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Today's one million heat pumps are already in essential role in smart energy transition towards carbon neutral Finland

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Abstract

Finland reached one million heat pump installations in year 2019. Heat pump sales and stock in relation to population of 5.5 million is one of the biggest in the world. Heat pumps produce as much as 15% (>10TWh/a) of Finnish heating. Investments in heat pumps now amount to EUR 6 billion. The decarbonisation impact of heat pumps already over 2 million tons CO2 eq. Reasons behind this success story may be useful to understand. Good circumstances such as cold climate, moderate electricity prices, lack of gas network and good drilling conditions help create a very successful heat pump market without subsidies. But very active lobbying and market creating activities by the national heat pump association cannot be overemphasised, along with taking care of sufficient and appropriate information flow to all parties. The quality issues of products and installation have also been all the time under a critical eye. Finnish success story continues. According to recent studies, in 2030 heat pumps will produce 22 TWh/a with those 2 million heat pumps. The Finnish government has decided recently that Finland will be carbon neutral in 2035. In a large Finnish Smart Energy Transition research project a very challenging 35 TWh/a target has been set for heat pumps in 2040.

Keywords: Heat pump market;Finland;lobbying;Heat pump association;market drivers;Smart Energy Transition

1. Introduction

The significance of heat pumps has grown in Finland in the heating of single-family houses, multi-storey buildings as well as large service-facility buildings such as shopping centres and logistics centres. Also, the use of heat pumps is continuously increasing in heat-recovery and process solutions as well as in the production of district heating and cooling. The role of heat pumps as a producer of Finnish renewable energy is much greater than that of, e.g., solar and wind energy.

This article describes the size, development and structure of the Finnish heat pump market as well as its special characteristics. This market has also been adjusted in line with the heat-pump market in other European countries.

The Finnish heat pump market has increased a thousand-fold over the past couple of decades. Annual heat pump purchases made by individual people, worth EUR 600 million in 2019, form the biggest Finnish investment in renewable energy.

This article looks also at the drivers that have had, and still have, an impact on the success of the heat pump sector, and it considers whether those drivers can be influenced. The experiences of the rapid market development in Finland and an analysis of the market drivers, as well as the possibilities to influence those market drivers, may provide a basis for the development of the heat pump market in countries where the significance of heat pumps is not yet this great.

In 2035 Finland should be carbon neutral. For this purpose a study has been published which estimates that heat production by heat pumps should be increased to 38 TWh/a by 2040. In the Finnish heating system district heating plays a very big role, about 50% of the Finnish heating market. Decarbonisation of the heat market by

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heat pumps means a lot of heat pumps in the production of district heating but also saving district heating and other heat production by enormous amounts of heat pumps installed locally in individual houses.

2. The Heat Pump Market in Finland

2.1 Special Characteristics of the Finnish Heat Pump Market

On a European scale, the Finnish heat pump market is big and quite unique. When looking at the number of heat pumps per type, the heat pump market is dominated by air-source heat pumps, whereas ground-source heat pumps lead the market when looking at the figures in Euros. 75% of single-family house builders choose a heat pump. In over 50% case the choice is Ground Source Heat Pump. Heat is already being extracted from 150 000 geothermal wells, the combined depth of which totals half of the earth's circumference, i.e., 20,000km.

300,000 owners of houses where heating is based on oil and hydronic electricity have not yet replaced their heating with a heat pump even though the return on capital invested is, almost always without exception, 10%/a. More than half a million people who use electric heating are wondering whether the affordable electricity price of 12 cents per kWh will increase.

Efforts have been made to start saving energy also in district heating that has been produced with combined power and heat production (CPH) or other means. This happens more and more often with exhaust-air heat pumps that have been installed in apartment houses and office buildings. Big buildings are also increasingly replacing district heating entirely with ground-source heat pumps. New, large shopping and logistics centres increasingly use large geothermal fields for cooling and heating instead of district heating. The largest geothermal site in Finland, a logistics centre, has 316 geothermal wells, each 300 metres deep, totalling 100km of drill holes.

The role of cooling in the Finnish climate is not great. However, the demand for it in housing, too, has increased due to living-comfort reasons as well as nearly zero-energy buildings. This is beginning to have an impact on the profitability of investments, since heating and cooling is provided through the same investment.

The most important reason behind the success is clear, yet this reason is also distinctive on a European scale. Heat pump systems are a very profitable investment. The return on capital invested is often 10-15%/a. The Finnish government does not offer so far any subsidy to heat pumps apart from the household tax deduction that can be claimed for the installation work of a heat pump.

Heat pumps are easy to use, they are carefree, they require little space and they have a cooling feature. These are arguments that also speak in favour of choosing a heat pump. Affordable electricity, the lack of a gas network, the high consumption of heating energy that is caused by the Nordic conditions, a suitable bedrock for drilling, the customer-friendly heat pump system supply all create favourable preconditions for profitable investments.

2.2. The Finnish Heat Pump Market Is Big, Even on a European Scale

2.2.1 Over 10 TWh per year production with 1,000,000 Heat Pumps

At the end of 2019, the cumulative sales of heat pumps heat reached the limit of one million pumps. We must remember that Finland is a country with a population of only 5.5 million people. A heat pump is by far the most popular form of heating in new single-family houses, and heat pumps are rapidly replacing oil and electric heating as well as district heating in old buildings.

At the end of 2019, as many as 1,000,000 heat pumps have already been sold in Finland. Their total annual output is more than 10 TWh which corresponds to over 15% of the heating of Finland's residential and service building stock. About 7 TWh of renewable energy and waste heat is recovered annually and used in heat pumps [1]. It is noteworthy that this huge investment in the environment and in fighting against climate change has been made mainly by house owners using their own money. The excellent profitability of heat pumps has made consumers' decision-making easier. People have also started to understand the significant role of heat pumps in heat decarbonisation and demand response.

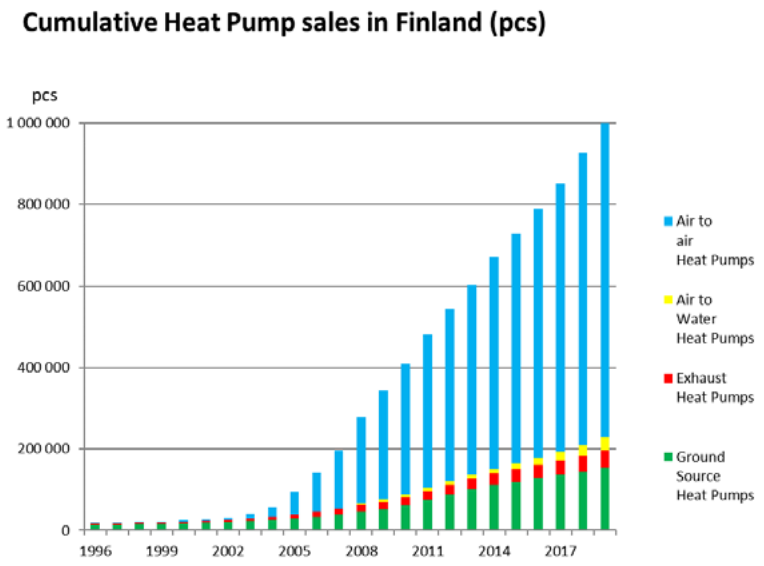

Fig. 1 Number of Heat Pumps Installed in Finland, Cumulative 1996-2019 [1]

75% of single-family house builders choose a heat pump as their main heating system. 53% choose a ground-source heat pump, which apparently is a world record of its own in new construction. Just over 15% of builders choose an exhaust-air heat pump, and approximately 5% choose an air-to-water heat pump. Furthermore, electrically heated houses are most often being fitted with air-source heat pumps as an electricity-saving and cooling fixture.

The greatest potential for heat pumps, however, lies in the already-existing houses. 200,000 oil boilers, more than 100,000 hydronic electric heating users, and 500,000 direct electric heating users most often pay double or triple the price for their heating energy as compared to heat pump heating. With the current interest rates, not making the decision to invest in a heat pump shows only ignorance.

The value of about 100 000 annual heat pump system deliveries is EUR 550 million. When the megawatt-size heat pump systems for district heating/cooling production, industry, shopping centres, and other service buildings as well as other ancillary operations such as planning, delivery supervision, maintenance, and other services (not yet included in the SULPU statistics) are added, the heat pump sector reached annual investment levels exceeding half a billion in 2019. This meant approximately one extra TWh per year to CO2-free heat production. It should be noted that most of this investment consisted of investments made by individual consumers using their own money, as it was a good investment for them.

The heating business concerning residential and service buildings amounts to between 70 and 80 TWh per year. Of this already 15%, over 10 TWh per year, is clean, individual heating generated by heat pumps. This has been achieved through Finland's close to one million heat pumps, in which consumers have invested EUR 6 billion. Heat pump investments in the production end of district heating and cooling as well as in industrial waste heat recovery are also growing.

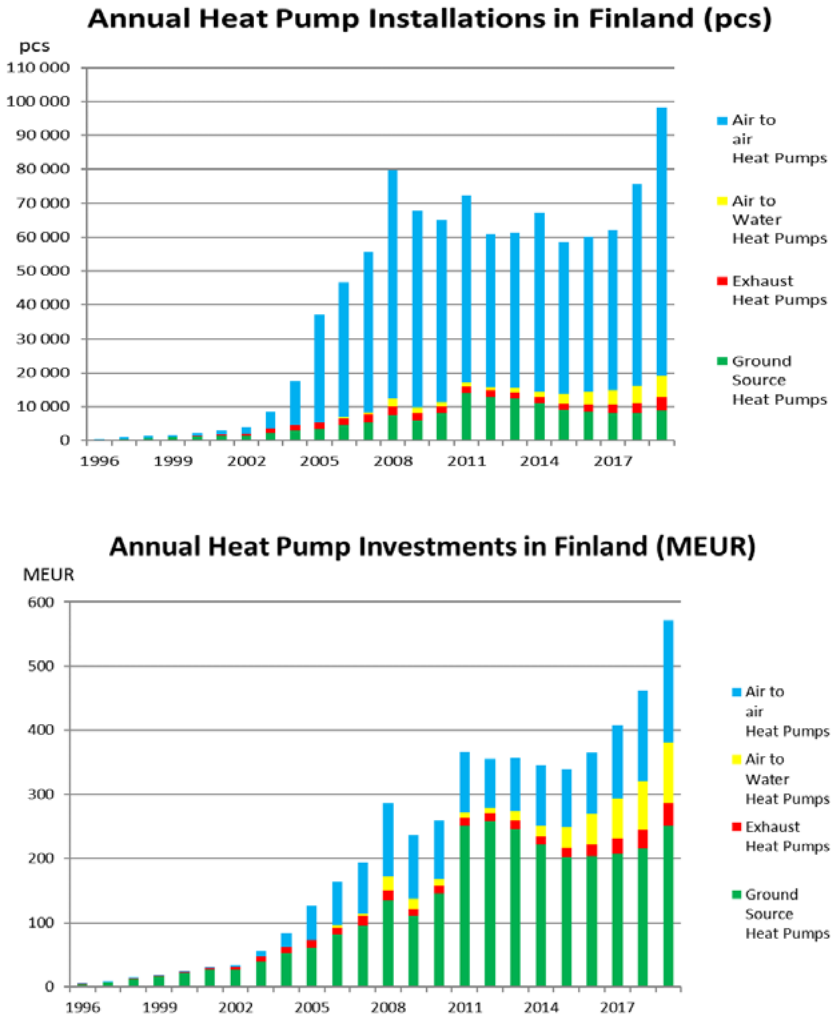

Fig. 2 Heat Pumps Installed in Finland per Type of Heat Pump; Quantities and in Euros, 2005-2019 [1]

2.2.3 On a European Scale, the Heat Pump Market Is Big

When comparing the success of the heat pump market in European countries, the market must considered in proportion to the population or to the number of houses. In the EHPA, the European Heat Pump Association, statistics of 2018, Table. 1, the sales volumes have been presented in proportion to the number of households.

When looking at Fig. 3, two main observations can be made. Firstly, there are roughly three groups of countries. The first group comprises Northern European countries: Norway, Estonia, Finland, Sweden, and Denmark. All of these countries boast sales of more than 20 units per 1,000 households. After these countries, there is rather a large gap. The second group is led by France with sales of 9.5 heat pumps per 1,000 households, followed by Switzerland (9.3), Lithuania (9.0) and Italy (7.8). The last group, mainly Central European countries, is characterised by very low heat-pump market shares, or in other words, very high potential. [2]

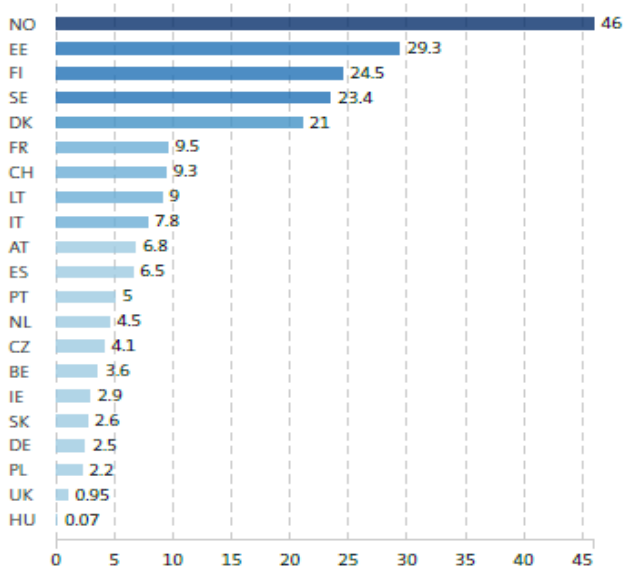

Fig. 3 Heat Pump Sales in Europe per 1000 Households, 2018 [2]

2. Market Drivers and How to Have an Impact on Them

The prerequisites for heat pumps in Finland are excellent. In a cold climate, a lot of energy is needed. In a typical single-family house, the usual annual consumption for heating and domestic hot water is 15,000-25,000 kWh of electricity or 2,000-3,000 litres of oil. Since Finland is a big country with a small population of 5.5 million, having e.g. a comprehensive gas network is unprofitable. The lack of this competitor favours heat pumps.

When considering the recent general developments in the construction business, the heat pump business has clearly strengthened its position in the heating and cooling of houses. However, it is only in the early stages of its success. The direction of the heat pump market development is clear, but the right type of advocacy, lobbying, will have an enormous impact on the degree of this development. The real market drivers have to be identified the means as well with which to influence them. The areas of this lobbying are multifaceted and, therefore, here are a few examples of current, genuine sectors in which lobbying is conducted in practice.

The heat pump market has increased a thousand-fold in Finland for 20 years. It is necessary to investigate the true market drivers and to consider whether they can be influenced and how.

3.1 Profitability

The most important of them is certainly profitability. The investor is a consumer, the user of energy, a house owner, most often a private individual. They must, at least, get the feeling that they are getting a sufficient return on their investment.

This they very often get in Finland. Fig. 3 shows the investments and the savings in both energy as well as in Euros for different types of heat pumps, indicating the price levels of 2019, in single-family houses as compared to electricity and oil heating. Approximately the same investment and savings ratios are reached with larger facilities where the comparison is usually with district heating.

Table. 1 Savings and Investments of Various Heat Pump Types in Single Family Houses [1]

Heat-pump type	Savings per year, kWh	Savings per year, €	Investment, €
Ground-source heat pump	14 000…17 000	1 800…2 200	14 000…20 000
Air-to-water heat pump	8 000…13 000	1 000...1 700	8 000…12 000
Exhaust-air heat pump	3 000…7 000	400…800	6 000…10.000
Air-source heat pump	2 000…7 000	250…800	1 500…2 500

Is it possible to have an impact on profitability? Yes, it is, at least on a long-term basis. As the market grows, market mechanisms bring system investments to the right level. Various subsidies are, in practice, always temporary and may boost the market for a short while but should not be allowed to disturb market-based development in the long run.

The profitability of heat pumps is very dependent on the price of fuels, electricity and district heating. In any case, they include a lot of taxes. Having an impact on these taxation structures is possible in the long run. Indeed, this is one of the foremost objectives of lobbying for the Finnish heat pump industry. For instance, by taking away the tax subsidy for fuel oil and by putting it in the same tax class as diesel transport fuel, heat pumps would receive a 20-30% leap in profitability. This is, after all, what our neighbour Sweden already did in the 1990s. The flourishing of the heat pump business that this, in part, created is something that we as a neighbouring country have been left to envy for a couple of decades now already.

Furthermore, the increase of electricity-price taxation would suit the heat pump business, since the competitiveness of heat pumps would improve in 700,000 electrically heated houses and almost 500,000 holiday homes.

3.2 Information, Communication and Visibility

Consumers, decision-makers and politicians must all have the most accurate information as possible and as much of it as possible. If they do not know that the profitability of heat pumps is excellent, business will not flourish, nor will heat pumps feature in discussion agendas, nor will they be acknowledged in regulations, law, rules or instructions.

Here, if anywhere, is the place for advocacy, for lobbying. The Finnish heat pump interest organisation, the Finnish Heat Pump Association SULPU, has extensively focused on providing this information, both qualitatively as well as quantitatively, in various media, such as the press, TV, radio, social media, with presentations, panel discussions, statements, and expressions of opinion. Regarding the development of the heat pump market, it is also very important to participate in the preparatory work of regulations, laws and instructions in ministries.

The principal messages when relaying this information must be carefully chosen and repeated systematically in the media, regardless of the channel of communication. A heat pump is profitable, the return on capital invested is excellent, it improves Finland's current external balance, it offers employment, and is a major and profitable environmental act. These arguments must be expressed repeatedly in all communication.

There is never enough of this type of lobbying, influencing. Nevertheless, it has been rewarding in Finland and can be seen in the development of the heat pump market.

3.3 Surveys Are the Best Fuel for Lobbying, Increasing Information, and for Quality

The heat pump business has carried out and participated in surveys that shed light on the possibilities of heat pumps and prospects. Here are three survey examples in which the heat pump industry has been involved and has used in its lobbying.

According to a survey conducted by the independent consultants Gaia Ltd, a total of EUR 12 billion will be invested in heat pumps by 2030, creating approximately 3,000 new jobs in the field. By then, heat pumps will be producing 22 TWh/a, 15 TWh of which is renewable energy that is extracted from around the building. These investments will also have a billion-class effect on Finland's current external balance and the value of

its building stock. [3] The breath-taking result of this survey has brought heat pumps a lot of credibility and weight now when, e.g., the Finnish Climate and Energy Strategy is being prepared.

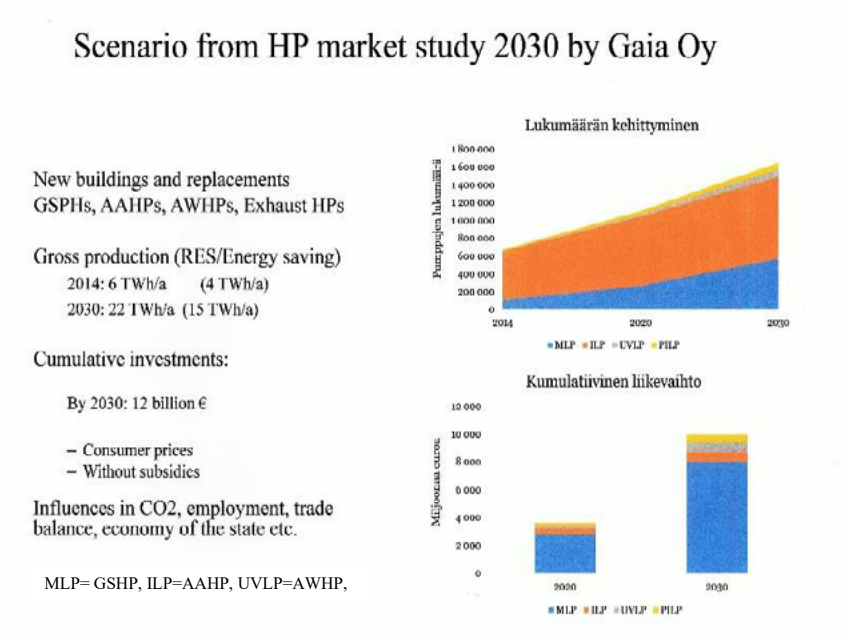

Fig. 4 The Role of Heat Pumps in 2030 [3]

Also, a study of how much exhaust air heat pumps can save of district heating in an apartment building. More than 30,000 apartment buildings release exhaust air that is warmer than 20 degrees Celsius. The entire air volume of the building is changed once every two hours, and that air vanishes up into thin air. Therefore, exhaust-air heat pumps have gradually become more common also in apartment buildings. About 2,000 apartment buildings have already been fitted with a heat pump that retains the heat of the exhaust air. This reduces even as much as 50% of the district-heating or other energy consumption of the building. After the fitting of this heat pump, it is also often decided that the remaining energy need will be covered with a ground-source heat pump, and district heating becomes redundant. Finnish Energy Industry, with the support of the heat-pump industry, commissioned VTT Technical Research Centre of Finland Ltd to study the effects of exhaust-air heat pumps on the district-heating network as well their market potential (3-5 TWh /a) [4].

There are 600,000 air-source heat pumps in Finland, and approximately 50,000 more are installed every year. It is common knowledge that in a Finnish house they save money, they cool the building, they work, and people buy them. There was no reliable information available as to how much energy they extract from around a building. That's why a study on the Energy Saving Potential of Exhaust Air Heat Pumps in Single Family Houses was performed a couple of years ago. Commissioned by the Ministry of the Environment and the heat-pump industry, VTT Technical Research Centre of Finland Ltd modelled an air-source heat pump for the heating system of a few houses and studied their energy-consumption effects in old, new and in the upcoming nearly zero-energy single-family houses. For the first time now, it has been possible to reliably define, in figures, the energy-saving potential of an air-source heat pump in Finnish conditions. The study took into consideration, in detail, the characteristics of the heat pumps and the buildings [5]. The result of this complicated and challenging modelling was that air-source heat pumps can provide 40-60% of the heating of a single-family house. The authorities, constructors and single-family house inhabitants will benefit from these results. These results have been used, e.g., in the nearly zero-energy buildings (NZEB) regulations that will be finalised shortly. Naturally, these results have been used to acquire lots of positive visibility in the Finnish media.

4. Summary

The heat-pump industry has become a significant renewable-energy business in Finland. 1,000,000 heat pumps produce over 10 TWh/a of energy, over 7 TWh of which is energy that is extracted from around the building. This already represents as much as 15% of the heating energy of all Finnish buildings. The prospects for heat pumps are good. The market will certainly develop in the future. The heat pump business can be described as an integrator that operates amidst and between renewable energy, electricity, and heating and cooling production. Heat pump technology and its applications can also be seen as an interface to a carbon-free age.

This paper looked at the Finnish heat pump market, at market drivers and whether they can be influenced. The heat pump industry market drivers must, indeed, be identified in order to be able to influence them. Finnish heat pump industry market drivers include profitability, the quality and quantity of information and communication, visibility, study results, and the quality of operations. It is certain that the significance of the heat pump industry will become greater. However, the degree of that significance can be influenced by influencing these drivers.

Profitability is affected by not only investments but also by the price of energy. The state taxes both fuels as well as electricity heavily. The structure and the scale of taxation are not, however, carved in stone. Taxing of CO2 releases must be accelerated.

The quality and quantity of information and communication as well as visibility have an immediate impact on the market. Increasing these is challenging in terms of resources, know-how and shaping the media environment. It has, however, proved to be possible and rewarding. Research that supports the development of the heat pump industry, research that is preferably conducted close to the market interface, plays a significant role in the management of this information. Developing quality and training schemes alongside the development of the heat pump market is important, and it is also a means for lobbying.

All too often, the importance of lobbying is forgotten, even though it is a very essential aspect in creating the preconditions for a new industry. The material required for lobbying, and the vision and goal for the heat pump industry, can be acquired from, e.g., surveys that are conducted by independent consultants. But also, close co-operation and communication on an international (IEA HPT TCP) and European scale (EHPA) and, of course, at a wider national level provide the basis for lobbying.

According to one of those above-mentioned independent surveys in 2030, there will be 2 million heat pumps in Finland producing 15 TWh worth of renewable energy. By then, a total of EUR 12 billion will have been invested in heat pumps, and 3,000 new jobs will have been generated. The savings that will have been made will by then be in the region of one billion euros per year.

More pressure or possibilities for heat pumps have been created by the political promise to make Finland carbon neutral by 2035. For this purpose, the Smart Energy Transition consortium has published a study estimating that heat production by heat pumps should be increased to 38 TWh/a by 2040 [6]. In the Finnish heating system district heating plays a very big role, about 50% of the heating market. Decarbonisation of the heat market by heat pumps means a lot of heat pumps in the production of district heating but also saving district heating by heat pumps installed locally in individual houses.

After fulfilling one million heat pump vision in 2020, the next target of two million heat pumps can be set for 2030.

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