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ISGAN
INTERNATIONAL SMART GRID ACTION NETWORK

## Flexibility Markets: development and implementation

# Working Group 9 Incubator team scoping study report

## Discussion Paper

Energy Systems Catapult
ISGAN Annex 9

**January 2022**

## About ISGAN Discussion Papers

ISGAN discussion papers are meant as input documents to the global discussion about smart grids. Each is a statement by the author(s) regarding a topic of international interest. They reflect works in progress in the development of smart grids in the different regions of the world. Their aim is not to communicate a final outcome or to advise decision-makers, but rather to lay the ground work for further research and analysis.

## Disclaimer

## Acknowledgments

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## Preface

In 2020 a scoping study was conducted to understand the potential need for a new ISGAN workstream focusing on flexibility market development. This report aims to draw out key extracts from the results of that scoping study and has added additional example flexibility projects to Section 2.3.3. Other than the addition to that section, it should be noted that the information herein represents a snapshot from 2020, and there may be elements that are now outdated or have since been updated.

## Executive Summary

Many developments are taking place around flexibility within energy system(s), particularly around electricity network reinforcement avoidance and trading platforms. However, the scoping study hypothesis was that there are also significant gaps in research. As such, the study conducted a literature review to confirm areas that are being considered and concurrently surveyed ISGAN member countries to gather additional thoughts and concerns.

Conclusions were that there are areas that still need to be addressed, namely:

1. Integration of trading with dispatch
2. Understanding of multiple actors', requirements (including where those requirements are conflicting) for flexibility and the commercial implications
3. A need to identify the characteristics that different flexibility options provides and how to access them
4. Interoperable markets to support the development and usage of flexible products and services at scale
5. Consumer focused flexibility
6. Avoiding stability/security of supply issues through loss of diversity

This report summarises the findings of the literature study and the survey, and explains the thought leadership, to date, in the areas described as gaps above.

Finally, the report delivered a set of key recommendations for next steps, including the creation of a new Annex under ISGAN. This has since been launched (Annex 9). Since there are multiple recommendations which are market focused, it is recommended that any new Annex concentrates on the development of recommendations for flexibility markets that communicate all useful parameters to users and incorporate the dispatch function. It is also worth noting that there is a huge opportunity to become more consumer focused with flexibility options, and this is a strongly recommended focus for future work.

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# 1. Introduction

Energy systems worldwide are facing huge levels of change. Drivers for this include:

- the need for decarbonisation
- the rapid growth of decentralised renewable energy sources and the intermittency that comes with them
- the proliferation of new consumer technologies enabling ever more solutions, yet with potentially much less diversity

Demand Side Flexibility, or the ability to change the behaviour of consumption in response to the availability of supply, is seen as an enabling feature needed to decarbonise the world's energy systems.

At the ISGAN Executive Committee (ExCo) meeting in September 2019, members expressed that ISGAN could do more to be closer to recent trends around flexibility markets, new business models, and the opportunities presented by digitalisation. As a result, it was agreed that the UK delegates would start a scoping exercise to explore what a new Annex ("Creating Flexibility Markets") could potentially focus on. At the time interest was also shown by other countries including Italy, Sweden, Canada, Belgium, USA, Netherlands, and India.

As the Alternate Delegate to ISGAN from the UK, the Energy Systems Catapult (ESC) was commissioned to do this work. In response to the call to engage with the developments around flexibility more fully, an incubator team was set up to perform the activities described below. This report represents the final output of the ESC incubator team's work.

The activities undertaken by the ESC incubator team and documented in this report are:

1. Literature / past initiative review
   Perform a light-touch review of existing "creation of flexibility market" work and documents to ensure the capture of key insights from other relevant work

2. Questionnaire/survey on flexibility issues
   Develop a survey of key questions for ISGAN members and other relevant stakeholders to gather input and insights

3. Identification of gaps around flexibility
   The presentation of a hypothesis about the promising areas of development for flexibility markets that are under-represented in existing work

The insights from the literature review, the responses to the survey and identified gaps have been presented in this final report and have motivated the initiation of a new ISGAN Annex on Flexibility Markets, which is attempting to look at some of the gaps identified.

# 2. Literature Study

Energy systems worldwide are facing huge levels of change. Drivers for this include:

- the need for decarbonisation
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Demand Side Flexibility, or the ability to change the behaviour of consumption in response to the availability of supply, is seen as an enabling feature needed to decarbonise the world's energy systems.

## 2.1. Introduction

Flexibility market design is a very active space globally. Stakeholders in government, utilities, regulators, NGOs, and a host of diverse energy businesses have published numerous reports, studies and thought pieces, and many conferences and workshops have been convened on the topic. The reason for this interest is clear- flexibility is a central component of many nations' plans to manage the energy transition to low carbon energy systems in an economical, efficient, and reliable way. Moreover, this flexibility assists with integrating weather-dependent generation and making the best use of network capacity. What is less clear is how to develop the market mechanisms that will deliver flexible, low carbon grids in the coming decades.

This review of the current landscape attempts to capture the range of perspectives present today on how increasing volumes and new forms of flexibility should best be integrated into our energy systems through market design.

There are a number of definitions of flexibility. The one that has been used here is that from GB's regulatory body, Ofgem, which is:

> ***"Modifying generation and/or consumption patterns in response to an external signal (such as a change in price) to provide a service within the energy system."***

The rest of the literature study report is structured as follows:

Section **Error! Reference source not found.** describes the scope and methodology of the review.

Section **Error! Reference source not found.** summarises key insights from the literature review, giving a general overview of industry perspectives on flexibility market design.

## 2.2. Scope and Methodology

The landscape was reviewed through desktop research complemented by attendance at workshops on relevant topics. The work aimed at understanding views globally (although most publications found at the initial stage had a European focus) and was authored by a range of participants with different market roles.

Resources were found through investigating references within primary resources, internet searches, consultation with ESC experts, workshop supporting materials and discussion with other stakeholders. These sources were supplemented with attendance at numerous international collaboration events, where further expert views were gathered. The set of resources clearly cannot claim to be exhaustive, but it is likely with the breadth of sources that were found through this method that the views extracted are reasonably representative.

The literature review methodology consisted of two phases:

- The first aimed to find a list of possible resources through very brief investigation of materials
- Subsequently, the list was analysed in more detail to extract the key hypotheses presented in the report, and create signposts to interesting models, frameworks or datasets indicated in the resources

## 2.3. Summary

Flexibility has always formed a key component of grid operation (for instance through reserve and response), but in the past years, its nature has changed with the decline of traditional sources, decentralisation of new sources and the changing nature of the requirements to be fulfilled. Many actors are developing principles, frameworks and market structures leading to the recommendations that have been captured in this report. The following sections elaborate on the findings from the literature review by discussing the drivers for flexibility, principles of effective Flexibility market design and example demonstrator markets.

### 2.3.1. Drivers

The dynamics of the typical energy system have been changing due to the drive towards decarbonisation. Many conventional technologies that have long dominated global production are being phased out, and low carbon (often intermittent) generation technologies that are set to replace them have different characteristics that significantly change system properties. This can be seen, for example, in systems that are generally meeting more demand with wind generation, whilst phasing out coal plants- the system now has generation that is dependent upon intermittent weather conditions. This reduces certainty of the availability of power in time and implies less synchronised rotating mass connected to the network, meaning the frequency is harder to control. Both phenomena are key drivers of flexibility.

As network loading approaches its capacity, flexibility of both generation and demand is an alternative to network reinforcement. To this end, given the locational dependency of network capacity, it is important that flexibility in demand and/or generation is procured in the relevant parts of the networks.

On the demand side, a range of changes are expected, as other vectors (notably transport and heat) may look to electrify, introducing further new dynamics to energy systems.

The net effect of these drivers is that systems require more flexibility and cannot rely on conventional resources.

### 2.3.2. Principles of effective flexibility market design

There are several assertions and principles put forward within the body of evidence provided in literature. The key principles are summarised below:

- **DER can provide valuable flexibility services, but requires market and regulatory reform (to differing degrees depending upon market)**[2,4,5,8,10,12,19,24,26]

  A number of market evaluations (which are mostly focussed on Europe) monitor progress of flexibility markets and find many markets have yet to allow DER full access into flexibility markets.

- **A level playing field is needed- small, non-traditional providers such as aggregators can be disadvantaged by market rules**[3,4,6,16,17,19,26]

  These barriers to entry for aggregators and other small providers include issues such as: qualification processes being onerous, monitoring requirements for distributed, aggregated resources introducing significant costs.

- **The introduction of DSOs presents a TSO/DSO interface that must be catered for in market design**[3,6,9,20]

  DSOs are set to become a growing feature of global energy systems, driven by the increase in distributed energy assets, heavier loading of networks and decentralisation of system control. This leads to a new set of interfaces between DSOs and TSOs that will require management to ensure that all organisations' flexibility needs are met optimally.

- **Digitalisation is a key enabler**[15,21,25]

  One barrier to digitalisation is cultural- large utility companies are not well placed to quickly embrace new technologies due to conventional ways of working and resistance to change.

- **The lack of availability of system and network data is acting as a barrier to deploying business models**[3,4,5,6,17]

  Developing business models that are sufficiently robust to drive investment often depends on having reliable forecasts of present and future network requirements, and network data currently have low levels of availability and transparency across the industry.

- **Business models require better understanding of consumer values to work**[4,5,6,24]

  Behind the meter flexibility has been demonstrated to provide considerable value, especially when EV/Heating demand is considered. What has not been thoroughly addressed is understanding what consumers value in order to deliver a business model that effectively incentivises domestic participation.

- **Cyber security is a critical topic, and could act as a barrier**[7]

  Decentralisation changes the nature of the cyber security challenge- and perhaps necessitates a change of strategy to be more resilience focussed.

- **Availability contracts should be investigated**[6]

  The nature and structuring of contracts for being available in specific time frames could deliver more flexibility by making a wider range of business models feasible

- **DSOs should not offer services to flexibility markets**[19]

DSOs are sometimes able to use network assets to provide flexibility, for example by tapping down voltage to reduce the effective demand on a network node. This may distort competition, and the role of neutral market facilitator is compromised, leading to an overall non-optimal solution.

- **Market development metrics show most markets have a long way to go[1,16]**

  There are no standardised metrics for rating flexibility markets level of development, however organisations have developed their own schemes based on a mix of categorising what rules and products exist within the market, and subjective assessments of qualities such as having a level playing field and transparency of requirements. These assessments generally show few markets having advanced levels of development.

- **Control hierarchies could solve some coordination challenges[10]**

  Agreeing an order of priority and precedence in procuring and dispatching flexibility, or simply defining how flexibility procurement is conducted between organisations, will help solve some coordination challenges.

### 2.3.3. Demonstrator markets

Market demonstrations of flexibility have been implemented where there was no market before, driven by the changing requirements outlined in the previous section. Below is a non-exhaustive description of pilots and business-as-usual markets around the world, which are delivering flexibility to the system in line with the energy transition.

*Local Energy Oxfordshire (LEO):*

LEO takes a DSO approach by creating a local area energy market across Oxfordshire, which enables aggregation of electricity loads, flexible dispatch and peer-peer trading at a local level. LEO will investigate business models to maximise the value for consumers and enhance market opportunities for local renewables, electric vehicles, battery storage, vehicle-to-grid (V2G) technology and demand side response. A local capacity exchange will also be tested in this region, which would reduce the need for network reinforcements.

*Cornwall LEM:*

Both the local DNO, Western Power Distribution, and the GB's Electricity System Operator, National Grid ESO, are procuring flexibility on a single third-party platform. The aim is to find alternative solutions to conventional network reinforcements, by using battery storage, energy efficiency, solar PV and combined heat and power (CHP) system to provide flexibility. It has been operating since 2017 and has seen solar and battery storage installed into 100 homes across Cornwall region and over 125 businesses have been involved.

*Brooklyn Microgrid:*

Brooklyn Microgrid is an energy marketplace for trading locally generated, solar energy. Exergy is a permissioned data platform which facilitates local energy marketplaces for selling and buying flexibility across the exiting grid infrastructure. In this project, both residential and commercial PV owners can sell their excess of energy to NYC residents who prefer to consume clean renewable energy. This transaction can happen via the Brooklyn Microgrid mobile app, where consumers can choose to buy local solar energy via auctions.

*Power potential:*

National Grid ESO and UK Power Networks have launched this initiative aiming to create a new reactive market for Distributed Energy Resources (DER) in the South East region of the UK, where connection of DER is growing rapidly. Power Potential is creating a platform known as Distributed Energy Resources Management System (DERMS) to support technical and commercial optimisation and dispatch by gathering commercial availability, cost, and capability of each DER. This project will increase system flexibility by utilising DER's capability providing reactive power and supporting both transmission and distribution networks.

*DSO flexibility markets - UK*

In the UK one of the independent marketplaces for trading flexibility online is Piclo Flex, which is used by DNOs to announce procure Flexibility tenders. The platform acts as a marketplace and flexibility providers register their assets in order to notify DNO of their availability, technology type, location and price. In addition, the platform provides a geographical mapping of Flexibility requirements. Piclo Flex enables flexibility providers to share the location and connection voltage of their assets and matches active assets with new Flexibility tenders as these are published.

*California ISO ramping product*

California's ISO (CAISO) aims at co-optimising ancillary services and energy to mitigate uncertainties caused by the integration of forward and real-time markets. This is conducted by dispatching Flexibility resources economically, based on supply bids and load predictions. To ensure there is a sufficient level of real-time supply bids, the CAISO has introduced a day-ahead flexible ramping product to compensate Flexibility resources for committing to an obligation to bid into the real-time market.

*Decentralised Energy Exchange (deX) Australia:*

Australian Renewable Energy Agency (ARENA) has provided $10 million fund to an Australian energy technology company, GreenSync, in order to create a digital marketplace that allows consumers to get more value from DER assets, such as solar, EVs, and battery storage systems. Flexibility providers can be contracted to provide grid services such as constraint management, voltage support, managing system frequency and supplying energy during peak demand period.

*Project TraDER:*

Project TraDER, brings together Community Energy Scotland, CGI, EDF in the UK, Elexon, Energy Systems Catapult, Kaluza [an OVO Group company] and Scottish and Southern Electricity Networks, alongside other key players in the emerging flexibility arena including Downing LLP and United Utilities. It is designed to help demonstrate how a market based approach to curtailment of renewable generation can produce value. The project aims to deliver a single access point to multiple energy services such as balancing, stability and network capacity, making it quicker and simpler for assets to provide these services. The market went live in May 2020 on the Orkney islands, where renewable energy generation often exceeds grid capacity, creating a huge opportunity for flexibility.

*HONOR*

The HONOR Project is an ERA-Net funded research project aimed at development and evaluation of a trans-regional flexibility market mechanism, integrating cross-sectoral energy flexibility at a community-wide level.

*Coordinet*

The CoordiNet project will help to demostrate how DSOs and TSOs shall act in a coordinated manner and use the same pool of resources to procure grid services in the most reliable and efficient way through the implementation of large scale “TSO-DSO-Consumer” demonstrations, in cooperation with market participants (and end users).

*OneNET*

The project “OneNet” (One Network for Europe) is funded through the EU’s eighth Framework Programme Horizon 2020 titled “TSO – DSO Consumer: Large-scale demonstrations of innovative grid services through demand response, storage and small-scale (RES) generation” and responds to the call “Building a low-carbon, climate-resilient future (LC)”. The scope of OneNet is to create a fully replicable and scalable architecture that enables the whole European electrical system to operate as a single system in which a variety of markets allows the universal participation of stakeholders regardless of their physical location – at every level from small consumer to large producers. The project, led by the Fraunhofer Institute for Applied Information Technology FIT, brings together a consortium of over 70 partners.

*Crossbow*

CROSS BOrder management of variable renewable energies and storage units enabling a transnational Wholesale market. CROSSBOW is a TSO driven project with two interrelated and equally important strategic goals: on the one hand, it aims at the successful deployment in the market, within a 24 months horizon after project completion, of a set of technological solutions which enable increasing the shared use of resources to foster transmission networks cross-border management of variable renewable energies and storage units, making possible a higher penetration of clean energies whilst reducing network operational costs and improving economic benefits of RES and storage units.

*EU-SysFle1*

EU-SysFlex stands for “Pan-European system with an efficient coordinated use of flexibilities for the integration of a large share of RES “. EU-SysFlex will come up with new types of services that will meet the needs of the system with more than 50% of renewable energy sources. It will find the right blend of flexibility and system services to support secure and resilient transmission system operation.

*INTEERRFACE H2020*

INTERRFACE (TSO-DSO-Consumer INTERFACE aRchitecture to provide innovative grid services for an efficient power system). With the growth of renewables, the increased interconnection of European grids, the development of local energy initiatives, and the specific requirements on TSO – DSO cooperation as set forth in the different Network Codes and Guidelines, TSOs and DSOs face new challenges that will require greater coordination. The European Commission adopted legislative proposals on the energy market that promote cooperation among network operators as they procure balancing and other ancillary services and provide congestion management. Therefore, this creates the need for a project such as

INTERRFACE having the greater coordination between TSOs and DSOs as its core objective.

The aforementioned measures encourage procurement of services at both the transmission and distribution level, recognizing that this will enable more efficient and effective network management and will increase the level of demand response and the capacity of renewable generation. Digitalization is a key driver for coordination and active system management in the electricity grid, enabling TSOs and DSOs to optimize the use of distributed resources and ensure a cost-effective and secure supply of electricity but also empowers end-users to become active market participants, supporting self-generation and providing demand flexibility.

*ReFLEX*

ReFLEX aims to decarbonise the three main areas of energy use on Orkney - heat, transport and electricity - by digitally linking 100% renewable energy with demand and storage into a flexible integrated energy system.

## 2.4. ISGAN Survey Results

A Flexibility Market Survey was conducted to identify the gaps around Flexibility markets regarding technological aspects such as interoperability and digitalisation, and with regards to policy, regulation and business models. It drew insights from international subject matter experts and has motivated the initiation of the ISGAN Annex 9 on Flexibility Markets.This review of the current landscape attempts to capture the range of perspectives present today on how increasing volumes and new forms of flexibility should best be integrated into our energy systems through market design.

### 2.4.1. Survey Methodology

The flexibility market survey was developed around five high-level topics and was carried out independently by the ESC incubator team. These high-level topics covered:

1) Definition of flexibility
2) Importance of flexibility
3) Enablers and barriers for flexibility
4) Digitalisation and flexibility
5) Importance of a new ISGAN Annex on Flexibility Markets

Around the above areas, respondents were given a variety of questions, scoring measures and free text options to express their views.

### 2.4.2. Demographics

ESC invited individuals in various roles within the energy sector from ISGAN countries, to complete the survey online between March and April 2020. There were 32 responses that were analysed by the incubator team at ESC, and the resulting data and findings are presented in this section, in an anonymised and aggregated form.

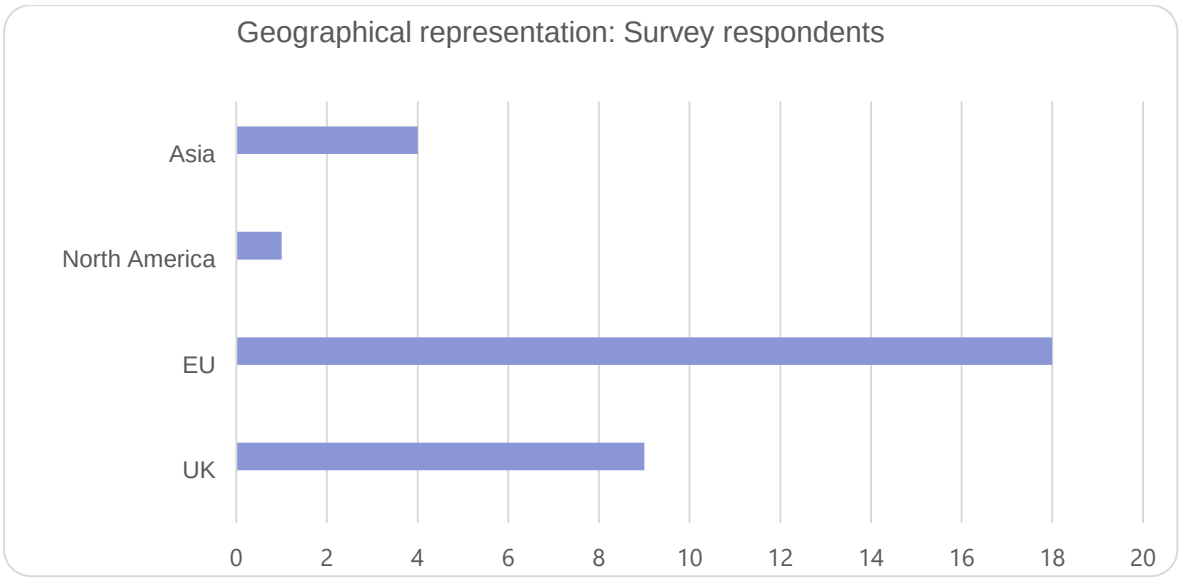



**Figure 1 - Geographical representation of survey respondents**

The respondents were from thirteen countries, including UK, Canada, Italy, Germany, Belgium, Austria, Ukraine, Sweden, Denmark, Finland, Japan and India.

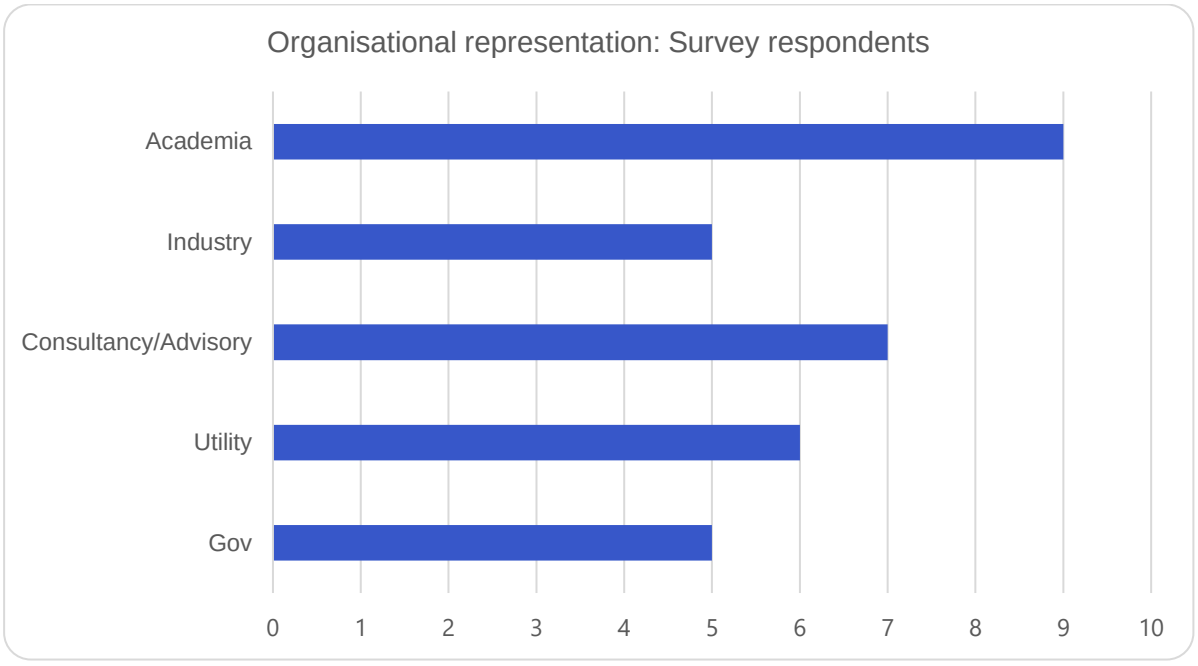



**Figure 2 - Organisational representation of survey respondents**

Respondents represented different organisations around the world; 28% were from academia; 22% were from consultancy or independent advisory roles, and 19% directly from a utility. Respondents from industry and respondents from government/policy making roles each accounted for an equal 16% share in the mix.

## 2.5. Key Findings of the Survey

The survey first asked for the respondent's interest with regards to flexibility; and the most common interests recorded were renewable energy integration, policy formulation, achieving decarbonisation objectives, market transformation and research and technology development.

We then asked the respondents to rate 'How important will flexibility be in 2050 to power system operability?' on a scale of 1 to 5 (with increasing importance). 90% of the responders said **flexibility will be critically important in 2050** for power system operability, enabling open markets and increasing consumer value. When asked to rate 'How important flexibility trading is to electricity system operability today, in the power systems you have awareness of,' the majority expressed an average rating saying that it is not critical in the current context.

### 2.5.1. Definition and Importance of Flexibility

Flexibility and Flexibility markets, in the context of a power system can assume different meanings in different contexts. Moreover, depending on the context, the importance of flexibility can change. With this variability in defining what flexibility means, and identifying its importance, respondents were prompted to lay out their views on the application of flexibility.

A significant majority, nearly two thirds of the participants, believed that Flexibility markets should **focus on energy generated/consumed within traded periods** over power/capacity. A similar number of participants had views that providing operational services such as inertia and reactive power support are a type of flexibility. They strongly believed that there are **other tradable capabilities** of energy assets that should be part of a Flexibility market structure. These include Inertia, active/reactive power, energy storage and ancillary services. But some power systems (Japan) consider them as non-tradeable products. When further asked about the composition of a Flexibility market, 69% believed that a Flexibility market should focus on both meeting national requirements and optimising local requirements. Only a slim majority (53%) was behind the idea that metering assets are central to the Flexibility market design.

> ***"flex markets help reach decarbonisation goals by allowing to integrate more renewables and to unlock demand-side flexibility"***

Interestingly, there was an equal split between the participants over whether the carbon emission reduction could be one of the explicit objectives of flexibility.

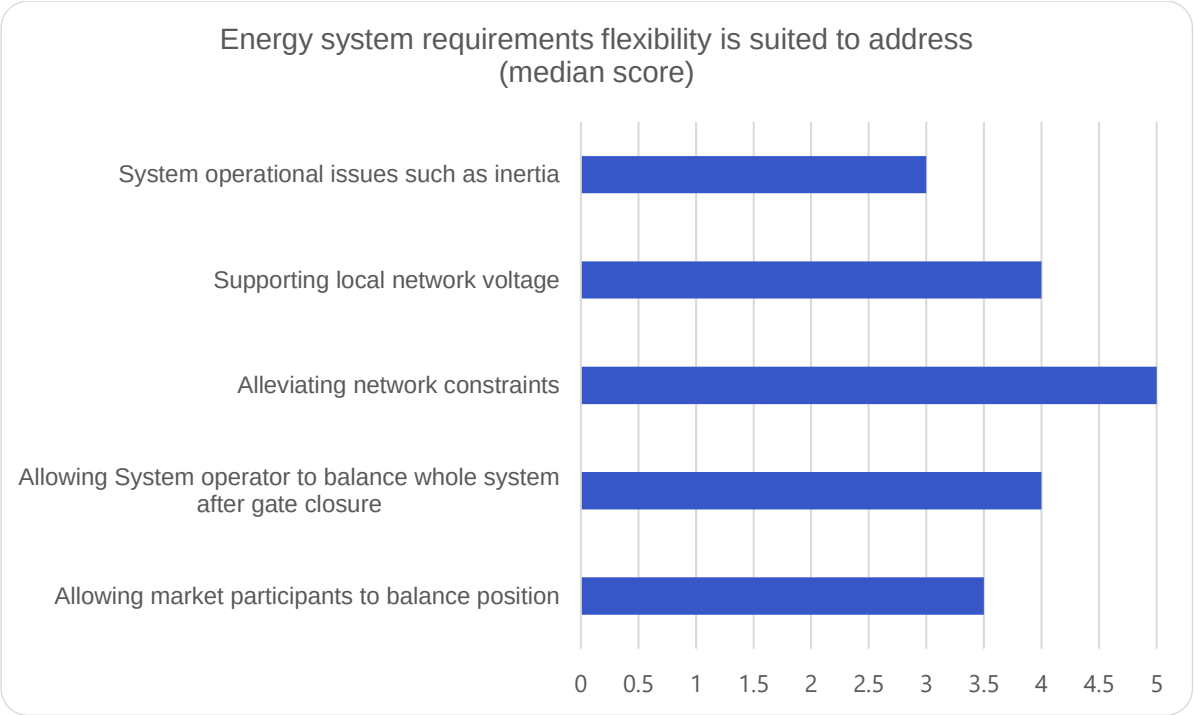



**Figure 3 - Median score of priority energy system requirements flexibility is suited to address**

Respondents were given five choices of energy system requirements for which flexibility is well suited to address; and were asked to rank them in the order of priority based on the power system of their interest. The **alleviating network constraints** came as the top priority across the respondents. Both, **supporting local network voltage** and **allowing system operator to balance whole system after the gate closure** came in joint second place. Allowing market participants to balance position came third and system operational issues such as inertia came last. Although the position of top three priorities changes slightly between different demographics, the picture looked similar across the world.

### 2.5.2. Barriers to Flexibility

***How easy it is today for distributed resources to access flexibility markets?***

***RESPONDANTS SCORE: 2/5***

A vast majority of respondents indicated a clear pessimism over accessibility of flexibility markets for distributed resources. They have pointed out three key barriers that slow the progression of flexibility, namely:

- **Regulatory restrictions** or no regulation.
- Difficulty for distributed resources to access flexibility markets with **fair access to data.**
- Traditional system approach.

A majority of respondents considered current policy and regulatory status quo to be responsible for creating uncertainty in investors. Lack of transparency and instability of the regulation frameworks were also regarded as hindering participation and investment.

> ***"…policy uncertainty is the biggest problem in GB. In order for this market to thrive there needs to be a wholesale change to the energy act or similar and the grid codes. Until we know exactly what these are, it will always be risky creating a business around providing flexibility."***

When asked whether they believe there is fair access to the network data required for a well-functioning Flexibility market, only 43% believed so. When the same question was asked about the access to asset data, the response was even lower, around 37.5%. The audience was divided over whether the system's digital infrastructure (communications, monitoring, data) currently supports the widespread deployment of a Flexibility market.

There were other factors mentioned by a few respondents, such as respondents from USA reporting a **lack of market structures**, and those from India mentioning low periodicity and granularity of measurement and settlement as their greatest barriers. Some respondents from EU countries have also mentioned **lack of clear economic benefits hampered by taxonomy** as a top barrier for flexibility.

### 2.5.3. Enablers of Flexibility

***How important is digitalisation to unlocking flexibility?***

***RESPONDANTS SCORE: 5/5***

Respondents clearly indicated that **digitalisation** is the most important enabler of unlocking flexibility. Other important enablers reported include:

- Smart grid approaches
- Transparency and visibility of requirements
- Ability to stack services
- Digital device and solution standardisation

Respondents mentioned that transparency and visibility can be achieved via forecasting and measurements, open data, stakeholder participation, regulations, and tech tools. Also, stacking of services was viewed as a way of integrating flexibility with other markets. **Standardisation** of digital devices and services were widely seen as important to enable flexibility. Some viewed standardisation as key to interfacing utility and the consumer end points, while some predicted that it is essential to create effective and unbiased collaboration leading to better solutions and devices that are **interoperable**.

***"Standardised communication enables integration of hardware and standardised flexibility products enable integration of flexibility markets."***

When asked about which particular data types standardisation is vital for, respondents named asset registers, interface data points, data for the end-user and the aggregator as examples.

The respondents were prompted for their views regarding distribution and transmission system operators being able to directly control digital devices, to use flexibility on the demand side, for system reliability and efficiency. Views here were varied and divided. Just over half of the respondents perceived direct control positively and as essential for reliability especially during emergencies. Some of them indicated that this requires development of necessary tools to improve observability of the grid and to forecast the behaviour of users. The other half of the participants, who were not in favour of direct control, said that it could be intrusive and too orchestrated. Further they said that this can limit consumer participation in flexibility and hence recommended that direct control should be used as a last resort. Some also suggested that control should be based on market and pricing signals while recognising that smart metering can play a greater role before considering direct control.

### 2.5.4. Other Non-quantifiable Benefits

Flexibility brings non-quantifiable benefits and respondents were asked to provide their views on this. Most reported non quantifiable benefits include:

- Consumer engagement
- Grid stability and reliability
- Social values resulting from energy equality and reduced fuel poverty

> ***"Democratisation of energy; more involved customers (happier); increased resilience; increased role in smart cities and enabler of electrification."***

**Consumer engagement** promotes democratisation of energy, by making all users responsible actors within the energy system. This will allow **cost effective penetration of renewables** while improving the **resilience of the grid**.

### 2.5.5. Importance of a new ISGAN Annex on Fleixbility Markets

> ***53% of RESPONDANTS Agreed that cross border alignment of flexibility market structures, such as through standardisation of products, is important***

The participants' views were tested on aspects of cross-border alignment. The resulting views varied between countries with great contrast. Aspects reported favourable to cross-border alignment included:

- Standardisation of data formats, communication protocols and devices,
- Operational procedures
- Market structures (to some extent)

The standardisation of assets (devices) and communication protocols was largely seen as a facilitator to a common market for asset manufacturing; thereby, bringing the overall cost down. Some indicated that standardised communications protocols also enable companies to work across markets. In total, 53% were in favour of standardisation of products.

The others viewed cross-border alignment not as important outside single electricity markets and maybe not possible, as electricity networks around the world run on different currents and voltages.

We then asked the respondents, 'How well developed is the global understanding of delivering flexibility markets?' The choices given were 'advanced', 'emerging' and 'low'. 58% of the respondents said the understanding is 'emerging' and 38% said it is 'low'; only one respondent said it is 'advanced'.

There was a clear lack of examples that participants could provide for an efficient and successful Flexibility market. But there was apparent agreement among the respondents that sharing of knowledge, best practices and lessons learnt between successful markets and less developed markets is beneficial to a larger extent. A few expressed concerns that knowledge sharing may be limited due to differences between electricity systems and markets. One participant said it is also important to learn from other sectors.

# 3. Identification of Market Areas for Development

Following on from the survey and literature study, analysis and consideration suggests that there are areas which still need to be addressed in more detail. These include:

1. Integration of trading with dispatch / monitoring of balancing actions required on a sub-settlement period basis
2. Understanding of multiple actors (aggregators, consumers, retailers, generators, physical network owners, system operators) requirements for flexibility and the commercial implications
3. A need to identify the different characteristics that different flexibility options provide and how to access them (e.g., active power, reactive power, inertia, responsiveness, duty cycle, repeatability, continuous duration etc.)
4. Interoperable market development. For example, future flexibility is determined by investment and infrastructure decisions made today, yet there are no links between flexibility markets and long-term investment decisions in the markets meaning that investors cannot get confidence on the commercial aspects of their decisions
5. Consumer focussed flexibility. The industry often talks about paying customers for the inconvenience flexibility will cause, rather than demonstrating how flexibility is giving customers what they want at a price point they want to pay for it
6. Utilising the power of digitalised flexibility offerings to avoid the risks of coincident responses to control signals and lack of diversity, integrated with critical national infrastructure

## 3.1. Dispatching Flexibility

Most flexibility trading is carried out in the 15 or 30-minute time window depending on the local settlement period and matches generation. Dispatch of large generation, which dominates the generation mix today, is also dealt within the same time-period but we know that in the future the generation mix is likely to be dominated by intermittent renewables, whose output will be highly dynamic and dependent on prevailing conditions. It, therefore, stands to reason, that demand side flexibility will need to be capable of responding to much quicker control signals. The GB balancing mechanism is already set to work in these timescales but the cost to deliver is increasing.

Flexibility platforms available today are concerned primarily with trading and any dispatch is performed at the speed of today's settlement periods. In the future, with millions of distributed sources/loads, more fine control is likely to be needed.

Additionally, there is a risk that dispatching loads can be made to game the system and create new issues for which the person or organisation causing the issue can then sell the solution as well.

Each line in the following diagram represents a different way of delivering 100 units of something in a 30-minute settlement window. Each have a different effect on the energy system and the actions that might need to be taken to balance supply and demand. The balancing market expresses delivery requirements to participants, but it is not clear how this can work with millions of point sources.

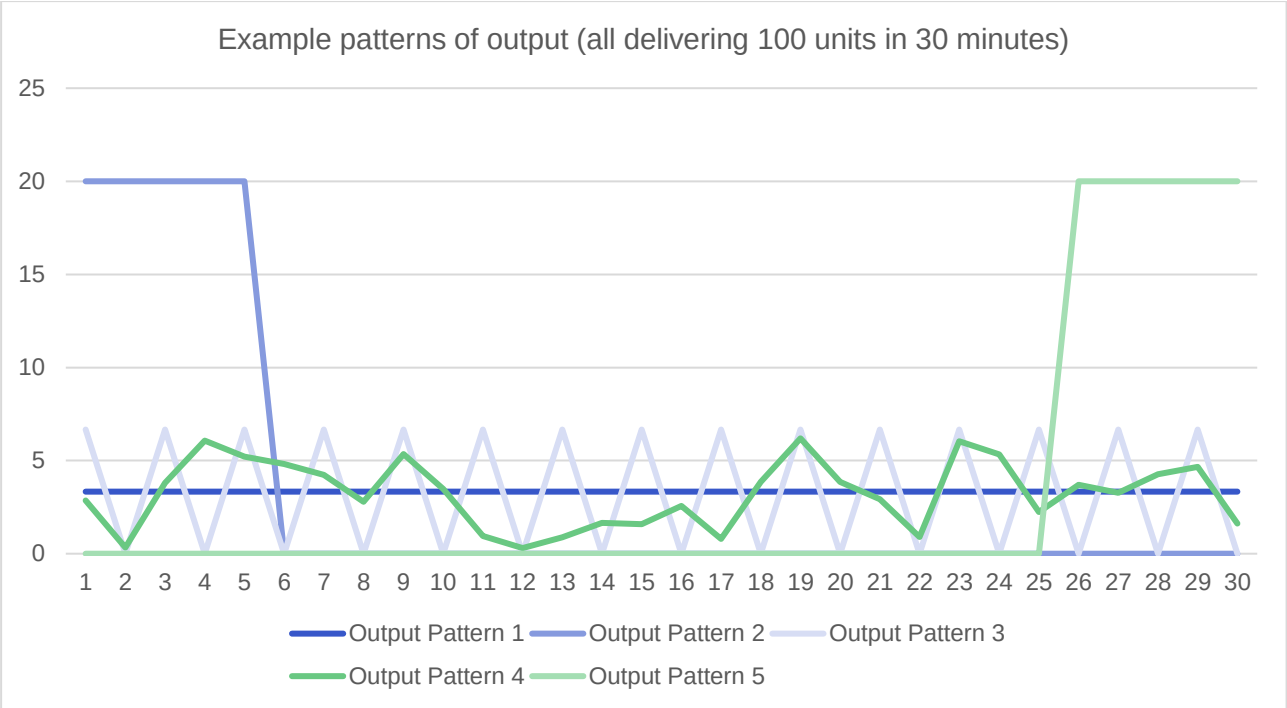



**Figure 4 - Different ways of dispatching 100 units in 30 mins**

## 3.2. Integrating Different Actor Needs

Different market players or “actors” in the energy systems supply chains have differing needs when it comes to “flexibility”.

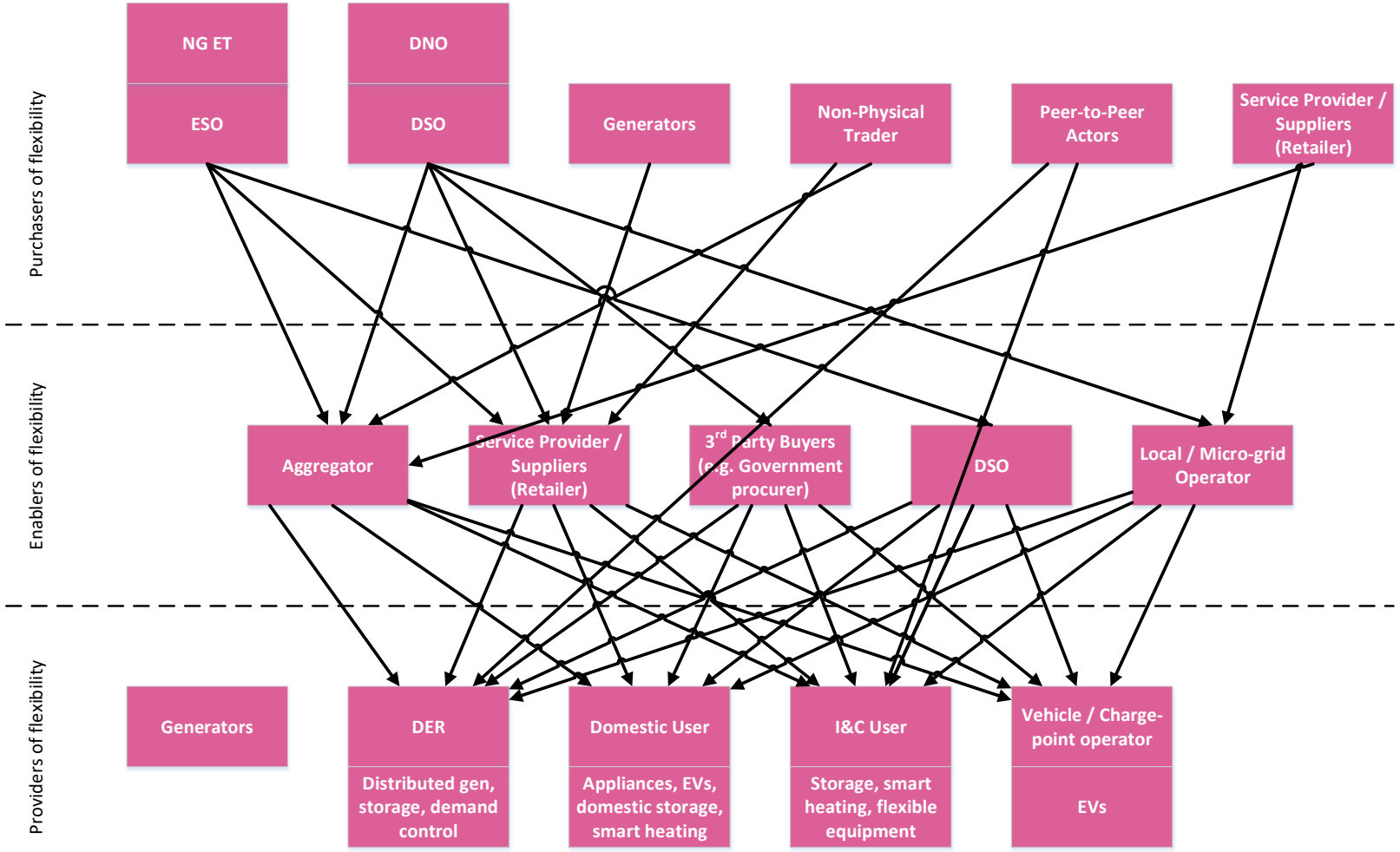



**Figure 5 - Matrix of possible commercial paths for flexibility (using UK terminology as an example)**

The diagram above attempts to illustrate just how many different commercial paths to flexibility there might be, each transaction is also likely to vary in terms of geographical specificity, duration, and many other factors. Some actors appear in multiple rows because it is perceived that those actors might be able to act in multiple capacities in the future. The bottom row of actors is supplemented with examples of the products and technologies which might deliver those solutions.

Taking just the first box, the ESO needs flexibility for a number of reasons, two of which are managing transmission constraints and frequency management. The former is geographically sensitive whilst the second can be delivered by assets nationally, often quite large amounts of kWh are needed to make changes. Taking the second box, a DSO of the future who will have to perform more active management of low voltage networks. In trying to manage power quality in their area, they might have 40, 60, 100 buildings connected to a phase of a low-voltage transformer. Power quality issues are instantaneous and localised meaning that there will be a smaller pool of flexibility options, potentially less diversity and likely much more granularity, likely leading to many more transactions of smaller amounts. In just these two actors, trying to achieve just some of the things they need to achieve it is clear to see that “Flexibility” means different things to different people.

Figure 5 shouldn’t be considered exhaustive, but rather an illustration of the complexity of what different actors might require.

## 3.3. Flexibility Characteristics

Devices which indicate that they are flexible are likely to be able to help different actors in different ways. Different equipment might even need to communicate different information to support different decisions. For example, the diagram below clarifies that installed Flexibility is one measure, but planners need to know any constraints (e.g., how much charge is in a battery), at least some time in advance to make sure that each time of the day is solvable (this could simply be expressed through the trades they can make). Meanwhile, network operators need to know what price is available at (near real-time) so they can make decisions around dispatching. The way for these actors to make choices (and these are just examples, not exhaustive) is to ensure that sufficient data is made for all the services that flexible devices can deliver.

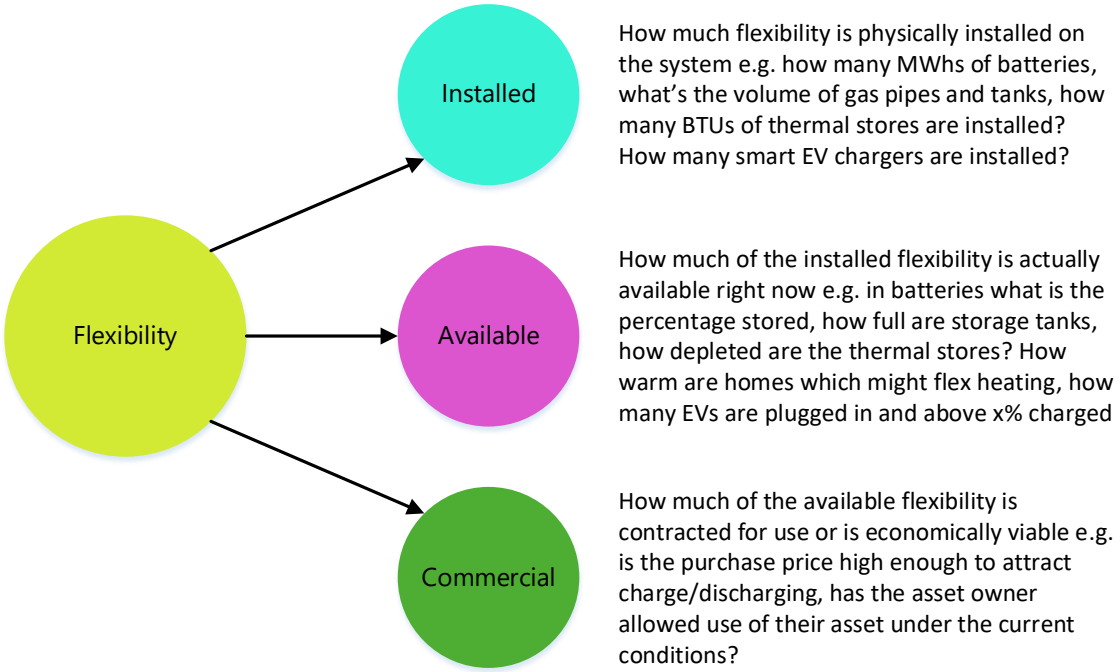



**Figure 6 - Different ways of considering "how much flexibility is there?"**

Suggested characteristics which could be assessed for value in flexibility markets are included in Table 1 below.

**Table 1: Value characteristics in flexibility markets**

| | | |
|---|---|---|
| Real power component | Speed of response | Additional considerations (e.g., synchronicity to support black start recovery etc.) |
| Active power component | Cost to deliver | Seasonal alignment |
| Dispatchability | Capacitance / inductance | |
| Repeatability | Duration | |
| Storage capacity | Duty cycle | |

## 3.4. Joined-up Markets

There are many ways to trade but there are common objectives which need to be met. Using the UK market names as an example, the figure below aims to show the 5Cs that are traded and/or tradeable and the sorts of markets which allow participation. Increasingly it is expected that these markets drive each other more and more. For example, you can only be flexible with the assets you have but there is no link from flexibility markets to the capacity market to influence what gets built, in order to maximise future choices.

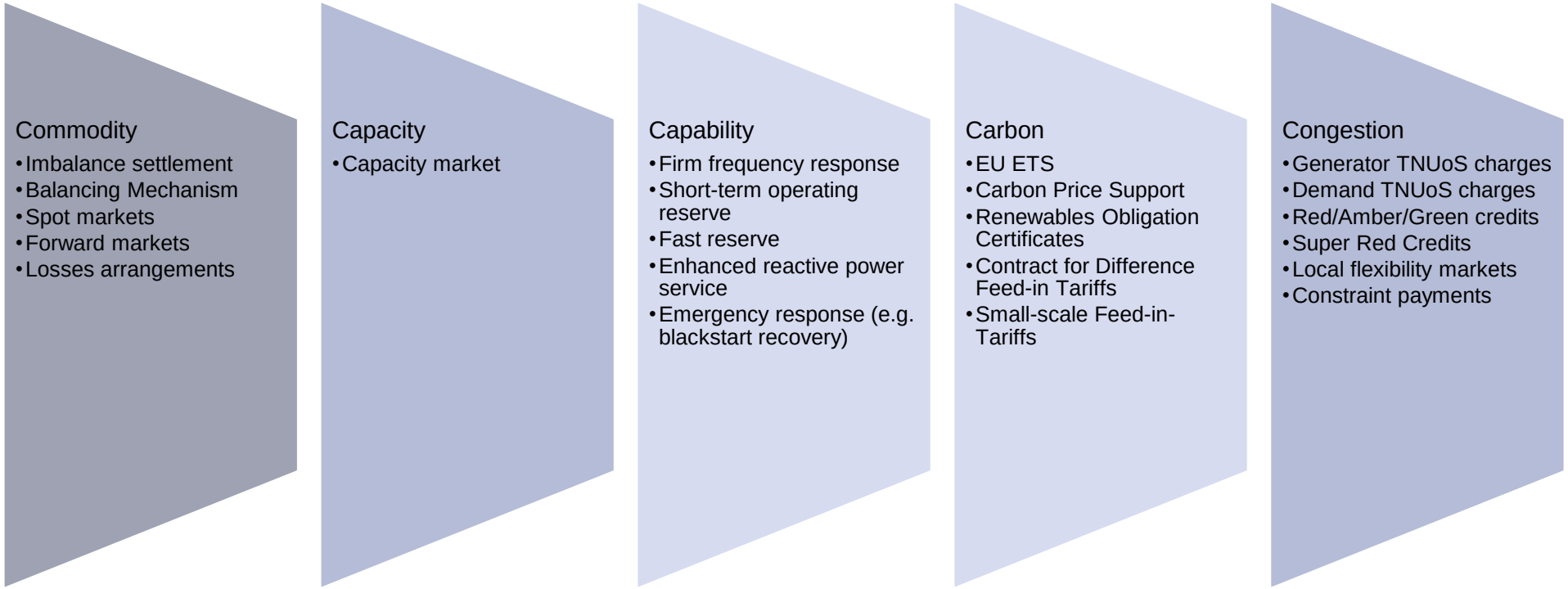



**Figure 7 - The 5Cs of energy market trading**

## 3.5. Consumer Focus

Flexibility is often talked about as an enabler for the energy system. But it is important to remember that it is also useful to bring about changes which can enhance consumers' experiences.

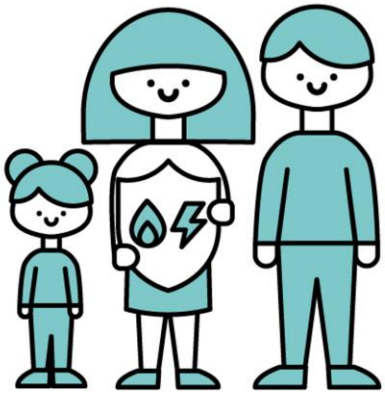
Furthermore, if the Flexibility that aggregators, service providers or system operators want to use relies on having certain products and services inside customers' homes, then it might even be better to start with understanding what the customer wants, values and would benefit from *followed* by the system benefits? Because without consumers buying products and taking up services, domestic flexibility cannot exist.

It has been observed that there are often two approaches to talking about domestic Flexibility. One is that we must recompense consumers for the disruption and inconvenience that Flexibility services may bring. The other is that you set out to deliver the best consumer experience possible, with great technology and what is left over after delivery (at an appropriate price of course) is the Flexibility to deliver to the system. This latter school of thought is less prevalent in the literature.

Another key consideration for consumers, in benefiting from emerging Flexibility products and services, is choice and that naturally leads to interoperability. Interoperability is another term which means many things to many people, but key points around the consumer include:

1. Avoiding lock-in to one device/technology/service/provider for excessive periods
2. The access to their own data, gathered through existing arrangements, to take to future products and/or providers
3. The ability to make non-energy system choices with their Flexibility (e.g. comfort / performance choices, carbon choices etc.)

Who is responsible for my problems? For example, if I'm cold is that the fault of the manufacturer of my heating system, the installer and their setup process, or the operator of flexibility service that I've signed up to, or some other party?




## 3.6. Digitilisation Benefits and Threats

Digitalisation is happening in the energy sector and is bringing benefits. By the breadth of literature still being released it seems that there is still a long way to go. However, there are emerging behaviours which could be addressed.

Homogeneous behaviour: Single devices sold in large numbers which act similarly to each other can cause a loss of diversity across the system.

The use of randomised delay functions has several limitations:

1. The delay must be commensurate with the duration of the activity it is delaying. For example, delaying the start of a 3-hour charging event by 10 minutes will stop a sudden step change but will only delay the coincident peak
2. The delay in control must be aligned to changing price signals. For example, a randomised feature which stops consumers getting access to low prices or prevents moving away from high prices is likely to be politically unpopular
3. It may still lead to problematic rates of change in the level of demand

Coordination of digital products may be required. If all equipment responds to external signals, then a requested response may be too great. Self-organisation (of millions of devices) seems more likely than a single point of control.

# 4. Concluding Remarks

The recommendations from the sections above are summarised here.

It is recommended that further research is undertaken to:

- look at future dispatch control requirements as they relate to Flexibility trading
- look at the creation of one or more interoperable Flexibility markets that different actors can all access to get what they need but which can allow any viable asset to be accessed through any appropriate market transaction
- look at how future markets might value and trade different characteristics of Flexibility according to the actors that value them
- look at the creation of future, truly integrated energy markets.
- understand what consumers really want, and where that is relevant to choices around flexible products, services and markets for Flexibility
- focus on customer protection issues around future Flexibility impacts
- look at the digitalisation implications of devices which will act within future Flexibility markets with an emphasis on the emergent behaviour following roll-out at scale

An online workshop and following engagement with other Annexes and initiatives suggested that:

- There is considerable interest in the above areas, although there are some other projects/initiatives that have done some relevant work and should be closely aligned with going forward
- There appears to be support for progressing with work on these topics, but there need to be sufficient resources and international backing. Any wok should be coordinated carefully across ISGAN Annexes and groups (including other relevant TCPs, such as the Users (formerly DSM) TCP
- Several parties expressed the desire for a structured and systematic approach to the topic of flexibility

The ESC incubator team would like to make the following key suggestions:

- Since there are multiple recommendations which are market focused, it is recommended that any future work concentrates on the development of recommendations for joined up markets, which incorporate Flexibility, are linked to controlled dispatch and make all useful parameters available for all actors who want to trade

It is also worth noting that there is a huge opportunity to become more consumer focused with Flexibility options, and this is a strongly recommended focus for future work

# 5. References / Bibliography

| No. | Resource name | Weblink | Author | Year |
|---|---|---|---|---|
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| 2 | Status of Power System Transformation 2019 | https://webstore.iea.org/status-of-power-system-transformation-2019-power-system-flexibility | IEA | 2019 |
| 3 | Towards the Flexible Energy System of Tomorrow 10/07/19 | - | Mikael Mikaelsson | 2019 |
| 4 | Accenture_Flex_Balances_POV | https://www.accenture.com/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/dualpub_26/accenture_flex_balances_pov.pdf | Accenture | 2018 |
| 5 | CPI India-Flexibility-February 2019 | https://climatepolicyinitiative.org/publication/developing-a-roadmap-to-a-flexible-low-carbon-indian-electricity-system-interim-findings/cpi-india-flexibility-february-2019/ | CPI | 2019 |
| 6 | European Smart Grids Task Force Expert Group 3 | https://ec.europa.eu/energy/sites/ener/files/documents/eg3_final_report_demand_side_flexiblity_2019.04.15.pdf | European Smart Grids Task Force | 2019 |
| 7 | Flexible Electricity Systems - UK Parliament | http://researchbriefings.files.parliament.uk/documents/POST-PN-0587/POST-PN-0587.pdf | Houses of Parliament-Parliamentary Office of Science & Technology | 2018 |
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| 9 | Flexibility needs in the future power system- Discussion Paper | https://www.iea-isgan.org/wp-content/uploads/2019/03/ISGAN_DiscussionPaper_Flexibility_Needs_In_Future_Power_Systems_2019.pdf | ISGAN | 2019 |

| No. | Resource name | Weblink | Author | Year |
|---|---|---|---|---|
| 10 | Delivering a highly distributed electricity system: Technical, regulatory and policy challenges | https://www.sciencedirect.com/science/article/pii/S0301421517307851 | K Bell, I Gill | 2018 |
| 11 | Future Power Systems Architecture (FPSA) | https://es.catapult.org.uk/capabilities/systems-integration/future-power-systems-architecture/ | ESC/IET | - |
| 12 | Flexibility Enabling Contracts in Electricity Markets | https://www.oxfordenergy.org/wpcms/wp-content/uploads/2014/07/Flexibility-Enabling-Contracts-in-Electricity-Markets-EL-21.pdf | Oxford Institute for Energy studies | 2016 |
| 13 | China Power System Transformation – Assessing the Benefit of Optimised Operations and Advanced Flexibility Options | https://webstore.iea.org/china-power-system-transformation**v** | IEA | 2019 |
| 14 | Investigating the Economic Value of Flexible Solar Power Plant Operation | https://www.ethree.com/wp-content/uploads/2018/10/Investigating-the-Economic-Value-of-Flexible-Solar-Power-Plant-Operation.pdf | Energy & Environme-ntal Economics | 2018 |
| 15 | Digitalization and the Future of Energy | https://www.dnvgl.com/power-renewables/themes/digitalization/index.html | GNV-DL | 2020 |
| 16 | The SmartEn map-European Balancing Markets Edition | https://www.smarten.eu/wp-content/uploads/2018/11/the_smarten_map_2018.pdf | SmartEn | 2018 |
| 17 | SmartEn Position Paper-Design Principles for (Local) Markets for Electricity System Services | https://www.smarten.eu/wp-content/uploads/2019/09/20190903-smartEn-Flexibility-Markets-Position-Paper-Final.pdf | SmartEn | 2019 |
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| 23 | Ofgem's Future Insights Series- Flexibility Platforms in electricity markets | https://www.ofgem.gov.uk/ofgem-publications/155489 | Ofgem | 2019 |

# 6. Appendix: Resource List

### Industry events

| Index | Event Name | Host/sponsor | Date |
|---|---|---|---|
| 1 | Rewarding Flexibility for the Value it Provides to the Electricity System | BEIS/Ofgem | 7th February 2020 |
| 2 | Data & Innovation: Driving the electrons that make your future | EDSO / InnoEnergy | 4th February 2020 |
| 3 | Market design for demand-side flexibility | IEA | 7th February 2020 |

### Demonstrator projects

| Index | Project name | Weblink | Organisation(s) |
|---|---|---|---|
| 1 | Local Energy Oxfordshire (LEO) | https://www.energy.ox.ac.uk/wordpress/events/event/local-energy-oxfordshire-leo/ | Scottish and Southern Electricity Networks along with EDF Energy, Nuuve, Open Utility, Origami Energy, Oxford Brookes University, Oxford City Council, Oxfordshire County Council, The Low Carbon Hub C.I.C. and the University of Oxford |
| 2 | Cornwall LEM | https://www.centrica.com/innovation/cornwall-local-energy-market | Centrica |
| 3 | Brooklyn Microgrid | https://www.brooklyn.energy/ | A community driven initiative |
| 4 | Power potential | https://www.nationalgrideso.com/innovation/projects/power-potential | National Grid ESO and UK Power Networks |
| 5 | DSO flexibility markets (UK) | https://www.energynetworks.org/electricity/futures/flexibility-in-great-britain.html | ENWL, NPg, SPEN, SSEN, UKPN, WPD, ENA |
| 6 | California ISO ramping product | http://www.caiso.com/informed/Pages/StakeholderProcesses/CompletedClosedStakeholderInitiatives/FlexibleRampingProduct.aspxy | CAISO |
| 7 | Decentralised Energy Exchange (deX) Australia | https://arena.gov.au/projects/decentralised-energy-exchange-dex/ | Lead by GreenSync, project partners: United Energy Distribution Pty Limited, The Australian National University, Mojo Power, ACT Environment and Planning Directorate, DELWP (Victoria), ActewAGL Distribution |