



Heat pump flexibility as a key driver for reducing consumers' bills and energy system costs

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Abstract

The EU must decarbonise and electrify its energy system to meet its climate targets and become carbon neutral by 2050. In this context, demand-side flexibility and the active engagement of consumers will become increasingly more central to align consumption with intermittent renewable generation and reduce grid congestion. Accelerating the deployment of heat pumps and unlocking their flexibility potential is key, since heating and cooling needs account for half of EU's energy consumption and up to 80% in households.

This paper expands on the benefits of demand-side flexibility in buildings, both for consumers and the overall energy system. It then provides a brief overview of the developing EU regulatory framework, which still presents numerous gaps and bottlenecks. Lastly, three priorities are identified to unlock heat pump flexibility: regulatory simplification; incentivising flexibility through dynamic energy contracts and cost-reflective network tariffs; empowering and rewarding flexible consumers for providing system services.

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1. Introduction

The European Union has set ambitious climate and energy targets, including achieving net-zero emissions by 2050. The transition to carbon neutrality calls for radical changes in managing and planning energy systems. As the uptake of renewables grows, energy generation becomes more intermittent and, therefore, price volatility increases. At the same time, renewable technologies already allow for self-consumption and for consumers to become active players in the energy system, both individually and collectively.

However, transitioning to a more decentralised energy system running on renewables requires shifting the paradigm from fossil-based energy systems where energy generation follows consumption patterns to energy systems where consumption adapts to energy generation patterns. This brings both new opportunities and challenges. Firstly, flexibility is key to shifting energy consumption when renewable power generation is abundant and therefore cheaper; this reduces the costs linked to curtailment of renewable energy generation as well as the need for costly fossil-based backup generation capacity. Secondly, it contributes to balancing the electricity grid and reduces the risk of power outages. Thirdly, demand-side flexibility is essential for cost-effective grid expansion, since power networks are designed to accommodate peak demand.

This paper provides a concise overview of the growing importance of demand-side flexibility in the energy system, highlights the flexibility potential of heat pumps, particularly residential ones, and identifies three priorities to fully unlock this potential. It is intended as guidance for EU and national policymakers on how smart electrification of heating and cooling through heat pumps contributes to reducing both greenhouse gas emissions and energy bills.

2. Methodology

The European Heat Pump Association (EHPA) is a membership-based organisation and the leading voice of the heat pump sector in Europe. As such, EHPA actively participates in all the relevant fora established at

EU level to advance the digitalisation of the energy sector and contributes to shaping the discussion on the future of electricity systems.

The work presented in this paper is based on the analysis of the EU regulatory framework on demand-side flexibility, primarily the Electricity Regulation and the Electricity Directive, and an extensive review of public resources, with a particular focus on key stakeholders such as the EU Agency for the Cooperation of Energy Regulators (ACER) and Smart Energy Europe (SmartEn), the European association of the Flexible Demand Management Industry.

It is then complemented with three streams of evidence: a) Quantitative market data and monitoring from EHPA and its members; b) Qualitative insights from EHPA task forces, bilateral meetings, and wider stakeholder consultations; c) The ongoing work of key EU fora on flexibility and digitalisation of the energy system, notably the European Commission's Smart Energy Expert Group (SEEG), the Code of Conduct on Energy Smart Appliances (Coc ESA), and the European Stakeholder Committees for the relevant Grid Network Codes.

3. The role of flexibility in a decarbonised and decentralised energy system

In an increasingly decarbonised and decentralised energy system, demand-side flexibility plays a key role and benefits both consumers and the energy system as a whole.

3.1. Lower energy bills for consumers

For consumers, flexibility offers the opportunity to generate significant cost savings by shifting consumption when electricity is more abundant. Renewable power generation is intermittent and often does not align with consumption patterns. Solar power follows of course the seasonal sun path, peaking in the middle of the day and with low or no production in the early morning and late evening when people are traditionally at home and use most of their daily electricity. On the other hand, wind power is generally abundant during the night, when consumption is at its lowest.

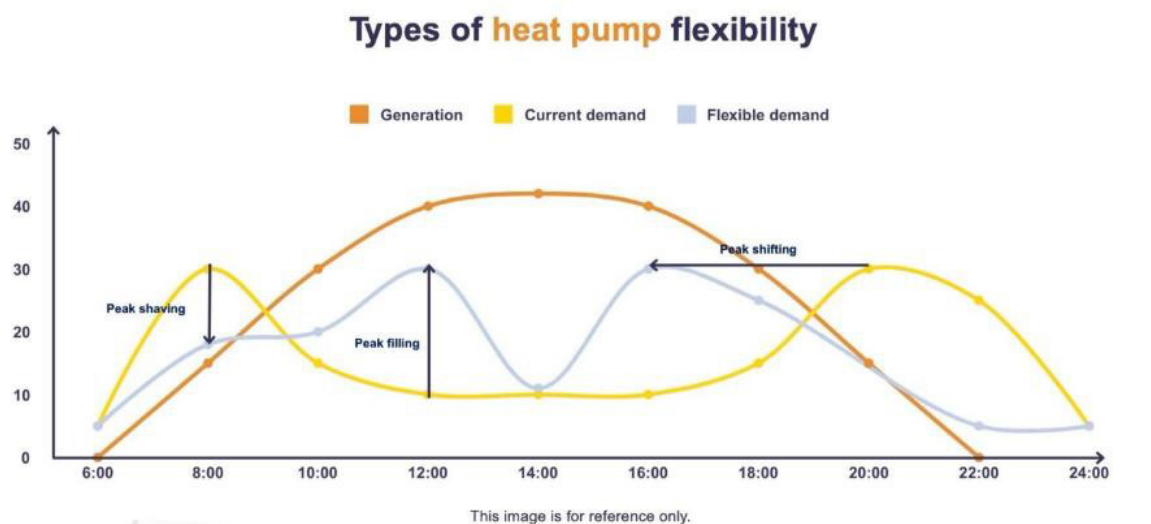


Figure 1 Example of heat pump flexibility, EHPA

Shifting energy consumption when electricity is more abundant can dramatically reduce energy bills but requires three essential elements. First, **energy smart appliances that can operate flexibly**, notably heat pumps. Every household can already count on some degree of flexibility, for example operating appliances like dishwashers and washing machines during the night. Nonetheless, since heating needs account for up to 80% of the energy consumption in EU households [1], heat pumps hold the highest flexibility potential for EU consumers (besides EVs). Second, the **rollout of smart meters** is essential to provide real-time data on energy consumption to both consumers and energy providers. Third, the availability of **dynamic pricing schemes** is necessary to incentivise consumers to move their consumption patterns.

In 2023, BEUC commissioned a study on the impact of owning a heat pump in four Member States (Belgium, Italy, Spain, Hungary) with and without dynamic price contracts, using real price data from July

2021 to June 2023. In all countries but Hungary, switching to a dynamic tariff led to significant savings even without smart controls that optimise daily consumption; for Hungary, opting for a dynamic tariff was found to be inconvenient because of the subsidised price cap for fixed-price energy contracts, de facto funded by all taxpayers [2].

3.2. *Reduced energy system costs*

In a progressively decarbonised and electrified energy system, demand-side flexibility can contribute to solving a number of new challenges and the associated costs. These include increasing hours of negative electricity prices; curtailment costs during excessive renewable power generation; the continuation of fossil-powered electricity generation to meet peak demand; rising investments into grid upgrades; growing costs for balancing the grid. Exploiting the flexibility potential of decentralised energy resources like heat pumps is cost-effective and their deployment should be accelerated, since it reduces the need for investing in utility-scale assets to provide the same services.

SmartEn estimated the cost savings provided by demand-side flexibility in the EU in 2030, besides the benefits in terms of lower wholesale prices: -61% in renewable curtailment costs; up to €29.1 billion/year in grid reinforcements investments; €9 billion on lost load not served by the available generation; €262–690 million in balancing energy costs [3].

In recent years, renewable power generation has seen a rapid growth in Europe, driven by the sharp increase in PV installations, reaching 47% in 2024 (up from 34% in 2019). Yet the electrification of end-uses has been lagging, and the electrification rate has stagnated at 23% for the past decade [4]. Low electricity demand and inflexible consumer behaviour are the two primary causes of low and negative power prices, whose incidence is on the rise in Europe and can slow down the decarbonisation of the power sector [5].

Another consequence of high renewable penetration but insufficient and inflexible demand is more frequent curtailment of renewable power generation. According to a study by Aurora Research, the volume of congestion management measures in the EU, Norway, and the UK increased by 26% between 2021 and 2024, with costs reaching €8.9 billion in 2024 [6].

In parallel, fossil-based electricity generation remains central to meeting peak demand in the EU, slowing down the decarbonisation of the power sector. In the first six months of 2025, electricity produced by fossil fuels rose by 13% compared to the previous year because of lower output from wind farms and hydro power [7].

Lastly, the required investments into expanding and modernising the electricity grid are expected to grow significantly since electrification is the main driver for the decarbonisation of the energy sector; the European Commission estimated an investment gap of €584 billion by 2030 to achieve the REPowerEU objectives [8]. These costs are normally passed onto consumers through network tariffs, although some Member States are exploring innovative practices to avoid grid upgrades leading to higher electricity bills and slowing down electrification [9]. Electricity grids must be designed to accommodate peak demand, therefore the deployment of flexible assets like heat pumps must be considered when planning grid investments to ensure cost-effectiveness.

4. **EU framework on demand-side flexibility: state of play and main bottlenecks**

Over the last few years, the European Union has been working on a comprehensive regulatory framework on demand-side flexibility. In 2024, SmartEn published “Implementing EU Laws. A guide to enable demand-side flexibility in the EU27”; the report deep-dives into this regulatory framework and provides a detailed overview of around 70 provisions stemming from 6 legislative files that “enable buildings, vehicles and industries to consume, store, and generate renewable electricity in a time-dependent way, in reaction to external signals received from the energy system they are connected to” [10].

The report highlights seven key bottlenecks and provides targeted recommendations to the relevant actors addressed in the legislation, including Member States, national regulatory authorities, system operators, as well as energy suppliers, aggregators and other market players. Overall, the analysis identifies significant gaps and delays in implementing the existing regulatory framework at national level, which slow down the deployment of flexible assets and limit the active participation (and rewarding) of flexible consumers in the management of the energy system.

Importantly, the European Commission is also expected to adopt a new Network Code on Demand Response in 2026, based on the proposal submitted by ACER in 2025. This Regulation will “address the

remaining regulatory barriers to facilitate market participation of demand response including load, energy storage and distributed generation, individually or aggregated, and facilitate market-based procurement of services by DSOs and TSOs, while supporting the achievement of the Union's targets for penetration of renewable generation" [11]. As such, the Network Code represents an important milestone to unlock demand-side flexibility in the EU, but the national implementation will be critical and could produce further fragmentation among Member States.

5. Three steps to unlock heat pump flexibility

5.1. Reduce the administrative burden on flexible assets

Heat pumps are the main technology to decarbonise heating and cooling in buildings, district heating, and industry thanks to their higher efficiency and advantages compared to fossil heating equipment. With a total stock of 25.5 million units installed in Europe as of 2024, heat pump sales have seen a sharp increase in the last decade, peaking during the energy crisis, but must further accelerate to meet the EU's climate and energy targets for 2030 [12].

Reducing the administrative burden on heat pump manufacturers is key to lowering upfront costs for consumers, which constitute one of the main barriers to a faster uptake of heat pumps. Therefore, the emerging regulatory framework on flexible assets, and heat pumps specifically, should be streamlined. Currently, manufacturers increasingly face overlapping requirements coming from different pieces of legislation and initiatives at EU level, and some countries are developing new rules at national level. This produces additional costs linked to product redesign, recertification and reporting with unaligned timelines, weakening the Single Market.

EU and national policymakers should act on three fronts to ensure that the new regulatory framework on digitalisation and flexibility acts as an enabler and not a barrier to the rollout of heat pumps in Europe. First, priority should be given to implementing existing legislation evenly across Member States. Second, product requirements should be established exclusively through product-specific legislation or initiatives, such as Ecodesign and the Code of Conduct on Energy Smart Appliances—CoC ESA. Third, national requirements should be aligned with the overarching EU framework and should not undermine the Single Market.

5.2. Drive down electricity bills through flexibility

The deployment of flexible assets, notably heat pump, EVs and batteries, opens the possibility for consumers to become active customers that are able to adapt their consumption based on price signals and to participate in the management of the electricity system. However, barriers are still in place and prevent consumers from fully exploiting their flexibility potential, particularly residential consumers.

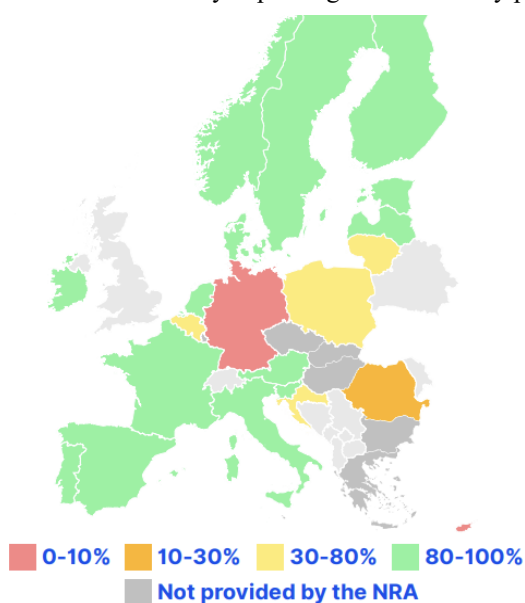


Figure 2 Roll out of smart meters as of 2024, ACER

Firstly, EU Member States must complete the roll out of smart meters, which can measure electricity consumed and fed into the grid more accurately and provide data on actual time of use. The 2019 recast of the Electricity Directive introduced dedicated provisions on smart metering systems (articles 19 and 20), but their deployment is not complete yet, with seven Member States reporting a coverage lower than 80% in 2024 and five countries not providing data (see figure) [13].

More broadly, digital tools and automation like Home Energy Management Systems (HEMS) play a key role in an increasingly more complex energy system where consumers respond to wholesale price signals but also incentives to shave peak demand and supply and avoid grid congestion.

Secondly, in line with the Electricity Directive, consumers shall be given the opportunity to opt for flexible and dynamic tariffs (article 11) and have access to independent and transparent tools to compare offers from energy suppliers (article 14).

Currently, flat-price and regulated energy contracts dominate most EU Member States. On one hand, these contracts ensure high protection against price spikes and volatility, but on the other hand they take out any incentive to adjust consumption to match higher supply (lower wholesale prices) or reduce peak demand [14]. Since the share of renewable power generation will only increase to achieve EU's decarbonisation targets, energy contracts must also become more flexible to pass-on the benefits of lower wholesale prices to consumers. Moreover, perpetuating inflexible consumption generates additional costs that are borne by consumers, for example in the form of hedging costs included in fixed-price contracts, or by taxpayers when regulated contracts are kept artificially low to mitigate social impacts, such as during the 2022 energy crisis.

Opting for a more dynamic energy contract means increasing the exposure to volatility of energy prices, which can be riskier in more volatile energy markets and especially for less affluent and/or less flexible consumers. Therefore, the way forward is not a dichotomy between static and dynamic prices. Ideally, consumers shall be offered a diverse range of energy contracts with different levels of flexibility and safeguards to match different profiles, while ensuring that all consumers can participate in the energy market to some extent and benefit from the cost savings generated by the energy transition.

Thirdly, another consequence of the decarbonisation and electrification of the energy system is that energy bills will see the energy component shrink and network costs rise to cover investments to expand and modernise the grid but also the higher costs of balancing and managing the system. As a result, cost-reflective network tariffs will become increasingly more important to incentivise flexibility, complementing wholesale price signals.

Traditionally, network tariffs for small-scale consumers (residential and commercial) have been mainly volumetric (in €/kWh) in most EU Member States, often with a flat price throughout the day [15]. However, these tariffs fail to capture the costs and needs of the evolving electricity grid. Therefore, Member States are gradually shifting towards capacity-based network tariffs (in €/kW), which contribute to reducing peak demand and therefore the need for grid investments, and can be complemented by time-of-use and locational elements. In its recent Guidance on future proof network charges, the European Commission stressed that network charges must incentivise network users to adapt their behaviour to the needs of the electricity system, while preserving transparency and simplicity [16].

5.3. Empower and reward consumers for providing system services

Consumers owning flexible assets like heat pumps can benefit economically from them in two ways, namely by reducing their electricity bills and generating revenues providing energy system services, either directly or through an aggregator. These include balancing services, congestion management, capacity mechanisms, and non-fossil flexibility support schemes.

According to EU legislation, decentralised energy resources should be able to participate in all these remunerated markets and Member States, and system operators shall ensure transparent, non-discriminatory and market-based procedures to procure these services. Nonetheless, these principles are yet to be implemented in many Member States [17].

6. Conclusions

The transition to climate neutrality calls for a paradigm shift on how the energy system is managed and the role that consumers play in it. On one hand, the growth of intermittent renewables creates a misalignment between energy generation and consumption; on the other hand, electrification offers the opportunity to consumers to become active nodes of the system but requires costly investments to modernise and strengthen the electricity grid.

In this context, demand-side flexibility plays a key role but is still facing several barriers in the EU. Policymakers at EU and national level shall urgently address these bottlenecks and promote a faster uptake of energy smart appliances, particularly heat pumps since heating and cooling needs make up the lion's share of EU's final energy consumption.

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