

# Powering our buildings: how policies can support energy efficiency through building electrification



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## Introduction

Electrification of energy consumption plays a key role and electricity demand for heating is expected to increase considerably in the next years. According to the annual World Energy Outlook 2022 by IEA, electricity is taking on an ever-more central role in the lives of consumers, and more efficient homes and electrified heat have provided an important buffer for some – but far from enough – consumers. With natural gas prices skyrocketing across Europe, the reliability, efficiency and convenience of clean electricity is set to become even more critical to all aspects of people's lives and well-being. For an increasing number of households, electricity promises to become the energy source on which they rely for all their everyday needs: mobility, cooking, lighting, heating and cooling.

According to European Commission figures, buildings are responsible for about 40% of the EU's total energy consumption, for more than 50% of the EU's gas demand in end uses -amounting to almost the gas imports from Russia in recent years- and for 36% of its greenhouse gas emissions from energy. Buildings are as well the biggest contributor to harmful pollution from particulate matter in urban environments. Europe's building stock is unique, culturally rich, and diverse. But not surprisingly, it is also old and changes very slowly. More than 220 million building units, representing 85% of the EU's building stock, were built before 2001 and most often still rely on fossil fuels to satisfy the energy needs of their occupants. It is estimated that as many as 75% of European buildings are energy inefficient, meaning that much of the energy used in them is wasted. 85-95% of the buildings that exist today will still be standing in 2050.

Electrification of the European building stock can lead to multiple benefits other than energy savings. The focus on non-energy benefits, especially better comfort, healthier and more sustainable homes, public spaces and workplaces, and reduced energy poverty can help stimulate demand for a host of programmes including building renovation efforts. The last report produced by the Energy Efficiency Financial Institutions Group (EEFIG, established by EC Directorate-General for Energy) underlines the multiple benefits of energy efficiency with a focus on building sector.

Reverting the trend in the buildings sector is challenging and requires of notable investments but may imply as well relevant benefits for the economy. According to a study performed by the European Climate Foundation and Cambridge Econometrics, Europe could cut its annual spending on gas imports by 15 billion in 2030 and 43 billion in 2050 by increasing the energy renovation rate and electrifying heat supply. Consistently, Europe's GDP would see a 0.7% increase in annual GDP in 2030 and a 1% increase by 2050. Renovating Europe's building stock and electrifying the heating supply will help create 1.2 million net additional jobs by 2050 and halve households' energy bills. Another study by the Buildings Performance Institute Europe indicates that for every €1 million invested in energy renovation of buildings, an average of 18 jobs are created in the EU. Energy efficient renovation of buildings would imply other positive effects such as increased productivity in offices, reduced hospital stays, reduced healthcare costs and substantial economic returns.

This study starts from these premises to analyse the available technologies to electrify the energy consumption in buildings, considering also the current trends, and linking them with the existing barriers. The current policies at EU level are then described, considering also the Fit for 55 and REPowerEU proposals. Many key stakeholders at EU level have been interviewed on these topics, in order to collect and better understand their view on the technologies, the barriers, and the available policies.

The last two chapters are dedicated to present policy proposals to overcome the barriers, create the conditions to reach the EU targets on decarbonisation, energy consumption, and energy security through the electrification in the building sector.



## Methodological note

To write this study an in-depth research on the available literature (studies and researches, scientific papers, positioning documents, etc.) has been carried on, in addition to the know-how of the authors, most of them senior experts in the energy sector. Most of the literature has been referenced in the document to allow an easy check of the information included in the study<sup>1</sup>.

In order to add value and strengthen the quality of the document, a series of interviews to 25 key stakeholders has been carried on and part of their comments has been integrated in the study. The stakeholders were selected among consumer associations, industry association, public institutions, research bodies, manufacturers, and utilities and grid operators. To facilitate the creation of the document and allow those stakeholders to share their view more freely, it has been decided to maintain comments anonymous. A web-based survey among energy manager appointed in Italy has also been conducted, the results and graphs of which are presented in aggregated way.

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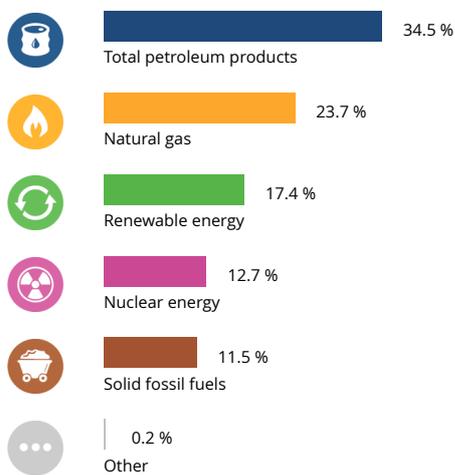
<sup>1</sup>The authors have tried to ensure the correctness and reliability of all data and information provided in the document. However, some incorrect information can be present. We will welcome any comment on that: please write to [osservatorio@fire-italia.org](mailto:osservatorio@fire-italia.org).

# 1. Energy efficiency in the EU

This chapter summarizes the energy efficiency market dimensions in EU, with a focus on Italy. The current state of the energy market, the main trends, the EU decarbonisation targets, and, finally, the role of electrification are described.

## 1.1 Current state

According to the publication *Shedding light on energy in the EU* developed by Eurostat (published on May 2022 and referring to 2020 data), in 2020 the EU produced around 42% of its own energy while 58% was imported from third countries. The report presents EU energy mix that in the reference year was mainly made up by five different sources: petroleum products (including crude oil) (35%), natural gas (24%), renewable energy (17%), nuclear energy (13%) and solid fossil fuels (12%).



In 2020, almost three quarters of the extra-EU crude oil imports came from Russia (29%). A similar analysis shows that over three quarters of the EU's imports of natural gas came from Russia (43%). The European dependency rate (a parameter that shows the extent to which an economy relies upon imports in order to meet its energy needs) was equal to 58%, which means that more than half of the EU's energy needs were met by net imports.

Figure 1 - Energy mix for EU in 2020 (source: Eurostat)



Figure 2 - Energy dependency rate - Natural gas (% of net imports in gross available energy, based on terajoules) (source: Eurostat)

The Covid-19 economic crisis contributed to reduce the dependency rate compared with 2019 (60%) but it still remained higher compared with 2000 (56%), with an increasing trend in the following year due to the partial economy recover. Analyzing the different energy import patterns among the EU Member States, it's possible to discover that in Italy, Hungary and Austria more than a third of total energy imports was natural gas



Figure 3 - Share of natural gas in total energy available, 2020 (in%) (source: Eurostat)

The International Energy Agency (IEA), in its Gas Market Report, Q3-2022, analyzes the Europe's dependence on energy imported from Russia issue, a central topic after the invasion of Ukraine by Russia. According to the report, this dependence has been thrown into sharp relief by Russia's invasion of Ukraine in February 2022. The European Union's commitment in the Versailles Declaration to phase out Russian fossil fuel imports "as soon as possible" is set to transform Europe's energy and gas markets in the years to come, with implications for global trade and market dynamics.

The IEA report underlines that the reliance of EU states on Russian gas has increased steadily over the past decade. EU natural gas consumption stayed broadly flat over this period, but production has fallen by two-thirds since 2010 and the gap has been filled by rising imports.

In the last ten years, EU has kept on increasing its reliance on Russian gas imports amid rising tensions and crises (e.g., Russia's annexation of Crimea in 2014) so the share of Russian gas (including LNG) meeting total EU demand rose from 30% in 2009 to 47% in 2019.

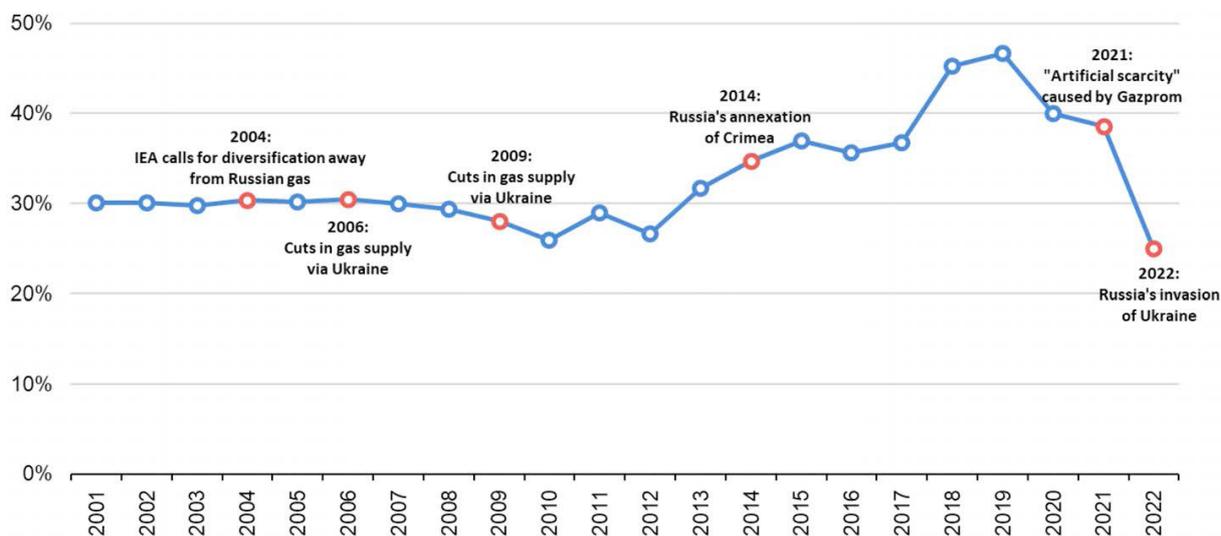


Figure 4 - Share of EU gas demand met by Russian supply, 2001-2022 (source: International Energy Agency)

About investments on energy efficiency, in its Energy Efficiency 2021 report, IEA writes that despite the Covid-19 crisis, overall energy efficiency investment was stable in 2020 at nearly USD 270 billion, but trends differed widely across sectors and regions. Unprecedented growth in the buildings sector outweighed a heavy decrease in transport efficiency investments, while spending in the industry sector remained largely unchanged.

While global building activity contracted over much of 2020, buildings energy efficiency investments in Europe increased strongly enough to boost global investments in this area by 11% to nearly USD 180 billion.

In the report, IEA mentions the Italian Superbonus programme (released in 2020) as one of the most important government energy efficiency measures in EU.

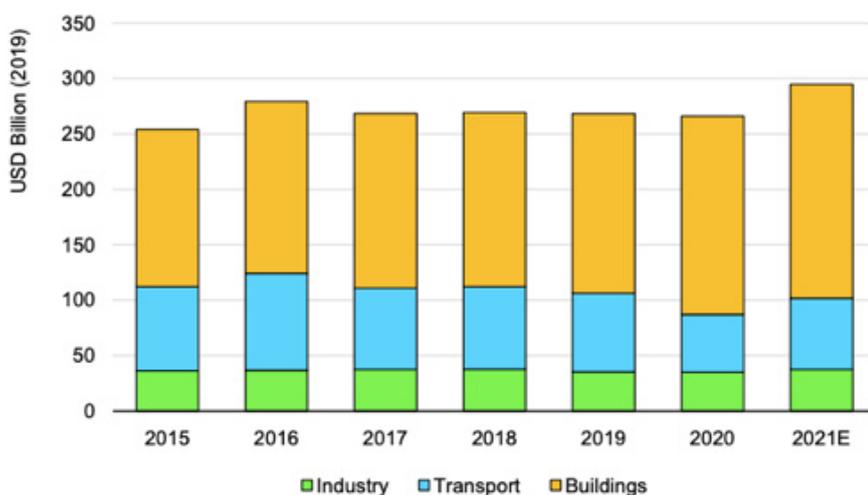


Figure 5 - Global investment in energy efficiency by sector, 2015-2021 (source: IEA)

Focusing on the Italian case, the Annual Energy Efficiency Report developed by the National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA) in its 2021 edition confirms that for Italy natural gas is the main energy resource: in 2019 natural gas consumption was 60,9 Mtep, 39,2% of total primary energy consumption.

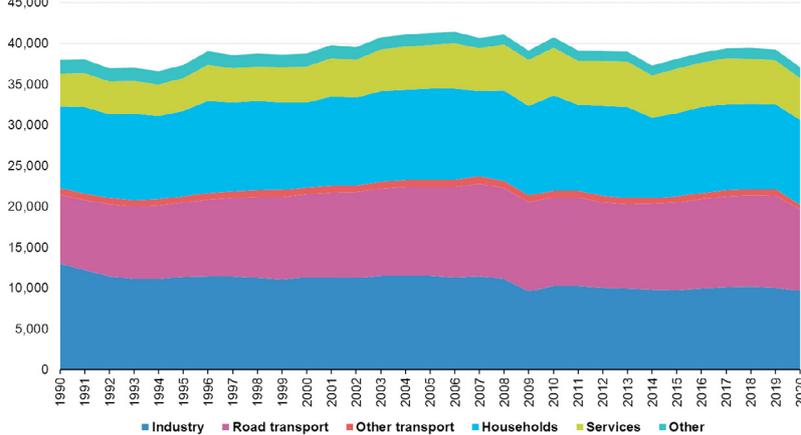
In the period 1990–2019, energy demand grew by 4.9% at an average rate of 0.2%. In terms of energy sources, we can note the significant growth of natural gas (+ 56.3%) and the simultaneous reduction of oil (-36.4%) which made natural gas the first energy source.

## 1.2 Trend of energy consumption

Looking at which sectors in the EU consume the most energy, the industry sector (32% of final energy consumption) consumed the most energy in 2020, followed by the transport sector (26%), households (25%), services (12%) and agriculture & forestry (3%).

**Final energy consumption by sector, EU, 1990-2020**

terajoules (TJ)



Source: Eurostat (online data code: nrg\_bal\_c)

eurostat

Figure 6 - Final energy consumption by sector in EU from 1990 to 2020 (TJ) (source: Eurostat)

**Final energy consumption by fuel, EU, 1990-2020**

Petajoule (PJ)

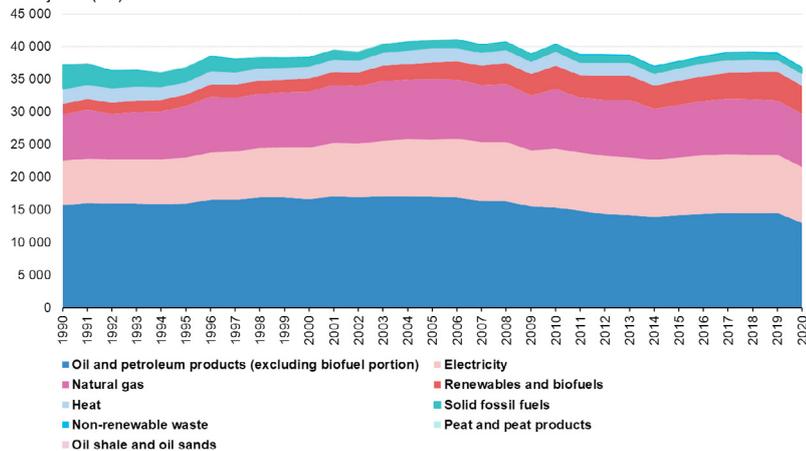
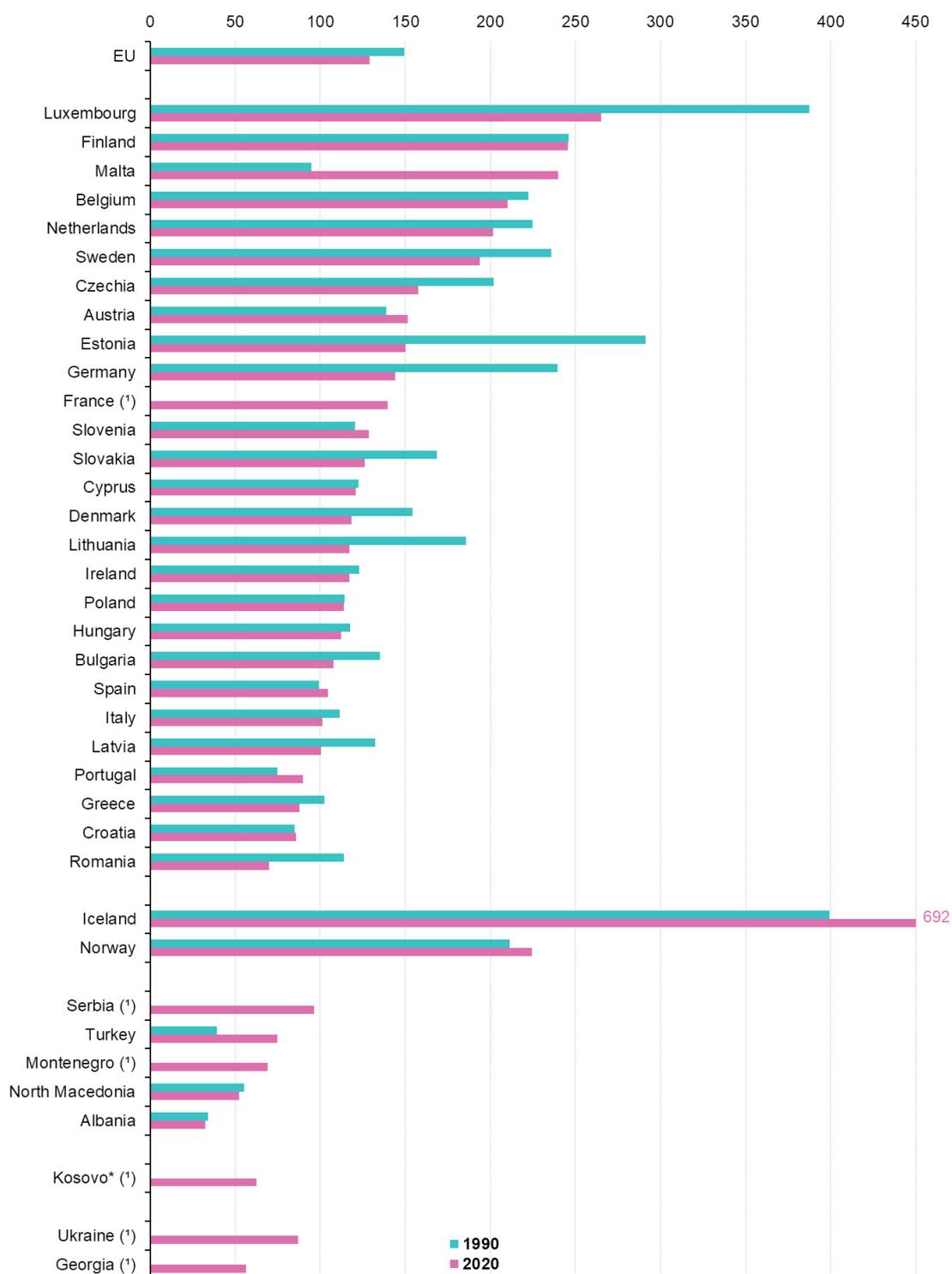


Figure 7 - Final energy consumption by fuel in EU from 1990 to 2020 (PJ) (source: Eurostat)

Source: Eurostat (online data code: nrg\_bal\_c)

eurostat

## Gross available energy, 1990 and 2020 (terajoules per capita)



(¹) No data for 1990.

\* This designation is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Source: Eurostat (online data codes: nrg\_bal\_s, demo\_pjan)

eurostat

Figure 8 - Gross available energy, 1990 and 2020 (TJ/cap) (source: Eurostat)



In 2020, primary energy consumption dropped to its lowest level since full records have been available (1,236 million tonnes of oil equivalent (Mtoe)). This is 5.8% below the EU 2020 efficiency target (no more than 1 312 Mtoe primary energy consumption) and 9.6% above the EU 2030 target (no more than 1 128 Mtoe). Final energy consumption also saw a significant decrease (to 907 Mtoe), 5.4% below the 2020 target (no more than 959 Mtoe final energy consumption) and 7.2% above the 2030 target (no more than 846 Mtoe). The result is clearly affected by the Covid-19 pandemics and in 2021 the energy consumption rised again.

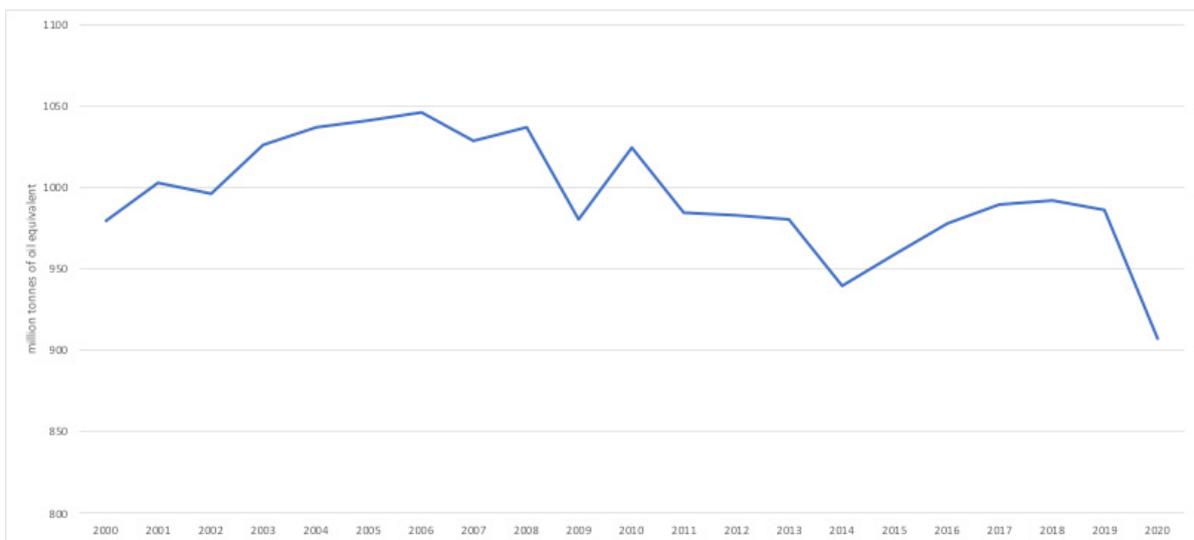


Figure 10 - Final energy consumption in EU (in million tonnes of oil equivalent) (source: Eurostat)

Looking at the energy efficiency trend in the past ten years, primary energy consumption declined steadily in the period 2011 to 2014, then increased until 2017 before declining again in 2018 and 2019. Final energy consumption also decreased continuously starting from 2010 to reach the level closest to the target in 2014, then increased until 2018 to decrease again in 2019. Between 2019 and 2020, however, primary and final energy consumption recorded significant decreases, largely due to the Covid-19 related restrictions.

Primary consumption fell by 8.7%, an historical drop, and final energy consumption by 8.0%, the largest fall since 2009.

Compared to 2010, primary energy consumption fell in 25 Member States, with decreases of 20% or more in Greece (-28%), Denmark (-23%), Estonia (-22%), Italy (-21%) and Malta (-20%). Final energy consumption decreased in 21 Member States, with the largest reductions in Greece (-25%) and Italy (-20%).

For Italy, the energy mix for energy demand in the period 1990–2019 has undergone an important evolution: the consumption structure continues to assign a significant weight to fossil sources (78.1% of primary energy demand in 2019) but this share has decreased by more than 15 percentage points since 1990, characterized by an increase in natural gas versus a decline in oil and solid fuels. Renewable sources have met the share of energy demand lost from fossil fuels. The weight of renewable sources is constantly and significantly increasing (+5.4% annual average in the period 1990–2019).

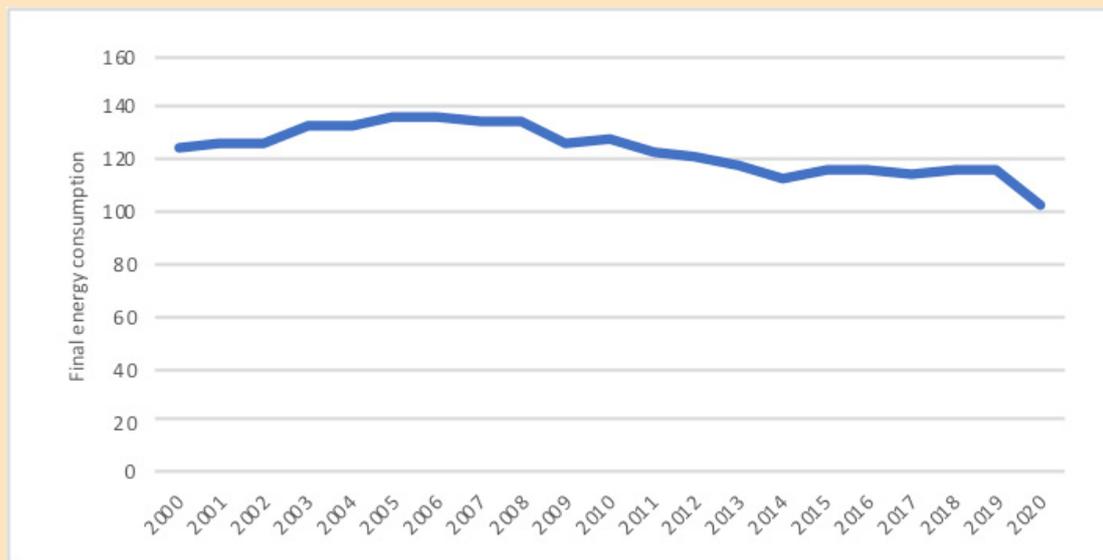


Figure 11 - Final energy consumption in Italy (in million tonnes of oil equivalent) (source: Eurostat)

In Italy, the buildings sector (residential and services) absorbs 41.1% of final consumption, followed by the transport sector 29.8% and industry, 20.7%: buildings have always been the sector with the largest share of consumption but over the years they have increased by more than 10 percentage points lost by industry while the transport sector has maintained its percentage share.

### 1.3 Energy efficiency targets

The amended Energy Efficiency Directive, entered into force in 2018, has updated some provisions of the previous Directive and introduced some new elements to reduce final and primary energy consumption in sight of 2050 net-zero goal. An EU energy efficiency target for 2030 of at least 32.5% has been established. To contribute to this energy efficiency 2030 target, as well as the other targets about renewable energy and GHG emission, each country was required to provide an integrated national energy climate plan for 2021-2030, explaining the strategies and actions to put in place to reach the goals.

In July 2021, the Commission adopted its proposal for a recast of the Energy Efficiency Directive as part of the European Green Deal package, which contains legislative proposals to meet the EU objective of at least 55% reduction in greenhouse gas emissions by 2030.

The recast directive puts forward an increased and binding EU energy efficiency target of 9% in 2030 compared to the projections of the 2020 Reference Scenario (787 Mtoe in final and 1,023 Mtoe in primary energy consumption, respectively). This

corresponds to a reduction of 36% for final energy consumption and 39% for primary energy consumption by 2030 compared to the 2007 Reference Scenario. National contributions to the common EU target would remain indicative but need to be based on a formula combining identified criteria reflecting national circumstances, such as energy intensity, gross domestic product per capita and energy savings potential, to complement the fixed rates of energy reduction. The proposal also provides enhanced 'gap-filling mechanisms' to be used in case EU countries fall behind in delivering on their national contributions towards the EU target.

In May 2022, in the context of the REPowerEU plan, the Commission proposed an increase to the binding EU energy efficiency target from 9% to 13% compared to the 2020 Reference Scenario (750 Mtoe in final and 980 Mtoe in primary energy consumption, respectively). The negotiations of the proposal are currently ongoing in the Council and the European Parliament through the ordinary legislative procedure. Once the legislative proposal is adopted by both co-legislators, the new 2030 energy efficiency targets will apply.

### 1.4 The role of electrification and its effects in terms of multiple benefits

In this scenario, electrification of energy consumption plays a key role and electricity demand for heating is expected to increase considerably.

According to the annual World Energy Outlook 2021 by IEA, electricity is taking on an ever-more central role in the lives of consumers and, for an increasing number of households, it promises to become the energy source on which they rely for all their everyday needs: mobility, cooking, lighting, heating and cooling. The reliability and affordability of electricity is set to become even more critical to all aspects of people's lives and well-being.

Electricity's share of the world's final consumption of energy has risen steadily over recent decades, and now stands at 20%. Its rise will accelerate in future years as the pace of transitions will pick up. In the Net Zero Emissions by 2050 Scenario (NZE), electricity accounts for around 50% of final energy use by 2050 (around 30% in the Announced Pledges Scenario). Given that electricity delivers useful energy services with better efficiency than other fuels, the contribution of electricity is even higher than these numbers would suggest.

In buildings, electrification mainly implies the substitution of fossil fuel boilers for heating with electric heat pumps. IEA confirms that significant cost declines in the last decade, allowed heat pumps to become more and more competitive as the technology and market matured. They are especially attractive for the one-third of the global population living in regions requiring both space heating and cooling, since reversible heat pumps are able to deliver both services (IEA, 2020a).

## 1.5 Multiple benefits of electrification

Electrification of building stock can lead to multiple benefits other than energy savings. The focus on non-energy benefits, especially better comfort, healthier homes and workplaces, and reduced energy poverty can help stimulate demand for a host of programmes including building renovation efforts. In this phase of pressure from high energy prices, the benefits on poor and disadvantaged families are particularly important to ensure an adequate level of comfort and to avoid health issues.

Also from a financial side, the reduction in returns from not counting multiple benefits in financial appraisals, and failure to make energy efficiency investments strategic, are

major contributors to the energy efficiency gap, i.e. the gap between financially viable projects and what is actually invested. The EU Commission estimates that to achieve the 55% climate target by 2030, around EUR 275 billion of additional investments are needed per year.

EU funded project M-Benefits<sup>2</sup> provided several pilot projects all over Europe, identifying and quantifying different types of benefits and their contribution to value proposition, reduced costs, and risks. Some of the benefits quantified in the case studies include safety improvements, improved occupant comfort, reduced maintenance costs, and reduced carbon (CO<sub>2</sub>) costs.

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<sup>2</sup> <https://www.mbenefits.eu>

<sup>3</sup> [https://www.bpie.eu/wp-content/uploads/2020/06/DBU-Factsheet-MFH\\_Zusatznutzen\\_20200618-Eng.pdf](https://www.bpie.eu/wp-content/uploads/2020/06/DBU-Factsheet-MFH_Zusatznutzen_20200618-Eng.pdf)

In this framework, an interesting example of multiple benefits of an electrification project comes from the implementation of an advanced control system for the air conditioning of a commercial building. The installation of this BMS allows environmental monitoring and management of the heating system through the control of generation, distribution and emission of the building. It was estimated that such intervention generates economic benefits attributable to the following aspects:

- reduction of sickness absenteeism by guaranteeing optimal thermal comfort conditions for the workers;
- greater productivity of workers, who perceive optimal environmental conditions and not experience thermal stress during their stay in the workplace.
- The following table shows how the economic indicators of the project vary if considering this benefits in the analysis or not:

	<b>Energy benefits only</b>	<b>All benefits</b>
<b>CAPEX (€)</b>	32'000	32'000
<b>Net Present Value (NPV)</b>	15'900	69'000
<b>Internal Rate of Return (IRR)</b>	15%	42%
<b>Simple payback (years)</b>	5	3

An energy efficient renovation of a residential building, that comprises the installation of efficient electro technologies, is able to achieve benefits from different perspectives, both for the building owners and for the tenants. The acceptance of the building's retrofit measures can be increased due to recognisable and tangible benefits, such as increased thermal comfort, a healthier air (less CO<sub>2</sub>, mold, radon, etc.), an improved materials lifetime, the effectiveness of which can be validated through an appropriate monitoring and a direct experience of an improved housing.<sup>3</sup>

	<b>Building owners</b>	<b>Residents</b>
<b>Energy saving</b>	Better rentability	Lower energy costs
<b>Health benefits</b>	Higher tenant satisfaction	Better health (fewer respiratory diseases), higher thermal comfort
<b>Reduced maintenance in renovation buildings</b>	Lower administration costs, fewer customer complaints	Less noise pollution and disturbance to everyday life from frequent repairs
<b>Climate-resilient building</b>	Lower long-term risks due to potentially increasing climate regulations or performance	Lower CO <sub>2</sub> footprint, protection against potentially rising costs due to CO <sub>2</sub> price

Table 1. Multiple benefits of energy-efficient renovation from different perspectives. Source data: BPIE, Multiple benefits as driver of energy efficient building renovation

## 2. Development of electrification in the building sector in the EU

### 2.1 Introduction

This chapter illustrates the situation and market trends for the main technology solutions linked to electrification of energy consumption in the building sector. Dedicated subchapters add details for the Italian market. The listed solutions include electric heat pumps, electric hobs, smart technologies for buildings like building automation systems and electric vehicle recharging stations, and other solutions.

### 2.2 Final consumption trends

The EU energy balance from Eurostat<sup>4</sup> provides an overview of the general trends in the final energy consumption (FEC) of buildings (residential and services sectors), and the related share of electricity as an indicator of the electrification of energy use in buildings. Electricity consumption is reported as electric TWh, whereas heat and global consumption are expressed in ton of oil equivalent (toe) and multiples, in accordance with Eurostat data and to avoid confusion between electric and thermal kWh.

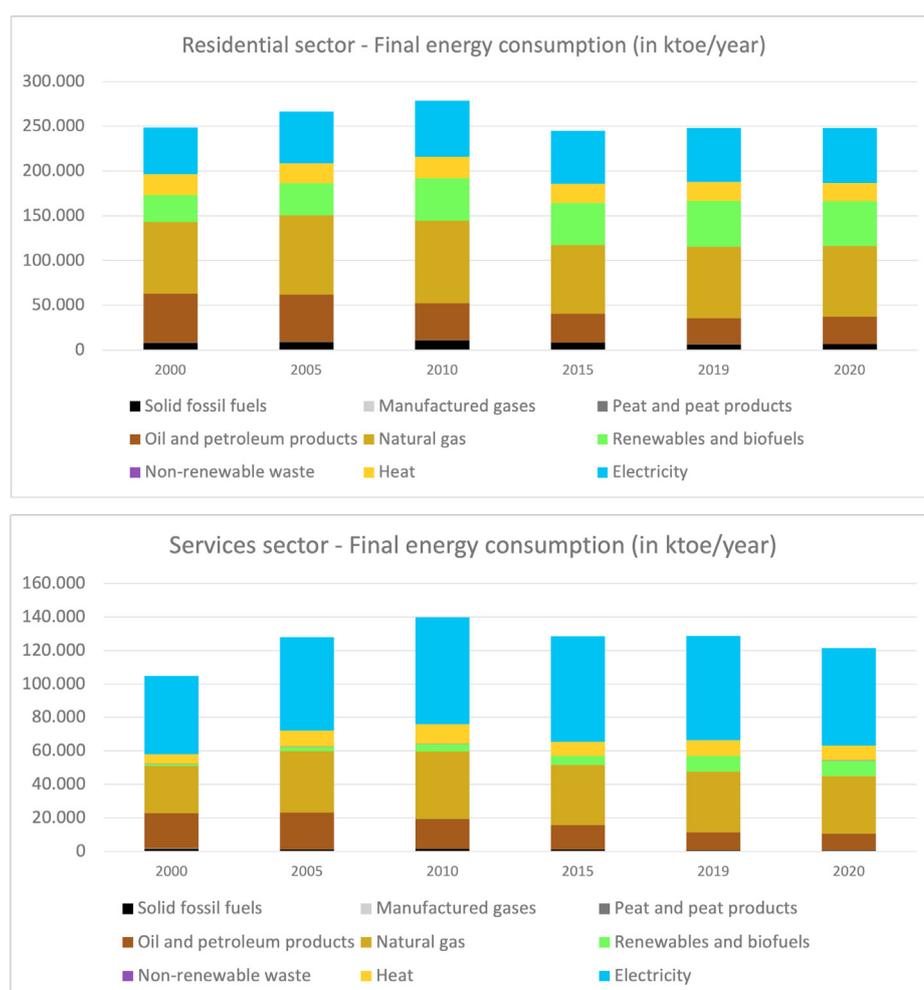


Figure 12 Final Energy Consumption (FEC) per sector in the EU27

<sup>4</sup> source: Eurostat energy balances for EU27, unless otherwise specified.

Table 2. Focus on final electricity consumption in the residential sector.

	2000	2005	2010	2015	2019	2020
Final electricity consumption in TWh	605,7	669,2	730,2	692,4	705,7	713,7
Share of electricity in residential FEC	21,0%	21,6%	22,5%	24,3%	24,4%	24,7%

**Residential sector:** The final electricity consumption and electricity share in residential FEC both increased by 16.5% between 2000 and 2019. But the final electricity consumption decreased by 3.5% between 2010 and 2019, while the electricity share increased by 8%.

Table 3. Focus on final electricity consumption in the services sector.

	2000	2005	2010	2015	2019	2020
Final electricity consumption in TWh	544,5	648,8	744,5	733,3	725,9	676,7
Share of electricity in services FEC	44,7%	43,6%	45,7%	49,0%	48,5%	47,9%

**Services sector:** The final electricity consumption increased by about 33% between 2000 and 2019, while the electricity share increased by 8.5% ("only"). But the final electricity consumption decreased by 2.6% between 2010 and 2019, while the electricity share increased by 5.7%.

Table 4. Statistics on ambient heat, as a proxy of the development of heat pumps in the energy mix of buildings.

Ambient heat (in ktoe)	2000	2005	2010	2015	2019	2020
Residential	59,6	453,5	1 964,8	3 168,0	5 636,5	6 041,5
Services	2,6	146,3	358,8	1 294,8	4 697,9	4 869,4

Use of ambient heat (in ktoe/year) multiplied by 94 (residential) and 179 (services) between 2000 and 2019, and by close to 3 (residential) and 13 (services) between 2010 and 2019. However, the share of ambient heat in the total FEC of the residential and services sector remains small (2.4% and 4% respectively in 2020). These data can be compared with data on the installation of heat pumps provided later in this chapter to obtain a better understanding on the diffusion of heat pumps and their usage.

The main end-use in the residential sector is by far space heating. Then, appliances+lighting or domestic hot water, according to the countries. Except in a few countries, cooking represents a small share of European households' energy consumption. Likewise, space cooling is still a small share (except in Malta, Cyprus, Bulgaria and Croatia).

Specific consumption of households by end-use (2019)

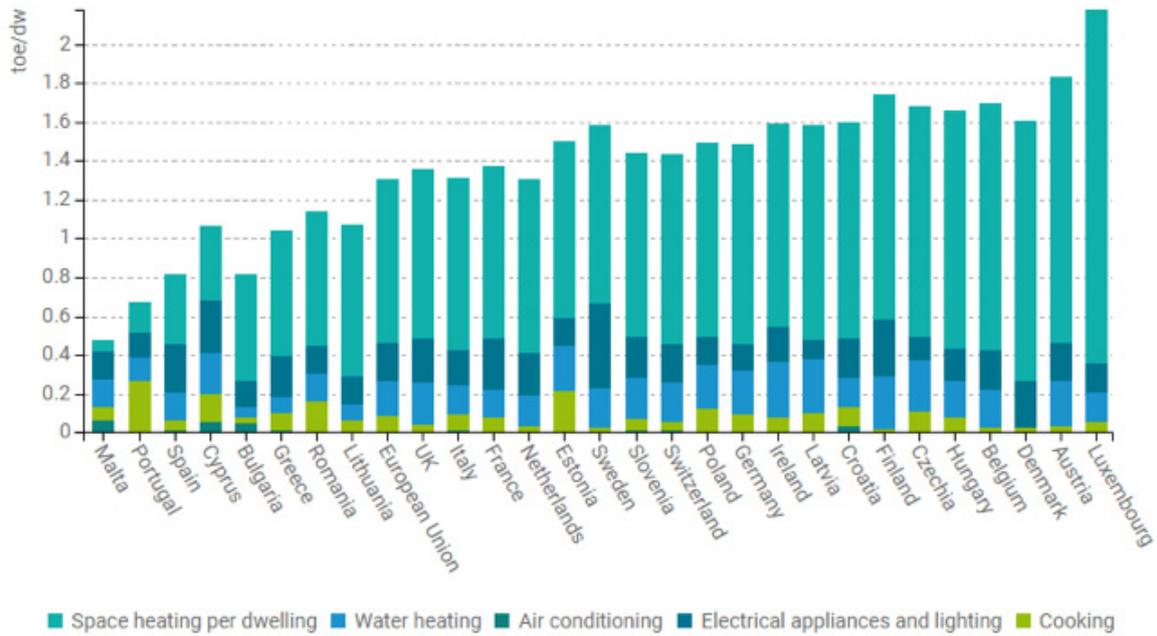


Figure 13 Consumption of households per end-use (source: ODYSSEE)

The diversity of the services sector makes it more difficult to provide an overview of energy consumption per end-use. However, the following graph from ODYSSEE provides the evolution between 2000 and 2019 of the share of electricity in services' final consumption per country:

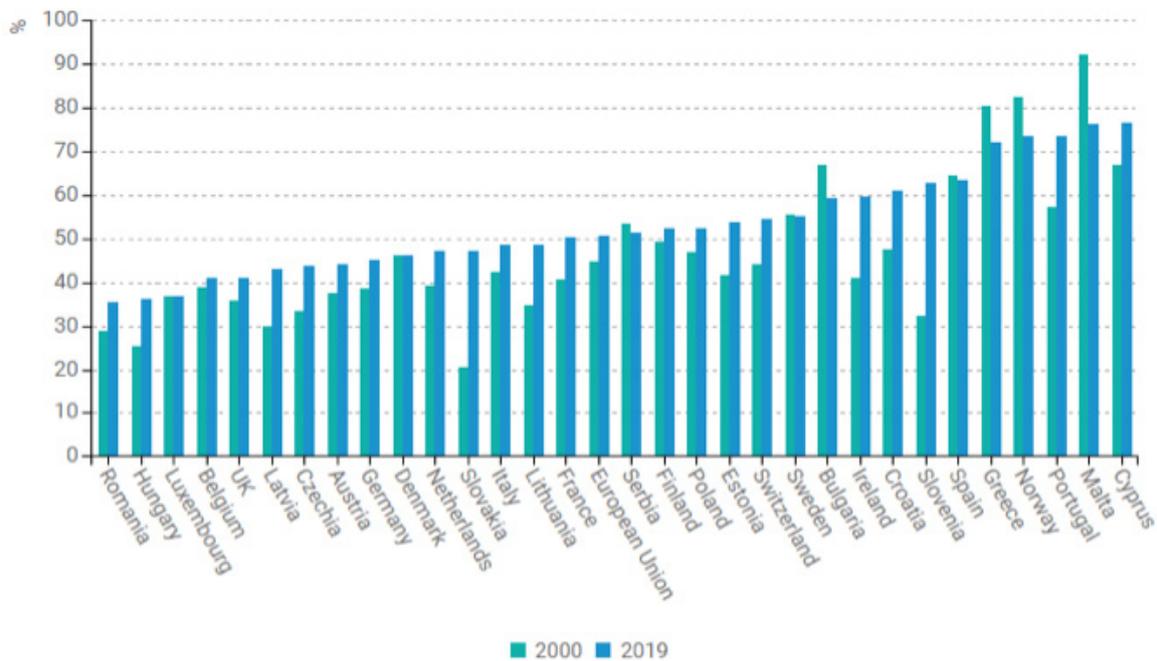


Figure 14 Share of electricity in services' final energy consumption (2000 and 2019, per Member State) (source: ODYSSEE)

The impact assessment (part 2) of the Climate Target Plan published by the European Commission ([SWD\(2020\) 176 final](#), September 2020) describes several scenarios to meet the revised climate targets (reduction by 55% GHG emissions by 2030, and reaching carbon neutrality by 2050). More specifically about buildings, it highlights the need for an accelerated electrification together with a higher efficiency of use:

*"In the residential sector, the share of electricity would increase from almost 25% today to 35-37% in all policy scenarios in 2030 and this share will be around 45% in all scenarios by 2050. In services, the electricity share today is already much higher: almost 50% and would increase to around 55% in all policy scenarios by 2030 and will reach some 60% in all scenarios by 2050. (...) electrification of the demand combined with decarbonised electricity supply and self-generation of renewables are fundamental aspects in order to reach climate neutrality by 2050. In both sectors, electrification is driven by **rapid deployment of modern electric heating** that also helps with moderation of energy demand (...). **Efficiency of the use of electricity** in buildings sector is well illustrated by the limited **growth in absolute consumption of electricity contrasted with rapid increase in electricity shares**, especially in services sector"*

These combined trends of limited growth in absolute electricity consumption and increase in electricity shares are **in line with the trends observed over 2010-2019**.

The focus on **accelerating the electrification** of energy end-uses in buildings has been recently strengthened by the new REPowerEU plan **to reduce the gas imports from Russia**. "Electrify Europe" is one of the three tracks of action included in the European Commission's communication (COM(2022) 108 final) released on 8 March 2022, with the objective of "30 million newly installed heat pumps installed in 2030" to substitute 35 bcm of natural gas in 2030:

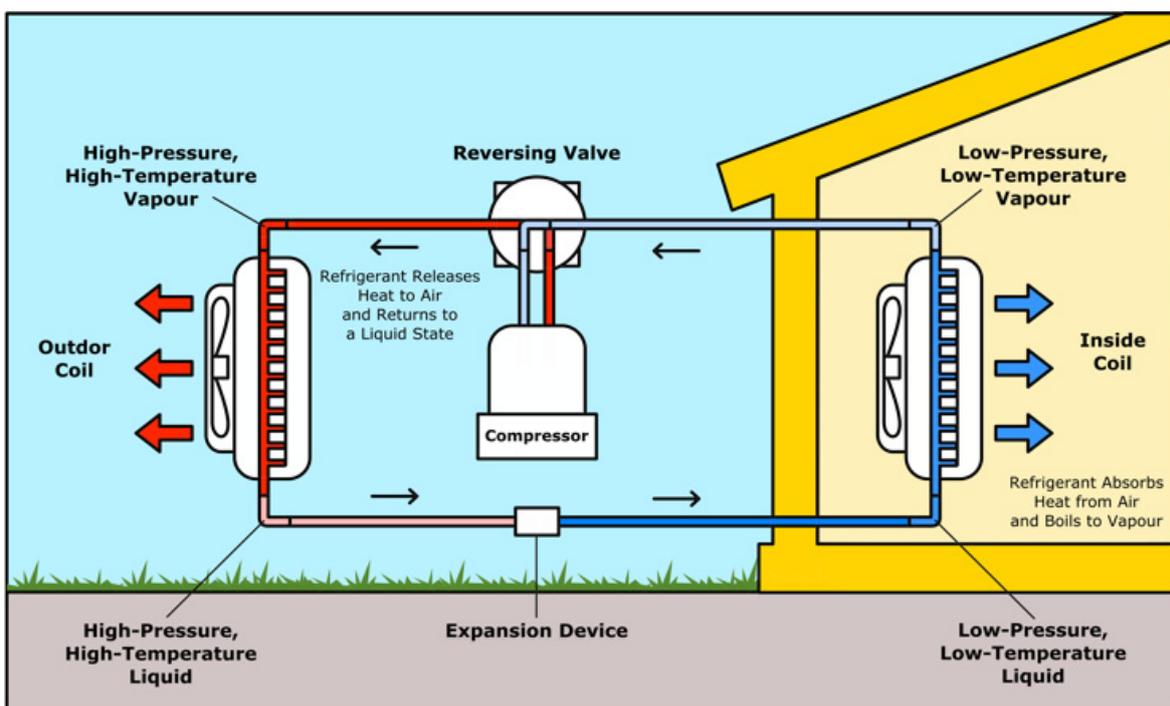
*"By doubling its planned yearly pace of deployment of heat pumps in the first half of this period, the EU would reach 10 million heat pumps installed in the next five years. This would save 12 bcm for every 10 million heat pumps installed by households. The accelerated market deployment of heat pumps will require rapid upscaling of the entire supply chain and be accompanied by measures to boost building renovation and district heating system modernisation."*

In short-term, this plan estimates that the newly installed heat pumps in 2022 could substitute 1.5 bcm of natural gas. Residential sector energy efficiency and heat pumps measures are supposed to jointly replace 37 bcm of gas. The target for solar photovoltaics is over 320 GW newly installed by 2025, with the introduction of the European Solar Rooftop Initiative.<sup>5</sup>

## 2.3 Heat pumps

### 2.3.1 Introduction on available technologies

Heat pumps (HP) are electrical devices that can be used to convert energy from external heat sources to useful heat used for space heating, domestic hot water and/or space cooling in residential and commercial buildings.<sup>6</sup> They are regarded as one of the most energy efficient and environmentally friendly technologies for heating, capable of achieving worldwide decarbonisation of heating.<sup>5</sup> For example, Jarre et al. (2018) found that heat pumps for residential space heating result in nearly 30% savings in primary energy consumption and similar reductions in emissions compared to natural gas boiler-based heat generation systems due to their high coefficient of performance and relatively low primary energy consumption.<sup>7</sup> For on-site heating, HPs are considered superior to several common heating technologies and alternatives such as solar collectors, biomass, oil and natural gas boilers.<sup>5</sup> The IEA still projects that fossil fuels and conventional heating technologies, which are less efficient and more carbon intensive, will dominate the heating sector, however, with supportive policies, the sale of energy efficient technologies will increase market share.<sup>8</sup>



<sup>5</sup><https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483>

<sup>6</sup><https://www.sciencedirect.com/science/article/abs/pii/S221462962030339X>

<sup>7</sup>M. Jarre, M. Noussan, M. Simonetti, Primary energy consumption of heat pumps in high renewable share electricity mixes, *Energy Conversion and Management* 171 (2018) 1339–1351 <https://doi.org/10.1016/j.enconman.2018.06.067>.

<sup>8</sup>International Energy Agency, Heating in buildings Tracking Clean Energy Progress, 2019, <https://www.iea.org/tcep/buildings/heating>.

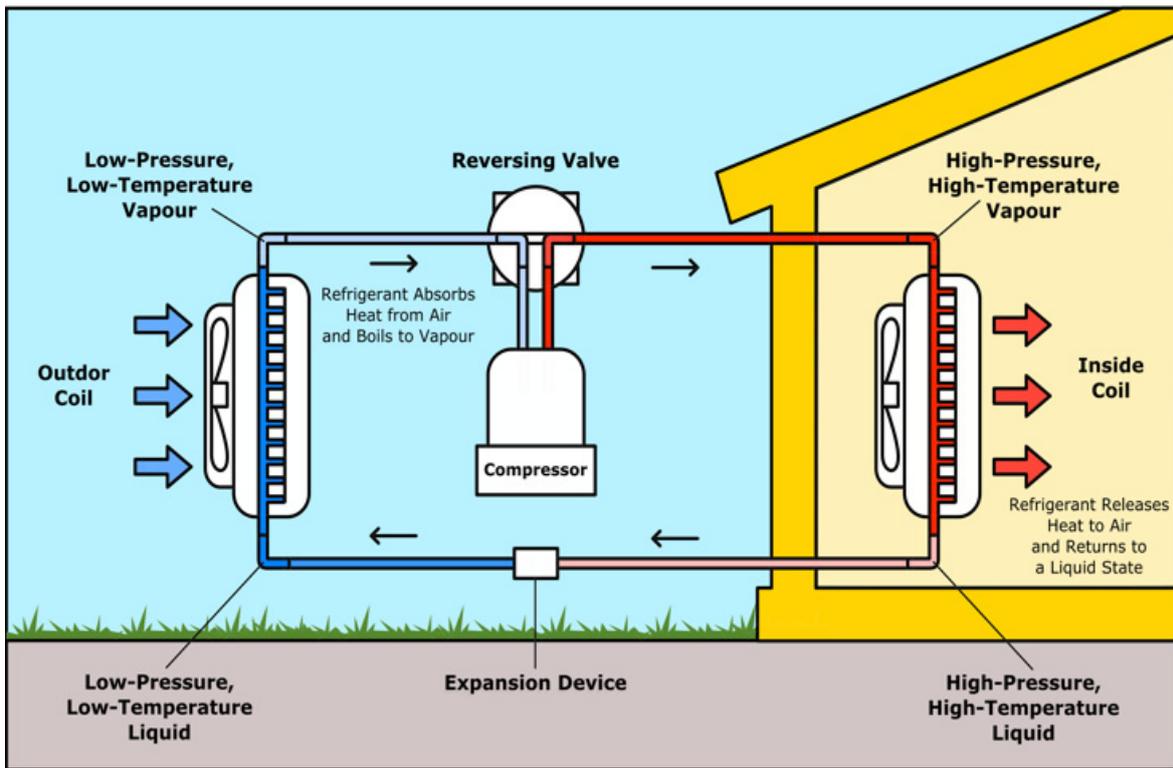


Figure 15. Reversible heat pump working modes: cooling on top and heating below.

As Figure 15 shows, a heat pump is a machine that exchanges heat with an external source, which can be the air, the ground, or water, to transfer heat inside (in winter) or outside (in summer) the building. The internal distribution system can use air (e.g. controlled mechanical ventilation systems) or water (e.g. radiant floor or fan coils) depending on the characteristics of the building and the available retrofit options. Typically heat pumps perform better with low temperature distribution systems and with external sources with stable temperatures. Simple air to air and air to water systems are nevertheless widely used due to their lower cost and constraints that can prevent heat exchange with the ground or the water.

Due to the different external sources and internal distribution systems, there are several HP types that can conveniently replace traditionally carbon intensive heating technologies. These range from air source HPs

(ASHP), which can use either air-to-water or air-to-air technology, to water source HPs (WSHPs), ground source HPs (GSHPs), geothermal HPs as well as sorption HPs (that use adsorption membranes to utilise waste and renewable heat sources).<sup>5</sup> Currently, fossil fuel technologies used for space heating have lifetimes of around 15 years<sup>9</sup>. This means that most owners will have had to make a choice on how to heat their homes by 2037. In a backcasting view, the EU's 2050 climate goals of achieving carbon neutrality by 2050 implies that the installation of new fossil-fuel heating systems should be banned by the latest by 2035, and probably even earlier especially for collective boilers that have a lifetime longer than 15 years. The IEA thus proposed a ban of new gas boilers by 2025<sup>10</sup>, along with other policies to decarbonise the heating sector, however no clear deadline for such ban has been set yet at the EU level. The currently proposed legislations would implement a progressive approach beginning with

the stopping of any public incentive for fossil fuel heating systems by 2027 the latest (cf. proposed EPBD recast).

In the scenarios mentioned in this report, heat pumps, together with district heating, are the main alternative to fossil fuel heating. The needed massive switch from fossil-fuel boilers to heat pumps will require overcoming the higher investment cost of heat pumps compared to gas or heating oil boilers<sup>9</sup>, which might necessitate financial support, especially for low-income owners. Despite their high initial investment cost, heat pumps generate high energy savings and thus pay for themselves through lower energy bills.<sup>11, 12, 13, 14</sup> In fact, HP smart heating alone (e.g. when electricity is cheaper at off-peak times) can reduce consumers' heating costs by up to 31% compared to conventional heating.<sup>15</sup> Despite the high upfront costs, Lang et al. (2021) found that homeowners' average valuation of energy efficiency actually exceeds heat-pump associated cost savings, suggesting that they also consider non-monetary benefits as being important when evaluating this type of investment, indicating that a switch to heat pumps would be less resisted than initially thought due to cost alone.<sup>16</sup> Higher investment cost with lower operation cost then means a split incentive for the renting sector, when the energy bills are paid by the tenants while the heating system is paid by the owner.

Spatial variations in technology uptake can also have an effect on the perceived costs and benefits of heat pumps. Heat pumps are thus usually the preferred alternative to rural oil-heated buildings, while district heating is deployed in cities and towns, and bioenergy uptake can be prominent at sites located away from the gas grid.<sup>8</sup> In case of district heating, large-scale HPs can also be part of the decarbonisation options considered, although the decision lies with district heating companies (or often municipalities) and not the building owners.<sup>17</sup>

The following figures show the market development of HPs in Europe and the expected growth under the REPowerEU programme. Heat pumps are growing and substituting fossil fuels boilers, a process that started with new buildings and oil fuelled boilers and is now going on according to EU and national policies. According to the EU association EHPA (<https://www.ehpa.org>) in 2021 51% of HPs sold have been hydronic (45% air-water), 38% air to air, and 11% HPs for sanitary hot water on sales of around 2.2 million HPs (a growth of 34% on 2020). France and Italy alone represented around 42% of the EU market. The global stock in 2021 has reached over 17 million HPs installed. The growth requested by the REPowerEU programme requires that current barriers are analysed and overcome in order to deliver the expected high numbers.

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<sup>9</sup> <https://www.seai.ie/publications/National-Heat-Study-Summary-Report.pdf>

<sup>10</sup> <https://www.iea.org/reports/net-zero-by-2050>

<sup>11</sup> <https://carbonswitch.com/heat-pump-savings/>

<sup>12</sup> <https://www.greenmatch.co.uk/blog/2014/08/heat-pumps-7-advantages-and-disadvantages>

<sup>13</sup> [e-quality Eurelectric and EF.pdf](#)

<sup>14</sup> <https://europeanclimate.org/wp-content/uploads/2022/03/modelling-the-socioeconomic-impact-of-zero-carbon-housing-in-europe-final-technical-report-march2022.pdf>

<sup>15</sup> [heuc-x-2021-112\\_goodbye\\_gas\\_why\\_your\\_next\\_boiler\\_should\\_be\\_a\\_heat\\_pump.pdf](#)

<sup>16</sup> <https://doi.org/10.1016/j.reseneeco.2021.101231>

<sup>17</sup> [https://www.researchgate.net/profile/Krystyna-Brys/publication/330986269\\_Heat\\_pump\\_placement\\_connection\\_and\\_operational\\_modes\\_in\\_European\\_district\\_heating/links/5c5ef94392851c48a9c5f7d9/Heat-pump-placement-connection-and-operational-modes-in-European-district-heating.pdf](https://www.researchgate.net/profile/Krystyna-Brys/publication/330986269_Heat_pump_placement_connection_and_operational_modes_in_European_district_heating/links/5c5ef94392851c48a9c5f7d9/Heat-pump-placement-connection-and-operational-modes-in-European-district-heating.pdf)

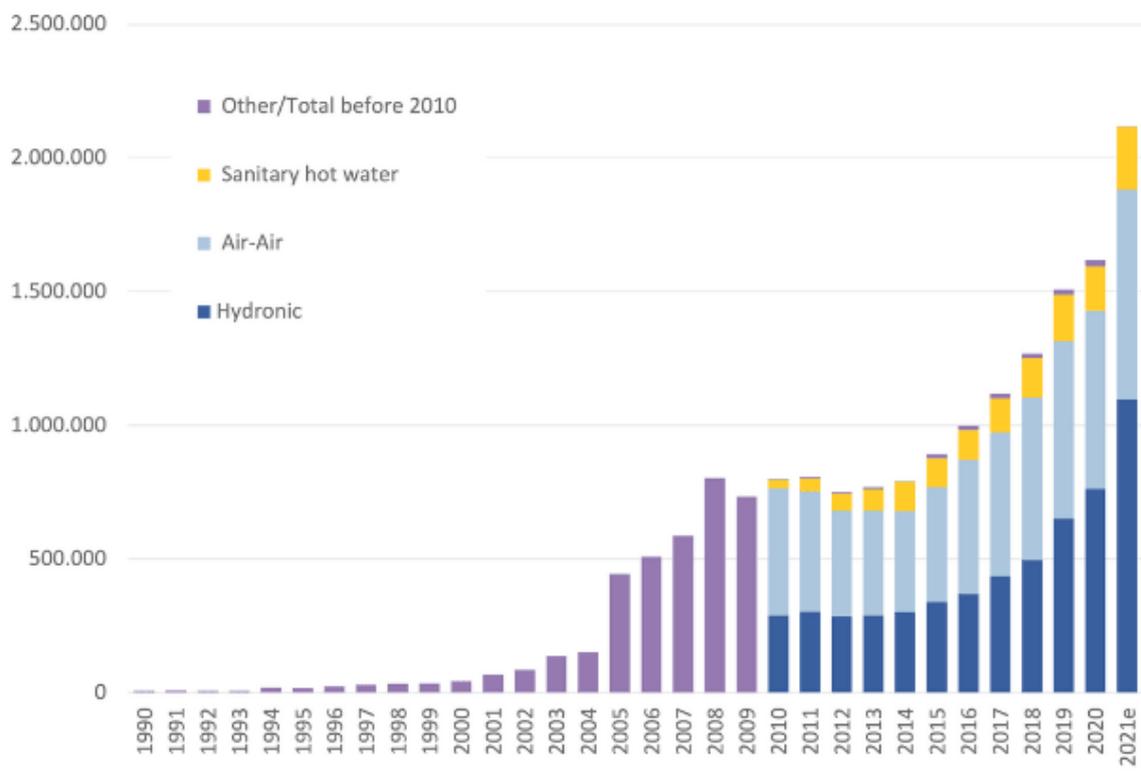


Figure 16. Heat pump sales across European countries. Source: EHPA (<https://www.ehpa.org>).

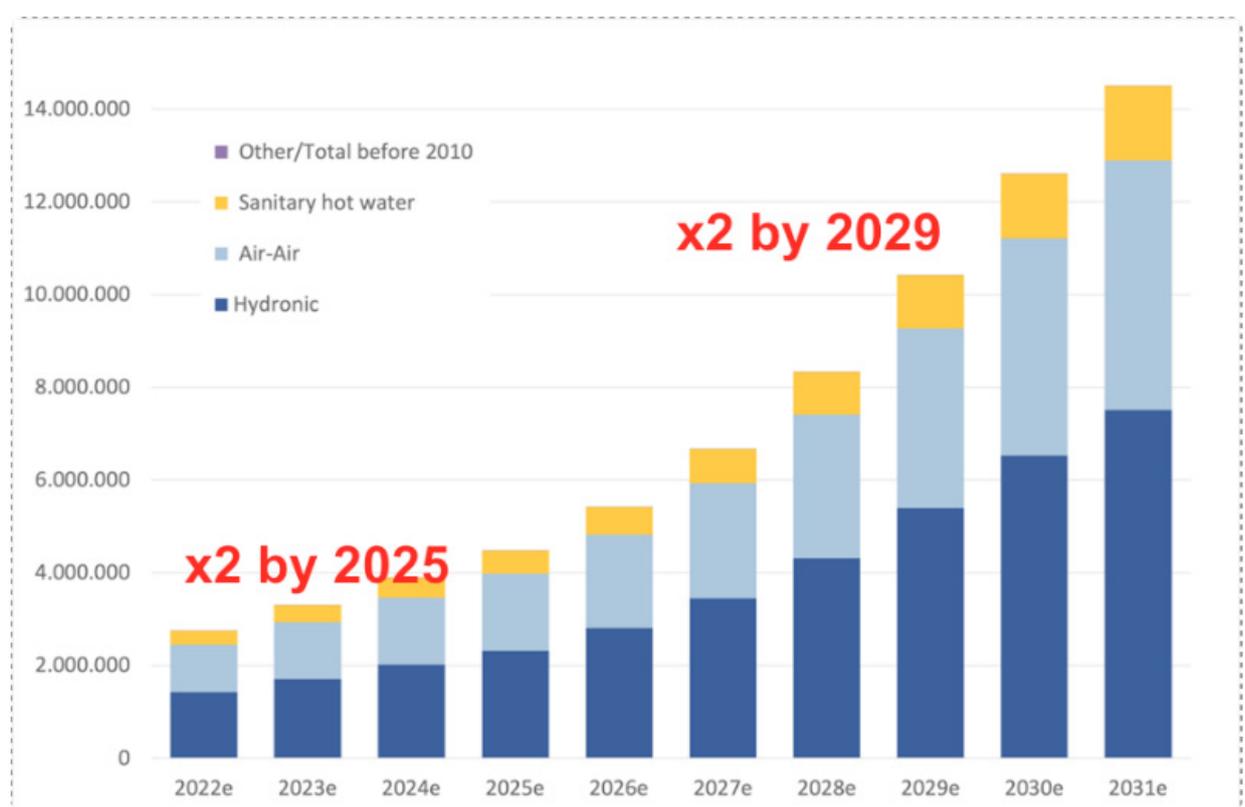


Figure 17. Expected growth according to evaluation from EHPA on REPowerEU targets.

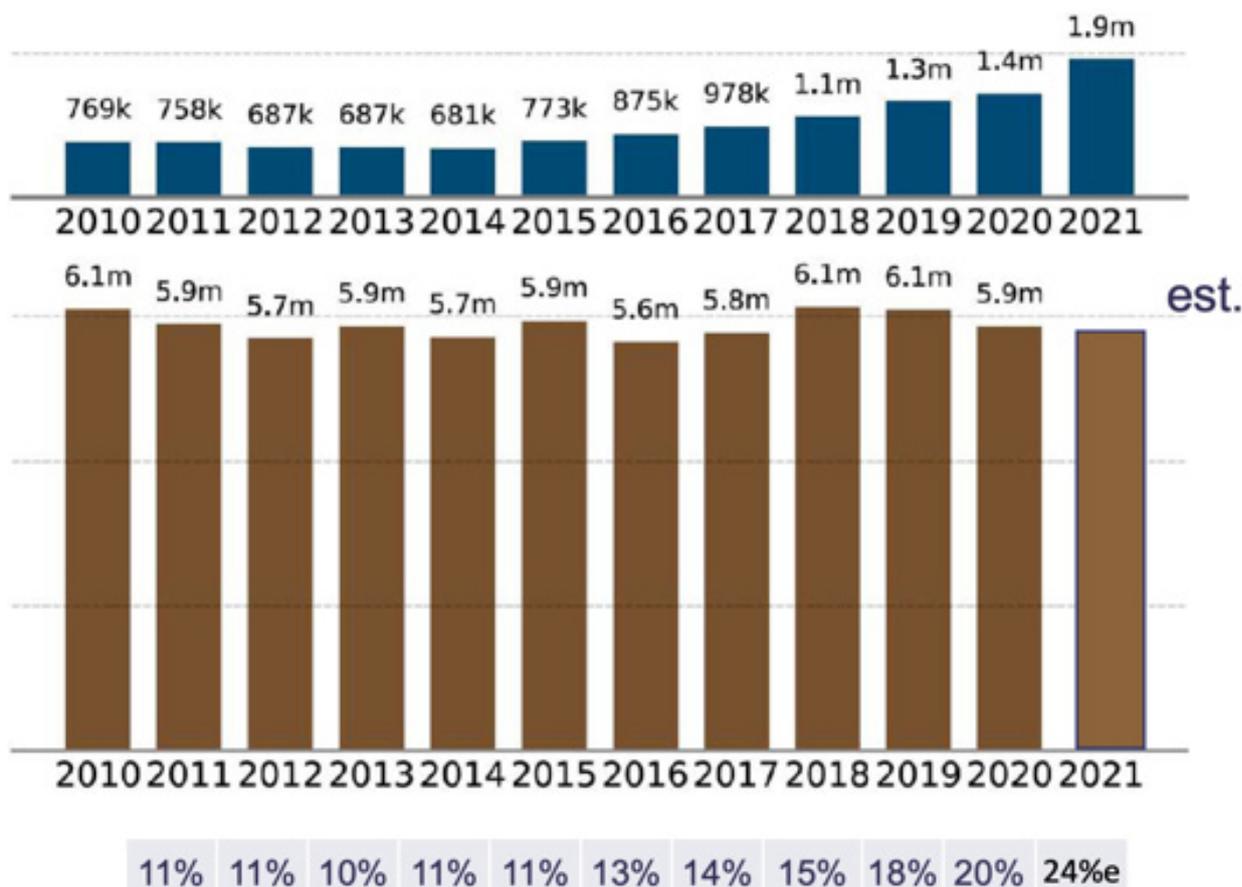


Figure 18. Market development of boilers (brown) and HPs (blue) and HPs' share. Source: EHPA.

### 2.3.2 Cooling systems

Since most buildings have a HVAC system based on boilers and designed to convey only fluids for heating purposes, over the last decades a large market of cooling systems has developed, often based on air-to-air reversible heat pumps. Such systems are sometimes used also for heating, especially in mild climates or, seldom, as integration to central heating. In this subchapter some information is provided on systems used mainly or exclusively for cooling. It is worth noticing that whenever possible, in case of deep renovation of buildings it is always advisable to consider an HVAC system designed to cover both heating and cooling.

There is a plethora of cooling technologies available for single and multifamily buildings, both new and old. The main categories of cooling technologies fall within district cooling, heat pump, and generic air conditioning systems.<sup>23</sup> Many of these cooling systems used internationally run on electricity for air conditioning, such as compressors, cooling towers, and chillers, while reversible heat pumps use refrigerants and either air, water, or the ground to generate cold air for homes during hot months. Solar cooling is a cooling technology which can be used within urban areas, while biomass-based cooling systems and other fossil fuel systems which generate both heat and

electricity can also be used for cooling purposes in remote large single family housing units or buildings requiring a backup system (e.g., hospitals). With the electrification of cooling, biomass-based cooling for single-family households and hybrid natural gas to air conditioning units<sup>18</sup> can be replaced by their more energy efficient electrical counterparts. However, their prevalence is rather small in comparison to the market share of electric coolers, thus the switch would be nearly negligible in terms of energy demand since most families already make use of electric-powered cooling technologies (when using space cooling).

Due to the increasing temperatures resulting from climate change, larger numbers of households are now having to rely on cooling systems within their homes during summer months.<sup>19</sup> Although electrification is considered environmentally friendly in the HVAC sector, the increased demand on the grid stemming from global warming should not be ignored, as it is growing with increasing ambient temperatures throughout the entirety of Europe.

According to projections, the European cooling market is expected to steadily grow in the future.

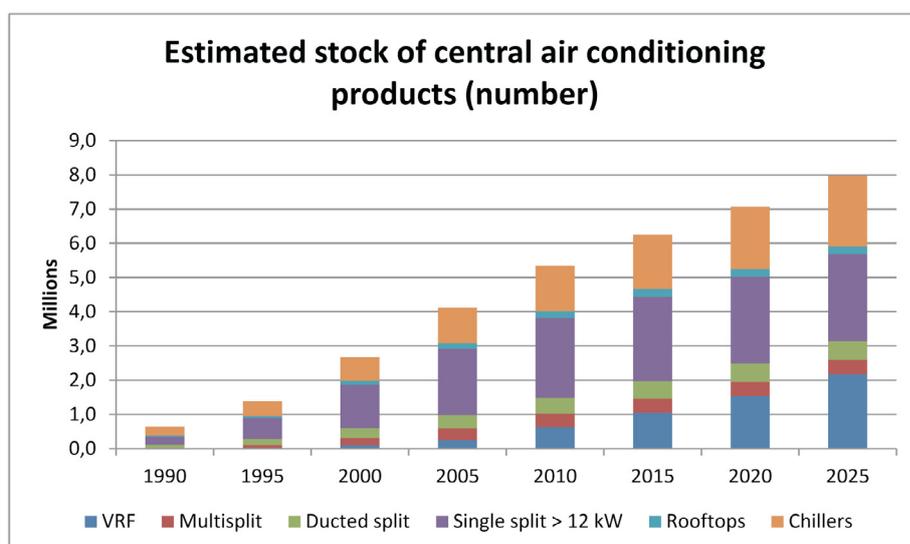
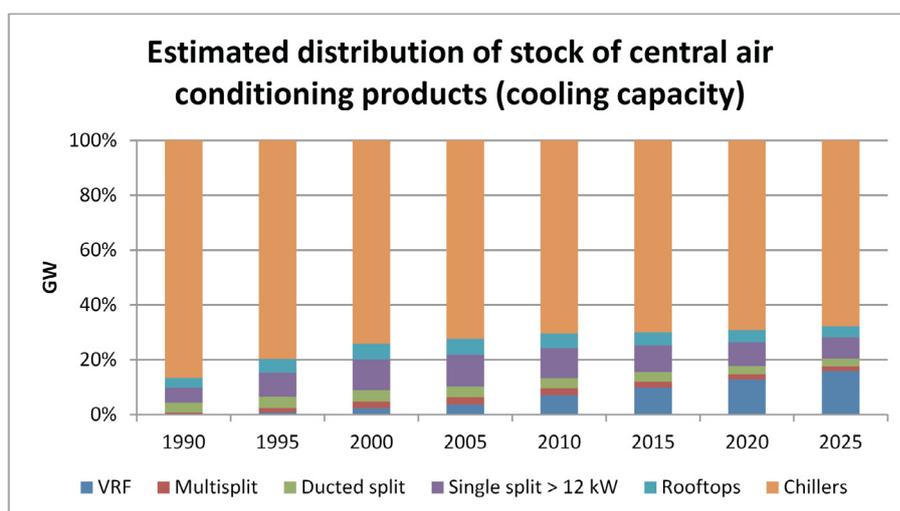


Figure 19 - Estimated stock of central air conditioning products by cooling capacity (left) and by number (right) (source: economic and market analysis as part of the preparatory study on air conditioning in the context of the Ecodesign Directive )

<sup>18</sup> <https://blogs.scientificamerican.com/plugged-in/the-air-conditioner-that-makes-electricity/>

## 2.3.3 Current state of the market

### 2.3.3.1 Europe

Around 1.8 million European households purchased a heat pump in 2020 (showing a 7.5% growth relative to 2019, despite the pandemic). Germany topped Spain in the three markets with France and Italy, amounting for almost half of all HP sales in the EU in 2020. Spain, Sweden, Finland, and Norway occupy the other first seven positions, confirming the flexibility of heat pumps and the capability of modern technologies to deal with cold climates (Figure 20).

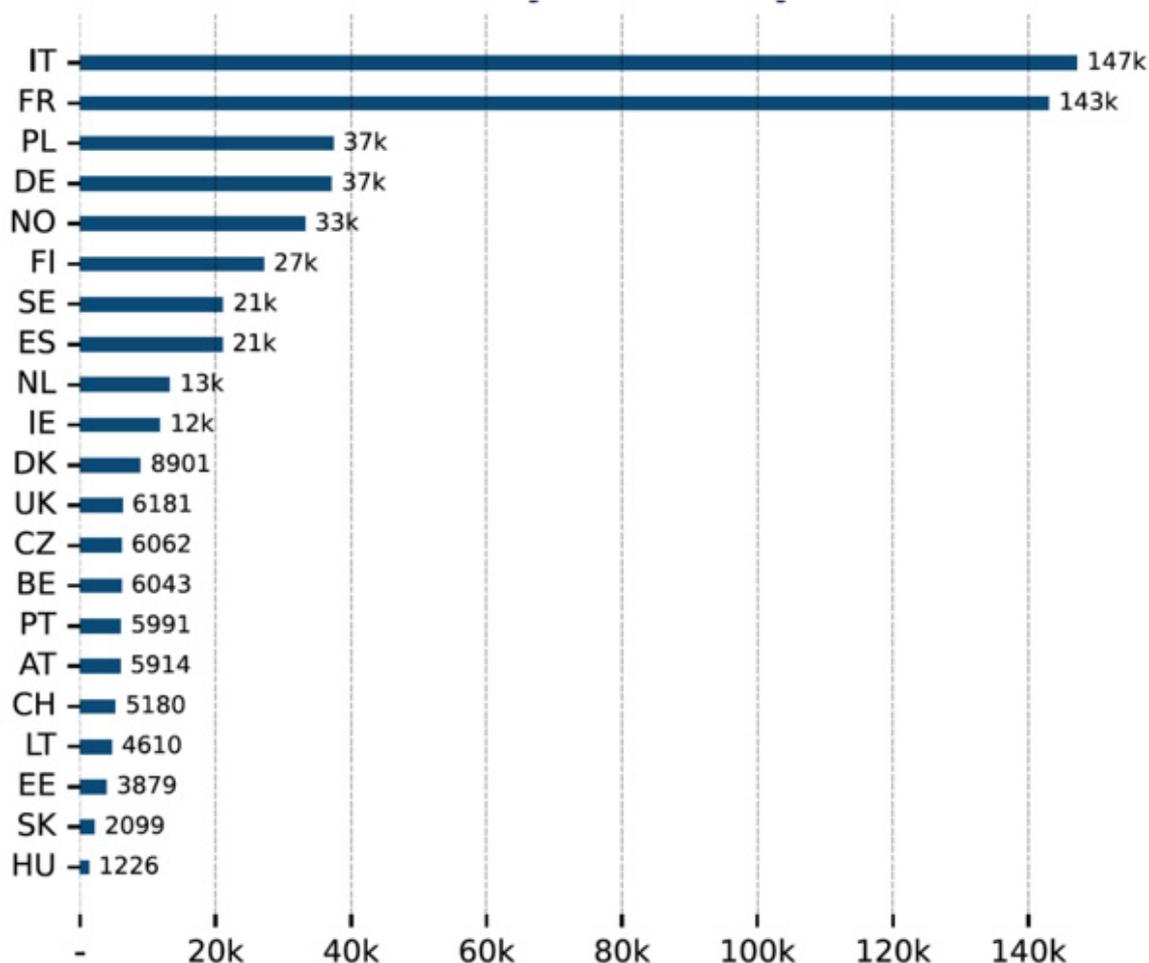


Figure 20. Heat pump sales increase by country. Source EHPA 2021 global outlook

It is important to note that Sweden, Estonia, Finland and Norway have the highest market penetration rates, with more than 25 heat pumps sold per 1,000 households each year.<sup>21</sup> After the 2020 slowdown of the Covid-19 pandemic, data suggests the HP market saw a strong recovery in 2021, as the European Heat Pump Association (EHPA) foresees market growth will go beyond 25% in 2021, hitting 2 million units sold yearly for the first time.<sup>22</sup>

<sup>19</sup> DOI: [10.1080/10789669.2008.10391022](https://doi.org/10.1080/10789669.2008.10391022)

<sup>20</sup> [Task\\_2\\_Lot\\_6\\_Air\\_Conditioning\\_Final\\_report\\_July\\_2012.pdf](https://www.iaea.org/reports/heat-pumps)

<sup>21</sup> <https://www.iea.org/reports/heat-pumps>

<sup>22</sup> [https://www.ehpa.org/fileadmin/red/03\\_Media/Publications/The\\_European\\_Heat\\_Pump\\_Outlook2021\\_2M\\_heat\\_pumps\\_within\\_reach\\_01.pdf](https://www.ehpa.org/fileadmin/red/03_Media/Publications/The_European_Heat_Pump_Outlook2021_2M_heat_pumps_within_reach_01.pdf)

The French heat pump market had a 3% rise in 2021, but the air-to-water segment rose by 53% (which can at least partly be explained by a special bonus for HPs in the French white certificate scheme). It is the currently the largest heat pump market in Europe, with more than 1 million units sold in 2021, with the most important HP being the air-to-air HPs (which can be also linked to the progressive ban of inefficient electric radiators, being the air-to-air HP the less expensive and less intrusive solution and offering also summer cooling).

The German heat pump market grew by 28% in 2021, with 154,000 units sold due to the expansion of air source heat pump sales. The adoption of a carbon tax on heating fuels in 2021 partly explains the growth observed.

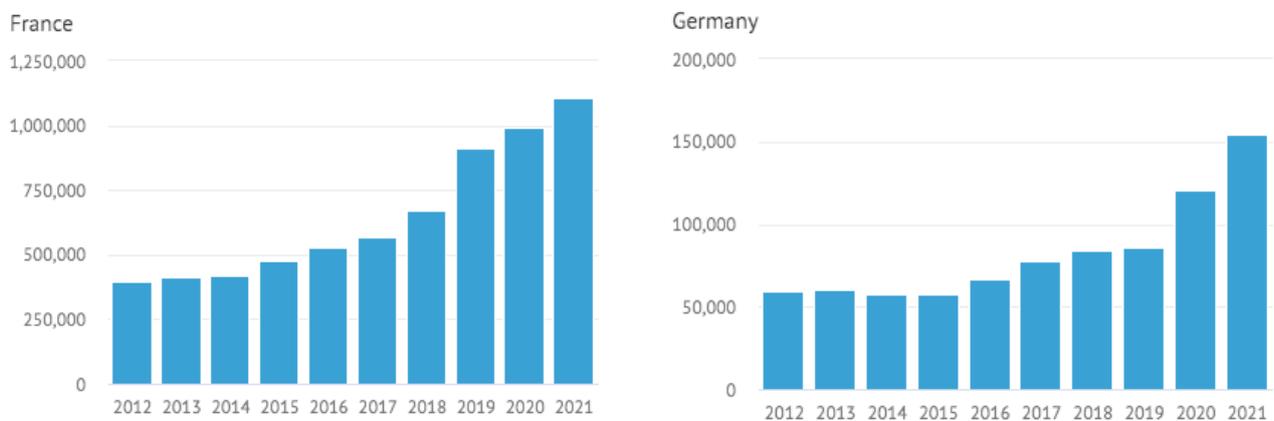


Figure 21 Annual heat pump installations in selected countries, 2012-2021. Source: National heat pumps associations in France and Germany. Chart by Joe Goodman

### 2.3.3.2 Italy

The Italian heat pump market has been the second largest market in the European context in 2021, with around 380,000 units sold. Figure 22 shows a steady and constant increase over the last decade of the national stock. Thanks to the superbonus, in 2021 almost all type of heat pumps witnessed a very strong increase in terms of units sold. Data published from the Italian sectoral association Assoclima highlights an increase over 2020 of 107% of sales figures in terms of volume for hydronic heat pumps and of 352% for hybrid systems. Air-to-air reversible HPs or air-source heat pumps (ASHPs) remain dominant in terms of stock due to their uses for summer cooling.



Figure 22 2017 HP sales in Italy by type16

## 2.3.4 Trends

### 2.3.4.1 Europe

Due to the recent increases in gas prices in 2021 and 2022, heat pumps have become financially more attractive than gas boilers, as heating with a very efficient heat pump in comparison to a gas boiler can result in an average savings of €313/year/household.<sup>23</sup> In addition, in the case of high electrification of heating, the average spending per dwelling would decrease from €474/year in 2022 to €144/year in 2050. However, prices and affordability can change as they are linked to policies and initiatives which provide support for low-carbon technologies, or alternatively ones that continue to allow for fossil fuel technologies to be sold. In the EU, the European Green Deal and the associated push for decarbonising heating through a variety of directives means the market for heat pumps is expected to double from 2 million<sup>25</sup> to 4 million installations per year.<sup>26</sup> Measures to achieve this objective include the EU Commission proposal to extend the EU Emissions Trading System to heating fuels, which would improve heat pump economics relative to oil-and-gas heating. New regulations in various European countries have released bans or limits for fossil-fuel heating in both new and existing buildings, as well as pledges to decrease dependency on fossil-fuels. For example, Norway, Sweden, Denmark, France and

Finland have announced bans of new fossil oil-based heating systems in all buildings, while the Netherlands no longer allows new homes to connect to the gas grid, whereas Ireland, Flanders in Belgium, and Austria have announced bans on oil boilers for new buildings. In line with future EU needs, Germany has announced that all new heating systems must run on at least 65% renewable energy from 2026.<sup>24</sup>

In light of the Russian-Ukraine war, the EU is also forced to make decisive choices about the future of European energy supply resulting from decreased access to Russian gas, which makes up a sizeable portion of the EU gas market. For example, Russian gas imports in Germany provided 32% of their supply in December 2021. With gas accounting for 15.3% of German electricity generation in 2021, and keeping half of the country's 41.5 million households warm, losing a large source of gas may result in a short-term increase in coal-fired generation or imports of power from neighbours. The recent European Commission's communication about the REPowerEU plan to reduce the gas imports from Russia includes an objective to accelerate the HP deployment, with the objective of 30 million HPs installed by 2030, which would substitute 35 billion cubic meters of natural gas in 2030.<sup>28,29</sup>

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<sup>23</sup> <https://www.raponline.org/knowledge-center/analysis-running-costs-of-heat-pumps-versus-gas-boilers/>

<sup>24</sup> <https://europeanclimate.org/resources/renovating-and-and-electrifying-buildings-strengthens-europes-economy-and-energy-security/>

<sup>25</sup> [https://www.ehpa.org/fileadmin/red/03\\_Media/Publications/The\\_European\\_Heat\\_Pump\\_Outlook2021\\_2M\\_heat\\_pumps\\_within\\_reach\\_01.pdf](https://www.ehpa.org/fileadmin/red/03_Media/Publications/The_European_Heat_Pump_Outlook2021_2M_heat_pumps_within_reach_01.pdf)

<sup>26</sup> <https://www.carbonbrief.org/guest-post-how-heat-pump-sales-are-starting-to-take-off-around-the-world>

<sup>27</sup> <https://www.reuters.com/business/energy/how-dependent-is-germany-russian-gas-2022-03-08/>

<sup>28</sup> <https://windeurope.org/newsroom/press-releases/europe-wants-more-renewables-to-increase-its-energy-security/>

<sup>29</sup> [https://ec.europa.eu/commission/presscorner/detail/en/ip\\_22\\_1511](https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1511)

<sup>30</sup> <https://www.ehpa.org/market-data/market-report-2021/>

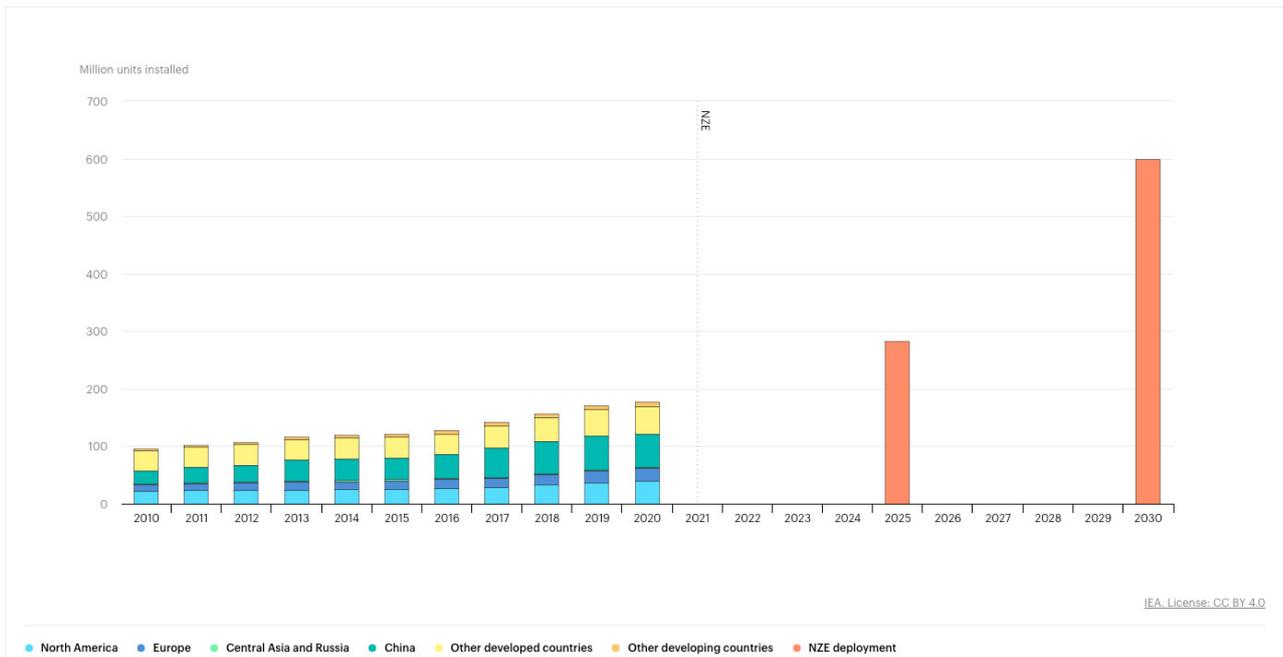


Figure 23. Installed heat pump stock by region and global Net Zero Scenario deployment, 2010-2030 – Charts – Data & Statistics – IEA

Heat pump market growth will continue to be influenced by three main factors and trends, namely the advancement of technology which allow HPs to function efficiently in more extreme climates, the need to accelerate the energy transition via the passing of policies and regulations which favour or mandate the integration of renewable energy and low-carbon technologies, as well as decreasing investment costs associated with economies of scale.

### 2.3.4.2 Italy

Aside from the increasing popularity of AH-SPs, a promising trend can be seen for other systems as well, with sales volumes having tripled since 2008 according to EHPA data. Nevertheless, the current market share of these heat pumps is small due to their high investment costs, despite the role that incentives introduced by the government have played. In the future, the market could be boosted by players in the supply chain such as particularly installers, who could act to increase end-users' awareness so that they fully understand the environmen-

The fourth, and newest factor relates to the Russo-Ukrainian war that may force change upon the EU energy system. Regardless of these variables, experts see heat pumps as one of the main solutions for tackling space heating's carbon emissions for the foreseeable future<sup>25</sup>, in line with the IEA's predictions depicted in Figure 22. In fact, experts believe that growth rates resulting in over 50 million heat pump installations will be feasible within the EU this decade.

tal and economic benefits of heat pumps. In a heating scenario dominated by HPs, an overall cost reduction of 4% is estimated in Italy, with savings of €4 billion per year.<sup>33</sup> According to the Italian 2020 NECP (drafted before the introduction of the New green deal targets and then to be updated with increased targets also for HPs), heat pumps will see their ambient heat more than doubled by 2030, with respect to 2017, reaching 5.7 Mtoe.<sup>34</sup> By applying REPowerEU targets, we should double or more probably triple the present NECP target by 2030.

## Heat Pumps

**Energy Efficiency Performance:** Under ideal conditions, a HP can transfer 300% more energy than it consumes, compared to a high-efficiency gas furnace's 95% rating. This performance metric for heat pumps is also referred to as the coefficient of performance, or COP (Tri-State, 2022). At 8°C, the COP of ASHPs typically ranges from 2.0 to 5.4, meaning that up to 5.4 kWh of heat are transferred for every kWh of electricity supplied to the HP. At -8°C, COPs can range from 1.1 to 3.7. For water temperatures entering GSHPs above 0°C, a COP of around 3 for most systems can be observed.

Installed Volume in the EU: 21.8 Million units until 2020

**Volumes to be added by 2025 and 2030:** 30 million by 2030<sup>26</sup>, 50 million units within the decade<sup>26</sup>, or a global level of around 13%, year on year to 2030<sup>15</sup>

**Potential Savings:** In 2020, heat pumps with a thermal capacity of 14.24 GW were installed producing approximately 27.11 TWh of useful energy and integrating 16.92 TWh of renewables in heating and cooling while avoiding 4.31 Mt of CO<sub>2</sub>-equivalent emissions, while the heat pump stock (heat pumps sold in the past twenty years) contributed 41.07 Mt of greenhouse gas emission savings. The distribution of emission savings per country is very similar to that of renewable energy production, since both calculations are directly linked to the number of units installed and the related reduction in demand for fossil energy. Thus, future emissions savings can be calculated based on renewable energy production, which will be influenced by national and EU policies encouraging these technologies.

### 2.3.5 The point of view of some stakeholders

According to the main stakeholders, electrification market in practice coincides with heat pumps. The main share of the electrification is given by heat pumps producing heat, being this the field in which they go to replace the fossil fuels. Heat pumps will make heat demand smart, allowing dialogue with electrical system. Associations and producers agree that heat pumps produce economic benefits for end users because they can generate hot and cold with a single equipment compared to traditional configurations in which gas boilers and air conditioning systems are needed.

The main EU heat pump association believes that both on the policy level and on the reception level of the end user's electrification of heat is ongoing and heat pump solutions are accepted as one of the solutions that are reliable, mature, available; this potential seems to be confirmed by several bodies independent by HP industry. It also links with flexibility needed by high shares of photovoltaic and wind electricity and the coupling with heat pumps is something that has not been valued enough.

<sup>31</sup> <https://www.linkedin.com/feed/update/urn:li:activity:6911313741053624320/>

<sup>32</sup> <https://www.ehpa.org/about/news/article/the-european-heat-pump-outlook-2021-2-million-heat-pumps-within-reach/>

<sup>33</sup> Gas addio! Ecco perché passare a una pompa di calore e abbandonare la caldaia a gas by BEUC and Altroconsumo

<sup>34</sup> Italian NECP - [https://energy.ec.europa.eu/system/files/2019-06/it\\_swd\\_en\\_0.pdf](https://energy.ec.europa.eu/system/files/2019-06/it_swd_en_0.pdf)

The main target should be make every building ready for heating at 55 degrees centigrade and the possibility for heat pumps to provide heat efficiently at 55/60 degrees is something that is understood: associations see that a lot of people are starting this journey towards a decarbonized building that includes a decarbonised heat source.

A new interesting technology pointed out by association of producers is the smart heat pump. In traditional heat pump installations there is a remote control of the machine, but the machine itself is not allowed to dialogue with the electrical system. The smart heat pump technology allows to interrupt the supply only to the compressor, using thermal inertia of the building or of a hot water tank with a thermal storage function placed on the plant that continues to provide thermal energy to the building even if compressor is disconnected.

Association of consumers stated how from energy efficiency and renewable projects carried out (like PV and heat pumps) emerges that those who install efficient technologies greatly increase their awareness towards energy saving, with a different approach also on the management of energy consumption (e.g. appliance used in sync with the peak of self-production), so as to introduce a new paradigm.

From a survey made among Italian energy managers, it has been revealed that electric heat pumps are the leading technologies in the electrification process and their installation or planification is more important than other electro-techs like building automation systems or recharging stations.

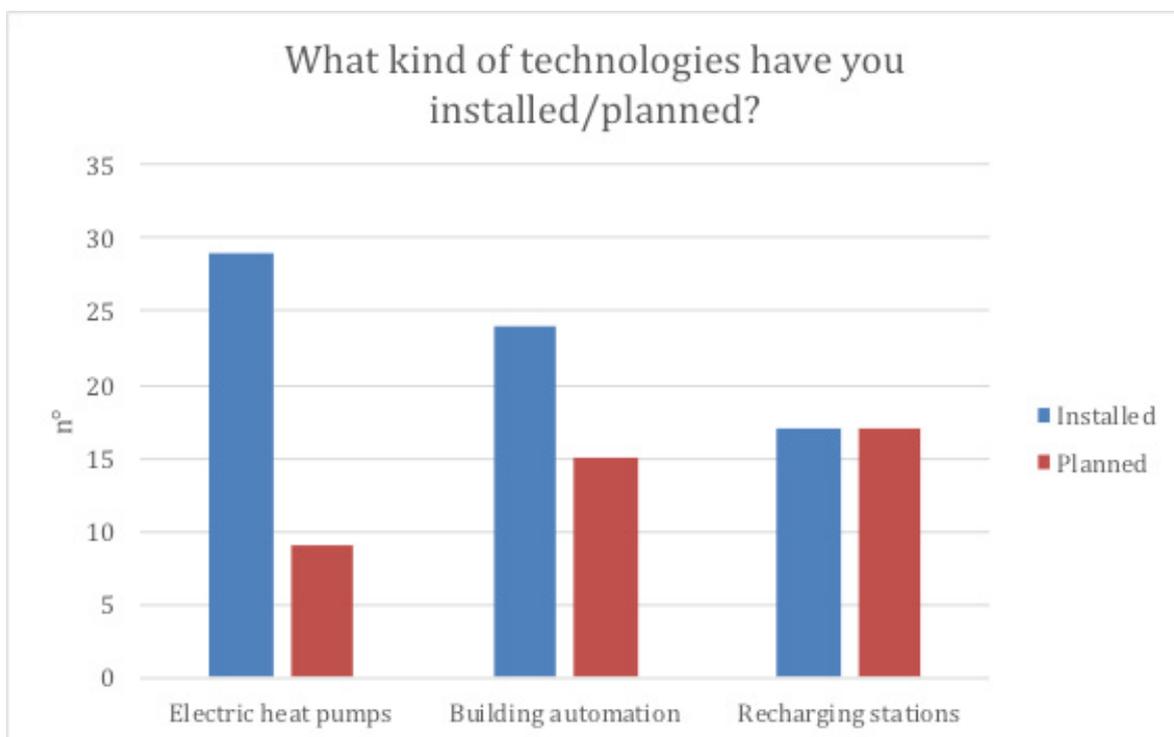


Figure 24. Interest of Italian energy managers towards some electrification technologies. Source: FIRE.

## 2.4 Electric hobs

### 2.4.1 Introduction on available technologies

A hob is a domestic appliance used for heating food. It generally works as a primary heat source which is used to warm a cooking vessel (a pan, pot, etc.), which then becomes the secondary heating source, transferring heat to the food within it. The European Commission differentiates between electric hobs, gas hobs and mixed hobs.

- **Gas hob.** Appliance which incorporates one or more cooking zones/areas, including a control unit, which is heated by gas burners of a minimum power of 1.16 kW (efficiency: 40-55%).
- **Mixed hob.** Appliance that incorporates at least one gas burner and at least one electric heater (efficiency: 40-60%).
- **Electric hob.** Appliance which incorporates one or more cooking zones/areas, including a control unit, and which is heated by electricity. They can be further divided in three types:
  - **Solid plate** hobs contain a sealed electric resistance, through which circulates electrical current, transferring heat to the cooking vessel on top of it (efficiency: 45-60%).
  - **Radiant hobs** are a type of radiant cooking appliance. They use an electrical resistance wire or ribbon with a current that makes it glow red hot, so that most heat is transferred to the cooking vessel by conduction via a glass-ceramic surface (efficiency: 45-60%).
  - **Induction hobs** are an electric cooking appliance where the hob itself is not specifically heated. Instead, below the surface of the hob there is a planar copper coil that is fed electrical power via a medium frequency inverter. This alternating current induces eddy currents in nearby metallic objects (cooking vessel). These eddy currents heat up the cooking vessel, transferring the heat to the food<sup>36</sup> (efficiency: ≈90%).

An important usability factor when comparing domestic hobs is the ability to control temperature, as this is a key aspect of the cooking process. In general, it is considered that gas hobs offer a basic level of control, whereas radiant ones allow the user to be slightly more accurate thanks to different levels offered in this kind of cooktops. Also, electric hobs are the only possible solution for low energy consumption buildings (Italian technical standards require kitchens where gas hobs are installed to have two small "holes" in the wall, - one for inletting outside comburent air, the other to ensure a way out for exhaust of combustion products).

Induction hobs offer additional advantages: they generally install a timer shut off and a safety shut off in case of no interaction. They are generally easier to clean, have the quick-

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<sup>35</sup> Regulation 65/2014 <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014R0065&from=EN>

<sup>36</sup> Rodríguez Quintero, R., Boyano, A., Bernad D., Donatello, S., Paraskevas, D., Villanueva, A., Review study of Ecodesign and Energy Labelling for Cooking appliances, JRC Technical reports, March 2021.

est response to temperature changes and have the best time response: as an average, the time needed to boil 2 litres of water with an induction hob is 5 minutes. This is mainly due to the fact that the electromagnetic fields created in these hobs do not heat the cooking surface, but rather directly the cooking vessel. Moreover, the flat surface prevents heat to be lost (highest energy efficiency among hobs).

In terms of durability, gas hobs have been widely used over time and their durability has been long proven. 19 years is a widespread figure used for gas hobs lifetime (ETSAP, 2012). On contrast, glass- ceramic is more prone to scratching and breaking. If a pot is accidentally dropped over the cooktop it may damage the surface, affecting its performance. Induction and radiant hobs may have a slightly lower average lifetime because of that (a range between 15 and 19 years is provided in ETSAP, 2012). Moreover, the significant amount of electronic components present in induction hobs may reduce lifetime of these appliances. As reported in Favi et al, (2018), lifetime bottleneck is usually represented by electronic components, which tend to have the shortest lifetime among all components of a product. It is suggested that lifetime may be lower than gas or radiant cooktops, more similar to other consumer electrical products (10-15 years)<sup>2</sup>.

## 2.4.2 Current state

### 2.4.2.1 Europe

Cooking appliances such as ovens, hobs and range hoods have been subjected to European (EU) energy labelling and eco-design requirements since 2015. Looking at the European energy consumption reports, household appliances represent the highest impacting system after space and water heating . According to EUROSTAT , electricity is the first fuel in the energy consumption in the residential sector in the EU27 for cooking, with an average share of 49%, followed by natural gas (27,7%), oil and petroleum products (16,3%) and renewables and wastes (6,6%). Member states where a deeper penetration of electrification is observable are Sweden, Denmark, Germany and Austria. In the case of Sweden and Denmark, the (very) low share of gas in cooking corresponds to an equally (in the case of Sweden) or anyhow low (for the case of Denmark) share of gas in space and water heating, mostly derived by electricity, derived heat or renewables and wastes. Austria has a more differentiated fuel mix when it comes to space and water heating, with half of its demand being filled with derived heat and renewables and wastes. The space and water heating market in Germany is comparable to the Italian one (almost half of the heating demand satisfied by gas).

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<sup>37</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy\\_consumption\\_in\\_households#Energy\\_products\\_used\\_in\\_the\\_residential\\_sector](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households#Energy_products_used_in_the_residential_sector)

<sup>38</sup> [https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy\\_consumption\\_in\\_households#:~:text=Energy\\_consumption\\_households\\_data2019](https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Energy_consumption_in_households#:~:text=Energy_consumption_households_data2019)

Table 5 - Share of fuels in the final energy consumption in the residential sector for cooking, 2019 (EUROSTAT)

	Electricity	Derived Heat	Gas	Solid fuels	Oil & petroleum products	Renewables and Wastes
<b>EU</b>	<b>49,0</b>	<b>0,0</b>	<b>27,7</b>	<b>0,4</b>	<b>16,3</b>	<b>6,6</b>
Belgium	68,9	0,0	26,8	0,0	4,3	0,0
Bulgaria	75,2	0,0	2,3	0,7	9,9	11,8
Czechia	47,5	0,0	47,7	0,2	2,1	2,5
Denmark	97,1	0,0	2,9	0,0	0,0	0,0
Germany	92,6	0,0	2,9	0,0	0,0	4,5
Estonia	43,9	0,0	16,5	0,0	14,4	25,2
Ireland	75,8	0,0	22,4	0,0	1,8	0,0
Greece	83,6	0,0	1,0	0,0	2,9	12,5
Spain	53,1	0,0	29,9	0,7	13,9	2,4
France	49,3	0,0	32,2	0,0	18,5	0,0
Croatia	34,6	0,0	21,6	0,0	24,8	19,0
Italy	15,8	0,0	69,2	0,0	10,2	4,8
Cyprus	38,0	0,0	0,0	0,0	62,0	0,0
Latvia	15,3	0,0	39,0	0,0	14,9	30,9
Lithuania	15,1	0,0	38,1	0,5	37,2	9,1
Luxembourg	34,9	0,0	62,2	0,0	2,9	0,0
Hungary	12,4	0,0	68,3	0,0	19,1	0,2
Malta	18,9	0,0	0,0	0,0	81,1	0,0
Netherlands	34,2	0,0	65,8	0,0	0,0	0,0
Austria	91,0	0,0	4,9	0,0	0,2	3,9
Poland	16,6	0,0	44,3	4,0	32,0	3,0
Portugal	44,4	0,0	9,6	0,0	15,4	30,6
Romania	0,1	0,0	60,2	0,4	33,2	6,1
Slovenia	52,1	0,0	10,1	0,0	27,1	10,7
Slovakia	25,5	0,0	69,0	3,1	1,0	1,3
Finland	88,9	0,0	0,7	0,0	10,3	0,0
Sweden	98,5	0,0	1,5	0,0	0,0	0,0

For what concerns sales of cooking appliances, data suggests that more consumers are moving away from stand-alone cookers to install complete hobs. In fact, cookers indicate a slow decrease over the period 2018-2023, reaching slightly above 1.7 million units sold in 2023 (see Figure 24). In this product group, less than half a million correspond to gas heated appliances, which appears to be in line with the reference scenario.

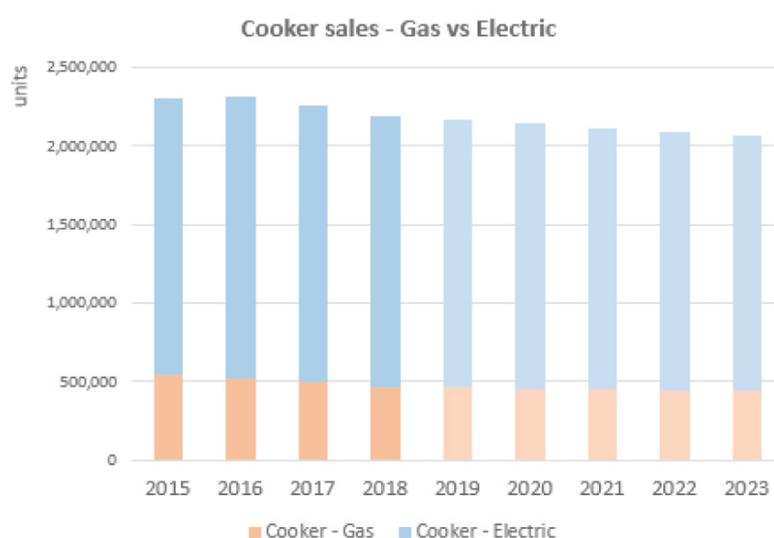


Figure 25 - Cooker sales – Gas vs. Electric (Source JRC)

In terms of hobs, sales are expected to grow up to nearly 6.4 million units in 2023, with most of the sales being on that year of induction appliances. Induction hobs will be more widespread at the expense of other types of electric hobs. Gas fuelled ones, however, appear to stay quite stable, representing about one fourth of future sales.

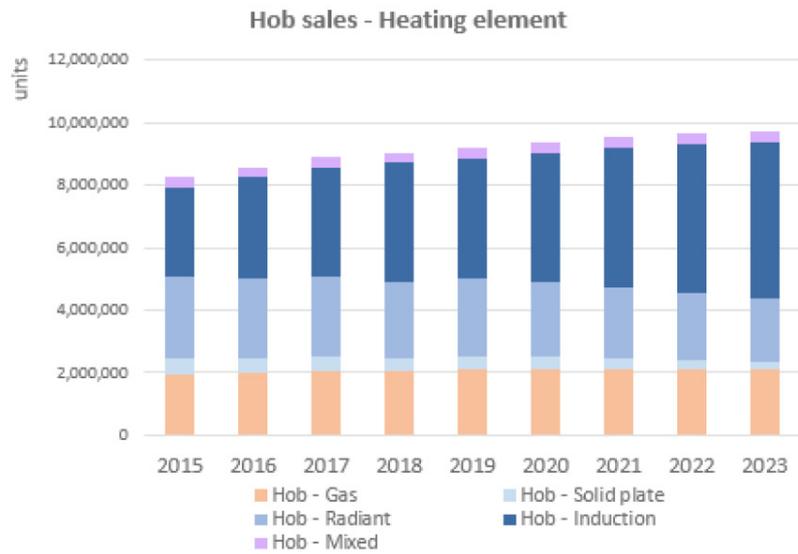


Figure 26- Hobs sales per heating element (Source JRC)

### 2.4.2.2 Italy

In the USA and Europe, the great majority of cooking appliances are of the electric type, followed by natural gas appliances. On the contrary, in Italy the most common kitchen stove consists of four hobs, mainly powered by natural gas or LPG. The electric or induction hobs are currently less used mainly because their simultaneous run with other home electric appliances results in a greater electricity demand, this shifting the configuration of the power purchasing contract from a normal 1.5- to 3.0-, 4.5- or 6.0-kW power supply. As it can be observed in Table 5, penetration of electricity in Italian's kitchen stoves is well below the EU27 EU average, as electricity represents a 15.8% share in terms of fuels. Only a few countries use a lower amount of electricity in cooking, which is in the majority of cases compensated by a larger use of oil and petroleum products and/or renewables and wastes. Not surprisingly, Italy has the highest share of natural gas as fuel option, peaking the chart with 69.2%.

#### The case of Germany

The space and water heating market in Germany is comparable to the Italian one (45.6% of the heating demand satisfied by gas in DE vs. 59.5% in IT; and 49.3% of water heating demand in DE vs. 65.1% in IT). However, in terms of main fuel used for cooking, the situation is completely the opposite: 92.6% of German households use electricity (vs. 15.8% in IT) and 2.9% use gas (vs. 69.2% in IT). This could be due to the fact that most multi-apartment buildings in Germany use a collective gas boiler, with no direct gas access to single apartments. Another factor to consider are gas and electricity tariffs in the two countries - it could be not advantageous for German households to have a gas contract for cooking only, while it is not advantageous in Italy to increase the energy demand for supporting induction cookers.

## 2.4.3 Trends

### 2.4.3.1 Europe

The total stock of hobs in EU27 households is estimated to grow between 2019-2040 up to almost 200 million units in 2040.

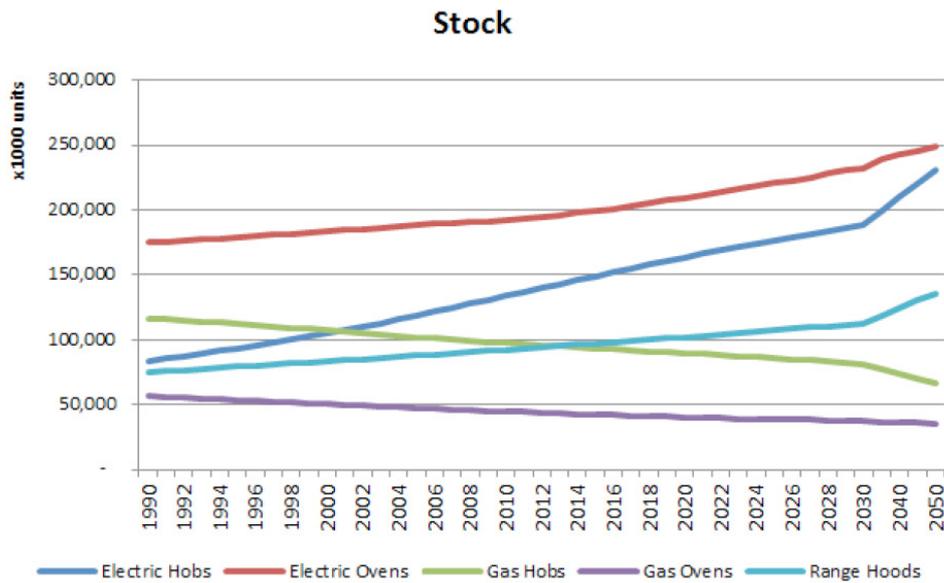


Figure 27 - Hobs stocks – Gas vs. Electric (Source JRC)

In terms of hob technologies, a significant increase in the amount of induction hobs can be expected between 2019 and 2040, with induction becoming the most common technology in the coming years.

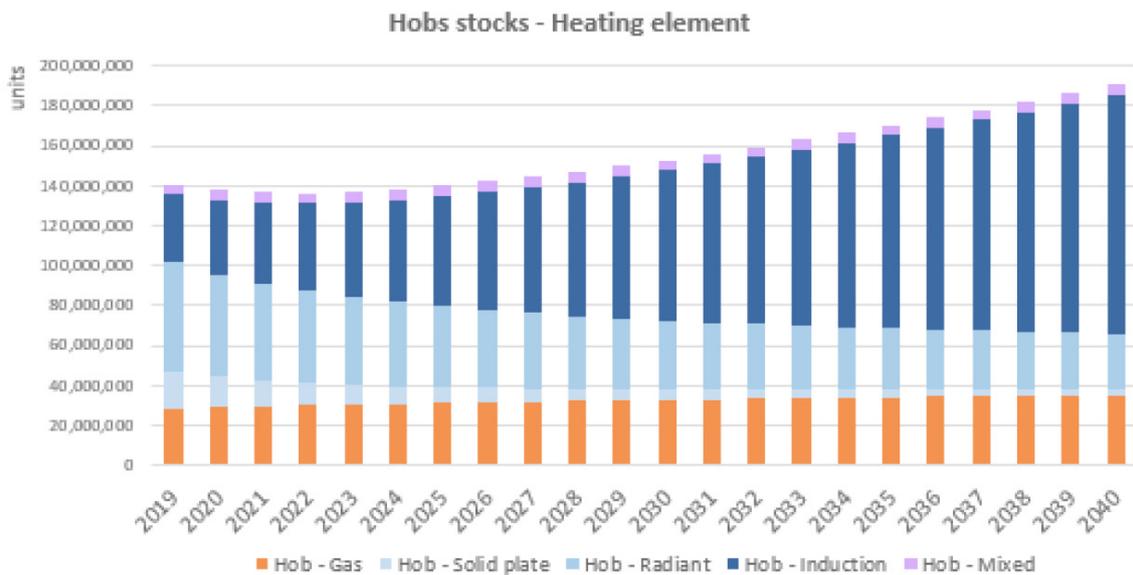


Figure 28 - Induction vs radiant hobs (Source JRC)

<sup>39</sup> Cimini A., Moresi M., (2017) Energy efficiency and carbon footprint of home pasta cooking appliances, Journal of Food Engineering, Volume 204, 2017, Pages 8-17, <https://doi.org/10.1016/j.jfoodeng.2017.01.012>

### 2.4.3.2 Italy

The push for a further penetration of electricity in end uses foreseen in the Italian National Energy and Climate Action Plan (NECP) includes the electrification of Italian kitchens, which would mostly install induction hobs. This move might, however, have a huge impact on the Italian power sector. As shown by Lombardi et al. (2018), in terms of GHG emissions the intervention produces positive net effects on the primary energy balance of the energy sector only when sustained by adequate shares of renewables; otherwise, increased operation of fossil-fuel plants offsets gas savings. Nonetheless, feedbacks on other productive sectors entail additional energy consumption and emissions, thus counterpoising positive effects obtained within the energy sector even in the NECP scenario. Still, higher renewables penetration reduces overall additional emissions by more than half.

### 2.4.4 The point of view of some stakeholders

According to associations, despite space heating is still the main issue in the buildings' electrification process, cooking represents an aspect that should not be underestimated and is still challenging for a comprehensive electrification strategy, especially in countries like Italy or Netherlands in which kitchens are mainly powered by fossil fuels.

According to energy agencies, electric cooking appliances are easier to install and use if compared to electrifying space heating and domestic hot water. Moreover, electric hobs can often include more control features (compared to gas). In order to incentivize the switch to induction/electric cooking a change in end user habits is needed because the main barrier is cultural. Many utilities around Europe (especially in the Netherlands) are currently offering consumers who go electric new sets of pans, cooking courses, demonstrations, etc. as they understood that what needs to change is consumers culture. In 2018 27% of new hobs were gas ones, while the rate was 52% in 2015.



<sup>40</sup> [https://energy.ec.europa.eu/system/files/2020-02/it\\_final\\_necp\\_main\\_en\\_0.pdf](https://energy.ec.europa.eu/system/files/2020-02/it_final_necp_main_en_0.pdf)

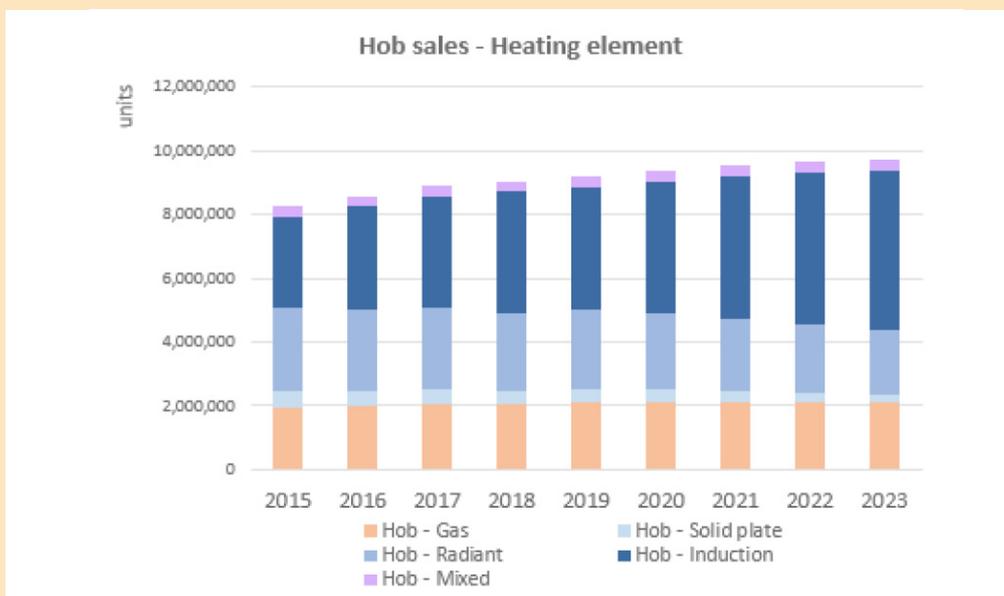
<sup>41</sup> Lombardi F., Rocco M. V., Colombo E., (2018) A multi-layer energy modelling methodology to assess the impact of heat-electricity integration strategies: The case of the residential cooking sector in Italy, Energy 170, pages 1249-1260, <https://doi.org/10.1016/j.energy.2019.01.004>

## Electric Hobs

**Energy Efficiency Performance:** Energy efficiency is defined as the ratio of energy into food/water versus the energy into the appliance. In general, according to Aisyah et al. (2021), induction is more efficient compared to halogen and electric coil, although the efficiency is highly dependent on the power used by the cooker. The energy efficiency of induction ranges between 59.46% to 81.78%, between 63.86% to 66.75% for halogen, and between 32.43% to 42.02% for electric coils.

**Installed Volume in the EU:** Roughly 5 million (excluding gas hobs) according to Rodríguez Quintero et al. (2021)

**Volumes to be added by 2025 and 2030:** The market analysis performed by Rodríguez Quintero et al. (2021) shows that induction technology is steadily replacing radiant technology in EU households. The sales of induction hobs will double the sales of radiant hobs, and by 2030, the number of induction hobs will surpass the radiant hobs. This technology replacement has been underpinned by the current Ecodesign regulation, which sets a common requirement for electric hobs.



**Potential Savings:** In BAU scenario presented by Rodríguez Quintero et al. (2021), GHG emissions decrease from 2.1 to 1.7 MtCO<sub>2</sub>e between 2020-2040 which is mostly driven by the natural replacement of old hobs for new and more efficient ones. In the case of stricter minimum ecodesign requirements and removal of the energy label, GHG emissions decrease from 2.1 to 1.7 MtCO<sub>2</sub>e between 2020-2040, for a total savings of 0.1 Mt in comparison to BAU.

## 2.5 Smart technologies in buildings

### 2.5.1 Introduction on available technologies

Smart technologies in buildings are expected to optimise energy use, energy storage, help with maintenance and improve comfort.

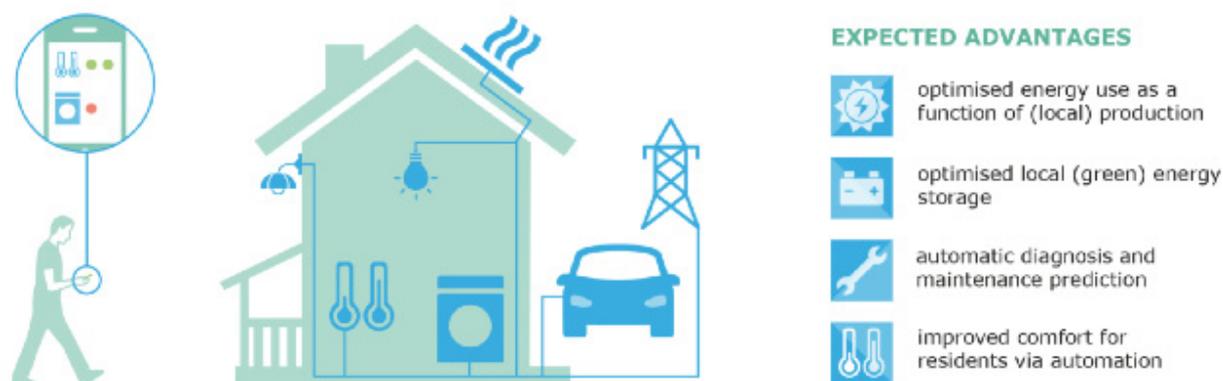


Figure 29 Expected advantages of smart technologies in buildings<sup>42</sup>

The Smart Readiness Indicators have been promoted by the amending EPBD adopted in 2018, to easily evaluate the readiness of the buildings and the available technologies: for example, how buildings interact with people and with the grid, or how the efficiency and performance is elevated through different ICT technologies. Due to the broad spectrum of information and smart technologies that could be used in buildings, we only concentrated on those technologies and aspects that have high influence on total energy consumption.

BPIE in their study on smart environment of buildings<sup>43</sup> evaluates the characteristics of a smart built environment (not only relevant for buildings but also interacting with the whole energy system). According to their evaluation, smart, meaning dynamic and self-regulating building system includes :

- efficiency and health (energy efficiency, ability to keep adequately warm/cool, healthy living and working),
- renewable energy uptake (efficient cooling and heating – EE1st, on-site production),
- dynamic operability (smart meters deployment, dynamic energy market and connectivity),
- responsiveness and interaction with energy system (demand response and interoperability, energy storage in building and vehicles penetration).

<sup>42</sup> European Commission, Directorate-General for Energy, Verbeke, S., Aerts, D., Reynders, G., et al., Final report on the technical support to the development of a smart readiness indicator for buildings: summary, Publications Office, 2020, <https://data.europa.eu/doi/10.2833/600706>

<sup>43</sup> De Groote, Volt, Bean, Is europe ready for the smart buildings revolution? Mapping smart-readiness and innovative case studies, BPIE, 2017

Some of the technologies related to the smart operability and integration to the grid are solutions to overcome barriers in deployment of electrification. Such are smart meters roll-out, which has been successfully implemented in Italy. The development of demand – response is also important in Europe, with progress in integrating flexibility sources and relevant business models differing according to the countries' energy markets' regulations.<sup>44</sup>

For example in Italy, the energy markets are not officially open for demand side participation, there are only pilot projects of DSP at the ancillary services market. Interaction with the grid and with the neighbouring buildings is not part of the analysis. On-site electricity generation systems are relevant part of the smart building systems, but the scope of this document is demand side in buildings.

Commission Recommendation from 2019 on building modernisation<sup>45</sup> suggested the technologies including:

- development of the infrastructure necessary for the smart charging of electric vehicles,
- building automation and the electronic monitoring of technical building systems (BACS),

Other relevant technologies are:

- IoT ecosystem for smart buildings,
- And building energy storage systems.

## 2.5.2 Building infrastructure for smart EV charging

### 2.5.2.1 Current state - Europe

In 2021, electrically chargeable vehicles made up 18.0% of total car registrations, up from a 10.5% share in 2020\*. Most owners of electric vehicles charge their cars at home, overnight, 61% of EV owners in Europe had access to home charging and 15% to charging at work in 2020\*\*. Home charging, as it is controllable, can interact with the building and includes extended periods in which vehicles are parked. To make use of the smart charging options, therefore the private chargers should also be equipped with V2G (Vehicle-to-Grid) if possible and consider

the peak load of the grid (link with dynamic tariffs). Calculations show that if the EPBD directive draft is implemented, the electricity consumption of the parking lot of the buildings (especially office buildings) would double the current consumption of the offices. That is why the smart charging is highly important. Studies show that there are different motivations among citizens for smart charging options, for example, UK citizens are interested if the costs were reduced, if users could retain control and/or if broader advantages to society were clear, Ger-

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<sup>44</sup> Forouli, A.; et al. Assessment of Demand Side Flexibility in European Electricity Markets: A Country Level Review. *Energies* 2021, 14, 2324.

<sup>45</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32019H1019>

\* <https://www.eea.europa.eu/ims/new-registrations-of-electric-vehicles#:~:text=There%20has%20been%20a%20steady,of%20newly%20registered%20passenger%20cars>

\*\* Source: <https://www.transportenvironment.org/wp-content/uploads/2021/07/01%202020%20Draft%20TE%20Infrastructure%20Report%20Final.pdf>



mans are interested in contributing to the stabilization of the electricity grid and integrating renewables, not only economic benefits, whereas environmental benefits and the integration of renewables is important in the Netherlands.<sup>46</sup>

Among the countries that have high developed EV market, Sweden is the top in the EU. In Sweden, 80% of electric car users live in individual houses, compared with only 50% of the general population, meaning the access to own parking and possibility to have their own charging spot seems crucial for EV<sup>47</sup> owners. However, the number of EV owners of households living in apartment buildings is likely lower in general, as these buildings tend to be located in areas with public transportation, and with less parking space. Another reason could also be that the share of lower income households is higher in apartment buildings. In parallel, having a charging facility at work premises can also be an enabling factor for owning an EV.

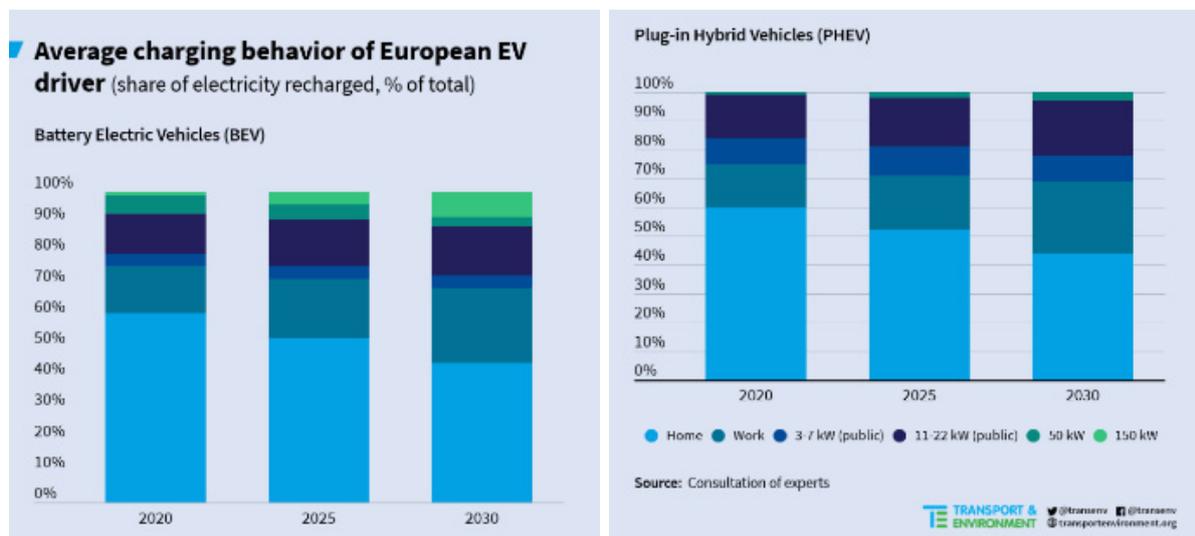


Figure 30 Distribution of the charging behaviour of European EV drivers

<sup>46</sup> Henriksen, I.M., Throndsen, W., Ryghaug, M. et al. Electric vehicle charging and end-user motivation for flexibility: a case study from Norway. *Energ Sustain Soc* 11, 44 (2021)

<sup>47</sup> Sarah LaMonaca, Lisa Ryan, The state of play in electric vehicle charging services – A review of infrastructure provision, players, and policies, *Renewable and Sustainable Energy Reviews*, Volume 154, 2022

**PRESS EMBARGO FOR ALL DATA**  
8.00am CET (7.00am GMT), 2 February 2022

**BATTERY ELECTRIC VEHICLES (BEV)<sup>1</sup>**  
EUROPEAN UNION + EFTA + UK

	Q4			Q1-Q4		
	Units		% change	Units		% change
	2021	2020	21/20	2021	2020	21/20
Austria	9,237	7,037	+31.3	33,380	15,986	+108.8
Belgium	7,381	5,683	+29.9	22,677	14,994	+51.2
Bulgaria <sup>2</sup>	129	60	+115.0	321	139	+130.9
Croatia	737	272	+171.0	1,475	533	+176.7
Cyprus	14	20	-30.0	82	42	+95.2
Czech Republic	840	1,534	-45.2	2,701	3,284	-17.8
Denmark	9,986	6,721	+48.6	25,000	14,275	+75.1
Estonia	121	131	-7.6	484	342	+41.5
Finland	3,730	1,563	+138.6	10,152	4,244	+139.2
France	55,222	40,540	+36.2	162,167	111,127	+45.9
Germany	119,368	95,862	+24.5	356,425	194,471	+83.3
Greece	687	387	+77.5	2,176	679	+220.5
Hungary	1,985	1,274	+55.8	4,312	3,046	+41.6
Ireland	827	400	+106.8	8,646	4,013	+115.4
Italy	20,205	14,979	+34.9	67,283	32,502	+107.0
Latvia	128	78	+64.1	425	307	+38.4
Lithuania	572	125	+357.6	1,155	453	+155.0
Luxembourg	1,557	992	+57.0	4,650	2,473	+88.0
Netherlands	34,232	44,150	-22.5	64,149	73,005	-12.1
Poland	3,068	1,510	+103.2	7,164	3,679	+94.7
Portugal	5,421	2,564	+111.4	13,260	7,830	+69.3
Romania	4,428	1,439	+207.7	6,342	2,845	+122.9
Slovakia	390	340	+14.7	1,105	918	+20.4
Slovenia	589	630	-6.5	1,722	1,647	+4.6
Spain	8,657	8,010	+8.1	23,690	17,927	+32.1
Sweden	20,087	11,674	+72.1	57,489	27,973	+105.5
<b>EUROPEAN UNION</b>	<b>309,598</b>	<b>247,975</b>	<b>+24.9</b>	<b>878,432</b>	<b>538,734</b>	<b>+63.1</b>
<b>EU14</b>	<b>296,597</b>	<b>240,562</b>	<b>+23.3</b>	<b>851,144</b>	<b>521,499</b>	<b>+63.2</b>
<b>EU12</b>	<b>13,001</b>	<b>7,413</b>	<b>+75.4</b>	<b>27,288</b>	<b>17,235</b>	<b>+58.3</b>
Iceland	1,202	603	+99.3	3,561	2,356	+51.1
Norway	33,193	28,626	+16.0	113,751	76,804	+48.1
Switzerland	7,768	8,345	-6.9	31,889	19,545	+63.2
<b>EFTA</b>	<b>42,163</b>	<b>37,574</b>	<b>+12.2</b>	<b>149,201</b>	<b>98,705</b>	<b>+51.2</b>
United Kingdom	65,586	41,594	+57.7	190,727	108,205	+76.3
<b>EU + EFTA + UK</b>	<b>417,347</b>	<b>327,143</b>	<b>+27.6</b>	<b>1,218,360</b>	<b>745,644</b>	<b>+63.4</b>
<b>EU14 + EFTA + UK</b>	<b>404,346</b>	<b>319,730</b>	<b>+26.5</b>	<b>1,191,072</b>	<b>728,409</b>	<b>+63.5</b>

SOURCE: NATIONAL AUTOMOBILE MANUFACTURERS' ASSOCIATIONS

<sup>1</sup> Includes fuel cell electric vehicles (FCEV)

<sup>2</sup> Estimates

**PRESS EMBARGO FOR ALL DATA**  
8.00am CET (7.00am GMT), 2 February 2022

**PLUG-IN HYBRID ELECTRIC VEHICLES (PHEV)<sup>1</sup>**  
EUROPEAN UNION + EFTA + UK

	Q4			Q1-Q4		
	Units		% change	Units		% change
	2021	2020	21/20	2021	2020	21/20
Austria	3,286	3,212	+2.3	14,626	7,641	+91.4
Belgium	10,490	14,215	-26.2	47,761	31,694	+50.7
Bulgaria <sup>2</sup>	21	12	+75.0	97	41	+136.6
Croatia	124	58	+113.8	399	143	+179.0
Cyprus	14	17	-17.6	97	83	+16.9
Czech Republic	864	792	+9.1	3,907	1,981	+97.2
Denmark	12,425	7,340	+69.3	40,478	18,243	+121.9
Estonia	27	25	+8.0	167	75	+122.7
Finland	4,157	3,634	+14.4	20,139	13,231	+52.2
France	39,175	34,305	+14.2	141,001	74,592	+89.0
Germany	84,385	94,587	-10.8	325,449	200,469	+62.3
Greece	1,475	862	+71.1	4,785	1,456	+228.6
Hungary	1,032	1,257	-17.9	4,236	2,996	+41.4
Ireland	439	153	+186.9	7,891	2,492	+216.7
Italy	17,029	14,969	+13.8	70,472	27,407	+157.1
Latvia	46	16	+187.5	144	73	+97.3
Lithuania	0	0		0	0	
Luxembourg	964	1,176	-18.0	4,443	2,685	+65.5
Netherlands	7,590	4,845	+56.7	31,016	14,891	+108.3
Poland	2,538	2,107	+20.5	9,269	4,505	+105.7
Portugal	4,086	4,985	-18.0	15,660	11,867	+32.0
Romania <sup>2</sup>	908	480	+89.2	2,630	1,036	+153.9
Slovakia	336	333	+0.9	1,166	863	+35.1
Slovenia	51	34	+50.0	191	39	+389.7
Spain	13,420	12,048	+11.4	43,226	23,309	+85.4
Sweden	18,241	25,845	-29.4	77,842	66,105	+17.8
<b>EUROPEAN UNION</b>	<b>223,123</b>	<b>227,307</b>	<b>-1.8</b>	<b>867,092</b>	<b>507,917</b>	<b>+70.7</b>
<b>EU14</b>	<b>217,162</b>	<b>222,176</b>	<b>-2.3</b>	<b>844,789</b>	<b>496,082</b>	<b>+70.3</b>
<b>EU12</b>	<b>5,961</b>	<b>5,131</b>	<b>+16.2</b>	<b>22,303</b>	<b>11,835</b>	<b>+88.4</b>
Iceland	1,093	625	+74.9	3,420	1,859	+84.0
Norway	9,585	9,547	+0.4	38,166	28,909	+32.0
Switzerland	5,993	6,400	-6.4	21,790	14,429	+51.0
<b>EFTA</b>	<b>16,671</b>	<b>16,572</b>	<b>+0.6</b>	<b>63,376</b>	<b>45,197</b>	<b>+40.2</b>
United Kingdom	27,514	24,651	+11.6	114,554	67,134	+70.6
<b>EU + EFTA + UK</b>	<b>267,308</b>	<b>268,530</b>	<b>-0.5</b>	<b>1,045,022</b>	<b>620,248</b>	<b>+68.5</b>
<b>EU14 + EFTA + UK</b>	<b>261,347</b>	<b>263,399</b>	<b>-0.8</b>	<b>1,022,719</b>	<b>608,413</b>	<b>+68.1</b>

SOURCE: NATIONAL AUTOMOBILE MANUFACTURERS' ASSOCIATIONS

<sup>1</sup> Includes extended-range electric vehicle (EREV)

<sup>2</sup> Estimates

Figure 31 Share of EV and PHV in the EU<sup>48</sup>

### 2.5.2.2 Trends

Home solutions are currently representing the vast majority of EV charging in Europe (Transport & Environment, 2018), mostly due to lower electricity costs and the high number of hours during which cars remain parked. It is expected that the share of public EV charging in EU countries will increase from 5%–28% in 2020 to 47%–59% in 2030, depending on the scenario, meaning that the around 75% owners of EV that now charge their cars at home or at work will fall to around 60%. In the next decades, an increased deployment of EVs in middle- and lower income households without home-charging options, especially in urban environments, will likely require a significant public charging infrastructure. According to ACEA (European Electric Vehicle Charging Infrastructure Masterplan, 2022) up to 6.8 million public charging points are required to reach the 55% emission reduction target. However, this is still a large number of citizens depending solely on the home chargers or topping up or charging while at work (24% share projected for 2030). Therefore, it is important to take into consideration that the demand profiles are changing, that there is a huge need for smart charging and other technologies assisting grid flexibility. This will be particularly important for household charging in countries with a very high share of detached and semi-detached housing.

Moreover, the current amended EPBD as of 2018 (Article 8) requires Member States to set legislations for non-residential buildings with more than twenty parking spaces (threshold down to ten spaces for new buildings or in case of major renovations) to include recharging points that new non-residential buildings.

The same applies to new residential buildings and residential buildings undergoing major renovation, with more than ten parking spaces. Which will likely support the trend that the largest share of charging is done either at home or at work.

The current EPBD proposal foresees also pre-cabling targets and more ambitious charging points installation targets for most of new buildings and buildings undergoing renovation. A clear definition of pre-cabling is needed to effectively guarantee the possibility to install a charging point when needed. On the other hand, though the withdrawal of existing barriers – such as complex permitting procedures and the need to obtain the consent from the landlord or co-owners for the installation of a private charging point (right to plug) – can play a positive role, additional measures should be implemented by Member States to ensure the right to plug in existing residential buildings. Those are not covered by the EPBD proposal, which is critical, particularly for multi dwelling units.

Furthermore, the Directive should include provisions for the charging of heavy-duty vehicles. Those are most conveniently charged with minimal interferences to their schedule, when stationary during their normal operating patterns – i.e. during loading and unloading at logistics hubs and distribution centers, or while parked at private truck depots at night. Therefore, the future EPBD should cover new or renovated private truck depots, as well as logistic hubs and distribution centers, requiring them to be ready for battery electric truck charging. This should include both pre-equip-

<sup>48</sup> European Automobile Manufacturers' Association report

<sup>49</sup> Giacomo Falchetta, Michel Noussan Electric vehicle charging network in Europe: An accessibility and deployment trends analysis, Transportation Research Part D 94 (2021)

<sup>50</sup> Noussan, Michel and Neirotti, Francesco, (2020), Cross-Country Comparison of Hourly Electricity Mixes for EV Charging Profiles, Energies, 13, issue 10, p. 1-14, 2020

ment and proper grid connection. Finally, the definition of “zero-emission buildings” currently does not allow for these buildings to cover their low residual energy requirements from distributed sources of flexibility such as electric vehicles. This possibility should be explicitly included.

All this also requires the internal cabling of houses and buildings to be adequate to manage the power peaks related both to EV charging and to smart solutions and heat pumps. According to the presentation from prof. Angelo Baggini from University of Bergamo “Are EU homes ready for full electrification?” (February 2022), there is an issue with the adequate capacity and readiness of residential buildings to accommodate the electrification process without proper retro-

fit, to be obtained through a mix of technical standards, proper design, and qualification of operators. An aspect usually not considered in the evaluations of EV charging is that the AC charger is in the vehicle (“AC charging infrastructures are only adapters, communicating with the vehicle and eventually with the grid and with safety features) and its efficiency decrease at lower power. Each vehicle has different efficiency at full and partial load (this data isn't disclosed by the vehicle manufacturer and could be very difficult to measure, requiring disassembling – in many cases deeply – the vehicle). Thus it may happen that at very low power it could be more convenient to stop the charging, which usually isn't a viable solution since there is the possibility that some vehicles won't restart without unplugging and plugging again.

### 2.5.2.3 Italy

According to the EC's European Alternative Fuels Observatory\*, by the end of 2021 in Italy there were around 237,000 EVs and 24,000 public recharging points, which doesn't compare unfavourably with other EU Member States\*\*. Among the aspects to improve in Italy there is the need to better distribute the charging points outside the largest cities and in particular over the highways, in order to favour the diffusion of EVs across small cities and towns and the usage of EVs outside cities for medium and long journeys.

## Smart Technologies in Buildings: EV charging stations

**Energy Efficiency Performance:** EV chargers are an integral part of EV G2V drivetrain efficiency. The G2V efficiency for EVs should be close to 45–50%.

Installed Volume in the EU: The number of electric vehicles per charging station has increased from 2 in 2010 to 11 in 2020. In other words, 11 cars need to share one publicly available charging station (Intertraffic, 2021). Today, there are 374,000 public charging points in Europe (EY & Eurelectric, 2022), with around 2,400,000 to 4,000,000 in residences (based on calculations from multiple studies).

**Volumes to be added by 2025 and 2030:** Europe's EV fleet will grow from its current base of less than 5 million to 65 million by 2030 and then double over the following five years. The EU will need 65 million chargers to fuel these cars, trucks, and buses, with 85% of plugs installed at homes, while 56 million of these would pertain to residential units (EY & Eurelectric, 2022). It is expected that the share of public EV charging in EU countries will increase from 5%–28% in 2020 to 47%–59% in 2030, de-

\* <https://alternative-fuels-observatory.ec.europa.eu>

\*\* See for example MotusE's article: <https://www.motus-e.org/news/la-ricarica-pubblica/>

pending on the scenario, meaning that the around 75% owners of EV that now charge their cars at home or at work will fall to around 60%.<sup>43</sup>

**Potential Savings:** The use of EVs instead of gasoline vehicles can save (about 60% of) GHG in all or in most of the EU MSs, depending on the estimated consumption of EVs (Moro & Lonza, 2018).

## 2.5.3 Building automation and the electronic monitoring of technical building systems (BACS)

### 2.5.3.1 Current state

BACS is a cost-efficient solution that can reduce thermal and electrical energy consumption. Of course, this highly depends on the current situation and the implemented solution. According to the BACS providers, BACS can reduce thermal and electrical energy consumption up to 26% in educational institutions and hospitals, 27% in residential buildings, 41% in hotels and restaurants, 49% in wholesale and retail buildings and 52% in offices and lecture halls. In practice, the energy savings rate depends on the type of end-use controlled, the type of buildings (e.g., offices, hospitals, etc.), and what was the situation before BACS were installed. An example of differentiated values can be found in the data used to set the deemed savings for BACS in the French white certificates scheme. These estimates range from 2% savings rate in lighting in retail up to 54% for space heating in offices when A-class BACS are used while there was no energy management before (i.e., to D-class BACS)<sup>52</sup>.

The purpose of BACS includes, in residential buildings, room temperature controls. Without it, consumers know how much they are spending, but remain largely un-

able to take effective action. This can have a huge impact on fighting energy poverty. In commercial buildings, BACS monitoring, and automation functions help staff to maintain availability, lower consumption and run a building against budgets / measures taken. BACS improves the indoor environment quality, with positive impacts on health, well-being, comfort, and productivity. The advantage of BACS is its price, from 12EUR/m<sup>2</sup> in commercial sector to around 30EUR/m<sup>2</sup> in households, for the whole installation and other expenses. This means that the investments return in average in 3 years. Calculated savings for the building stock would be huge, and the investments would be in line of 6 billion EUR, as compared to much higher cost for import of energy. BACS can also contribute to the deployment of renewables, by increasing the flexibility of buildings' energy demand. And more specifically about the development of on-site RES, BACS can facilitate their integration with the grid, and optimise the use of on-site for own consumption or to supply the grid. Therefore, the benefits BACS lie not only in energy savings but also in flexibility and support to RES deployment<sup>53</sup>.

Another feature that can be added to BACS,

<sup>51</sup> The New Dimension of Energy-Efficient Homes and Buildings, eu.bac, 2021

<sup>52</sup> See presentation by Hadrien Serougne (ADEME) at the streamSAVE dialogue meeting of 9 November 2021 (from slide 24): <https://streamsava.flexx.camp/support-contribution-313>

<sup>54</sup> [https://ee-ip.org/fileadmin/user\\_upload/DOCUMENTS/Content/Building\\_Automation.pdf](https://ee-ip.org/fileadmin/user_upload/DOCUMENTS/Content/Building_Automation.pdf)

usually with a limited additional investment or provided by separate systems, is limiting the maximum electrical power absorbed from the grid by switching or modulating large electricity users (EV charging, hot water heater, air conditioner, kitchen appliances) or minimizing the costs, shifting some consumptions to cheaper time bands or following in real time the energy price, considering also – if present – the on-site electric production and/or storage. Systems limiting the peak power absorption could be particularly interesting in Italy due to limited available power of the standard contracts for residential users and consequently could enable a higher electrification without raising the contract power or

where there are power constraints. In Italy the smart meters (all low voltage meters, thus usually up to 100 kW) can send data to the users via powerline, thus theoretically simplifying the integration. There are standalone receiving devices of the size of a cell phone charger that can communicate via wireless protocols with other system, show the real-time consumption and activate a buzzer over a certain threshold. These receivers aren't much diffused also because the powerline communication of the meter is activated only via authorised service provider, which usually offers the adaptor and the activation only together other services at a monthly fee, making it not particularly interesting for many users.

### 2.5.3.2 Trends

As the market forecast shows, the BACS market is expected to grow with CAGR of 10.52%<sup>54</sup>. There is a rise in demand in commercial building services interoperability and communication protocols. The amended EPBD as of 2018 includes provisions in Articles 14(4) and 15(4) to require the installation of BACS by 2025 in non-residential buildings with an effective rated output for heating or cooling systems over 290 kW. Which should support the trend, with a market likely led by installations of BACS in large buildings. The problem with the deployment includes also the Covid-19 pandemic which has stalled the activities in construction sector, but the expected source of recovery is the European funding for the purpose.

### 2.5.3.3 Italy

Italian residential utilities are poorly electrified and flexible loads are low.

## Smart Technologies in Buildings: BACS

**Energy Efficiency Performance:** According to the BACS providers, BACS can reduce thermal and electrical energy consumption up to 26% in educational institutions and hospitals, 27% in residential buildings, 41% in hotels and restaurants, 49% in wholesale and retail buildings and 52% in offices and lecture halls.<sup>46</sup>

Volumes to be added by 2025 and 2030: The amended EPBD as of 2018 requires the installation of BACS in non-residential buildings with an effective rated output for heating or cooling systems over 290 kW by 2025.<sup>48</sup>

**Potential Savings:** Annual energy savings up to 20.3% of all EU service sector building energy consumption or 49.7 Mtoe and up to 23.4% or 98.1 Mtoe for EU residential building energy consumption (eubac.org).

## 2.5.4 The point of view of some stakeholders

According to independent organisation, all around Europe development of charging at home and workplace is happening, but not in adequate pace. When looking at charging at workplace, the main barrier is that many parking spaces are not provided with chargers while for buildings chargers are not the priority. The market for chargers is demand driven (aligned with e-vehicles). The most important transformation to lead to the massive implementation of these technologies is integrating the solar inverter and the charger into one system, lowering costs, and making easier to use solar DC power to charge the vehicle and bi-directionality between vehicle and grid with cars becoming energy storage (integrated component approach).

There is also support at the level of regulation, such as testing for night charging without increased power for electric mobility, which inevitably generates impacts on the networks but makes it more attractive for citizens, avoiding the burdens for increased power.

Regarding to BACS, some stakeholders consider them as a fundamental tool to move towards safer and more efficient buildings especially because home automation systems allow the automated and decentralized management of house parameters (e.g. automatic temperature adjustment). Many stakeholders agree that smart automation systems are to be simple to use and capable to provide demand side response services, possibly with the capability to adapt whether or not people want to configure it depending on their competences. Moreover, stakeholder underline influence of end user age. With young people innovation is interpreted as a lifestyle so home automation is not an added value but a way of expressing and relating to others.

From a survey for energy manager implemented by FIRE, it emerged that the majority of Italian energy managers consider energy management automation systems as the most important aspect in the process of electrification besides space heating.

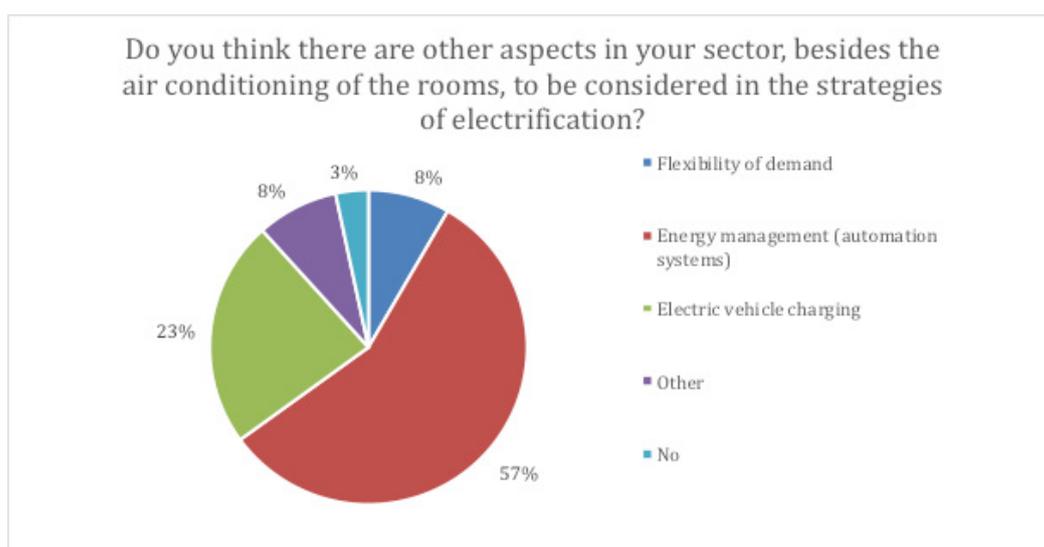


Figure 32. Interest of Italian energy managers towards some electrification technologies. Source: FIRE.

<sup>54</sup> Europe Building Automation Systems Market - Growth, Trends, Covid-19 Impact, and Forecasts (2022 - 2027), Mordor Intelligence

## 2.6 Other observable trends on the electricity market

Although not as relevant when considering the electrification of the market, since the following technologies are already mostly electrified, it is worth considering another sector which presents an increasing electricity demand: tumble dryers.

### 2.6.1 Tumble dryers

Household tumble drier means an appliance in which textiles are dried by tumbling in a rotating drum through which heated air is passed and which is designed to be used principally for non-professional purposes. According to the European Commission's review study on households tumble driers, driers can be divided into the following categories:

- **Electric tumble drier:** the drier generally uses a coiled wire heated with electric current. The amount of electric current is varied to adjust the temperature.
- **Gas tumble drier:** a gas burner is used to heat the air. The air temperature can be altered by adjusting the size of the gas flame or, more commonly, by merely extinguishing and relighting it.
- **Air condenser drier:** the ambient room air is used as a heat sink. It is blown across the outside of the heat exchanger to cool and dehumidify the warm air used for the drying process. This is the most common type of condenser drier in the market at the time of writing.
- **Water condenser drier:** water is used to cool the warm air and condense the moisture. At the time of the preparatory study there was no tumble drier on the market using this technology, but for washer-driers this technology was prevalent.
- **Heat pump condenser drier:** the heating and condensing is performed by the hot and cold plates of a heat pump.

The total sales increased on average 1.6% per year from 2007 to 2016, but given the otherwise quite stable sales over the years, it is assumed that this sales growth rate will decrease towards 0% per year in 2030. Assumptions were made for the continued development of the market shares for 2025 and 2030 based on the trends seen in the market until now, with linear interpolation of market shares in the years between<sup>56</sup>.

Sales million units		1990	1995	2000	2005	2010	2015	2020	2025	2030
Condenser	Heat pump	-	-	-	-	0.34	2.22	3.05	3.60	4.46
	Heat element	3.55	3.55	3.44	2.38	2.54	1.78	1.68	1.55	1.11
Air vented	Heat element	0.14	0.14	1.06	1.66	1.11	0.75	0.59	0.39	-
	Gas-fired	0.001	0.001	0.001	0.001	0.001	0.000	0.001	-	-
<b>Total</b>		<b>3.70</b>	<b>3.70</b>	<b>4.50</b>	<b>4.04</b>	<b>3.99</b>	<b>4.74</b>	<b>5.32</b>	<b>5.53</b>	<b>5.57</b>

Table 6 - Derived tumble drier sales from 1990 to 2030 (source DG ENERGY)

## 2.6.2 The point of view of some stakeholders

Some stakeholders confirm that household appliances like tumble dryers have very small loads compared to HPs and electric vehicle recharging so there is the need for the automation systems of these technologies to be smart because they have a huge impact on the grid if they're not managed well.

## 3. Analysis of barriers to electrification

This chapter illustrates the main barriers that hamper the electrification of energy consumptions in the building sector. Five barriers, considered of relevance, are investigated in detail. The point of view of a group of relevant stakeholders offers interesting insights.

### 3.1 The barriers to the electrification of energy consumptions in buildings

Europe's power system is evolving rapidly. According to ENTSO-E study on System Needs<sup>57</sup>, action is needed by 2040 to ensure continuous access to electricity throughout Europe. In addition to the 35 GW of cross-border transmission capacity reinforcement, by 2030 and 2040 it would be necessary a further upgrading of the lines for 50 and 43 GW respectively, also thanks to the increasing in Renewable Energy Sources (RES). Focusing on the Italian scenario, in the next two years, RES will account for around 48% of the total electricity supply, rising to over 85% in 2050. This change will foster the process of electrification, which will reach significant percentages in various sectors over the next thirty years: from industry (42%) to transport (41%) and residential (53%)<sup>58</sup>.

Heat transition<sup>59</sup> is crucial for achieving the EU climate targets. Nevertheless, there is a broad consensus that none of the available technologies will dominate in the coming decades as much as the gas boilers do today. Thus, there is a need to develop a range of reliable technologies to be able to sufficiently fit for a wide range of building types, consumers, climatic conditions, local potentials, and constraints. Unlike the power sector, where decarbonised technologies are commercially available at a large scale, decarbonisation pathways in the residential heat sector<sup>60</sup> requires a breakthrough in some of the existing technologies, namely strong improvements in the application of heat pumps. Some research suggests that the current market, technology, and power system have the capacity to accommodate further uptake of heat pumps, sufficient to cover up to 32% of space-heating demand of EU buildings. However, it is estimated that electrification of the residential heating, mostly through air and ground source heat pumps, could potentially cover up to 90% of the heat demand in buildings (after energy efficiency improvements aimed at reducing buildings' energy demand). Achieving this goal would require the deployment of around 100 million heat pumps for buildings or city districts across Europe. Some countries, e.g., UK, Germany and Sweden, have already started relying on heat pumps in their heat roadmaps. However, the accomplishment of the heat pumps' mission requires fundamental developments in the power and construction sectors in parallel.

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<sup>55</sup> [https://www.applia-europe.eu/images/Library/Review\\_study\\_on\\_tumble\\_dryers\\_06-2019.pdf](https://www.applia-europe.eu/images/Library/Review_study_on_tumble_dryers_06-2019.pdf)

<sup>56</sup> [https://www.applia-europe.eu/images/Library/Review\\_study\\_on\\_tumble\\_dryers\\_06-2019.pdf](https://www.applia-europe.eu/images/Library/Review_study_on_tumble_dryers_06-2019.pdf)

The evidence based on available technologies demonstrates that heat pumps will cost more to run and release higher carbon emissions in less-insulated properties. Therefore, the building stock needs to be upgraded in terms of physical characteristics and usage to unleash the full potential of HPs. Furthermore, some changes in heating systems' configuration are required, e.g. fitting larger radiators or radiant floors, setting lower flow set points, and using smart controllers, each of which imposes considerable up-front costs<sup>61</sup>. This causes difficulties to people without enough capital or renters who do not have the required authority.

In addition and/or as alternative to the building envelope's improvements, the development of new high-temperature heat pumps for buildings without upgrading capability is required to serve the market needs. To this end, new promising technologies are under development and could play an interesting role in the future, together with the continu-

ous improvements applied to existing high temperature heat pumps.

Also building automation and infrastructures for the recharge of electric vehicles face technological barriers. BACS profited in the last decade by a continuous reduction of prices and, above that, by the diffusion of reliable wireless connections. Also, communication protocols have evolved. That has allowed for a simpler installation of these devices and for an improved possibility to connect various utilities. Recharge systems are more recent and need control and automation systems capable of connecting them with building electric facilities, to allow an optimal control of energy flows over the day.

Barriers to electrification can be economic or non-economic. The latter can be classified into technical, behavioural, informational, and regulatory ones. The following table summarizes the identified barriers that will be described in the next paragraphs.

<b>Barrier</b>	<b>Classification</b>
Poor economic indicators	Economic
Lack of access to finance	Economic
Split incentives dilemma	Economic/Informational
Inadequate capacity of the electric grid	Technical
Lack of users' expertise	Informational
Users' attitudes and habits	Behavioural
Risk of performance gaps and qualification of market operators	Technical/informational
Challenges in integration and complexity	Technical
Lack of awareness in public sector	Regulatory/informational
Heavy bureaucracy on RES installation	Regulatory
Tariff's barrier	Regulatory

<sup>57</sup> ENTSO-E, Completing the map. Power system needs in 2030 and 2040: <https://eepublicdownloads.blob.core.windows.net/public-cdn-container/tyndp-documents/TYNDP2020/Foropinion/lo5N2020MainReport.pdf>

<sup>58</sup> Enel, Studio Electrify Italy: la transizione energetica favorisce risparmi sulle bollette e sulle spese sanitarie: <https://corporate.enel.it/it/media/press/d/2020/12/studio-electrify-italy-la-transizione-energetica-favorisce-risparmi-sulle-bollette-e-sulle-spesse-sanitarie>

<sup>59</sup> IWES/IBP, Heat Transition 2030.

<sup>60</sup> Howard, et al., Too Hot to Handle? How to decarbonise domestic heating.

<sup>61</sup> Frerk, et al., Heat Decarbonisation: potential impact on social equity and fuel poverty.

A list of economic and non-economic barriers is reported in the following chapters. To reach the 2030 and 2050 targets, putting efficient technologies on the market is not enough but the whole related supply chain needs to be properly developed too. Non-economic barriers are sometimes referred to as "intangible costs" in literature.

### 3.1.1 Poor economic indicators for interventions in buildings

Electrification interventions in the building sector (e.g., insulation + heat pump) have often long payback time, beyond the threshold that can be considered acceptable by a potential investor. This is caused by the low energy savings value/CAPEX ratio of these technologies. This is a major barrier as many investors (especially households) tend to focus on the investment cost. The need to consider the analysis over many years (due to both, the long payback time and the long lifetime of the actions) makes it difficult for many investors to assess properly the lifecycle cost. The current situation reminds how difficult it can be to handle uncertainties in energy prices for example.

Acting on the ratio between cost and benefits by helping technology producers to reduce the cost of their technologies through research and development support programmes can improve the first item. Taxation measures (either energy or carbon taxes) can then provide a price signal for fuel switching, by increasing the gain on operation cost. The price of electricity paid for using the technologies included in this study can also be part of this barrier, especially if the tariff structure penalises the in-

crease in electricity consumption (globally or in the time slots where technologies like heat pumps are supposed to operate), given its impact on the operative cash flows of such investments. This is discussed in the chapter dedicated to the tariff's barrier.

On the other side, including whenever possible a quantification of multiple benefits (e.g., comfort and sanitary conditions, green value of buildings) in the analysis can strengthen the economics. These are benefits occurring after an energy efficiency intervention that are not strictly related to energy saving.

There is also the possibility of informing end-users about the correct ways to evaluate investments, based on economic indicators such as NPV, IRR, and pay-back period. Standards like EN 17463, EN 15459, and ISO 50044 offers guidance for enterprises and public bodies on how to correctly evaluate energy investments.

Almost all electrification solutions can face this economic barrier. The more the CAPEX, the higher the perceived barrier, even with positive economic indicators.

In Italy, the typical mild Mediterranean climate makes energy savings lower than in northern EU countries for the heating service. That means this barrier is even higher. On the other hand, the same climate implies that there is more demand for the cooling service in the warm seasons. Technologies like heat pumps capable of answering both needs efficiently can help in overcoming this barrier, provided the existing distribution system is able to deliver both, heating and cooling.

### 3.1.2 Lack of access to finance

Renovations are often resource-intensive, both in terms of financing and time. Few building owners can have the capacity to finance fully on their own the investment needed. While high income households can easily access credit, this can be much more difficult for low income (and even sometimes medium income) households. The issue also exists with elderly people, even if high income, because they prefer to use money for more important aspects of life (e.g. health, comfort, children and grandchildren, etc.).

This issue is stressed since low-income users are often the category most in need of energy efficiency, at least to alleviate their energy costs and to increase the comfort of their homes. In its Recommendation on Energy Poverty released in October 2020, the European Commission reported that nearly 34 million Europeans are unable to afford to keep their homes adequately warm. When other aspects of energy poverty are considered, most significantly the inability to keep the home adequately cool, the number of people at risk can be as high as 125 million – one in four European households.

Moreover, energy renovation projects are rarely considered profitable by financing institutions: from their viewpoint, these remain small and scattered projects, and more difficult to assess compared to typical purchase (e.g., vehicle). Several Member States have thus struggled to get banks or other financial institutions involved in their financial schemes for en-

ergy efficiency (e.g., France with its 0%-rate loan). At the opposite, the KfW programmes in Germany are a well-known example of success in involving commercial banks, thanks to a favourable refinancing concept.

This explains why financial incentives are sometimes weak, either because the incentive offered is not enough to make the investment attractive to the end-user (e.g., when the remaining cost to them is still too high vs. their financing capacities), or because the banks or financial institutions did not promote, or even were reluctant to offer, the financing solutions promoted by public authorities. Moreover, external risks such as price volatility cause people to lack the motivation. Therefore, it is important to provide a clear framework of the cost and saving for citizens, companies, and local authorities to encourage to be themselves part of the energy transition.

Another financing issue is that most banks and financial institutions do not acknowledge the guarantee that an energy efficiency investment brings by itself. Unlike typical purchases of goods, an energy efficiency investment will generate monetary savings that can help reimburse the investment. This is very rarely considered by banks when they assess creditworthiness and set interest rates for these investments, even in case of EPC (energy performance contracts), despite the included performance guarantees. They do not make a difference with, for example, creditworthiness and in-

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<sup>62</sup> NPV: net present value, indicates the actual value of an investment summing up all revenues and cost over its lifetime, discounted to WACC (weighted average cost of capital) or other discount rates. IRR: internal rate of return, indicates the return of the investment assuming all earnings are invested at the same rate of return. Pay-back period, or pay-back time, is the time needed to recover the investment, without discounting its cash flows.

terest rate for renovating a kitchen. This is particularly problematic for energy efficiency projects with high investments and long payback time.

With public buildings, an issue can be the constraints on public expense and public debt, that reduce the possibility to add investments to the balance sheet. To overcome such problem, it is possible to act in accordance with the Eurostat's guidelines on PPP (public-private partnerships) and EPC that define the conditions under which investment in building retrofits can be done off-balance (i.e. basically risks and opportunities shall be passed through ESCOs and other suppliers implementing the interventions)<sup>63</sup>.

Alternative instruments such as green

bonds, minibonds, financial guarantees, green or energy efficiency mortgage, pay-as-you-save or on-bill financing, and crowd financing are spreading. The green bond market is developing, particularly in low-consumption buildings and energy efficiency sectors. This kind of bond's emission is related to projects that have a positive impact on the environment, such as energy efficiency, the production of energy from clean sources, the sustainable use of land, etc. Green bonds allow to finance many kind of projects with an environmental sustainability imprinting. Overall, bonds were issued up to the end of 2020 for over 1,000 billion dollars (about 19 billion dollars in Italy). The issuance of green sovereign bonds reached over 80 billion dollars in 2020 (source S&P global Ratings).

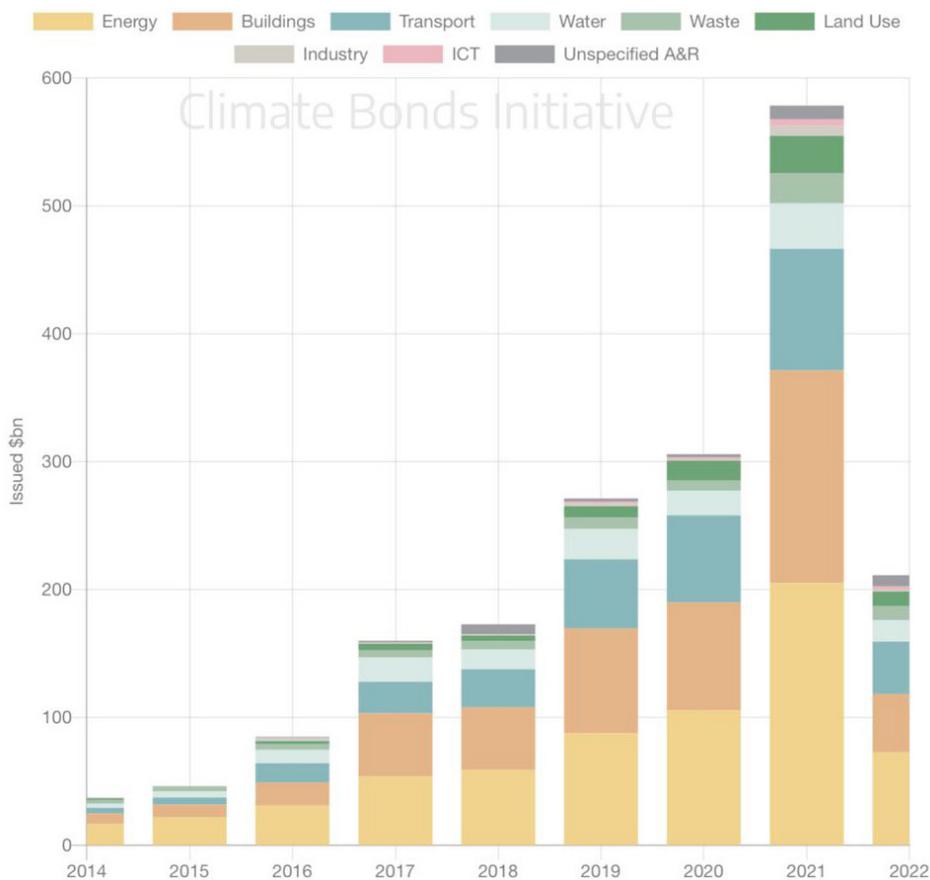


Figure 33. Green bond's emission during the years shared by sector

<sup>63</sup>The guidelines on the statistical treatment of EPC and PPP are available at <https://ec.europa.eu/eurostat/web/government-finance-statistics/methodology/guidance-on-accounting-rules>.

In the framework of the European Green Deal, a Just Transition mechanism has been also introduced to help European fossil-fuel dependent regions to switch to a greener economy. The fund supports economic reconversion of territories, in terms of transformation of existing carbon intensive installations and clean energy. The fund will be accessible until 2027, with a total budget 2021-2027 of 19.32 billion euros.

Moreover, carbon revenues, that are generated when a price is put on carbon, can fund

efficiency programmes that deliver benefits to consumers. Actually, the main system for pricing carbon in Europe is the Emission Trading System (ETS), which has recently been reformed increasing the price for carbon allowances fourfold compared to 2017. As a result, the revenue received by European Member States is also rising rapidly and is projected to total 165 billion euros over the next 10 years. Member States now can direct as much as 10 billion euros more towards climate solutions per year and a big fraction of this should be spent on energy efficiency (source RAP).

In 2021 Italy issued the first green bonds, whose issue is linked to projects that have a positive impact on the environment, such as energy efficiency, production of energy from clean sources, etc. Green bonds allow to finance different kind of projects characterized by environmental or energy sustainability. However, creditworthiness is still a key parameter in the evaluation of projects. The superbonus policy, introducing both a 110% tax credit and the possibility to transfer the credit either to a bank or to the company performing the intervention, created a new dimension for the financial market for building renovation. However that is true only for renovations that meet the eligibility criteria of the policy. Besides, large frauds affected the credit transfer possibility (paradoxically mainly for interventions falling other the traditional tax credit at 50% and 65%) and the policy measures issued to counteract this negatively affected the financial market in 2022.

### 3.1.3 Split-incentives problem

Electrifying a building stock often requires a deep renovation. The distribution of costs and benefits deriving from energy efficiency interventions among the different stakeholders is often an issue, especially for rented facilities. The same applies for heat pumps that have a higher investment cost (for the owner) and a lower operation cost (for the occupant).

Contract models that allow a fair sharing of interventions' costs and benefits among the parties should be introduced to mitigate this barrier. A legislative option that can help is to have programs like PACE that link the repayment of a 100% financing to the property tax. Another legislative option is to allow owners to increase the rent by an amount smaller than the energy savings expected for the occupant. This approach has developed in social housing<sup>64</sup>.

<sup>64</sup> See for example in Italy, the LEMON project that promoted Energy Performance Contracts complemented with 'Energy Performance Tenancy Agreement' (agreement between the social housing body and tenants about an increase in the rent for a limited period of time, this increase being lower than the energy savings): <http://www.lemon-project.eu/>.

In Italy the large spread of apartment buildings makes this barrier more relevant, being a plurality of residential units in the same building. Both for family apartments and commercial buildings the main solution is to promote rental contracts that allow for sharing both the CAPEX and the benefits of the building retrofit between the landlord and the tenant.

### 3.1.4 Evolution of electric grid capacity

The existing European electric grid infrastructure will be the enabler of electrification trends. This infrastructure was designed half a century ago to satisfy national electricity needs, which were largely based on fossil and nuclear generating plants, usually located near important load areas. In the last decade the development of distributed generation and the diffusion of non-programmable power sources like solar and wind changed the usage and the requirements of the grids. More recently the diffusion of new electric energy services, like air conditioning, and the electrification of traditional energy services, like heating, cooking, and transport, is going to introduce additional modifications. Moreover, many manufacturers characterised by a traditional stable load (e.g. ferro-alloy) have de-localised their production and gone from Europe.

Consequently, due to the advent of new technologies it seems clear the necessity to digitalize and modernize both the distribution and the transport grids. Distribution grid at low voltage will undergo the main transformation. Distributed generation will be part of the solution to grid problems because it will make the distribution grid at low voltage capable to man-

age the higher demand due to the massive residential electrification.

Regulatory frameworks need to evolve in order to guarantee a continuous bi-directional dialogue with end users. This task could be accomplished if the regulatory framework will establish a price system to penalize peak loads and reward constant consumption. Regulation should stimulate distribution system operators to offer training courses and technical support for end users and to maintain a continuous integration with gas distribution system operators, if they are two different actors. Changing and training end user habits will be a key component so specific policies in this direction and information campaigns will be helpful.

The electrification of the heat supply<sup>65</sup> in the buildings sector has cross-sectoral implications as it results in additional electricity demand. The current power systems are designed for non-contemporary loads and to deal with peaks. Electrification in buildings sector need to lower peaks and have a more constant load; this transformation will make residential power curve closer to the industrial one and it's a process pushing against the original electric system design. Electri-

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<sup>65</sup> Thomassen, et. AL, The decarbonisation of the EU heating sector through electrification: A parametric analysis.

fication of usages and distributed generation and storage will affect both electrical energy consumption and electrical power required by each single residential user. To make EU building stock ready for massive electrification it will be crucial also an efficient design of electrical installation to reduce energy losses and guidelines for the design of electrical installations anticipating future needs and to assess readiness of current installations. Moreover, qualified professionals for design, installation and control and inspections of existing installations will be other decisive aspects<sup>66</sup>.

Therefore, it is essential to anticipate demand peaks by designing electrification pathways for the heating sector, which are accompanied by the necessary investments in the power sector.

The seasonal profile of the heat demand<sup>67</sup> leads to large increases of electricity demand along half of the year, especially in winter. Demand-side flexibility could reduce this number of hours, spreading out the peak demand more evenly.

Throughout the period from April to October, when energy demand is undergoing photovoltaic production<sup>68</sup>, batteries should ensure the flexibility of the availability of electricity from renewable sources, both on a daily and weekly basis. For the winter period it is necessary to consider that photovoltaic production is 40% of the summer production so the main issue will be searching for a way to store some energy during summer in order to use it during winter (seasonal storage). This task could be accomplished by Power-to-X (P2X) conversion technologies that are designed to convert surplus electric power to other forms of energy for storage and reconversion. There are many possible P2X technologies: it seems useful talk about P-to-hydrogen. Surplus electric power from summer PV production can be used to produce hydrogen by electrolysis of water and during winter hydrogen can be converted to methane via methanation reaction (using carbon dioxide and hydrogen to produce methane and water). Obviously, this solution has its barriers to overcome (difficult hydrogen storage and maintenance in residential spaces) but seasonal storage will be indispensable to reach the optimal performance of the grid and to reduce the use of thermoelectric power<sup>69</sup>.

In winter period photovoltaic production is reduced and it is necessary to exploit wind power. In Italy a limited wind development is expected, with offshore proposals that will have strong delays and will be located in the south of the country, away from buildings. Existing Italian wind farms (mainly located in South regions like Puglia and Campania) should be repowered replacing the old turbines by more powerful and efficient models that use the latest technology.

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<sup>66</sup> Baggini, et al., Are EU homes ready for full electrification?

<sup>67</sup> Felten, et al., The value(s) of flexible heat pumps – assessment of technical and economic conditions.

<sup>68</sup> Felte, et al., Photovoltaics and heat pumps – limitation of local pricing mechanisms.

<sup>69</sup> Felte, et al., Photovoltaics and heat pumps – limitation of local pricing mechanisms.

With respect to the demand side, the heat pumps impact on the hourly load will depend on many factors, like:

- The higher the insulation of the building, the less electric power will be absorbed by the grid and the flatter the load diagram can be, since the building can retain the generated heat much longer, allowing for a reduction of the peaks<sup>70</sup>. This can suggest pushing for a "fabric first" approach in policies, aimed at coupling the renovation of the building envelope with the adoption of heat pumps.
- End-users' behaviour can affect both load peaks dimension and temporal shift, that can be addressed either technologically through automation systems capable of optimizing the heat pumps working cycle, or regulatorily, for example through adequate tariffs structure promoting a usage less impacting on the grid.
- The adoption of different temperatures at homes – and eventually in buildings – according to the usage of different rooms and spaces could also affect the hourly electric load, both in terms of efficiency and peak control.

In Italy there are both national issues – like the installation of large power capacity from RES far from the end-users, with the consequent need to build new transmission capacity across different zones – and local ones, with the need to adjust the distribution grid in cities. The need to go over the 3 kW threshold in many houses or apartments with the adoption of electric appliances will make digitalization a priority in order to increase reliability and efficiency of grids. Besides, during the months of December and January about 50% of the demand for heat is concentrated, mainly in a few hours in the morning and a few hours in the early afternoon. Demand for heating is thus concentrated in a thousand hours in a few months, in which the average demand for power in urban residential grids would be more than doubled. To solve this issue both an update of the distribution grids, end-user technological solutions (e.g. heat storage), and regulatory solutions (to facilitate the temporal distribution of the load) are required. Building automation is needed to manage this new degree of complexity, to put together generation and usage, and to avoid risks of grid interruptions on critical days and hours.

Supply-demand balance during the year is another issue in Italy, where renewable electricity sources are mostly installed in the south of the country, while the demand for buildings is largely in the north; the transport network is though designed to be central to the old power plants.

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<sup>70</sup> Moreau, et al., Household energy usage behaviour – is it mightier than energy efficiency? Accounting for the impact of behaviour diversity on household space heating hourly national power demand. The reduction of the heat demand granted by the insulation will also facilitate the adoption of heat pumps in existing buildings with high temperature distribution system.

<sup>71</sup> ECORYS, Assessment of non-cost barriers to renewable energy growth in EU Member States – AEON

### 3.1.5 Lack of users' expertise<sup>71</sup>

The lack of expertise in the theme of energy efficiency and renewable energies has been identified as an important barrier for their development. It is not just a question of knowing about the availability of new technologies, but also the expertise related to having seen them adopted by neighbours and relatives and knowing that they perform as expected. To make this issue stronger, there is the traditional lack of measure and verification of energy performance (M&V) in buildings, especially related to specific energy efficiency measures. Instead, the request to install and share data on the performance of energy efficiency interventions should be a priority for energy efficiency incentives. Such data not only will help in producing the needed expertise and trust in the new technologies but will also provide important feedback to enhance the design, installation, and O&M of those technologies.

One of the main issues in approaching this barrier lies in the technical nature of electrification technologies. They often interface with the existing system and require a proper design and management to maximise the achievable benefits. Many technologies listed in chapter 2 are not well known to the end users and are perceived as innovative. Whereas with daily usage devices – such as smartphone, cars, or TVs – innovation is usually well perceived and accepted by users, and even desired, with technical services, such as HVAC systems, innovation is seen as an added risk. Heat pumps, induction hobs, and building automation systems are more at risk to incur in this barrier. The technical nature of energy efficiency also represents a linguistic and understanding barrier, which only the habit of hearing about energy issues

can help to overcome. On the other hand, it is not uncommon to find non-technical people who know everything about cars and engines, or smartphones and PCs, testifying that even complex issues can become publicly understood if correctly disclosed. In the absence of a direct interest on the part of the end-user, however, it becomes essential that the government and operators providing products and services become responsible for promoting information and dissemination campaigns<sup>72</sup>. It is important to understand that such campaigns shall be tailored on the proposed solutions and their usage and shall clearly show how the new technologies will improve both the life, comfort, productivity, safety, etc. and the energy consumption of the client. Credible and truthful success case studies should be included, in order for the client to verify and reduce the perception of risks related to the adoption of such technologies. It is of interest of technology producers that their commercial network, including partners and affiliates, is provided with guidelines and adequate training.

For more aware end-users, it is important to have access to case studies and information on the effective performance of these new technologies. That means the technology providers should encourage M&V in when their solutions are installed. The collected data on the performance will both help in creating trust about such technologies and provide information useful to improve them and/or their installation and usage. In this sense, were energy performance certificates enhanced to include data on the effective energy consumption of the building, they will contribute in creating a better understanding of heat pumps.

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<sup>71</sup> ECORYS, Assessment of non-cost barriers to renewable energy growth in EU Member States - AEON

<sup>72</sup> FIRE, Soluzioni regolatorie per le barriere non-economiche alla diffusione dell'efficienza energetica in Italia nell'uso dell'elettricità.

There are no significant differences between Italy and other European countries in relation to this barrier.

### 3.1.6 Users' attitudes and habits

In relation to energy efficiency issues, attitude means the approach of users towards daily actions that have an impact on energy consumption. The behaviour of the building's occupants can affect the use of the energy facilities. That is the reason why in many informative guides on energy efficiency there are plenty of suggestions on closing the windows while the HVAC is on or turning off the light when leaving a room. However, this issue is a barrier to the reduction of the energy demand, not to the adoption of energy efficient technologies.

When speaking of new technologies, attitudes can play an important role in hampering their diffusion if such technologies imply a change in the user behaviour and/or in everyday tools. This is for example the case of induction cooking, which requires some adaptation and sometimes new pots and pans (in that case it can also become an economic barrier), or of heat pumps coupled with mechanical ventilation in detached houses, which need a different control logic and usage if compared with gas boilers.

Since the required change is primarily behavioural, results are not so easy to achieve but in case of success employees tend to transfer the focus on energy saving to their own homes as well. Among the solutions there are EPC contracts, which transfer to ESCOs the need to effectively manage the new solutions, and guidelines provided by technology

manufacturers coupled with maintenance sessions aimed at supporting the end-user in achieving the optimal performance.

The behaviour of end users can affect the use of equipment, so it becomes useful to identify actions that can lead to a reduction in energy consumption thanks to the willingness to change habits. Since the change required is primarily behavioural, the results are generally not easy to achieve, especially in a country tending towards individualism such as Italy.

This barrier mainly affects heat pumps and induction hobs. With respect to heat pumps' management, it could be interesting to make a comparison with traditional heating systems, like gas boilers. In the case of condominiums or commercial buildings, the management of the heating system will be done by an ESCO or a service provider, so the end-users shouldn't notice differences. Of course, it will remain difficult to ascertain if the heating system is managed in the best way, but this is true also with traditional boilers. An EPC can help in overcoming this issue. In the detached house case, however, the situation is different. With the traditional heating system, the logic of the family manager is usually to turn on the boiler at maximum power, when it's cold like in the morning and in the evening. This is not the most efficient way to manage such a system (for example, it won't profit by condensing boiler higher

efficiency at partial load). If a heat pump<sup>73</sup> is managed in the same way, the result is both to work at low efficiency if external air is used as heat source, if compared with midday temperatures, and to contribute to create a peak of electricity demand that most surely will translate in higher tariffs (and will put the distribution grid under test, a potential issue for distributors). So, there are two reasons to adopt a different management approach:

- Especially when the heat pump is coupled with a photovoltaic system, it could be efficient to self-consume as much of its own photovoltaic electricity as possible, even if it is available in the hours of sunshine when there is minimum heat request, but also higher COP for air heat pumps, accumulating heat in the building structures and thus reducing the need of peak demand in the evening (the effect depends on the inertia of the building envelope); this approach will produce mid-day temperatures higher than 20°C, needed to ensure the right temperature in the other times of the day;
- Where photovoltaics is not available, most depends on the tariff structure (linked to regulation and the global electricity demand and supply over the day) and to control logic as highlighted in the chapter Evolution of electric grid capacity. It may then be preferable to maximise the production of heat during the most convenient hours to profit from reduced electricity tariffs, anticipating the ignition time in order to reduce the morning peak, and to spread the working time over the afternoon to reduce the load at evening.

Any policy for the promotion of heat pumps needs to carefully consider the impact on consumers, their awareness and wellbeing. Switching to this system requires changes in buildings, gas appliances, and heating distribution systems in most cases. In addition to these, noise levels linked to position of the external heat exchanger (for external air systems) or the adoption of fan coils can lead on issues for people used to silent systems. On the other hand, heat pumps make a different heating experience by delivering more sustained ambient heat compared to the immediate response of gas boilers at very high temperatures. Surveys suggest that utilizing advanced control systems and increasing awareness of the consumers could enhance the level of customer satisfaction. Moreover, holistic planning and management are required to pass the transitional phase with minimum financial shock and disruption to consumers.

An important role can be further played by installers in the interventions' proposal, which can push on any non-energy benefits that can bring end-users within their scope of interest.

There are no significant differences between Italy and other European countries in relation to this barrier.

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<sup>73</sup>Capova, et al., Customer experience of demand side response with smart appliances and heat pumps

### 3.1.7 Performance gaps and qualification of market operators

A new technology usually requires specific skills and needs to be investigated to better understand how to manage it and in what differs from the traditional ones in terms of installation and O&M. Disseminating information on energy efficiency opportunities is essential, but not sufficient to achieve good results. It is crucial that market operators – such as technology producers, installers, ESCOs, utilities, designers, etc. – are properly qualified to put in action the good practices spread through informative campaigns.

Qualification is an issue especially with installers and plumbers since they usually don't see advantages in leaving their business to attend to training courses. The problem exists also with other market operators, but is usually more limited due to qualification schemes (e.g. engineers, architects, energy auditors, etc.) or by the understanding that qualification can translate in a competitive advantage. An important role in this respect can be played by technology providers, ESCOs and suppliers, as they take advantage from their target audience made up of installers, retailers and qualified technicians. The improved quality of the installation results in higher profits, increased efficiency, lower emissions, fewer complains from dissatisfied customers and a higher return in terms of image.

Performance gaps, i.e. low performance of devices related to bad installation, incorrect or improper management, etc., can further decrease economic indicators such as NPV, IRR and PBT. Low-qualified operators could tend to offer the same solution

to different customers without carrying out a detailed analysis or to install oversized systems as they do not comply with the energy efficiency first principle. That could result in some users having to deal with the low performance of the installed solution, with the result of negative campaign against the technology. This was for example the main reason why a first boom of heat pumps in the late 1970's/early 1980's ended in a collapse of the heat pump market for more than 10 years<sup>74</sup>, or, to focus on Italy, the negative experience with solar thermal systems in the same period, due to technologies not-ready for the market and incorrect installation. The difficulty to provide an effective measurement and verification of savings in the building sector (compared to industry) can further emphasize this barrier, even if the diffusion of smart meters can reduce such issue, especially in the residential sector.

Changing energy source implies that the high growth predictions expected into the market do not simply require an adjustment of technology providers' production lines, but a more complex maturity of the overall market. It is up to the stakeholders to assess whether their potential market is suitable for creating a connection with a particular supplier, to which all others will then adapt.

Similarly, distribution, sales and installation chains often need to be updated or modified. Sometimes the novelty has implications on authorisation processes, especially when the new technology goes beyond the technical standards in force.

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<sup>74</sup> "But the rapid growth of the heat pump business brought to many competitors with insufficient know-how. This was one of the reasons for the collapse of the European heat pump boom by the end of the 1980s. The other reason was an oil price decline after 1982. Therefore the 1980s had been characterised as the second "valley of tears". See p. 42 in: Zogg, M. (2008). History of Heat Pumps – Swiss Contributions and International Milestones

Generally speaking, the level of qualification of market operators, such as designers, installers, ESCOs, etc., is important to ensure a positive outcome for any type of retrofit. With innovative technologies this is even more important, since there is not only the risk of implementing a wrong or underperforming installation, but also the preceding risk that these operators will suggest to their customers not to adopt those technologies. This can be particularly true with heat pumps in the case of electrification.

Theoretically market operators should consider worthy to invest time in understanding new technologies, since that could result in a competitive advantage towards competitors. But in the building sector this is often untrue, mainly because end-users lack expertise and so don't push for innovative technologies. A reason for this is the inertia of the technician/installer, related to the wide availability of workload and the remunerative margins that he/she can obtain. The result is a little or no propensity to take care of updating and professional training, which are considered only when market demand forces them to do so. So, it falls to technology producers and policy makers to fill the gap. Technology producers have an interest to act because qualified operators will both reduce the risk of bad reputation due to wrong installation and facilitate the adoption of their innovative technologies. Policy makers have both the possibility to introduce training or certification schemes, promote EPC and other business models based on guaranteed results<sup>75</sup> and qualified operators, and stimulate the diffusion of energy performance insurances.

As mentioned above, this barrier should be

faced together with the expertise of end-users, since an aware and competent demand side is required to optimize results. Besides, competent end-users will stimulate market operators to learn about new technologies and how to deal with them. Technology suppliers, ESCOs, and utilities can play an important role in that respect, as they benefit from using networks of installers, vendors, and qualified technicians. Another issue is the still low level of digitalisation in the building sector, as for the use of building information modelling (BIM) to assist in the design, implementation, and O&M of buildings. Companies that in recent years have implemented this kind of solutions are exploiting in a simpler and more direct way complex tools, and articulated interventions like those involving building envelopes, plants, and electricity generation. Industrializing building sector allows to achieve shorter times for carrying out interventions, higher quality, and lower costs.

In Italy installers and practitioners involved in issuing building performance certificates are not subjected to adequate controls, neither by public bodies, nor by their associations. These issues have been amplified by the short-term market distortion generated by the 110% tax deduction scheme that has led to an imbalance between demand (very high, due to near zero CAPEX costs for citizens) and supply (limited in terms of available human resources, materials, etc.). The job opportunities created by mechanisms such as the 110% tax deduction should be exploited by promoting skills and requesting the use of BIM and other digitalisation means, with the aim of qualifying operators to adequately manage the in-depth buildings' renovation.

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<sup>75</sup> An example of such business models is the GoSafe approach developed under the ESI Europe project ([www.esi-europe.org](http://www.esi-europe.org)).

There are no significant differences between Italy and other European countries in relation to this barrier.

### 3.1.8 Integration challenges and complexity

In some cases, the solutions given to improve energy performance may not be easily applicable to the existing building, resulting effective from the perspective of energy saving, but not feasible within the context of the installation since each type of user has its own needs (space, flexibility, possibility of deep renovation of internal spaces, etc.). For this reason, the solutions identified do not fit for all the buildings. The main difficulties affecting the building sector concern: the limits of intervention in historic buildings especially in countries with plenty of historical heritage, the difficulty of simultaneous operations on the building and systems to maximize the results, and the complexity of replacing heat distribution systems with low temperature ones. Also, the internal cable network can sometimes prove to be under dimensioned to deal with the increased electric currents. Appropriate expertise of designers and operators could be a solution to overcome this barrier.

In Italy there are strong limits related to intervention on historical building, which are widely spread across the country. Condominiums have high temperature heat distribution system and usually air-to-air reversible split systems have been installed. This means that the insulation of the building envelope becomes fundamental for the installation of heat pumps that can be used only for heating purposes. In most cases it is also difficult to adopt heat pumps for the production of domestic hot water due to lack of space.

### 3.1.9 Lack of awareness and commitment in public sector

Public administration often doesn't consider energy efficiency a priority, even when they know about the opportunity to implement energy efficiency measures. It is important to understand that the required awareness is not limited to such knowledge, but public officers need to master the legislation and regulations about public procurement procedures. Even project financing options are often hindered by the lack of data on energy consumption and building characteristics needed to introduce the guarantees on the performance. So, the first need is to answer this weakness.

Explicit public procurement policies in favour of renewables and energy efficiency should also be adopted, empowering, and possibly obliging the managers of public institutions to take in full consideration the energy costs during building's lifetime, based on realistic assumptions about the long-term increase of non-renewable energy prices. The necessary financing opportunities (additional funds, soft loans) should be provided for the managers of public buildings willing to invest in renewables. Public building managers should be the target of dedicated awareness raising

and training initiatives, to make them fully aware of the electrification technologies available, and of the importance of the exemplary role of public buildings.

Wherever measures are taken, their visibility for people using the building (public and workforce) should be ensured, for instance by standard and visible displays showing the amounts of energy saved/produced, possibly with comparisons easily understandable for ordinary citizens.

In Italy there is a significant non-compliance in the appointment of energy managers for public facilities, coupled with the complexity of laws and regulations and the risk for public officers to incur in tax damage. This makes information campaigns often ineffective. A role can be played by regional agencies and by champions.

### 3.1.10 Heavy bureaucracy on RES installation

Procedures hindering the obtaining of the necessary permits for RES are often lengthy. Legal-administrative barriers can have a severe impact also on the development of small and building integrated RES systems. In several Member States an inhomogeneous and partly unpredictable patterns of application of laws is registered. Geothermal heat pumps are particularly affected by this barrier.

In Italy a typical problem is the extreme and contradictory fragmentation of political competences among different levels (Regions, provinces, municipalities). This leads to higher costs and legal uncertainty.

### 3.1.11 Tariffs' barrier

In many countries a barrier to electrification is related to electricity tariffs compared with gas and other fuels tariffs. In some cases, the issue is related to higher excise duties or taxes. In other cases, the structure of the electric tariff disfavours the increase of households' power capacity. Besides, where the tariff structure has increased the weight of the fixed component (i.e. euro/client or euro/kW) versus the variable one (i.e. euro/kWh), energy efficiency in general is not advantaged.

In Italy the residential sector is particularly affected by the increase of costs for contracts above 3 kW.

## 3.2 Summary of barriers for electrification technologies

	Poor economic indicators	Lack of access to finance	Split incentives dilemma	Need to improve the grid	Lack of users' expertise	Users' attitudes and habits	Operators' skills	Challenges in integration and complexity	Lack of awareness in public sector	Heavy bureaucracy on RES installation	Tariff's barrier
Heat pumps	•••	•••	•••	••••	••••	••••	••••	••••	•••	••••	••••
Induction hobs	•••	••	•	•	••••	••••	•	•	•	-	••••
Building infrastructure for EV charging	•••	•••	•	••••	••	••	•	•••	••	-	•••
BACS	•	••	••••	•	••••	•	••	••	•••	-	•
Cooling	•••	•	••	•••	•	•	•	•	•	•••	••
Tumble driers	••	•	•	•	••	••	•	•	-	-	•

Table 7. Impact of different barriers on specific electrification technologies.

## 3.3 The point of view of some stakeholders

### 3.3.1 Consumers

For consumers the main problem is not the fact that they don't trust in the technologies, but rather than the narrative is wrong, and technologies are still not attractive for them. People are personally not against technologies, since they don't care about them but are more interested in outcomes (e.g. house warm, meal cooked, etc.). Being the energy market complex, this discourages people from engaging; a better narrative of multiple impacts would certainly help. Other barriers perceived by consumers are:

- gap between gas and electricity prices: in most countries, expenses not directly linked to electricity are paid in electricity bill. There is the need to reduce the proportion between electricity and gas expenditure, otherwise additional measures will be needed to complement price signals;
- connection to the grid, in terms of period needed to get connected and power demand limit above which retail prices tend to become very high;
- lack of installers and admin and legal procedures (e.g. expensive disconnection from the gas grid), that hold consumers back to install heat pumps;
- non targetisation of subsidies for energy poverty.

In Italy the main barrier to the electrification is deemed to be the financial one. In this sense the incentive systems are fundamental, and tools such as 110% tax deductions, characterized by operational and technical criticalities and that have upset the market, do not represent the excellence. From an operational perspective, heat pump needs a correct sizing and insertion inside the building, which must be managed in an appropriate way starting from the phase of information and training to the installation of the product and the management in operation (which can often lead to discomfort). Another barrier that can be manifested in some contexts is the electro-sensitivity of some users that prevents them from handling electrical devices: to deal with this is fundamental the electro-magnetic insulation of the cables of all the systems needed for a home automation (e.g. induction plan), which also brings benefits in terms of safety and better acceptance of technologies.

### 3.3.2 Associations

Associations of energy experts, ESCO and small companies believe that the panorama of available technologies for electrification is adequate, as well as the ability to respond to adjustments, even sudden, that the market requires. What is lacking is the ability to have an integrated vision that goes beyond individual products, especially in relevant contexts such as apartment buildings.

Regarding heat pumps installations, according to European association in a perfect heat pump market, all the following criteria would be fulfilled:

- heat pumps would be known to decision makers;
- heat pumps are trusted and perceived as reliable and mature;
- heat pumps are available for all types of buildings and industrial processes;
- heat pumps able to fulfil the request for lower total cost of ownership. This is a challenging concept since then investment costs, operating costs, maintenance costs have to be addressed.

There is a lot of things that can be done in this sense. Many associations consider the biggest barrier is the reluctance of manufacturers and installers to change the type of technology which requires, among other things, more time (research and development, construction, and expansion of networks, etc.). While there is a part of installers who are inclined to install heat pumps, among those who work in older companies (for example thermohydraulic with few employees) there is a resistance to change.

The transition implies a paradigm shift that requires changing the logic of management, reducing the number of energy suppliers and identifying a neutral entity for consumption monitoring.

Shortage of supply is considered by EU association a temporary problem, not something that will stay. A lot of decision makers in the value chain believe that within the next 18

months, maybe 24 months, this supply chain problems will disappear. Factories are built on all levels, not only heat pump, but also fan factories are build, pump factories, electric motors and if all of them come into operation the supply situation will improve significantly.

Focusing on Italian situation, associations believe that the main barriers are connected to the electricity distribution grid that in many cases is obsolete and does not allow to increase the necessary power. Moreover, the presence of many old buildings with high temperature heating systems (heaters) makes heat pumps less efficient and must be integrated with gas boilers. In addition, many buildings have columns for the transport of electricity that are undersized and very old, obviously designed for the electrical needs of many decades ago.

### 3.3.3 Manufacturers

Technology manufacturers believe that main barriers to electrification are the lack of know-how and trust in technology from end users, often not supported by construction companies and installers. There is often little preparation from the latter, for example in terms of lack of dialogue with electricians for the installation of photovoltaic or installed systems without intervening on the management of the same. The issue of interoperability and interface between multiple activities (e.g. heat pump-photovoltaic, electric vehicle-battery) is central and should be managed through dedicated protocols.

Furthermore, in Europe there is an issue related to supply chains for components needed by technologies that drive the electrification process (chips, materials, compressors, cooling gasses, chemicals, etc.). This shortage of material is huge and is a common issue for all European manufacturers.

Focusing on heat pumps, there are several problems which can arise with their installation, depending on the actual need of the building. Although installing a water-to-air HP is easy, this is only possible in some circumstances, for example if hot sanitary

water is not needed (or provided through other technologies). Moreover, heating on low temperatures can only work if a building is well insulated, and preferably with floor heating and cooling. Heterogeneity of buildings does not allow one-fit-all solutions, which is another big obstacle that the industry is facing at the moment.

The uncertainty regarding the type of HPs in which end users should invest discourages additional investment. The sector demands a clear investment framework to develop HPs which are environmentally friendly, green, silent and efficient. If this is not provided soon, the market may become too fragmented as each MS may invest in their own way.

Finally, there is a need for upgrade in many buildings, because of increased consumption and the need of integration, for example PVs. Flexibility has a lot of potential, (SMART EN) evaluated that demand side flexibility is currently available. This should have a positive impact on the connection of the grid, shifting, load shifting, peak shaving, storage as for example batteries, bi-directional charging etc.

### 3.3.4 Institutions

Institutions like national energy authorities all around Europe agree that the target of massive electrification is mostly the residential sector, where end users do not have adequate technical preparation and where the types of buildings do not always lend themselves to a switch of this type. Technical difficulties deal with improving the energy performance of the building stock, in terms of energy performance of the building envelope. Important obstacles to the electrification of consumption at a general and system level are the cost of electricity (tax), grid and the lack of knowledge.

Focusing on heat pumps, institutions are convinced that increasing the rate of heat pump installation is not a problem but this massive installation must be preceded by increasing the rate of building insulation, which is a major challenge. Authorities warn that there is a big risk of major disillusionment on the actual performance of heat pumps in effective conditions. Scenarios for electrification must use realistic COPs in their assumptions, considering that COPs are lower when the building is poorly insulated, especially during cold days.

If this is not considered properly, there is

a risk that the deployment of heat pumps would not lead to lowering energy consumption, or at least not to the expected extent. This can be a problem for the power system at national level. And also a risk of bad surprise for end-users to get higher electricity bills than expected. It is therefore of utmost importance to anticipate the risks of counter-references.

Moreover, if public policy focuses on fuel switching and replacing heating systems, it also leads owners to prioritise heating replacement over building insulation.

Other important barriers can include:

- the complexity of heat pump vs. boiler, making it less easy for customers to appropriate. It can also be more difficult for customers to better manage their consumption, as it is difficult to know the actual COP according to the condition of use, or when the heat pump switches to direct electric heating/resistors. Likewise, the performance of heat pumps varies more according to the outside temperature.
- the noise of the heat pump vs. boiler, especially in dense areas.
- the higher difficulty to install a heat pump for multifamily buildings compared to individual houses.



In Italy, tariff barrier is not deemed particularly relevant since the reform of domestic tariff overcame the staggered structure (which characterized above all network tariffs and general system charges) and gave greater weight to the power component at the expense of the energy component, the latter charged in any case in a flat way (independent in terms of consumption). On the other hand, the weight of taxation on the various competing fuels needs to be taken into account.

End users do not have adequate technical preparation and the types of buildings do not always lend themselves to this kind of fuel switch: for example, many apartment buildings have no internal car space for charging, with a consequent impact on charging costs, there are technical barriers for the installation of heat pumps as well as more general communal conflicts. The obstacles are therefore more structural than regulatory, and in this context the incentives available are beneficial for the end customer.

### 3.3.5 Research

The barrier number one in many places is still the economic barrier. First there is the CAPEX: the upfront costs of the heat pump itself depends on the country but in most countries tends to be more expensive than a gas boiler or an oil boiler, so that's already a hurdle that consumers face. Such cost represents a barrier also for the supply chain in terms of marketing and effort. Secondly there is the OPEX, that is the part of the cost barrier related to running costs. Gas and oil prices before the war in Ukraine and the recovery after the pandemic were significantly lower in most countries compared to electricity and the unit cost of heat delivered by heat pumps tended to be higher in many countries. Heat pumps tend thus to be both more expensive to install and more expensive to run. So that's a barrier I think you need to solve before you can even think about addressing the others.

The second barrier is related to the supply chain. In many countries there is a push toward the adoption of heat pumps, and this is creating pressure on the availability both of technologies and components, and of

people needed to carry on the intervention, from designers to installers.

A third barrier is the difficulty to find the needed qualified people. There are lots of programmes dealing with energy efficiency and renewables so all companies are trying to hire massively but they can't find people with the right qualification. There are then the traditional barriers that customers face with energy efficiency: lacking information, lacking trust, etc.

Grid capacity in cities can be a country-dependent issue, thinking that in some countries much more electricity (even double or triple) is going to be used. Electrification will actually reduce total energy demand because of the energy efficiency of HPs but it's still an issue and that means investments in generation must be massively done but also the grid and there will be a cost to that in urban areas, especially where there are old wires and old substations that were not built for that level of demand. These will need to be upgraded and the network companies are already

looking at that and looking at forecasts and projections. On the other hand, in many regions grid is underutilized: it has been found that quite often the average level of the grid utilisation is around 60% and maybe at peak times go 80-90%. A smart control of the heat pump and EV recharge station can reduce that impact on the grid and in some areas reinforcements are not needed at all since the grid is already dimensioned in a way that can accommodate significant load growth.

### 3.3.6 Utilities and network operators

In terms of tariff, the aim is to make part of the tariffs variable, however it is a topic strongly differentiated between countries. At European level it is necessary to extract the common drivers of affordability applicable since in each country the tariff is composed differently and has the pieces that weigh it down and make it less attractive to prosumer. In some countries there are

subsidies, in others there is the massive installation of new meters (which users will have to pay) so the situation is different in different contexts. The tariffs then impact the political choices that shift the subsidies between domestic and industrial.

A focus on Italian distribution grid has been made (box below).



Grid development is an opportunity for electrification process. Networks can support electrification, and evaluations have already been carried out to prepare investments enabling the network to respond to increased demand. Investments in the grid will still have to increase and it is necessary to invest today to achieve results on long-term horizons (10–15 years).

Investments to be made concern the upgrading of infrastructure: localized power injection, new primary cabins to evaluate the possibility of creating a new node in a specific electrical area. This leads to an expansion of the medium voltage and low voltage grid. The development of the network will therefore cover all voltage levels both for the load and for the connection requests of the manufacturers (already available and evaluated).

The need for new structures implies the need for tools to better manage them. The key point is having an electronic meter that allows to know the consumption up to the last level of supply and to perform a monitoring that is as granular as possible. By going to higher levels of aggregation, the tools to be used are secondary cabin level meters and measuring instruments that provide information on power transits along the network to assess how the consumption curve changes as a function of the penetration of electrification.

One of the crucial issues concerns the predictions on load peaks. In this sense, the following were considered:

- increase in users connected to the network;
- increases in power;
- increase in electric mobility.

In a typical large city, a condominium with heat pumps needs on average a power of 200/300 kW, so in large cities it is expected that the condominium makes a prior request for connection to the distributor. The installation of a cabin is sometimes not easy, requiring a space of about 25 m<sup>2</sup> on the ground floor.

Association of distributors points out critical issues in terms of supply chain, e.g. the case of 2G electrical meters, also needed to measure the productivity of photovoltaic systems: due to the current economic framework we are in a phase of shortage of meters and materials, which are imported as European Union. In this sense, the global scale of electrification will create a very strong demand that will be difficult to meet; some ideas have been put forward to increase European semiconductor production, including by easing state aid constraints.

Another important barrier is on the side of the risers, which in the case of meters inside the building are owned by the distributor and on which it is not easy to intervene. The risers in the cities often date back several decades, and their modernization is preparatory to a massive increase in power.

## 4. Analysis of the policies in place in the EU

This chapter illustrates the main policies adopted at EU level that promotes energy efficiency and electrification in the building sector. After the general background and the main policies, the new programmes are described, like Fit for 55 and REPowerEU.

### 4.1 General EU background

Following the Paris Agreement, in 2018 the European Commission launched its Clean Energy for All Europeans package which set its direction of travel on climate and energy policy to lead the energy transition. The package contained 8 possible decarbonization scenarios, ranging from 80% reduction of GHG emissions to carbon neutrality. The package included 8 new laws, among which a revision of the **Energy Performance of Building Directive** (EU 2018/844), a revision of the **Renewable Energy Directive** (EU 2018/2001), a recast of the **Energy Efficiency Directive** (EU 2018/2002), the **Regulation on the Governance of the Energy Union and Climate Action** (EU 2018/1999) and the new electricity market design, including the **Electricity Regulation** (EU 2019/943) and the **Electricity Directive** (EU 2019/944).

Building on the Clean Energy for All Europeans, and focusing only on the complete decarbonization scenarios, at the end of 2019 the European Commission approved the **European Green Deal**, a growth strategy that aims at transforming the EU into a fair and prosperous society, with a modern resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. In 2020, the European Commission proposed the European Climate law addressing a pathway to get to the 2050 target – the Commission pledged to propose a new package of laws by the summer 2021.

This package, called **Delivering the European Green Deal**, but also known as the **Fit-for-55 package**, was released in July 2021. The package includes a comprehensive and interconnected set of proposals for the introduction of new laws and revision of existing ones to set clear goals for 2030, and primarily to be fully on track for climate neutrality by 2050. These proposals include:

- a **stronger and extended Emission Trading System** to maritime, road transport and buildings;
- **updated Renewable Energy Directive, Energy Efficiency Directive** and Energy Taxation Directive;
- other measures, e.g. a Carbon Border Adjustment Mechanism, updated Effort Sharing Regulation, updated Land Use Land Use Change and Forestry Regulation and others, including support measures such as a Social Climate Fund and enhanced Modernisation and Innovation Funds.

The proposal was later complemented with another package of proposed legislations in December 2021, including a recast of the **Energy Performance of Buildings Directive** and of the **Energy Efficiency Directive**.

In parallel with the Fit-for-55 package, the European Commission also released its **Taxonomy Regulation** (EU 2020/852). The EU taxonomy is a classification system, establishing a list of environmentally sustainable economic activities, which will play an important role helping the

EU scale up sustainable investment and implement the European green deal. It provides companies, investors, and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable.

According to Figure 33 (Gerard, F. et al. Policy support for heating and cooling decarbonization), based on National Energy and Climate Plans, only a few MS meet the RES target of 1.3% annual increase in the heating and cooling sector set in the **Renewable energy directive**. Heat pumps are one of the main solutions available to meet such

target. Italy is among the MS meeting the target only partially. However, almost all the target is linked to heat pumps, given the difficulties in pushing on alternative technologies like biomass boilers for pollution concerns. Figure 33 shows the share of RES in heating and cooling (H&C) in 2020 (blue lines) and the expected outcomes in terms of 1.3% annual increase of RES in the H&C sector in 2030 according to national NECPs (dark green: target met, light green: target met partially, orange: target not met). The black dots (right axis) illustrates the weight of H&C with respect to final energy consumption.

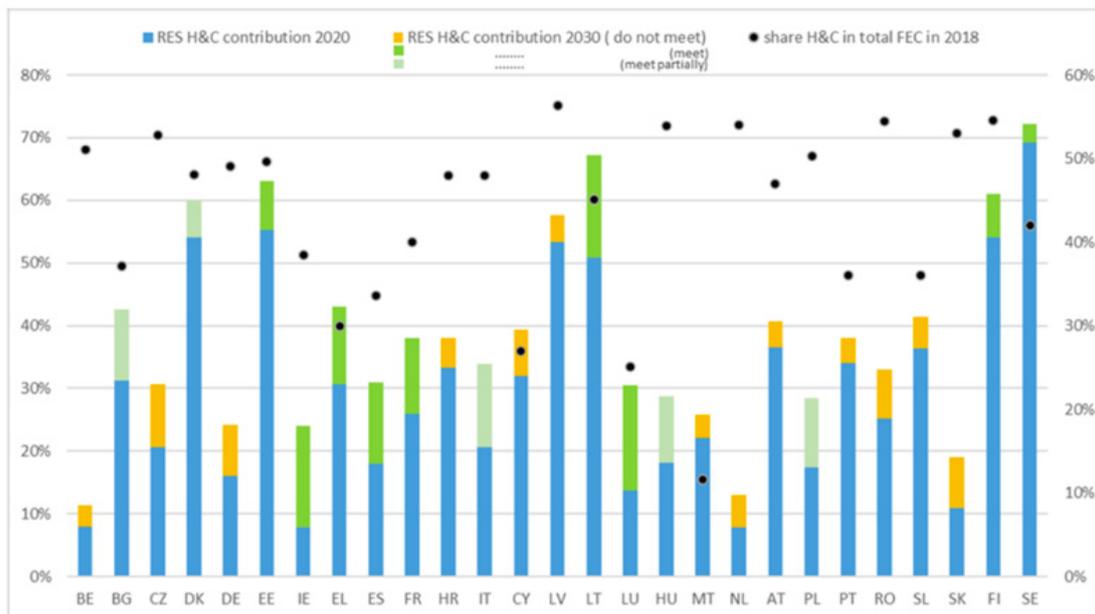


Figure 34. Shares of RES in heating and cooling in all MS in 2020 and 2030 including share of heating and cooling in final energy consumption.

In this report, we will focus on the three most relevant EU legislations in force (also mentioning the proposed revisions of their current provisions): the Energy Efficiency Directive (EU 2018/2002), the Energy Performance of Buildings Directive (EU 2018/844) and the EcoDesign and Energy Labelling Directives. We will then discuss the possible impacts deriving from the Fit-for-55 package, including the new provisions incorporated in the proposed recasts of the EED and EPBD and the proposed extension of the ETS scheme to the building and the transport sectors. Moreover, we will consider what indirect impacts could derive from the Taxonomy Regulation and the F-gas regulation.

<sup>76</sup> European Commission, Directorate-General for Energy, Gerard, F., Smit, T., Rademaekers, K., et al., Policy support for heating and cooling decarbonisation : roadmap, 2022, <https://data.europa.eu/doi/10.2833/977806>.

## 4.2 Analysis of the main relevant legislations

### 4.2.1 The EED

#### a. Overview

The Energy Efficiency Directive (EED) is a European Union directive which mandates energy efficiency improvements within the European Union. The EED promotes legally binding measures to encourage energy efficiency in all stages and sectors of the supply chain. It establishes a common framework for the promotion of energy efficiency within the EU in order to meet its energy efficiency headline target of 20% by 2020. The recast of the EED has undergone new objectives and provisions including new requirements on Member States to take measures to implement energy efficiency improvements in energy poor households, vulnerable consumers and in the social housing buildings. It is also focused on strengthening energy efficiency first implementation as compared to the active EED where it was only introduced as a principle. The revised directive requires EU countries to collectively ensure an additional reduction of energy consumption of 9% by 2030 compared to the 2020 reference scenario projections. This 9% additional effort corresponds to the 39% and 36% energy efficiency targets for primary and final energy consumption outlined in the Climate Target Plan, and is simply measured against updated baseline projections made in 2020. This means that the overall EU energy consumption should be no more than 1023 million tons of oil equivalent (Mtoe) of primary energy and 787 Mtoe of final energy by 2030.

Article	Relevant contents	Cross-cutting	Heating & cooling	Cooking & Appliances	BEMS & BACS	EVs
Art.5	Objective of renovating 3%/year of the areas of central government buildings, which can favour the <b>replacement of heating systems in public buildings</b> , and possibly the installation or enhancement of <b>BACS</b> (cf. links with EPBD Art.##)		X		X	
Art.7 (and Annex V)	Energy savings obligation (rate of 0.8%/year of additional new energy savings) that aims at triggering energy efficiency investments. The additionality principle makes that only energy savings beyond the requirements of EU legislations (e.g., Ecodesign regulations) can count to the energy savings obligation, unless an <b>'early replacement'</b> can be demonstrated. Similarly, in case of policy clearly aiming at <b>fuel switching</b> , the savings from a <b>heat pump</b> can be calculated against a baseline defined according to the Ecodesign regulations applicable to the type of replaced system (e.g., gas boiler).	X				

Art.14 (and Annex VIII)	Member States shall prepare a comprehensive assessment of the potential for the application of high-efficiency cogeneration and efficient district heating and cooling. In practice, this implies a <b>mapping of the heating and cooling demand</b> (per sector) <b>and supply</b> (per main technology and energy source), and identifying the potentials for using waste heat and developing district heating and cooling. If linked properly with a decarbonisation strategy, this comprehensive assessment might be used as a basis to prioritize types of heating and cooling systems according to the		X			
Art.16	Member States may have to develop <b>certification and/or accreditation schemes and/or equivalent qualification schemes</b> (including, where necessary, suitable training programmes) for providers of energy services, energy audits, energy managers and installers of energy-related building elements, in case the national level of technical competence, objectivity and reliability is insufficient. This can for example apply to the installers of heat pumps and RES systems, and also possibly for BEMS and BACS.		X		X	

Also Art. 9 and 11, related to metering and billing, can be mentioned. The diffusion of smart meters both for electricity and natural gas and some of the provision related to billing (e.g. the information about the consumption trend, the availability of energy consumption data both for electricity and gas and for heating through suppliers) can facilitate the adoption of energy efficiency measures and thus also of electrification measures. In Italy is it now possible to also get electricity hourly data if a second generation smart meter is installed through a centralised platform managed by Acquirente Unico, a company controlled by GSE.

- b. Impact on the different sectors (also considering possible changes according to the proposed EED recast)
  - l. Heating and cooling (with a focus on heat pumps)

Major relevant changes included in the proposed EED recast are listed below.

**The EED** recommends the use of heat pumps under technologies with economic potential in heating and cooling as well as technologies and for waste heat recovery.

**Article 23** of the EED provides a framework for planning in terms of identifying the energy efficiency and renewable energy potential in heating and cooling, and requires that Members States implement policies and measures to exploit this potential. These policies and measures directly support the achievement of the renewable energy target in heating and cooling.

**In Annex V**, there is a proposal to exclude fossil fuel technologies from the scope of action types eligible to the energy savings obligation. In other words, energy savings from new efficient heating, oil and gas boilers would no longer be eligible due to Art.7 (that will now be Art.8). This could be a major change for Italy, as gas boilers have represented the largest share of energy savings from the tax credit scheme, which is one of the main policy measures reported by Italy to Art.7 (especially about energy savings in buildings).

In relation to this, it could be worth mentioning that currently the following countries in EU have adopted plans to exclude fossil fuels boilers from the market or push heat pumps:

- France – ban on oil boilers from July 2022
- Austria – ban on gas boilers from January 2023
- Germany – share of 65% of renewable energy sources From January 2024
- Flanders – ban on gas boilers from January 2025
- Netherlands – minimum hybrid heat pump required from January 2026
- EU – discussion undergoing to exclude gas boilers since 2029 via Ecodesign

With the current definition under **Article 24** of efficient district heating being at least 50% RES, 50% waste heat, and 75% cogenerated heat by 2025, with only RES and waste heat (where RES is at least 60%) after 2050. Article 24 underlines that any new or substantially refurbished system needs to meet criteria for efficient district heating and cooling when it starts or continues its operation after the refurbishment. Furthermore, starting in 2025, plans for all the district heating and cooling systems above 5 MW are to be converted into efficient district heating and cooling.

**The Energy Efficiency Directive** recast set by the Commission will set a more ambitious binding annual target for reducing energy use at EU level. It will guide how national contributions are established and almost double the annual energy saving obligation for Member States. The public sector will be required to renovate 3% of its buildings each year to drive the renovation wave. Furthermore, the recast enhances stronger rules on metering and billing of thermal energy by giving consumers – especially those in multi-apartment building with collective heating systems – clearer rights to receive more frequent and more useful information on their energy consumption, also enabling them to better understand and control their heating bills.

## 4.2.2 The EPBD

### a. Overview

The Energy Performance of Buildings Directive (EPBD) and its revision upgrade the existing regulatory framework to reflect higher ambitions and more pressing needs relating to climate action while taking into account the differences between building stocks across Member States. The revised directive proposes measures to be implemented so that Europe can achieve a fully decarbonised zero-emission building stock by 2050, which includes (i) an increase in the rate of renovation, particularly for the worst-performing buildings in each Member State; (ii) modernize the building stock by making it more resilient and accessible; (iii) supporting better air quality; (iv) digitalizing energy systems for buildings; and increasing infrastructure for sustainable mobility. In addition, the revised EPBD facilitates more targeted financing to investments in the building sector and complements other EU instruments dedicated to supporting vulnerable consumers and fighting energy poverty.

In line with the Renovation Wave, the EPBD introduces EU-wide minimum energy performance standards for worst performing buildings and grants Member States the ability

to set additional standards on a case-by-case basis. The proposal includes a definition of zero-emission buildings, deep renovations, mortgage portfolio standards, renovation passports, and facilitates the use of new performance metrics including final energy consumed and lifecycle carbon emissions. A summary of relevant articles for electrification can be found below.

Article	Relevant contents	Cross-cutting	Heating & cooling	Cooking & Appliances	BEMS & BACS	EVS
Art.2a	Member States shall define and revise periodically a long-term renovation strategy, with the objective "to ensure a highly energy efficient and decarbonised national building stock". It includes the identification of cost-effective approaches to renovation, according to building type and climate zone. While not explicitly mentioning the replacement of heating systems, this is a major part of the renovation packages, together with the improvement of the building envelope. Moreover, the improvement of the building envelope can favour fuel switching. As part of their renovation strategy, the Member States define the policy measures in place or planned to promote building renovations, that can include incentives for replacing heating systems, either following an approach of staged renovation or as part of deep renovations.		X			
Art.3, 4, 5, 6 and 7 (and Annexes I and III)	These provisions set the framework for the specifications of the building regulations and related energy performance requirements, that can have an influence of the choice of heating systems (especially for new buildings). The Primary Energy Factor used for electricity is often a key parameter about this.		X			
Art.8	Requirement about technical building systems (link with BACS) Requirement for the ensuring a minimum number of recharging points for electric vehicles in non-residential buildings, and in new residential buildings or residential buildings undergoing major renovation				X	X
Art.9	As of 2021, all new buildings must be nearly zero-energy buildings (NZEB) and since 2019, all new public buildings should be NZEB. Clause 3 of EPBD Article 9 requires Member States to define their nZEB requirements in their national plans, including a numerical indicator of primary energy use expressed in kWh/m2 per year. When a building is sold or rented, energy performance certificates must be issued and inspection schemes for heating and air conditioning systems must be established. In addition to the minimum energy performance standards established for buildings and building units owned by public bodies, non-residential buildings and building units other than those owned by public bodies, and residential buildings and building unit, each Member State may establish minimum energy performance standards for the renovation of all other existing buildings with a view to the national roadmap and the 2030, 2040 and 2050 targets contained in the Member State's building renovation plan and to the transformation of the national building stock into zero-emission buildings by 2050.		X			
Art.14,15 and 16	Provisions about the inspection and maintenance of heating and cooling systems: opportunities to identify systems that would need to be replaced. And requirement about installing BACS to optimize large heating and cooling systems		X		X	

- a. Impacts on the different sectors
  - i. Heating and cooling (with a focus on Heat pumps)

To encourage the swift deployment of heating systems with zero direct emissions, the EPBD proposal includes the requirement that zero-emission buildings will not be able to generate carbon emissions on-site. It also pushes for renewable energy sources in the calculation of the overall performance of the building, particularly when a building is part of a larger energy grid, such as a district heating or cooling system.

For individual heating systems with a lifetime of around 20 years, the EPBD foresees that fossil-fuel powered boilers will not be eligible for public support as of 2027. While the directive does not mandate an EU-level phase out date for fossil fuel boilers, it introduces a clear legal basis for national bans, allowing Member States to set requirements for heat generators based on greenhouse gas emissions or the type of fuel used. It thereby supports the replacement of inefficient fossil-fuel boilers by systems with no direct GHG emissions, such as heat pumps (which can also be used for cooling) and other renewable based technologies. With the increasing use of BACS, the energy mix of buildings will also be optimized as heat pumps could be operated if local PV-power or wind power is available nearby.

## **II. Appliances**

The EPBD complements products legislation such as the Energy Labelling Regulation, which incentivizes consumers to purchase best-in-class energy-related products and appliances placed in buildings. It also works in tandem with the Ecodesign Directive, which sets energy performance and other environmental performance requirements on energy-related products, in particular for technical building systems such as boilers, heat pumps or light sources, and equipment used in buildings including household appliances.

## **III. Smart technologies in buildings**

One of the scopes of the EPBD is establishing the definition of the smart readiness indicator alongside a methodology by which it measures the capacity of buildings to use information and communication technologies and electronic systems to adapt their operation to the needs of occupants and the grid, as well as to improve their energy efficiency and overall performance. The smart readiness indicator will cover enhanced energy savings, benchmarking and flexibility, enhanced functionalities and capabilities resulting from increasingly interconnected and intelligent devices. The methodology will consider smart meters, building automation and control systems, self-regulating devices for the regulation of indoor air temperature, built-in home appliances, recharging points for electric vehicles, energy storage, as well as benefits for the indoor climate condition, energy efficiency, performance levels and enabled flexibility. As a result, this should raise awareness amongst building owners and occupants regarding the value behind building automation and electronic monitoring of technical building systems, and should inspire confidence about the actual savings of these technologies in occupants, thereby increasing their adoption.

b. Possible changes put forth by the commission (also considering possible changes according to the proposed EPBD recast)

The decision to undertake a further reform of the EPBD so soon after the previous revision can be attributed to the growing urgency for climate action as set out in the European Green Deal in December of 2019, as well as the recognition of the major role that buildings can play in terms of meeting the 55% GHG target by 2030. In December 2021, Parliament noted that buildings are responsible for 36% of GHG emissions and that deep renovation of existing buildings is crucial for any convincing strategy for decarbonization since at least 110 million buildings are potentially in need of renovation. As such, a series of observations and recommendations on how to improve the implementation and effectiveness of the EPBD were put forth, with a particular focus on long-term renovation strategies (Article 2a), later replaced by National Building Renovation Plans (Article 3), which include targets for increasing the renovation rates by 2030, 2040 and 2050. Other provisions introduce the previously mentioned building renovation passports and smart readiness indicator, the end of subsidies for fossil fuel boilers, and the support for making building automation and control systems more widespread.

### 4.2.3 Ecodesign and Energy Labelling

#### a. Overview

The EU energy labelling and ecodesign legislation helps improve the energy efficiency of products on the EU market.

Ecodesign sets common EU wide minimum standards to eliminate the least performing products from the market. The energy labels provide a clear and simple indication of the energy efficiency and other key features of products at the point of purchase.

The European Commission estimates that the EU legislation for energy labels and ecodesign will bring energy savings of approximately 230 million tonnes of oil equivalent (Mtoe) by 2030, which means an average saving of up to €285 per year for consumers on their household energy bills.

**Directive 2009/125/EC** sets the framework for the setting of the ecodesign requirements for energy related products. Specific requirements for the different products are included in other legislative texts, as follows: welding equipment ([Regulation \(EU\) 2019/1784](#)), power transformers ([Regulation \(EU\) 548/2014](#)), electric motors and variable speed drives ([Regulation \(EU\) 2019/1781](#)), water pumps ([Regulation \(EU\) 547/2012](#)), circulators ([Regulation \(EC\) 641/2009](#)), industrial fans ([Regulation \(EU\) 327/2011](#)), professional refrigeration equipment ([Regulation \(EU\) 2015/1095](#)), air heating/cooling products ([Regulation \(EU\) 2016/2281](#)), external power supplies ([Regulation \(EU\) 2019/1782](#)), computers ([Regulation \(EU\) 617/2013](#)), servers and data storage products ([Regulation \(EU\) 2019/424](#)), simple set-top boxes ([Regulation \(EU\) 107/2009](#)), vacuum cleaners ([Regulation \(EU\) 666/2013](#)), electronic displays – including TVs ([Regulation \(EU\) 2019/2021](#)), light sources and control gears

([Regulation \(EU\) 2019/2020](#)), dishwashers ([Regulation \(EU\) 2019/2022](#)), washing machines and washer-dryers ([Regulation \(EU\) 2019/2023](#)), tumble driers ([Regulation \(EU\) 932/2012](#)), domestic cooking appliances: ovens, range hoods, hubs ([Regulation \(EU\) 66/2014](#)), household fridges and freezers ([Regulation \(EU\) 2019/2019](#)), refrigerating appliances with a sales function ([Regulation \(EU\) 2019/2024](#)), ventilation units ([Regulation \(EU\) 1253/2014](#)), space and combination heaters ([Regulation \(EU\) 813/2013](#) and [Council Directive 92/42/EEC](#)), water heaters, storage tanks and solar devices ([Regulation \(EU\) 814/2013](#)), local space heaters ([Regulation \(EU\) 2015/1188](#)), solid fuel space heaters ([Regulation \(EU\) 2015/1185](#)), air conditioners – including air to air heat pumps ([Regulation \(EU\) 206/2012](#)) and stand by/off mode consumption ([Regulation \(EC\) 1275 /2008](#)).

**Regulation (EU) 2017/1369** sets the framework for the setting of the energy labelling requirements for energy related products. Specific requirements for single products are included in other legislative texts, and specifically for electronic displays – including TVs ([Regulation \(EU\) 2019/2013](#)), light sources and control gears ([Regulation \(EU\) 2019/2015](#)), dishwashers ([Regulation \(EU\) 2019/2017](#)), washing machines and washer-dryers ([Regulation \(EU\) 2019/2014](#)), tumble driers ([Regulation \(EU\) 392/2012](#)), domestic cooking appliances – ovens and range hoods ([Regulation \(EU\) 65/2014](#)), households fridges and freezers ([Regulation \(EU\) 2019/2016](#)), refrigerating appliances with a sales function ([Regulation \(EU\) 2019/2018](#)), residential ventilation units ([Regulation \(EU\) 1254/2014](#)), space and combination heaters ([Regulation \(EU\) 811/2013](#)), water heaters, stor-

age tanks and solar devices ([Regulation \(EU\) 812/2013](#)), local space heaters and solid fuel space heaters ([Regulation \(EU\) 2015/1186](#)), solid fuel boilers ([Regulation \(EU\) 2015/1187](#)) and air conditioners – including air to air heat pumps ([Regulation \(EU\) 626/2011](#)).

## **b. Impacts on the different sectors:**

The scope of both the Ecodesign Directive and of the Energy Labelling Regulation is to help improve the energy efficiency of products on the EU market. The former sets the minimum standards in terms of energy consumption for certain categories of products in order to eliminate from the market the least efficient ones, while the latter helps consumers choose products which are more energy efficient. As such, both eco-design and energy labels encourage manufacturers to drive innovation by making their products more and more efficient, however, their direct impact on the level of electrification in the EU is quite small.

### **I. Heat pumps**

Ecodesign: air heating/cooling products ([Regulation \(EU\) 2016/2281](#)), space and combination heaters ([Regulation \(EU\) 813/2013](#)), air conditioners – including air to air heat pumps ([Regulation \(EU\) 206/2012](#)).

Energy label: space and combination heaters ([Regulation \(EU\) 811/2013](#)), and air conditioners – including air to air heat pumps ([Regulation \(EU\) 626/2011](#)).

### **II. Appliances**

Ecodesign: computers ([Regulation \(EU\) 617/2013](#)), servers and data storage products ([Regulation \(EU\) 2019/424](#)), simple set-top boxes ([Regulation \(EU\) 107/2009](#)), vacuum cleaners ([Regulation \(EU\) 666/2013](#)), electronic displays – in-

cluding TVs ([Regulation \(EU\) 2019/2021](#)), light sources and control gears ([Regulation \(EU\) 2019/2020](#)), dishwashers ([Regulation \(EU\) 2019/2022](#)), washing machines and washer-dryers ([Regulation \(EU\) 2019/2023](#)), tumble driers ([Regulation \(EU\) 932/2012](#)), domestic cooking appliances: ovens, range hoods, hobs ([Regulation \(EU\) 66/2014](#)), household fridges and freezers ([Regulation \(EU\) 2019/2019](#)),

Energy label: electronic displays – including TVs ([Regulation \(EU\) 2019/2013](#)), light sources and control gears ([Regulation \(EU\) 2019/2015](#)), dishwashers ([Regulation \(EU\) 2019/2017](#)), washing ma-

chines and washer-dryers ([Regulation \(EU\) 2019/2014](#)), tumble driers ([Regulation \(EU\) 392/2012](#)), domestic cooking appliances – ovens and range hoods ([Regulation \(EU\) 65/2014](#)), household fridges and freezers ([Regulation \(EU\) 2019/2016](#)),

### **III. Smart technologies in buildings**

Battery charger and power supply are covered by 278/2009.

Since home EV charging will become pretty common and one of the main “domestic” consumption in a near future, possibly also the efficiency of the internal EV charger could fall within ecodesign.

#### **4.2.4 Fit-for-55:**

The Fit for 55 package is the set of new policy proposals to achieve at least 55% emission reduction by 2030. The objective of the package is the revision of a framework which ensures also socially fair and competitive EU, not only emissions' reduction.

Among 20 policies that are being reviewed and adjusted, relevant for this study are the recast in the area of energy efficiency and emission trading. The part of the revision that means changes of the existing provision, for example changes of objectives, targets and conditions, has been targeted in the respective policy chapter. In this section the presentation includes new provisions of the existing regulation and how they influence the included sectors.

### **Energy efficiency**

#### **a. Recast of the Energy Efficiency Directive**

Besides the increase in savings and changes in the existing articles, European Commission has also introduced new objectives and provisions including new requirements on Member States to take measures to implement energy efficiency improvements in energy poor households, vulnerable consumers and in the social housing buildings. It is also focused on strengthening energy efficiency first implementation as compared to the active EED where it was only introduced as a principle.

The introduction of the policy in its recitals & Articles mentions some of the crucial new parts of the EED:

**Energy efficiency first principle:**

It emphasizes the importance of energy efficiency first principle, not only by its introduction, but also by the obligation for it to be applied in all relevant policy, planning and major investment decisions, along with the recommendation and the guidelines for implementation. The Commission also provided indicative guidance on indicators for measuring energy poverty and defining what a 'significant number of households in energy poverty' is. This is linked to the whole directive, but also specifically to the principle.

**Role of the public sector:**

The role of the public sector as a leader in energy efficiency is strengthened. Article 5 clearly states a very large role of the public sector entities and local and regional authorities in pursuing savings and in prioritizing energy efficiency in local planning.

**Environmental protection:**

The mention of the whole life cycle of emissions of buildings is also relevant, along with the climate and environmental standards. This is especially relevant for public procurement, as described in Article 7 of the revised directive, where

both environmental aspects and life-cycle assessment should be included in procurement processes.

**Energy poverty:**

Articles 8 and 9 emphasise very much not only the protection of the vulnerable consumers of energy, the obligation, the promotion, uplift etc., but also the importance to take into consideration the possible negative impacts that the measures implemented could have on the vulnerable groups. New Article 22 is completely dedicated to the alleviation of energy poverty, introducing the comprehensive program to cover all the areas of vulnerability. This includes technical assistance, but also the holistic approach to the issue with creation of one-stop shops, involvement of various experts and development of financial solutions.

**Energy management and audits:**

Article 11 which was earlier Article 8 is no longer determining the obligation of energy audit based on the size of the company, but on its average annual consumption in the last three years (higher than 100TJ for the energy management system and 10TJ for energy audit), unless they have implemented an energy performance contract.

All of these changes have relevant impacts on different sectors included in the study:

Table 8 Impact of EED changes on targeted sectors

	Heat pumps	Appliances	Smart technologies cooling
<b>Energy efficiency first principle</b>			✓
<b>Public sector</b>			✓
<b>Environmental protection</b>	✓	✓	✓
<b>Energy poverty</b>	✓	✓	✓
<b>Energy management and audits</b>	✓		✓

The introduction of the energy efficiency first principle in a much-detailed manner with accompanying guidelines, will influence the deployment of **smart technologies in buildings**, with them being the cost-effective solution for the implementation of energy efficiency alongside other investments, for example small renewable energy sources. As buildings can function as efficient micro energy hubs with flexible system, smart technologies are crucial to help them balance. Public sector obligation to lead the renovation and information is also directly linked to energy efficiency increase, where **the smart technologies** have major role. New **public procurement rules**, focusing on emissions reduction and environmental protection, for sure have an influence on the **deployment of all technologies**. If the green public procurement takes into consideration energy consumption, CO2 consumption and materials, then the efficiency and use of the as clean fuels as possible have a major relevance in the implementation. As for the new obligation regarding energy poverty, introduction

of long – term solutions that are having multiple benefits on households, like efficiency in heating, cooking or achievement in health. **Smart technologies** in buildings assist in health and comfortability of buildings, besides lower bills due to lower energy use. Putting higher obligation to implement energy management in companies will for sure lead to the **integration of smart technologies** (at least for the measurement and management), but it will also result in the suggestion for the implementation of measures like installation of heat pumps.

All the provisions that have been changed a lot or added to EED are not directly describing the contribution to any of the technologies' market, but their influence derives for the general elevation of energy efficiency in all of the cases and on more emphasis on environmental and climate protection. The mentioned technologies are, as described above, key solutions towards the achievements of newly set obligation.

## **b. Recast of the Energy Performance of Buildings Directive**

The proposal for the revision of the EPBD has increased the ambition in the renovation of the building stock of the EU, but also introduced some new obligation to the Member States. First of them is the obligation to achieve a zero – emission building stock, with the higher internal air quality, digitalized management systems and with energy poverty targets.

The measures relevant for this study that have been introduced in the revision include:

### **Introduction of Minimum Energy Performance Standards to trigger worst buildings renovation**

MEPS are considered as much needed regulatory tool for the renovation of the worst performing buildings, being the only tool to also take into consideration the split incentives and other ownership related barriers. This means the gradual phase out of the worse buildings and the renovation of the buildings that could both decarbonise the system but also ensure energy poverty reduction. Technically, introduction of MEPS

means defining the lowest performing 15% of buildings as class G in the building stock and harmonising other energy performance classes and then change it from class G to the cost- optimal level, as described in Articles 5 and 6.

**Initiation of deep renovation and the introduction of building renovation passports**

Deep renovation is introduced for the first time as a name and a concept, meaning renovation that makes the building zero- emissions, combining energy refurbishment with all the other needs as seismic and health needs of the household. 'Deep renovation' means a renovation which transforms a building into a nearly zero (before 2030) or zero – emission building (after beginning of 2030). Member states are obliged to promote and to substantially fund the deep renovation.

**Modernisation of buildings and their systems, and better energy system integration (for heating, cooling, ventilation, charging of electric vehicles, renewable energy)**

There are several introduced provisions relevant for this chapter, for example a suggestion for the building codes to be effectively used to introduce targeted requirements to support the deployment of recharging infrastructure in car parks of residential and non-residential buildings. In the case of this recast, the pre-cabling of every of the parking spaces has been introduced in Article 12, with the objective to quickly install the charging unit if needed. This is also directly linked to the integration of smart charging, where the same article obliges the installers that the chargers are to be capable of smart charging and, where appropriate, bidirectional.

The EPBD revision also includes the Digital Single Market agenda alignment, meaning digitalization of energy system, building sector for example, by financing smart readiness and digital solutions in the buildings. This should also be linked to the deployment of possible smart services, all measured with smart readiness indicator. Article 13 introduces smart readiness, described in more details in Annex 4.

All of these changes/add-ons have relevant impacts on different sectors included in the study:

Table 9 Impact of EPBD changes on targeted sectors

	Heat pumps	Appliances	Smart technologies cooling
<b>Introduction of Minimum Energy Performance Standards to trigger worst buildings renovation</b>	✓	✓	✓
<b>Initiation of deep renovation and the introduction of building renovation passports</b>	✓	✓	✓
<b>Modernisation of buildings and their systems, and better energy system integration (for heating, cooling, ventilation, charging of electric vehicles, renewable energy)</b>	✓	✓	✓

The introduction of the Minimum Energy Performance Standard both with deep renovation influence the possible development of the technology markets in two ways: lower energy consumption and the willingness to achieve savings will motivate the consumers to also measure, monitor and manage energy consumption using a level of smart technologies. Other than that, if for example the household has been using electrical energy for heating, lower consumption of energy could open the space (either budget or power capacity) for the installation of heat pumps and electricity powered appliances. Modernisation of the building sector is much more relevant for the markets as it directly introduces the need to install smart technologies, EV chargers, to align with the digital agenda and deploy smart services. This added Article in the EPBD will for sure influence all three sectors, but mainly smart technologies.

## **Emission trading**

### **a. Strengthening and extension of the Emission Trading Scheme**

Of the elements changing in the revised ETS, the legislation dealing with around 45% of EU emissions, what is interesting for the study are:

#### **More ambitious linear reduction factor for GHG emissions**

To achieve the EU climate objectives, the proposal increases the linear emissions reduction factor from 2.2% per year to 4.2%. This ensures that the overall quantity of allowances will decline at an increased annual pace resulting in an overall emission reduction of sectors under the EU ETS of 61% by 2030 compared to 2005.

#### **Separate new ETS for buildings and road transport**

A separate emissions trading system for fuel distribution for road transport and buildings will be established starting from 2025. This does not mean that the single sources of emissions like buildings will be charged in the EU ETS or will enter the market system, but the upstream distributors of fuels, for example gas. The projections show the possible steep increase of the ETS extension prices.

The changes/add-ons have relevant impacts on different sectors included in the study:

Table 10 Impact of ETS changes on targeted sectors

	<b>Heat pumps</b>	<b>Appliances</b>	<b>Smart technologies cooling</b>
<b>More ambitious linear reduction factor for GHG emissions</b>	✓		✓
<b>Separate new ETS for buildings and road transport</b>	✓	✓	✓

More ambition in the traditional ETS sector would mean the need for reduction of the emissions from the electricity production and district heating. This would, for the introduced technologies, mean possible need to switch to more efficient energy transforma-

tion technologies (if the used fuel is electricity, meaning **heat pumps**) but also to strengthen demand side services, for which the **smart technologies** need to be introduced. As for the separate new ETS, this has much more influence on the electrification of buildings. First, it is a high motivation to switch from fossil fuels (gas) to **heat pumps** as the difference between the fuel prices will be on the side of heat pumps. This is also relevant for **appliances** (e.g., gas cooking switching to electricity) and mostly to the deployment of the **systems** able to connect the needs of the consumer and the needs of the network.

**ETS extension seems to be one of the crucial policies triggering electrification in the building sector. Also in transport, which then again contributes deployment of smart technologies in e- charging.**

#### 4.2.5 Taxonomy regulation – possible impacts on electrification

The Taxonomy 2020/852 Regulation entered into force on 12 July 2020. It establishes the basis for the EU taxonomy by setting out the conditions that an economic activity has to meet in order to qualify as environmentally sustainable. The Taxonomy Regulation establishes six environmental objectives:

- Climate change mitigation
- Climate change adaptation
- The sustainable use and protection of water and marine resources
- The transition to a circular economy
- Pollution prevention and control
- The protection and restoration of biodiversity and ecosystems
- Different means can be required for an activity to make a substantial contribution to each objective.

Under the Taxonomy Regulation, the Commission had to come up with the actual list of environmentally sustainable activities by defining technical screening criteria for each environmental objective through delegated acts. Up to now a first delegated act on sustainable activities for climate change adaptation and mitigation objectives was published on 9 December 2021 and is applicable since January 2022. A second delegated act for the remain-

ing objectives will be published in 2022. On 2 February 2022, the Commission approved in principle a Complementary Climate Delegated Act including, under strict conditions, specific nuclear and gas energy activities in the list of economic activities covered by the EU taxonomy. It was formally adopted on 9 March and is presently pending the co-legislators scrutiny.

Under the taxonomy many voices related to the electrification of energy consumption are present. An EU Taxonomy Compass is available to facilitate the access to the contents of the Taxonomy regulation (initially for the two objectives addressed in the first delegated act). Most of the solutions indicated in this document are enabling or transitional activities under the taxonomy, contributing to climate mitigation. That means taxonomy can support their development while the push towards compliant actions increases. It is interesting that some voices in the taxonomy, like construction of new buildings, introduce requirements higher than those set by the current EU mandatory regulations (e.g., a primary energy demand at least 10% lower than the threshold set for NZEB buildings). In this case the support from the taxonomy can even be higher.

## 4.2.6 F-gas

F-gases are a group of synthetic gases mainly used in refrigeration, air-conditioners, heat pumps, and the electricity sector. Though F-gas emissions are relatively small in terms of volume, the global warming potential of some F-gases reaches thousands of times that of CO<sub>2</sub>.<sup>78</sup> On April 5th, 2022, the Commission made a legislative proposal to update the current F-gas Regulation or Fluorinated Gas Regulation ([Regulation \(EU\) No 517/2014](#)), which applies since January 1st, 2015. The current Regulation strengthened the previous measures and introduced far-reaching changes by (i) limiting the total amount of the most important F-gases (HFCs) that can be sold in the EU from 2015 onwards and phasing them down in steps to one-fifth of 2014 sales in 2030; (ii) banning the use of F-gases in many new types of equipment where less harmful alternatives are available, such as fridges in homes or supermarkets, air conditioning, foams and asthma sprays and; (iii) preventing emissions of F-gases from existing equipment by requiring checks, proper servicing and recovery of the gases at the end of the equipment's life. Due to the F-gas Regulation, the EU's F-gas emissions will be cut by two-thirds by 2030 compared to 2014 levels given that climate-friendly alternatives are available and relatively low cost for many of the products and equipment in which F-gases are commonly used. This regulation also serves the purpose of driving innovation in the refrigeration and air conditioning sector.

The new proposal pushes for the alignment

of the F-gas Regulation with the European Green Deal and the European Climate Law as well as recent international obligations on HFCs under the Montreal Protocol. Moreover, it is intended to deliver higher ambition through a tighter quota system for HFCs, ensure compliance with the Montreal Protocol, improve enforcement and implementation, as well as achieve more comprehensive monitoring with the aim of preventing an additional 40MtCO<sub>2e</sub> by 2030 and 310 MtCO<sub>2e</sub> by 2050.

However, the proposal contains worrying prohibitions on equipment critical to Europe's decarbonisation. Due to insufficient alternatives and trained installers, the new f-gas regulation is foreseen to greatly decelerate the deployment of heat pumps and other heating, domestic hot water, and cooling solutions required to achieve EU's 2030 climate and energy goals expressed in the recent REPowerEU communication. In fact, it would ban certain stationary split air-conditioning and split heat pump equipment. According to Folker Franz, Director General of EPEE, representing the Refrigeration, Air Conditioning and Heat Pump Industry in Europe, the current EU F-Gas Regulation quota already cuts HFC use by 88% by 2030. Modelling shows that this will be just enough to install the needed 50 million new heat pumps by then. Thus, the EU would harm its own cause by further cutting the quota as greenhouse gas emissions from F-gases are very small when compared with the emissions that can be saved by replacing fossil fuel heating with heat pump equipment.<sup>79</sup>

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<sup>77</sup> <https://ec.europa.eu/sustainable-finance-taxonomy/>

<sup>78</sup> [https://ecostandard.org/news\\_events/will-the-new-f-gas-regulation-curb-the-use-of-the-worst-greenhouse-gases-four-aspects-that-will-be-decisive/](https://ecostandard.org/news_events/will-the-new-f-gas-regulation-curb-the-use-of-the-worst-greenhouse-gases-four-aspects-that-will-be-decisive/)

<sup>79</sup> [https://www.ehpa.org/fileadmin/user\\_upload/Joint\\_industry\\_Press\\_Release\\_on\\_F-gas\\_Regulation\\_proposal\\_-\\_5\\_April\\_2022\\_52\\_.pdf](https://www.ehpa.org/fileadmin/user_upload/Joint_industry_Press_Release_on_F-gas_Regulation_proposal_-_5_April_2022_52_.pdf)

With the measures to further reducing the use of HFCs, opportunities for natural refrigerants like hydrocarbons open up. The proposal would support the uptake of hydrocarbon-based appliances like propane (R290) and butane (R600a) based heat pumps and air conditioners and commercial R290 heat pumps. It is still to be seen, due to the low availability on the market of products with such gases, if end users will accelerate their adoption or wait for the market to develop.

## 5. Policy proposals for the electrification

This chapter lists a series of policy recommendations aimed at favouring the electrification of energy consumption in order to reduce the demand of primary energy, the dependency from fossil fuels, the decarbonisation of the economy and other important benefits (health, safety, pollution, etc.).

The recommendations are illustrated here taking into account the different scopes that can be achieved (e.g. improving the supply chain or removing market distortions between energy types). Then chapter 6 complements with synthetic tables linking these recommendations with the existing policy framework (i.e. the main regulations and directives) or examples of actions to implement these recommendations.

Recommendations are referred to the European market, not considering any particularities that may exist within single national contexts.

### 5.1 Supply chain: avoiding bottlenecks, lowering costs and ensuring quality from manufacturers to installers

**a. Market analysis and monitoring:** anticipate the **needs and risks of bottlenecks in materials and equipment** in line with the policy objectives, and anticipate possible cost increases due to high demand – making information available to policy makers, ensuring support schemes are in place and policies are designed having supply chain capabilities and needs in mind.

**b. European market of components:** support investment of the manufacturers of electrification solutions to reduce the dependence from extra-EU countries for the provision of crucial components (e.g. chips, refrigerants, etc.) which are scarcely produced on the European market.

**c. Platforms for joint purchases:** create, implement and run platforms facilitating joint purchases of components by EU manufacturers at European level, promoting economies of scale. Promote integrated models to supply final customers like Octopus<sup>80</sup> in UK to ensure low costs, standardisation, and high-quality installations. Ecosystems and platforms are also very important to give market access to the smaller players.

**d. Foster investment in research and development (R&D):** create a clear and transparent policy and legal framework which can create the right conditions for investment in research of improved electrification technologies, and especially heat-pumps (gases,

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<sup>80</sup> <https://octopus.energy/blog/heat-pump-revolution/>

noise, efficiency, high temperature, cost, etc.) by large manufacturers, in partnership with electricity suppliers (e.g. providing sites for experimentations, monitoring in-situ performance). Promote the diffusion of systems using limited impact gases (e.g. replacing F-gas in heat pumps).

**e. Skilled professionals:** anticipate the **needs in skilled professionals** in line with the policy objectives. Promote energy transition jobs with public campaigns to increase their visibility and attractiveness, which should be complemented by collective agreements ensuring good working conditions (e.g. current shortage in the construction sector is partly due to bad working conditions). Review periodically the market trends and needs, and coordinate with educational and vocational training organisations and market actors (e.g. trade organisations) to organise **training, qualification, and certification schemes**. Financial incentives can be conditioned to contracting qualified or certified professionals (e.g., case of the RGE label in France), which create an incentive for professionals to get qualified or certified.

**f. Scale up innovative business models providing guarantees and new financing solutions:** promote EPC contracts and other forms of guaranteed contracts (e.g. Pay-for-Performance or Pay-as-you-Save<sup>81</sup>, or GoSafe with ESI Europe<sup>82</sup>) to ensure that the performance of "innovative" systems is in line with expectations and theoretical potential and that there is a retroaction on bad installation and/or low performance technologies, at the same time improving the qualification of market operators. Make investments into services: besides EPC, other concepts of selling electricity of energy efficiency equipment as service (this is easily applicable for BACS) removes the upfront costs and enables easier access to investment.

**g. Organise the end of lifecycle and link with circular economy policies:** anticipate the possible environmental impacts from electrification (e.g. F-gas leaks from heat pumps).

## 5.2 Renovation rate & phase out of fossil fuels: giving a clear, coherent and strong signal to market players and building owners

**a. Accelerate deep renovation of existing buildings:** prioritize building retrofits granting low energy demand, ensuring that retrofitted buildings are energy efficient and ready for electrification, which will also reduce the power required for heat pumps for both heating and cooling. Policies for building renovation should be designed to favour projects achieving low energy demand, in line with the Energy Efficiency First principle (e.g. through minimum energy performance requirements, higher/bonus rates and/or higher grant or loan cap when achieving lower energy demand).

**b. Promote building smart readiness indicator** and cost – efficient solutions for energy management, ensuring smartness and flexibility of consumption.

**c. Create a transparent, easily accessible, comprehensive and long-lasting subsidy scheme or incentive for deep renovation:** the scheme should be transparent to foster trust in all market actors, easily **accessible** to be exploited by all consumers (including vulnerable ones), **comprehensive** as it should take into account the ancillary costs that might arise when implementing the main improvements of renovation (e.g. replacing radiators when installing a heat pump) and **long-lasting** to allow the market to create

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<sup>81</sup> About these approaches, see for example the SENSEI project: <https://senseih2020.eu/>

<sup>82</sup> About this approach: <https://www.esi-europe.org>

a substructure needed for the scheme to be widely used (e.g. helpdesks set up by consumers organisations or local information centres, information material published and distributed, involved actors like financing institutions able to set up operational ancillary tools, etc.). Manufacturers, installers, and consumers should also be consulted when setting incentive rates, with a mutual commitment: public authorities commit to maintain the incentives over the commitment period (i.e. clear budget commitment), while market actors commit not to increase their prices (with regular review to take into account changes due to external factors).

**d. Eurostat compliance:** ensure that EU funds like structural funds are compatible with EPC and PPP contracts (especially for social housing). This includes following the Guidance on statistical treatment of EPCs and PPPs, considering all the global costs of EPC or PPP to ensure that the EU funds are compatible with payments over the years of the contract.

**e. Plan public funding on societal benefits rather than individual benefits:** some solutions might be cost-effective from a society's viewpoint, but not for the individual building owner; public funding can then be planned to fill this gap, in proportion to the collective benefits that the promoted solution will bring to the society - e.g. better air quality, reduced health costs, etc.

**f. Phase out fossil fuel:** set **overall deadlines to phase out** new installation of fossil fuel technologies in all buildings (starting from public buildings) to make sure that all legislations are consistent on the objective of phasing out fossil fuels in buildings. EU deadlines should be the ultimate deadlines, and Member States should be encouraged to adopt earlier deadlines.

**g. Stop fossil fuel incentives:** stop any public incentives to the installation of fossil fuel technologies in buildings, as soon as possible and at the latest by 2027. Member States should be encouraged to already stop any remaining public incentives to the installation of fossil fuel technologies in buildings and ensure that **no legislation or public scheme would send an opposite signal**. This is not contradictory to tackling energy poverty: the support to low-income, vulnerable or energy poor households should not lock them in with fossil fuel heating systems, that, even with improved efficiency, will expose them to increasing energy prices. This support should be focused first on improving their dwelling and then giving them access to clean and affordable heating.

## 5.3 End users: making the transition easy, attractive, and trustworthy

### 5.3.1 Changing narratives: making the transition desirable and building trust

**a. Change the narratives**<sup>83</sup>: the **policy narratives** should focus on the benefits that electrification brings to consumer rather than on the efforts or constraints required (e.g. phase out fossil fuels). In this context, the role of **multiple benefits of energy efficiency measures** (such as better air quality, improved health conditions, lower costs, single energy supply contract, easier energy management and control) should be emphasised. Arguments also include climate change and the consumption shift of cooling in southern parts of Europe.

**b. Providing examples that show a desirable way:** lead by example with implementing

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<sup>83</sup> About examples of narratives, see for the example the narratives toolbox developed by the Energy Efficiency Watch project: <https://www.energy-efficiency-watch.org/narratives.html>

measures in the public sector, make the achievements visible to citizen and communicate on the positive impacts: measures in the public sector are too often focused on meeting targets, without exploiting the possible spill-over effects. Showcase real-life examples, with testimonies from households and companies (electricity companies can support this, for example in partnership with local authorities or consumer organisations).

**c. Involve consumers in the policy process, and in particular:**

**i. Inform:** communicate market options (e.g. billing, information about changes in tariffs), raise awareness about **different energy behaviours** (e.g. comparing their expenses to the average in the neighbourhood) and enable solutions that can fit their needs **providing real-life examples** (see point b above);

**ii. Consult:** make sure to **consult** consumers and to get **experience from front-runners** who already made the move to electrification, thereby providing the basis for a communication that helps building the **legitimacy** of the related policies and schemes;

**iii. Engage and involve: clearly communicate to consumers (and market actors) about the planned progressive steps** towards the phase out of fossil fuel (from stopping incentives to complete phase out), and involve them in the process of **deploying new or existing technologies, preventing the feeling of imposition** which could lead to misperceptions and sense of violation of other fundamental rights such as access to personal data (e.g. demand-response, smart technologies, etc.);

**iv. Empower:** enhance the energy labels or similar existing tools (e.g. top-ten<sup>84</sup>) to allow for a comparison of different technologies delivering the same function (e.g. electric/induction hobs vs. gas hobs).

**d. Use all available policy instruments:** ensure to use a policy mix including different instruments, not relying solely on market signals (e.g. through carbon pricing or subsidies) but also advocating for regulatory, voluntary and informative measures (e.g. energy labels), considering that consumers tend to respond better to regulations than pure market signals.

**e. Organise monitoring and measurement campaigns:** assess the performance of heat pumps (and possibly other key technologies) in real-life conditions, and how they evolve over time. This can help answering criticisms that heat pumps (or other technologies) would not be effective under certain conditions (e.g. very cold days). This would also provide evidence to showcase the "real-life" performance of technologies, and to develop advice about optimal use and maintenance of technologies to ensure that performance is maintained over time.

### 5.3.2 Ensuring neutral advice and qualified skilled professionals

**a. Develop one-stop-shops** (or similar structures) which can:

**i. Foster trust:** make sure consumers can **easily access neutral advice**, so that installers or retailers are not the only source for information for final customers;

**ii. Go beyond single measures:** Provide an **overall picture** about all energy sav-

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<sup>84</sup> <https://www.topten.eu/>

ings measures which can be implemented in buildings in a comprehensive manner (e.g. with building renovation passports), avoiding lock-ins or overall higher costs and offering structured and comprehensive solutions. This also includes taking into consideration the energy efficiency first principle, ensuring the design of the HVAC system is aligned with the reduced needs of the renovated building.

**iii. Ease the quest for trustworthy professionals:** make it easy for consumers to find the skilled professionals they need (e.g. with user-friendly online registers of qualified or certified professionals).

**b. Collective decisions (condominiums):** review regulations to facilitate collective decision-making in condominiums and avoid that the minority of inhabitants may block the majority, while providing specific solutions for vulnerable co-owners or tenants.

### 5.3.3 Support consumers according to their needs

**a. Distributional effects:** whenever a revision or a new policy might generate higher costs to consumers, **assess** how these impacts are distributed (according to income levels, to areas, etc.) and **how consumers can overcome these impacts or not**. This applies especially to low-income and vulnerable households but is not limited to them (e.g. middle-class households, SMEs or small municipalities might also face difficulties due to increasing energy prices or high upfront costs of energy efficiency and electrification solutions). Whenever regressive effects or significant impacts on low-income or vulnerable households or SMEs are identified, **plan measures to compensate these effects**.

**b. Split incentives:** design solutions which can be used in the private-rented sector in order to overcome the landlord-tenant dilemma. This can be done by promoting contracts capable of dividing the costs and benefits between the parties.

### 5.3.4 Promote safety of the buildings' electricity installations

**a. Introduce incentives for improving internal cabling in buildings coupled with standards designed to ensure that new and retrofitted buildings are compliant with electrification loads.**

## 5.4 Regulatory framework – removing market distortions: making the price signal right

**a. Make the switch in energy taxation: push Member States to revise their taxes on electricity and fossil fuels** so that energy taxes do not favour fossil fuels over electricity (see for example how the Netherlands have progressively inverted the taxation rates of natural gas and electricity to encourage switching to electricity)<sup>85</sup>.

**b. Remove market distortions on the electricity bill:**

**i. RES charges** should be **fairly distributed among energy types**, and not only applied to electricity;

**ii. Other charges (not related to own electricity consumption** – e.g. TV charges, cost of public lighting, etc.) should be well highlighted, so that they are not per-

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<sup>85</sup> For more examples, see: <https://www.raponline.org/knowledge-center/aligning-heating-energy-taxes-levies-europe-climate-goals/>

ceived by consumers as part of the cost of electricity. If possible, remove these other charges from electricity bill;

**iii.** The **cost of the distribution & transmission grid** should be more equitable and cover all market actors (including large consumers) in a proportionate manner.

**c. Integrate externality costs in all energy prices:** make sure that **externalities** (i.e. GHG emissions) are well and fairly integrated in all energy prices (currently a carbon price is included in the electricity prices due to the ETS, whereas this is not always the case for fossil fuels in buildings, depending on Member States), while anticipating the regressive effects of **carbon pricing**.

**d. Provide cost comparisons using comparable scope** (between technologies and energy types, but also types of consumers and consumptions). In particular, the comparisons should be based on energy costs (= energy prices \* energy consumption) and not on energy prices alone or investment costs alone. Ideally the comparisons should consider **lifecycle costs** (including investment, operation and maintenance costs).

**e. Promote dynamic tariffs:** value the flexibility that new electricity technologies or energy management devices can bring. For example, the network tariffs in Spain have been changed in June 2021 to make it possible for consumers to subscribe to two different power levels, according to two timeslots (peak / off-peak), to make it attractive to consumers to move flexible high-power usage (e.g. EV charging, dishwashers, etc...) to off-peak periods (night and week-ends).

## 5.5 Grid and network

**a. Promote investment on the electric grid:** facilitate the dynamic process of electrification. Flexibility can be achieved, ensuring reliability, availability, and safety of energy services based on electricity consumption.

**b. Enhance flexibility:** foster a regulatory framework oriented towards untapping the full potential of electrification, such as enabling the participation of electricity appliances in the provision of flexibility to local flexibility markets, regulations aimed at reducing and/or moving peak loads for heat pumps and EV recharging (e.g. through variable prices and differentiated temperature according to the usage of different rooms and spaces).

**c. Promote alternative models for heat pumps:** traditional and micro district heating/cooling networks powered by RES solutions can both reduce the numbers of systems to install and reduce the load on the low voltage distribution network (both thanks to large thermal storage and to the possibility to link directly to medium voltage networks). Information activities can be tailored to the target groups (e.g., local authorities and urban planners, building owners, technical consultancies).

**d. Automation systems:** support the development of monitoring and automation systems designed for heat pumps considering the possibility to manage them according to market prices and demand response schemes (managed by distributors instead of dispatchment and transmission operators). Many changes are occurring – cloud technologies, more and more the building management part, trends like IoT, clouds, many more intelligent devices, cyber security – between technology and regulation that require flexibility and a step by step approach.

## 6. Policy matrix and suggestions for actions

As a first general note, the changes needed do not always require new policies. A first precondition to achieve the electrification of buildings is that existing or planned EU legislations be fully transposed, enforced and implemented with appropriate means, including about financing, monitoring and verification. Complementary initiatives might be as important as the legislations, to ensure an effective implementation. Moreover, national legislations and programmes are also essential, due to the diversity in situations among European countries, and thereby the need for tailored interventions.

The tables provided in this chapter are designed to put together the proposal of Chapter 5 with the existing legislation at EU level.

### 6.1 Supply chain

The major changes needed in the supply chain of electrification technologies and services are **unlikely to happen at a sufficient pace by market effects alone**. This requires a **strategic planning**, with a comprehensive view of what is needed for the energy transition expected in the prospective scenarios to happen in practice. EU legislations and complementary initiatives can support, promote, and even require, the development of such planning by the Member States. Moreover, **cross-country cooperation** could help the upstream part of the supply chain (raw materials, manufacturers). Whereas the downstream part (installers) includes a majority of SMEs that can be supported by national schemes.

	EED	EPBD	Eco-design/ energy - labelling	Governance Regulation	Electricity market reg.	RED (II)	RepowerEU / cross - cut / other
<b>Market analysis and monitoring</b>				●			●

The **Joint Research Centre** could prepare a regular update about the materials demand needed for the energy transition on the end-users' side, like done about RES technologies<sup>86</sup>. Or the end-users' technologies (like heat pumps) or materials (e.g. insulation materials) could be included in the **"strategic technologies"** for which the European Commission monitors the demand for critical materials<sup>87</sup>.

Detailed elaboration of policy measures in **NECPs** could assist the analysis of market impacts. An *EU-wide assessment of National Energy and Climate Plans from 2020*<sup>88</sup> notes lack of details in some aspects of policy measures, including identifying investment needs, mobilising funding, research and innovation and competitiveness. By

<sup>86</sup> See for example: Carrara, S., Alves Dias, P., Plazzotta, B. and Pavel, C. (2020). Raw materials demand for wind and solar PV technologies in the transition towards a decarbonised energy system, doi:10.2760/160859, JRC119941

<sup>87</sup> See [https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials\\_en](https://single-market-economy.ec.europa.eu/sectors/raw-materials/areas-specific-interest/critical-raw-materials_en)

<sup>88</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52020DC0564&from=EN>

providing details of policy measures and impact on markets of materials and needed equipment, the capability of the market to meet the expected impacts from the policies (e.g. increase in renovation rates or installations of heat pumps) could be identified. This is particularly important to identify possible bottlenecks or risks of inflation effects (the same point applies to the needs in skilled professionals, see below). At national level, electricity companies can review the studies and information available (e.g. in partnership with the national energy agency or research institutions), for discussions with the national authorities and the trade organisations.

Consultation about policies should include discussions with the trade organisations about how fast they can adapt their production and delivery compared to what would be needed to meet the policy objectives.

<b>European market of components</b>							●
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The **European Raw Materials Alliance** (ERMA), launched in September 2020, is part of an [Action Plan on Critical Raw Materials](#), which looks at the current and future challenges and proposes actions to reduce Europe's raw materials' dependency on third countries, also strengthening domestic sources and diversifying supply options. The Action Plan and related Alliance have firstly be meant to secure the supply chain of critical materials for renewable energy technologies, batteries, and e-mobility. Hence an initial focus on the rare earths and magnets value chain. The scope of the Action Plan and ERMA could now be broadened based on the market analysis mentioned above, to cover other critical materials needed to achieve the electrification of buildings.

<b>Platforms for joint purchases</b>							●
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As part of the REPowerEU plan, the European Commission and Member States have set up an EU Energy Platform for the voluntary common purchase of gas, LNG and hydrogen. A similar initiative could be proposed to secure the supply chain of energy efficiency technologies and services, after **consulting the stakeholders** about their needs and the opportunities to **develop platforms for voluntary joint purchases**.

While large manufacturers already have their own supply chain strategies (as part of improving their competitive advantages), the stakeholders involved in delivering the electrification of buildings include many SMEs (and even a majority of individual or very small companies, when considering the installers). Platforms for joint purchases could **help SMEs face the effects of inflation**, and optimize the supply chain. Which should ultimately result in **better prices for final customers**.

Investment in research and development				●			●
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Research, innovation and competitiveness are one of the five dimensions of the Energy Union. This is therefore one part of the **NECPs** reported by the Member States. However, the actual R&D plans and capacities vary significantly among countries. Investments in research and development are also supported by **European research programmes** (e.g. Horizon Europe) and **operational programmes (ESIF, InvestEU, CEF)**. It is also relevant for the national modernization plan for the **Modernisation Fund** if the country is eligible<sup>89</sup> (Italy is not).

At EU level, the Strategic Energy Technology (SET) Plan supports technologies that have higher impact on transition, promoting, among other strategic research, also storage, integration, cost reduction and new technologies for consumers. There is no SET working group focused on the technologies needed for electrification of buildings. However, these technologies are covered by the working groups on energy efficiency in buildings and energy systems, and positive energy districts".

However, the implementation of the SET Plan tends to be **more focused on technologies for energy supply and networks** than on technologies for the demand-side. For example, all European Technology and Innovation Platforms (ETIPs) are mostly about energy supply technologies plus one on smart networks. Nevertheless the ETIP on heating and cooling technologies includes a technology panel on heat pumps. **Another ETIP on energy management technologies** (including technologies for EV charging) **could be suggested**.

Moreover, the massive roll out of electrification technologies might raise questions about their end of lifetime, and how they can either be repaired, reused or recycled (see point below about the link with the circular economy legislation and plans).

Skilled professionals	●	●				●	
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**EPBD** recast (Art 15) obliges Member States to put in place measures and financing to **promote education and training** to ensure that there is a sufficient workforce with the appropriate level of skills corresponding to the needs in the building sector, which is planned to be a part of **national building renovation plan**. Overall the issue of skills and possible **shortage** of building professionals has been raised since 2011 at EU level with the Build Up Skills initiative. Similarly, the European organisations representing the electrical and construction industries (e.g., European Electrical Contractors' Association EuropeOn, EHPA, AVERE) launched the Skills4Climate initiative in December 2019, along the first announcements by the Commission about the EU

<sup>89</sup> <https://modernisationfund.eu/>

Green Deal, to remind that this would not happen without skilled workers. However, this has not impeded that many countries currently face shortage of skilled professionals to implement their renovation plans.

Article 26 of the **EED recast** clarifies and reinforces the provisions on **availability on qualification, accreditation and certification schemes** for different energy services providers, energy auditors, energy managers and installers. New provisions will require Member States to assess the schemes every four years starting as of December 2024. The current Article 16 on these issues has indeed been transposed and implemented to various extents according to the countries.

Article 18 of **RED II** states that Member States shall, among others, ensure that certification schemes or equivalent are available for **heat pump installers**.

Qualification, accreditation and certification schemes are essential to make that final customers can trust the installers and other service providers. However, complementary measures are needed to overcome the current shortage of skilled professionals<sup>90</sup>, not only faced by the building industry but also for electric contractors in general. In many countries, this can be due to the bad image of technical curriculums and jobs.

A quick change in this situation would require **national plans to improve the attractiveness of technical curriculums and jobs**, the development of the **capacities for education and vocational training** in the fields of energy transition. Initiating these measures should be a **top priority** as it is an essential precondition for the energy transition to happen. The shortages already observed now will worsen when considering the needed increase in installation rates for electrification technologies. While upskilling professionals already active in the field could be done within several months, increasing significantly the number of new professionals will require several years. It is therefore **urgent** that the Member States take action now to plan the development of the energy transition workforces.

<b>Scale up innovative business models</b>	●	●					
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The **EED** previously promoted EnPC and motivated public bodies to save energy and reduce procurement via contracting energy performance services. The role of EnPC is emphasized in **EPBD** recognizes the capacity of EnPC to deliver performance in thermal systems (Art. 14 and Art. 15) and strengthens national obligations regarding the establishment of National building renovation plans (earlier called LTRS).<sup>91</sup>

<sup>90</sup> This was discussed in details in a recent episode of the Watt Matters podcast: <https://foresightdk.com/an-attractive-profession/>

<sup>91</sup> <https://publications.jrc.ec.europa.eu/repository/handle/JRC123985>

## 6.2 Renovation rate & phase out of fossil fuels

	EED	EPBD	Eco-design/ energy - labelling	Governance Regulation	Electricity market reg.	RED (II)	RepowerEU / cross - cut / other
<b>Accelerate deep renovation</b>		●					●

In the **EPBD** recast Mandatory minimum energy performance standards (MEPS) for existing buildings means existing buildings need to meet a certain energy efficiency level. The recommendation would include MS to follow on this standard and the deep renovation standards in their **National building renovation plans & EPC scale**. Important suggestion by BPIE also includes changing and adding the legally binding **definition of deep renovation** into related legislative framework, like Taxonomy or Recovery and resilience plans.<sup>92</sup>

<b>Create a transparent, easily accessible, comprehensive and long-lasting subsidy scheme or incentive for (deep) renovation</b>		●					●
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There are many clear recommendations, mostly linked to **EPBD**, for countries to align their funding programs with renovation plans and to ensure, as stated in EPBD, a one-stop-shop, which offers information on the renovation to citizens. This can lead to integrated home renovation services.<sup>93</sup>

<b>Eurostat compliance</b>							●
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**Guidance on statistical treatment of EPCs and PPPs<sup>94</sup>** should be used for the purpose by the public sector stakeholders.

<b>Plan public funding on societal benefits rather than individual benefits</b>							●
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<sup>92</sup> [https://www.bpie.eu/wp-content/uploads/2021/11/BPIE\\_Deep-Renovation-Briefing\\_Final.pdf](https://www.bpie.eu/wp-content/uploads/2021/11/BPIE_Deep-Renovation-Briefing_Final.pdf)

<sup>93</sup> Milin, Bullier, Towards large-scale roll out of "integrated home renovation services" in Europe, ECEEE, 2021.

<sup>94</sup> [https://ec.europa.eu/eurostat/documents/1015035/8885635/guide\\_to\\_statistical\\_treatment\\_of\\_epcs\\_en.p%20df/f74b474b-8778-41a9-9978-8f4fe8548ab1](https://ec.europa.eu/eurostat/documents/1015035/8885635/guide_to_statistical_treatment_of_epcs_en.p%20df/f74b474b-8778-41a9-9978-8f4fe8548ab1)

Refers to all the policies, but mainly national strategies and operational programmes' planning. One of the possibilities is also using the results of the existing projects COMBI & Multi-EE, but mainly upcoming results of the MICAT Project, focusing on how to integrate the multiple benefits (from the societal perspective) of the energy efficiency projects into the CBAs.

<b>Phase out fossil fuel</b>	●	●	●				●
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**Ecodesign** recast or **Energy labelling** could be the tool for starting the phase out by setting up common efficiency requirements for all technologies and phasing out technologies in certain energy classes.<sup>95</sup> As stated in the **EPBD**, the National building renovation plans could require phaseout strategy (as some already do have), and the performance requirements for buildings could explicitly include renewable energies, fossil-free new builds and technical systems. New (recast) EED excludes energy savings from fossil fuel from the energy savings obligation of countries, a proposal that should be supported. Member states should also encourage regional and local authorities to prepare local heating and cooling plans at least in municipalities having a total population higher than 50.000.<sup>96</sup>

<b>Stop fossil fuel incentives</b>		●					●
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The **EPBD** recast bans public funding for fossil fuel boiler installations from 2027. The **EU 'Save Energy' plan (REPowerEU)** recommends moving forward the EU deadline to 2025.<sup>97</sup>

### 6.3 End users

	EED	EPBD	Eco-design/ energy - labelling	Governance Regulation	Electricity market reg.	RED (II)	RepowerEU / cross - cut / other
<b>Change the narratives</b>	●	●					●

Art. 3 of recast **EED** obliges the application of cost-benefit methodologies with proper assessment of multiple benefits of energy efficiency from the societal perspective.

<sup>95</sup> <https://ecostandard.org/wp-content/uploads/2020/12/Five-Years-Left-How-ecodesign-and-energy-labelling-Coolproducts-report.pdf>

<sup>96</sup> [https://www.oeko.de/fileadmin/oekodoc/Phase-out\\_fossil\\_heating.pdf](https://www.oeko.de/fileadmin/oekodoc/Phase-out_fossil_heating.pdf)

<sup>97</sup> [https://ec.europa.eu/commission/presscorner/detail/en/fs\\_22\\_3137](https://ec.europa.eu/commission/presscorner/detail/en/fs_22_3137)

<sup>98</sup> <https://www.penny-project.eu/>

**Chapter IV** of recast **EED** is dedicated to “consumer information and empowerment”, which is already aiming at changing the narrative on energy efficiency towards end users.

Art. 21, recital 2, requires Member States to take appropriate measures to promote and facilitate an efficient use of energy, including a range of instruments and policies to promote behavioural change (e.g. incentives, access to finance, information provision, training activities, digital tools, etc.). Moreover, market actors should also facilitate consumers by setting up one-stop-shops, single point of contacts, and spreading information on available measures and actions. This article could be further strengthened and could directly refer to new art. 3 of the recast EED (see above).

Art. 18 of the **Electricity Directive** (2019/944) is dedicated to billing information. Recital 1 states that information directed to consumers must be *accurate, easy to understand, clear, concise, userfriendly and presented in a manner that facilitates comparison*. In future recast of this directive the article could be further strengthened and include further indications.

On top of European legislation, the change of narrative should be pushed at national level (e.g. through measures listed in the Integrated National Energy and Climate Plans).

Finally, a list of best practices on how to best address consumers can be found in past or ongoing EU projects, such as PENNY<sup>99</sup>. Quantification and monetisation of multiple impacts of energy efficiency measures can be done using tools such as the upcoming MICATool<sup>99</sup>.

<b>Providing examples that show a desirable way</b>	●		●				●
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Art. 6 of recast **EED** refers to the exemplary role of the public sector, pushing MS to renovate at least 3% of the flooring area occupied by public bodies each year. In addition to the older version of the EED, buildings not owned but occupied by public bodies should also undergo the same principle. Instead of merely setting requirements or targets that the public sector should comply with, and that it can go beyond that by exploiting better the potential spill-over effects from using actions in the public sector to demonstrate positive impacts for engaging others to do the same (e.g. the case of BATEX in Brussels<sup>100</sup>). Exemplary role of the public sector is also included in art. 9 of the recast **EPBD**.

<sup>99</sup> [www.micat-project.eu](http://www.micat-project.eu)

Art. 18 of the **Electricity Directive** (2019/944) is dedicated to billing information. Recital 1 states that information directed to consumers must be accurate, easy to understand, clear, concise, userfriendly and presented in a manner that facilitates comparison. Research has shown that facilitating comparison amongst similar consumers (e.g. amongst neighbours with the same number of family members) is an effective driver to increase the adoption of virtuous behaviour<sup>101</sup>.

On top of European legislation, the change of narrative should be pushed at national level (e.g. through measures listed in the Integrated National Energy and Climate Plans).

The Energy Labels could also provide examples on how to use appliances in a desirable way.

Art. 21, recital 2 of the **EED** requires Member States to take appropriate measures to promote and facilitate an efficient use of energy. Moreover, market actors should also facilitate consumers by setting up one-stop-shops, single point of contacts, and spreading information on available measures and actions. Art. 9 of the recast EPBD is also advocating for creation of supporting facilities and one-stop-shops which can showcase examples of successful renovation projects (a successful example is the OKTAVE initiative in France – Grand Est)<sup>102</sup>.

<b>Involve consumers in the policy process</b>							●
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Involving consumers in the policy process relates to all policies and all levels (EU, national, regional, local, etc.). Some insights can be found in documents such as RE-Power EU<sup>103</sup> or Playing my part<sup>104</sup>.

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<sup>100</sup> [https://enfirst.eu/wp-content/uploads/13\\_OPTIMISING-BUILDING-ENERGY-DEMAND-BY-PASSIVE-LEVEL-BUILDING-CODE.pdf](https://enfirst.eu/wp-content/uploads/13_OPTIMISING-BUILDING-ENERGY-DEMAND-BY-PASSIVE-LEVEL-BUILDING-CODE.pdf)  
<sup>101</sup> [https://www.penny-project.eu/wp-content/uploads/2019/10/PENNY-Deliverable-5.8-Policy-Brief\\_final.pdf](https://www.penny-project.eu/wp-content/uploads/2019/10/PENNY-Deliverable-5.8-Policy-Brief_final.pdf)  
<sup>102</sup> <https://www.oktave.fr/>  
<sup>103</sup> [https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe\\_en#saving-energy](https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en#saving-energy)  
<sup>104</sup> <https://iea.blob.core.windows.net/assets/cbc97c70-8bcf-4376-a8a9-4cd875195f6a/Playingmypart.pdf>

<b>Organise monitoring and measurement campaigns</b>		●					
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Art. 20 of the recast **EPBD** mandates MS to set up inspection schemes for residential and non residential buildings. Campaigns should be organised on a regular basis and include an assessment proposing improvement measures for increasing energy savings.

<b>Use all available policy instruments</b>				●			●
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A policy to define different measures are **NECPs**, where a combination of appropriate policy instruments could be defined. It's also relevant to use tools to evaluate policy interactions so that the double accounting or non-adequate financial analysis is avoided.<sup>105</sup>

<b>Develop one-stop-shops</b>	●	●					
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One-stop-shops are already an obligation from the on-going **EPBD**. There are many examples of how effective roles could be introduced to one-stop-shops.<sup>106</sup> Art. 21, recital 2, of the recast **EED** also require market actors to set up one-stop-shop or similar initiatives.

<b>Collective decisions</b>							●
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In MS with single owners of apartments in multi-family buildings, the decision on implementing collective energy efficiency measures, such as the thermal renovation of the building envelope, are taken collectively by the majority (51%) of apartment owners.<sup>107</sup> If not, this should be the case of the policy adjustment. This is defined in non-energy regulation linked to co-ownership of buildings.

<b>Distributional effects and split incentives</b>							●
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Both refer to all the policies, but mainly national strategies and operational programmes' planning.

<sup>105</sup> V. Oikonomou, A. Flamos & S. Grafakos (2014) Combination of Energy Policy Instruments: Creation of Added Value or Overlapping?, Energy Sources, Part B: Economics, Planning, and Policy

<sup>106</sup> [https://e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/jrc113301\\_jrc113301\\_reportononestop-shop\\_2017\\_v12\\_pubsy\\_science\\_for\\_policy.pdf](https://e3p.jrc.ec.europa.eu/sites/default/files/documents/publications/jrc113301_jrc113301_reportononestop-shop_2017_v12_pubsy_science_for_policy.pdf)

<sup>107</sup> Blumberga, A.; Bazbauers, G.; Vancane, S.; Ijabs, I.; Nikisins, J.; Blumberga, D. Unintended Effects of Energy Efficiency Policy: Lessons Learned in the Residential Sector. Energies 2021

Promote safety of the buildings' electricity installations							●
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Art. 20 of the recast **EPBD** mandates MS to set up inspection schemes for residential and non residential buildings. On top of assessing the current status of heating and air conditioning equipment of buildings, a check on the safety of the electricity installations in buildings could be included.

## 6.4 Regulatory framework – removing market distortions

	EED	EPBD	Eco-design/energy – labelling	Governance Regulation	Electricity market reg.	RED (II)	RepowerEU / cross – cut / other
Make the switch in energy taxation							●

The **Energy Taxation Directive** was evaluated in 2019, it can play an important role as one of the incentives for energy transition, low greenhouse gas emissions and energy savings. Within the proposed ETD recast, the suggestion is that fuels start being taxed according to their energy content and environmental performance rather than their volume. Which would provide a fairer ground. The ETD sets the minimum rates and conditions for the energy taxes. It is then up to the Member States to set their own tax rates and conditions. The **Member States** should ensure that the energy taxes create **price signals in line with their objectives for the energy transition** (as done in the Netherlands for example, to promote the phase out of fossil gas)<sup>108</sup>.

Remove market distortions on the electricity bill					●		
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Bills should be clear, correct, concise and presented in a way that makes comparisons easy, this is a part of the Directive on the internal electricity market. This was also previously covered by the current **Article 10 of the EED (Billing information for gas and electricity), whereas now billing information for electricity is covered by the Directive on the internal electricity market**, and the billing information for gas is covered by the new Article 16 of the EED recast. When not the case already, the Member States should set requirements so that electricity suppliers make it clear and simple for consumers to distinguish the costs related to their electricity consumption, the network costs and the other charges or taxes.

<sup>108</sup> For a more detailed discussions on how to make fair energy taxation, see: <https://www.raonline.org/knowledge-center/aligning-heating-energy-taxes-levies-europe-climate-goals/>

More generally, the Member States should design the funding scheme for RES so that it does not rely on charges on electricity only. The development of RES for electricity is indeed not only meant to replace current fossil fuel electricity generation, but also to replace energy supply from other energy carriers (e.g. when switching from fossil gas to electricity for heating, or from combustion engines to electric motors for mobility). **The charges used to finance this energy transition should therefore be spread fairly among the different energy carriers**, and not restricted to electricity.

About networks tariffs (that are regulated), the Member States should ensure that the tariff design does not create **cross-subsidisation between sectors or customer groups**. As this may then create a disadvantage for the use of electricity for certain customer groups.

<b>Integrate externality costs in all energy prices</b>								●
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**Emission Trading Scheme** revision and extension proposal (agreed by the Environmental Council) includes parallel ETS for road transport and buildings from 2025, with fuel suppliers (rather than households or car drivers) required to surrender allowances from 2027. This should help to ensure a level playing field among energy carriers, as regards the internalisation of carbon price, as up to now only electricity and district heating were covered by the ETS. Which created a market distortion with an advantage given to heating oil and natural gas (when considering options for heating). Except in the Member States that already corrected this by introducing carbon taxes on oil and gas.

It is also relevant to follow on the proposal and national Social Climate Fund plans to follow on the financing of transition.

<b>Promote dynamic tariffs</b>								●
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**Directive on the internal electricity market** defined dynamic electricity price contract. An important point for dynamic tariffs is that electricity cost comparisons between fixed and dynamic pricing contracts can be calculated and that broad policy actions for regulators are defined.<sup>109</sup>

Moreover, **National Regulatory Authorities** have an essential role in designing the conditions for **network tariffs** in a way that can send price signals to consumers about when to use electricity (for flexibility end-uses), thereby valuing the flexibility in electricity use.

<sup>109</sup> [https://www.beuc.eu/sites/default/files/publications/beuc-x-2022-033-report\\_risks-and-benefits-of-dynamic-electricity-pricing.pdf](https://www.beuc.eu/sites/default/files/publications/beuc-x-2022-033-report_risks-and-benefits-of-dynamic-electricity-pricing.pdf)

Similarly, National Regulatory Authorities should also ensure that energy companies and aggregators developing demand-response offers can take part in the electricity and capacity markets, to create opportunities of business models for demand-response.

## 6.5 Grid and network

	EED	EPBD	Eco-design/ energy - labelling	Governance Regulation	Electricity market reg.	RED (II)	RepowerEU / cross - cut / other
<b>Promote investment on the electric grid</b> <b>Enhance flexibility</b>	●				●		

In the **EED** (Art 15) the Commission should ensure that energy efficiency and demand-side response can compete on equal terms with generation capacity and that it implements a cost-efficient and energy-efficient infrastructure investment programme and properly account for the energy efficiency and flexibility of the grid.

<b>Promote alternative models for heat pumps</b>						●	●
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Article 24 of **RED II** obliges the MS to (as one of the two options) to increase the share of energy from renewable sources and from waste heat and cold in district heating and cooling by at least one percentage point as an annual average calculated for the period 2021 to 2025 and for the period 2026 to 2030.

<b>Automation systems</b>		●					●
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The recast **EPBD** mentions BACS a lot, with automation being obligatory in some building types and incentivised in others. It also introduces a smart readiness indicator (SRI) which, although voluntary at the Member State level, could assist further implementation of BACS.<sup>110</sup>

<sup>110</sup>[https://eubac.org/wp-content/uploads/2021/03/EPBD\\_impacts\\_from\\_building\\_automation\\_controls.pdf](https://eubac.org/wp-content/uploads/2021/03/EPBD_impacts_from_building_automation_controls.pdf)

## Conclusions

The study highlighted the solutions available to electrify the energy consumptions of the building sector. Through technologies such as heat pumps, building automation control systems and smart technologies, induction hobs, etc. it is possible to achieve many benefits of relevance in these days. These are the main ones:

- Reduction of GHG emissions.
- Reduction of final and primary energy consumption.
- Reduction of dependence from natural gas.
- Improvement of comfort and safety in buildings.
- Strengthening of an important value chain at EU level, from technology manufacturing to installation and maintenance.

The diffusion of electrification technologies is key to reach the EU energy and climate targets and the new objectives defined in the REPowerEU package. For this reason it is fundamental to overcome the existing barriers, summarised in the following table.

	Poor economic indicators	Lack of access to finance	Split incentives dilemma	Need to improve the grid	Lack of users' expertise	Users' attitudes and habits	Operators' skills	Challenges in integration and complexity and complexity	Lack of awareness in public sector	Heavy bureaucracy on RES installation	Tariffs' barrier
Heat pumps	•••	•••	•••	••••	••••	••••	••••	••••	•••	••••	••••
Induction hobs	•••	••	•	•	••••	••••	•	•	•	-	••••
Building infrastructure for EV charging	•••	•••	•	••••	••	••	•	•••	••	-	•••
BACS	•	••	••••	•	••••	•	••	••	•••	-	•
Cooling	•••	•	••	•••	•	•	•	•	•	•••	••
Tumble driers	••	•	•	•	••	••	•	•	-	-	•

Table 11. Relevance of existing barriers for single technologies.



The existing policies already work in the direction of reducing the effect of the barriers that hampers or delay the use of electrification technologies, however, there is much more to be done to develop the industrial and commercial value chains and distribution chains. This requires action both from the EU side, to ensure that the adoption of the Fit for 55 and REPowerEU packages provide for clear directions and the right tools, and from Member States, required to transpose the new directives when available and to introduce local regulations tailored to their national bottlenecks.

The study produced a series of proposals aimed at:

- Developing the supply chain for electrification technologies.
- Giving clear indication to the path toward the substitution of fossil fuels.
- Making the transition to electrification solutions attractive and trustworthy for end-users.
- Removing market distortions through appropriate taxes and carbon pricing.
- Promote and accelerate the development and digitalisation of electric grids.

The following table summarises the link between proposed policies and the *acquis communautaire*.

Link between proposed policies and EU directives, regulations, and proposals	EED	EPBD	Eco-design/energy labelling	Governance regulation	Electricity market regulation	RED	REPowerEU / cross – cut / other
Market analysis and monitoring				•			•
European market of components							•
Platforms for joint purchases							•
Investment in R&D				•			•
Skilled professionals	•	•				•	
Scale up innovative business models	•	•					
Accelerate deep renovation		•					
Create a transparent, easily accessible, comprehensive and long-lasting subsidy scheme or incentive for (deep) renovation		•					•
Eurostat compliance							•
Plan public funding on societal benefits rather than individual benefits							•
Phase out fossil fuel	•	•	•				•
Stop fossil fuel incentives		•					•
Change the narratives	•	•					•
Providing examples that show a desirable way	•		•				•
Involve consumers in the policy process							•
Organise monitoring and measurement campaigns		•					
Use all available policy instruments				•			•
Develop one-stop-shops	•	•					
Collective decisions							•
Distributional effects and split incentives							•
Promote safety of the buildings' electricity installations							•
Make the switch in energy taxation							•
Remove market distortions on the electricity bill					•		
Integrate externality costs in all energy prices							•
Promote dynamic tariffs					•		
Promote investment on the electric grid to enhance flexibility	•				•		
Promote alternative models for heat pumps						•	•
Promote automation systems		•					•

Table 12. Link between proposed policy and EU legislation and proposals.

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The views expressed in this document are the sole responsibility of the authors and do not necessarily reflect the views of the interviewed stakeholders.