

Heat Pump Implementation Scenarios until 2030

An analysis of the technology's potential in the building sector of Austria, Belgium, Germany, Spain, France, Italy, Sweden and the United Kingdom



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Executive Summary

Aim of this study is to quantify the potential of heat pumps to save CO₂-eq emissions and energy and to increase the use of renewable energy in the EU's building sector until 2030 and to assess related impacts on investments and energy costs. In relation to the F-Gas debate, also the amount of F-gases necessary to realise these potentials is calculated.

For that purpose, eight European key markets (Austria, Belgium, Germany, Spain, France, Italy, Sweden and the United Kingdom) have been analysed.

In this study three scenarios are calculated, which all comprise the same very ambitious energy efficiency measures on the demand side, but different implementation shares for heat pumps on the supply side. In the scenario with the highest heat pump implementation shares ("HP++") the overall CO₂-eq emissions for heating, cooling, hot water and auxiliary energy in buildings can be reduced by 47% from 2012 until 2030.

As a consequence the EU-climate targets for the building sector for 2030 would be more than met, which means that the long-term targets for 2050 can be better achieved than with less ambitious paths.

Background

The importance and potential of reducing greenhouse gas emissions in the EU building sector is undoubted and has been proven in various studies¹. At the same time, related measures to increase energy efficiency and use of renewable energies in new building and renovation projects support various other important societal and individual goals, such as creation of jobs, improvement of quality of life, security of supply and reduction of dependencies on (fossil) fuels.

Consequently, the EU formulated a sectorial target, which aims at decreasing the emission levels by 88%-91% for the residential and services sector compared to 1990 level by 2050². To achieve such targets, significant actions need to be triggered in the EU's national building markets, which need clear prospects and guidance to allow building owners, building industry and financing partners to take timely and well founded decisions.

The push of policies towards energy efficiency and use of renewable energy will continue to be a driver, with energy policies, regulations and subsequently building codes coming with stricter requirements for buildings and their constituent parts. At the same time, increasing energy prices

¹ i.e. Wesseling, B., Deng, Y. et. al: Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC), Ecofys 2009.

² see European Commission: Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final, Brussels, 8.3.2011.

make investors more aware of potential saving options and available alternatives. Together, this will create demand for new technologies and systems.

This competition thereby takes place at project and market level, where building owners make decisions on systems/technologies to be used. Furthermore it also takes place on policy level, where policy targets need to be translated into concrete policy frameworks at EU and Member State level. This basically creates favourable conditions for the use of heat pumps in both new buildings and in refurbishments. This study aims at quantifying the potential role of heat pumps in the future supply mix. Therefore the *applicability and performance of heat pumps* at building level is analysed in this study. Based on this analysis, three *heat pump implementation paths* until 2030 for the eight focus countries Austria, Belgium, Germany, Spain, France, Italy, Sweden and the United Kingdom are analysed.

This study on implementation potentials for heat pumps aims to clarify and underpin the role that heat pump technology can play in the building sector.

Heat Pump Implementation Scenarios

Table 1 shows the definition of the heat pump implementation scenarios. Apart from a *Current-Policy Implementation* (CPI) scenario, which assumes the full and timely implementation of legislation, the "HP+" and "HP++" scenarios assume a development of heat pump shares towards 50% (HP+) respectively 100% (HP++) of all new buildings and 30% (HP+) respectively 50% (HP++) of retrofitted buildings to be equipped with heat pumps in 2030. Additionally, all scenarios assume very ambitious energy efficiency measures³ to be applied for retrofits and new buildings. Furthermore a decarbonisation of the electricity generation according to the long-term power-sector targets is taken into account.

Table 1: Overview on heat pump implementation scenarios

Scenario	Definition
<i>Scenario "CPI"</i>	Current Policy Implementation: Full and timely implementation of all legislation related to energy performance of buildings (and specifically heat pumps) by the Member States.
<i>Scenario "HP+"</i>	Ambitious heat pump scenario with increasing shares of heat pumps in new buildings and retrofits (target: 50% share ⁴ for new buildings in 2030 and 30% in retrofits in 2030).
<i>Scenario "HP++"</i>	Very ambitious heat pump scenario with increasing shares of heat pumps in new buildings and retrofits (target: 100% share ⁴ for new buildings in 2030 and 50% in retrofits in 2030).

³ See Annex of the study

⁴ For the "HP+" and "HP++" scenarios the decisive factor "Implementation shares gained from competing Technologies" was chosen, which quantifies the share that heat pump technologies can take in 2030 from the competing non heat pump technologies. Figure 5 (in section 1.6) gives an illustration of this indicator.

Main Results

Table 2 gives an overview on the main results of the heat pump implementation scenarios for all key markets, which are the overall reductions of CO₂-eq emissions, final energy as well as the total yearly costs (covering investments for the building envelope and HVAC-technologies and energy costs).

Table 2: Overview on main results per implementation scenario

Scenario	Energy-related CO ₂ -eq emissions in 2030 [Mt/a]	Relation to CO ₂ -eq emissions in 2012 (638 Mt/a)	Final energy in 2030 [TWh/a]	Primary energy in 2030 [TWh/a]	Total yearly costs (Investments and energy costs) in year 2030 [billion € ₂₀₁₂ /a]	Amount of F-gases needed for production of heat pumps in 2030 [Mt _{F-gas} /a]	CO ₂ -eq emissions from F-gas leakages in heat pumps in 2030 [Mt/a]
Scenario "CPI"	424	-34%	2,272	2,197	718	0.0086	17
Scenario "HP+"	385	-40%	2,112	2,074	723	0.0181	26
Scenario "HP++"	342	-46%	1,951	1,945	734	0.0313	39

Conclusions

1. What is the effect of heat pumps towards the 2030 and 2050 GHG saving targets including F-Gas leakages?

The **total CO₂-eq emissions drop** by 34% in the scenarios "CPI" from 638 Mt/a in 2012 to 424 Mt/a by 2030, by 40% in the scenario "HP+" to 385 Mt/a by 2030 and by 46% in the scenario "HP++" to 342 Mt/a by 2030.

For a better understanding and interpretations these CO₂-eq emission reductions are put in context to the existing buildings sector specific GHG reduction targets from the "EU Roadmap for moving to a competitive low carbon economy in 2050" (COM2011-112).

Hereby the CO₂-eq emissions should be reduced by 37% to 53% by 2030 (based on 1990 numbers) and by 88% to 91% by 2050. From this target corridor in Table 1 it becomes obvious that the targets are getting more ambitious in the period 2030-2050.

With all 3 scenarios staying within this GHG target corridor until 2030, especially the HP+ and HP++ scenarios can also pave the way towards 2050 targets.

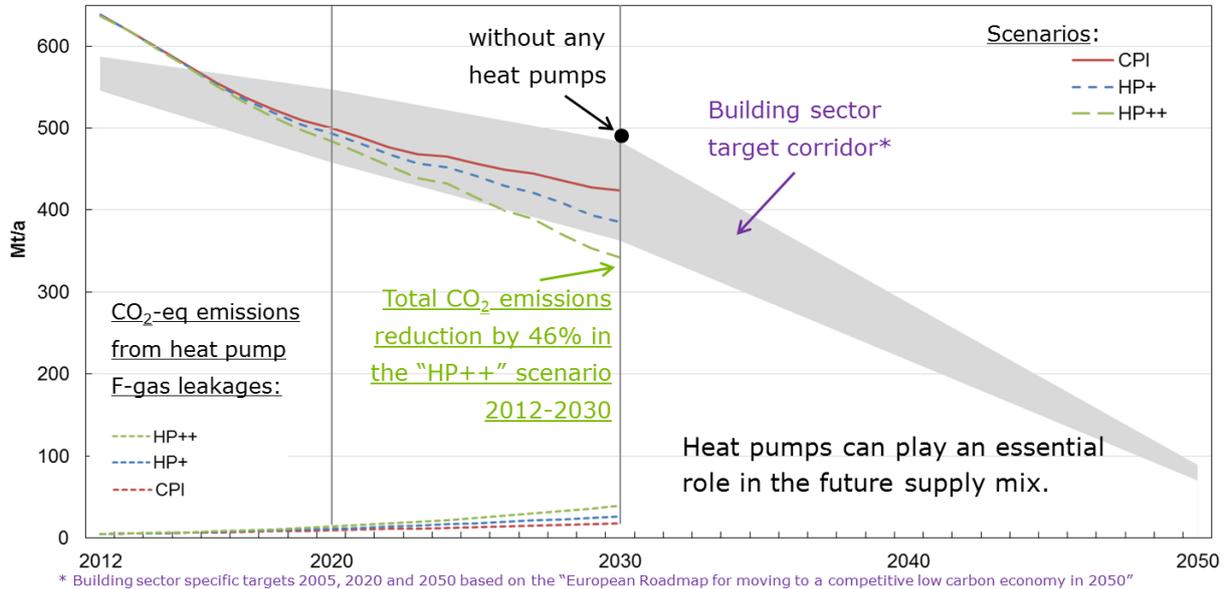


Figure 1: Total CO₂-eq emissions for all Countries

A prerequisite for increasing heat pump shares is the availability of F-gases for the production of heat pumps. The CO₂-eq emissions from F-gas leakages are growing over time, they account for up to 17 Mt/a by 2030 in the "CPI" scenario, for 26 Mt/a in the "HP+" scenario and for 39 Mt/a in the "HP++" scenario (not included in scenarios, but shown separately at the bottom of the graph). As an average in the assessed scenarios, **3.7 tons of CO₂-equivalents are saved per 1 tonne "invested" CO₂-equivalent emissions from F-gas leakages of the applied heat pumps systems.**

2. How much final and primary energy savings can be realized in the scenarios?

The overall final energy use for space heating, hot water, cooling and auxiliary purposes is decreasing by 17% in the scenario "CPI" from 2,752 TWh/a in 2012 to approx. 2,272 TWh/a in 2030, while a reduction of 23% to 2,112 TWh/a can be realized in the "HP+" scenario and a reduction of 29% to 1,951 TWh/a in the "HP++".

The primary energy for space heating, hot water, cooling and auxiliary purposes is decreasing by 31% in the scenario "CPI" from 3,203 TWh/a in 2012 to 2,197 TWh/a by 2030, while a reduction of 35% to 2,074 TWh/a can be realized in the "HP+" scenario and a reduction of 39% to 1,945 TWh/a in the "HP++" scenario.

3. What are the costs of increasing heat pump implementation in the scenarios?

The total energy costs (for all systems in the building stock) by 2030 are slightly lower in the scenario "HP++" with 290 billion €₂₀₁₂ in comparison to 299 billion €₂₀₁₂ in the scenario "HP+" and 309 billion €₂₀₁₂ in the scenario "CPI".

The annualised costs (annuities) of all investments (total costs of energy efficiency measures and HVAC systems) are amounting to 409 billion €₂₀₁₂ in the scenario "CPI" by 2030, to 424 billion €₂₀₁₂ in the scenario "HP+" and to 444 billion €₂₀₁₂ in the "HP++" scenario.

The total yearly costs in the building sector (energy costs and annualised investment costs) are used as the indicator for economic evaluation. Total costs in 2012 account for 248 billion €₂₀₁₂ and increase up to 718 billion €₂₀₁₂ by 2030 in the scenario "CPI", whereas they increase up to 723 billion €₂₀₁₂ in the scenario "HP+" and up to 734 billion €₂₀₁₂ in the scenario "HP++". This represents additional costs of 0.6% in the scenario "HP+" and 2.4% in the scenario "HP++" compared to the scenario "CPI".

4. Do we achieve the renewable energy shares from the RES-directive?

Related to the renewables directive (DIRECTIVE 2009/28/EC), the aggregated target from the Member States` National Renewable Energy Action Plans (NREAPS) for renewable energy delivered by heat-pumps is a share of 2.4% of the gross final energy for 2020 .

Figure 2 gives the heat pumps shares (calculated according to the methodology from DIRECTIVE 2009/28/EC) for the three scenarios. The RES-share from heat pumps in the "CPI" scenario could reach 6.3% by 2020, while levels of 7.6% and 9.8% can be reached in the "HP+" respectively "HP++" scenario.

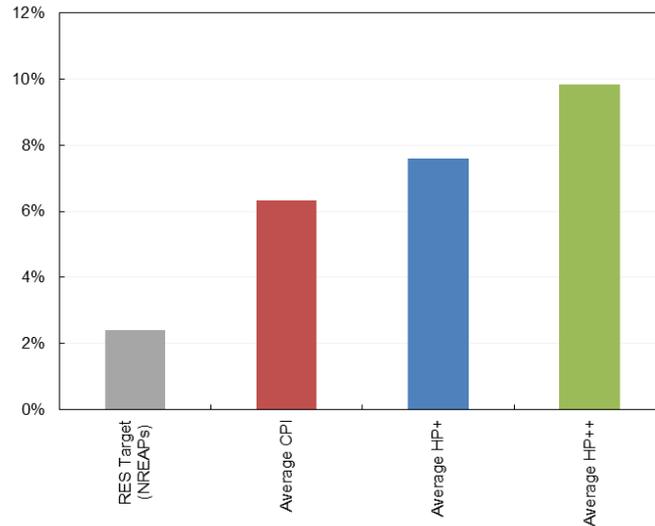


Figure 2: RES-shares for heat pumps in scenarios

As the contribution from heat pumps to the overall RES-share in the scenarios is higher than expected or targeted by the Member States in their NREAPs, they most likely predict lower heat pump growth rates until 2020 compared to this study.

5. What does that mean?

The overall conclusion is that heat pumps can contribute significantly to the mitigation of CO₂-eq emissions, energy savings and to an increasing share of renewable energies and is thus an important puzzle piece for reaching the EUs long term targets . This can be realized at moderate additional overall costs in the “HP+” and “HP++” scenarios compared to the “CPI” scenario. Hence heat pumps can play an essential role in the future supply mix. Nevertheless additional policy actions for heat pumps are required with respect to higher implementation.

For the “HP+” scenario legal requirements towards nearly-zero-energy-buildings in retrofits (which are now set for new buildings only) should be put in place, with financial incentives to support this development. Furthermore information measures, education and training as well as quality assurance are important elements for higher share of heat pumps in both new buildings and retrofits. For details on further heat pumps specific policies see also the study “*Unleashing the Opportunity – European Best Practice in Building Successful Heat Pump Markets*”⁵.

As the “HP++” scenario is defined as a theoretical maximum, there are no additional policy recommendations compared to the “HP+” scenario.

⁵ By Delta-EE

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1 Methodology

1.1 Structure and Scope

Aim of this study is to quantify the potential of heat pumps to save CO₂-eq emissions and energy and to increase the use of renewable energy in the EU’s building sector until 2030 and to assess related impacts on energy use, investments and energy costs. In relation to the F-Gas debate, also the amount of F-gases necessary to realise these potentials is calculated.

For that purpose, eight European key markets (Austria, Belgium, Germany, Spain, France, Italy, Sweden and the United Kingdom) have been analysed.

The application of heat pumps will be investigated for space heating and cooling and domestic hot water purposes in residential buildings (differentiated by single and multi-family buildings) and commercial buildings (such as offices, retail, and administration buildings) both for new buildings and retrofit situations. The application of heat pumps in industrial processes is not included in the scope of this study.

1.2 General Approach

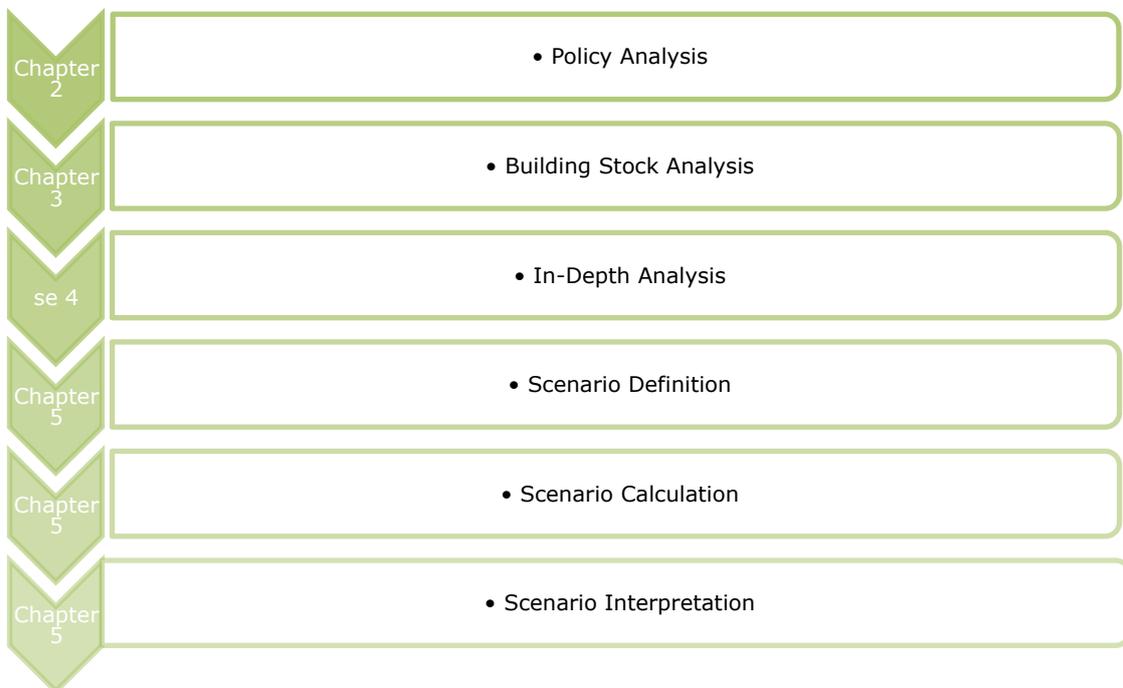


Figure 3: Project Approach

Figure 3 shows the outline of the general approach to the present study. In a first step a **policy analysis** is conducted in section 2. This analysis gives an overview of all current and future policies

under discussion which are already and will be affecting heat pumps in the key markets. The analysis is done on European and national level. The **building stocks** of all key markets are investigated in section 3. After having assessed technical improvement potentials for heat pump technologies in an **in-depth analysis** in section 4, calculations on building level show the technical and economical applicability of different systems in different situations. The results on country level determine possible developments in the future and secure that most cost-effective systems are selected as reference cases.

Based on this information, the **scenario definition, calculation and interpretation** is done in section 5 using the Built-Environment-Analysis-Model BEAM² developed by Ecofys⁶.

In general the following three scenarios are set up for all key markets. They follow possible heat pump development paths up to the year 2030:

- Scenario "CPI":* Current Policy Implementation: full and timely implementation of all legislation related to energy performance of buildings (and specifically heat pumps) by the Member States.
- Scenario "HP+":* Ambitious heat pump scenario with a 50% share⁷ of heat pumps in new buildings and 30% in retrofits by 2030.
- Scenario "HP++":* Very ambitious heat pump scenario with a 100% share⁷ of heat pumps in new buildings and 50% in retrofits by 2030.

The following subsections describe the different methodologies used for the separate work packages.

1.3 Policy Analysis

The policy analysis is the first step within the analysis process. Its aim is to quantify the impact of all current policies and those under preparation with regard to the heat pump development and provide the input for the scenario calculation.

Therefore a variety of directives on *European level* are taken into account (such as the Directive on the promotion of the use of energy from renewable sources (RES), the Ecodesign Directive, the European Performance of Buildings Directive (recast) (EPBD), Energy Labelling Directive and Energy Efficiency Directive) as well as the F-gas regulation and some communication documents.

Furthermore, an analysis on *Member State level* focuses on the differences and specifics of the key markets. Here country specific instruments and policy measures as well as heat pump incentive programmes are evaluated.

⁶ see section 1.6.2 for further information on BEAM².

⁷ For the "HP+" and "HP++" scenarios the decisive factor "Implementation shares gained from competing Technologies" was chosen, which quantifies the share that heat pump technologies can take in 2030 from the competing non heat pump technologies. Figure 5 (in section 1.6) gives an illustration of this indicator.

The policy analysis provides an input to the heat pump implementation forecasts in the key markets for the scenario "CPI". This scenario is based on historic sales data together with the current policies and those under preparation, while the scenarios "HP+" and "HP++" are based on theoretical market potentials without a direct input from policy development. A detailed description of the methodology for heat pump implementation in the different scenarios is given in section 1.6.1.

In order to better understand the historic sales data, the main drivers and barriers for all key markets are identified by taking into account the influencing factors policy and market conditions. This enables a better analysis of the current situation and of the impact that policies under development will have.

1.4 Building Stock Analysis

The building stock analysis is an important input to the scenario calculation in section 5. To develop a forecast for the future potential of heat pumps in Europe in 2030 a good knowledge of the building stock in the key countries is necessary. In order to investigate the implementation potential for heat pumps in national markets, the building stock will be clustered according to different characteristics. The building stock is first divided into residential and non-residential buildings and then categorized into different building types, age groups and retrofit levels. Furthermore, construction and renovation rates in the key markets will be evaluated. Non-heated buildings are excluded from this analysis.

The following building categories are used for every country:

Residential sector

- Single-family buildings (SFH)
- Multi-family buildings (MFH)

Non-residential sector

- Office buildings (OFB)
- Education buildings (EDB)
- Trade and retail buildings (TRB)
- Touristic buildings (TMB)
- Health buildings (e.g. hospitals) (HEB)
- Other non-residential buildings (ONB)

On the basis of current statistics and building stock inventories an accurate representation of current building stocks of the key markets is defined. The geometry of the reference buildings and the energy related parameters of the building shells (u-values etc.) for the status quo are adjusted to the local situation.

Section 3 provides a comprehensive overview on the representative building stock for all key markets. Specific values, assumed geometries and other detailed parameters used to define the building stocks of the examined key markets can be found in Appendix A and its subsections.

1.5 Performance of Heat Pumps on Building Level

This section provides an overview on the methodology for the analysis of heat pumps on building level.

1.5.1 Useful Energy Demand for Heating and Cooling

The calculation of the useful energy demand (energy demand of the building, excluding system losses) is performed using the building simulation software TRNSYS. For each of the reference buildings a single zone model is created. The calculations are performed with an hourly resolution considering the local reference climate data, the building's physics as well as schedules for occupation and internal loads. The simulation determines annual hourly values of the useful energy demand for heating and cooling. Demand adapted system supply temperatures are considered for the calculation of the hourly coefficients of performance (COP) values. The heating supply temperatures are derived from a linear interpolation between the design heating temperature (55°C or 35°C) at 100% of the design heating demand and 20°C at 0% heating demand.

1.5.2 Coefficients of Performance

The calculated Coefficients of Performance (COP⁸) values of the heat pump systems as well as the derived Seasonal Performance Factors (SPF) consider the energy demands required for compressors as well as other heat pump system related components like fans (air source heat pump) and brine or water system pumps.

The electrical energy demands of the pumps within heating and domestic hot water systems are not included. As those are independent from the heat production system they are not further considered.⁹

The final energy demand is determined by division of the hourly useful energy demands by the COP values. Apart from the significant losses of the domestic hot water systems, which have been assumed for all cases to be 50% of the domestic hot water demand, no further heating system losses are considered.

The used heat pump system models describe highly efficient systems. The resulting efficiency of those systems can be assumed to be standard in the period until 2020. The detailed calculation methods of COPs, as well as determination of EER values of the cooling systems in countries with cooling demand, are described in Appendix B.3.

⁸ The calculated COP values are variable system values, which are determined based on the actual boundary conditions at the specific hour. Those should not be mixed with the laboratory values, which are determined under fixed conditions.

⁹ For the gas heat pump the related el. energy demands have been neglected

1.5.3 Final Energy Demand for Heating and Cooling

The hourly final energy demands are derived by division of the useful energy demand (plus losses for domestic hot water systems) by the actual COP value of the specific hour, which is dependent on the external and internal system temperatures.

1.5.4 Greenhouse Gas Emissions

To reflect the environmental impact of each heat pump technology CO₂-eq emissions are calculated based on CO₂-eq emission factors. The CO₂-eq emission factor for gas is the same for all countries and is considered for gas based air heat pump systems for each building type. The factors for electricity vary due to different shares of energy sources in each country. Thus, CO₂ intensity for total power generation for electricity is calculated by using emission factors of primary fuels, combined with the conversion efficiencies of electricity production by using the database providing energy statistics (IEA, 2011). The data is presented in Table 3.

Table 3: CO₂ Emission factors (g CO₂eq/kWh)

Energy type	AT	BE	FR	DE	IT	ES	SE	UK
Electricity	165	198	88	489	439	294	34	453
Natural gas	202							

The total CO₂-eq emissions associated to a specific heat pump technology for each country is calculated according to equation (3):

$$E_{i;j;k} = \left(Q_{i;j;k} + Q_{(DHW)i;j;k} + Q_{(Cooling)i;j;k} \right) \cdot EF_{i;k} \cdot 0.001 \quad (1)$$

with

- $E_{i;j;k}$ Total CO₂-eq emissions for heat pump technology (i) for building type (j) in country (k) in kg/m²a
- $Q_{j;k}$ Annual energy demand for space heating for building type (j) in country (k) in kWh/m² a
- $Q_{(DHW)ij;k}$ Annual energy demand for domestic hot water for building type (j) in country (k) in kWh/m² a; for only heat pump types based on electricity
- $Q_{(cooling)ij;k}$ Annual energy demand for cooling for building type (j) in country (k) in kWh/m² a
- EF_k CO₂-eq emission factor for heat pump technology based on energy type (i) in country (k) in g CO₂eq/kWh

1.5.5 Investment and Energy Costs

In addition to technology prices (see section 4.2.3.5) the economical applicability of each heat pump technology is considered based on the unit price of energy in key markets. Table 4 provides the assumed unit prices for electricity and natural gas including taxes.

Energy prices for oil, gas, coal and electricity are adapted to the energy price trends estimated by the European Commission. As a basis the energy prices for 2010 were taken from Eurostat: Band DC: 2 500 kWh < Consumption < 5,000 kWh incl. taxes.

Table 4: Average unit energy prices in key countries based on electricity and gas (€/kWh),

Source for Baseline: Eurostat

Energy type	AT	BE	FR	DE	IT	ES	SE	UK
Electricity	0.19	0.20	0.13	0.24	0.19	0.18	0.19	0.14
Natural gas	0.06	0.05	0.05	0.06	0.07	0.06	0.10	0.04
Ratio electricity/gas	3.2	4.0	2.6	4.0	2.7	3.0	1.9	3.5

The ratio electricity/ gas ("energy price ratio") was specified for the different countries. The energy price ratio is relevant for the comparison of economical performances of systems using different energy carriers. Gas heat pump solutions show much better economic performance in countries with a high energy price ratio, as it is the case for Belgium and Germany.

The cost of energy generation with specific heat pump technology for each country is calculated as follows:

$$EC_{i,j;k} = \left(Q_{i,j;k} + Q_{(DHW)i,j;k} \right) \cdot P_{i;k} \quad (2)$$

with

- $EC_{i,j;k}$ Energy cost for heat pump technology based on energy type (i) for building type (j) in country (k) in €/m²a
- $Q_{j;k}$ Annual final energy demand for space heating for building type (j) in country (k) in kWh/m² a
- $Q_{(DHW)ij;k}$ Annual final energy demand for domestic hot water for building type (j) in country (k) in kWh/m² a
- $P_{i;k}$ Average energy price for the specific final energy based on energy type (i) in country (k) in €/kWh

Determination of costs

For the economical evaluation the methodology of the cost optimal calculation according to EU Directive No 244 (2012) is applied.

Using an interest rate of 3.5% on capital (financial perspective), all future cash flows over the period under consideration are discounted to t = 0 (starting time). In addition to the investment costs

(divided into equipment and building envelope) the energy and maintenance costs are included in the net present value representing the total costs.

Among other things it is considered in principle:

- Calculation period of 30 years for residential buildings and 20 years for non-residential buildings
- Residual values

Energy cost increase rates are assumed in accordance with the guideline to cost optimality calculation as follows:

- ⇒ fossil fuels: 2.8%
- ⇒ electricity: 2.9% until 2015; 2.0% 2016-2020; 0.8% 2020-2025; after 2025-0.3% (according to the average for households, industry and services)

Reduced HP tariffs, which are available at some regions at some countries, have not been considered. Potential regional or national subsidies have also not been considered.

The lifecycle (HPs: 17 years, wells and geothermal probe as well as floor heating system: 50 years) and maintenance costs (3% for el. HP and 4% gas HP) are assumed according to EN15459. Replacement investment and residual values have been considered in accordance to the method of the EU Directive No. 244 (2012).

1.6 Heat Pump Implementation Scenarios until 2030

First step in the scenario calculation is the forecast of heat pump implementations until 2030. This section gives an overview on the methodology for future heat pump implementation and the methodology for the scenario calculation.

1.6.1 Forecast on Heat Pump Implementations until 2030

As the market environment is different for new buildings and replacement installations, the forecast for implementation is differentiated between new buildings and retrofit situations. In this approach a general split per technology in the yearly implementation mix of heating systems is done (heat pumps and competing technologies). Starting point is the current yearly implementation mix for all key markets.

Market Phases

The development of markets from first introduction of a product or technology until saturation in a mature market can be described as an S-curve. After a market introduction phase, which is typically connected to relatively low growth rates, a technology has the potential (if accepted by the market) to grow in implementation shares. After being well introduced in a stable market, saturation is likely to happen, in which the implementation of a specific system remains stable, but does not further increase. These different phases are shown in Figure 4.

Markets like the United Kingdom, France, Germany, Austria and Belgium are at the lower end of the S-curve for heat pump sales in a growing market which is taking up and accelerating its growth, while Sweden will most likely have market saturations in the near future. Italy and Spain rank in between. The red dotted lines indicate growing implementations per year (slope of tangent is increasing) while the orange dotted lines indicate decreasing implementations per year (slope of tangent is decreasing).

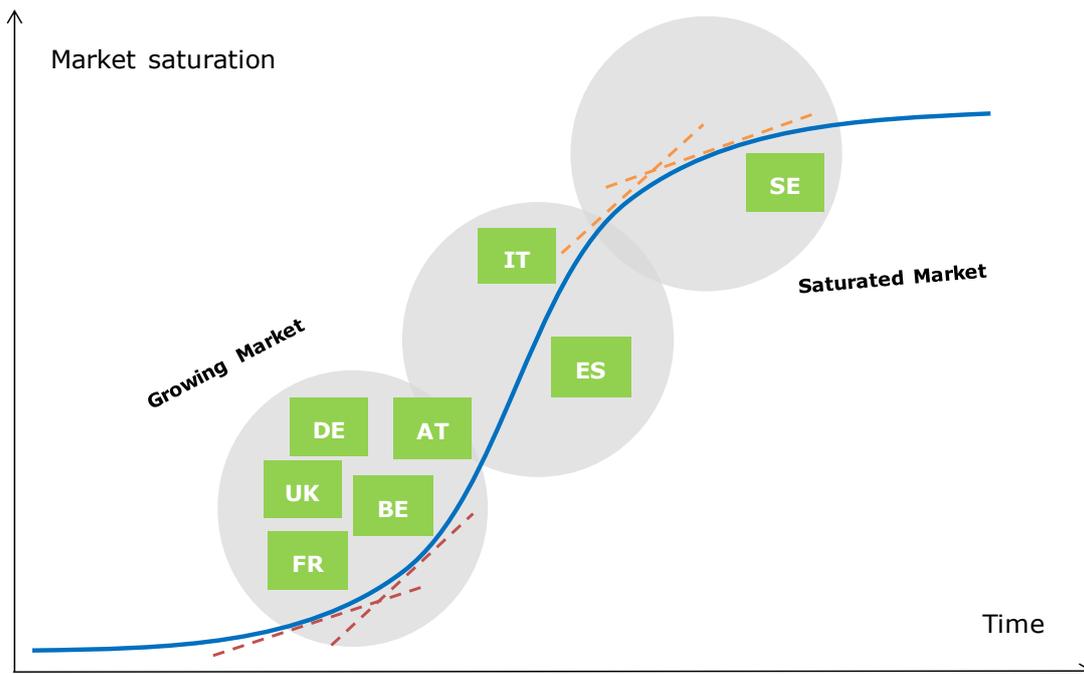


Figure 4: Illustration of the position of different markets within a classical market development curve

Market Growth per Scenario

The future growth of heat pump markets in the key markets is depending on the market development phase the different countries are in and the assumptions per scenario path. While the market phase per country is assumed as shown in Figure 4, the assumptions per scenario paths are set as follows.

For the **scenario "CPI"** the *"Future growth rates of heat pump technologies per year"* is the leading indicator. This approach is based on historic data and forecasts the future growth rates in yearly implementations by taking the position on the S-curve into account.

In this scenario the implementation of heat pumps is increasing for new and promising markets (higher slope of tangent than observed in the past), while they are decreasing for mature markets (lower slope of tangent). Furthermore it is assumed that policies have an impact on the sales potential, see also section 2 "Policy Analysis". In consequence a leverage factor for expected policy impacts is applied to the sales numbers per key market (describing the assumed increase in sales per year) which is differentiated for new buildings and replacement installations in retrofit situations due to different conditions for heat pump installations.

For new buildings no further policy action results in a leverage factor of 1.0, little policy action in 1.2, moderate policy action in 1.5 and high policy action in 2.0. As heat pumps are more difficult to install in replacement installations (retrofits), the leverage factors are lower, see Table 5.

Table 5: Leverage Factors for Heat Pump Implementation in the "CPI" Scenario

Impact of further Policy Action	New Buildings	Retrofits
No	1.0	1.0
Low	1.2	1.1
Medium	1.5	1.25
High	2.0	1.5

While using the above described leverage factors, it seems reasonable to **additionally** set a cap to the achievable market growth for the complete timeframe 2012 to 2030 based on limitations in production and installation capacity by country size. Derived from examples of historic market developments, a maximum market growth factor for the timeframe 2012 to 2030 for heat pumps of 10 is applicable for large countries such as DE, FR, UK, ES and IT with little or no import options and a factor of 50 for small countries such as AT, BE and SE with a maximum population of 11 million and technology import options.

As a different approach, compared to the leverage factors that are used to develop the CPI scenario, the decisive factor that was chosen to develop the **"HP+" and "HP++" scenarios** is the *"Implementation shares gained from competing Technologies"*, which is based on market potentials rather than on historic data. It quantifies the share that heat pump technologies can take in 2030 from the competing technologies. Figure 5 gives an illustration of this indicator, which is equal to the ratio B/A. This approach implicitly includes the position of the country on the S-curve, as the potential becomes smaller with a growing market. The *"Implementation shares gained from competing Technologies"* are again differentiated, 50% for new buildings and 30% for retrofits. For retrofits the existing district heat supply is considered not to be part of the potential that could switch its technology to heat pumps.

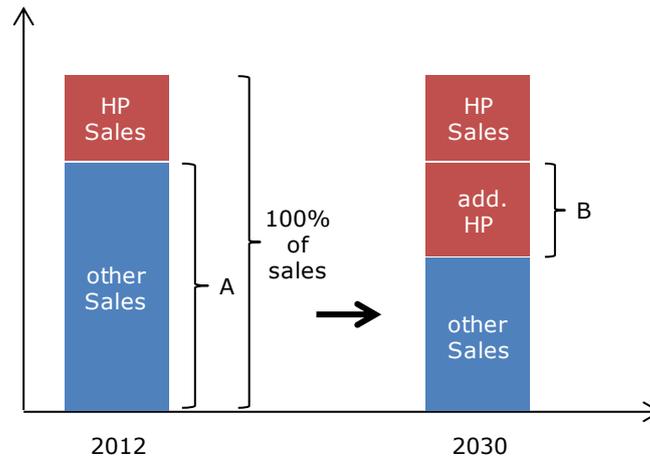


Figure 5: Illustration of "Implementations gained from competing Technologies" in the "HP+" Scenario

1.6.2 Scenario Modelling

Based on the expected development and deployment of heat pumps and other technologies described in the previous section, integrated scenario calculations show the impact of different technology paths and implementation numbers for heat pumps in the future.

For the scenario calculation the Built Environment Analysis Model (BEAM²) has been used. Ecofys developed this model over the last years to analyse national and international building stocks. Results of the model are energy demand, CO₂-eq emissions and energy costs for space heating and domestic hot water in the built environment. The results can then be presented for different types of buildings, building ages, climate zones etc. Input to the model calculation is a database containing international building stock data distinguished by climatic regions, building type/size, building age, insulation level, energy supply, energy carrier, energy costs and emission factors. This can be applied in a scenario tool used for calculating the development over time of the building stock as a function of demolition rate, new building activity, refurbishments and energy-efficiency measures in retrofits, see Figure 6. So far the model has been used in various projects (e.g. for the European Commission) and has contributed to the perception and reputation of Ecofys in Europe.

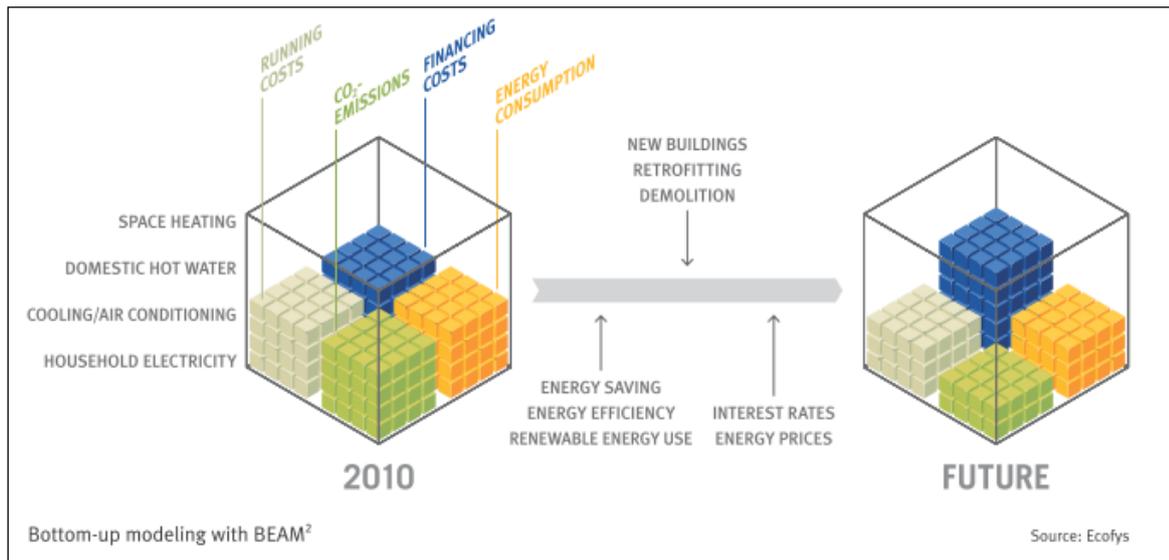


Figure 6: Structure of the Built Environment Analysis Model BEAM²

Key results of the model are floor area development, final and primary energy demands for heating, hot water and cooling¹⁰, greenhouse gas emissions as well as investments required for Heating, Ventilation and Air Conditioning (HVAC) systems, building envelope measures and energy costs. Based on these numbers, employment effects are quantified, while scenario comparisons lead to CO₂-eq abatement costs.

In addition to these results the fluorinated greenhouse gases are included in the analysis. Based on the outputs of the model on number of heat pumps, the yearly amount of F-gases required for production of heat pumps and the assumed leakages during lifetime of heat pumps are calculated.

¹⁰ The cooling demand is fully integrated in the model. As uncertainties and lack of data about the cover ratio of the theoretical cooling demand exist, rough assumptions on the coverage are made. Based on the remaining cooling energy demand one average cooling technology is assumed.

2 Policy Analysis

This section gives an overview on heat pump related current and planned policies on both European and Member State level for the assessed countries. Section 2.1 describes and analyses the European framework policies and section 2.2 the national policies.

The impact of current policies and those under discussion with regard to the heat pump development and sales forecasts are quantified for the scenario path "CPI", while the scenarios "HP+" and "HP++" represent a theoretical case with measures going beyond the current policy discussions. The input to the scenario calculations are summarized in section 2.1.10 for European policies and in section 2.2.9 for national policies.

2.1 Overview on European Level

This section provides an overview of the current policy framework in place that is relevant for the heat pump technology development and implementations. It is based on the EHPA monitoring report *Outlook 2012 – European Heat Pump Statistics*.

In the effort to realising the 20/20/20¹¹ targets of the EU, the framework conditions have been continuously evaluated and updated throughout the past years. The building sector with its hardly tapped potential has been identified as one of the key sectors to reaching these targets.

All of the selected legislation for this overview set requirements for product and building energy efficiency, an increased use of renewable energy and the reduction of greenhouse gas (GHG) emissions. They are discussed with regard to their current as well as expected impact on the heat pump market development.

The current legal framework in place sets strong boundaries for the employment of technologies with higher energy efficiency. Also the shift from the use of energy from non-renewable to the use of energy from renewable sources is supported by several measures. Especially, the promotion of renewable energy will have a positive impact on the heat pump market.

However, what becomes apparent when examining the legislation presently in place, the support for renewable energy is usually implemented at general level (covering various available renewable energy technologies) and does not specifically target or promote heat pumps. This aspect will be further examined in the following parts.

¹¹ 20% reduction of greenhouse gas emissions compared to 1990, 20% energy savings by 2020 (compared to a business as usual scenario) and a 20% share of renewables in 2020

2.1.1 The Directive on the Promotion of the Use of Energy from Renewable Sources (RES Directive)

The Directive on the Promotion of the Use of Energy from Renewable Sources “RES Directive” EC/28/2009 aims at increasing the share of renewable energies in the overall energy mix within the EU, leading towards reaching a share of 20% renewables by the year 2020. The significance of the RES Directive for the heat pump technology is that it officially recognises it as a technology that makes use of renewable energy sources (RES).

In addition to setting the target share of RES to be reached by Member States (MS) it also aims at reducing final energy demand as well as GHG emissions and therefore securing a stable independent energy supply within the EU on a long term basis. The RES Directive also delivers a common framework of guidelines as a support tool for MS to reach the defined targets. These guidelines touch topics such as eligibility, statistical transfer, joint projects, guarantees of origin, administrative procedures, information, training and access to the electricity grid.

Overall, the RES Directive can be reviewed as having a positive impact on heat pump technology, as it acknowledges heat pumps as a technology that makes ambient energy from air, water and shallow ground useful (applies to electrical as well as to gas driven heat pumps). Furthermore, the amount of renewable energy used by heat pumps will be calculated based on final energy. A minimum requirement on seasonal efficiency to be reached at standard rating points is set by the RES Directive and only the heat pumps that reach a minimum efficiency (SPF of 2,53) will be counted.

2.1.2 Energy Performance of Buildings Directive (EPBD)

As of July 2010, the recast of the Energy Performance of Buildings Directive (EPBD) 2010/31/EU is in force, focusing on the improvement of energy performance of buildings, building elements and technical systems via a set of minimum requirements. The directive centres on topics such as providing a framework for the calculation of energy performance, the share of nearly-Zero-Energy-Buildings (nZEB), energy certification of buildings and regular inspections of heating and air-conditioning systems.

The directive has already been transposed into national law by Member States. It includes obligatory reporting on the process which is handed to the Commission who can then assess the progress the MS are making. Upon request, the Commission can also provide guidance to MS for a quicker implementation.

The EPBD, as well as the RES Directive, has a positive impact on the development of heat pump technology and heat pumps can benefit greatly from the improved requirements set in the recast. Similar to the directive discussed above, the EPBD recast acknowledges heat pumps as a technology that transfers heat from natural surroundings (air, water and ground) to buildings or industrial applications. The EPBD recast sets minimum requirements for the building envelope and it also requires taking into consideration available heating alternatives prior to construction. Heat pumps can further benefit from the requirements set by the recast on the efficiency of heating, hot water, air-conditioning and ventilation systems alone or as a combination, if a comparison of systems and energy sources is allowed or even encouraged.

2.1.3 The Ecodesign for Energy-related Products Framework Directive, Lot 1 (Ecodesign Directive)

The framework for the setting of Ecodesign requirements for energy-related products (recast) (Directive 2009/125/EC) aims at establishing Ecodesign requirements for several product groups of the heating sector, where Lot 1 encompasses products like heat pumps, boilers, output capacity as well as heating and combi-systems, Lot 2 covers water heater and Lot 10 includes air-conditioning units below 12 kW.

Through the implementation of this directive consumers will have direct insight into the energy consumption of various heating installations and giving them the opportunity to take the energy efficiency into consideration when choosing such a system. The requirements are based on a common methodology and the result will be visualized on a label in the same way as it is already done for several other appliances, starting with a grading system from A+ to G, which will then later be upgraded to A+++ to D in order to take into account expected technical progress. Through this rating system the energy label will function as an advertisement for efficient products for a tenant or buyer. Once implemented, the Ecodesign Directive will have far reaching implications for manufacturers, importers, consumers, contractors, consultants and architects. It is linked to the EPBD and will promote innovation in design and marketing of boilers.

So far the final working document is positively perceived by the industry in general and a quick implementation is desired. The document:

- maintains comparability among functionally equivalent products,
- enables performance declaration for two different temperature distribution levels (35 °C and 55°C),
- is applicable to 3 climate zones (average, warm and cold) and
- incorporates system performance via installer label.

The implementation of the Ecodesign Directive will most likely have a positive effect on heat pump technology as it enables the comparison of functionally equivalent heat generators on the basis of efficiency. It applies to a wide range of systems and products, incl. combi-systems for heating and hot water production. At the same time it is independent of the energy source used, covering fossil fuel combustion, solar thermal, electric or thermally driven heat pumps as well as cogeneration. Basis of this comparison is the primary energy efficiency which is determined through the ETA value, where ETA is the ratio of useful heat provided by the product and its annual primary energy consumption.

2.1.4 Energy Labelling Directive

The Energy Label for heat pumps is part of the "*Directive on the Indication by Labelling and Standard Product Information of the Consumption of Energy and other Resources by Energy-related Products*" 2010/30/EU. It applies to all energy-related products with significant direct or indirect effect on the consumption of energy and other essential resources during their use.

Similar to the Ecodesign Label discussed prior, the energy label will include the energy performance of a product (with a rating system A to G). Currently, a delegate act for an energy label applicable to heat generators is being developed simultaneously to the implementation process of the energy-related products, Lot 1 and 2.

The impacts of the Energy Labelling Directive on heat pump technology can be expected as positive impact. It will be based on system efficiency as determined by the energy-related products Lot 1/2/10 and enable end-users to compare different functionally identical heat generators with respect to this characteristic. This gives the end-users the chance to consider system efficiency and based on this quality, to select the appropriate product for their specific needs. Furthermore, heat pumps benefit from the Energy Labelling Directive as the currently proposed transitional calculation method will place heat pumps in top tier/classifications of the label, making them a desirable option for heating. In the course of implementing the Directive the only heat pumps that will be allowed to enter the market will score an efficiency class of A + or higher.

2.1.5 Energy Efficiency Directive

The Energy Efficiency Directive (EED) (2012/27/EU) aims at increasing the efforts currently made by Member States to use energy more efficiently throughout all stages of the value chain. It therefore contributes directly to the 20/20/20 target of 20% primary energy reduction by 2020. However, according to current energy demand it is necessary for the European Union to more than double its energy saving efforts in order to achieve this ambitious target.

The EED was adopted in summer 2012 and will replace both the Cogeneration Directive (2004/9/EC "CHP Directive") and the Energy Services Directive (2006/32/EC "ESD"). The new directive will cover and regulate all sectors with energy savings potential.

In order to improve the energy efficiency of products and installations, measures must be taken to achieve the non-binding target by 2020. The progress will be re-assessed in 2014. If Member States fail to reach the non-binding targets, binding targets will come into force.

Among other things, the EED states that Member States should set indicative national energy efficiency targets that are based either on primary or final energy consumption or energy intensity. Furthermore Member States are obliged to renovate 3% of the total floor area of heated and/or cooled buildings owned and occupied by their government each year.

National energy efficiency obligation schemes achieving annual savings of 1.5% will have to be put in place and policies promoting the use of efficient heating and cooling systems (using high efficiency cogeneration at local and regional level) will need to be adopted. In this context, a cost-benefit analysis by the Member States based on climate conditions, economic feasibility and technical suitability will need to be performed in order to identify saving potentials. Member States will also have to take on authorization criteria for new electricity production taking CHP and district heating into consideration (incl. urban and rural spatial planning requirements). Member States should create certification schemes for providers of energy services, energy audits and other energy efficiency improvement measures and installers of building elements (e.g. heating, cooling, and hot water). This will help advance the energy services market and ensure access for small and medium-sized enterprises to this market.

Overall, a long-term strategy beyond 2020 needs to be established by Member States that deals with mobilizing investment for the renovation of residential and commercial buildings. This strategy should aim at improving the energy performance of the building stock and should address cost effective deep renovations. These renovations should reduce the delivered as well as the primary energy consumption of a building.

With the final version of the Directive on its way it is now expected that it will be possible for the EU to realise around 15-17% of energy savings by year 2020, thereby almost fully reaching the target of 20%.

The future impact of the Energy Efficiency Directive on heat pump technology is yet unclear, but can be expected to be a rather positive impact. As the EED will be concluded quite quickly and Member States will be obliged to start implementing energy efficient measures in the near future, heat pumps as a well-developed technology can already play a role in energy efficiency obligation schemes. The fact that the EED mentions the efficiency potential of buildings and of distributed energy production is essential for the advancement of heat pump technology. The Energy Efficiency Directive is more focused on increasing the efficiency of large-scale installations, especially CHP and district heat. Therefore the impact on heat pumps is not as big as for other policies.

2.1.6 EU Energy Roadmap 2050

The European Commission has issued a roadmap for moving to a competitive low carbon economy in 2050 (COM(2011) 112 final) to ensure that the political measures in place to achieve the 2020 targets are continued to deliver beyond 2020. For instance it is expected that GHG emissions will be reduced by about 40% in 2050. The "Energy Roadmap 2050" presents different pathways towards a low-carbon energy sector, while at the same time keeping Europe competitive and securing the energy supply. The political measures to achieve the 2020 targets will continue to deliver beyond 2020.

The Commission identifies four main components of decarbonisation for the energy sector on which it bases its scenario development:

- Energy Efficiency (mostly impact on demand side),
- Renewable Energy Sources,
- Nuclear Energy and
- CCS (impact on supply side).

Within the Roadmap these components are combined into two current trend scenarios and the following five decarbonisations scenarios:

- High Energy Efficiency scenario, which eventually leads to 41% decrease in energy demand in the building sector by 2050 (compared to 2005 levels)
- Diversified supply technologies scenario, all energy sources compete on a market basis, decarbonisation is led by carbon pricing
- High Renewable Energy Sources scenario,
- Delayed CCS Scenario
- Low Nuclear Scenario

The Roadmap states that “renewable heating and cooling are vital to decarbonisation” and gives a clear reference that “locally produced energy sources (incl. heat pumps and storage heater) and renewable energy [...] is needed.” Unfortunately this is the only reference within the entire Roadmap leaving the heat pump technology and the entire heating and cooling sector underrepresented and overlooked in all the presented scenarios. We assume that the EU Energy Roadmap 2050 most likely will have no significant impact on the heat pump technology. The roadmap does not contain any direct reference to heating and cooling neither in the council conclusions nor in the report of the ITRE Committee.

2.1.7 Renewable Energy Communication

The Renewable Energy Communication complements the RES Directive. The communication outlines possible policy options for beyond 2020 and further explains how renewable energy and respective technologies can be integrated into the single market to become competitive and ultimately market driven. While fostering competitiveness through administrative regimes, stable and reliable support schemes and easier access to capital the communication also aims at advancing cooperation mechanisms and trade between Member States and thereby encouraging a cross border energy infrastructure.

The communication also deals with topics such as completing the internal energy market in the electricity sector by 2014 and allowing the consumers to become producers (*prosumers*), e.g. promoting smart metering etc. Additionally research and development in the energy sector are encouraged through different EU funding Schemes, such as the Cohesion Policy Fund with Horizon 2020.

The Commission is currently working on drafting a legislative proposal which will be published in 2013. However, this communication is considered to have no significant impact on heat pump technology. On the one hand, we consider the equal treatment of technologies, the bonus to those that make use of RES as well as administrative procedures and the R&D programmes that are put into place as positive aspects of the communication that may lead to positive impact. On the other hand, aspects, such as no dedicated recognition and support for the heating and cooling sector in general and heat pump technology in particular may impact the potential of heat pump technology in the future in a negative way. The only reference found in the communication is: “The heating and cooling sector is a very local market, needing local reforms and infrastructure”.

2.1.8 F-Gas Regulation

The F-Gas Regulation (EC Regulation No 842/2006) controls the use of the three fluorinated Gases groups covered by the Kyoto Protocol. Within the regulation heat pumps fall into the category “air conditioning systems and stationary industrial applications” and the regulation follows two main principles:

- Avoiding F-Gases whenever cost-effective & environmentally superior alternatives are available and

- Improving leak tightness of equipment containing F-gases via labelling, training and certification of personnel and companies handling this type of gases, containment and proper recovery.

So far the regulation has not been properly implemented in all Member States, however it should be noted that in countries where it has been transposed into legislation the regulation has led to stabilized emissions of the F-gases. Currently, the Commission plans to come forward with a review proposal to strengthen the F-Gas regulation and overall EU measures to reduce F-gas emission. There are four policy options based on these efforts:

- No further action,
- Strengthening of specific provisions within the F-Gas regulation,
- Phasing down by introduction of maximum, gradually declining, limits for the quantity of F-Gases placed on the EU market, expressed in terms of CO₂ equivalent and
- Bans by prohibiting the use of F-gases on certain applications

The impact the regulation will have on the heat pump technology is dependent on the outcome of the decision. Most heat pumps use F-gases, as these gases are neither toxic nor flammable and very energy efficient. Therefore change in legislation would have a major impact on the heat pump technology and market and it is not possible to give a realistic assessment of whether the effect of the reviewed regulation will be positive or negative.

Assuming it is decided on a ban on F-gases the heat pump market would be faced with major consequences that will be difficult to cope with. Therefore the majority of stakeholders as well as several NGOs have spoken out in favour for a gradual phase-out, giving the market a chance to adapt to the new requirements. How this will affect heat pump technologies depends strongly on the time frame and the strictness of the requirements. Thus, the draft proposal of the Commission will bring more clarity.

So far it can be observed that heat pump manufactures are aware of the global warming potential of these F-gases and an effort is made to find more environmentally friendly and safe alternatives while simultaneously ensuring the leak tightness of systems and system elements.

2.1.9 EU Commission decision on an Ecolabel for Heat Pumps

The Commission has decided on an Ecolabel with ecological criteria covering all electrical driven, gas driven and gas absorption heat pumps with a maximum output capacity of 100 kW. The label is based on regulation 66/2010 on the EU Ecolabel. Within this decision sanitary hot water heat pumps as well as exhaust air heat pumps are deliberately excluded.

However, it has become apparent that the Ecolabel for this product group is less necessary than for others, as heat pumps and other heat generators are already nearly completely governed by legislation for the duration of their useful life. Based upon this fact the future use of the label is being debated among stakeholders and it remains questionable if the present Ecolabel offers any additional benefits.

A positive benefit is that the Ecolabel enables a direct comparison of heat pumps with competing technologies like gas and oil boilers, which highlights the efficiency of heat pumps.

Therefore the decision is supposed to have a positive impact. Most likely the acceptance as well as the impact of the Ecolabel will be moderate, especially when taking into account the introduction of the mandatory energy label discussed previously, which offers guidance in the same direction.

2.1.10 Summary of European Policies

The previous sections have discussed the major legislative acts currently in place or under discussion on the European level. Table 6 gives an overview of the political instruments and their expected impacts on the heat pump technology.

Table 6: Summary of the main legislative acts and their impact on heat pump technology

Legislative Acts	Impact on Heat Pump Technology
RES Directive	Positive Impact
EPBD	Positive Impact
Ecodesign for ErP - Framework Directive; Lot 1	Positive Impact
Energy labelling Directive	Positive impact
Energy Efficiency Directive	Rather positive Impact
EU Energy Roadmap 2050	No significant Impact
Renewable energy communication	No significant Impact
F-Gas Regulation	Depends on Decision
EU Commission decision on an Ecolabel for heat pumps	Positive Impact

In the first place, the European legislation has an impact on the national legislation of the Member States and an indirect impact directly on heat pump sales. In principle the current national legislation for heat pumps is assumed in the "CPI" scenario with a full and timely implementation of all legislation pending on national or EU level. As previously explained, the H+ and H++ scenario are developed from a market potential perspective and do not include specific assumptions on (additional) policies, but would make additional policies necessary to be implemented.

Apart from the F-Gas Regulation, where a decision is still pending, all policies are included in the "CPI" scenario as they are agreed on already.

The following section will discuss national policies for key markets of heat pump technologies while subsection 2.2.9 gives summary tables of the discussed policies and their likely impacts on heat pump technology.

2.2 National Policies for Key Markets

2.2.1 Austria

In the time period between 2000 and 2009 Austria has experienced a strong growth in the space heating heat pump market. A decline was observed in the years 2009 and 2010 before in 2011 the market picked up again with a 5.1% overall increase in sales compared to prior years and a growth of 13.3% in 2012.

Austria is aiming at fulfilling its binding target of 34% for the use of renewable sources by 2020. In 2010 the share of renewable energy sources in final consumption of energy increased to 30.1%. Austria aims at achieving around 80% savings through the combination of energy efficiency measures regarding building shells (63.8%) and heat provision (16.2%) in 2016. Other regulations and requirements aim at promoting the use of RES through "innovative climate-relevant systems" that should be used within the residential and public sectors. Further measures for the increased use of solar heat, heat pumps and biomass heating are currently being planned.

In Austria the major instruments related to energy efficiency and RES-use in buildings (subsidies to the residential building sector, building code and inspection in residential buildings) fall into the competence of regions. Efforts have been made towards a harmonisation of building codes based on the individual building codes of the different federal states, the so called *OIB-Richtlinien*.

Additionally minimum requirements on energy-related criteria in the residential building subsidy scheme ("Wohnbauförderung") have been set in place; however there still exists a large variety of regional subsidy schemes which also include financial incentives for the installation of heat pump technology.

In general the amount of financial support, i.e. subsidy depends on type of heat pump (in combination with solar thermal or PV system), on the SPF (4.0, in combination with PV/Solar sometimes less with 3.8-3.5) and the household income as well as the situation (retrofit or new build).

Overall the policies in place in Austria have a low impact on future heat pump sales. Most action takes place on a regional level. Among regulatory law the current regulations and requirements promoting the use of RES are most likely to have a low to medium impact on heat pump sales. The planned measure for increasing the use of renewables and heat pumps in the heating sector will most likely have a medium impact on sales number. Other laws like the "OIB Richtlinien" and the planned harmonisation of building codes as well as the housing subsidy "Wohnbauförderung" only have low impact on sales numbers.

2.2.2 Belgium

In Belgium energy and related certification of RES installations is administered on regional level in Flemish, Walloon and Brussels Region. Certain policy instruments exist in all regions, with possible difference in the level of implementation. For example the Walloon regional government decided to adopt a more ambitious 20% renewable energy consumption target by 2020, compared to the 13% mandatory Belgian target.

Implementation of the EPBD in Belgium includes the energy performance standards for new buildings and the energy performance certificate for existing buildings. Both initiatives define maximum levels of annual primary energy consumption and specific transmission heat loss conditions, combining system efficiency and good insulation in buildings.

Several policies aim at promoting the development, installation and usage of RES-installations on the federal level in Belgium. There are training programmes for RES-installers. Moreover, the European quality label, EHPA EUcert, is applied on national level for heat pump installations. A certification scheme for companies and installers of heat pumps is also applied in all three regions within implementation of the F-gas regulation. CE-marking of products is also applied under ErP Lot-1 in all regions.

Additionally, in the Flemish region a more profound support scheme is developed in form of an action plan. The Flemish government implements the *Green Heat Action plan* to propose support for specific systems, particularly renewable energy in heating and cooling. Under the action plan grid operators and municipalities are responsible for setting up premium schemes. In the Flemish region a minimum share of 85% of heat demand is to be provided from RES. The seasonal performance is determined to be larger than 4.

Among the tax reductions offered by the Federal Government for energy saving measures, a 40% tax reduction is offered for heat pump installations. Heat pumps are also supported by direct or indirect subsidies. In new buildings, the subsidies are linked to the building energy performance index, in terms of primary energy consumption. In existing buildings, the subsidies are related to the energy performance of the system (minimum Ecolabel criteria). Heat pump boilers are only subsidized in the Walloon Region.

Similar to Austria a lot of activities are still governed on a regional level. Most regulatory law, financial incentives and information instruments currently in place have a low impact on heat pump sales. Apart from the Green Heat Action plan (in the Flemish region) which will most likely only have a low impact on heat pump sales, hardly any further measures or incentives are in a final planning stage. Among the discussed actions only the financial incentive of a 40% tax reduction for a heat pump installation may have a low to medium impact on the development of heat pump technology.

2.2.3 France

The French government has set the target of a 23% share of renewables in the energy mix by 2020. With this aim the RES Directive is implemented in France by the Grenelle law. In addition to this target, France aims at a 38% reduction in energy demand and a 20% reduction in CO₂ emissions. Specific targets for each technology are stated in statutory texts (PPI: "Programmations pluriannuelles des investissements"). The PPI chaleur 15/12/2009 regarding heat pumps mentions that *The National RES Industry Roadmap* projects are aiming at having two million individual households heated by heat pumps in 2020. This project will be implemented in one step in 2012, aiming at 2,245 million heat pump installations. In order to reach this interim target the French government has included air to air heat pump to the technologies.

Within the implementation process of the EPBD, France applies a specific regulation on thermal energy in buildings: RT2012. The RT2012 provides a maximum allowable demand of 50 kWh/m²a for new buildings. Specific targets have been fixed for RES used in single-family dwellings with a

minimum consumption threshold of 5 kWh/m²a. However, these targets have not been extended to multi-family dwellings. As renewable energy becomes mandatory for individual housing, the heat pump market in new buildings will necessarily increase. The method used for calculating RES for heat pump is different from the one described in the RES directive. It is done in primary energy. The primary to final energy ratio for electricity is taken as 2.58.

In France the subsidy scheme for heat pumps operates mainly with a tax reduction since 2005. The cost of the heat pump unit serves as a basis for the deductible amount and the subsidies vary depending on the year of purchase and the type of heat pump. In 2012, the rates were 26% of the cost for a ground source heat pump and sanitary hot water heat pump, and 15% in the case of air/water heat pumps.

The French product labelling scheme NF PAC was initiated in 2006. This label sets a minimum COP level, with test conditions in accordance with EN 14511 (nominal and application conditions). Moreover, NF PAC specifies requirements regarding minimum quality levels. Random audits are carried out for monitoring and control by a random and independent body. Additionally, energy saving certificates and white certificates managed by energy suppliers are in operation to financially support heat pumps installations.

In France the regulation on thermal energy in buildings (RT2012) with its maximal allowable heating demand for new buildings has a medium impact on heat pump development. Together with the RT2012, the target of increasing the number of households that have heat pumps installed will also have a medium to high impact for heat pumps in the French market. Other policies and financial incentives like the RES Directive, the National RES Industry Roadmap only have low impacts on heat pump development.

2.2.4 Germany

German energy policy is based on the principle of providing balance between security of supply, affordable energy prices, effective environment protection and climate change mitigation in an efficient manner.

The Energy Savings Ordinance (EnEV) came into force in 2002 and combines regulations for the insulation of houses with efficient systems engineering to enhance reduction of primary energy use in the German housing stock. This combination makes it possible for building owners to rely on a combination of existing house insulation with efficient heating systems to reach the required standards set by the EnEV. Within this regulation an energy performance certificate EPC (Energieausweis) based on DIN V 18599 and DIN 4701-10 must be provided by owners containing information on the energy balance and energy efficiency of the building to buyers or tenants.

The German Act on the Promotion of Renewable Energies in the Heat Sector (Erneuerbare Energien-Wärmegezet, EEWärmeG) entered into force on January 1st 2009. The EEWärmeG introduces an obligation to use renewable energies to cover the heating energy demand in new buildings and public buildings already erected. The law makes it mandatory that by 2020, 15% of the energy used for heating in newly built houses comes from renewable energy sources. The use of heat pumps is explicitly mentioned as a contribution to reaching that goal.

Germany has special support incentives within 2012 Guidelines for the support of measures to utilise renewable energies in the heat market providing subsidies for installation and market penetration of heat pumps. The market incentive programme contains two segments, namely investment grants for renewable heating installations up to 100 kW thermal (*competency Bundesamt für Wirtschaft und Ausfuhrkontrolle, BAFA*) and long-term low-interest loans (soft loans), including a redemption grant, for installations larger than 100 kW or infrastructure measures (competency The Federal Bank Kreditanstalt für Wiederaufbau (KfW)). The basic support offers funding for the utilisation of renewable energies for heat generation. Support for ground source heat pumps is on average approx. €2800 per installation with an additional support for every kW over 10 kW depending on the heat output. Support for air source heat pumps varies between €1300-1600 whereas the support amount for gas-driven heat pumps is the same as ground source heat pumps. There are limits for seasonal performance of heat pumps in order to benefit from the support incentives. (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, MAP 2012).

Additionally among various renewable energy technologies installations for utilising deep geothermal energy (drilling depth of more than 400 m) and large, efficient heat pumps with a rated heat output capacity of more than 100 kW at the design point are listed as eligible for support. KfW grant amounts to €80 per kW heat output capacity at the design point, but at least €10,000 and at most €50,000 per individual installation (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, 2012).

In Germany the Renewable Energy Heat Law (EEWärmeG) and the Market Incentive Programme are promising measures that have a medium impact on heat pump sales. Other instruments like various labels and the Energy Saving Ordinance (EnEV) and its planned recasting only have a low impact on heat pumps.

2.2.5 Italy

Both, heating and cooling are requested with high seasonal demand in Italy due to prevailing Mediterranean climate throughout the country. Heating and air conditioning systems constitute about one-third of total energy needs. Heat pumps are therefore considered to play an increasingly important role, as they can be used for both, heating and cooling. However, currently they are a niche market in remote locations.

Regulations governing Renewable Energy Sources (RES) derive from international regulations and European Commission directives. In June 2010, Italy submitted its National Renewable Energy Action Plan. In March 2011 the RES Directive was implemented by National Legislative Decree n°28. The Decree sets specific targets in order to achieve the overall national target of 17% share of energy from renewable sources in the gross final consumption of energy in 2020. The Decree also reforms the whole system of incentives for RES and introduces some changes in the administrative procedures.

National laws are interdependent with regional, provincial and municipal legislative authority. The Legislative Decree provides the general framework, whereas the definition of the specific norms remain the responsibility of further Ministerial Decrees to be adopted namely by the Ministry of the Economic Development (usually in concert with the Ministry of the Environment and Land and Sea Protection) and in some cases with the agreement of the so called "Unified Conference" of regions,

provinces and towns. For example, water discharge resulting from heat pumps is regulated by the municipalities. The new law will require the adoption of 14 Ministerial Decrees. Additional decrees are required for the obligational use of renewables in new or restructured buildings (article 11), for the certification of installers (in accordance with EU Cert scheme Art. 15 and Annex 4), for incentives for "thermal renewable systems" for small installations (up to 500 KW) for heat pumps, for biomass and for solar thermal (Art. 28). Further a decree is needed for revision of Annex 3 concerning the total demand for heating, cooling and hot water. Annex 3 states three suggestions for renewable shares as 20% from May 2012, 35% from January 2014 and 50% from January 2017.

White Certificate schemes or Energy Efficiency Titles (EET) are important market oriented instruments in force in Italy which represent marketable documents issued by the Energy Market Administrator testifying the energy saved by the energy distribution companies, as well as by their controlled partnerships, and by the Energy Service Companies (ESCO). This incentive scheme has been introduced in the national Decree no 28/2011 also to promote renewable energy sources. Similar to the adoption of the RES Directive, the implementation of the EPBD in Italy is a shared task between the state and the 21 regions and autonomous provinces. Implementation started in 2005, with a national transposition decree, which established a transitional period during which:

- the minimum requirements were tightened by about 30%, with respect to previous levels,
- methodologies for determining energy performance of buildings were confirmed, in reference to the already existing advanced regulations,
- Energy Certification of Buildings (ECB) was replaced by a declaration produced by a professional designer (assessor accreditation was not available yet), which was limited to new or renovated buildings, and then in 2006 was also extended to buildings on sale and rental,
- boiler inspection procedures were slightly improved, in respect to the already existing regulation from 1993.

The implementation of ErP Directive in Italy is done under National Legislative Decree n°15 issued in February 2011. The implementation measures include requirements for electric motors, fans between 125 W and 500 W, air conditioners and comfort fans.

Italy as a Member State also undertakes requirements of the Energy Efficiency Directive. However, as the directive is relatively new (September 2012) there are no regulations in Italy for its national implementation yet. Nonetheless, it is highly possible that the directive will have a positive influence on the heat pump market with its requirement of 3% renovation of heated and cooled buildings owned and occupied by the government.

In terms of financial incentives, Italy introduced a tax deduction of 55% for the installation of energy efficient heat pumps. This deduction also covers the expenses related to the installation of these systems to substitute existing systems. The timeline of the incentive was extended to June 2013 by the Italian Financial Law of 2012, Law no.83/2012. The same "Decree on Growth" increased the deduction for general buildings renovations from 36% to 50% until June 2013; in this case, also the maximum deductible cost was increased from €48,000 to €96,000.

Several regulatory laws and financial incentives with medium impact are in place or being planned in Italy. Among them are planned decrees including the decree for revision of Annex 3 and for the

implementation of the Energy Efficiency Directive. A 55% tax reduction and a decree for incentives for thermal renewable systems also have medium and low to medium impact, respectively.

2.2.6 Spain

Renewable energy policy of Spain is influenced by EU policies as European Regulations are automatically incorporated as national laws. Three Royal Decrees have been published in the last years to transpose the Ecodesign Directive and the EPBD. So far the RES Directive on the promotion of the use of energy from renewable source has not been transposed.

- Royal Decree 187/2011, related to the establishing of Ecodesign requirements for energy-related products incorporates Ecodesign Directive.
- Royal Decree 1390/2011 aims to regulate the indication of energy consumption and other resources of energy-related product by means of labelling and standard product information. This Decree also incorporates Ecodesign Directive.
- Royal Decree 47/2007 is developed to approve the basic procedure for the certification of the energy efficiency in new buildings. The Decree partially transposes the content of EPBD (Directive 2002/91/CE).

The purpose of the activation plan is to reduce the energy consumption of 330 energy consuming centres belonging to the central government by 20% by 2016, as set out in "Savings Plan and Energy Efficiency in Buildings of the General State Administration (PAEE-AGE)" The savings are supposed to be achieved by performing saving measures and energy efficiency, in the form of energy service contracts, conducted by energy service companies. The objective of the saving plan is a better efficiency of the final use of the energy in line with Directive 2006/32/CE put into force on April 5th in 2006 on energy end-use efficiency and energy services.

Additionally the Spanish government developed specific measures or legislation that are directly or indirectly related to the development of the heat pumps.

The so-called GEOTCASA Programme aims to promote use of ground source heat pumps for heating, hot water and refrigeration installations. The instruments of the programme are ESCO's (Energy Service Company) that are authorized according to their technical, economical and operative capacity with prospect to geothermal installations. The programme enhances the firms in the sector to execute a comprehensive service contract with the user to provide renewable energy adapted to their needs. The calls relating to the authorisation of collaborative firms were published in May 2010, within the Spanish Renewable Energy Plan 2005–2010 framework. The financing period is set as 10 years and the total amount varies between 800 €/kW and 2,600 €/kW (max €350,000/project) with an interest rate of 2.2%.

The so-called RENOVE project aims at enhancing the replacement of inefficient installed air conditioners that have less than 12 kW capacity, by new class A air conditioner units. Due to the fact that more than 90% of all air conditioners units below 12 kW capacity in Spain are reversible type, the RENOVE Plans are in fact promoting sales of heat pump units. Subsidies within programme vary

from 150 to 500 € per unit, depending upon capacity, type of equipment or autonomous region. A documentation of the purchase and replacement is required from the installer.

Several autonomous regions have launched specific programmes to promote the use of the geothermal energy in heating, cooling and hot water applications with varying scope, duration and the amount of the incentives. However, the fact that several regional governments have programmes in operation with the same aim show the increasing attention that Spanish authorities are conceding to the use of energy coming from renewable sources and specifically geothermal.

Spain is currently planning to finance incentive programmes that will most likely have a medium to high impact on heat pumps. The GEOTCASA supports the use of ground source heat pumps while the RENOVE aims at replacing air conditioners which is often done by heat pumps. The current policies in place like the Ecodesign Directive and the planned implementation of the RES Directive have a low to medium impact on heat pumps. The Energy Performance of Buildings Directive already has a medium impact on heat pumps for the Spanish market.

2.2.7 Sweden

The Swedish market is already mature for domestic heat pumps (esp. geothermal heat pumps). The acceptance and use of renewable heating have been quite good for already some years. Parallel to the market saturation for single family houses, the use of heat pumps in multi-family houses and commercial buildings are increasing. However, the prevailing energy policy is promoting the use of biomass and trying to limit the use of electricity for heating. There is no specific policy support to increase the use of heat pumps in heating and cooling. This results in promotion of biomass-based district heating and pellet systems rather than heat pumps.

Exhaust air heat pumps that recover energy from the outgoing ventilation air, using it for heating and DHW production, have been frequently installed in new built single family houses during the last 30 years. Around 200.000 exhaust air heat pumps have been installed. The new building regulations set down strict limitations on yearly energy demand per m² and also on electric peak power demand. More efficient and powerful inverter driven exhaust air heat pumps that fulfill the new regulations have been developed. Moreover; direct electricity heating will only be allowed in houses meeting passive house standards and in houses where no viable alternative exists.

Air source heat pumps are often used to complement direct electric heating mainly in single family houses. Due to lack of waterborne systems almost all air source heat pumps in this the residential market are of single split type in the single family houses.

As a consequence of regulations and due to climatic reasons air to water heat pumps may only be deployed in the southern part of Sweden in the case of new buildings. They may however be installed without restriction throughout the country in the case of retrofit.

A tax reduction scheme is applied for heat pump installations since December 8th 2008, both for renovation and extension works in private households. For each owner of a private property the

scheme provides offsetting of up to 50% of the labour costs related to retrofit works against tax. The maximum amount that may be deducted is approximately € 5,500.

Being a mature market for domestic heat pumps there are now regulatory laws in place or underway that have a possible impact on heat pump technology. There are tax reduction schemes that have a low to medium impact on heat pump sales and also various labelling schemes that function as information instruments, but their impact can also be categorized as low.

2.2.8 United Kingdom

The UK government set out its Renewable Energy Strategy in 2009 for achieving the 15% target in 2020. The UK government thus retains responsibility for energy regulation, energy services, appliance labelling, mandatory obligations and energy services. The liberalised energy markets are regulated by an independent body, Office of the Gas and Electricity Markets (OFGEM).

Policies related to environment are the responsibility of the Department for Environment, Food and Rural Affairs (DEFRA). DEFRA has lead involvement in all labelling activities of heat pumps, the various preparatory studies (e.g. Lots) and also implementation of F-gas regulations. They are operating the Market Transformation Programme (MTP) that directly addresses Ecodesign and Labelling. The department also has responsibility for the heating systems under the EPBD and administers the National Calculation Methods (Standard Assessment Procedure (SAP) for dwellings and the Simplified Building Energy Model (SBEM) for non-dwellings). The department is in close co-operation with the Department for Communities and Local Government (DCLG) on Building Regulations that requires compliance with CO₂ targets that are calculated using the National Calculation Methods and approves any vendor software that uses them. As DEFRA is responsible for F-gas regulation implementation, it has allowed at least four separate commercial registers of "safe refrigerant handlers", using two different qualification regimes: City and Guilds 2079 and a separate one from Construction Skills.

Matters relating to housing and building as well as implementation of EPBD both via Building Regulations for efficiency matters related to air conditions (except heating) and Energy Performance Certificates/ Air Conditioning Inspections are currently under the responsibility of the Department for Communities and Local Government (DCLG). There are no heating system inspections in the UK, but just an information provision arrangement.

A number of schemes supported by the relatively new Department of Energy and Climate Change (DECC, established in 2010) provides support tools for heat pumps:

- Enhanced Capital Allowance (ECA) scheme provides tax relief on energy-saving equipment for businesses considering a list of products. Products eligible for the list must meet certain criteria e.g. COPs measured to EN 14511. The scheme is regarded as a certification of quality runs on manufacturer's self-declaration which is subject to control. The scheme is recently being operated by the Carbon Trust (CT).
- Green Deal and the Energy Company Obligation (ECO) are the government support mechanisms for the uptake of energy efficiency measures, operated by GEMSERVE. The

Green Deal finance mechanisms are based on the principle that eliminates the need to pay upfront for energy efficiency measures by enabling use of estimated annual savings on an individual property to obtain a loan to buy efficiency enhancements with a loan tied to electricity bill to the property. The proposed solution includes a new financial payment mechanism, accreditation of the associated Green Deal participants, increased consumer protection and the provision of information to assist consumers in making an informed decision about investing in energy efficiency measures. However, concerns are raised as the Green Deal starts to emerge, as generating electricity and heat will probably be of secondary importance after all insulation measures have been installed.

- Renewable Heat Initiative (RHI), operated by OFGEM, currently only addresses non-dwellings. The initiative pays a tariff for every kWh of useful heat across a range of technologies. Air to air source heat pumps are considered to be a mature market and too difficult to meter and hence are not seen in the need of incentives. Air to water may be included as long as they are not reversible. So far the majority of the applications were for biomass boilers. There are significant concerns regarding the quality of information provided and quality of heat meter installations which is a fairly novel idea in the UK.
- Micro-generation Certification Scheme (MCS) certifies micro-generation technologies used to produce electricity and heat from renewable sources. It has started life as Clear Skies programme which is the principle source of grants for heat pumps provided that the product and installer are accredited. It is accepted as eligibility requirement for the Government's financial incentives, which include the Feed-in Tariff and the Renewable Heat Incentive RHI. The scheme has its own set of criteria, uses EN14511 as Standard for heat pumps which covers all renewable products up to 45 kW capacity.
- The Renewable Heat Premium Payment (RHPP) is a one-off grant aiming to meet the cost of renewable heat technologies until formal launch of domestic Renewable Heat Incentive (RHI) tariffs for domestic customers. Eligibility criteria are launched by the government and require micro-generation Certification Scheme (MCS). Air to water and ground source heat pumps are available within the scheme but not air source heat pumps.

Two independent entities, funded by DEFRA, the Energy Savings Trust (EST) and the Carbon Trust (CT), are responsible for administering many of the policies directly related to investment in carbon emissions reduction. The Carbon Trust aims at reducing carbon emissions from all aspects throughout the UK excluding dwellings. The Energy Savings Trust is principally focused on dwellings and has commissioned major research on performance of heat pumps in domestic settings as well as on wind turbines, hot water energy and water consumptions, condensing boilers and other aspects such as solid wall insulation.

Compared to the other examined markets many activities are taking place in the UK, especially the planning of regulatory laws and financial incentives. However, most of the measures will only have a low impact on heat pump sales. Other policy and information instruments only have low impacts on heat pump technology.

2.2.9 Summary of national Policies

Table 7 and Table 8 give an overview on national policies for all key markets in the categories “regulatory law”, “financial incentives” and “information instruments”. All policy instruments are rated according to their impact on the promotion of heat pump technologies with “low impact” (L), “medium impact” (M) or “high impact” (H). Furthermore, a differentiation between current and planned policies is made (both considered in the “CPI” scenario).

The scenarios “HP+” and “HP++” are not dependent on current or planned policy implementation, as they are rather defined as theoretical market implementation potential with additional policies until 2030.