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Energy Management and Grid Flexibility Report

Contents

Introduction

Grid flexibility is a simple concept. The Energy Networks Association (ENA) describes it as: “Flexibility is about changing where or when electricity is consumed or generated”.[1]

Flexibility has been used to manage power networks for many decades, but there is growing interest as we move towards net zero energy systems. The move to renewable power generation and electric cooling, heating and transport is forcing a move away from traditional techniques of grid management and ever greater use of grid flexibility.

Although flexibility at all scales is important, from industrial to residential, it is residential flexibility that has been the main focus of standardization given its role in managing Electric Vehicles (EVs) charging loads and electric heating.

This report focuses on the application of flexibility to the residential sector and sets out the key concepts, implementations of residential flexibility around the world, and standards, published and in preparation, that are supporting both decision-makers and technical practitioners in this important development.

Governments and power network operators around the world are developing flexibility services, and manufacturers are preparing appliances to work with these. Electricity users will increasingly be offered the opportunity to engage with the new flexibility products, and their new appliances will be pre-enabled to respond to signals from the power networks, offering a lower cost transition to clean energy and lower electricity charges for consumers with no or little impact on their lives.

Standards are at the centre of this activity, allowing end-to-end communications and interoperable appliances.

1 Energy Network Association, 'Insights Forum'. Available at https://www.energynetworks.org/assets/images/insights-forum-slides.pdf?1723711173 [Accessed 22 May 2025].

Flexibility: scope and application

Grid flexibility describes the ability of electrical loads and generators to alter their operation in response to signals from the networks to keep supply and demand equal, avoid overloading the cables and assets and keep the network stable. Flexibility can be applied at all scales of the power network, to both generators and loads and encompasses a host of market sectors, applications and technologies. The term Demand Side Response (DSR) is also used and has a similar meaning.

Until now, supply and demand on the networks has largely been managed by adjusting generation output, and consumer loads have generally been taken as a given, although there have been exceptions to this, such as Economy 7 in the UK, which offered lower cost electricity to charge electric storage heaters during the nightly demand trough in order to maintain load on the large power stations.

A key principle of flexibility is that, in most cases, it moves demand from a period of high demand to one with lower demand and, ideally, the customer is unaware of the change. For instance, an EV that needs to charge overnight and only needs a couple of hours charging can have the charging period moved to any two-hour period overnight without any impact on the customer.

This is not always the case and for some flexibility schemes. Heating and cooling demand can be curtailed over a short period by adjusting the thermostat set point and reducing comfort levels. However, this is normally kept small enough to be accepted by customers and they can be rewarded with lower tariff to compensate.

Drivers for flexibility

The transition to net zero means that we must make much greater use of demand-side flexibility for several reasons.

- The shift to wind and solar generation takes away the ability to control energy generation output; their low marginal cost of generation means they will be kept on and their output will vary depending on the weather. With this loss of dispatchable generation, we must increasingly look toward managing demand instead.
- Shifting major energy demands, such as the move of transport and heating to electricity and growing use of air conditioning, will put increased demands on the power network, potentially beyond its current capacity. Widescale adoption of heat pumps and EVs in urban areas creates a need to control these loads at the distribution network. And where large scale renewable generation moves generation further away from the main load centres, it can mean that there isn't sufficient capacity in the transmission lines to deliver it to customers.
- New device capability, such as EVs and home power storage offer new ways to support the grid. Exporting stored power onto the grid from individual homes is a new option that is called Vehicle to Grid (V2G) and, given the combined size of the storage capacity provided by EVs nationally, could offer significant support to networks.[2]

2 NIC (2025), 'Electricity distribution networks: Creating capacity for the future'. Available at https://www.biee.org/nic-electricity-distribution-networks-creating-capacity-for-the-future, p46. [Accessed 22 May 2025].

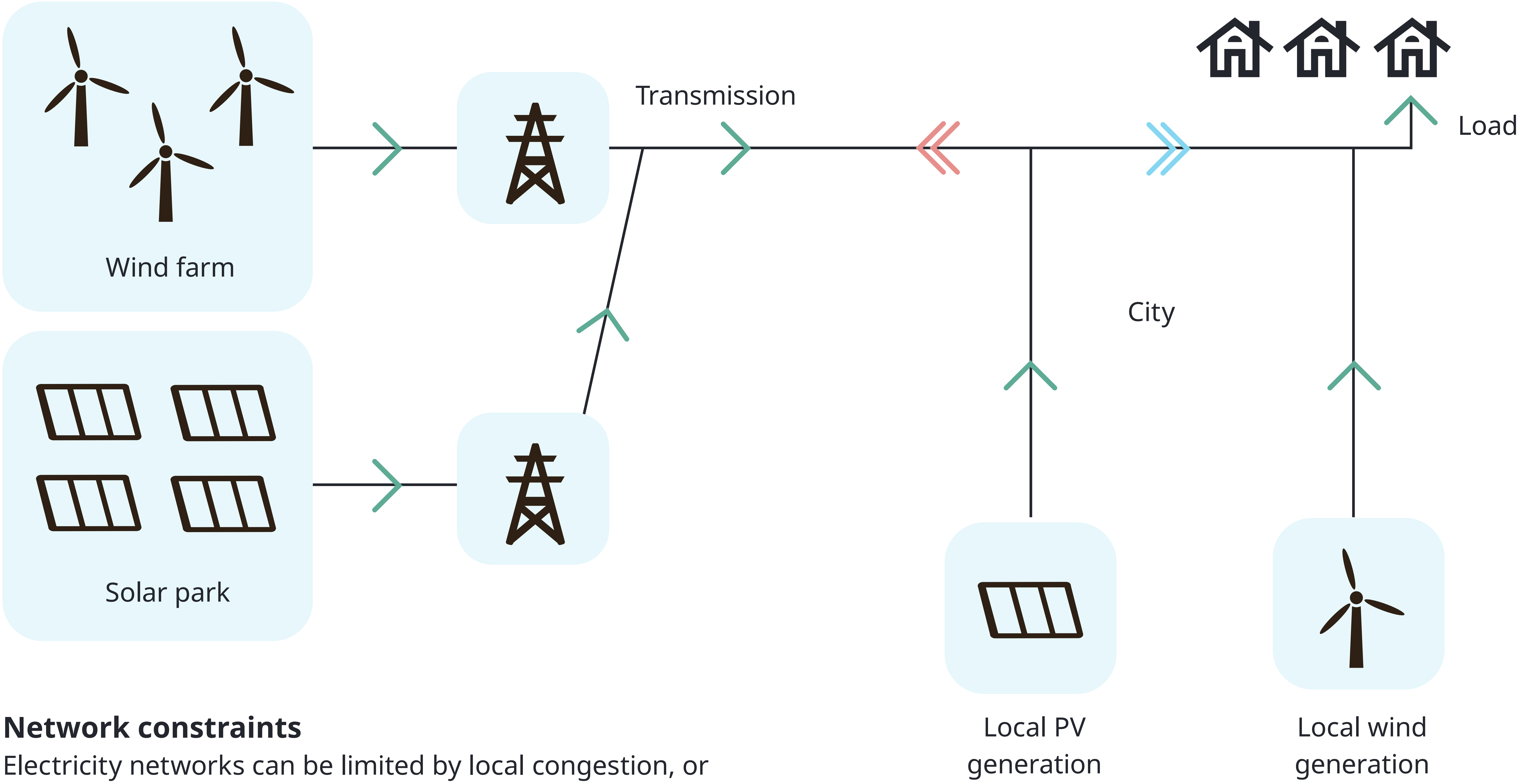
Frequency vs voltage constraints

There are two major roles for flexibility in meeting this challenge; roughly equated to frequency and voltage constraints.[3]

Frequency constraints arise when there isn't enough power being fed into the system to meet the demand and the grid frequency falls. Using flexibility to manage this is referred to as frequency response. In principle, flexibility anywhere on the system will contribute to frequency response.

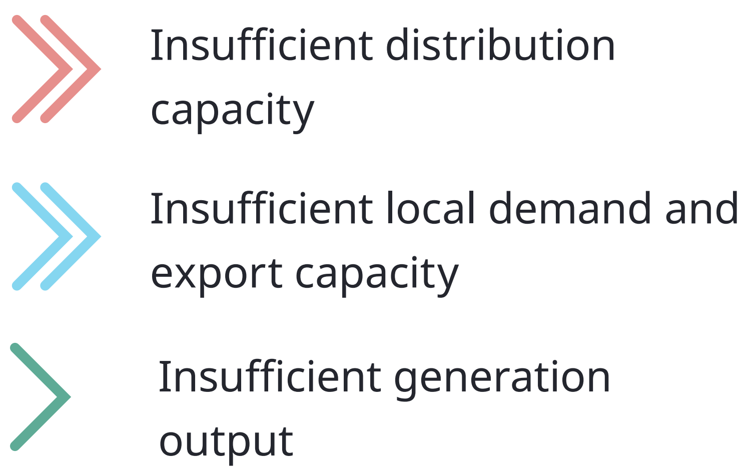
Voltage constraints arise when transmission or distribution cables reach their maximum capacity and the resistance of the power lines causes a voltage drop. Flexibility is used to keep cables within their operating limits. Voltage flexibility is only helpful if it affects the load on the overloaded lines, so is typically a regional or local service. It follows that when flexibility is being used to reduce constraints on the Low Voltage (LV), network close to homes then the flexibility must come from the same part of the network; if that load is made up of residential loads, then it is to residential loads that we must look for the flexibility.

3 PD IEC SRD 63460, Architecture and use-cases for EVs to provide grid support functions contains a list of the many forms of flexibility and indicates those that EVs are able to support.



Network constraints

Electricity networks can be limited by local congestion, or imbalances between supply and demand. Flexibility helps manage these constraints by shifting or adjusting demand away from periods when there is insufficient supply or network capacity.



Frequency response from residential loads, although individually small, can make a significant contribution when many homes are responding and the individual loads are combined or aggregated. Happily, new technologies, supported by international standards, are providing the tools to allow this to happen.

Residential flexibility

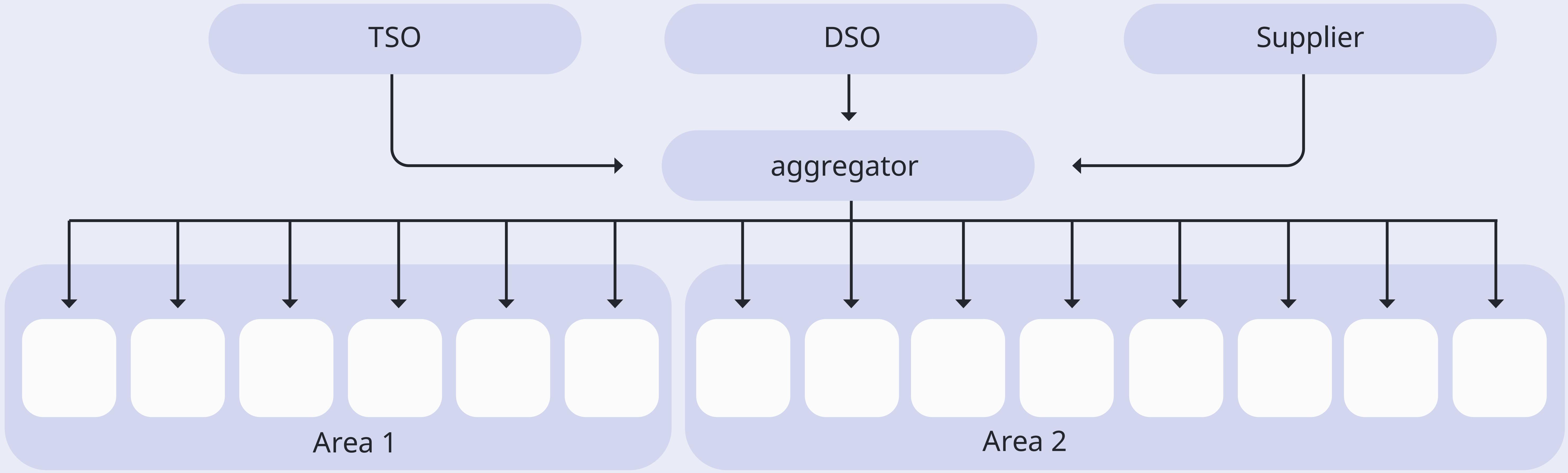
Although flexibility at all scales share the same fundamental concepts, the different market sectors have very different requirements; the financial value of a flexibility service from a single large site justifies bespoke arrangements whereas the value of residential flexibility from a single property is much lower and arrangements must be readily scalable with low cost per site.

One feature of residential flexibility is the use of aggregators[4] who contract with individual customers and combine them into a load large enough to contract with the network companies. The aggregator contracts with the Distribution System Operator (DSO) and manages the customer loads in response to signals from the DSO. The DSO makes any payments to the aggregator who then passes these onto their customers.

An additional challenge for residential flexibility is around technology neutrality. It is highly desirable for aggregators and DSOs to be able to ignore the details of the equipment they are controlling. This challenge has been met by developing standards that define general forms of flexibility that can be applied to any smart appliance so that the aggregator can request flexibility from all Energy Smart Appliances (ESAs) and then dispatch what is offered when requested by the DSO.

Residential flexibility delivery

Aggregators combine flexibility from many households and coordinate responses to signals from Distribution System Operators, enabling small residential loads to provide meaningful system services.



4 Referred to as Demand Side Response Service Providers (DSRSPs) in the UK.

International examples of residential flexibility

Governments around the world are looking to grow residential flexibility capacity. In the UK the Department for Energy Security and Net Zero (DESNZ) has set out its ambitions for flexibility: "The opportunity is huge, as battery storage and consumer-led flexibility are scalable and could be relatively quick to deploy.

Their deployment could not only cut bills for consumers but minimize the amount of more costly generation and associated network infrastructure that needs to be built, whilst maintaining security of supply."[5]

Australia is using flexibility to manage the output from embedded photovoltaic (PV) generation[6] and New Zealand has identified savings of NZ$4bn through to 2050 on distribution network reinforcement through the use of EV smart charging.[7]

In Japan, the ECHONET Consortium was established in 1997 with the "ECHONET Lite specifications" announced in 2011 and recognized as a standard protocol for HEMS (Home Energy Management Systems).[8]

The US, especially in California, has pioneered demand flexibility. The Californian Energy Commission states that "... however, many renewables produce varying amounts of power throughout the day. To ensure grid reliability, power available from renewable resources needs to match the amount of electricity used and time used".[9]

5 Department for Energy Security & Net Zero 'Clean Power 2030 Action Plan: A new era of clean electricity' (April 2025). Available at https://www.gov.uk/government/publications/clean-power-2030-action-plan/clean-power-2030-action-plan-a-new-era-of-clean-electricity-main-report [Accessed 22 May 2025].

6 CitiPower & Powercor, 'Flexible solar exports trial'. Available at https://www.powercor.com.au/network-planning-and-projects/network-innovation/flexible-exports/ [Accessed 22 May 2025].

7 EECA (March 2024) 'Residential smart EV chargers and demand flexibility'. Available at https://www.eeca.govt.nz/insights/eeca-insights/residential-smart-ev-charging-and-demand-flexibility/ [Accessed 22 May 2025].

8 ECHONET, 'Greeting'. Available at https://echonet.jp/greeting_en/ [Accessed 22 May 2025].

9 California Energy Commission, 'Load Flexibility'. Available at https://www.energy.ca.gov/programs-and-topics/topics/load-flexibility [Accessed 22 May 2025].

Forms of flexibility

There are many forms of flexibility that networks can use to manage their systems[10] and only some of these are relevant to residential customers.

In the UK, **PAS 1878**, Energy Smart Appliances. System Functionality and Architecture, identifies three forms of residential flexibility and, while these are UK specific terms, they describe basic approaches to flexibility shared across international implementations.

10 A full range of flexibility services (DFS) offered by the UK's National Energy System Operator (NESO) can be found here: ESO, 'Demand Flexibility Service (DFS)'. https://www.neso.energy/industry-information/balancing-services/de-mand-flexibility-service-dfs [Accessed 22 May 2025].

Routine: The customer and their systems follow kWh price signals to minimize their energy costs. Generally, the price signal follows the cost of generation but when the local network constraints are predictable, the DSO can, in principle, use routine mode to manage local network demand.

Response: The customer responds to signals from their DSO, either directly or via an aggregator when the DSO needs to manage local network constraints.

Frequency: ESAs or HEMs can be enabled to monitor network frequency and alter their behaviour depending on the frequency. A heat pump, for instance, might be required to delay start up if the grid frequency was too low, indicating insufficient supply capacity.

Increasingly flexibility is also being used to manage the demand for network connections. Normally, generation connections are offered after the network has been reinforced, to accept the new capacity. But flexibility can be used to allow the network to offer constrained connections before reinforcement is completed, so the generator can be instructed to reduce their output when the network can't accept it. This approach can also be applied to new demand connections, even at residential level.

An example of this is in Germany,[11] where in 2024 a regulation was introduced that, in return for a faster connection and lower tariff, heat pumps, EV chargers and battery storage units must be controllable by the local power network when required to manage local demand.

PAS 1878 - Energy Smart Appliances

PAS 1878 defines the technical framework that enables energy smart appliances to participate securely and interoperably in DSR. The newly published 2026 edition reflects significant industry maturation and feedback, supporting consumer-led flexibility at scale.

Download

11 EnWG, Individual provision. Available at https://www.gesetze-im-internet.de/enwg_2005/__14a.html [Accessed 22 May 2025].

Customer experience and control

There is an important distinction to be made regarding the degree of customer control offered. Many schemes provide for the DSO to directly control the customer appliances, for instance, in Germany, Article 14 allows the local DSO to reduce customer demand for a period of up to two hours and the signal cannot be refused.

Other implementations allow the customer more control. For **PAS 1878**, the customer informs their aggregator of what flexibility their appliances can provide. The aggregator can then trigger that flexibility offer if the DSO calls for flexibility; thus, customers only offer flexibility when they are willing to.

Allowing control over these commands creates new challenges. For example, a flexibility command won't necessarily come through when the customer is free to consider them or even awake. Nor are they likely to want to devote much of their time to considering flexibility commands. Hence, they are likely to need automation to stand in for them.

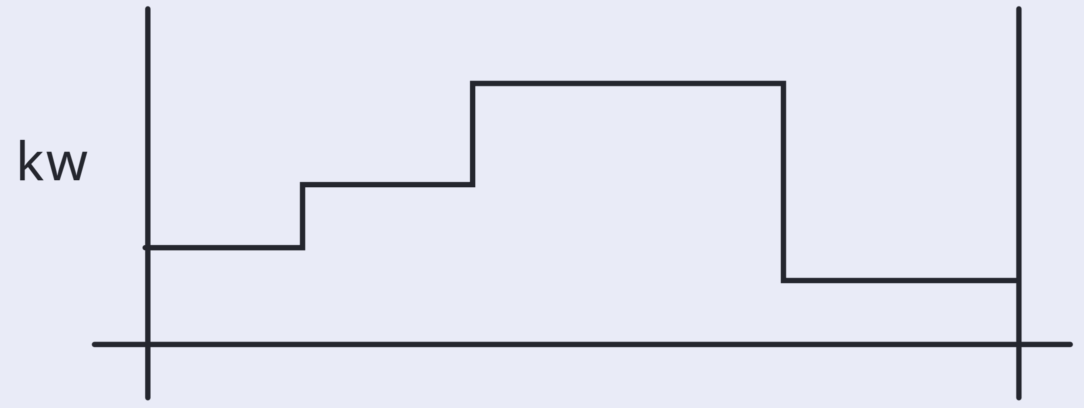
This is no small challenge given the different needs of all the users of a house, and the need to link a number of data sources; weather data, energy price data, daily schedules and even personal diaries. It follows that this means that users will need full confidence in the privacy of their data.

Flexibility data models

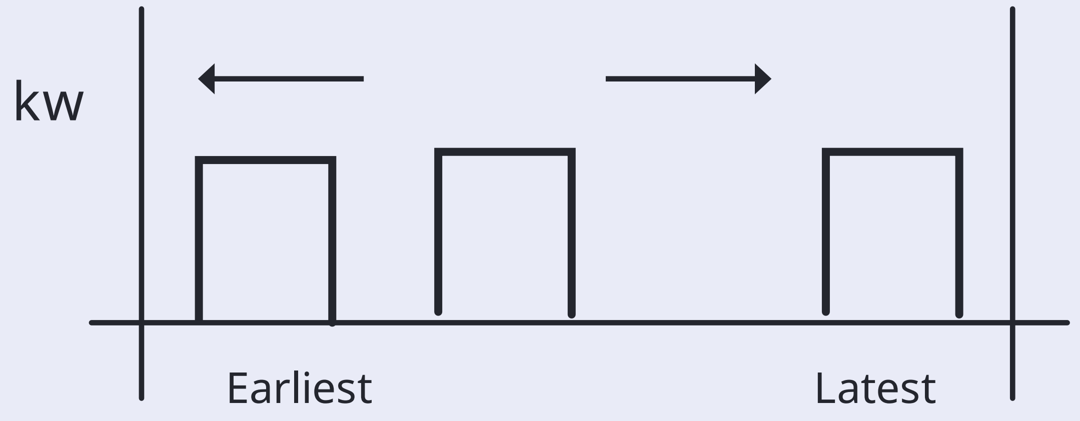
A number of data models have been defined in CENELEC **BS EN 50491-12-2** and these are being used as the basis for **BS EN IEC 63402-2-2** standard which is currently in development.

These models describe how appliances can adjust power, energy use, or timing in response to network signals while meeting user needs.

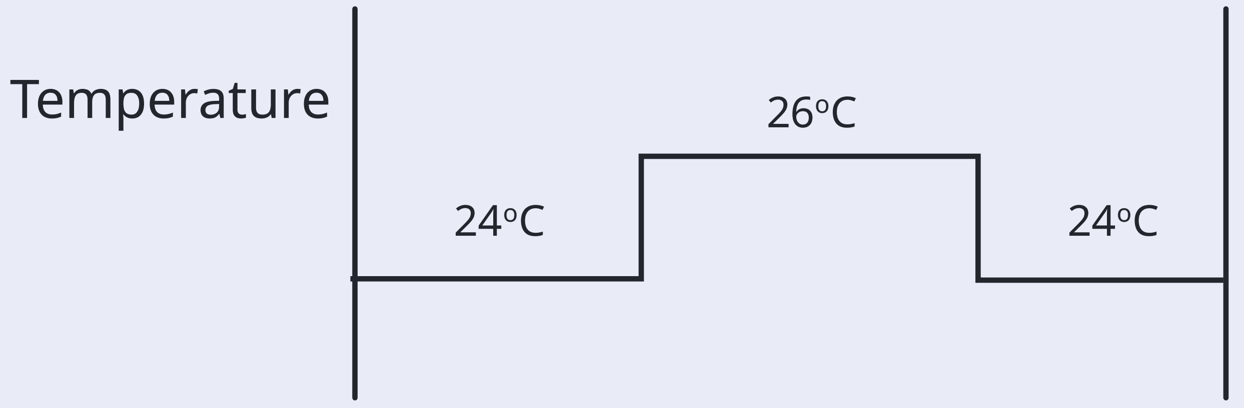
Power envelope-based control
Defines allowable power limits over time rather than direct on/off control.



Time window
Allows users to shift their demand within a range of times.



Device control
Adjusts user device settings to manage load.



Enabling technologies

Enabling residential flexibility presents a major technical challenge but is made possible by the development of new technologies, key amongst these the digital transformation.

The European Commission has stated that “Europe needs to build an energy system that is much smarter and more interactive than it is today. Energy and resource efficiency, decarbonization, electrification, sector integration and decentralization of the energy system all require a tremendous effort in digitalization.”[12]

This is reflected by the UK government, “… we have published the UK’s first Energy Digitalization Strategy, as digitalization is an essential requirement for realizing a smart and flexible energy system.”[13]

Digitalization is transforming many of the components of the energy system, allowing them to be securely connected and controlled. Digitalization also allows smart home systems to be established to take away much of the burden from the consumer in managing an increasingly complicated home energy system.

12 European Commission (2022). 'Digitalising the energy system - EU action plan'. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0552 [Accessed 22 May 2025].

13 Transitioning to a net zero energy system’. Available at https://assets.publishing.service.gov.uk/media/60f575cd8fa8f50c7f08aecd/smart-systems-and-flexibility-plan-2021.pdf [Accessed 22 May 2025].

Smart appliances and home energy management
Increasingly, home appliances include smart home capabilities and can be remotely managed. This capability can readily be integrated into a DSR system as it provides much of the necessary functionality.

Electric vehicles: smart charging (EVSE) and Vehicle-to-Grid (V2G)
Managing the demand from EVSE and avoiding network peaks is a key role of DSR but also there is the possibility of using the power stored in batteries to support the network using V2G functionality. Power can be exported from the EV during periods of high demand and the battery re-charged when demand falls.

Smart metering and settlement
Smart metering also reflects this transition from analogue to digital systems and provides a critical component of the DSR system. Routine mode will depend on customers moving to short time periods, such as ½ hour tariffs and smart meters will be able to record and report these usage patterns for settling bills.

Rooftop solar PV, storage and self-consumption

Rooftop photovoltaics (PV) have become widespread, a trend that is expected to grow, often combined with a battery or EV. PV generation is not very controllable and the benefits for the customer can be maximized if they are included in an HEM system such that the output of the PV can be stored during the day and used in the evening when the customer’s demand is higher and energy is more expensive.

Whole-home automation and device control

A fully equipped home could have PV, EV, heat pump, electrical and thermal storage and managing these for the maximum benefit of the resident is a complex task that will require automation. This control system can then be connected to external controllers, such as an aggregator, and used to let the home provide flexibility for the wider energy system.

A further, and less helpful feature of new home technologies, is their increasing complexity. Traditional loads, such as an electric storage heater could readily be switched on and off without damage and they could be controlled simply using an external power switch.

Heat pumps and many other modern appliances, on the other hand, can be damaged by repeated sudden loss of supply and they should always follow their shutdown process. This means that flexibility using heat pumps (and other similar products) needs to involve the heat pump control system; the heat pump should be instructed to shut down, rather than simply interrupting the supply.

Incentives and operating the flexibility system

Consumer reward

Obtaining this level of flexibility from customers will be a new experience for them, and getting their support and positive engagement is vital. Consumers can be rewarded in several ways, and market models and offerings are being developed to persuade consumers that getting involved in this is worth their while. Adjusting demand against variable tariffs should automatically reward customers as they seek the cheapest power periods.

Acceptance of contracts such as the German Article 14.a is rewarded by earlier connections and cheaper tariffs. Responding to flexibility requests from DSOs can be made mandatory but can also be rewarded via DSO payments to the aggregator for the availability of a response service and its dispatch. The aggregator then rewards the consumer. An important requirement for this is the ability to detect and measure flexibility responses.

Making it work

Introduction of the latest advancements in energy management and grid flexibility solutions

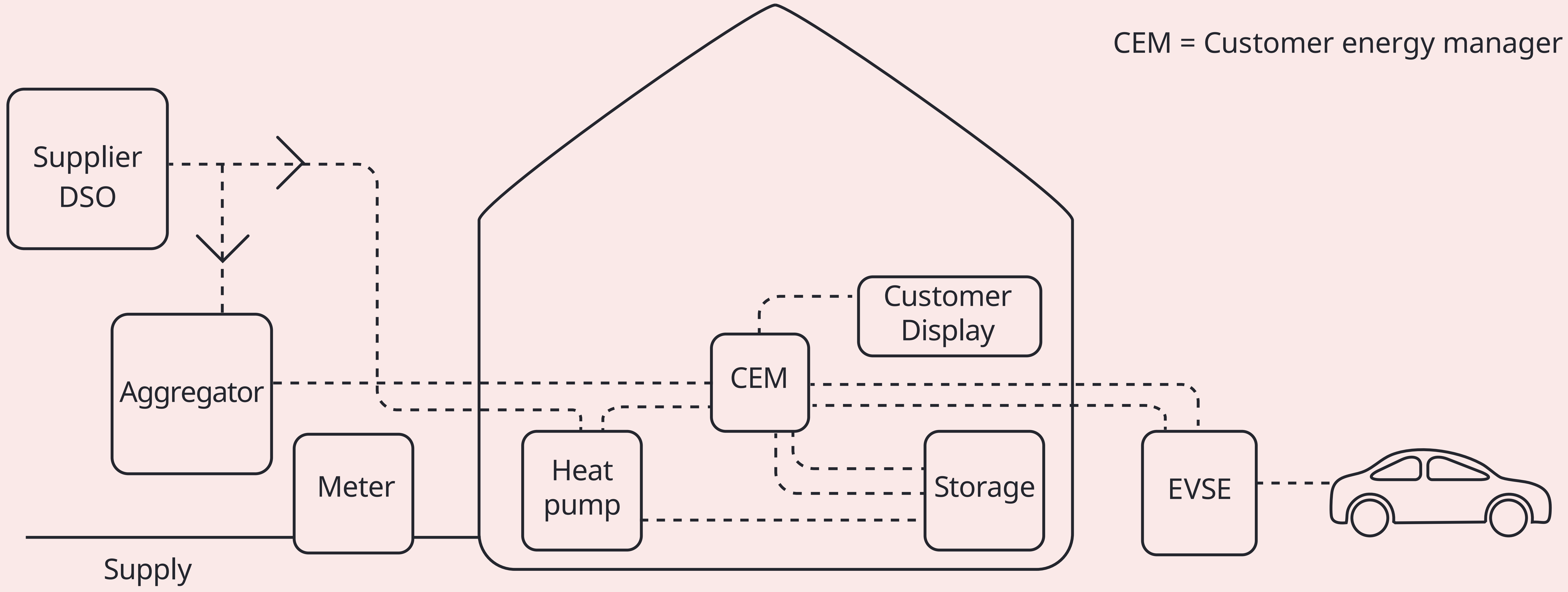
Much has already been done developing flexibility standardization but it remains a work in progress. A flexibility regime requires the communication of signals from the DSO network through to devices in the home and these messages are delivered via a series of stakeholders and domains supported by interlinking standards.

Many of the standards already exist with further work underway to complete the full set of standards covering these processes and to streamline them to open up as much flexibility capacity as possible.

International standards must cater for applications from across the world with many different market structures, local requirements and infrastructures. A statement on the standardization challenges can be found on the IEC website.[14]

14 IEC, SyC Smart Energy, 'Main standardization challenges'. Available at https://syc-se.iec.ch/smart-energy/main-standardization-challenges/ [Accessed 22 May 2025].

A flexibility system will contain a number of elements, which need to be developed and standardized, when necessary.



Set-Up

Contracts setting out the details of the flexibility services between the participants (for example, the energy system operator, transmission system operator, distribution system operator, aggregator and the consumer) are required, setting out how the system will be operated, what aggregator and consumer systems need to offer to qualify to take part as well as how the response will be dispatched, measured and paid for.

Whilst such contracts are not standardized, the flexibility market will benefit from common terms and conditions and will likely require compliance with standards for operation and performance.

Operation

The DSO requires a dispatch process based on communications protocols between the DSO and the aggregator. The aggregator must then forward the flexibility request to the ESAs in the home of relevant customers. In some jurisdictions, the DSO may send the signal directly to the consumer ESA with the DSO acting as an aggregator. Once it receives a call for a flexibility response, the ESAs in the home must accept the signal and act accordingly.

Once flexibility is triggered the aggregator needs to monitor the customer response and advise when the service is no longer needed, so that the consumer can return to normal operation.

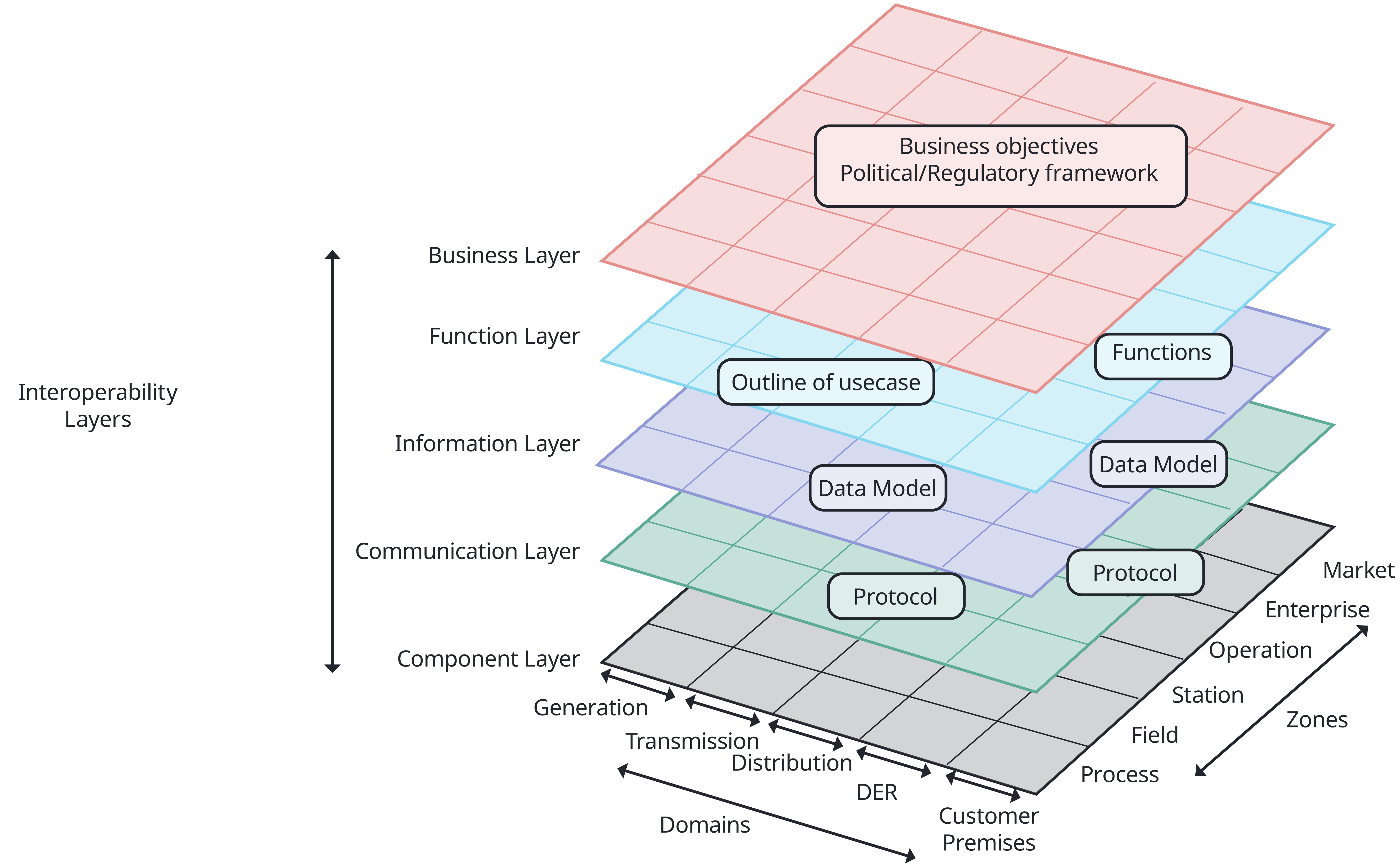
Settlement

Following a flexibility call, the customer system must report its measured response to the aggregator who will collect this data for all consumers and report to the DSO, who in turn will check the response for compliance with the operating rules, and assuming all is well, trigger payment.

It is clear that there are many steps involved and a real need to bring all of this within international standards to reduce transaction costs, benefit from economies of scale and allow learning from across the world to be shared.

Smart Grid Architecture Model (SGAM)

SGAM is a reference framework developed by IEC SyC Smart Energy to describe interoperability across domains, zones and layers of the smart grid.[15]



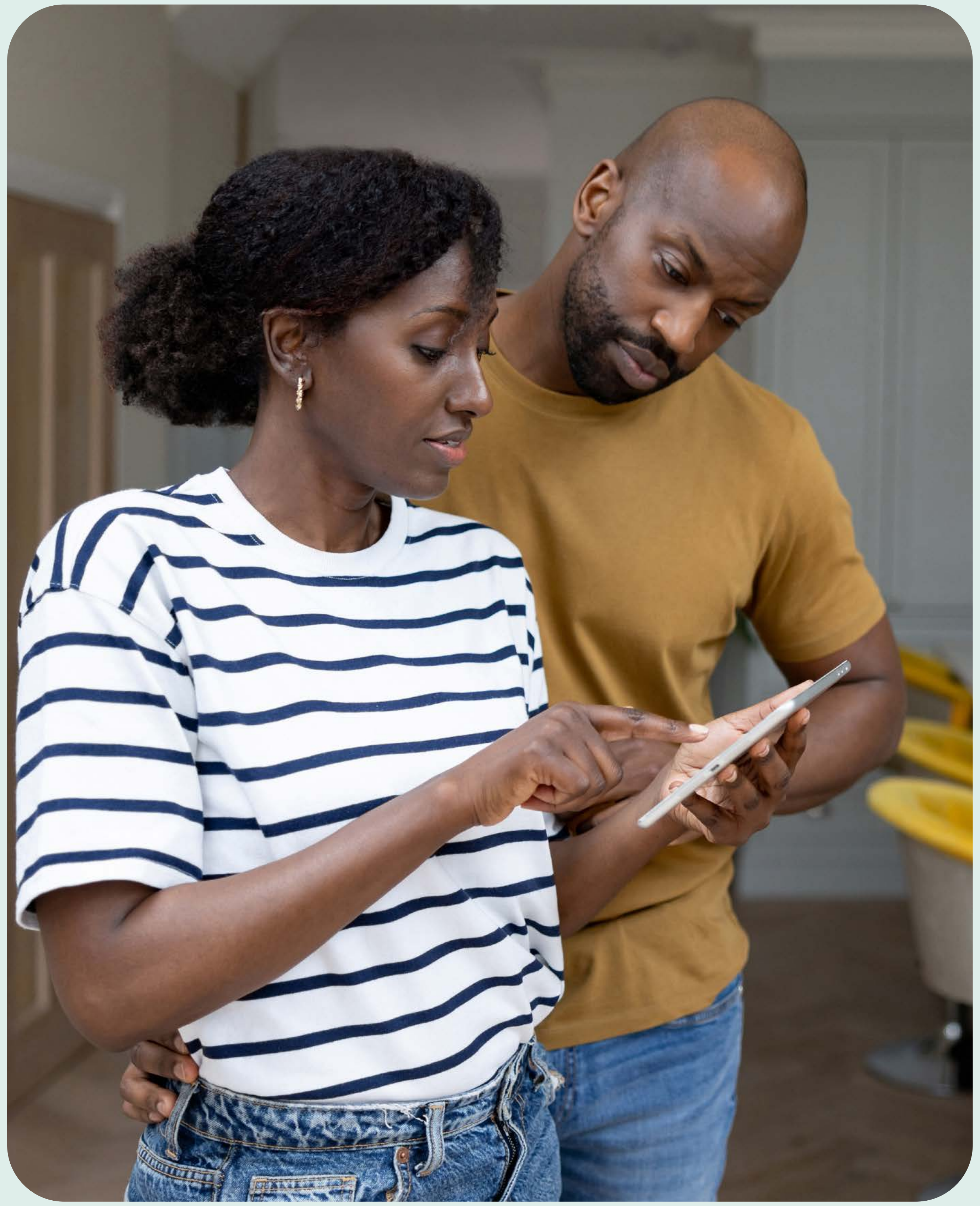
15 IEC SyC Smart Energy, 'SGAM architecture framework'. Available at https://syc-se.iec.ch/deliveries/iec-tr-63097-smart-grid-roadmap/architecture-framework-sgam/ [Accessed 22 May 2025].

Interoperability and cybersecurity

Interoperability

Interoperability is a major challenge and the focus of much of the work on DSR. Interoperability has a variety of interpretations within flexibility.

- **Device interoperability**: A consumer should be able to swap an energy smart appliance with another without loss of service.
- **Service interoperability**: A consumer should be able to switch their aggregator without needing to change their ESAs.



Device interoperability

There are several initiatives around the world addressing device interoperability.

Japan has developed the ECHONET-Lite[16] specification **BS ISO/IEC 14543-4-3** that provides for the remote management of residential energy appliances. In 2023, it was reported that one hundred and fifty million ECHONET-Lite enabled devices had been installed.

In the US, and gaining support around the world, the OpenADR protocol **BS IEC 62746-10-1** was developed in response to the California energy crisis of 2002 and its original purpose was to allow DSOs to remotely manage loads. Version 3.0 has now been published and it supports the remote management of residential loads. It can directly control devices or send signals to a HEM.

The UK government commissioned BSI to produce **PAS 1878**, Energy Smart Appliances. System Functionality and Architecture to enable device interoperability. **PAS 1878** defines interoperability as ''Ensuring that energy smart appliances adhere to common standards, allowing seamless communication and integration within the electricity system''.

PAS 1878 currently references OpenADR 3 for communication between the aggregator and CEM and defines a flexibility data model that the developer is free to incorporate into any smart home protocol.

The European Commission Joint Research Centre (JRC), working with industry and other stakeholders, has developed a Code of Conduct (CoC) defining a more limited device interoperability as "Enabling users to buy ESA from manufacturer A and replace them at any time without any restrictions with an equivalent appliance from manufacturer B, ESA must be interoperable to enable exchangeability".[17]

A first Code of Conduct has been published and the JRC is commencing work on expanding the CoC to include new devices like energy management systems (EMS), wider stakeholders interactions and the possibility of updating the first version of the CoC to include new solutions and protocols.

16 ECHONET, 'Overview of the ECHONET Lite specifications'. Available at https://echonet.jp/features_en/ [Accessed 22 May 2025].

17 Europeann Commission, 'Code of Conduct on energy management related interoperability of Energy Smart Appliances (V.1.0)'. Available at https://ses.jrc.ec.europa.eu/sites/default/files/2024-04/code_of_conduct_on_energy_management_related_interoperability_of_energy_smart_appliances_v.1.0.pdf [Accessed 22 May 2025].

Smart energy protocols

Delivering flexibility at scale depends on secure, reliable communication between devices, home energy systems and grid operators. A number of smart energy protocols have been developed either to support residential flexibility or to extend their scope to cover it.

An example of the former is EEBus, which was first developed in 2012 and is supported by over sixty manufacturers of energy relevant devices. Examples of the latter are ZigBee, Matter and KNX, which are all general purpose smart home protocols that have progressively added energy device management functions.

Each protocol has different strengths depending on the market, device type and use case. What unites them is their role in enabling consistent behaviour, smoother integration and a clearer pathway towards interoperability, all essential for future residential flexibility services.

Service interoperability

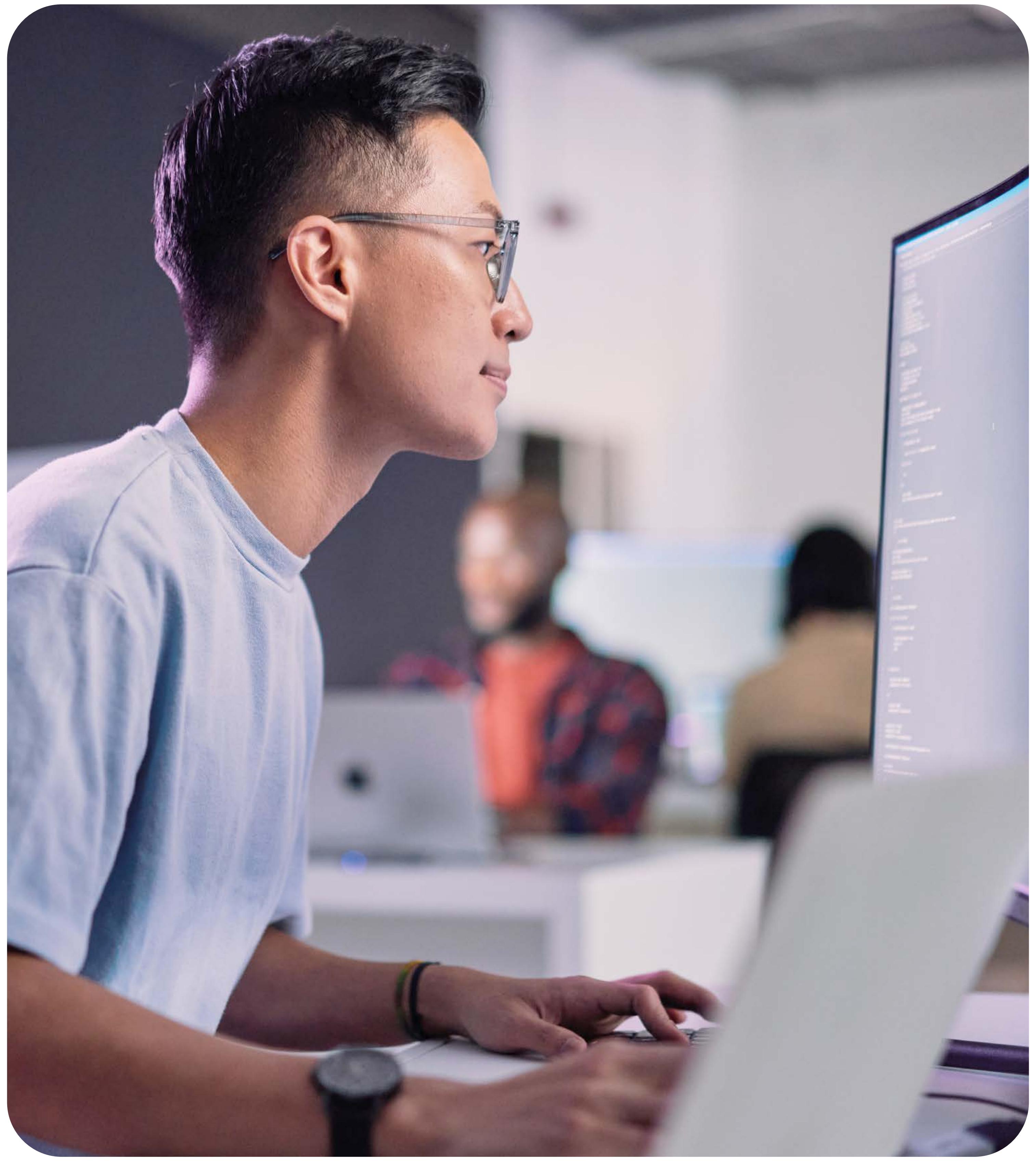
Standardization to support service interoperability faces greater challenges with different countries and markets having different requirements. Consumer willingness to allow their power utilities to directly manage their homes varies around the world. The critical loads for countries vary as well; it can be EV charging demand, PV generation, air conditioning or space heating loads that dominate and these local conditions will influence system design.

Cybersecurity

It can also be expected that DSR will attract the attention of cyber criminals looking to disrupt electricity systems by gaining control over large numbers of domestic loads. IEC System Committee Smart Energy has published a report on cyber resilience for smart energy systems, setting out principles for protecting energy systems.[18]

We can also expect to see governments bringing aggregators that control significant loads (> 300MW in the case of the UK government) into the requirements for operators of Critical National Infrastructure (CNI). In Europe, the requirements of the Cyber Resilience Act will cover ESAs, which may also be covered by Radio Equipment Regulations Delegated Act for which CEN/CLC Standards **BS EN 18031 Parts 1, 2 and 3** have been developed.

18 IEC, Cyber security and resilience guidelines for the smart energy operational environment. Available at https://www.iec.ch/system/files/2024-04/tec_cyber-security-and-resilience_en_lr_0.pdf [Accessed 22 May 2025]..



Managing energy in a flexible grid demands trusted standards

As energy systems become more decentralized and dynamic, organizations must balance efficiency, resilience and compliance across multiple assets and sites. BSI Knowledge provides access to the latest energy management, grid and digital standards, helping teams make informed decisions in an increasingly flexible energy landscape.

Explore how BSI Knowledge supports energy management and grid flexibility

Standardization landscape

There are many initiatives around the world seeking to establish residential flexibility markets.

BSI and IEC

BSI is the national standards body in the UK. We work closely with various global industry experts and committees to develop standards and make them easily accessible on **BSI Knowledge**.

Recently published, **PAS 1878** defines the system functionality and architecture that enable energy smart appliances to participate securely and interoperably in DSR. **PAS 1879**, the companion code of practice, provides guidance on the operation of DSR services using energy smart appliances.

At international level, IEC System Committee Smart (SyC SE) has produced an online mapping that is available to the public and can be used to explore the IEC standards and use cases covering the whole electricity system, including DSR.[19]

Updates of **PD IEC/TR 63097**, Smart grid standardization roadmap have been published and **BS IEC SRD 63199**, Top priority standards development status in the domain of smart energy assess the key areas for standards development. **PD IEC SRD 63417**, Guidance and plan to develop smart energy ontologies is also being developed.

PD IEC SRD 63460, Architecture and use-cases for EVs was also published to provide grid support functions.

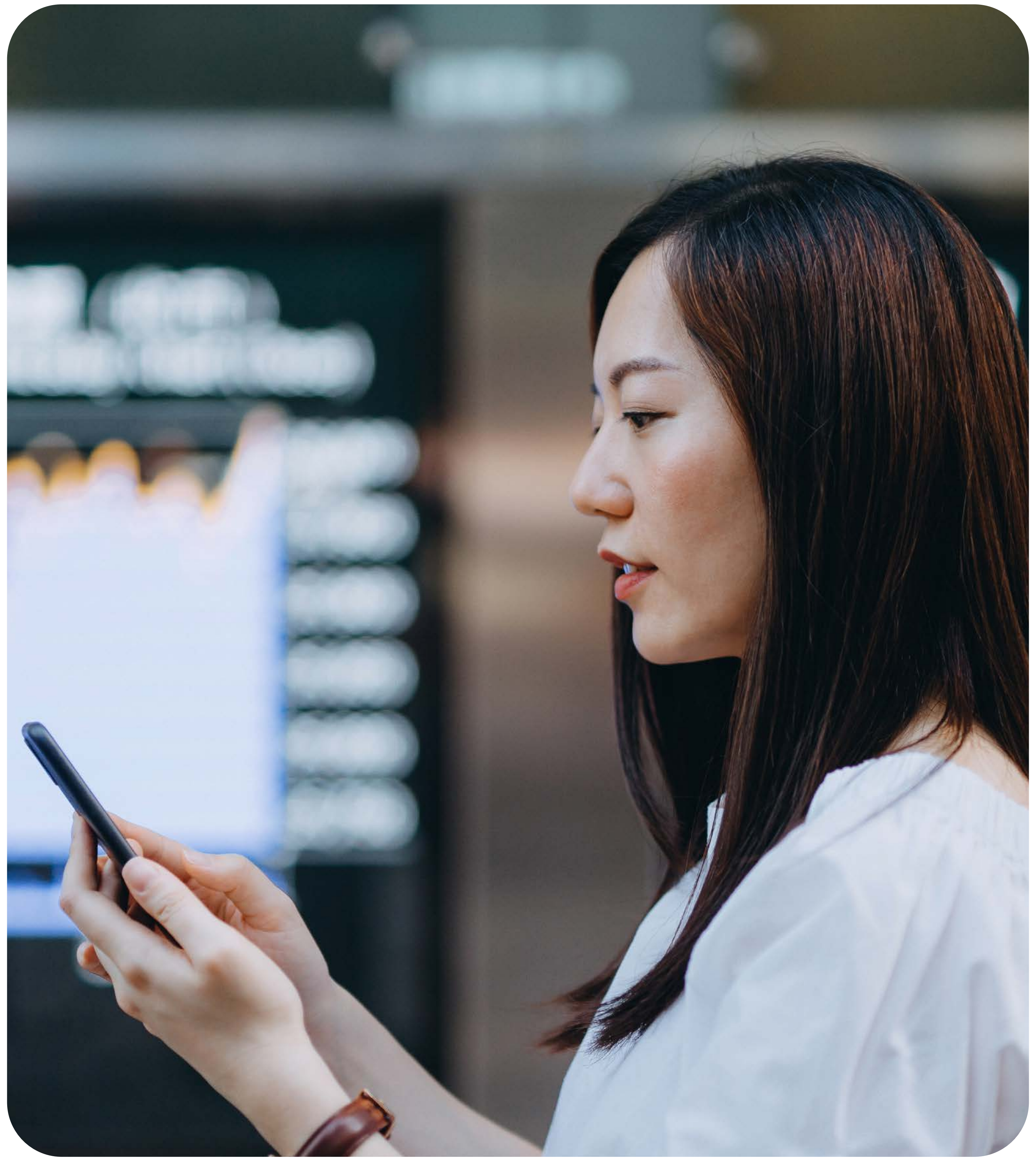
IEC SC 23K Electrical Energy Efficiency products committee led the development of flexibility standards, with the **BS EN IEC 63402 series** published. These are based on the CENELEC standards, **BS EN 50491-12 series**, General requirements for Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS). Smart grid. Application specification. Interface and framework for customer.

19 Mapping platform, Smart grid map. Available at https://mapping.iec.ch/#/maps/1 [Accessed 22 May 2025].

OpenADR

Initially focused on US use cases it has seen widescale adoption across the world[20] and has broadened its use cases. OpenADR provides for communication between the DSO, DSRSP and home and is based on **BS IEC 62746-10-1**. The OpenADR Alliance is also collaborating with several IEC committees – TC 57, PC118, and TC 65. OpenADR is being examined by the DSOs in the UK for use here for signals from the DSO to the aggregator.

20 Home. Available at openadr.org [Accessed 22 May 2025].



EEBus

EEBus[21] standards have been developed to enable residential flexibility and provide communication paths between market actors, aggregators, appliances and customers. EEBus standards support a number of different forms of flexibility. Based on **BS EN 50631-2**, Household appliances network and grid connectivity. Product specific mappings, details, requirements and deviations and ETSI TS 103 410-1 V2 'SmartM2M; Extension to SAREF; Part 1: Energy Domain'.

21 Home – EEBus, Empowering the digitalisation of Energy transition. Available at https://www.eebus.org/ [Accessed 22 May 2025].

Conclusion

Network residential flexibility is expected to be an important component of net zero power systems and is subject to major development efforts around the world. Trials and full-scale implementations are to be found internationally, and this activity is supported by many existing and planned standards developments.

This work will allow the development of large markets for interoperable energy smart appliances and make residential flexibility a practical and attractive development for governments, utilities and consumers around the world.

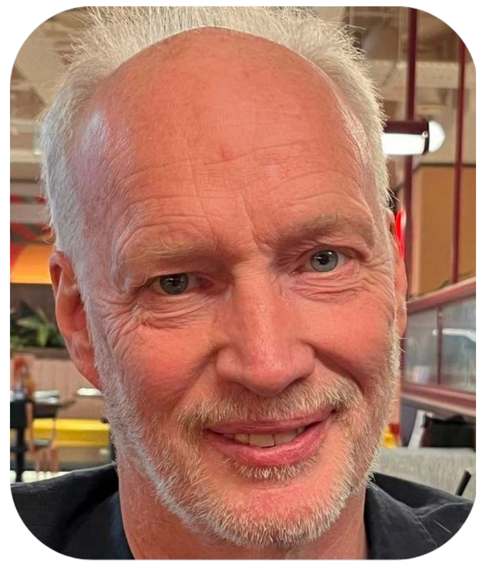
For both decision-makers and technical specialists, the examples in this report highlight not only what is possible today, but where further collaboration, standardization and innovation can help unlock the full potential of residential flexibility in the years ahead.

Next steps

1. **Review readiness and capability**
   Assess how residential flexibility aligns with your organization's strategy, technical architecture or operational needs.
2. **Understand relevant standards and protocols**
   Identify which communication approaches, device requirements or data models are most relevant to your technologies or markets.
3. **Engage with emerging market models**
   Stay informed on national or regional developments in flexibility markets, including opportunities to join trials or demonstration programmes.
4. **Prioritize interoperability and consumer trust**
   Consider how device behaviour, data protection, user experience and automation will influence uptake and long-term reliability.
5. **Explore support and guidance**
   Arrange a demonstration of BSI Knowledge subscription to see how standards and related insights can support planning, procurement and implementation.

Get a demo

Author



John Parsons, Consultant

John Parsons MEI C. Eng has fifty years' experience in the energy industry across many different energy technologies, including research on fuel cells, heat pumps, microCHP, smart meters and energy flexibility. He was the chair of the EV energy technology work stream 'Smart Charging Working Group' and was chair of BSI's smart energy committee. He is currently convenor of the IEC system committee smart energy ahG 11 'Energy flexibility and residential DSR: common ground', examining international developments in residential energy flexibility and making recommendations for future standards activity.

Turn energy strategy into operational reality

From energy management to grid flexibility and digital integration, applying the right standards is essential for resilient and futureready energy systems. BSI Knowledge enables organizations to manage and apply energyrelated standards efficiently, supporting compliance, performance and longterm value.

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