat pumps), high energy density (when compared to biomass and biogas). Some disadvantages are the relatively high overall costs, limited locations and size limitations, the availability of district heating infrastructure (for large-scale installations) and the need to have another heating source. The main drivers are national legislation and regional CO_2 reduction targets (e.g. the Energy Savings Agreement in Denmark) and availability of public funding and district heating infrastructure (for the solar-thermal district heating). Constraints include inadequate national implementation of Articles 13 (administrative procedures, regulations and codes) and 14 (on information and training) of the Renewable Energy Directive, limited support schemes for heating and cooling and subsidies to fossil fuel technologies.

Renewable energy in heating and cooling is on the increase in the EU stimulated by national and EU level policies, including support schemes. That said, **this study identifies areas where further policy initiatives could improve the overall competitiveness of RES in heating and cooling** and thereby pave the way for a stronger penetration of RES in Europe.

Today there is **no effective EU carbon price**[51] in the heating and cooling industry[52]. As a result, fossil-based solutions are more cost competitive than they would otherwise be compared to RES-based alternatives. This is at the core of improving the competitiveness of RES in the EU heating and cooling sector. RES technologies play an important role in ensuring that the EU and its Member States deliver on CO_2 emissions reductions, but there is not a price-tag associated with the different heating and cooling technologies and their contributions in this regard. This impact is further reinforced in situations where the fossil fuels are still subsidized.

Creating a heating and cooling market for renewables where carbon prices are internalised would provide a level playing field and increase competitiveness of RES-based alternatives compared to fossil-based solutions. Fiscal tools are a logical choice in this direction. Support and subsidies including feed-in tariffs can be said to constitute other fiscal means by which the competitive advantage of fossil fuels is reduced. In addition to the importance of costs, competitiveness of RES can also be negatively affected if there is an imperfect information basis against which technology buyers can base their decisions. In that regard, installers play an important role. Installers often guide and advice technology buyers and there is a risk that they are inclined to be biased towards the solutions that they know of, are most familiar with and trained in. Addressing this information bias, will provide consumers with the opportunity of making more informed choices and improve the competitiveness of RES solutions compared to fossil-based solutions, and strengthen competition between the different RES-based technologies.

Different technical requirements, certification, standardisation and licensing requirements in Europe create **administrative burdens and costs** that affect the competitiveness of the RES technologies in heating and cooling negatively. It may limit the possibility for companies to expand across national boundaries if local systems vary significantly. This puts a limit to the ability of individual companies to grow and provide for economies of scale. An accelerated and coordinated implementation of Articles 13 (on administrative procedures, regulations and codes) and 14 (on information and training) of the Renewable Energy Directive 2009/28/EC would be an important instrument in reducing this barrier. Reducing this barrier may open local markets via easing the access to outside players. This may intensify competition within the different RES segments to the benefit of technology buyers and consumers. Similarly, energy labelling and eco-design

[51] It is difficult to compare the cost of fossil and RES installations, as long as, in most Member States, fossil-based heating appliances (e.g. condensing gas and oil boilers) remain heavily subsidized and while fossil fuel prices are still regulated, and the carbon not substantially priced. There is no specific carbon tax on EU level, but some Member States have established it on a national level. The EU Emission Trading System (ETS) covers combustion installations with a rated thermal input above 20 MW. The total heat supply which is covered by the EU ETS is estimated to be around 25% of the total heat supply. http://www.heatunderyourfeet.eu/decarbonising-the-heating-and-cooling-sector-strategic-policy-priorities-for-renewable-heating-and-cooling-in-europe/

[52] Electric heating with heat pumps is under the ETS, while fossil fuel-based heating is under the Effort Sharing mechanism, with no carbon pricing in place). https://orsted.com/-/media/WWW/Docs/Corp/COM/News/Carbon-pricing-declaration-november-2018.pdf

are means by which the idea of uniform and EU wide standards can be used thus easing the administrative burden.

Skills and awareness on the side of installers and technology buyers may to some extent be biased towards the well-known and familiar technology types. While RES technologies in heating and cooling are on the increase, their acceleration may be dampened by an inclination of individual installers and buyers to opt for solutions that are familiar to them and which appear well tested (while also cheaper). This effect is further accentuated when replacement decisions are made under pressure, i.e. when a heating system breaks down. Technology buyers, particularly smaller buyers, depend on the advice and guidance of installers who are thus key technology promoters. Upgrading skills, knowledge and awareness of installers (and other professionals such as architects) to consider RES technologies on par with fossil-based technologies will thus help promote the competitiveness of RES technologies by providing a more 'even' decision basis.

Upgrading of skills, knowledge and awareness can be promoted for example through information material clearly targeting installers and related professions providing the information that is relevant and necessary to them, as well as through the integration of such aspects into educational curricula such as vocational training. Further, awareness raising and information campaigns targeting the technology buyers can stimulate their demand. At EU level, such initiatives can be promoted and supported through the ESIF. Further, information campaigns targeted at technology buyers and project owners possibly combined with technical assistance in the initial phases could be a means of stimulating the buy-in on the side of buyers and project owners. Such assistance could be relevant for example for smaller actors such as municipalities or residential complexes.

In much of the **existing building stock** there are potentials for refurbishments that involve the introduction of RES technologies to deliver heating and cooling and replacing old, and often fossil-based solutions. Incentives to promote such choices can help to accelerate the use of, and demand for RES technologies through promoting the awareness of the costs and benefits of such choices. Such schemes are in place in some Member States, and EU mechanisms such as ELENA and ESIF also provide for it. An effort – at Member State level and possibly coordinated at EU level – to promote such schemes across the whole of the EU may help to accelerate the demand for RES technologies, and thereby make RES technologies a more competitive choice and ensure that upfront investment costs do not become the binding constraint.

Support schemes play an important role in promoting RES in heating and cooling. They help to offset the effect of the lack of a carbon price. Support schemes are largely nationally established and reflect national priorities and contexts. There is a risk that this 'fragmentation' may lead to an unintended **distortion of competition from national support schemes**. A concerted effort across EU Member States, in particular between neighbouring states, could help to identify and remove such unintended distortion of competition.

Annex A: Case studies on heating and cooling

Four case studies are attached separately.

Annex B: Member State plans for heating and cooling by 2030

Attached separately.