The joy of flex

Embracing household demand-side flexibility as a power system resource for Europe

Sophie Yule-Bennett and Louise Sunderland

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Regulatory Assistance Project (RAP)®

Rue de la Science 23
B - 1040 Brussels
Belgium

Telephone: +32 2 789 3012
Email: info@raponline.org
raponline.org
linkedin.com/company/the-regulatory-assistance-project
twitter.com/regassistproj

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Figures

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Executive summary

Achieving net zero total emissions in Europe by 2050 demands a zero-emissions power sector by the mid-2030s. This means integrating variable renewable energy resources at an unprecedented scale and pace. Only one path allows us to decarbonise rapidly while maintaining a reliable system, minimising system costs and increasing energy democracy. We must create environments in which electricity customers are willing and able to modify the flexible, non-time-specific proportion of their electricity demand in response to system conditions. By doing this, we can harness the natural advantages of high renewables penetration; mitigate the inherent challenges of variable generation; and avoid unnecessary costs of backup power, network management and upgrades, and more expensive alternative flexibility options.

Demand-side flexibility is therefore essential to balance supply and demand and make best use of renewable generation. Because it increases system flexibility and enables local grid constraints to be managed more efficiently, demand-side flexibility creates a virtuous cycle by facilitating faster decarbonisation via electrification of end uses such as transport and heat, as long as smart readiness is built into new products. The most recent energy price crisis has underscored the urgent need to release Europe from gas dependency — and therefore from exposure to gas price volatility — by progressing swiftly to a clean, efficient and electrified energy system.

There is no official definition of demand-side flexibility in EU legislation, but the EU Smart Grids Task Force[1] defines it as: *"the ability of a customer (Prosumer) to deviate from its normal electricity consumption (production) profile, in response to price signals or market incentives. Demand side flexibility consists of: load, demand side generation & demand side storage."*

One definition of demand-side flexibility is "the ability of a customer (Prosumer) to deviate from its normal electricity consumption (production) profile, in response to price signals or market incentives. Demand side flexibility consists of: load, demand side generation & demand side storage."

Demand-side flexibility is already mobilised to some extent, largely through commercial or industrial users contracted to turn energy-using operations off or down at times of extreme system stress. This paper focuses on the significant and largely untapped resource of household flexibility. Households collectively offer the greatest future source of flexible demand across Europe. Household demand can increasingly be flexed without compromising utility or comfort, thanks to new digital technologies and storage. A good example is smart charging of electric vehicles, where charging is shifted to times when the cost of electricity is lower, without compromising the vehicle owner's needs. The same principles and opportunities apply to other household electricity demand, if the right incentives, offers and technologies are in place.[2]

1 Küpper, G., Hadush, S. Y., Jakema, A., & Staschus, K. (2020). *ASSET study on regulatory priorities for enabling demand-side flexibility*, p. 16. European Commission. https://asset-ec.eu/wp-content/uploads/2021/05/05-2021-ASSET-EC-Regulatory-priorities-for-enabling-Demand-Side-Flexibility.Final_.pdf

2 Hildermeier, J., Kolokathis, C., Rosenow, J., Hogan, M., Wiese, C., & Jahn, A. (2019). *Start with smart: Promising practices for integrating electric vehicles into the grid*, p. 11. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/start-with-smart-promising-practices-integrating-electric-vehicles-grid

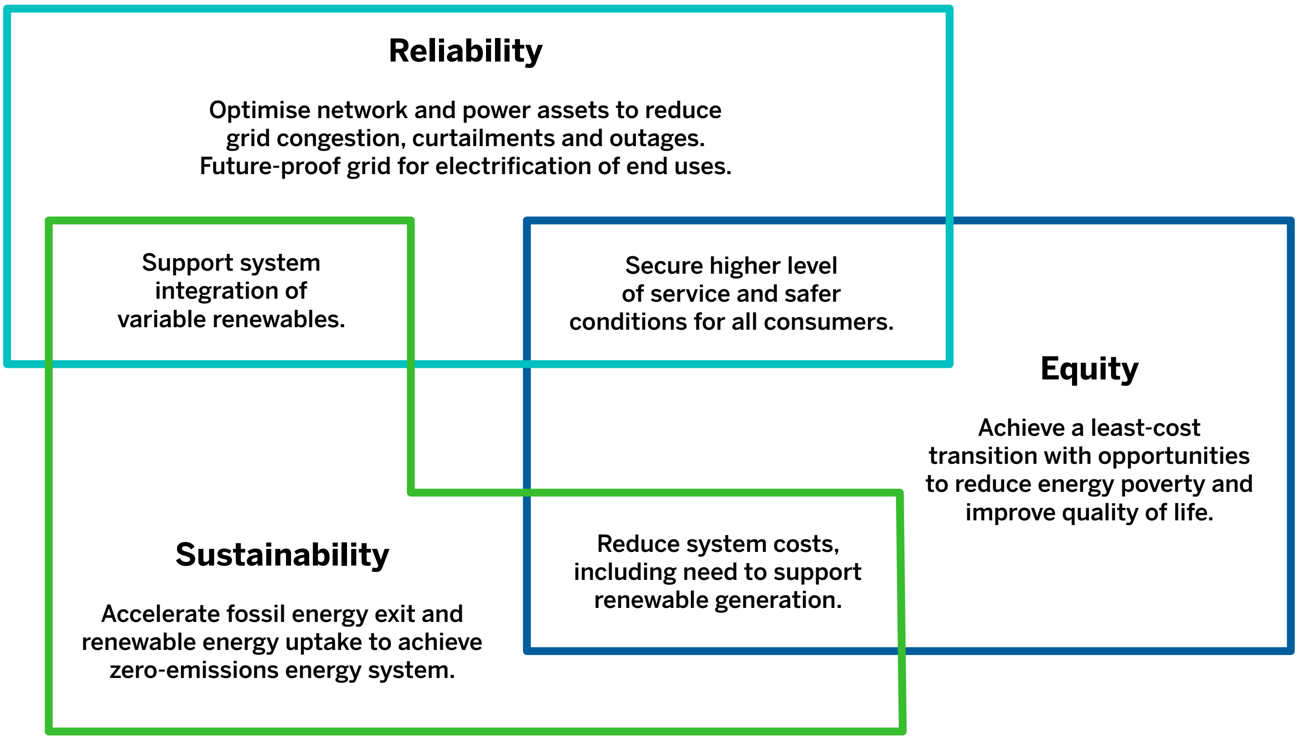
As the users with the lowest individual electricity use, households often face the greatest barriers. In focusing on households, it is our intention to design recommendations that enable participation for all users and therefore mobilise the greatest potential flexible resource. The principles outlined are applicable to households in all forms, including multi-occupancy buildings, and at the community level.

These innovative examples illustrate the unrealised but significant potential of household flexibility to provide a variety of grid services and benefits for communities and customers:

- A smart electric heating controller, developed by home energy company geo, allows households to set time and temperature parameters and delivers the heat required at optimal times when considering energy market spot prices.
- An electric vehicle charging subscription from electricity supplier OVO offers a preferential low flat rate to customers who opt in to smart charging technology. This automatically ramps up charging during periods when systemwide demand is low compared with supply, without customers having to track time or varying prices.[3]
- A community-based 'virtual power plant' developed by the RESCoopVPP project (www.rescoopvpp.eu) optimises the use of local renewable generation assets by matching local demand with supply through monitoring and control systems.

As shown in Figure 1, demand-side flexibility boosts grid reliability and resilience, allowing for full decarbonisation. It also promotes effective use of existing generation and grid resources, reducing costs for all and enabling customers to take an active role and benefit directly from doing so.

Figure 1. Demand-side flexibility benefits



3 OVO Energy. (n.d.). *OVO Drive + Anytime*. https://www.ovoenergy.com/electric-cars/anytime

Getting best value from our assets: The train analogy

Outside of the energy sector, it is axiomatic that customers should have the option of capitalising on their willingness and ability to be flexible. We can access cheaper off-peak rail fares, midweek concert tickets and early-bird restaurant deals. Taking the train example: A number of benefits result if ticket prices are closely correlated with how busy the trains are at certain times and if the price differential between peak and off-peak is enough to incentivise those who can travel off-peak to do so.

- The numbers of passengers on trains are distributed more evenly throughout the day.
- Fewer trains are needed overall because less carriage space is being wasted.
- There is less congestion delay outside stations at peak times, resulting in a more reliable service. Those who really do need to travel during the peak can reach their destination on time.
- The rail company and track operator are under less pressure to put on more trains or commit to expensive expansion programmes to accommodate peak times.
- The rail company and track operator receive useful information about how many trains and tracks are necessary now and how many are likely to be needed in the future.

Using price signals to make the fullest use of existing train carriages and track infrastructure is an example of asset optimisation. All rail customers — and taxpayers, to the extent that costs are publicly funded — benefit in the medium to long term from the lower cost of maintaining a reliable rail service. On top of this, flexible rail customers get the immediate, direct benefit of cheaper rail tickets. Policies and technologies go some of the way to increasing the ability of customers to travel flexibly.

The energy sector works in a similar way. It is not a perfect analogy because:

- Energy flexibility is not 'all or nothing.' Part of every customer's demand is inflexible and part is inherently flexible, with the potential to exponentially increase flexibility through technology.
- The energy sector needn't rely on price signals alone, as automation of equipment and 'lifestyle' services can help households to flex.
- Demand-side flexibility benefits are multifaceted. Their applications go far beyond peak demand reduction: for example, matching demand to renewable energy supply.

As in the train example, however, there are considerable individual, system efficiency and societal benefits to be enjoyed when customers are willing and able to be flexible. Just like the railway, our energy system ultimately serves people, not just load.

Progress to scale up demand-side flexibility has been hampered by the fact that Europe does not yet have coherent strategies to manage renewable energy intermittency at a systemic level. To elevate household demand-side flexibility so it can take its rightful place in the energy transition, swift and concurrent effort is needed on multiple levels of policy and regulation. Underpinning this process is the principle that demand-side flexibility is more than an individual customer right; it's a vital, cost-effective power system resource that should be valued as such.

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This means that — as with any other essential system resource — responsibility for delivering the enabling infrastructure for large-scale, aggregated customer flexibility must rest with policymakers, not individual customers. A robust legal framework is essential for customer buy-in. Households must have easy access to new ways of realising value from their flexibility, through transparent, comparable tariffs and services, with appropriate incentives and safeguards in place. Accomplishing this requires a cohesive regulatory strategy for demand-side flexibility in Europe. The strategy should cover the need to reorganise power market roles, responsibilities and incentives so that the true system value of flexibility is recognised and harnessed, aligning objectives across multiple sectors and policy areas. As a starting point, this paper presents a five-point action plan for scaling up household flexibility in Europe.

Recommendations

Figure 2 sets out an action plan for unlocking household flexibility in Europe. The steps are interlinked and must happen concurrently.

Figure 2. Summary of action plan and recommendations

We must approach demand-side flexibility as a system resource, crucial for the achievement of a cost-efficient, reliable and clean power system. This requires five key actions:

Create robust tools for measuring and valuing customer flexibility	Establish a common methodology for measuring current and future contributions and benefits	Factor in market reform options and incorporate findings from real-world case studies
Incentivise flexibility through energy market price signals	Ensure that wholesale pricing and network charging encourage actions that reduce system costs	Minimise interventions that undermine market incentives for flexibility, such as capacity mechanisms
Ensure a level playing field for demand-side resources	Tackle discrimination, including implicit bias, in all energy markets and grid services to ensure genuine market inclusivity	Consolidate and harmonise flexibility platforms, while unlocking grid data, to maximise value and minimise cost
Accelerate installation of flexible assets in homes	Use building, product and infrastructure standards to ensure that homes and vehicles are smart-enabled and flex-ready	Coordinate and support the rollout of flexible assets, just like any other vital energy infrastructure
Make flexible actions easy and safe for customers	Foster innovative, inclusive retail offers and business models so customers can mix and match according to needs and preferences	Use customer safeguards such as transparent pricing, supplier hedging and upside-only offers

Introduction

There is a growing consensus that net zero total emissions by 2050 will require the power sector to reach zero emissions in the mid-2030s.[4] EU figures indicate that offshore wind capacity will need to grow six times as quickly throughout the next decade as the average annual growth rate from 2010-19. During the same period, annual rates of onshore wind and solar expansion must be maintained at double what they averaged in the last decade.[5] All decarbonisation scenarios rely on rapid electrification of energy uses such as heat, transport and industrial processes, combined with deep integration of variable renewable energy resources[6] within ambitious time frames.[7] Although overall energy demand will decrease, decarbonisation will require an almost threefold increase in electricity demand across the EU between 2018 and 2050.[8] The good news is that, with the right policy framework in place, these newly electrified loads will come with a built-in superpower: demand-side flexibility.

As with any energy resource, renewable energy resources have natural strengths that can be exploited and present challenges that must be managed. The variable nature of many of the renewables that will dominate our decarbonised electricity system requires a change of thinking. As it is sometimes said: *We used to schedule supply to meet load. Now we need to schedule load to meet supply.* Demand-side flexibility can act as a fleet of 'virtual batteries,' increasing energy demand when electricity is cheap and plentiful and enabling less power to be drawn from the grid when supply is tight and costly. A decarbonised power system will need many more sources of flexible demand, deployed in a more habitual and bidirectional way.

Demand-side flexibility can act as a fleet of 'virtual batteries,' increasing energy demand when electricity is cheap and plentiful and enabling less power to be drawn from the grid when supply is tight and costly.

Mobilising the intrinsic flexibility of aggregated demand in all its forms to optimise clean, low-marginal-cost renewable assets will be essential for keeping costs down. The International Energy Agency estimates that, to meet net zero emissions by 2050, a tenfold increase of demand-side resources is required worldwide by 2030, compared with 2020 levels.[9] Early strategic action is required to escape overreliance on more expensive or higher-emissions options for system flexibility later on.[10]

4 Rosslowe, C. (2021). *Zero-carbon power is a key milestone on the route to net-zero*. Ember. https://ember-climate.org/project/zero-carbon-power

5 Rosslowe, 2021, p. 10.

6 Variable renewable sources are solar and wind; geothermal, tidal and hydro sources are not considered variable renewables.

7 International Energy Agency. (2021). *Net zero by 2050: A roadmap for the global energy sector*. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

8 Currently, only approximately 22% of energy consumption in the transport, industry and buildings sectors is electrified. The EU association for the electricity industry, Eurelectric, calculates that, for the EU to reach 95% energy emissions reduction by 2050, direct electrification needs to supply close to 60% of final energy consumption. See Eurelectric. (2018). *Decarbonisation pathways*. https://cdn.eurelectric.org/media/3457/decarbonisation-pathways-h-5A25D8D1.pdf, cited in European Commission. (2018). *A clean planet for all — A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy*. COM(2018) 773 final. https://ec.europa.eu/clima/policies/strategies/2050_en

9 International Energy Agency. (2021). *Demand response*. https://www.iea.org/reports/demand-response

10 The European Climate Foundation estimates potential savings in energy spending for households of up to €23 billion from smart electrification, compared with a current policies baseline. European Climate Foundation. (2019). *Towards fossil-free energy in 2050*. https://europeanclimate.org/wp-content/uploads/2019/03/Towards-Fossil-Free-Energy-in-2050.pdf. See also VaasaETT and Joule Assets Europe. (2017). *Demand side flexibility through smart homes*. ESMIG, Energy@Home and EEBus. https://www.esmig.eu/esmig-publications/report-demand-side-flexibility-through-smart-homes, which concentrates on the costs and benefits of the demand-side flexibility and savings capabilities of smart appliances in France, Germany, Italy and the UK.

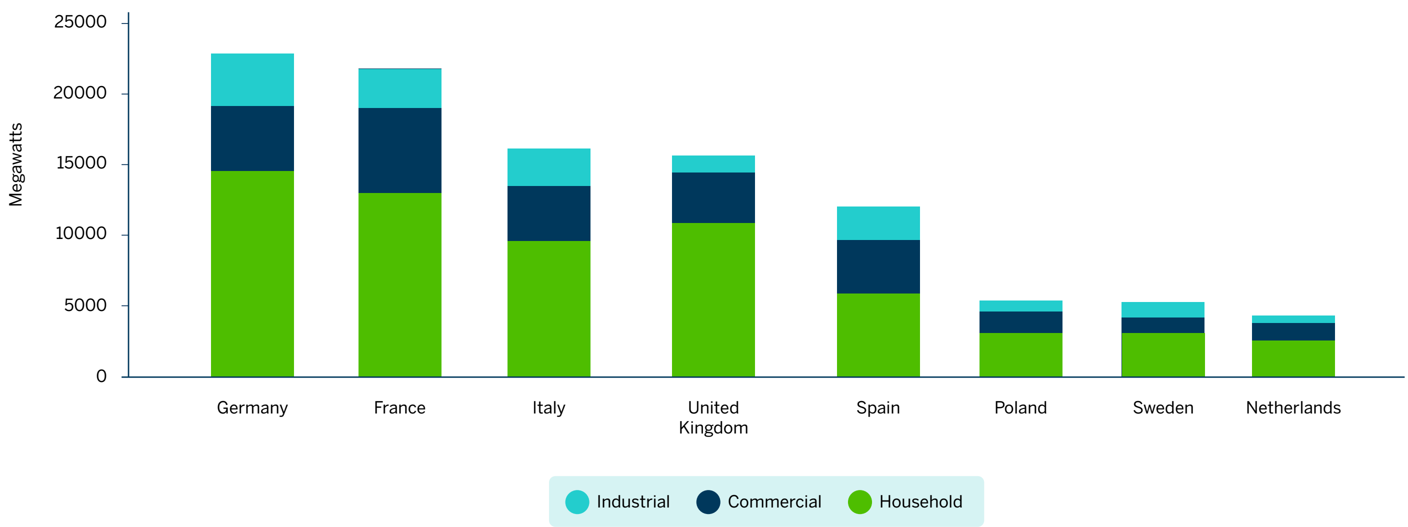
By unlocking the value of customer flexibility — while bringing in new forms of energy storage and digitalisation — we can integrate renewable generation, optimise newly electrified assets and accelerate decarbonisation. As Europe's focus is drawn to mitigating the effects of the energy price crisis, it is essential that policy responses bring us closer to our decarbonisation and social objectives, not farther away. This requires strategies that accelerate progress towards a clean and electrified system that is not exposed to gas price volatility — rather than undermining these objectives.[11] Only then can we minimise costs through genuine system efficiency, creating permanent savings and improved system security for the benefit of all customers.

We need new thinking and new tools to enable customer flexibility to play its proper role in our clean and efficient future electricity system. Part 1 of this paper sets out what we mean by demand-side flexibility. Part 2 outlines the benefits that greater demand-side flexibility can deliver to the power system and customers. Part 3 sets out why demand-side solutions are underprioritised and summarises the barriers to be overcome.

Finally, Part 4 sets out five actions across a range of policy areas for measuring and assessing demand-side flexibility potential, mobilising the market value of this flexibility, deploying flexible assets in homes and communities, and inspiring the customer products and services required to access the full advantages of this vital system and decarbonisation resource.

This paper focuses on flexibility provided by households, as the sector has substantial existing and anticipated flexible demand. Analysis by the European Commission found that the greatest potential for demand-side flexibility in 2030 lies with residential customers, due to the so-far untapped nature of this market and projected electrification and digitalisation.[12] Figure 3 shows each customer segment's projected capacity for a subset of flexibility — demand response, discussed in the next section — in 2030, based on analysis in 2016. Actual flexibility potential of households is likely to be much higher, due to progress already made on some of the enabling factors explored in this paper, including access to markets, better economic incentives and increased electrification ambitions.

Figure 3. Theoretical 2030 demand-response potential in select countries (2016 estimate)



Source: European Commission. (2016). *Evaluation report covering the evaluation of the EU's regulatory framework for electricity market design and consumer protection in the fields of electricity and gas; Evaluation of the EU rules on measures to safeguard security of electricity supply and infrastructure investment (Directive 2005/89)*

11 Claeys, B., Hogan, M., & Scott, D. (2021). *Responses to fossil gas price volatility*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/responses-to-fossil-gas-price-volatility

12 European Commission. (2016). *Evaluation report covering the evaluation of the EU's regulatory framework for electricity market design and consumer protection in the fields of electricity and gas; Evaluation of the EU rules on measures to safeguard security of electricity supply and infrastructure investment (Directive 2005/89)*. SWD(2016) 412 final, Part 2, graph 2 [Commission staff working document]. https://energy.ec.europa.eu/system/files/2016-12/2_en_autre_document_travail_service_part2_v2_412_0.pdf

Importantly, in the digital age, this demand can increasingly be flexed while maintaining a household's full enjoyment of the energy service. Technologies such as electric vehicle charging, heat pumps and district heating — when operated flexibly — enable the drawing of power from the grid to be decoupled in time from customer use.

Household flexibility also represents the last mile of customer flexibility, so unlocking this sector enables the completion of a flexible demand side. Notwithstanding the household perspective, many of the recommendations in this paper — such as those related to the wholesale and flexibility markets — will also be relevant to other categories of customer.

PART 1:

What is demand-side flexibility?

There is no official definition of demand-side flexibility in EU legislation. The EU Smart Grids Task Force defines it as "*the ability of a customer (Prosumer) to deviate from its normal electricity consumption (production) profile, in response to price signals or market incentives. Demand side flexibility consists of: load, demand side generation & demand side storage.*"

For a resource to be demand-side, it must generally be located on the customer's side of the meter.[13] Demand-side flexibility is technology agnostic. It encompasses the capacity of a customer to react to an implicit or explicit price signal by shifting controllable loads (by turning load on, off, up or down), or utilising on-site storage such as batteries, on-site generation and energy efficiency. Controllable household loads are enabled by smart meters and digital services and include appliances, smart charging for electric vehicles, and forms of air cooling and heating like heat pumps with storage and electric boilers.

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Customers who participate in demand-side flexibility are defined as active customers in Article 2(8) of the Electricity Directive ((EU) 2019/944).

In the household context, on-site generation is increasingly solar photovoltaics, but nonrenewable generation is included in the definition of demand-side flexibility. For example, in larger buildings, on-site electricity might be generated from a gas-fired micro combined heat and power unit or a small-scale diesel generator.[14] This paper focuses on strategies to unlock household flexibility through clean, renewable resources.

13 With the possible exception of public electric vehicle charging stations.

14 It has been argued that nonrenewable generation should be excluded from the definition of demand-side flexibility. However, limiting the definition rather than implementing marketwide standards risks perpetuating existing discrimination against the demand side while pushing polluting supply-side resources. Strict environmental criteria should be applied consistently across supply- and demand-side resources, such as in eligibility criteria for markets and grid services.

Examples of household demand-side flexibility

The following technologies could be deployed at the level of individual households, multi-tenant apartment blocks or community-scale projects. Building energy efficiency measures are an important enabler for demand-side flexibility in heating. They reduce overall demand and enable homes to stay comfortable for longer periods while heating or cooling is turned off or is scheduled to respond to the grid conditions. This allows electric heating and cooling loads, in particular heat pumps, to follow renewable generation patterns and increases time periods when customers can avoid using the grid or withstand a power outage without compromising comfort levels or their health.

- **Heat storage systems**, often water based, can buffer heating systems and move water heating or space heating from critical times. For example, electric storage heaters with timers draw power from the grid overnight to coincide with surplus wind power and can provide cheap heat in the morning. Individual electric heat pumps can heat insulated spaces or hot water reserves, and, at the community scale, district heating systems can store heat in tanks and pipes.
- **On-site renewable generation**, when self-consumed or exported locally, can reduce wider grid demand at peak times and ease grid congestion. On-site generation also gives customers discretion to avoid expensive periods and enables self-sufficiency if there is a power outage.
- **Electric vehicle charging and stand-alone batteries** can make use of renewable generation at times of abundance — for example, during a daytime solar surplus. Emerging bidirectional charging can allow on-site generation to be stored and released for use at the building level to avoid drawing power from the grid when electricity prices are higher. In emergency situations, customers may also be able to offer power back into the grid from the battery in the vehicle in return for revenue.[15]
- **Smart appliances** can turn on or off or ramp up or down in response to market and grid signals. For example, well-insulated chiller units can be flexed to pre-chill food and drink before an expensive period and monitor temperature to ensure that it remains within a safe and desirable range during the peak period.
- **Energy management systems** control technical building systems or home appliances. Such systems can be used to ramp demand up or down, optimise on-site generation, store energy, and supply generation or demand-response services to the grid in response to market signals.

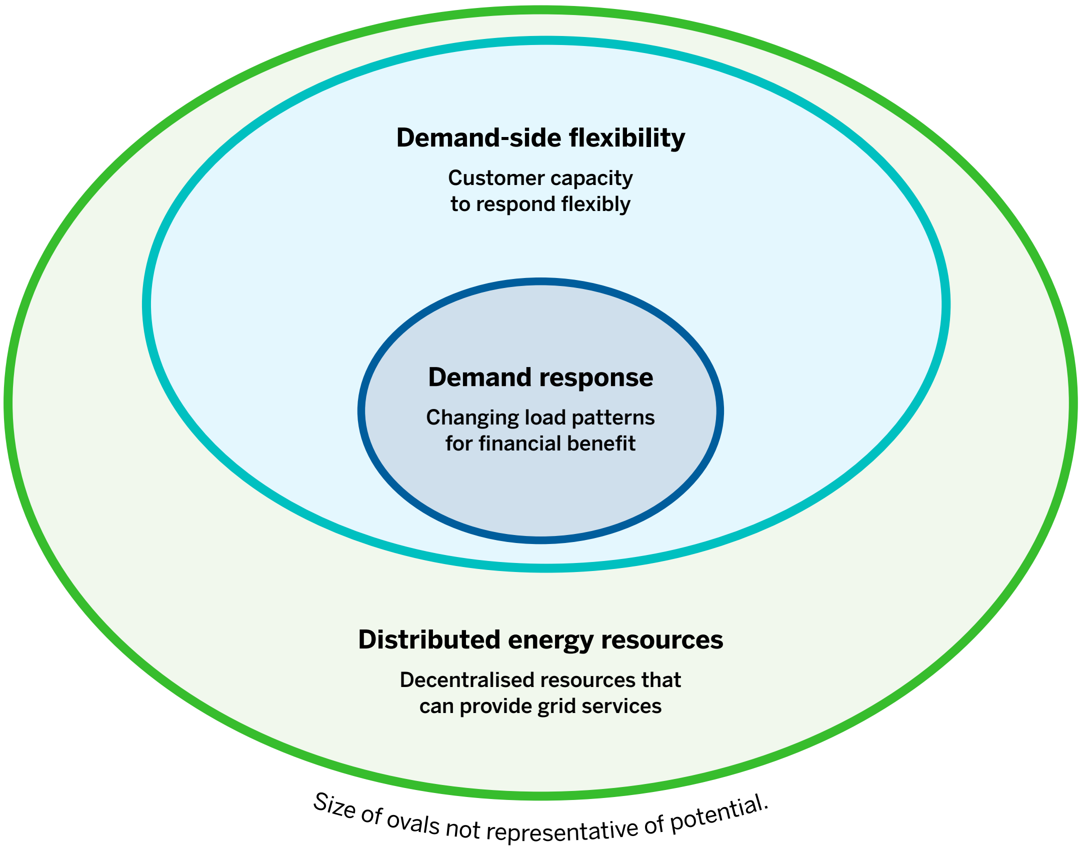
15 Burger, J., Hildermeier, J., Jahn, A., & Rosenow, J. (2022). *The time is now: smart charging of electric vehicles.* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/time-is-now-smart-charging-electric-vehicles/

Demand-side flexibility falls into the category of distributed energy resources. These are decentralised resources, capable of providing services to the grid, which are connected to the local distribution system or otherwise located near the end user. Distributed energy resources also include supply-side generation and storage. Although all distributed energy resources are important for system flexibility, this paper focuses on the specific role of demand-side flexibility.

When electricity customers use their flexible capability to change their electricity demand patterns within a specific time period in return for a financial reward, this is called demand response — a subset of demand-side flexibility.[16] The reward could be a payment for a specific service to the grid (explicit demand response), usually arranged by an independent aggregator.[17] Alternatively, the financial reward could be realised through electricity bill savings via a time-of-use or dynamic retail tariff or another flexible retail offer (implicit demand response), usually offered by an electricity supplier. Figure 4 summarises the interaction among the categories outlined above.

Demand response can be delivered through either manual actions — switching things on or off, turning things up or down — or automated processes, such as electric vehicle smart charging. Such actions could be delivered via third-party control over appliances with customer consent, whereby an external organisation such as an aggregator manages load remotely, while maintaining pre-agreed comfort and safety parameters.

Figure 4. Relationship among distributed energy resources, demand-side flexibility and demand response



16 The legal definition of demand response is contained in Article 2(20) of the Electricity Directive: "[T]he change of electricity load by final customers from their normal or current consumption patterns in response to market signals, including in response to time-variable electricity prices or incentive payments, or in response to the acceptance of the final customer's bid to sell demand reduction or increase at a price in an organised market as defined in point (4) of Article 2 of Commission Implementing Regulation (EU) No 1348/2014, whether alone or through aggregation."

17 Independent in the sense that they are not the customer's electricity supplier. Article 2(1) of the Electricity Directive defines 'aggregation' as meaning "a function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market." Article 2(19) adds that "'independent aggregator' means a market participant engaged in aggregation who is not affiliated to the customer's supplier."

Demand response in action

The examples below give a flavour of just some of the tools and technologies already being employed to engage household demand-side flexibility and bring the benefits to households, communities and the grid.

- **Operating flexibly to reduce the cost of electric heating**[18]

  The majority of Nordic homes are all-electric. Home energy company geo has developed a system through which heat in each room or zone is smartly controlled from an app. Users set parameters for how warm they want their rooms at which times and the system calculates the time it needs to heat the room while taking power market spot prices into account. Initial analysis, excluding spot pricing, shows that homes can on average save around 15% on their energy bill. Modelling suggests that including spot prices could deliver a further saving of 10%, resulting in a total savings of around €500-€750 per year.

- **Simple subscription to off-peak charging**[19]

  Austin Energy in the U.S. state of Texas offers electric vehicle drivers a simple way to reduce the cost of charging while minimising the impact on the electricity grid. Drivers pay a flat monthly subscription fee of $30 for unlimited charging of their car during off-peak hours. In addition to charging at home, the subscription includes unlimited charging on public chargers Austin Energy owns in and around the city, at any time of day. Trial results have shown that more than 99% of drivers with this subscription charge their car during off-peak hours.

- **Community-driven virtual power plant**

  The RESCoopVPP project (www.rescoopvpp.eu) aims to establish a community-driven virtual power plant that can provide flexibility services to the grid and maximise the use of community renewable energy assets. The project has developed a set of tools to make buildings smarter and enable citizen collectives called energy communities to organise themselves as aggregators and retailers of renewable energy. The energy management system communicates with devices like solar panels, batteries, electric vehicles and heat pumps, and provides local monitoring and control. Smart boxes are placed in buildings to collect data from end users which is visualised in an end-user energy monitoring application. Electricity suppliers within the project are refining a tool to help them optimally forecast the amount of electricity that their production installations will generate and the amount of electricity that their customers will demand at a given moment in the near future. In this way, producers and suppliers can contribute to maintaining the balance of the electricity grid. The project is active in communities in Belgium, France, the UK, Germany and Spain.

18 smartEn. (2020). *Smart energy prosumers*. https://smarten.eu/wp-content/uploads/2020/05/Smart_Energy_Prosumers_2020.pdf

19 smartEn, 2020.

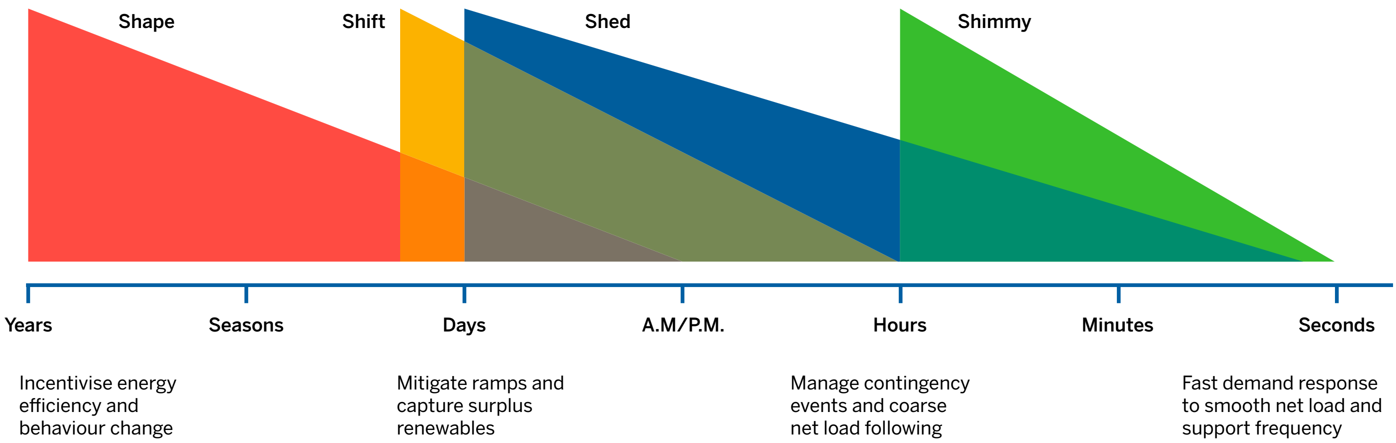
Historically, there has been a tendency to treat demand response primarily as a capacity resource for load shedding, or reducing demand, with a disproportionate focus on emergency situations. The reality is that demand response can deliver — and has delivered in numerous settings — a range of valuable implicit and explicit services across different time frames. The range of actions, as shown in Figure 5, has been effectively described as shaping, shifting, shedding and shimmying.

- Shape: Reshape load profiles in response to prices or behavioural campaigns.
- Shift: Move consumption from times of tight supply to times when there is a surplus of renewable generation.
- Shed: Curtail loads to provide peak capacity and to support the system in emergency or contingency events, often at the local level.
- Shimmy: Dynamically adjust demand on the system to alleviate short-run ramps and disturbances; this could be as granular as second-by-second adjustments.[20]

Although these actions are all valuable to system operators, for customers the technical application of their flexibility is unimportant. Customers do not need to become experts in energy networks and wholesale pricing to provide essential grid services. To them, the main questions remain, "How will this impact my life and what are the rewards?"

For simplicity, in the remaining parts we use 'demand-side flexibility' as an umbrella term for both traditional demand response and other flexible household actions — including export of on-site renewable generation or electric vehicle battery capacity to the grid — rather than differentiating between them.

Figure 5. Demand-response contributions across different time frames



Source: Alstone, P., et al. (2017). *2025 California demand response potential study — Charting California's demand response future: Final report on Phase 2 results*

20 Alstone, P., Potter, J., Piette, M. A., Schwartz, P., Berger, M. A., Dunn, L. N., Smith, S. J., Sohn, M. D., Aghajanzadeh, A., Stensson, S., Szinai, J., Walter, T., McKenzie, L., Lavin, L., Schneiderman, B., Mileva, A., Cutter, E., Olson, A., Bode, J., … Jain, A. (2017). *2025 California demand response potential study — Charting California's demand response future: Final report on Phase 2 results*. https://eta-publications.lbl.gov/sites/default/files/lbnl-2001113.pdf

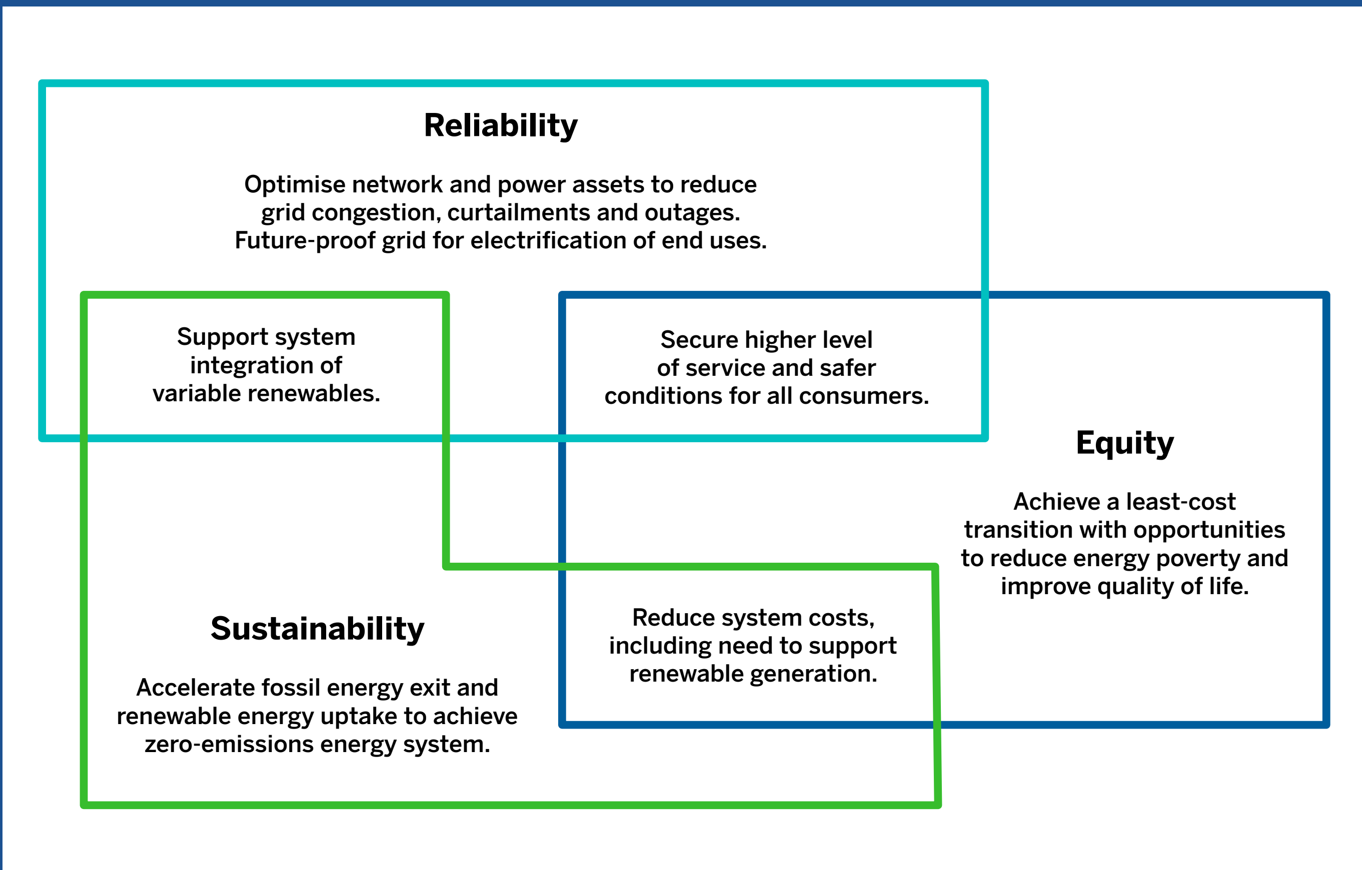
PART 2:

The joy of flex: What can demand-side flexibility do and who will benefit?

This section takes a closer look at the benefits of demand-side flexibility for the decarbonised grid and wider society, for customers as a whole and for individual households — specifically those who are active customers.

The challenge of finding the right balance among reliability, affordability and sustainability in how we access and use energy in our daily lives has historically been depicted as an 'energy trilemma.' Where customers are willing and able to create a flexible demand side the sometimes competing needs of the energy trilemma can be reconciled. The trilemma remains, however, a useful way of framing the different needs that energy solutions must meet. Figure 6 summarises how demand-side flexibility, when properly enabled, can deliver the whole package. We change the 'affordability' component to 'equity,' which encompasses not just affordability but also the ways in which costs, risks and benefits are distributed between customers and other market actors.

Figure 6. Demand-side flexibility benefits organised according to the 'energy trilemma'



Sustainability

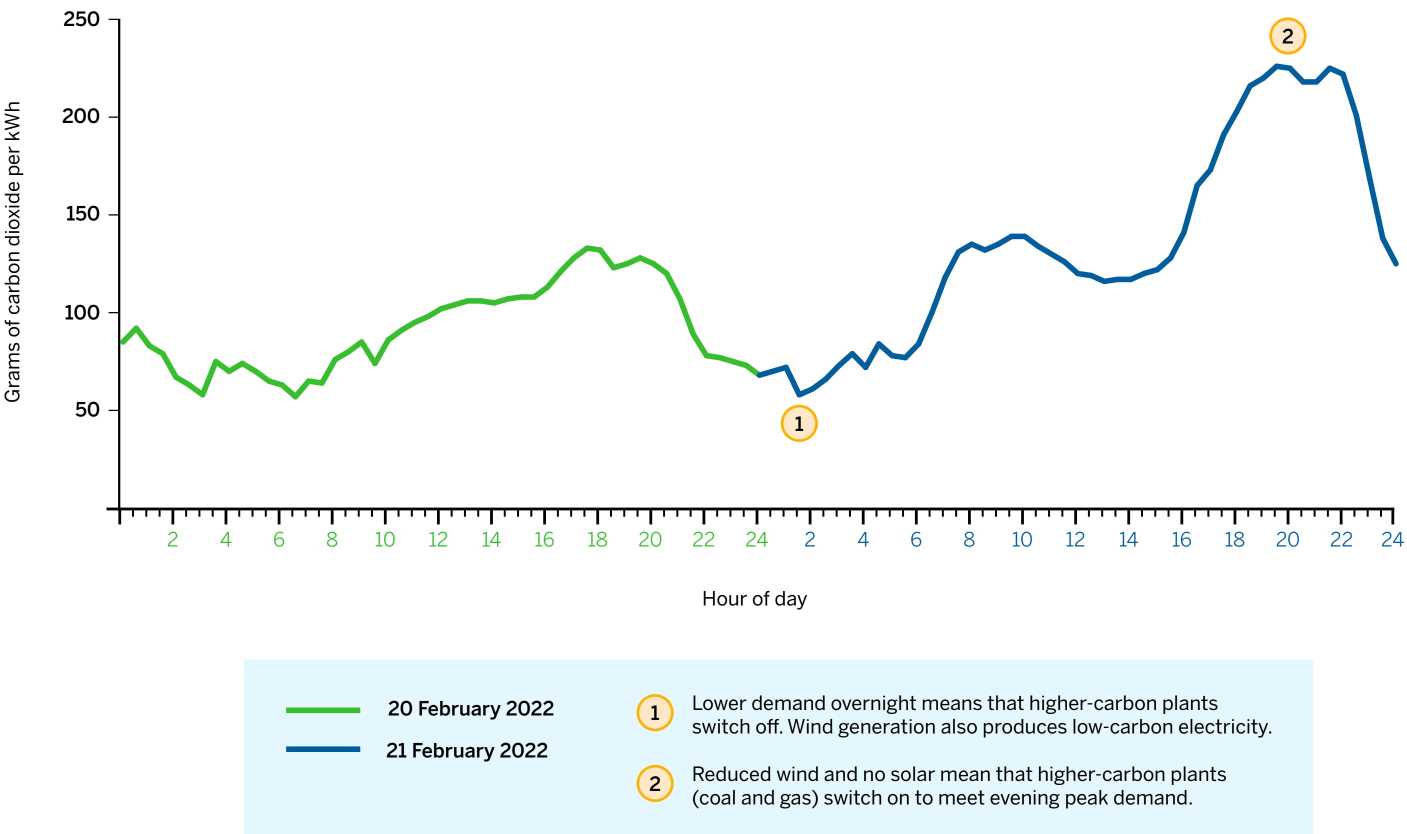
Demand-side flexibility enables faster decarbonisation of the electricity system in a number of ways.

At the system level, responsive demand can be dynamically matched to times of high renewable energy grid penetration so that less renewable generation goes to waste. Ultimately, flexibility displaces fossil-fuel backup generation, reducing carbon in the wider energy mix and enabling a timely fossil fuel exit — as long as subsidies are not artificially keeping it in the market.

As more end uses are electrified, the carbon content of the generation source that meets this new demand is critical. The last generating unit added to the generation mix to meet the demand at any time is referred to as the marginal unit. The carbon content of this marginal unit differs across the day and year, as data from the UK shows in Figure 7.[21] Flexing can directly contribute to reducing emissions associated with adding new loads by shifting demand to those hours when electricity is cleanest.

The 2021 Carbon Flex project modelled the impact of installing heat pumps and home batteries in several buildings and then using these devices to match the buildings' energy demand to the carbon intensity of the electricity grid. It showed that the buildings could avoid up to 8%-13% more carbon, compared with their baseline emissions, by being flexible with the use of the batteries and heat pumps to avoid the times of highest carbon intensity. This could be achieved at low cost without impacting the energy services to the building occupants.[22]

Figure 7. Carbon intensity of generation



Source: Based on National Grid ESO. (2018). *Future energy scenarios.* Updated by RAP with data from National Grid ESO. (n.d.). *Carbon intensity API*

21 Based on National Grid ESO. (2018). *Future energy scenarios*, p. 32. https://www.nationalgrideso.com/sites/eso/files/documents/fes-interactive-version-final.pdf. Updated by RAP with data from National Grid ESO. (n.d.). *Carbon intensity API*. https://carbonintensity.org.uk

22 Energy Unlocked. (2021). *The hidden carbon economy*. https://static1.squarespace.com/static/556c3a68e4b056fbbd35d60c/t/618909c3325ee10acf6688d6/1636370890660/TheHiddenCarbonEconomyReportNov2021.pdf

Demand-side flexibility can be deployed to reduce grid congestion. This means grid upgrade works can be delayed or avoided, minimising physical infrastructure in favour of virtual 'nonwires' solutions, further reducing emissions and future-proofing investments.

Demand-side flexibility in the electricity sector also enables swifter decarbonisation of other end uses. It supports electrification of transport, heat and cooking by enabling large new loads to make use of renewable generation when it is abundant, while increasing system flexibility and reducing grid constraints.

At the household and community level, demand-side flexibility provides customers with greater control over their energy sources and personal carbon footprint. It enables them to make full use of on-site, community and local renewable generation, minimising or even eliminating their reliance on fossil fuels. Demand-side flexibility therefore allows households to optimise for carbon reduction in addition to cost reduction.

Equity and affordability

Significant efficiency savings from customer flexibility can be realised in many ways across the system, providing both indirect savings to all and direct savings to active customers.

Currently, the physical grid and generation capacity are built to accommodate peak demand. By smoothing out demand spikes and optimising the use of renewables when they are abundant, unnecessary network infrastructure and backup generation costs can be avoided. This also reduces the risk of future 'stranded' fossil fuel investments — that is, investments in assets which cannot operate for their full natural lifetime, or are subject to premature devaluation, due (in this case) to climate needs. Customer flexibility therefore lowers the system cost burden for all bill payers.

A 2021 study by Imperial College London estimated system savings of around 1.9 to 2.2 pence per kWh from optimising assets through demand-side flexibility.[23] Energy is also most expensive when use is highest, so reducing demand spikes also brings down price spikes for all. Balancing the system through demand-side flexibility rather than just increasing generation also reduces physical network losses when electricity is conveyed over long distances.[24] Finally, fully utilising renewable resources improves their profitability, which reduces the need for customers to pay for green subsidies or investments in backup generation.

Demand-side flexibility also delivers direct financial rewards to active customers, allowing them to benefit through their bills from the value they create in the system. In a market that reflects the true value of demand-side flexibility, customers who can be flexible are incentivised to take advantage of very low-priced energy when it's available and avoid expensive periods. When combined with user-friendly, accessible retail offers, this empowers customers to tap into the maximum savings offered by suppliers and other service providers. Customers may also earn revenue through a separate contract with an aggregator or as part of an energy community.[25] Those with spare generation or storage capacity can earn by exporting power to the grid during times of scarcity, so they can benefit from temporary price spikes while helping to reduce the spike, to the benefit of everyone else.

If enabled effectively, through automation of equipment and third-party management services, there is an opportunity to improve energy services and reduce costs for low-income and vulnerable households. Given the rising issue of energy poverty, which is highlighting the burdens for different energy users[26] and the digital divide between individuals and geographical areas with different levels of

23 Aunedi, M., Wills, K., Green, T., & Strbac, G. (2021). *Net-zero GB electricity: Cost-optimal generation and storage mix*. IDLES programme white paper, Imperial College London. https://spiral.imperial.ac.uk/bitstream/10044/1/88966/7/EFL_Net%20Zero%20GB%20Electricity_White%20Paper.pdf

24 An EU average is difficult to obtain due to differences in reporting; for example, some figures include theft of power. A report on power losses states that: "Losses in transmission vary between about 0.5% and just under 3% in 2018. … The percentages in distribution are higher and vary between approximately 2% and 14% in 2018, not counting a specific case in Kosovo (28% in 2018). Finally, total losses in 2018 range between 2.5% and 11% (not counting 25% in 2018 in Kosovo)." Council of European Energy Regulators. (2020). *2nd CEER report on power losses*. https://www.ceer.eu/documents/104400/-/-/fd4178b4-ed00-6d06-5f4b-8b87d630b060

25 Claeys, B. (2021). *Energy communities with grid benefits: A quest for a blueprint*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/energy-communities-with-grid-benefits-a-quest-for-a-blueprint

26 Sunderland, L., Jahn, A., Hogan, M., Rosenow, J., & Cowart, R. (2020). *Equity in the energy transition: Who pays and who benefits?* Regulatory Assistance Project. https://www.raponline.org/knowledge-center/equity-in-energy-transition-who-pays-who-benefits/

access to information and communication technologies,[27] it is vital to pursue all opportunities in the energy transition to open up the benefits to disadvantaged groups.

Aggregating even relatively small individual flexible loads across whole communities can create a valuable resource from which low-income households can benefit.

Reliability

Flexibility can make households and communities more resilient during grid outages or price spikes. Energy efficiency measures can mean the difference between life and death in an ongoing power outage, and home batteries or electric vehicle batteries can provide backup power to the home. On-site generation, heat and battery storage, and energy efficiency, particularly when used together, can allow households to continue to access power and benefit from comfortable or at least safe indoor temperatures in emergency situations.

Demand response can also work to deliver more equitable outcomes during emergency conditions by maintaining service to critical sites like hospitals — especially where smart meters and the ability to isolate specific segments of the grid are in place. For example, rolling short-term outages combined with energy-efficient housing can ensure that everyone stays safe, rather than some houses being left without power for a long duration.

At the system level, a responsive demand side, combined with pricing that accurately reflects system conditions, provides crucial data for longer-term resource adequacy planning. It is also essential for the day-to-day balancing of variable renewable energy supply with demand, while bolstering system resilience during times of system stress such as extreme weather events.

27 Organisation for Economic Cooperation and Development. (2001). *Understanding the digital divide*. https://www.oecd-ilibrary.org/science-and-technology/understanding-the-digital-divide_236405667766

Demand-side flexibility for resilience and adaptation: A virtual grid defence

The presence or absence of sufficient flexibility resources in the toolboxes of system operators has been shown to significantly affect outcomes at times of system stress.

- During the 2014 U.S. polar vortex, coal stocks froze and gas stations ran out of fuel, while demand-side flexibility helped to maintain service to customers.[28]
- The events in Texas in February 2021, caused by an unforeseen and severe winter storm, saw sudden failures of gas supply and nearly half of all thermal power plants, leading to extended outages. Conditions were exacerbated by a lack of energy efficiency, flexible end-use technologies and distribution-level measures that would have allowed flexible customers to play a critical role in mitigating the consequences of the event.[29]
- During a system event in January 2021 in the Balkan peninsula caused by cold weather and technical failures, system operators in France and Italy called upon interruptible load capacity from industrial demand-response consumers, which provided 1.7 GW to enable frequency stabilisation.[30]

Extreme weather is expected to become more frequent in Europe in the coming years.[31] Although less visible than other resilience and adaptation measures such as flood defences, demand-side flexibility acts as a virtual defence for the electricity grid during times of crisis. In this way, customer flexibility can be mobilised to tackle the symptoms of climate change, in addition to the causes.

28 PJM Interconnection. (n.d.). *2016/2017 RPM base residual auction results*. https://www.pjm.com/~/media/markets-ops/rpm/rpm-auction-info/2016-2017-base-residual-auction-report.ashx. See also: Moore, J., & Clements, A. (2014). *The polar vortex and the power grid: What really happened and why the grid will remain reliable without soon-to-retire coal plants*. Natural Resources Defense Council. https://www.nrdc.org/experts/john-moore/polar-vortex-and-power-grid-what-really-happened-and- why-grid-will-remain

29 Hogan, M. (2021). *Real-life drama: Lessons for Europe from a Texas tragedy*. Euractiv. https://www.euractiv.com/section/electricity/opinion/real-life-drama-lessons-for-europe-from-a-texas-tragedy

30 European Network of Transmission System Operators for Electricity. (2021). *Continental Europe synchronous area separation on 8 January 2021: Interim report*. https://eepublicdownloads.azureedge.net/clean-documents/Publications/Position%20papers%20and%20reports/entso-e_CESysSep_interim_report_210225.pdf

31 Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Impacts, adaptation and vulnerability — summary for policymakers*. https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_SummaryForPolicymakers.pdf

PART 3:

Killjoys: What is holding back demand-side flexibility?

This section outlines features of the power system that are preventing us from tapping into the full benefits of flexibility in Europe. The scope is limited to regulatory barriers, which, in this context, means barriers that energy regulation — both markets-focused and broader, complementary policies — could help to overcome. They are interrelated; some perpetuate or are symptomatic of others.

The regulatory regime approaches demand-side flexibility only as an individual customer right, not a system resource. EU energy markets legislation now recognises that customers should be empowered to utilise demand-side flexibility for their own benefit — though full implementation of these provisions remains the exception rather than the rule.[32] Even where properly implemented, there is a missed opportunity for an integrated strategy across the entire legislative framework, including state aid, renewables and generation policy, and buildings regulation. The EU regulatory landscape focuses on the individual right of demand-side flexibility rather than its vital role as a system resource for efficient, affordable decarbonisation. It therefore fails to provide coherent, mutually supportive objectives and incentives to deliver customer flexibility at scale, for the benefit of the whole system. The other barriers outlined below result from this lack of cohesion, priority and focus.

Demand-side flexibility potential and value are poorly understood and underestimated, and data is outdated. You can only reward what you can measure, and you can only accurately measure what you understand. Poor understanding of the full spectrum of demand-side flexibility offerings has led to it being undervalued and underestimated in energy policy and economic planning, including in resource adequacy assessments and network planning.

The absence of a sophisticated, standardised methodology for assigning value to demand-side flexibility and the lack of real-world case studies are key contributing factors. This makes it harder to avoid unnecessary market interventions and stunts the development of flexibility targets and standards. Demand-side flexibility is a fast-changing technical and policy area, directly impacted by energy market reform. Yet the most recent comprehensive projections of European household flexibility potential in 2030 are from 2016.[33] The prominent dynamic tariff studies are from the U.S. and around a decade old. For obvious reasons, these do not consider incentives and opportunities offered by modern EU regulatory and retail landscapes, nor the impact of automation, electrification and digitalisation.[34]

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32 For detailed benchmarking of Member State implementation as of March 2022 see smartEn. (2022). *The implementation of the electricity market design to drive demand-side flexibility* (2nd ed.). https://smarten.eu/report-the-implementation-of-the-electricity-market-design-2022-smarten-monitoring-report/. See also Murley, L., & Alberti Mazzaferro, C. (2022). *European market monitor for demand side flexibility 2021*. Delta Energy & Environment and smartEn. https://www.delta-ee.com/report/2021-european-market-monitor-on-demand-side-flexibility

33 For example, COWI. (2016). *Impact assessment study on downstream flexibility, price flexibility, demand response & smart metering*. European Commission, Directorate-General for Energy. https://energy.ec.europa.eu/system/files/2016-12/demand_response_ia_study_final_report_12-08-2016_0.pdf

34 A study for the European Commission on dynamic retail pricing heavily references U.S. studies by The Brattle Group in 2010 and 2011 that are still regarded as leading studies in the field. See Boeve, S., Cherkasky, J., Bons, M., & Schult, H. (2021). *ASSET study on dynamic retail electricity prices*. European Commission, Directorate-General for Energy. https://op.europa.eu/en/publication-detail/-/publication/a8b8e55f-a17f-11eb-b85c-01aa75ed71a1/language-en. See also Cappers, P., Spurlock, A., Todd, A., Baylis, P., Fowlie, M., & Wolfram, C. (2016). *Time-of-use as a default rate for residential customers: Issues and insights* (LBNL-1005704). Lawrence Berkeley National Laboratory. https://emp.lbl.gov/publications/time-use-default-rate-residential

Wholesale market design does not reflect the true system value or cost of user actions. Energy retailers, independent aggregators and other energy innovators can only pass on to customers the value that can be captured from the energy market. Non-cost-reflective network charges and incentives, regulated wholesale pricing, capacity mechanisms and other policy subsidies currently dampen or even negate the real value that should be available for incentivising customer actions that create efficiency and cost savings.

Demand-side flexibility market opportunities and governance remain fragmented and limited. Even in the countries where active customers are already granted access to all markets alongside generation, they experience unduly onerous or exclusionary eligibility requirements, auction rules and product design. This limits revenues for new demand-side flexibility business models, which impacts their ability to expand, take on new customers and attract investors. Flexibility services are also fragmented across many different markets, each with different procedures, time frames and requirements. This adds to the administrative burden, makes it difficult to draw value from multiple services concurrently and creates inefficiencies that lead to risks being socialised rather than properly allocated and managed.

Customers lack ability and willingness to operate flexibly under current conditions. Most households are still not motivated to choose, or are unable to easily access, flexible products and services. This includes access to appropriate and attractive retail offers and affordable, hassle-free adoption of flexible assets: the technologies and building upgrades such as smart electric vehicle charging, controllable loads and on-site generation and storage necessary to significantly increase their flexibility potential. Policy strategy does not adequately support households in collectively reaching the critical mass of flexibility needed for system efficiency.

PART 4:

How to unlock household demand-side flexibility in Europe

This part explores the principles that must be upheld and the practical steps that should be taken to overcome the barriers outlined above, to maximise and activate household flexibility potential in Europe.

Overarching principle: Approach demand-side flexibility as a vital system resource

The Electricity Directive, as recast by the Clean Energy for all Europeans package,[35] officially recognises demand response as a tradeable, dispatchable resource for the first time in EU power regulation. However, the provisions — even assuming they are fully implemented in Member States, which they are not[36] — are limited to requiring that the customers who are already willing and able to participate in demand response are not prevented from doing so.[37]

Demand-side flexibility is still framed as a path that customers are entitled to take for their own benefit. In reality, it is also a path that the decarbonised system needs them to take for everyone's benefit.

While this represents significant progress from the directive's predecessors, demand-side flexibility is still framed as a path that customers are entitled to take for their own benefit. In reality, it is also a path that the decarbonised system needs them to take for everyone's benefit. Policymakers should internalise the overarching principle that household demand-side flexibility is more than an individual customer right; it is also a vital system resource and should be upheld as such. Policy should ensure that individual and collective interests are aligned wherever possible.

35 CE4All is a suite of eight legislative measures including a new EU Electricity Directive and Electricity Regulation, which were adopted in 2019, with one to two years to implement the provisions. European Commission, Directorate-General for Energy. (n.d.). *Clean energy for all Europeans package*. https://energy.ec.europa.eu/topics/energy-strategy/clean-energy-all-europeans-package_en

36 For example, the most recent EU market monitoring report reveals that dynamic retail tariffs are only available in France, Spain, Finland and Austria. Outside the EU, they are also available in the UK. Agency for the Cooperation of Energy Regulators & Council of European Energy Regulators. (2021). *Annual report on the results of monitoring the internal electricity and natural gas markets in 2020: Energy retail markets and consumer protection volume*. https://extranet.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202020%20–%20Energy%20Retail%20and%20Consumer%20%20Protection%20Volume.pdf

37 Article 11 of the Electricity Directive 2019 states that electricity suppliers must not block customers from contracting with independent aggregators. Suppliers with 200,000 customers or more are required to offer a dynamic tariff. National rollouts of smart meters are mandated where there is a positive cost-benefit analysis. In the absence of a national rollout, the legislation gives customers the right to request a smart meter at their own cost and to request a dynamic or time-of-use retail tariff. However, at the time of writing, implementation remains patchy. See smartEn, 2022.

Recommendations: Customer flexibility as a system resource

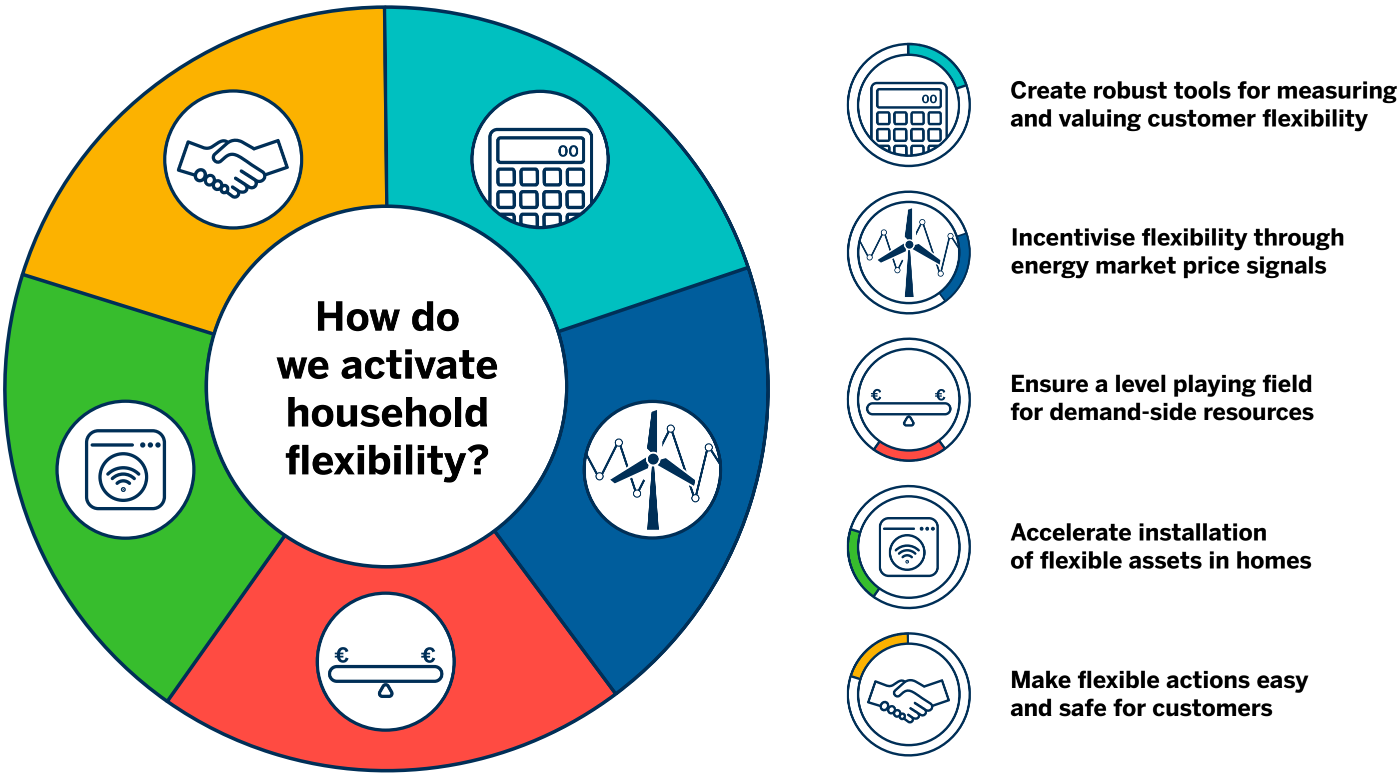
- European and national policymakers and regulators should unequivocally endorse household and community-level flexibility — including district heating — as a system resource, essential to meeting the objectives of the energy transition.
- This should be supported by a comprehensive governance review and demand-side flexibility policy strategy for Europe with the objectives of:
  - Reorganising power market roles, responsibilities and incentives so they work together to promote efficient user actions, while removing interventions that dampen incentives or create roadblocks for household flexibility.
  - Aligning objectives between energy policy and other sectors that are deploying flexible solutions on the ground, including building fabric, transport, heat and mobility, to ensure a mutually supportive approach.

Five-point action plan for scaling up household flexibility

This section sets out an action plan, intended as a starting point for a comprehensive demand-side flexibility policy strategy for Europe. It includes next steps that are needed — including evidence collection and measures that can be implemented immediately — to deliver joined-up, timely and equitable outcomes. The plan comprises five key actions, summarised in Figure 8 on the next page. These are interlinked and need to happen concurrently.

- Action 1: **Create robust tools for measuring and valuing customer flexibility.** Create a common methodology for assessing (current and future) customer flexibility potential, supported by real-world trials, so the full value is revealed and progress can be benchmarked.
- Action 2: **Incentivise flexibility through energy market price signals.** Adapt wholesale electricity market design to reflect the true value of efficient demand-side actions across the supply chain, so this value can be captured and passed on to customers.
- Action 3: **Ensure a level playing field for demand-side resources.** Ensure aggregated household flexibility can compete on explicit demand-response platforms, by removing discrimination, enabling data exchange, and facilitating collection of value across different flexibility services and timescales concurrently.
- Action 4: **Accelerate installation of flexible assets in homes.** Increase the technical flexibility potential of households through standards and other policy initiatives, so customers are able to be more flexible, with greater ease.
- Action 5: **Make flexible actions easy and safe for customers.** Foster accessible and desirable flexible retail offers, using innovation-friendly policy and appropriate regulatory safeguards.

Figure 8. Five-point action plan for mobilising demand-side flexibility



The actions are in principle all relevant to unlocking demand-side flexibility potential across all customer segments, but the recommendations for actions 4 and 5 are specifically tailored to households.

Market reform and complementary policy actions must take place simultaneously. To meet decarbonisation objectives, market design that drives efficient actions remains central, but it will not be enough to simply 'price and pray.' Policymakers also need to accelerate the growth of flexible assets, revenue streams and products. By tackling the challenge from multiple angles, it is possible to kick-start a positive feedback loop — whereby customers are enabled to mobilise flexible load, experience the benefits of doing so and then make decisions that allow them to be more flexible in the future. Table 1 on the next page maps the five key actions onto the most relevant EU directives and strategies.

Table 1. Key European Union regulatory vehicles for enabling demand-side flexibility

Action	Key EU regulation
Action 1: Create robust tools for measuring and valuing customer flexibility	• Electricity Regulation ➔ European Resource Adequacy Assessment ➔ EU Digitalising the Energy Sector action plan
Action 2: Incentivise flexibility through energy market price signals	• Electricity Directive and Electricity Regulation ➔ Demand-Side Flexibility Network Code
Action 3: Ensure a level playing field for demand-side resources	• Electricity Directive and Electricity Regulation ➔ Demand-Side Flexibility Network Code ➔ EU Digitalising the Energy Sector action plan • State aid rules and general competition law
Action 4: Accelerate installation of flexible assets in homes	• EcoDesign Directive and standards • Energy Performance of Buildings Directive • Energy Efficiency Directive • Renewable Energy Directive ➔ Alternative Fuels Infrastructure Regulation* • State aid rules and general competition law
Action 5: Make flexible actions easy and safe for customers	• Electricity Directive and Electricity Regulation • Energy Performance of Buildings Directive • Renewable Energy Directive ➔ EU Digitalising the Energy Sector action plan • General Data Protection Regulation ➔ Data Governance Regulation

➔ Indicates under development, proposed or otherwise pending as of April 2022.
References to legislation are references to the latest version, including any recasts and amendments.

* The Alternative Fuels Infrastructure Regulation will establish a European framework for electric vehicle charging infrastructure on public roads, which is essential to building smart electric vehicle charging infrastructure accessible to households.

Action 1: Create robust tools for measuring and valuing customer flexibility

This action focuses on creating reliable mechanisms for understanding the spectrum of demand-side flexibility functions — and the benefits that they bring — so the full potential contribution of customer flexibility can be accurately reflected in policy and market design.

Assessments of demand-side flexibility potential and value should not be based solely on a snapshot of current market circumstances or installed technical flexibility. To obtain a complete picture, it is necessary to incorporate the likely impacts of market reform and complementary energy and social policies, which could strengthen and streamline economic incentives for flexibility, while injecting flexible assets into the system.

Demand-side offerings, especially household flexibility, are currently undervalued and underestimated in energy policy and economic planning, due to inadequate understanding of the wide range of applications and virtues. Unlike in the renewable energy sector, where EU and national targets have accelerated market integration and brought down costs, flexibility targets have not yet left the drawing board. This is partly due to the absence of a common methodology for assessing demand-side flexibility potential. Targets are only effective where it is possible to set realistic goals, measure progress and verify compliance. There is a dearth of comparable data, case studies and sophisticated modelling around household flexibility potential and value, particularly studies that factor in the impact of wider market enablers. The first step is therefore to develop a clear evidence base that can be used to educate policymakers, system operators, investors and — crucially — customers on the full range of benefits.

Undervaluing the contribution of demand-side flexibility to resource adequacy in modelling scenarios also increases the risk of regulatory interventions such as national capacity mechanisms being introduced prematurely or unnecessarily. Capacity mechanisms are market interventions which reserve a defined amount of capacity outside of the market for a specified number of years, to be called upon to ensure sufficient capacity in situations where supply is particularly scarce relative to demand. They tend to favour large, fossil-fuel-powered generating stations, while removing market opportunities for customer flexibility to deliver comparable services at lower cost. Around 75% of the total capacity participating in capacity mechanisms in Europe is derived from natural gas, nuclear, and coal or lignite. In 2021, demand-side flexibility and supply-side battery storage provided only about 3% of capacity and only in a small number of countries.[38]

Lack of standardisation and poor transparency around underlying modelling assumptions make it difficult for affected demand-side flexibility stakeholders to challenge flawed assessments. It also hinders regulators' efforts to benchmark progress and identify opportunity costs. A robust methodology for assessing demand-side flexibility potential is therefore an essential step towards moving beyond market interventions and inflated system costs, so we can reveal and harness the full power of customer flexibility. The European business association for flexibility, smartEn, published a report on the way in which demand-side flexibility is valued in modelling scenarios, which reviews existing methodologies and pulls together a list of factors that should be included to ensure a comprehensive approach.[39]

Demand-side offerings, especially household flexibility, are currently undervalued and underestimated in energy policy and economic planning, due to inadequate understanding of the wide range of applications and virtues.

To complete the evidence base, market simulations should be supplemented with real-world trials and other initiatives. This serves the dual purpose of debunking modelling misconceptions while bridging the gap between small pilot studies and commercial-scale delivery of demand-side resources. To ensure meaningful and timely impact, governments and system operators should work closely with innovators, so they can measure the deployments and benefits of customer flexibility in the actual marketplace. For example:

- In 2021 the California Energy Commission awarded a $2 million contract to Packetized Energy, a developer of software systems and smart devices, to fund deployment and connection of 7,000 new and existing household smart energy devices. The project, which enables 4 MW of flexible capacity, will create one of the largest distributed energy resource aggregation networks from residential devices in California, providing not only peak load reduction but also dynamic balancing services and wholesale price arbitrage.[40]

38 Pinto-Bello, A. (2022). *The smartEn map 2021: Resource adequacy mechanisms*, p. 14. smartEn. https://smarten.eu/wp-content/uploads/2022/01/the_smarten_map_2021_DIGITAL_final.pdf

39 smartEn. (2021a). *Valorising demand-side flexibility in energy system-wide methodologies and modelling scenarios*. https://smarten.eu/wp-content/uploads/2021/07/smartEn-Position-paper-methodologies-FINAL.pdf

40 VermontBiz. (2021). *Packetized Energy awarded $2 million contract to help solve California grid challenges*. https://vermontbiz.com/news/2021/february/11/packetized-energy-awarded-2-million-contract-help-solve-california-grid

- Inspiration can also be taken from supply-side flexibility trials, such as the British system operator National Grid's experiment with battery asset technology in its balancing mechanism in September 2020. The three-week study, involving a grant to innovators, allowed National Grid to observe performance of battery storage across a range of operational and market conditions, revealing potential savings of £700 000 for consumers, compared to alternative actions in the balancing mechanism.[41]

Recommendations: Measuring and valuing flexibility

- Develop and adopt a robust EU methodology for assessing broad-ranging demand-side flexibility potential and value contributions — beyond the scope of resource adequacy assessments — to enable meaningful targets, benchmarking and planning.
- Require full transparency around system operators' underlying assumptions for network and resource adequacy planning. Methodologies should factor in the impact of market reform options — including implementation of EU legislation, and other complementary policies.
- Support simulations with real-world trials. Grant funding should be available to innovators to test modelling assumptions, help new entrant demand-side flexibility innovators move beyond pilot projects and demonstrate the value of flexibility, including household flexibility, to customers and the grid at scale.

Action 2: Incentivise flexibility through energy market price signals

This action focuses on how to design energy market regulation so that it reveals and rewards the true value that demand-side flexibility brings to the power system.

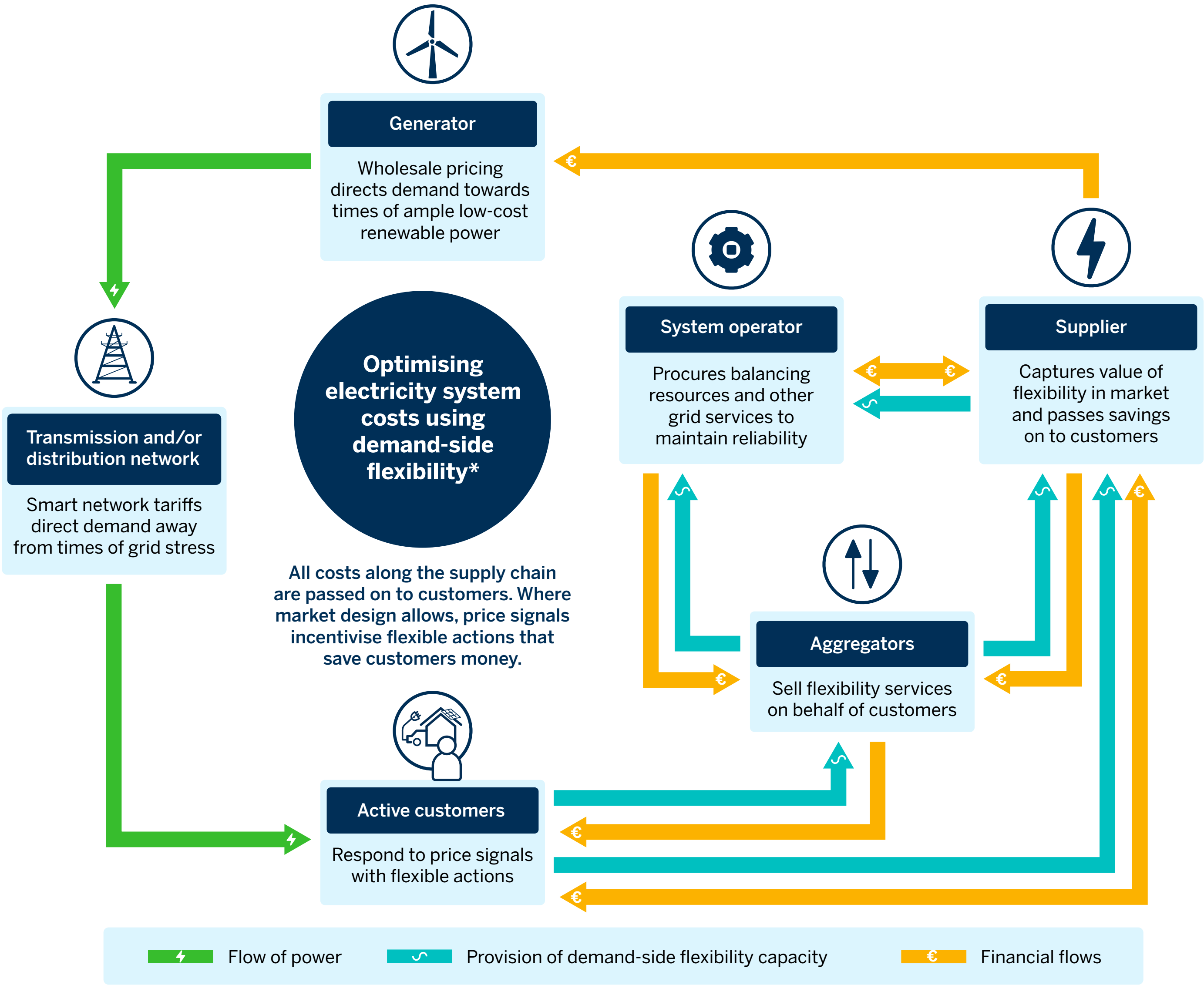
Retail energy suppliers are the gateway between customers and the wider power market. Network fees, wholesale energy prices, balancing services costs and policy levies all stack up in customer bills passed on by the retail supplier. Each layer represents a cost in the system, which could potentially be reduced through flexibility (see Figure 9). Even a supplier or independent aggregator with the best intentions, however, cannot pass on value that they themselves are not able to access, because the market design does not sufficiently reward system user actions that produce efficiency savings.

The charges and payments that take place in the electricity market should be constructed to drive efficiency savings at every point in the supply chain. Such savings can then be passed on to customers, maximising incentives for demand-side flexibility.

The charges and payments that take place in the electricity market should be constructed to drive efficiency savings at every point in the supply chain. Such savings can then be passed on to customers, maximising incentives for demand-side flexibility.

41 National Grid ESO. (2021). *Trial review: Reserve from storage in the BM*. https://data.nationalgrideso.com/backend/dataset/b3c55e31-7819-4dc7-bf01-3950dccbe3c5/resource/3efdf448-e5c2-4e41-98fe-ca0c98aa1af8/download/reserve-from-storage-trial-in-the-bm-phase-3-review-20210210.pdf

Figure 9. Capturing value of flexibility in electricity supply chain



*Note: This is a simplified, not exhaustive depiction of power system transactions. For example, the system operator has contractual relationships with other parties, but we are depicting those most relevant to demand-side flexibility.

Next, we look at how each of the primary cost components of electricity bills can be minimised through market incentives for demand-side flexibility.

Network and policy charges

Network tariffs are charges applied to customers for use of the grid to transport power. Network costs represent a sizable share of household electricity costs. Before the winter 2021-22 wholesale price increases, they constituted around 40% of total bills, but varying between 15% and 51% in different Member States.[42] Flawed network tariff design and incentives can undermine market signals for customer flexibility. Conversely, smart network tariff design and incentives can be used to activate flexibility, integrate prosumers[43] and optimise utilisation of networks.[44]

EU law requires that network charges reflect costs, but this has traditionally been interpreted narrowly as recovering the fixed cost of past investments from current users via

42 Explicit country-by-country breakdowns are set out in Agency for the Cooperation of Energy Regulators & Council of European Energy Regulators, 2021, Figure 50.

43 A prosumer is someone who both produces and consumes energy.

44 Regulatory Assistance Project. (n.d.-a). *Smart network tariffs*. Power System Blueprint. https://blueprint.raponline.org/smart-network-tariffs/

fixed fees.[45] Broadly, fixed fees are charged on a per customer basis, unlike volumetric fees, which vary according to the amount of electricity the customer uses.[46] With the arrival of smart meters and smart grids, it is now possible to charge individual households for network use in a way that much more accurately reflects the real costs and value they create in the system, depending on time of use.[47] In addition, the differentiation of network charges by location and the direction of power flow — consumption from the grid versus feed-in to the grid — can further improve efficiency signals.[48] Locational, bidirectional tariffs encourage cost-effective solutions to congestion challenges within certain parts of the distribution networks. This is particularly important for the smooth integration of distributed energy resources and new flexible, electrified customer loads.

Cost recovery methodologies for network companies that are primarily based on capital expenditures can create incentives to overinvest in avoidable grid infrastructure, displacing more cost-efficient demand-side solutions. This breaches the Energy Efficiency First principle, a cornerstone of the European Commission's energy policies (see the text box below). The Electricity Regulation requires network companies to consider demand-side resources and storage in their planning and operation, but many national regulators are yet to reconcile the tension between this obligation and network cost recovery methodologies.[49]

Like fixed network fees, policy levies — for example, for renewable energy support, energy efficiency schemes and capacity mechanisms — represent a sizable proportion of the final customer bill in some countries. In these cases, the presence of these levies as fixed elements of the bill could undermine efforts to make other costs dynamic, by reducing the share of the final bill that a customer is able to influence. Policy costs may also make electricity service relatively expensive, compared with gas, disincentivising electrification.[50]

Efficiency first

The European Commission enshrined the Energy Efficiency First principle in law in the 2019 Governance Regulation and published recommendations and guidelines for this decision-making philosophy in September 2021. The principle prescribes prioritising investments in demand-side resources whenever they would deliver better value at lower cost than investments in energy infrastructure, fuels and supply-side options.

45 Article 18 of the Electricity Regulation (EU) 2019/943 also requires that the network charges shall not discriminate either positively or negatively against energy storage or aggregation and shall not create disincentives for self-generation, self-consumption or participation in demand response.

46 Network costs can also be charged based on annual customer electricity capacity (demand charges).

47 With the introduction of large-scale renewable energy and distributed energy resources, more granular visibility of customer usage — in both time and location — is increasingly important.

48 See Artic le 15, Paragraph 2(e) of the Electricity Directive.

49 Article 18 of the Electricity Regulation. One successful example that combines these features is the reform introduced in British regulator Ofgem. RIIO (Revenue = Incentives + Innovation + Outputs) is a total expenditure-based revenue stream, focused on key outputs: safety, environmental impact, customer satisfaction, social obligations, connections, and reliability/availability. See Ofgem. (n.d.). *RIIO ED-1 annual report 2019-20*. https://www.ofgem.gov.uk/sites/default/files/docs/2021/03/ed1_network_performance_summary_2019-20.pdf

50 For analysis on the impact of levies on electrification, see Thomas, S., Sunderland, L., & Santini, M. (2021). *Pricing is just the icing: The role of carbon pricing in a comprehensive policy framework to decarbonise the EU buildings sector*, pp. 14-20. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/pricing-just-icing-role-carbon-pricing-comprehensive-policy-framework-decarbonise-eu-buildings-sector

Recommendations: Network and policy charges

- Establish smart volumetric network tariffs, which differentiate time, location and direction of power flow.
- Limit fixed price elements of network tariffs to costs that genuinely accrue on a per customer basis, regardless of use, such as meters.
- Analyse and build upon early experiences of dynamic network pricing, where smart metering and other smart technology is available. The rollout of dynamic, locational, bidirectional tariffs as default should be explored as smart, automated controls, metering and billing become more widespread.
- Implement performance-based remuneration for network companies to incentivise them to fully embrace demand-side flexibility, other distributed energy resources, smart metering systems and smart grid innovation.[51] Base cost recovery on total expenditure, to avoid bias towards capital investments and therefore traditional generation resources.
- Monitor policy levies and other fixed bill elements to ensure they are not unduly masking market signals for customer flexibility. Resource adequacy schemes such as capacity mechanisms should be charged against peak users to reduce overall cost burden.

Wholesale and balancing market pricing and regulatory interventions

The other significant component of final customer bills is the wholesale cost of electricity itself. The more accurately wholesale market prices reflect actual system conditions (demand vs. supply), the better the true marginal value of energy — and therefore the value of demand-side flexibility — can be recognised and rewarded by the market.[52] National regulatory interventions currently prevent wholesale prices from representing actual system conditions in some European countries. These interventions include:

- **Capacity mechanisms and wholesale price caps:** These mask the high cost of inflexible, conventional generation, deterring investment in more efficient alternatives and preventing customers from realising the full value of their flexibility. Capacity mechanisms with policy designs that favour coal and gas generation also create fossil fuel lock-in while hindering renewable energy integration, deployment and profitability.[53]
- **Wholesale price floors:** These prevent negative pricing, which could otherwise reward active customers for increasing electricity consumption at times of peak wind or solar generation, reducing curtailment and optimising renewable assets.[54]

Aligning wholesale prices more closely with actual system conditions can and should be combined with regulatory safeguards to reassure and protect customers

51 Performance-based remuneration means rewarding network companies with increased revenues for specific performance outputs that facilitate the energy transition, while penalising them with reduced revenues for failure to perform.

52 Article 3 of the Electricity Regulation requires that prices shall be formed on the basis of demand and supply. Market rules shall encourage free price formation and shall avoid actions which prevent price formation on the basis of demand and supply. However, many exceptions remain in practice.

53 Capacity mechanisms, often introduced under state aid schemes, tend to promote the overprocurement of less cost-effective backup generation, which depresses pricing in the energy ancillary services markets. This in turn crowds out more cost-effective demand-side flexibility measures, which rely predominantly on those markets, hindering the value demand-side flexibility can contribute to renewable energy integration and creating a need for yet more aid to support both resource adequacy and decarbonisation.

54 Recital 24 to the Electricity Regulation states it is "critical to ensure that administrative and implicit price caps are removed in order to allow for scarcity pricing," but this has not been included as a legally binding requirement. Article 20 merely requires Member States, when addressing resource adequacy concerns, to "consider" removing price caps and introducing a shortage pricing function for balancing energy.

from enduring high wholesale electricity prices during extreme and rare system events. For example, Australia uses a regulatory 'circuit breaker,' which temporarily turns off the reserve scarcity wholesale pricing mechanism[55] once the period of high prices has fulfilled its purpose of activating extra capacity.[56] Such measures are distinct from retail market safeguards, which target final customer bills and are covered in Action 5.

Another way to make prices better reflect system value is to design market arrangements so that wholesale prices vary according to the supply and demand conditions in different local zones (locational wholesale pricing).[57] Locational pricing boosts opportunities for customer flexibility to support system efficiency — for example, by encouraging electric vehicle drivers in areas with lots of solar to charge their vehicle when it is sunny, or those close to wind farms to charge when it's windy, reflecting local sources of renewable generation.[58]

The balancing market and imbalance prices can also be adjusted to motivate demand-side flexibility. Introducing a reserve scarcity pricing function helps to ensure that real-time prices represent the true value of the resources needed to secure supply, strengthening incentives for retail suppliers and aggregators to procure customer flexibility to balance their own position, ahead of real-time balancing actions by the system operator. This allows active customers to derive value from their flexibility and spares the system operator from having to step in to balance the grid at higher cost — a cost ultimately passed on by suppliers to customers.[59]

Recommendations: Wholesale market pricing

Wholesale prices should accurately represent actual system supply and demand conditions, to reveal the true value of customer flexibility. To deliver this, we recommend the following actions:

- Remove wholesale price floors and caps while introducing a regulatory 'circuit breaker' safeguard that kicks in during extended periods of exceptionally high prices.[60] Retail price caps are addressed separately in Action 5.
- Stick to noninvasive regulatory interventions that kick in only when necessary, rather than impacting wholesale price signals day to day. Phase out marketwide capacity mechanisms and other fossil fuel subsidies in favour of market-based resource adequacy options, including forward markets[61] and consolidated flexibility markets (see Action 3).
- Explore locational pricing options to encourage local grid and renewable energy optimisation.
- Introduce reserve scarcity pricing and marginal prices to motivate suppliers and aggregators to utilise customer flexibility to balance their own positions.[62]

55 Reserve scarcity pricing — also called reserve shortage pricing — functions are pricing methodologies that enable the value of scarce reserve capacity to be reflected in wholesale price formation. This serves efficient price formation in the wholesale market. Regulatory Assistance Project. (n.d.-b). *Scarcity pricing*. Power System Blueprint. https://blueprint.raponline.org/scarcity-pricing/

56 Australian Energy Market Commission. (2012). *Review of administered electricity price compensation arrangements*. https://www.aemc.gov.au/sites/default/files/content/f3e52c02-a01e-4672-8f50-6316683842c0/Information-sheet.PDF

57 Regulatory Assistance Project. (n.d.-c). *Locational marginal pricing*. Power System Blueprint. https://blueprint.raponline.org/locational-marginal-pricing/

58 Policy Exchange. (2021). *Powering net zero*. https://policyexchange.org.uk/wp-content/uploads/Electricity-Market-Design.pdf

59 Regulatory Assistance Project. (n.d.-d). *Efficient price formation*. Power System Blueprint. https://blueprint.raponline.org/efficient-price-formation/

60 Regulatory Assistance Project, n.d.-b.

61 Regulatory Assistance Project. (n.d.-e). *Thriving forward markets*. Power System Blueprint. https://blueprint.raponline.org/thriving-forward-markets/

62 Accompanied by a 15-minute settlement period or less as required by 2025 under the Electricity Regulation.

Action 3: Ensure a level playing field for demand-side resources

This action focuses on reform needed to ensure that household flexibility can, via aggregators, compete fairly against generation and other supply-side resources, to enable the most efficient solution to come forward in all markets and grid services.

Nondiscriminatory access to all markets

Under Article 11 of the Electricity Directive, active customers must be given "access" to balancing and intraday markets, either directly or through an independent aggregator. However, implementation remains patchy.[63] To achieve the aims of this provision, national transposing regulation should aim for full market inclusion rather than just surface-level openness. Such rights should be extended to all markets in which demand-side flexibility can contribute, including ancillary services and resource adequacy schemes such as capacity mechanisms.

Policy action is needed to ensure inclusive participation of all demand-side resources in grid services and other markets. This means tackling:

- Direct discrimination: such as limiting the contribution of certain technologies, allocating different contract lengths to different technologies, or favouring new, centralised resources over existing, decentralised ones.
- Indirect discrimination: such as designing eligibility criteria, auctions and energy or capacity products in a manner that inherently favours generation that involves high upfront capital expenditure.

Table 2 depicts examples of indirect discrimination against customer flexibility in grid services, electricity markets and adequacy schemes.

Table 2. Indirect discrimination against demand-side flexibility: Examples and recommendations

Design feature	Impact on generators	Impact on demand-side flexibility	Solution
Larger minimum bid sizes for entry	**NEUTRAL** Most supply-side generators are well over the threshold typically set.	**NEGATIVE** Demand-side flexibility comprises many customer actions, so larger thresholds increase cost/risk for aggregators.	Reduce all minimum bid sizes to 100 kW or less.
Long lead time between auction and payment	**POSITIVE** Suits large new generation with project financing or no debt. Benefit from overprocurement of capacity, which is more likely if procured years ahead.	**NEGATIVE** Too long for customers/ aggregators to wait for return on investment. Limited to year-ahead auctions so at competitive disadvantage.	Make all contracts year-ahead or less. Providers can bid every year on a rolling basis. Also allows fine tuning of resources rather than overprocuring.
Contract length tied to capital expenditure requirements	**POSITIVE** High capital expenditure, therefore can access longer revenue streams and gain advantage in auctions.	**NEGATIVE** Lower capital expenditure, more operational costs. In practice limited to a one-year contract.	Make all contracts one year to enable competitive price discovery and avoid promoting more expensive assets. Reduces fossil lock-in.
Service providers required to agree to provide open-ended (unlimited hours) duration of capacity rather than obligations being time-bound	**NEUTRAL** Generating is their main business; providing capacity does not disadvantage them.	**NEGATIVE** Customers cannot shift load for unlimited time without inconvenience but could provide a pre-agreed number of hours. Incentivises on-site diesel over clean demand-side flexibility.	Include (often cheaper) time-bound options (e.g., five hours maximum duration per customer), which system operators can call upon on rolling basis to meet need.

63 A 2022 analysis by smartEn examined implementation progress in 11 European countries. Out of these, only five countries (France, Finland, Italy, Romania and Slovenia) provided full, nondiscriminatory access to both the balancing market and day-ahead and intraday markets. smartEn, 2022.

Indirect discrimination can be tricky to identify and address because, on the surface, the same rules apply to everyone. In practice, however, they often play out in favour of larger, centralised generation resources while throwing up extra hurdles for new entrant aggregators and other innovative business models. This imbalance is perpetuated by the fact that the policy resources available to energy start-ups are considerably smaller than those that incumbents enjoy. These resources include staff time to respond to consultations and access to decision-makers, public affairs and lobbyists. This makes stakeholder engagement with aggregators and other new entrants particularly important. A more detailed list of policy design elements that should be included to avoid discrimination against the demand side is set out in the Annex.

Targeted, proactive facilitation of customer flexibility may be justified to address legacy bias in existing platforms, launch new flexibility markets and accelerate system efficiency savings. The principle that a universal approach is not always appropriate when dealing with new entrants and incumbents together is well-established in EU energy policy, especially when new entrants are key to decarbonisation; see renewable generation subsidies, for example. The European Commission has indicated that the long-term benefits of demand-side flexibility may justify positive discrimination in the short term, in the context of capacity mechanism policy design.[64]

Flexibility platforms and data-driven grid solutions

Another way of reducing burdens and maximising value for demand-side resources in marketplaces is through consolidated flexibility platforms. These are information technology platforms for coordinating trading, dispatch or support services for dedicated flexibility markets.[65] They improve the business case for demand-side flexibility by reducing administrative costs and enabling 'value stacking,' whereby multiple revenue streams can be obtained from the same assets being active in different markets or services at the same time. This can be contrasted with the current practice of multiple services being procured across different platforms, with contracts often containing exclusivity clauses.[66] Pooling flexibility also helps grid operators to reduce congestion and to maintain reliability in a more cost-effective and efficient way than is possible under separate services.[67]

Consistency and interoperability will be essential if Europe is to access the full benefits of demand-side grid solutions. The commission has announced a new EU Digitalising the Energy Sector action plan, to be developed in 2022.[68] A new Demand-Side Flexibility Network Code is also under development, overseen by the European Union Agency for the Cooperation of Energy Regulators (ACER). Together, these initiatives are expected to tackle issues such as data exchange, cooperation between distribution system operators and transmission system operators, and the development and harmonisation of standards — all of which are vital for the development of new data-driven services and consolidated flexibility platforms.

The sharing of data on grid capacity and network constraints — with appropriate security measures — combined with transparency over network planning opens the door to a wealth of innovative nonwires grid solutions. This will considerably broaden the pool of flexible options available to network companies as an alternative to network upgrades, allowing the most efficient course of action to be taken.[69]

64 A European Commission staff working document acknowledges that it is both common and legitimate (in U.S. capacity mechanisms) to design policy with the specific attributes of demand-side flexibility in mind, to actively facilitate demand-side capacity. See European Commission. (2016, 30 November). *Commission staff working document accompanying the document: Report from the Commission — Final report of the sector inquiry on capacity mechanisms*. SWD(2016) 385 final, paragraphs 461-462. https://ec.europa.eu/transparency/documents-register/detail?ref=SWD(2016)385&lang=en

65 De Heer, H., & van den Reek, W. (2018). *Flexibility platforms* [White paper]. USEF Foundation. https://www.usef.energy/app/uploads/2018/11/USEF-White-Paper-Flexibility-Platforms-version-1.0_Nov2018.pdf

66 European Smart Grid Task Force, Expert Group 3. (2019). *Demand-side flexibility: Perceived barriers and proposed recommendations*, https://web.archive.org/web/20220119141950/https://ec.europa.eu/energy/sites/ener/files/documents/eg3_final_report_demand_side_flexiblity_2019.04.15.pdf

67 De Heer & van den Reek, 2018.

68 European Commission. (n.d.). *Digitalising the energy sector — EU action plan*. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13141-Digitalising-the-energy-sector-EU-action-plan_en

69 smartEn. (2021b). *Setting a digital strategy for a cost-effective decarbonisation of the energy system* [Position paper]. https://smarten.eu/position-paper-setting-a-digital-strategy-for-a-cost-effective-decarbonisation-of-the-energy-system

Recommendations: Ensuring a level playing field

- Extend access rights for demand-side resources to all markets and platforms in which generating capacity is purchased, including wholesale markets, ancillary services and resource adequacy schemes such as capacity mechanisms.
- Design markets and grid services to actively facilitate customer flexibility, having regard to successful case studies, to overcome legacy bias and level the playing field. See Table 2 and the Annex for examples of indirect discrimination and proposed solutions.
- Ensure meaningful stakeholder consultation to help mitigate the effects of incumbent political power. Demand-side flexibility industry and consumer groups must be properly represented in policy working groups.[70]
- Consolidate services into flexibility markets to reduce costs and enable value stacking.
- Require transmission and distribution system operators to share granular data on grid constraints and information on planned network upgrades, including modelling assumptions, so that demand-side alternatives can be offered and considered on an equal footing.

Action 4: Accelerate installation of flexible assets in homes

This action focuses on the policy measures needed to ensure that customers are equipped with the metering, smart equipment and controls that will enable them to offer the flexibility of their demand and assets, including upgrades to building stock.

Flexible assets and smart readiness

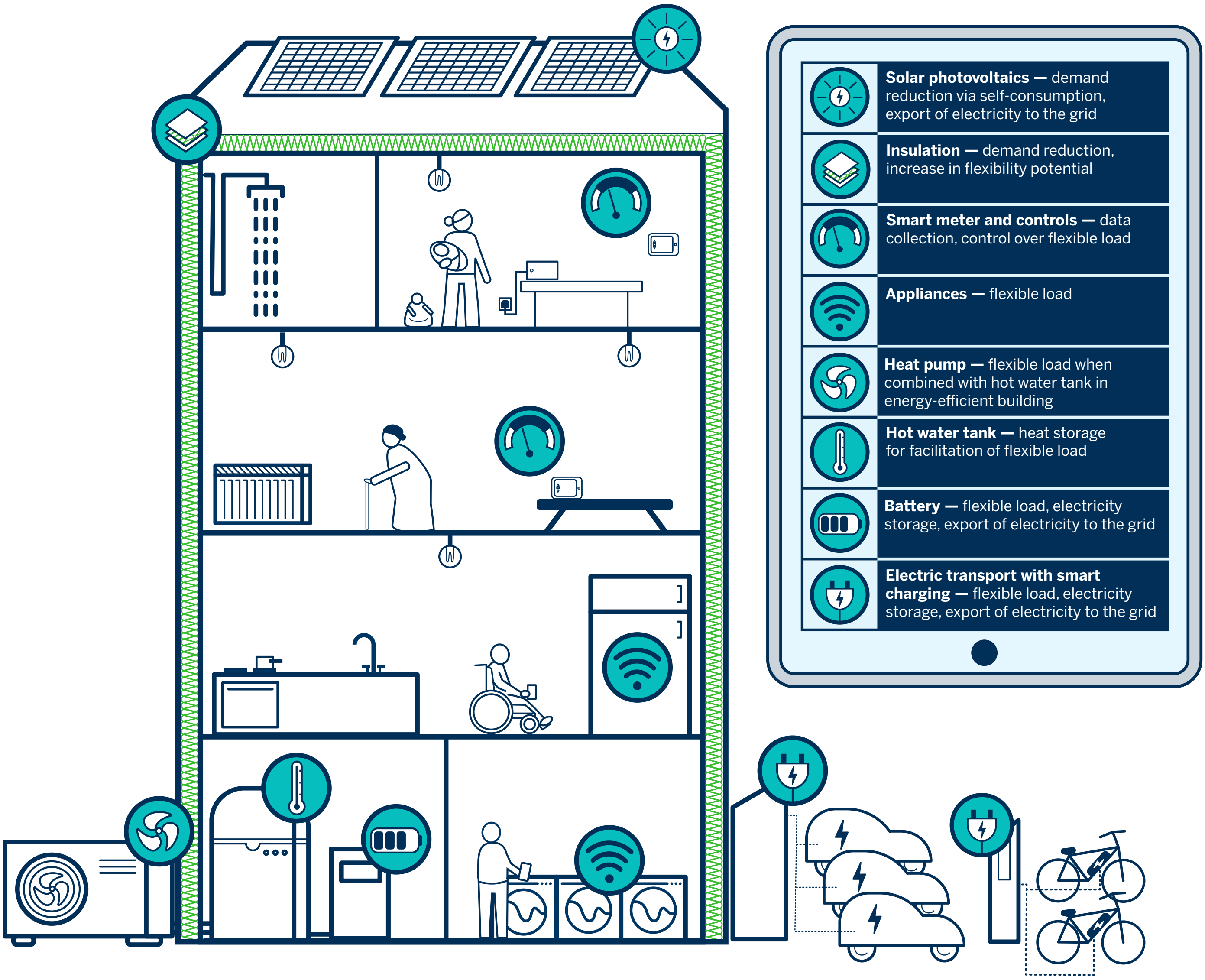
Deploying demand-side flexibility as a system resource at the scale and speed needed will require an environment where customers are both willing and able to be flexible. Ensuring affordable and minimal-effort access to flexible assets increases the technical ability of customers to be flexible. Supporting the emergence of attractive and inclusive retail offers and services cultivates willingness. This action focuses on the proliferation of flexible assets, while Action 5 focuses on the products and services to engage households. In reality, ability and willingness to be flexible are interrelated, as one makes the other more likely.

Flexible assets are technologies and building upgrades that super-size a customer's potential for flexibility, as illustrated in Figure 10 on the next page. In addition to the assets themselves, metering, communications systems and the grid need to be smart-enabled to accommodate new loads and utilise flexibility potential.

Ensuring affordable and minimal-effort access to flexible assets increases the technical ability of customers to be flexible. Supporting the emergence of attractive and inclusive retail offers and services cultivates willingness.

70 Useful precedents for consultation requirements can be found in the UK and the EU. See UK Government. (2008). *Code of Practice on Consultations*. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/100807/file47158.pdf; and European Commission. (2022). *Communication from the commission — Guidelines on state aid for climate, environmental protection and energy 2022* (2022/C 80/01), paragraph 4.8.4.4. Official Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.C_.2022.080.01.0001.01.ENG&toc=OJ%3AC%3A2022%3A080%3ATOC

Figure 10. Flexible assets in homes



A strong case can be made for approaching the uptake of flexible assets — and upgrades to communications and metering systems — like any other significant infrastructure investment, which would be centrally driven and supported. There is a key opportunity for stronger cross-sector coordination between the power, buildings, transport, telecommunications and heat sectors, which could provide mutual reinforcement of electrification and equity goals.

A number of opportunities exist within the EU and national policy frameworks to promote the uptake of flexible assets as standard:

- Building codes for new and existing buildings, as defined by the Energy Performance of Buildings Directive, should more effectively promote demand-side flexibility and storage.
- Building renovation programmes should promote energy and heat storage and smart building controls alongside the usual insulation, heating and cooling measures.
- Product standards should guarantee smartness of products and appliances.

- Information and advice tools for households — like energy performance certificates, building renovation passports and one-stop shops[71] — should integrate recommendations on the installation of smart equipment and heat and power storage more effectively, alongside the energy efficiency and renewable energy measures already covered.

Metering will be important to enable the operation of these assets within a flexible system. As a baseline, all consumers should have the right to adopt a smart meter — not just at their own cost, as provided for in the Electricity Directive, but at an accessible cost for them or, ideally, for no upfront cost. The smart meter will need at least hourly resolution and a reliable, rapid communication system to record and reward flexible actions.[72] Where submetering is available, individual appliances can be managed independently, creating more granular demand-response potential.[73] In the near future, a customer may pay a flat rate for heat but have a dynamic tariff for their electric vehicle charging point, plus an export tariff to provide vehicle-to-grid services.

Product standards are another powerful tool to build flexible capacity. They ensure that, when installed, equipment and systems are smart as standard, allowing them to be flexed or contribute to managing demand flexibly. The importance of these standards is that products are designed with these capabilities and products from different manufacturers can communicate with each other.[74] A mandate for smartness as a principle should be implemented as a priority for new electrified loads and, secondly, for electric loads that have material flexibility potential.

A mandate for smartness as a principle should be implemented as a priority for new electrified loads and, secondly, for electric loads that have material flexibility potential.

Prioritise flexibility of new loads

Newly electrified end uses should be prioritised for flexibility capability. Transport and heating are the primary examples.

The electrification of road transport is accelerating swiftly, driven in part by national bans on the sale of new cars with internal combustion engines.[75] The use of smart technology in electric vehicle charging is critical to ensuring that the choices users make to manage their charging are also beneficial for the power grid.[76] Smart charging can adjust the time and level of charging at different times in response to a number of factors, including conditions on the grid, the cost of the charge, or the fuel source and carbon content of supply.[77] Combined with smart pricing,[78] installing smart chargers as the standard[79] can enable significant new transport loads to be managed either by the individual customer or in response to national policies that, for example, set defaults to restrict charging to particular times of the day or grid conditions.

Access to smart charging requires both private and public charging infrastructure — at work, at home and out and about — to be smart or smart-enabled. The European policy framework already contributes by, for example, requiring the installation of charging points in new and

71 The EU Commission's communication *Clean Energy for all Europeans* encouraged the development of local facilities providing information, technical assistance, financial advice and support, as well as the monitoring of energy savings after completion of the works. See BPIE. (2021). *Underpinning the role of one-stop shops in the EU Renovation Wave*. https://www.bpie.eu/publication/underpinning-the-role-of-one-stop-shops-in-the-eu-renovation-wave

72 Higher resolution, such as 15-minute intervals, will be necessary for those providing ancillary services such as interruptibility schemes. Hughes, F., Joos, M., Foster, S., Slater, S., Acar, A., & Rogner, M. (2021). *Sector coupling for grid integration of wind and solar*, section 5.2.1. SHURA Energy Transition Center. https://shura.org.tr/en/sector-coupling-for-grid-integration-of-wind-and-solar

73 The Association for Decentralised Energy. (2020). *Let's talk about flex: Unlocking domestic energy flexibility*. https://www.theade.co.uk/resources/publications/lets-talk-about-flex-unlocking-domestic-energy-flexibility

74 De Bruyckere, L. (2021). *Smart standards for a smarter future — these two could change our lives*. ECOS. https://ecostandard.org/news_events/smart-standards-for-a-smarter-future-these-two-could-change-our-lives

75 Wappelhorst, S., & Cui, H. (2020). *Growing momentum: Global overview of government targets for phasing out sales of new internal combustion engine vehicles*. The International Council on Clean Transportation. https://theicct.org/blog/staff/global-ice-phaseout-nov2020

76 Burger et al., 2022.

77 Hildermeier et al., 2019.

78 Hildermeier et al., 2019.

79 Hildermeier, J. (2020). *Building a market for EV charging infrastructure: A clear path for policymakers and planners*. Regulatory Assistance Project. https://www.raponline.org/knowledge-center/building-market-for-ev-charging-infrastructure

refurbished buildings under the Energy Performance of Buildings Directive and increasing the density of the public charging network with the Alternative Fuels Infrastructure Regulation.[80]

To make sure smart charging is the default option, all charging points need to be ready for smart charging services with smart meters, digital connectivity and third-party access.[81]

Similarly, when heat is electrified — usually with heat pumps — the new loads can be designed to be flexed through smart-as-standard heat pump technologies and energy efficiency upgrades to the building. A range of fossil fuel phaseout regulations are increasingly driving the decarbonisation of heat, which will result in increased electrification.[82] Minimum energy performance standards for buildings can also be used to boost energy efficiency levels, the decarbonisation of heat and the uptake of heat pumps.[83] The heat pumps installed as a result of these measures should be flex-ready and grid interactive. For heat to be electrified efficiently and flexibly, the installation of the heat pump should be accompanied by approved energy performance and heat storage devices including heat batteries or water tanks within the building or district heating system.

Recommendations: Accelerating asset installation

- Grant all customers the right to a smart meter at no upfront cost to them. Technical standards for metering and control equipment should be outcomes-based and technology neutral, to avoid lock-in and stranded assets.
- Require that smart electric vehicle charging technology has measurement, communication and automation capabilities, using a combination of product standards and European and national legislation.
- Mandate smartness and interoperability for heating and cooling equipment, appliances and smart home management systems, using product standards.
- Coordinate smart-readiness standards across sectors, to reduce complexity and to pave the way for interoperability.
- Deploy minimum energy performance standards to drive building efficiency improvements that enable homes to be heated flexibly. Standards should be designed to effectively integrate flexible assets — particularly heat storage — alongside efficiency improvements.

80 European Commission. (2021). *Proposal for a regulation of the European Parliament and of the Council on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU*. https://ec.europa.eu/info/sites/default/files/revision_of_the_directive_on_deployment_of_the_alternative_fuels_infrastructure_with_annex_0.pdf

81 For detailed recommendations on how the EU legislative framework could be improved to increase smart charging, see Burger et al., 2022.

82 Braungardt, S., Keimeyer, F., Bürger, V., Tezak, B., & Klinski, S. (2021). *Phase-out regulations for fossil fuel boilers at EU and national level*. Öko-Institut 2021. https://www.oeko.de/fileadmin/oekodoc/Phase-out_fossil_heating.pdf

83 Minimum energy performance standards are binding standards that buildings must meet at a designated point in the future or at a natural trigger in the building life cycle, such as sale or renovation. Sunderland, L., & Santini, M. (2021). *Next steps for MEPS: Designing minimum energy performance standards for European buildings*. Regulatory Assistance Project. www.raponline.org/knowledge-center/next-steps-for-meps-designing-minimum-energy-performance-standards-for-european-buildings

Action 5: Make flexible actions easy and safe for customers

This action focuses on policy measures and market practices that are needed to make attractive, accessible energy services and tariffs available to all customers. These must be designed and delivered within a framework of robust customer-centric regulation.

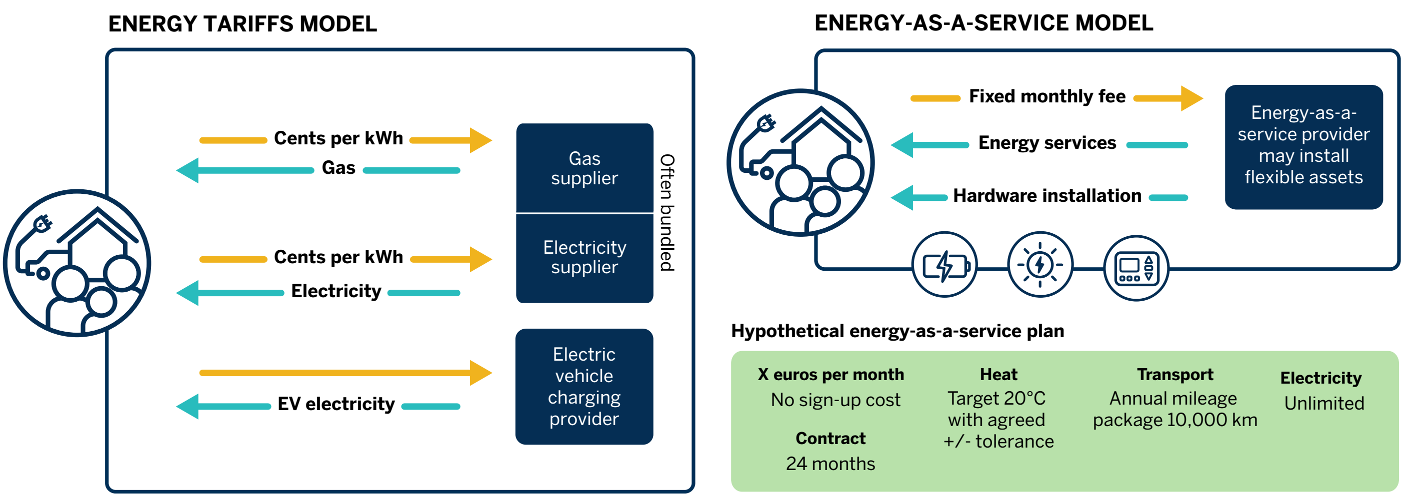
Alternative business models

As we move to a smart energy system, the way households engage with the retail market will evolve beyond the traditional model, under which customers purchase electricity on a flat rate per kWh. Alternative retail models are emerging, providing households with routes to be rewarded for the system value they create through demand-side flexibility.

The key alternative models can be categorised as follows:

- Time-of-use and dynamic retail pricing: Customers still purchase the product of electricity per kWh from a licensed supplier, but the price changes across different time periods. Under a fixed time-of-use tariff a price schedule is set for specific blocks of time, usually based on season, day of the week and time of day.[84] Dynamic tariffs comprise a range of power pricing models, which link to wholesale prices and system conditions to varying degrees — from real-time wholesale pricing to hybrid options such as critical peak pricing, where customers have a fixed rate with the exception of a predefined peak period, during which a market-based, dynamic rate applies.
- Energy as a service: Instead of purchasing electricity itself, customers pay a fixed monthly fee for energy-related services such as comfort, light and mobility. The service provider often installs flexible assets and optimises them within pre-agreed boundaries.[85] Figure 11 contrasts this model with the traditional retail model.[86]

Figure 11. Comparison between traditional and energy-as-a-service retail models



Source: Based on Everoze. (2019). *Swarm governance: Flying to a future of domestic energy-as-a-service – addressing demand-side response barriers*

84 Cappers et al., 2016.

85 Delta Energy & Environment. (2019). *How accessible are future energy business models*? Citizens Advice. https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/How%20accessible%20are%20future%20energy%20supply%20business%20models_Citizens%20Advice_FINAL.pdf

86 Everoze. (2019). *Swarm governance*: *Flying to a future of domestic energy-as-a-service — addressing demand-side response barriers*. https://everoze.com/app/uploads/2019/06/Everoze-Partners-Swarm-Governance-Report-2019-06-13.pdf

- Market operations: This is an umbrella term for business models that focus on transforming the marketplaces that offer energy solutions. Customers still purchase electricity as a product but with added qualities and opportunities. The most significant of these new market operations are trading platforms where customers, including prosumers, can match directly with renewable generators or each other (peer-to-peer trading) to buy and sell electricity. Energy communities may form peer-to-peer trading platforms, energy cooperatives or joint purchase schemes.[87] They may also team up with aggregators to provide flexibility services.[88] Citizen-led services offer the added value of being trusted intermediaries particularly suited to building trust with low-income and vulnerable groups. Other forms of market operations include smart markets, where energy can be purchased alongside other services.[89]

Other new business models have emerged that do not directly involve demand-side flexibility but still indirectly support it by increasing flexibility. These include 'lifestyle products' offering customers smart technologies that use connectivity of home devices to create added value. In addition, some business models focus on efficient consumption, applying data-driven approaches to the challenge of improving energy efficiency. They combine traditional physical solutions (such as insulation) with technical ones (such as granular tracking of energy use) to monetise a reduction in energy consumption. Other data-driven services include energy audits and deep retrofits, which can be tailored according to customer needs and building specifics.

To date, considerable focus has been placed on time-of-use tariffs as the main way to engage households in flexibility. As seen from the overview above, however, time-of-use tariffs are just one of several models. Customers are not a homogeneous group, so policymakers and regulators should enable and encourage a diverse marketplace where customers can 'mix and match' different tariffs and services according to their own needs and preferences. Incumbent suppliers must be prevented from restricting competition by making it difficult for third parties to access consumption data with customer consent, or by bundling flexibility services in with existing supply contracts or assets (including smart meters) in a way that creates barriers and restricts customer choice.[90] The Electricity Directive requires Member States to put in place rules for nondiscriminatory energy data access.[91] The EU Digitalising the Energy Sector action plan is to provide more detailed requirements on interoperability, customer protection and data sharing later in 2022.

Policymakers and innovators should look to the growing body of research that exists on inclusive design beyond the energy sector, to ensure that everyone can benefit from the new retail offers.[92] This means designing products and services for the most vulnerable, to enable maximum possible participation of all users.

87 EU legislation officially recognises two categories of energy community: Citizen energy communities are defined in the Electricity Directive (EU) 2019/944. Article 2(11) specifies that they are a legal entity that provides energy services for environmental, economic or social community benefits to its members. A related but not identical concept is that of renewable energy communities contained in the Renewable Energy Directive (EU) 2018/2001. These are energy communities with local renewable energy generation.

88 Claeys, 2021.

89 The Association for Decentralised Energy, 2020.

90 smartEn, 2021b.

91 Article 23 of the Electricity Directive.

92 Fair by Design & Money Advice Trust. (2021). *Inclusive design in essential services: A guide for regulators*. https://fairbydesign.com/inclusive-design

Recommendations: Easy and accessible flexibility

- Make it easy for customers to choose different providers for specific services (e.g., heat) or for large flexible assets (e.g., electric vehicles). Switching, metering and settlement rules may need to be reformed to facilitate this. Deploy public messaging campaigns to educate customers about their rights and the options available.
- Establish a regulatory regime for customer data sharing which requires explicit and informed customer consent for access to personal consumption data, mandates transparency around data use and includes the right to withdraw consent and to suitable customer redress mechanisms. Give innovators access to anonymised, aggregated data, with appropriate security measures.
- Build accessibility into the design of products and services. Promote and expand the use of inclusive design criteria into the development of new business models, services and tariffs, making it a prerequisite for research funding, technology grants and public procurement.

Building trust and confidence through regulation and best practice

Regulation and retail offers can be designed to maximise transparency, inclusion and confidence. Policies should aim to empower customers to explore new digital services and flexible assets, without being overly prescriptive about evolving technologies or business models. Notwithstanding the need to protect customers — particularly low-income and vulnerable customers — from adverse outcomes, it is not in the public interest to stifle innovation or perpetuate digital exclusion by exempting sections of society from potential rewards. A well-functioning retail market should provide enough diversity to accommodate different levels of customer flexibility, agency and engagement. Regulation should ensure that customers can access clear, comparable information, while providing appropriate safeguards and upholding due process.

Tools to support and reassure customers as they enter the world of flexibility include the following.

Supplier actions to reduce cost risk, such as hedging and price protection. Suppliers hedge by purchasing power on the wholesale market in smaller amounts across different price points rather than waiting to purchase it all together at the lowest anticipated price. This practice increases the cost to customers slightly but also lowers price risk.[93] Separately, some market-based tariffs include price protection as part of the offer. For example, Octopus Energy's Agile tariff in Great Britain includes a "price cap protect" function, which caps the dynamic rate. At the time of design, the dynamic rate was capped at 35 pence per kWh, compared with a fixed rate of 16 pence per kWh.[94]

Flexibility assessments, one-stop shops and trusted intermediaries. These help customers overcome apprehension about investing in flexible assets and offering their flexibility. Customers who have purchased flexible assets are more likely to embrace dynamic tariff offers.[95] Flexibility assessments involve the supplier, aggregator or energy-as-a-service provider estimating potential savings from flexibility, based on certain tariff and usage assumptions, which could then be combined with a money-back guarantee and billing that shows the customer what they would have paid otherwise. One-stop

93 Boeve et al., 2021.

94 These prices were set before the winter 2021-22 price increases, but the price cap had not been increased at the time of writing. For up-to-date rates, see Octopus Energy. (n.d.). *Introducing Agile Octopus*. https://octopus.energy/agile

95 Boeve et al., 2021, p. 35, citing Faruqui, A., & Palmer, J. (2012). *The discovery of price responsiveness — A survey of experiments involving dynamic pricing of electricity*. SSRN. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2020587

shops are integrated services hubs offering a simplified customer journey through home renovation and lifestyle decarbonisation.[96] These facilities would ideally work in harmony with the policy-driven deployment schemes and standards described in Action 4. Citizen energy communities can also play a role in engaging and organising groups of households to participate in providing grid services, building the trust needed when asking households to hand over a level of control to a third party to automate flexible assets and to provide reassurance of retaining comfort.

Early-warning mechanisms to prevent bill shocks. These mechanisms include platforms that customers can easily use to monitor consumption and costs incurred in real time, or that send alerts if a customer's usage puts them on a trajectory for a bill that is outside an agreed range.[97] Customer data could also be used to warn customers if they could be saving money on a different tariff. This is one example where sharing consumption data — with customer consent — with independent advisory organisations and competitors can pay dividends.

Easy switching rights that enable customers to quickly move to a new tariff or service provider. Early termination fees for fixed-term contracts should be limited to those directly linked to the genuine cost of an advantage provided, such as a discount, equipment or promotional rate.[98]

Upside-only and flat-rate options as alternatives to more dynamic time-of-use tariffs. Some customers would rather sacrifice a proportion of potential savings in return for a more predictable rate. Upside-only and flat-rate options such as peak-time rebate schemes and energy as a service are therefore a useful entry point. They help customers get used to smart energy technology and to being demand responsive in a low-risk environment, allowing them to build up to more dynamic offers.[99] As metering becomes more granular, customers may opt for a dynamic tariff for highly flexible loads such as electric vehicles but choose fixed or predictable time-of-use tariffs for other household consumption.

96 BEUC. (2021). *How to make one-stop-shops consumer-friendly: From basic information to complete service to consumers*. https://www.beuc.eu/publications/how-make-one-stop-shops-consumer-friendly/html

97 BEUC. (2019). *Fit for the consumer? Dos and don'ts of flexible supply contracts*. https://www.beuc.eu/publications/fit-consumer-dos-and-donts-flexible-electricity-contracts

98 BEUC, 2019, p. 11. Article 12 of the Electricity Directive contains easy switching rights, which customers can contract out of to some extent: "Member States shall ensure that a customer wishing to switch suppliers or market participants engaged in aggregation, while respecting contractual conditions, is entitled to such a switch within a maximum of three weeks from the date of the request. By no later than 2026, the technical process of switching supplier shall take no longer than 24 hours and shall be possible on any working day."

99 A 2017 UK report found that bill protection resulted in slightly higher uptake of time-of-use tariffs, 35% rather than 27%. Hledik, R., Gorman, W., Irwin, N., Fell, M., Nicolson, M., & Huebner, G. (2017). *The value of TOU tariffs in Great Britain: Insights for decision-makers — Volume I: Final Report*. Citizens Advice. https://www.citizensadvice.org.uk/Global/CitizensAdvice/Energy/The%20Value%20of%20ToU%20Tariffs%20in%20GB%20-%20Volume%20I.pdf. The report also cites an Australian study that found that bill protection had a modest positive impact on uptake (Stenner, K., Frederiks, E., Hobman, E. V., & Meikle, S. (2015). *Australian consumers' likely response to cost-reflective electricity pricing*).

Retail reassurance: Guarantees and flexibility bonuses

California's rollout of default time-of-use retail tariffs was accompanied by a shadow bill across one year for each customer to illustrate cost comparisons and give a customer-by-customer assessment of impact. For the first year of the tariff, customers who would have saved more on the old rate were also credited the difference. Such measures helped to remove risk during the transitional period and provided suppliers with an added incentive to help customers respond to price signals.[100]

Upside-only options also offer incentives, albeit lower ones compared with dynamic tariffs, for households as they reward those that reduce their consumption at peak times when compared against their previous profiles. These tariffs are based on the flat-rate tariff and provide rebates for lower peak use but no higher charge for greater peak use.[101] For example, the Dutch software company Jedlix collaborates with supplier Engie in Belgium to offer electric vehicle owners the chance to reduce their bills through smart charging bonuses — offering a 1.5-cent-per-kWh discount to their usual tariff, which includes a flat-rate option.[102]

With innovation moving faster than legislation, there is a high risk of patchwork regulation. Existing consumer protections around selling practices, transparency and customer redress mechanisms must be made fit for the smart energy era alongside new digital protections such as cybersecurity and data regulation. Model contract provisions and codes of conduct are a neat way of pulling these various strands together and demonstrating best practice. For example, the European consumer organisation BEUC has published model clauses for time-of-use tariff and dynamic price contracts, following an extensive assessment of retail offers across Europe.[103]

In the UK, the Association of Decentralised Energy has developed Flex Assure (www.flexassure.org), a voluntary industry code of conduct for aggregation of flexibility for explicit services, which providers must follow to market themselves as a scheme member. In the future, these could be incorporated into regulatory regimes for added protection and accountability, with minimum standards harmonised in EU legislation.

100 California utility regulators ruled in 2018 that two customer protections be included in the systemwide rollout of default time-of-use tariffs. First is a 'shadow bill' that shows customers whether they are better off with the time-of-use rate or their old rate. The other is a guarantee that, for the first year of the transition, customers who would have saved more on the old rate will be credited the difference. California Public Utilities Commission, Application 17-12-011 and related matters, Proposed Decision on 7 November 2018 addressing residential default time-of-use rate design proposals and transition implementation. http://docs.cpuc.ca.gov/PublishedDocs/ Efile/G000/M238/K286/238286413.PDF

101 Cappers et al., 2016.

102 Engie. (n.d.). *Slim laden: Laad goedkoper en word vergoed voor je flexibiliteit!* (Smart charging: Charge cheaper and get reimbursed for your flexibility!). https://www.engie.be/nl/energiepack-elektrische-wagen/slim-laden

103 BEUC, 2019, Annex 1.

Recommendations: Customer trust and confidence

- Ensure dedicated regulatory oversight of the customer transition to smart energy solutions, to provide focus and accountability.
- Establish a robust framework for customer protection and empowerment, including access to independent advisory services (including tariff comparison), fair and transparent contract terms, and appropriate redress procedures. Care should be taken to ensure that regulation is based on principles rather than being too prescriptive about technologies and business models, which are constantly evolving.
- Create a policy toolkit for encouraging a critical mass of demand-side flexibility uptake. This should be based on successful case studies and may include shadow billing, money-back guarantees, supplier hedging, retail price protection (especially for low-income and vulnerable customers), customer flexibility assessments, and mechanisms that provide early warnings to prevent bill shocks and enable easy switching.
- Explore upside-only price structures such as critical peak rebates, or flat-rate offers with flexibility agreements built in, in exchange for a lower rate. These structures provide a useful gateway to more market-based offers, as customers get used to digitalisation, automation and schedule changes.
- For emerging sectors where regulation is not currently in place, clearly define best practice through model contract provisions and codes of conduct for time-of-use offers and flexibility services, supported through accreditation schemes.

Conclusions

"People don't want raw kilowatt-hours. … They want hot showers, cold beer, comfort, mobility, illumination." **— Amory Lovins**

Demand-side flexibility is about creating mutually beneficial synergies between electricity customers and the system that exists to serve them. Europe must build a flexible demand side that moves dynamically en masse to optimise renewable resources and network capacity. That means unlocking the enormous and largely untapped value of flexibility, particularly household flexibility. We can do this by recognising and rewarding the value that flexible customers create in the system. The benefits of flexible customer actions are realised not only in real time but also in the future, through avoided system costs and improved reliability. The policy challenge that Europe now faces is how to address this value split and time lag, so that household customers today are both motivated and empowered to make choices that will pay dividends to all of us tomorrow. 'Price and pray' approaches alone will not deliver this; clear market incentives are a prerequisite rather than the end game.

Customers are not passive bystanders of the clean energy transition, they are key agents of change.

To avoid paying a much higher price later, Europe must invest now in strategies that wholeheartedly embrace household demand-side flexibility as a system resource.

By pulling these strands together, a positive feedback loop can be established, whereby customers are willing and able to respond flexibly, receive the benefits of doing so and are incentivised to increase their flexibility further. No segment of society should be locked out of this virtuous cycle. Upholding inclusivity as a policy priority for demand-side flexibility will create opportunities for innovators to step up and tackle user challenges, producing societal benefits. While it is incumbent on regulators to protect customers — particularly low-income and vulnerable customers — from undue price risk, we must find ways of doing so which do not exclude anyone from the benefits of flexibility and digitalisation.

Load control, automation and use of customer data raise fundamental questions about agency, informed consent and the importance of developing a social contract for the smart energy age. This is highlighted by the backlash against Germany's bungled attempt in 2021 to allow network operators to override electric vehicle charging, without regard for customer agency or compensation.[104] Without prejudice to the need for responsible implementation, this paper argues that the household flexibility opportunity is fundamentally about giving control to customers, not taking it away. Customers are not passive bystanders of the clean energy transition, they are key agents of change — and Europe desperately needs the kind of change that active customers can deliver. We must choose joy, not fear, as our primary motivator for change. The flexible household transformation is within our grasp, provided it comes with hot showers, cold beer and affordable energy bills.

104 Jahn, A., Burger, J., & Rosenow, J. (2021). *Trust not control: Germany, EVs and the power of consumer choice*. Euractiv. https://www.euractiv.com/section/electricity/opinion/trust-not-control-germany-evs-and-the-power-of-consumer-choice

Annex: Recommended policy design elements to facilitate demand-side flexibility in markets and grid services (Action 3)

To facilitate demand-side participation and avoid discrimination, the following policy design elements are recommended for platforms on which customer flexibility competes with supply-side resources.

Contract lengths: All technologies should be awarded the same contract length to enable competitive price discovery. Contract lengths should not favour more expensive technologies over cheaper ones.

Bid size: Minimum bid size should be 100 kW or less.[105] Larger bid sizes represent a significant and unjustifiable barrier for demand-side and other new entrant resources, even with aggregation. They make it difficult for aggregators to start small and manage cost and risk incrementally as they build up a customer base and fine-tune technology, or enter different assets into different markets to find the optimum blend of platforms. Many EU balancing, wholesale and capacity markets currently have a 1 MW bid size, twice the 500 kW threshold specified in Article 8(3) of the Electricity Regulation.

Exclusivity clauses: Value stacking across different products and time periods should be permitted where compatible with state aid aggregation rules. Exclusivity clauses impose the same barriers as large bid sizes.

Lead times: The time lag between auctions and payment should be as short as possible, ideally a year or less. More than this is too long for new demand-side entrants to wait to get a return on investments, especially when relying on debt financing to purchase equipment.

Derating factors: These should not discriminate against demand-side technologies or supply-side storage. Diverse pools of aggregated demand-side flexibility investments have demonstrated in multiple markets that they can be at least as 'firm' as traditional fossil-powered generators. Multiple technologies should be able to bid together as clean energy portfolios[106] of renewables, storage, energy efficiency and demand-side resources to hedge risks. Derating factors should be subject to comparative scrutiny across Member States, with standardisation of evidence-based methodologies to avoid discrimination.

Time-bound delivery options: These should be available so that contracts do not require active customers to deliver services for an unlimited or unspecified period of time. Such contract requirements are unnecessary and favour generators. It is often more cost-effective and efficient — especially compared with building new generation — to enable system operators to call upon multiple time-bound demand-side flexibility contracts (or supply-side storage) on a rolling basis. System operators are better placed to take this risk than new entrant aggregators. Such capability should be part of Member States' reliability and resilience plans along with grid sectionalisation, to ensure a safe and fair distribution of load curtailment during a system stress event.

Prequalification, testing and penalties: Prequalification criteria and processes and mechanisms to deter nondelivery should be designed in a manner that does not present an unreasonable cost or administrative barrier to demand-side flexibility providers. Upfront cash collateral requirements, particularly combined with larger minimum bid sizes, and onerous advanced testing regimes are disproportionate to the policy aim, if effective penalties for nondelivery are also in place — as they should be. Prequalification assessments should facilitate aggregators managing portfolios of flexible customers and not require frequent reapplications as customer contracts fluctuate.

105 In 2019 the distribution system operator UK Power Networks launched a £12 million tender for flexibility services "to deliver a stronger, more resilient electricity network by helping to manage electricity demand at peak times." A few months into the scheme the minimum size threshold was reduced from 100 kW to 50 kW to enable more demand-side providers to participate. UK Power Networks. (2019). *£12m funding announced for flexibility services in South East and East of England* [Press release]. https://web.archive.org/web/20210508200551/https://www.ukpowernetworks.co.uk/internet/en/news-and-press/press-releases/12m-funding-announced-for-Flexibility-services-in-South-East-and-East-of-England.html

106 Carbon Tracker Initiative. (2021). *Foot off the gas: Why the UK should invest in clean energy*. https://carbontracker.org/reports/foot-off-the-gas

In the case of capacity mechanisms, we recommend the following policy design elements in addition to those listed above.

Financing methodology: Cost recovery methodologies should be designed to minimise total cost to customers and create a secondary market for demand-side flexibility. Costs should be applied dynamically as this reduces the need for such subsidies in the first place.

Decentralised capacity procurement: Responsibility for adequacy should be located as close to the customer as possible, usually with suppliers, to increase the likelihood that demand-side measures will be employed, reducing the need for more costly and harmful fossil generation solutions. This likelihood is further increased by healthy retail market competition and fully unbundling supply from generation.

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Rue de la Science 23
B — 1040 Brussels
Belgium

+32 2 789 3012
raponline.org