15TH IEA HEAT PUMP CONFERENCE
MAY 26–29, 2026 | HOFBURG VIENNA 2026
DECARBONISATION THROUGH INNOVATION

"Product regulations: regulatory drivers and challenges for heat pumps"

Mélanie Auvray, Maria Spanó

European Heat Pump Association, Brussels, 1000, Belgium

Abstract

Heat pumps are a strategic technology for achieving the European Union's climate-neutrality, energy-security, and competitiveness objectives. Their large-scale deployment depends not only on market readiness but also on the coherence and proper functioning of the EU regulatory landscape. This paper analyses how the current EU product policy framework influences the roll-out of heat pumps and assesses the extent to which it enables – or inadvertently adds regulatory and compliance burdens that risk constraining – the deployment of 30 million heat pumps by 2030 as targeted under REPowerEU.

The study reviews the main legislations shaping product innovation and market access, including Ecodesign Directive and Energy Labelling Framework Regulation, the revised F-gas Regulation, emerging per- and polyfluoroalkyl substances (PFAS) restrictions, and the growing set of digital and grid-integration requirements. It places these within the broader context of Single Market governance, where interactions across legislative files, misaligned timelines, and divergent national interpretations often generate compliance burdens and market fragmentation.

The findings show that EU product rules have clearly driven progress in efficiency, quality, and long-term investment in heat pump technologies. Yet the cumulative effect of overlapping obligations and inconsistent implementation increasingly acts as a structural barrier. Additional national testing points, fragmented safety rules for flammable refrigerants, and divergent digital-data requirements undermine economies of scale and raise costs for both manufacturers and consumers. These frictions weaken the integrity of the Single Market at a moment when rapid and affordable deployment is essential. To address this, this research paper proposed some recommendation that should aim at better coordination and simplification of EU rules, by creating a more coherent regulatory ecosystem that would strengthen industrial competitiveness, enhance consumer access, and reinforce the conditions needed for a cost-effective, climate-neutral heating transition.

Selection and/or peer-review under the responsibility of the organizers of the 15th IEA Heat Pump Conference 2026.

Keywords: Heat pump deployment; EU product regulation; European Single Market;

1. Introduction Introduction

The transition to sustainable heating and cooling is central to the European Union's climate-neutrality and energy-security agenda [1]. Heating and cooling together account for half of Europe's final energy consumption and remain one of the hardest sectors to decarbonise [2]. Within this landscape, heat pumps have emerged as the most efficient and scalable solution. Field measurements and EU assessments show that modern heat pumps typically achieve seasonal performance factors of around 3–4 or higher in real-world operation, significantly outperforming fossil boilers in terms of delivered heat per unit of energy input, while system-level studies highlight that heat-pump can provide substantial demand-side flexibility and facilitate the integration of variable renewable electricity, underscoring their central role in credible decarbonisation strategies for Europe's heating sector [3].

This strategic importance is reflected in the EU's political commitments. The REPowerEU Plan calls for a rapid acceleration of heat pump deployment, with the aim of reaching 30 million additional units by 2030 [4]. Meeting this ambition requires not only industrial capacity and consumer willingness to adopt recent technologies but also a regulatory environment that supports their deployment: in practice, the regulatory framework can be just as decisive as the technology itself.

Today, the heat pump sector is shaped by a complex web of EU-level and national rules. Core product policies such as the Ecodesign Directive [5], together with the Energy Labelling Framework Regulation [6] and corresponding delegated regulations, establish minimum efficiency and performance standards. The refrigerant transition is driven by the revised F-gas Regulation [7], while emerging chemical policies, notably the proposed per- and polyfluoroalkyl substances (PFAS) restriction [8], are beginning to influence material choices and system design. Beyond these traditional pillars, new requirements are arising from digitalisation and data-governance initiatives, cyber-security legislation, and the integration of heat pumps into electricity-system planning. Some obligations stem from product regulation, others from broader energy-system or environmental frameworks. Their timelines and scopes do not always evolve coordinated.

The cumulative effect is a regulatory landscape that can both enable and constrain heat pump deployment. Well-designed rules push efficiency, accelerate innovation, and protect consumers. But overlapping obligations, misaligned revisions, and differences in national implementation can increase compliance costs, slow product-development cycles, and limit market access. These dynamics directly influence manufacturers' strategies, product affordability, and the ability of the EU Single Market to function as intended.

This situation raises two interrelated questions. First, ***to what extent does the current EU product regulatory framework act as an enabler of sustainable heat pump roll-out?*** Second, ***how can this framework be designed or coordinated so that it supports – rather than slows – Europe's heat pump ambitions?***

To answer these questions, the paper applies an integrated analytical approach that examines how the different layers of the regulatory framework interact – where they reinforce each other and whether they generate friction – and how these interactions shape industrial competitiveness and market deployment. After outlining the methodology, Sections 3 and 4 analyse the regulatory landscape across four dimensions. First, the paper considers product-specific requirements, such as Ecodesign and Energy Labelling. Second, it examines refrigerant and chemical legislation, particularly the F-gas Regulation and the emerging PFAS restriction. Third, it analyses system-integration rules related to grid connection, demand-side flexibility, and digitalisation.

These EU-level layers are then contrasted in Section 4 with a fourth dimension: national divergences in implementation, which play a decisive role in determining whether EU rules translate into a genuinely harmonised Single Market. Although EU product legislation is designed to ensure uniform market access, Member States continue to introduce additional requirements or apply divergent interpretations, creating fragmentation and imposing extra compliance and certification burdens on manufacturers.

By examining both the drivers and the barriers embedded in these regulatory layers, the paper assesses their cumulative impact on heat pump deployment and identifies where simplification, synchronisation, and stronger coordination are most urgently needed.

2. Methodology

This paper applies an integrated methodological approach that combines applied research with a structured analytical assessment to examine how EU regulations influence the deployment of heat pump technologies over the European union.

The analytical assessment draws an extensive desk review of relevant EU legislative and policy frameworks, with particular attention to how these instruments interact and shape the functioning of the Single Market. On the other hand, the applied research component analysis of this paper is based on the European Heat Pump Association (EHPA) accumulated knowledge, position papers, and ongoing technical and regulatory work. EHPA is a membership-based organisation which maintains continuous engagement with actors across the European heat pump value chain. In particular, the input and sources underpinning the present paper are grounded from that expertise and undergo internal peer review and validation by the EHPA members to ensure methodological robustness and sectoral relevance. These inputs rest on three main strands:

- Quantitative market data and monitoring from EHPA and its members.
- Anonymised company-level information gathered through targeted surveys and processed by independent third parties to comply with confidentiality and competition rules.
- Qualitative insights from EHPA task forces, bilateral meetings, and wider stakeholder consultations involving manufacturers of final products and components, research institutes, consultancies, and installers.

3. Setting the scene: the current European regulatory framework in between the drivers and the challenges

3.1. The Ecodesign and Energy Labelling legislative framework

The Ecodesign Directive establishes minimum efficiency and environmental performance requirements for energy-related products, driving continuous improvement in seasonal efficiency, material sustainability, and noise reduction for the heating technologies [9]. Together with the Energy Labelling Framework Regulation, it steers the market toward efficient, high-quality technologies and protects EU manufacturers against low-quality imports, acting as a "quality shield" that rewards innovation and ensures fair competition. Evaluations of the Ecodesign and Energy Labelling framework show that these measures have progressively removed the least efficient products from the market and shifted sales toward the highest label classes, with many regulated product groups now concentrated in the top tiers of the energy label scale and lower classes becoming absent. For energy-related products, Ecodesign and energy labels are estimated to deliver on the order of 150–200 Mtoe of primary energy savings per year around 2020 compared with a business-as-usual scenario, illustrating their substantial quantitative impact on both market transformation and energy consumption [10].

The forthcoming Ecodesign Regulations for space and water heaters are expected to stimulate further technological advancement and investment across the heating sector. Yet the delay in publishing these revisions, initiated in 2017 and still pending in 2025, creates major challenges. When regulatory outcomes remain uncertain for extended periods, manufacturers must plan for multiple scenarios simultaneously, diverting resources from innovation to regulatory hedging and slowing the introduction of improved products onto the market.

3.2. The refrigerant transition: F-gas Regulation and PFAS

The revised EU F-gas Regulation constitutes one of the most consequential policy developments for the heat pump sector, introducing both regulatory drivers and substantive challenges for manufacturers. Its central objective is to reduce the climate impact of fluorinated greenhouse gases through a progressive phase-down of their production and use, in line with the Kigali Amendment to the Montreal Protocol. This regulatory trajectory has already accelerated the transition toward low-GWP and natural refrigerants, including propane (R290), CO_2, and ammonia.

This policy signal is already visible in the market developments. Available market data indicate that the EU F-gas Regulation has already had a measurable impact on refrigerant choices in European heat pumps: in 2019, more than 80 % of units sold still relied on the high-GWP refrigerant R410A, while R32 accounted for around 37 % of split-system installations as a lower-GWP transitional option [11]. More recent programme and certification data from national markets, such as Germany, show a growing uptake of propane (R290) in new installations alongside a declining share of R410A in subsidised systems, illustrating how quota reductions and compliance requirements under the F-gas framework are steering manufacturers toward lower-GWP refrigerants [12].

As a result, refrigerant choice has become a key consideration in heat pump development, as it has a decisive influence on system efficiency, heating capacity, and the achievable operation range [13]. Because low-GWP refrigerants differ markedly from traditional F-gases in terms of pressure levels, thermodynamic behaviour, and flammability, their adoption requires significant adjustments in product development. For manufacturers, this shift therefore acts as an important technological driver that required specific product design adjustments, dedicated engineering approaches, and installers training [14]. This complexity is well documented in recent international research, notably under the IEA Heat Pump Technology Programme [15].

Conversely, the transition generates notable regulatory and technical challenges. Many low-GWP refrigerants are flammable, which introduces stricter requirements for product design, installation, and maintenance [16]. Moreover, these requirements interact with a fragmented regulatory landscape across EU Member States that will be analysed in more detail in the following Section 4.

Additional regulatory complexity may arise from proposed restrictions on PFAS substances, as certain synthetic refrigerants and lubricants used in heat pump systems fall under PFAS definitions and could therefore be affected. Industry stakeholders emphasise the importance of a balanced regulatory approach that safeguards environmental objectives while avoiding unintended disruptions to the deployment of clean heating technologies.

Addressing these challenges requires stronger EU-level coordination. If EU legislation promotes the shift toward low-GWP refrigerants through the F-gas Regulation, parallel efforts are needed to work with national

authorities to remove installation barriers. Aligning national rules with the latest CEN/CENELEC standards and harmonising aspects not covered by these standards – drawing, for example, on guidance developed within EHPA's SKILLSAFE EU project [17] – would facilitate a smoother and more consistent transition across the Single Market.

3.3. Grid Integration and Flexibility Requirements: between opportunity and Regulatory Fragmentation

The growing electrification of the heating and cooling sector means that heat pumps are no longer only efficient appliances; they are also active components of the energy system. Their ability to shift consumption in time and interact with the grid makes them a cornerstone of a future flexible, renewable-based power system [18]. This presents a major opportunity for manufacturers, as flexibility-ready heat pumps will play a leading role in future electricity markets. Yet two current problems risk undermining this potential. The first concerns diverging EU and national regulatory approaches, which create inconsistent requirements for grid integration and flexibility across Member States. The second stems from the fact that system-level regulations have evolved faster than the product-level frameworks that govern mass-market technologies, creating gaps, overlaps, and disproportionate obligations for manufacturers.

3.3.1. Grid Connection Codes and Regulatory Burden

The inclusion of heat pumps under the EU Grid Connection Codes (GCC) – a framework originally designed for large-scale power generation assets – has created new compliance challenges for manufacturers [19]. The GCC sets technical requirements intended to ensure system stability, but applying these system-level rules to individual consumer products introduces disproportionate complexity and cost for manufacturers. In practical terms, certain connection and control functionalities envisaged under the GCC could require substantial redesigns of product architecture, even though heat pumps already fall under detailed technical legislation such as Ecodesign and Energy Labelling.

The challenge arises because the GCC was designed for equipment connected at transmission level, not for household appliances with entirely different risk profiles, cost structures, and market dynamics. These requirements were also developed with limited consultation from the heat pump industry and without a dedicated impact assessment for consumer-level technologies. This results in a regulatory mismatch: non-product-specific legislation imposing obligations on products that are already regulated through dedicated product frameworks [20].

To maintain proportionality and avoid unnecessary redesigns, compliance costs, and overlapping rules, grid-related functionalities should be developed within product policy instruments, such as the Ecodesign Regulation or the Code of Conduct for Demand-Side Flexibility [21], which are tailored to product-level innovation.

3.3.2. Flexibility as a Missed EU-Wide Opportunity

Flexibility is one of the core advantages of heat pump technology and a key asset in the electrification of the heating and cooling. When integrated into a smart energy system, heat pumps can shift consumption to periods of low electricity prices or high renewable generation, reducing grid congestion and system costs while lowering consumer energy bills. This potential is not theoretical:
a study analysing a sample of 300 heat pumps found that Europe could achieve load reductions of 40–65 % under controlled flexibility events [22]. Another field study from the HeatFlex trial shows that automated control of heat pumps can reduce household electricity consumption by a 32 % (0.123 kWh) and a 74 % reduction in heat pump-specific electricity use (0.382 kWh) per half-hour during predefined flexibility events without compromising thermal comfort [23]. These results demonstrate the significant potential for event-level demand shifting, highlighting the value of coordinated heat pump operation for peak-load management and grid support.

Despite this demonstrated performance, flexibility remains difficult to scale. While technically proven and already operational in several EU Member States, the lack of a common baseline definition makes benefits difficult to compare, value and monetise across markets. As a result, identical heat pump technologies deliver quite different economic outcome depending on national tariff design, data access rules, and aggregation frameworks. Without harmonised assumptions on baseline and benefit allocation, flexibility remains

undervalued in regulation and invisible to consumers, limiting investment in smart-ready heat pump solutions despite their system-level value.

Currently policy choices reinforce these barriers. The lack of harmonised EU-level rules for flexibility participation has left Member States to define schemes, dynamic tariffs, and aggregation models independently, resulting in fragmented frameworks and uneven consumer access to incentives [24]. A common voluntary harmonized framework for flexibility and smart integration is therefore needed. Such a framework should define interoperability and data-exchange principles and ensure that consumers receive financial benefits from demand-response participation.

3.3.3. Digitalization and Data Complexity

The digital dimension of these requirements further compounds the regulatory challenge. Manufacturers face an overwhelming volume of overlapping data-related and digitalization initiatives – including the Data Act [25], the Cyber Resilience Act [26], the AI Act [27]. Although these initiatives reflect the EU's commitment to secure and interoperable digital markets, their combined effect is one regulatory overload and uncertainty. Even experts struggle to interpret the scope and interactions of these texts, leading to legal ambiguity and implementation delays.

For small and medium-sized enterprises, the complexity of the digital regulatory landscape acts as a barrier to entry, while for established players it increases compliance costs and administrative burdens. This fragmentation risks slowing innovation and reducing competitiveness in a market that is otherwise poised for rapid expansion.

In conclusion, grid integration and flexibility should be viewed as enablers of system efficiency, not as additional layers of compliance. To achieve this, the EU should:

- Address grid and flexibility requirements through product-oriented instruments (Ecodesign, CoC) rather than system-level Grid Codes.
- Develop a voluntary harmonised EU framework for flexibility participation and data interoperability.
- Simplify and align digitalisation legislation to reduce administrative burden.

Such an approach would safeguard the Single Market, accelerate the adoption of flexible heat pump technologies, and empower consumers to benefit directly from Europe's energy transition. It would also ensure that heat pumps can fulfil their role as distributed energy assets, supporting grid stability and enabling the cost-effective integration of renewables across the European Union.

4. When EU rules meet national reality: fragmentation and breakdown of the EU Single Market

Sections 3.1 to 3.3 analyses the EU-level regulatory framework and its internal interactions. However, even perfectly designed EU legislation cannot function as intended if implementation diverges across Member States. This section therefore turns to the national level, where differences in testing requirements, safety rules, documentation obligations, and digital practices create substantial fragmentation. These divergences redefine the operating environment for manufacturers and determine whether the Single Market delivers on its promise of uniform market access.

Although EU product regulations are designed to ensure uniform market access across all Member States, in practice significant fragmentation persists [28]. Several countries apply additional rules or divergent interpretations that go beyond EU legislation, creating a fragmented market and undermining the principle that a product compliant in one Member State should be accepted in all. This divergence appears in four main areas.

First, conformity assessment and testing differ across Member States. Some require extra performance tests or national certification steps for building codes or subsidy eligibility. These additional testing points, often based on different climate assumptions or data formats, force manufacturers to duplicate compliance processes and increase both cost and time to market.

Second, safety rules for flammable refrigerants vary widely. While EU standards allow the use of low-GWP refrigerants, several countries maintain stricter national fire-safety or building-code provisions that limit or prohibit their use. This inconsistency means a heat pump designed for the EU market may require different engineering solutions – or may not be installable at all – in certain jurisdictions. Without alignment, the wider refrigerant transition risks stalling.

Third, environmental documentation, such as eco-passports and Environmental Product Declarations, is far from harmonised. Countries use different formats, registries, and packaging requirements, obliging manufacturers to prepare multiple sets of documentation and adjust product packaging for each market.

Fourth, digital and data-related requirements are fragmented. In the absence of common EU rules on connectivity, data interoperability, or smart-flexibility participation, national authorities and utilities are developing their own approaches. Meanwhile, enforcement of horizontal EU digital laws differs across countries, creating uncertainty for product developers and slowing the introduction of smart services.

These divergences collectively increase administrative burden, raise compliance costs, and delay product launches. They also undermine consumer access to efficient technologies and risk slowing Europe's heat pump roll-out at a moment when rapid deployment is essential. Fragmentation, if not addressed, threatens the functioning of the Single Market itself.

5. Conclusion

This paper set out to answer two interrelated questions: to what extent does the current EU product regulatory framework enable sustainable heat pump roll-out, and how can it be designed or coordinated so that it supports, rather than slows, Europe's heat pump ambitions? The findings indicate that the regulatory framework functions as both an enabler and a constraint.

Reconnecting with the questions posed in the introduction, the analysis confirms that EU product regulation has provided essential drivers for technological progress. Ecodesign, Energy Labelling, and the F-gas Regulation have collectively pushed the sector toward higher efficiency, improved quality, and a rapid transition to low-GWP refrigerants. These regulatory drivers have shaped long-term innovation pathways and created a predictable direction of travel for manufacturers. Without them, Europe's heat pump sector would be less efficient, less innovative, and further away from its climate and energy objectives.

Yet the analysis also shows that the same regulatory system generates barriers when its components evolve asynchronously or when implementation diverges across countries. Misaligned timelines between Ecodesign revisions, refrigerant policies, and chemical legislation create uncertainty for product development cycles. System-integration requirements – grid codes, flexibility rules, and digital obligations – add layers of complexity not always proportional to consumer-level technologies. Most critically, national divergences in conformity testing, safety rules, environmental documentation, and digital interoperability undermine the Single Market, raising compliance costs and delaying product availability.

These findings shape the answer to the second research question. For EU regulation to function as a genuine accelerator of heat pump deployment, it must be coordinated, predictable, and consistently implemented. The paper therefore identifies five priorities for action: ensuring synchronised regulatory timelines; strengthening coherence across legislative instruments; reinforcing Single Market integrity through harmonised testing and documentation; anchoring flexibility and smart-integration requirements within product-level tools; and supporting implementation through skills development and administrative simplification.

By addressing these issues, the EU can turn its product regulatory framework into a strategic asset – one that rewards innovation, maintains industrial competitiveness, reduces compliance burdens, and enables the rapid and affordable deployment of heat pumps that is essential for Europe's climate-neutral heating transition.

References

[1] European Commission. A Clean Planet for All: A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy. COM(2018) 773 final; 2018.

[2] Eurostat. Heating and Cooling in the EU: 2022 Data. Luxembourg: Publications Office of the European Union; 2024.

[3] Energy Systems Catapult. Interim insights from heat pump performance data. Energy Systems Catapult; 2023. Fraunhofer ISE. Heat pumps provide efficient and climate-friendly heating also in existing buildings. Fraunhofer Institute for Solar Energy Systems ISE; 2025. Lyons L, et al. Heat pumps in the European Union. Joint Research Centre, European Commission; 2023; European Commission, Joint Research Centre. Heat Pumps in the European Union: Status Report. JRC Technical Report; 2023. Pirard F, et al. Assessing the flexibility potential of industrial heat pump systems. Energies; 2024.

[4] European Commission. REPowerEU Plan. COM(2022) 230 final; 2022.

[5] European Parliament and Council. Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products.OJ L 285/10; 2009.

[6] European Parliament and Council. Regulation (EU) 2017/1369 setting a framework for energy labelling. OJ L 198/1; 2017.

[7] European Parliament and Council. Regulation (EU) 2024/573 on fluorinated greenhouse gases (F-gas Regulation).2024.

[8] European Chemicals Agency (ECHA). Annex XV Restriction Report – Proposal for a Restriction on Per- and Polyfluoroalkyl Substances (PFASs). 2023.

[9] European Parliament. The Ecodesign Directive (2009/125/EC): European Implementation Assessment. 2017

[10] European Court of Auditors. Special report: Ecodesign and energy labels – initial achievements with energy efficiency and environmental impact need to be improved. ECA Special Report No 1/2020; 2020. European Court of Auditors. Special Report No 01/2020: EU action on Ecodesign and Energy Labelling: important contribution to greater energy efficiency reduced by significant delays and non-compliance. 2020.

[11] Cooling Post. R32 splits accounted for 37% of the market in 2019. Cooling Post industry news; 2019.
[12] IEA Heat Pumping Technologies Programme. Roll-out of large-scale heat pumps as a key factor for the German energy and heat transition. Heat Pumping Technologies Magazine, Vol. 43, No. 1; 2025.
[13] Domanski PA, Brignoli R, Brown JS, Kazakov AF, McLinden MO. Low-GWP refrigerants for medium and high-pressure applications. Int J Refrig 2017;84: 198–209. https://doi.org/10.1016/j.ijrefrig.2017.08.019.
[14] Christoph Höges, Jonas Klingebiel, Valerius Venzik, Jona Brach, Philipp Roy, Kaj Neumann, Christian Vering, Dirk Müller,Low-GWP refrigerants in heat pumps: An experimental investigation of the influence of an internal heat exchanger, Energy Conversion and Management: X, Volume 24, 2024, 100704, ISSN 2590-1745.
[15] IEA Heat Pumping Technologies Programme. Annex 54 – Low-GWP refrigerants for heat pumps: 2022 Annual Report. Progress Annual Report; 2023.
[16]*Ibidem*.
[17] EHPA & SkillSafe Consortium.SkillSafe EU Project: Harmonised Safety and Training Guidelines for Flammable Refrigerants. Brussels: EHPA; 2024.
[18] European Heat Pump Association (EHPA). Flexibility & Smart Integration Report. 2023.
[19] European Commission / ENTSO-E / ACER. EU Grid Connection Codes.
[20] European Heat Pump Association (EHPA). EHPA Briefing on Grid Connection Codes. 2023.
[21] European Commission. Code of Conduct for Demand-Side Flexibility. 2023.
[22] Müller, F., & Jansen, B. (2019). Large-scale demonstration of precise demand response provided by residential heat pumps. Applied Energy, 239, 836-845
[23] Centre for Net Zero. HeatFlex: The untapped potential of automated heat pump flexibility. Centre for Net Zero research paper; 2023.
[24] European Heat Pump Association (EHPA). Demand-Side Flexibility: EHPA Analysis. 2024.
[25] European Commission. Regulation (EU) 2023/2854 on harmonised rules on fair access to and use of data (Data Act); 2024.
[26] European Commission. Regulation (EU) 2024/2847on horizontal cybersecurity requirements for products with digital elements (Cyber Resilience Act); 2024.
[27] European Commission. Regulation (EU) 2024/1689 laying down harmonised rules for artificial intelligence (AI Act); 2024.
[28] European Heat Pump Association (EHPA). Single Market Barriers for Heat Pumps. 2024