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Next step: the mass market! Heat pumps on the verge of large-scale deployment in Europe

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Abstract

Heat pump sales have been growing since 2013, and the last four years even showed double-digit growth. By the end of 2018, 11.8 million heat pumps were operating in Europe. Jointly they used 128 TWh of renewable energy to provide heating and reduced final energy demand by 164 TWh. Heating related CO₂ emissions declined by 33 Mt/year. The technology is now everywhere – from whitegoods via industrial processes to residential and commercial heating and cooling systems as well as in district energy systems. In applications with an energy label, heat pump-based systems score highest on energy efficiency. In some implementations, like dryers and heating, the top category can only be achieved with heat pump-based systems. Heat pumps have achieved prominent recognition not only in policy but also with scientists and researchers, many of them pointing at the importance of this technology for a decarbonised heating and cooling sector. Heat pumps are covered in the renewables, energy efficiency and building efficiency legislation. Their contribution will become even more visible, once the different planning and reporting mechanisms put in place. But is this enough? Europe has between 115 and 120 million buildings in different categories. With heating heat pumps operating in approx. 5% of the building stock, fossil fuels still provide the majority of heat. To change this, the status quo needs to be reversed – instead of 75% of gas and oil using devices, we should see the deployment of 75% of heat pumps. That means between 86 and 90 million heat pumps, none of which has yet been installed. Consequently, the current annual sales of slightly above 1 million heating heat pumps must triple, ideally overnight. The paper will explore the underlying logic, look at the market developments over the last 10 years and present policy instruments that could help to make the much-needed growth a reality

Keywords: heat pump.; market development; sustainable energy system; decarbonisation; Europe; Green Deal; statistics; policy

1. Status quo

The need to address climate change in a meaningful way is picking up speed. While the United Nations Climate Change Conference meets for the 25th time [1], local, national and international legislators declare “climate emergencies” [2] and the general population, led by iconic figures like Greta Thunberg ask for science based action[3], the single measure indicating in increase in global mean temperature seems unaffected.

Global primary energy demand has increased by 2,9% in 2018 and CO₂ emissions have increased by 2 %, the fastest increase since 2010 and 2007 respectively.[4] It is safe to say: “we are not on track”.

2. Legislation for decarbonisation: Clean energy for all Europeans

From a European perspective, tackling climate change means decarbonising heating and cooling. This sector is responsible for approx. 50% of final energy demand and 27% of CO₂ emissions. The sector cannot be handled as lightly as it has been handled, if Europe is to become the first decarbonised continent, as recently re-iterated by the new president of the European Commission, Ursula von der Leyen at the COP25 conference.[5]

A first climate and energy package rolled out between 2007 and 2014 consisting of legislations and directives on

- renewable energy,
- energy efficiency,
- energy performance of buildings,
- minimum performance standards of buildings and related labelling,
- re-design of the electricity grid,
- emissions trading and the related scheme.

In addition, heat pump technologies are subject to product-based energy efficiency and labelling directives, the regulation on fluorinated gases and a number of legal provisions on the national level including those defining the requirements for support schemes and subsidies as well as those on vocational training, skills and university level education.

The European Parliament and the Council have recently passed the “Clean energy for all Europeans”-package in order to update and shape Europe’s energy and climate policy until 2030 and to deliver the EU’s obligations under the Paris agreement.[6]

This package acknowledges the importance of involving the individual citizen in the endeavour to make Europe carbon neutral. Thus several articles inside the eight legislative acts address the participation of this stakeholder group. The Member States now have up to two years to implement the directives into national law. The package also contributes towards the proposed Long Term Strategy (LTS) which covers the necessary measures until 2050.[7]

The clean energy package is a mix of revised and new legislation:

1. The recast renewable energy directive [8]
2. The amended energy efficiency directive [9]
3. The amended energy performance of buildings directive [10]
4. A directive and a regulation on the design of the electricity market [11]
5. A newly introduced regulation on the governance of the energy union and climate action [12]
6. A regulation on risk preparedness in the electricity sector [13]
7. A regulation establishing a European Union agency for the cooperation of energy regulators (ACER) [14]

The first four pieces of legislation listed here will directly affect the decarbonisation of heating and cooling in general, as well as the building sector [15]. Consequently, a high ambition in these areas will affect the market development of heat pumping technologies, as they are not only mentioned as technologies to use renewable energy but do contribute to energy demand reduction and are listed as one of the “high efficiency alternatives” to be considered in new construction and renovation of the building stock.[16]

The existing pieces of legislation affect the development of heat pump demand on different levels of the energy system in parallel and are expected to mutually reinforce each other (see figure 1).

1. **System level:** the focus on **energy efficiency** and the promotion of the use of **renewable energy sources** will result in a parallel reduction of energy demand and an increase in the share of renewable energy to cover it. Both directives apply to all sectors: electricity, transport and heating/cooling. The directives set **new targets** for the reduction of final energy demand (against a forecast value) of 32,5% and a share of 32% of renewable energy to cover that said total final energy demand. Both are to be achieved by 2030. For the first time, the renewable heating directive is giving ‘cooling’ more prominent recognition, allowing also renewable cooling to be counted in the renewable energy statistics. However a definition is yet to be found.

Impact: As heat pumping technologies are contributing to the renewables and energy efficiency targets, they can expect to receive increasing political recognition and support. The importance of energy efficiency including in cooling will give additional attention to heat pumps offering a heat-recovery / cooling-recovery function to the market.

2. **Sector level:** The **energy efficiency** directive (EED) sets energy saving obligations (art. 7). Under this requirement, measures to reduce the energy demand of existing buildings can be counted (Annex V).

Impact: As the technology development has made heat pumps much more suitable to be deployed in the building stock and as their installation exceeds the status quo of building renovation, resulting savings can be counted. This fact should increase the technologies recognition as a tool to achieve the energy efficiency target of 2030.

3. **Sector level:** The **renewable energy** directive [17] sets forth a specific growth trajectory in art. 23 for the use of renewable energy in heating and cooling. Member States are encouraged to take measures to increase this share by 1,3 percentage points per year. Article 24 obliges Member States to ensure also an increased share of renewable energy in district heating and cooling grids.

Impact: Comparing the target to the growth of renewable energy over the past 10 years shows that this sector target will have a tremendous impact if executed on the Member State level. The current growth rate needs to be nearly tripled on an annual basis which requires a broader effort in the national implementation. As the potential of heat pumps is currently underused, support and incentives for this technology will help policy makers to achieve even more ambitious targets. Large industrial heat pumps, as a relatively new segment are now manufactured in capacities of up to 35MW being able to provide temperature levels up to 160°C. Both – smaller residential and larger industrial heat pumps can be expected to move to the centre of attention as a key solution to quickly integrate significant amounts of renewable energy to the system.

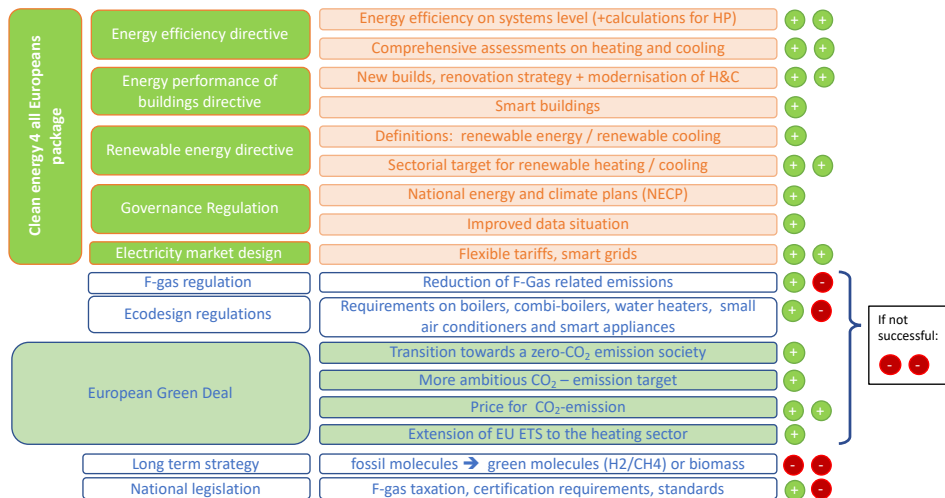


Fig. 1. Qualitative assessment of the impact of European energy and climate-based legislation on heat pump technology.

4. **Sub-system level:** the **energy performance of buildings** directive (EPBD) focussed first on new buildings. The introduced minimum efficiency targets for this building category were making near-zero energy buildings (NZEB) the standard for private (2021) and public (2019) buildings. With the introduction of the first directive in 2010 the requirement to reduce the energy demand of a building and to consider highly efficient heating and cooling solutions was established. In 2018, the amendment to the directive obliges Member States in art. 2a. to develop long-term renovation strategies that move the whole building stock – residential and non-residential, independent of ownership – to nearly zero-energy buildings.[18] These strategies were previously mentioned in art. 4 of EED and have now been moved to the EPBD to ensure a more coherent legislation.[19] Further reference is made to the provision of advisory tools (art. 20), financing solutions (art. 2a (3)), in particular for low income households and the recognition of indoor air quality, fire safety and possible impact from seismic activity.
It is surprising, that no reference is made to adapt buildings to the possible impacts from climate change, namely the need for cooling, resistance against storms or heavy rainfall / floods.

With reference to buildings becoming active nodes in an increasingly smart electric grid (see the electricity market design directive), EPBD also requires the European Commission to develop a smart readiness indicator (art. 8 (10) and Annex I A) that should rate the ability of the building to adapt to the grid while fulfilling the needs of the occupant. This can be seen as a bridge to the electricity market design directive.

Impact: The lower the energy demand for a building the easier it is to deploy heat pumping technologies. In areas where at least some cooling demand exists, the dual functionality to provide heating and cooling makes the installation of a single heat pump also a cost-efficient solution. Where heat demand is moving towards passive house levels, a combination system to provide ventilation, heating/hot water and cooling can efficiently be provided. A concept that is found already in the market and is meant to be optimised by the joint IEA HPT/ECES annex 55/34 (also part of mission innovation #7).[20]

5. **Consumer level:** The consumer is addressed in many areas. The electricity market design directive [11] aims at ensuring affordable and transparent energy prices as well as supply security. It also defines an active consumer as a generator of energy in the market (chapter 3). Among the rights defined for the consumer is the “entitlement to a dynamic electricity price contract” (art. 11) and the right to purchase and sell electricity services independent of their supply contract (art. 13), enabling them to become active customers in the market (art. 15). The precautions taken in these articles will give a value to demand side flexibility and will enable users that can provide such services to benefit economically. In case of heat pumps and storage systems, the heating and electricity sectors will be connected (sector integration) giving the heating sector a European dimension, as it will be able to contribute to grid stability and contribute from this service in a way that helps reduce operating cost for the end user and system cost for society.

Impact: It is expected, that this new consumer-centric market design will lead to the creation of new business models helpful to overcome the investment burden of heat pumps vs. incumbent fossil technologies and the technical uncertainty of end users, as most likely such models will be offered by service companies and or aggregators.

6. **System level:** The **governance regulation [12]** defines the cooperation between the European Union and the Member States. As Member States are free to decide on their energy policy but have to apply the related regulations and implement the different directives the governance regulation connects the European energy and climate targets to action ‘on the ground’. The different planning tools in connection with monitoring and reporting allow for a better management of the energy transition and a timely evaluation of the status of the Member States and the Union in achieving the 2030 targets. The regulation introduces national energy and climate plans (NECP) to govern the 10-year planning cycle. They integrate previously separate reporting obligations on a) renewable energy, b) energy efficiency, and c) greenhouse gas emission reductions. Based on a common template, Member States of delivered draft versions of their plans covering the period from 2021 to 2030. The European Commission has reviewed these draft versions and has sent improvement suggestions which have to be implemented in the final version [21]. Similarly, the community of non-governmental organisations active in Brussels supported the assessment. Much higher ambition seems to be possible.[22]

Member states must include their long-term renovation strategies into the NECPs and set indicative milestones and estimates on the amount of energy saved and the share of own building stock renovated (within the 3% renovation obligation).

Beyond the buildings sector, Member States are obliged to establish Long Term Strategies (LTR, art. 15) to plan and execute necessary action to make national societies carbon neutral. The governance documents reference multiple times to the need for a multi-level dialogue between different stakeholders in order to activate civil society and achieve public acceptance. The deadlines for these plans are overlapping and should be aligned in the future.

Impact: The NECPs and the Long-Term Renovation Strategy will improve knowledge about the energy demand in buildings and will help and encourage Member States to focus more on the need to address the decarbonisation of their societies in general making use in particular of the opportunities in the building stock. The required “evidence-based” estimates will make an improved

data basis for the building sector essential. As this is lacking today, an estimate of the impact of technology deployment is often difficult to achieve or not coherent. Thus, better building and technology statistics will make market assessments and forecast easier, an improvement that should be beneficial to all renewable heating technologies, including heat pumps.

The Long-Term Strategies create the bridge to connect Member State ambition with the Long-Term Strategy of the European Union, which aims at creating a decarbonised continent by mid-century.

In summary, the clean energy for all Europeans package establishes a multi-level framework to decarbonise society in general and the building sector in particular. Heat pump technologies will benefit, as they contribute to the renewable energy, energy efficiency and CO₂ emission reduction targets as well as providing flexibility to the grid, thus supporting its stability. The technology is readily available in volume and recent developments in research and innovation have opened industrial applications and the build environment for its deployment. From a societal perspective, most of the value chain is still local providing employment and paying taxes. Thus the technology can expect further positive recognition in the upcoming industrialisation strategy which should improve demand from end-users. What is the status of development and what needs to be done to accelerate?

3. The need for a fast acceleration of heat pump deployment

The European Heat Pump Market has grown continuously since 2012. By the end of 2018, a total of 11.8 million heat pump units have been installed in the 21 countries covered by the EHPA statistics [26]. This is a plus of 12% or 1.26 million units over 2017.

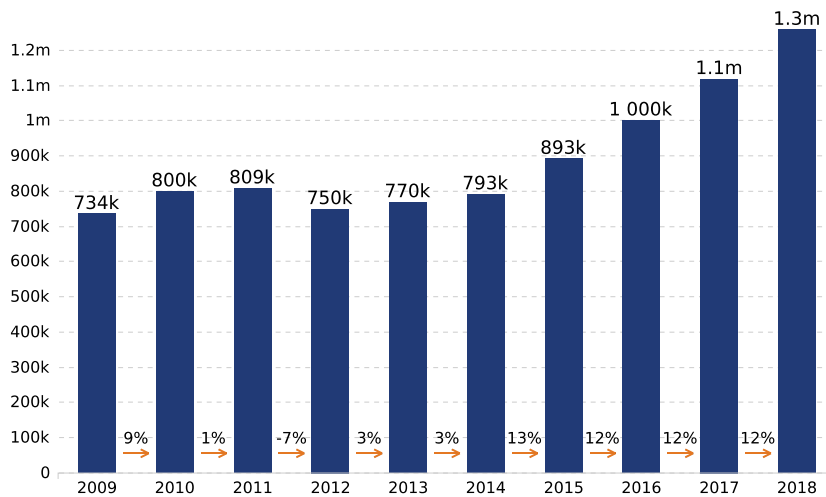


Fig. 2. Sales development of heat pumps in Europe Source: EHPA [26]

The leading markets continue to be France, Italy and Spain. Together they are responsible for more than half of the annual heat pump sales in Europe. Most remarkable – France is now close to completing an uninterrupted 10 year growth path and continues to be the engine for further growth. A recent assessment by AFPAC (Association Française pour la Pompe à Chaleur) has revealed a bullish outlook of +30% in a market that has been growing very strong in the past. Other countries are about to follow. The Netherlands has declared its aim to become “gas free” in residential heating, the UK has announced a ban of oil and gas boilers in new buildings, Ireland has put heat pumps at the centre of its efforts in decarbonizing the building stock. Even those countries that have no specific policy in place see a positive market development.

In 2018, heat pumps with a thermal capacity of 10.6 GW were installed producing approx. 20.7 TWh of useful energy and integrating 12.9 TWh of renewables in heating and cooling while avoiding 3.3 Mt of CO₂-equivalent emissions.

In order to produce the 2018 sales volume and to maintain the installed stock, a total of 68 277 man-years of employment were necessary. Obviously real employment related to the heat pump market is larger, as not all employees work full-time on heat pumps only.

In aggregated terms, the 11.80 million heat pump units sold since 1996 have an installed thermal capacity of 102.2 GW. The stock of heat pumps produces 201.5 TWh of useful energy, 128.5 TWh of which being renewable. Their use saved 164.1 TWh of final and 75.7 TWh of primary energy.

While heat pumps by now are the #1 heating technology in the new build segment of many national markets, they are also making an inroad into the renovation sector. Improved technologies and new business models help their deployment and prepare the technology for continues growth. This will be further fuelled by the implementation of the “Clean energy for all Europeans”-package as described in chapter 2 of this paper.

4. Position of heat pumps in the European heating and cooling market

In principle, heat pump technology can be used in most buildings and in many industrial processes. Precise data on these sectors is however difficult to find.

In 2019 Europe had 223 million dwellings [23]. No official figure exists on the number of buildings, but it can be estimated at around 115 and 120 million units based on the following assumptions:

1. On January 1st 2019 Europe had 513 million inhabitants [24]. With an average household size of 2,3 people, Europeans inhabit 223 million dwellings.
2. The number of single-family buildings is determined at approx. 90 million units, consequently, 207 million inhabitants live in single-family buildings.
3. The remaining 306 million inhabitants require 133 million dwellings.
4. If the typical multi-family building consists of 8 dwellings, 133 million dwellings are distributed across 16 million multi-family buildings
5. A separate statistic states that there are 10 million commercial buildings in Europe.

Europe’s building stock would thus consist of 90 million single family buildings, 16 million multifamily buildings and 10 million non-residential buildings – in total approx. 116 million units.

The majority of these buildings is today still being heated by fossil sources (see figure 3). A meaningful decarbonisation will require

- a) the replacement of the fossil technologies with renewable heating and cooling technologies, and/or
- b) the change of energy carrier from fossil to renewable sources, which may include green gases and hydrogen.

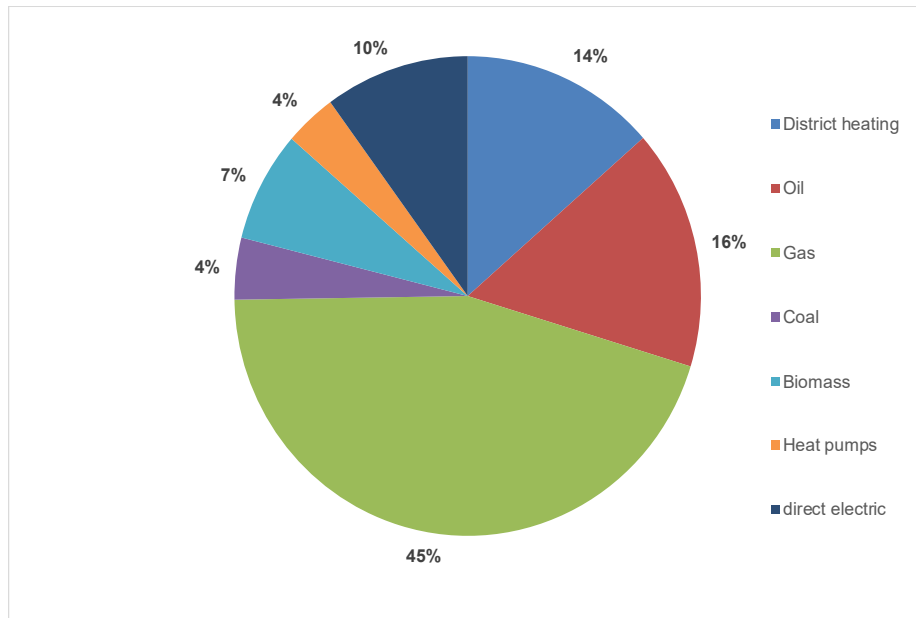


Fig. 3. Decomposition of European building stock by energy source used. Sources: Odyssee [25] and EHPA [26]

In order to evaluate the challenge a quick look the European heater market is essential. Combining data by BRG Ltd (UK) and EHPA results in an estimated market size for heaters of around 7 million units [BRG + EHPA]. This figure can be further dissected into the share of heaters installed in new build and in renovation projects as well as the number of units simply replacing existing heaters.

While this split is not part of available data, it can be deduced from a number of individual pieces of information.

- EUROCONSTRUCT estimates a rate of new construction of around 1,5% per year [29] [30]
- The renovation rate is generally reported as being too low without consistent data being available per member state. A typical figure found in the discussion is a rate around 1% [27] [28, p. 4]
 - ➔ based on 116 million buildings, approx. 1,16 million buildings are renovated per year

Thus the 2018 heater market of 7,16 million units can be split into 661 400 heat pump units in new builds, and 478 600 units in renovation project and 1 743 500 other heaters being installed in new and renovation projects. The remaining 4 270 000 units are replacements of existing heaters without significant renovation of the building.

Already today, all new buildings are fit for heat pump deployment (with a very few exemptions) and this will even be truer after 2020, when all new buildings have to comply with near zero energy performance standards. Consequently, a technical market potential of around 1,8 million units in new construction can be estimated. The same argument can be made for renovation projects: All buildings undergoing moderate to deep renovation are fit for heat pump deployment (while there is no definition for deep renovation, see [32, p. 36] for a typology).

No good data exist on heat pump opportunity in the case of like-for-like boiler replacement. It is not known, in how many existing boilers could be replaced with a heat pump (which would be considered a “minor renovation”), but anecdotal evidence shows that this is also successfully happening in many projects in Europe. An “installer rule of thumb” states that a building can be efficiently be heated with a heat pump, if on some of the coldest days in the year, the user is comfortable while the radiators can be touched by hand without burning the skin. In technical terms this means a feed-in temperature to the system of around 55°C.

Assuming around half of the direct heater replacements to be possibly executed with heat pumps results in an additional potential of 2,1 million units. Figure 4 gives an overview of the last 5 years of sales development and an outlook until 2021.

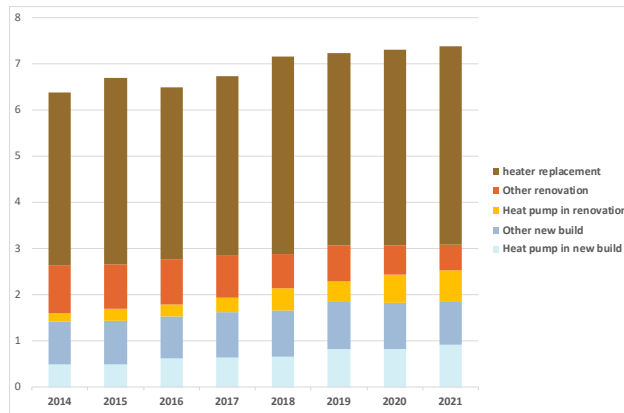


Fig. 4. The split of heat pumps in the European Heater Market (in million units).

However, these numbers are expected to increase as a result of the proposed legislation, as

- more renovated buildings create possibilities for heat pumps and
- technology development makes more heat pumps capable of efficiently providing also temperatures above 65°C.

5. Potential of heat pumps in a decarbonised European heating and cooling market

The impact assessment to the Energy performance of buildings directive estimates a necessary multiplication of today's renovation rate to min. 3% in order to significantly decarbonise the building stock. The in-depth analysis of the data on which the European Commission's long-term strategy is based expects a reduction of buildings energy demand of 48% by 2030 compared to 2015 and based on current policies. The assessment further expects a share of electrical appliances (mainly heat pumps) of 28%. [31, p. 94]

The two scenarios compatible with a 1,5°C mean temperature increase target foresee high shares of electrification in both residential and non-residential buildings. Translating the electrification share into heat pumps would result in an increase of the currently installed heat pump stock by a factor of 5 for residential buildings and about 4 – 4,5 for non-residential buildings. Based on a useful life of 20 – 25 years, all heat pumps expected to be installed in 2050 still have to be build and consequently the necessary production numbers are somewhere between 50 – 60 million units, to be manufactured and installed in the next 30 years. As production would not only have to cover new installations, but also the replacement of older units, it would require an average annual production of more than 2 million units. Compared to today's sales numbers the market would at least have to double, to fulfil this expectation.

Scientific studies looking at feasible pathways to fully decarbonize Europe's energy system similarly conclude that a high share of efficiently electrified heating and cooling is necessary. A technology specific assessment by Lappeenranta university and the energy watch group estimates the share of heat pumps in providing heat to be 44% of final energy demand. Applying this figure to today's building stock would result in 51 million units, very close to the in-depth assessment of the European Union.

Thus, the key question is: **How can the European Union and its Member States support a faster deployment?**

Over the past 10 years, the European Heat Pump market grew by 6,4% per year on average with the last four years seeing a growth of 12%. At the end of 2019, a total installed base for all heat pumps of 13 million will be reached, 12,4 million of which are expected to be heating units, the rest are hot water heat pumps. In the current very positive market environment experts expect growth to continue for the next 5 – 10 years and growth rates around 10% seem entirely feasible. This maybe pessimistic, considering that all measures of the

Clean energy for all Europeans are only currently translated into national law, thus their impact can only be expected to unleash starting in 2021.

However even if only the long-term average growth rate could be maintained, the annual heating heat pump market would arrive at approx. 2 million units around 2030, thus being able to deliver the estimated 50 – 60 million units by 2050.

An even faster growth could be achieved if not only the legal framework would be shaped more heat pump friendly, but if also the fundamental economics would be addressed and changed. The market growth over the previous years was achieved in many Member States of the European Union without significant subsidies and against an often-difficult economic framework. In particular the comparison of the cost of one unit of heat generated from fossil energy with one unit of heat provided by a heat pump shows that reveals an advantage of fossil-based heating. This disadvantage limits further heat pump deployment, as it adds an operations cost disadvantage to the still higher investment cost of heat pump technology.

The price ratio is directly affected by the taxation of the different energy carriers and thus the result of government action. The fact that in absolute terms electricity is taxed (much) higher than gas creates a disadvantage for (efficient) electric heating in the marketplace.

Against the backdrop of the need to reduce CO₂-emissions also from heating a economic disadvantage for heat pumps results from the fact that the negative environmental impacts of using fossil energy for heating are not internalised and thus are not reflected in the price of the energy carrier. Thus, heat pumps, whose main energy source is subject to the precautions of the European emission trading scheme (EU ETS), operate based on internal effects of their environmental impact, while fossil fuel boilers as the main competing technology are not subject to the same conditions. Instead, fossil heating is perceived as cheap while at the same time environmental pollution and health cost are born by society.

The heat pump industry is requesting a correction of both a) relative energy prices and b) cost of CO₂-emissions in order to be able to compete also economically with fossil heaters. It is expected that the European Green Deal, which is shortly to be presented by the European Commission, will address the need for an internalisation of external effects. Prices, taxation and subsidies must reflect the environmental impact of the respective energy carrier and in order to send the right behavioural signal to the end-user.

6. Conclusion

The outlook for heat pumps is positive for three reasons: a strong market foundation, a first legislative acceleration and an expected legislative booster.

1. The continued growth of heat pump technologies over the past decade has led to the technology representing nearly 10% Europe's heating equipment stock. This share was mainly achieved without (sometimes even despite of) government intervention. If the current growth only continued on a business as usual trajectory, heat pumps would be used in more than 1/3 of Europe's buildings by mid-century.

Fortunately, the currently implemented and the proposed legislative framework is recognizing heat pumping technologies more broadly across all sectors and functions and will thus have a re-enforcing effect on market growth, making heat pumps the dominant heating and cooling technology:

2. The clean energy for all package sets the right legislative framework for more energy efficiency and the deployment of renewable energy, leading to overall CO₂ emissions within the timeframe from 2020 to 2030. The unified reporting obligations will provide more detailed data enabling better modelling and more precise governance. The packages transposition to national law should **accelerate the development** of national heat pump markets by 2022, building on an already robust current growth path.
3. The long-term strategy has presented scenarios that make a decarbonised society by 2050 not only possible but also affordable. Its recognition of heat pumps as a robust contribution to a sustainable society will serve as a **booster to market development**. The upcoming European Green Deal is expected to also develop the necessary climate law. It is expected to include a re-assessment of the CO₂-emission reduction target, a discussion on how to apply a price on CO₂-emissions as well as additional legislation to increase ambition level in light of visible climate change.

Without doubt, the transition towards a decarbonised society is possible. In such a future, the typical answer to "what technology heats/cools your building?" or "which technology is used to run an industrial process or a district energy system" is answered simply by "a heat pump"!

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