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Power Transmission & Distribution Systems

Flexibility and its impact on stakeholder interaction

Survey results

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ISGAN Annex 6 and Annex 9

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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 groundwork for further research and analysis.

Disclaimer

List of Acronyms

BEMS	Battery Energy Management System
DSO/DNO	Distribution System/Network Operator
DER	Distributed Energy Resource
EV	Electric Vehicle
ENTSOE	European Network of Transmission System Operators for Electricity
ESO	Electricity System Operator
HEMS	Home Energy Management System
ICT	Information and Communication Technology
IT	Information Technology
kV	Kilovolt
LV	Low Voltage
MV	Medium Voltage
RAE	Regulatory Authority for Energy
RES	Renewable Energy Sources
RTO	Regional Transmission Organization
SCADA	Supervisory Control and Data Acquisition
TSO/TNO	Transmission System/Network Operator

Executive Summary

To ensure the safe and secure operation of the electrical network, system operators must guarantee that the balance between supply and demand is maintained. These aspects have created increased complexity in terms of bi-directional and unpredictable system power flows, which need to be managed by the respective system operators. Network operators are persevering towards finding solutions to mitigate these challenges where traditionally, at transmission level, congestion is typically addressed through redispatch techniques, while at the distribution level, network upgrades are implemented. With the rapid speed at which these system changes are occurring, alternative methods are becoming necessary to incorporate these developments, while finding the balance in investing into costly and time-consuming network reinforcement measures.

Flexibility within the electrical power system is becoming an increasingly prominent and sought-after solution, which can be utilized by both the Transmission system operator and Distribution system operator to solve/avoid network problems such as network congestion, voltage violations, system balancing etc.

Power system flexibility is expected to play a vital role in future networks as it will allow countries to:

- Replace fossil fuel generators with clean and renewable energy sources,
- Increase reliability and resilience against disruptive events,
- Improve performance and reduce costs of new and existing assets, and
- Transition to a low carbon economy.

The introduction of new market players, which contributes to both increased opportunities and challenges, is also receiving increased attention, which creates an additional dynamic.

To adapt to the various changes, the interaction between stakeholders within the electricity supply chain is becoming increasingly more important. These interactions, despite their various challenges, provide many opportunities for increased efficiency of the operation and planning of modern networks in the future. To utilize flexibility to its full potential, coordination between various stakeholders within the energy supply chain is required. The increased need for stakeholder interaction relies on the advanced collaboration between respective parties which needs to be facilitated through technology advancements, data exchange mechanisms, regulatory considerations, and economic analysis.

To evaluate the perspectives on the flexibility and stakeholder interaction, a survey was launched, and its findings are presented in this report. The results of this survey provide an overview of flexibility and stakeholder interaction based on the various perceptions from a wide range of respondents from different geographic locations and sectors. The survey highlights the current status of the related topics and allows for the opportunity to identify concepts, such as challenges and opportunities, which require increased attention by all stakeholders in modern power systems of the future. This work provides a foundation for future work which will be conducted in the next phase within Annex 6 and Annex 9.

Table of Content

1. Introduction

The survey and report were prepared within the framework of ISGAN Annex 6 (**http://www.iea-isgan.org/our-work/annex-6/**) and conducted jointly with Annex 9 (**https://www.iea-isgan.org/our-work/flexibility-markets/**). The Annex 6 focus area, Power Transmission & Distribution Systems, promotes solutions that enable power grids to maintain and improve the security, reliability and quality of electric power supply. The main objective of this focus area is to conduct studies on how distribution and transmission networks could interact in the future and ensure stable grid operation under high levels of renewables. Figure 1 positions this work in the ISGAN context. Annex 9, on Flexibility Markets, focuses on enriching and disseminating participant's understanding of flexibility market design; creating and curating an evidence base all can draw upon to support decision making in the flexibility market space; and furthering debate on best practice in market design. Figure 1 positions this work in the ISGAN context.

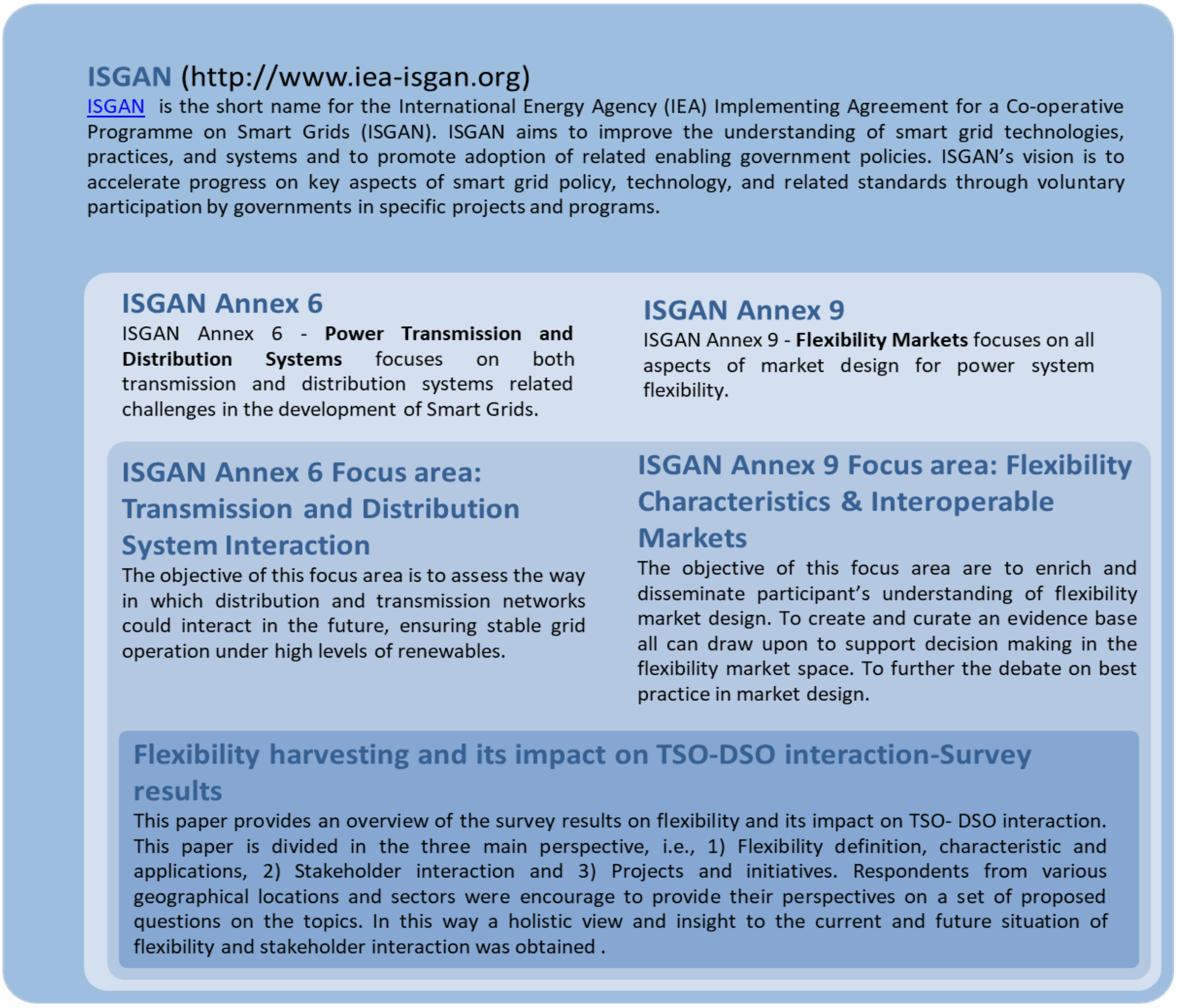


Figure 1 Position of the survey in the context of ISGAN

1.1. Background

In recent years, the electrical energy supply landscape has evolved from traditional power sources, which are centralized and controllable, towards those that are distributed and non-controllable. System loads have also transitioned from those that are fixed and non-controllable, to those which are now able to be controlled and time shifted. To ensure the safe and secure operation of the electrical network, system operators must ensure that the balance between supply and demand is maintained. With increasing changes, due to the increased penetration of renewable energy sources (RES) as well as customer participation (where consumers become prosumers) and demand response capabilities, sustaining this balance is becoming increasingly challenging. These aspects have created increased complexity in terms of bi-directional and unpredictable system power flows that need to be managed by the respective system operators. In such cases, network operators are persevering towards finding solutions to mitigate these challenges where traditionally, at transmission level, congestion is typically addressed through redispatch techniques, while at the distribution level, network upgrades are implemented [1]. However, with the rapid speed at which these system changes are occurring, alternative methods are becoming necessary to incorporate these developments, while finding the balance between investing into costly and time-consuming network reinforcement measures.

Flexibility within the electrical power system, from beyond traditional sources, is becoming an increasingly prominent and sought-after solution, which can be utilized by both the transmission system operator (TSO[1]) and distribution system operator (DSO[2]) for flexibility services, with the objective to solve or avoid network problems such as network congestion, voltage violations, system balancing, etc. Additionally, flexibility can be used as a short-term strategy to allow for network reinforcement deferral. Therefore, power system flexibility is expected to play a vital role in future networks as it will allow countries to [2]

- Replace fossil fuel generators with clean and renewable energy sources,
- Increase reliability and resilience against disruptive events,
- Improve performance and reduce costs of new and existing assets, and
- Transition to a low carbon economy.

To utilize flexibility to its full potential, coordination among various stakeholders within the energy supply chain is required [3]. This includes the adequate exchange of information, such that the simultaneous activation by two different network operators is avoided [1]. Furthermore, the introduction of new market players (such as aggregators), which contributes to both increased opportunities and challenges, is also receiving increased attention, of which creates an additional dynamic to the operation and planning of the network. Since the activation of flexibilities can also be made by third parties, it is important that these actions are carefully coordinated to avoid network violations [1]. In [3], the need for TSO-DSO interaction with market parties is clearly identified. Furthermore, the report reiterates the necessity for roles and responsibility definition of key stakeholders. The increased need for stakeholder interaction relies on the advanced collaboration between respective parties which needs to be

[1] TSO: Also known as transmission network operator (TNO) or regional transmission organization (RTO).

[2] DSO: Also known as distribution network operator (DNO).

facilitated through technology advancements, data exchange mechanisms, regulatory considerations, and economic analysis.

Due to the increased demand for flexibility and stakeholder interaction, various countries have incorporated and implemented research projects, which often include pilots and demonstrations, to allow for investigations and prototyping of various flexibility and stakeholder interaction concepts. The importance and value of such projects is that they allow for the testing of various strategies and provide a mechanism for the assessment of economic efficiency prior to a large-scale role out or implementation [3]. It is clear that there is an increased awareness, need, and willingness to develop and evaluate a variety of solutions to be realized within the modern electrical energy system.

Previous work conducted by Annex 6 on flexibility and TSO-DSO interactions includes[3]:

- Lessons learned from international projects on TSO-DSO interaction, 2020
- Ancillary services from distributed energy sources, 2019
- Flexibility needs in the future power system,2019
- ICT aspects of TSO-DSO interaction, 2019
- System efficiency, 2018
- Single marketplace for flexibility, 2017
- Storage and balancing as key elements for future network planning and electricity markets design, 2016
- The role and interaction of microgrids and centralized grids in developing modern power systems – A case review, 2016.
- Why the TSO-DSO Relationship Needs to Evolve, 2015
- TSO-DSO interaction: An Overview of current interaction between transmission and distribution system operators and an assessment of their cooperation in Smart Grids, 2014
- TSO-DSO interaction, 2014

1.2. Purpose of the survey

The purpose of this survey was to collect information and stakeholder perspectives on:

- How flexibility is understood and deployed within various countries/regions,
- How system/network operators and other stakeholders perceive the impact of flexibility and their interaction on the electric network, and
- International experiences and research projects related to flexibility in the power system.

The survey was conducted based on three perspectives:

- Flexibility definitions, characteristics, and applications
- Stakeholder interaction
- Projects and initiatives

[3] These publications are available and can be downloaded from: https://www.iea-isgan.org/publications/

1.3. Overview of survey participants

The survey was conducted online where representation from various locations, sectors, and projects was attained. The survey was conducted on a voluntary basis.

Figure 2 shows a world map of the participating countries and the total number of responses, respective sectors and projects and initiatives.

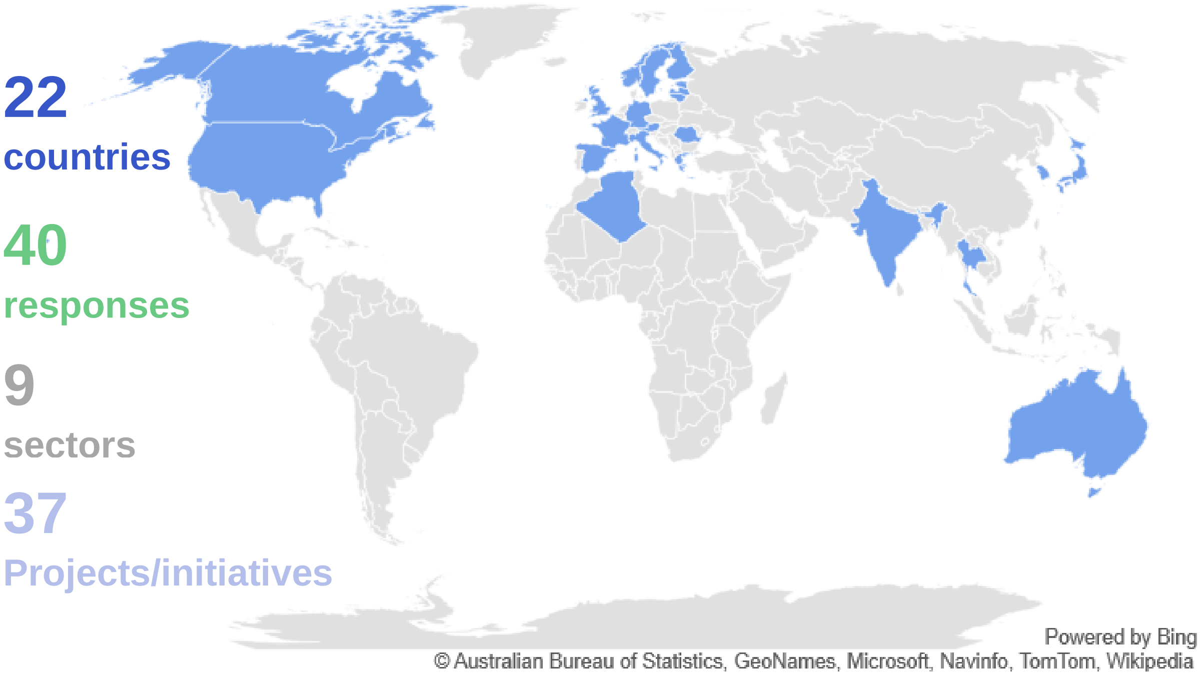


Figure 2 World map showing participating countries

In some cases, there was multiple responses from a given country, which allowed a wider range of perceptions from within that single country to be obtained. An overview of the number of responses per participating country can be seen in Table 1.

Table 1 Number of responses per participating country

Algeria	Austria	Australia	Canada	Estonia	Finland	France	Germany	Greece	India	Italy
1	2	1	1	2	2	1	1	5	4	3

Japan	Latvia	Lithuania	Norway	Romania	South Korea	Spain	Sweden	Thailand	UK	USA
1	1	1	2	1	1	2	2	1	4	1

With a wide range of respondents representing different sectors, Figure 3 shows an overview of the distribution of the number of respondents per sector. As can be seen, the majority of respondents are from the research, DSO, TSO sectors. In the cases where ‘network operator’ is listed, this indicates that the TSO and DSO is the same entity within the respective location. ‘Other’ includes respondents who indicated ‘energy utility,’ consultant, or non-profit industry.

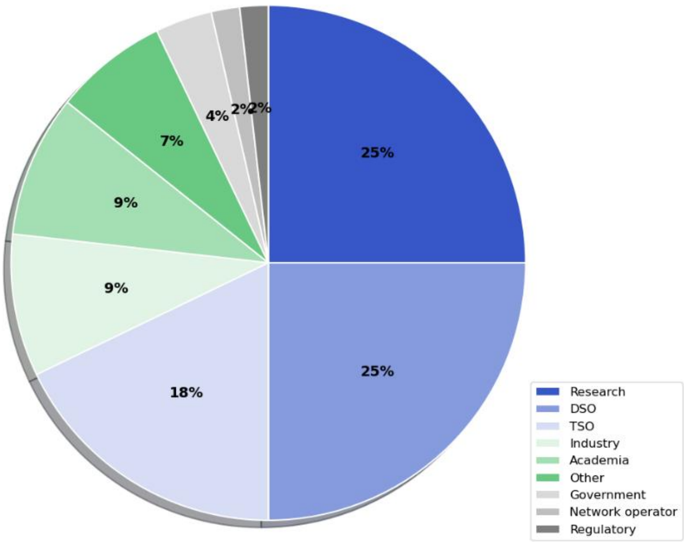


Figure 3 Overview of sector distribution of respondents

1.4. Methodology and analysis of results

Once the survey was completed, respondents were invited to answer each of the questions to obtain a holistic view on the topics presented. Thereafter, the results were collected and consolidated to evaluate the perspectives on the flexibility and stakeholder interaction. Due to the complexity of the topic, this report only provides a high-level analysis, with a focus on content, rather than providing a deep analysis to identify any correlation (country, sector, etc.) amongst the responses. Furthermore, it should be noted that multiple individuals from a given country have often responded to a single question, which may have resulted in that country being over-represented and thus, the results need to be interpreted accordingly.

2. Flexibility definitions, characteristics, and applications

The electric power system must modernize to accommodate new pressures from increased variable renewables, electrification, and climate change. Capture and application of new sources of flexibility (beyond that conventionally provided by large generators) will have a large role in the electrical grid's evolution. With such flexibility implementations being relatively immature, it is worthwhile to examine practices worldwide with the goal of identifying current state-of-the-art and possible future next directions, particularly with respect to flexibility characterization and applications.

2.1. Definition of flexibility

The definition and understanding of flexibility can be inferred to mean different things to different people, depending on background, experiences, expertise, etc. For example, a categorisation of different types of flexibility needs and solutions for the operation and planning of the future power system was made in the Annex 6's discussion paper "Flexibility needs in the future power system" [4]. In the report, flexibility resources are considered from the local, regional and system wide perspectives and in different timescales from fractions of a second to years.

This survey and report focuses on the characterization of flexibility and its utilisation in the electric power system. Given the numerous stakeholders involved, different perspectives that might exist on the definition of flexibility were first explored. Respondents were first asked to give their preference between two definitions of power system flexibility:

> **Definition 1**: [Flexibility is]: "the ability of power system operation, power system assets, loads, energy storage assets and generators, to change or modify their routine operation for a limited duration, and responding to external service request signals, without inducing unplanned disruptions." [5]
>
> **Definition 2:** "Flexibility is the ability of a power system to cope with variability and uncertainty in both generation and demand, while maintaining a satisfactory level of reliability at a reasonable cost, over different time horizons." [6]

Definition 1 focuses on <u>ability to respond</u> to a service request; it could be considered more focused on operations. *Definition 2* focuses on <u>satisfying needs</u> (variability and uncertainty) while explicitly noting reliability and applicability <u>across time horizons;</u> it could be considered the more general of the two definitions. Despite the significant differences, there was only a slight preference, noted in Figure 4, for the second definition. There was no discernible preference by respondent location or organizational type.

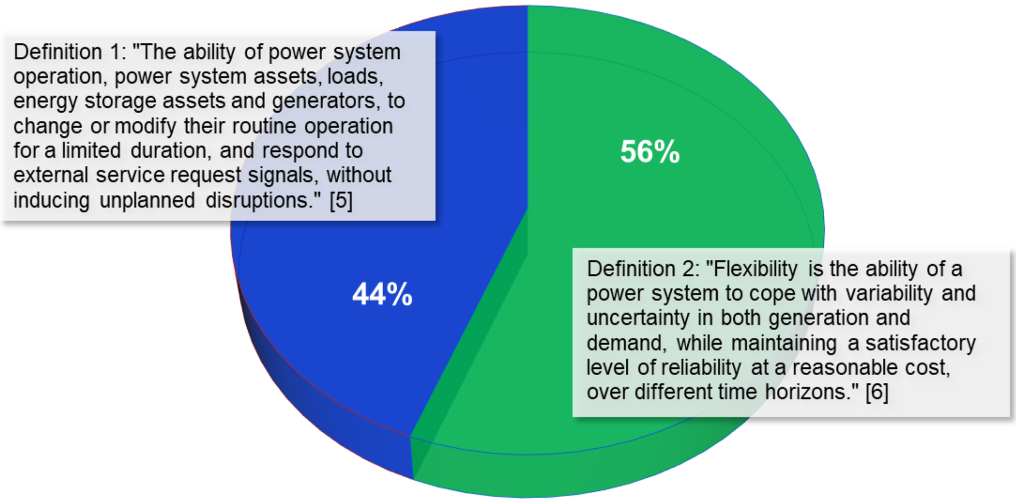


Figure 4: Flexibility definitions

Respondents were also given the opportunity to suggest changes or clarifications to either definition. For both, it was expressed that reliability considerations should be better reflected and that their respective temporal (duration/time horizon) aspects could be detailed to a higher degree. Under Definition 1, other considerations were to include implicit signals, e.g., market price signals, and add specifics elsewhere. Under Definition 2, it was recommended to broaden the scope to include cross-sector flexibility (energy) and other potential actors, e.g., aggregators.

It is clear that flexibility has a different meaning, or implication, to different stakeholders. It may be worthwhile to explore an all-encompassing definition or use one specific to the intended application. Regardless, future definitions will perhaps need to consider the perceptions/needs of stakeholders not participating in this survey.

2.2. Flexibility deployment and grid services

Respondents were asked to identify the current status of flexibility deployment in their location based on type and deployment mechanism; an overview of the responses are given in Figure 5.

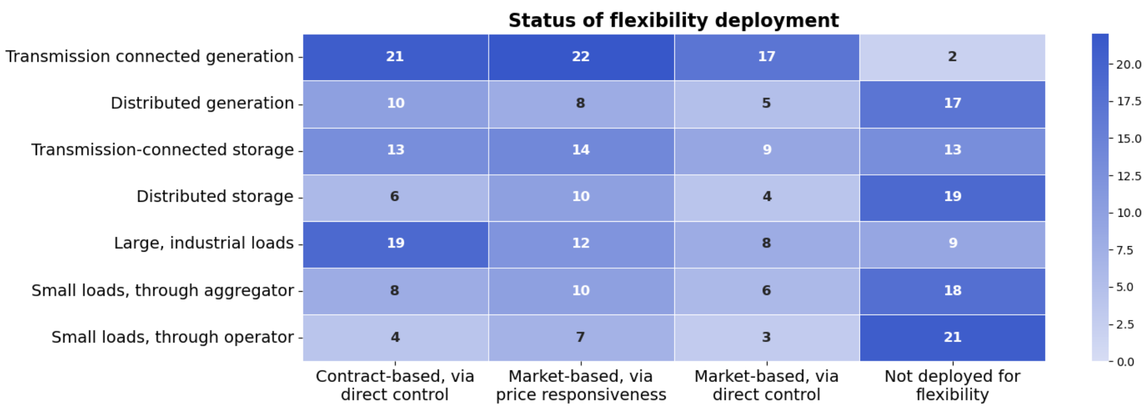


Figure 5: Status of flexibility deployment

Transmission-connected generation was identified as the most relied-upon flexibility resource; (not shown above but present in the responses), it was often deployed via two or three of the mechanisms (contract-based, market-based via direct control, and/or market-based via price responsiveness), with deployment via a single (identified) means not common. *Large industrial loads* were also likely to be drawn as a flexibility resource, mostly via contract mechanisms. *Transmission-connected storage* was next likeliest to be deployed for flexibility. *Distribution resources* (generation, storage, or loads) were the least likely to be drawn upon for flexibility, with the general exception of some European countries. Other than that, there were no patterns in deployment based on location.

In addition to those listed, it was also pointed out that some locations may also utilize load shedding for flexibility.

2.3. Progress or interest in allowing load flexibility to contribute to each of the following grid services

In this question, respondents were asked to identify the status of *load* flexibility deployment in their location, having a choice between deployed, piloting/demonstrating, under consideration, or not pursuing, for each of these pre-identified grid services:

- Capacity (for distribution)
- Economic dispatch (for transmission)
- Economic dispatch (for distribution/local energy markets)
- Frequency regulation
- Voltage regulation | reactive power support (for transmission)
- Voltage regulation | (non-reactive)
- Frequency regulation (dispatchable, minutes)
- Primary contingency reserve | frequency response
- Secondary contingency reserve A | spinning/on-line
- Secondary contingency reserve B | non-spinning/off-line

Responses are given below in Figure 6, sorted in descending order by deployment. Note that respondents may have slightly different understandings of the services listed based on, e.g., location.

	Deployed	Piloting or demonstrating	Under consideration	Not pursuing
Capacity | transmission	16	8	4	1
Frequency regulation	12	6	10	2
Economic dispatch | transmission	11	6	8	4
Primary contingency reserve | frequency response	11	6	7	6
Secondary contingency reserve | spinning/on-line	11	6	9	3
Secondary contingency reserve | non-spinning/off-line	11	7	9	3
Voltage regulation | transmission/reactive power support	9	6	7	7
Capacity | distribution	6	9	11	2
Voltage regulation | non-reactive power support	6	3	11	9
Economic dispatch | distribution/local energy markets	3	7	11	7

Figure 6: Load Flexibility Grid Service Applications

Load flexibility was frequently deployed (and, if not, piloted/demonstrated) to satisfy *transmission capacity* needs (e.g., provide generation capacity or alleviate transmission congestion). *Frequency regulation*, *transmission-level economic dispatch*, and *contingency reserve* services were also often deployed or piloted/demonstrated, and if not, under consideration. Applications of load flexibility for *voltage regulation (transmission)* via reactive power support and *capacity (distribution)* were less mature. Utilizing load flexibility for *voltage regulation (non-reactive power support)* or *economic dispatch* within distribution/local energy markets was the least mature (i.e., mostly under consideration or not pursued).

The following were given in a follow-up question asking what grid services should also be considered:

- Congestion management for DSO and TSO needs
- Inertia, ramping, and fast frequency response
- Energy management
- Residual system balancing

2.4. Importance of distributed energy resource characteristics

In this question, respondents were given a pre-defined list of characteristics that could contribute to a resource's flexibility. Considering only *distributed energy resources* (DER; distributed generation, loads, and storage), they were asked to indicate the characteristics a) most important to their location's current flexibility implementation, b) a limitation within available resources holding back flexibility fulfillment, and c) in need of more study to better understand impacts/capabilities. Results are presented in Figure 7, sorted in descending order by "most important".

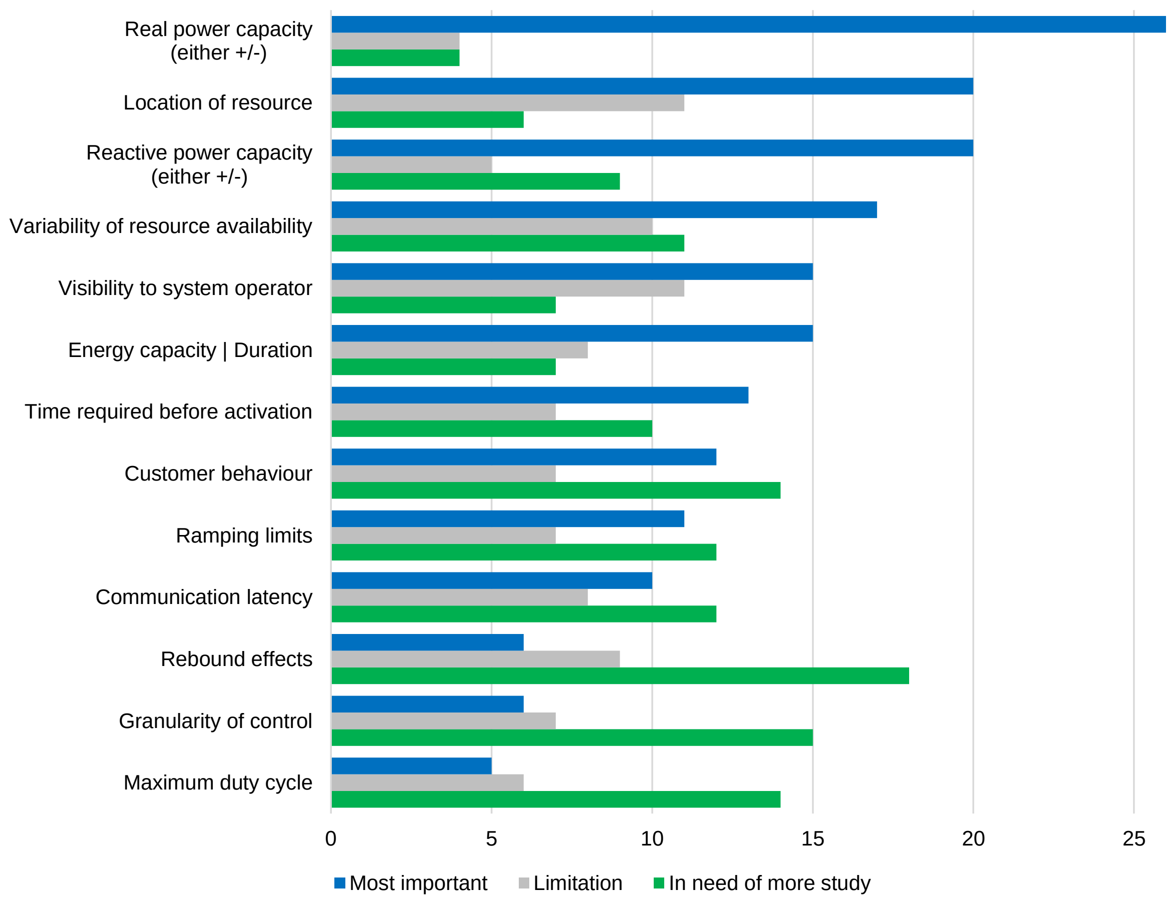


Figure 7: Flexibility Characteristics

Real and reactive power capacity, resource location, variability of resource availability, visibility, and *energy capacity (duration)* were regarded as the most important flexibility characteristics in current implementations. Roughly inversely, *rebound effects, granularity of control, maximum duty cycle, customer behaviour, ramping limits*, and *communications latency* were seen in need of further study. *Visibility, resource location, resource availability*, and *rebound effects* were seen as holding back flexibility potential.

2.5. Objectives of flexibility markets design and their importance

Flexibility markets can be designed around one or more objectives; respondents were asked rank pre-defined options from the most important to the least (a rating could be used more than once). A summary of responses is provided in Figure 8, sorted in descending order by weighted sum. Four points were given for each objective ranked “most important” and three, two, and one point for 2nd, 3rd, and 4th placed rankings, respectively.

	1 - Most Important	2	3	4	5 - Not at all important	6 - Decline to rank	Weighted sum
Provide transmission grid services	19	13	0	1	0	1	116
Provide distribution/local grid services	16	14	2	1	1	0	111
Capital cost reduction	13	14	7	0	0	0	108
Consumer/prosumer empowerment	16	7	9	2	0	0	105
Operational cost reduction	10	15	9	0	0	0	103
Decarbonisation and greenhouse gas reduction	13	11	5	4	1	0	99
National or provincial/state regulatory directives	10	7	8	3	3	3	80
Energy poverty reduction	7	12	2	7	2	4	75

Figure 8. Ranking of relative importance of flexibility market objectives

Overall, the weighted sums were consistent with the ratings of the majority of individual respondents (though less so for *energy poverty reduction*, which had a larger spread). *Provision of transmission and distribution grid services* were seen as the most important objectives for flexibility market design, followed by *capital and operational cost reduction* and *consumer/prosumer empowerment*. *Decarbonisation, regulatory directives*, and *energy poverty reduction* rounded out the list.

While important to most respondents, only those in Europe noted that support for *providing distribution/local grid services* was a "most important" design criterion. There were also some notable differences in responses based on the respondent type or organization: *provision of transmission/distribution grid services* was seen as the most important by academia, research, and industry whereas it ranked slightly lower by TSOs and DSOs. *Consumer empowerment* was consistently seen as important amongst industry, academia and DSO's and *energy poverty* important amongst TSOs, DSOs, and academia.

Other objectives that respondents considered to be important are:

- Energy efficiency and quality,
- Integration with energy and transportation sectors or within single energy market,
- Sustainability,
- Maintenance of service quality, reliability, and resiliency,
- Flexibility and stakeholder interaction,
- Business opportunities for energy service companies and aggregators,
- Digitalisation, and
- Community empowerment/resiliency.

3. Stakeholder interaction

This section aims to gain insight as to how flexibility impacts power system stakeholder interaction based on the perspectives of respondents from various sectors and geographical locations.

In the context of this survey, the following interpretations have been considered:

- **TSO**: Transmission system operator means a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity. Also known as transmission network operator (TNO) or regional transmission organization (RTO).

- **DSO**: Distribution system operator means a natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity. Also known as distribution network operator (DNO).

- **Third party:** all other entities which are not system operators (e.g., aggregators, energy services providers, etc.)

3.1. Boundaries between stakeholders

To gain insight as to where the boundaries between various stakeholders lies within different countries, the question, '*What are the boundaries between the stakeholders (where does the role of the TSO/DSO/stakeholder start and end etc.)*?', was posed.

In most cases, especially within European Union (EU) countries, where the boundaries are defined according to EU legislation, the distinction is made according to the network topology based on the technical boundaries and respective system voltage levels. The TSO is responsible for the HV transmission system while the DSO for the MV and LV system. The interface between the TSO and DSO is identified to be at the HV/MV substation, while the boundary between the DSO and customer is the metering point at customer premises. Interestingly, in one case (India), the distinction is made based on political structure i.e., TSO at national vs DSO at state level. In Japan, the TSO and DSO are the same entity, and flexibility procurement is considered at TSO level. In England and Wales, the DSO is responsible networks operating at voltages up to and including 132 kV, with the Electricity System Operator (ESO) being responsible for the 400 kV and 275 kV systems as well as the transformers linking the transmission system to the distribution system. In Scotland, 132 kV is considered to be a transmission voltage, so the DSO is responsible for networks up to and including 33 kV, with the ESO being responsible for 132 kV and above. In Northern Ireland, transmission and distribution are in common ownership.

Respondents also provided a distinction based on the roles and responsibilities of the stakeholder in the context of flexibility harvesting within the system. In Greece, the TSO and DSO identify the flexibility needs in their network and purchase flexibility based on the operational and market guidelines of the regulatory framework defined by the Regulatory Authority for Energy (RAE). In Finland, the DSO has no role in energy retail or other markets, hence they just provide the network. Aggregators, market operators, etc. have direct contracts with customers, however utilizing measurement data from DSO. In Norway, the TSO is responsible for dispatch, transmission, electric system balancing, and dispatch of resources either directly connected to the transmission grid or connected via aggregators residing on distribution networks. The DSO is responsible for the secure operation of the distribution grids. In the UK, the ESO is responsible for real-time electricity system balancing and security; the TO/TSO is responsible for transmission asset management; the DNO/DSO is responsible for distribution asset management and operation; suppliers are responsible for meeting demand; and aggregators are responsible for providing balancing and reserve/frequency response ancillary services.

3.2. The value of increased customer involvement

In recent years, customer engagement in the provision of flexibility has gained increased interest. From the perspective of various stakeholders, this value may differ in both magnitude (i.e., to what degree) and ranking (order of importance). Figure 9 provides an overview of the perceived value of increased customer involvement.

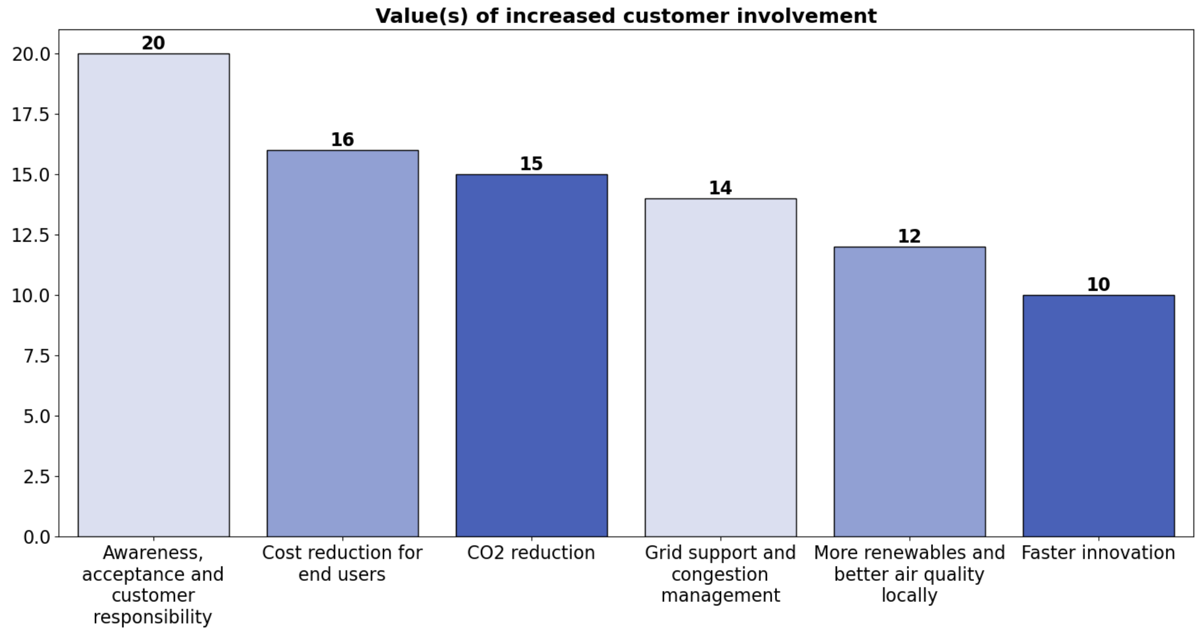


Figure 9 The perceived value of increased customer involvement

The respondents (with at least one representation from each sector) have indicated that ‘awareness, acceptance and customer responsibility’ plays the most significant role and, while ‘faster innovation’ the least. The global goal to decarbonize the energy system and thereby efforts towards ‘CO_2 reduction’ was ranked in the middle. This is linked to the consideration for the usage of increased integration of renewables and thus improved local air quality. Furthermore, the role of cost reduction for end users is also considered to be an important aspect especially since it may provide additional incentives and initiatives for the adoption and implementation of flexible devices. Naturally, from the perspectives of network operators, ‘grid support and congestion management’ becomes highly valuable for the safe and secure operation of the network and therefore, increased customer involvement, through the use of flexibilities can be beneficial for network operation as well as cost deferral in the case of network reinforcement requirements. From the perspective of TSO/DSO/Network operators only, 9 out of 15 consider that grid support and congestion management is important when it comes to customer involvement.

3.3. Identification of major barriers to TSO-DSO coordination with respect to flexibility.

Within the various geographical areas, there are several barriers that have been identified that may result in limited TSO-DSO interaction with respect to flexibility integration and activation.

In many cases, it was identified that a major barrier lies in the fact that the roles and responsibilities of various stakeholders in the energy sector are not clearly defined. In some cases, the DSO has no role when it comes to flexibility since the assets are currently market based, while it was also mentioned that the reason for the lack of/ limited flexibilities is because it does not provide a meaningful business case for market participants. From the consumer perspective, insufficient incentives for consumers and aggregators to participate proves to be a barrier in many countries due to limited integration within the regulatory framework. These regulatory frameworks, in some cases, do not facilitate the procurement of flexibility from resources located in the distribution system.

The need/requirement/objective for the use of flexibilities differs amongst system operators and thus may result in conflicting requirements. For example, the activation of a flexibility to satisfy the needs of the DSO, may result in a problem within the TSO network. The objective of the TSO, on the one hand, is to balance the system economically (through the optimization of the acceptance of bids and offers) and to ensure the secure operation of the system (through reserve and frequency response ancillary services), while the DSO aims to reduce peak power flows and minimize capacity reinforcement requirements. These respective needs are not always complementary and can be conflicting. In some cases, the actual status and need for flexibility is not homogenous amongst network operators. For example, the DSO grids are dimensioned to be relatively resilient and thus the integration of flexibility is not needed, and/or does not result in any significant impact in grid operation. The concept of value stacking based on the design of joint products such that the same flexibility can be used simultaneously for different system needs was also mentioned. Furthermore, it was highlighted that, in some cases, there is a lack of real-time coordination and lack of the respective IT infrastructure. This was attributed to the reluctance to adopt innovative solutions in system operation and coordination.

The sharing of grid information is often very limited amongst network operators and is, therefore, a barrier to flexibility utilization, and thus can hinder the ability to facilitate the increased flexibility within the network. The coordination between operators requires that adequate information be shared to facilitate joint grid qualification such that the activation of flexibility does not cause network violations and/conflicts within either network. Therefore, system observability, communication, data exchange and regulatory frameworks play a significant role. Many respondents acknowledged the lack (or limited) communication, data exchange platforms and/or control infrastructure integration between the system operators as well as flexibility service providers.

It has been acknowledged that in the future, the needs of the DSO will need to be increasingly considered when the increased integration and activation of flexibility becomes more prominent, and hence, the need for increased TSO-DSO coordination becomes necessary. However, the status of future networks remains to be questioned, and the impact of flexibility needs to be considered in the long-term network planning for both TSOs and DSOs which may emphasize the need for improved coordination. There needs to be a strategic approach to the formulation of the future networks which have a penetration of RES, alongside current architectural structures of the energy system.

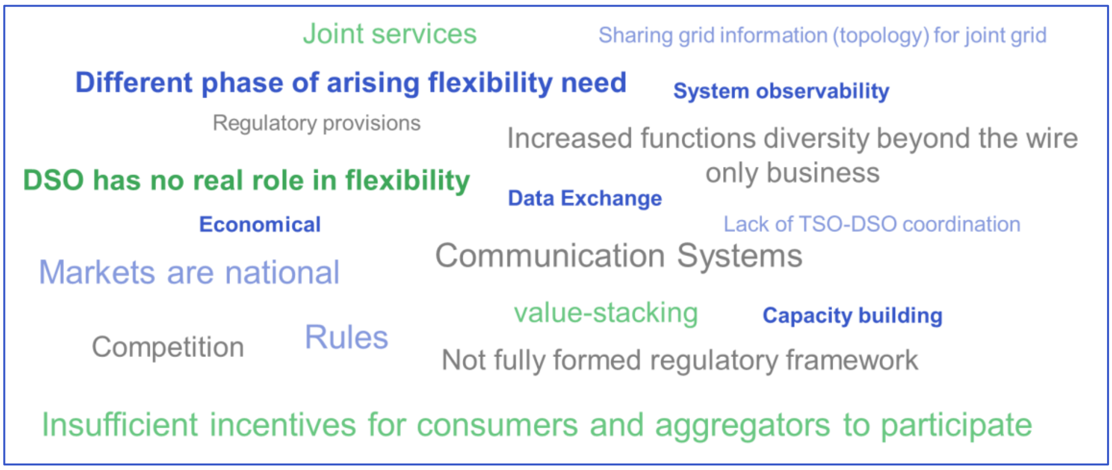


Figure 10 Overview of barriers to TSO-DSO coordination with respect to flexibility

3.4. Current and future challenges, mitigation and benefits for stakeholder interaction and flexibility harvesting

The respondents were asked to provide their views relating to the various current and future perceptions of flexibility integration into the electric network. Various aspects for evaluation were considered, which includes challenges, mitigations, and benefits. Two questions were posed:

- What current and future challenges do you foresee regarding stakeholder interaction and flexibility harvesting? What can / should be done to mitigate these challenges?
- How can flexibility harvesting be beneficial to network planning and operation in the context of stakeholder interaction?

Figure 11 provides a summary of the collected responses.

Challenges

Technical and ICT

- At technology level interoperability, reliability and latency of ICT solutions contribute to many challenges
- Consideration of congestions, frequency, and voltage control, and balancing in the future
- Reliability of flexibility solutions versus traditional network upgrades
- Addressing the availability of flexibility and aggregating larger fleets of flexibility where availability will also be partly solved statistically
- Discussion is needed between different stakeholders to understand the nature of flexibility supply and demand
- Increased investment in system monitoring and control are required
- Data interoperability among the system operators
- Implementation of demand response schemes
- Lack of customer engagement, due to limited knowledge and ease of flexibility implementation
- Smart meter rollout needs to be completed
- Lack of Advanced Metering Infrastructure prevents potential residential/commercial customers from participating in a compensated flexibility market.
- Clear understanding of the revolution in Electricity Delivery with the consideration of 'time'

Regulatory

•Incentive deviation from policy makers might distort the real flexibility objective and advantage.
•The distribution utility company needs to diversify its functions beyond the wire only business. Identifications of roles and responsibilities

Market and stakeholder participation (economic)

•The wholesale market needs further transition from the cost-based power pool and establish ancillary service markets

•Critical level of market liquidity required. For that easy access to marketplace, cross-border (regional) market, joint flexibility products are required

•Aggregator is expected to play an important role in providing flexibility >still many issues within market design

•Flexibility markets need to be developed so that it enables different kinds of flexibility to participate as equal conditions as possible

•New business models need to be developed, to motivate system users at different voltage levels to participate and provide flexibility services

•A lack of coordination between the DSOs and TSOs may decrease profit from flexibility resources, affect grid security, power quality, increase the overall cost of grid operation to end-users

Mitigations

- Demonstrators and sandbox can be used to evaluate stakeholder interaction and flexibility integration methods
- Allow for the easy access to the marketplace, cross-border (regional) market, joint flexibility products are required
- Discussion is needed between different stakeholders to understand the nature of flexibility supply and demand
- Cultural and behavioral barriers should be addressed
- Provide a definition of common data exchange protocols
- Harmonization of system services and products
- Increase end customer awareness and provide incentives for participation in demand response schemes
- Implementation of full half-hourly settlement for domestic and SME customers,
- Smart BEMS/HEMS (including smart EV charging) will enable full deployment of time-of-use and dynamic energy tariffs
- Deploy AMI universally
- The coordination between the DSOs and TSOs is crucial for a safe, reliable, and cost-effective implementation of flexibility-based services
- The roles and responsibilities of participants in the flexibility market should be assigned so that DSOs and TSOs will be able to support each other efficiently, provide cost-efficient operation of the grid, and proper utilization of flexibility resources
- System operators will need more tools to manage the system and more information about the development of generation and consumption assets and their behavior.

Benefits

- Network investment deferral
- Optimized operation and proper utilization of flexibility resources
- Provide cost-efficient operation for power systems
- Flexibility can be transacted between flexibility providers in demand side and TSO/DSO.
- Local stakeholders are able to take responsibility and manage their own area
- More options to manage networks constraints
- Improved network visibility
- Possibility to react to their own imbalance and reduce the cost of the imbalance, in case flexibility service providers are providing service to the stakeholder
- Possibility more effectively use of network assets
- Cheaper connections to network for new customers and distributed generation
- More robust stability and security of the Networks without excessive amounts of corrective facilities
- Lower carbon emission electricity system

Figure 11 Overview of the current and future challenges, mitigation and benefits for stakeholder interaction and flexibility harvesting

3.5. Stakeholders considered to be important flexibility providers

The perception amongst the respondents with regards to the importance of flexibility providers within specific countries was also considered. Four options were provided (industrial and commercial users, aggregated residential users, local energy communities, and distributed generation), with an additional option to add to the list. Respondents were able to select more than one option, as required. An overview of the outcomes of this question, ranked from highest to lowest number of responses, is shown in Figure 12.

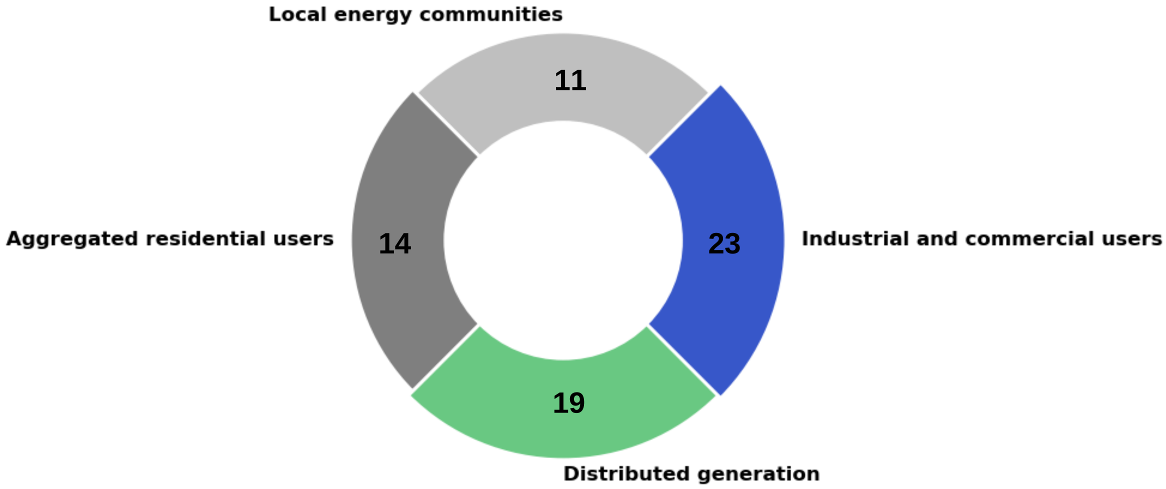


Figure 12 Stakeholders which are important flexibility providers

As can be seen, industrial and commercial users were considered to be the most important flexibility provider in various countries. Local energy communities also play an important role in the future, however, less so. Nonetheless, it is expected that a wide range of flexibility providers will begin to play increasingly important roles within the energy system in the future.

3.6. DSO contribution to congestion management and prequalification

The respondents were asked to indicate whether the DSO in their respective countries contributes to congestion management and prequalification of flexible resources. This was aimed in the context of ensuring that markets are able to participate without putting the security of the power system at risk. As shown in **Error! Reference source not found.**, most of the respondents indicate that currently, DSOs do not contribute to congestion management and prequalification of flexibilities.

In some countries, however, the contribution of DSOs toward congestion management does play a role and thus indicates that these methods are implemented successfully and have significant potential in future power systems.

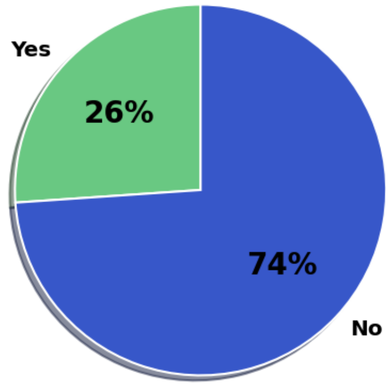


Figure 13 Overview of DSO contribution to congestion management and prequalification

3.7. Current status of accessibility of TSOs to DSO assets

In this question, respondents were requested to indicate the current status of TSO access to flexibilities owned and/or operated in the DSO network. Four options were provided for selections and the outcomes are shown in Figure 14.

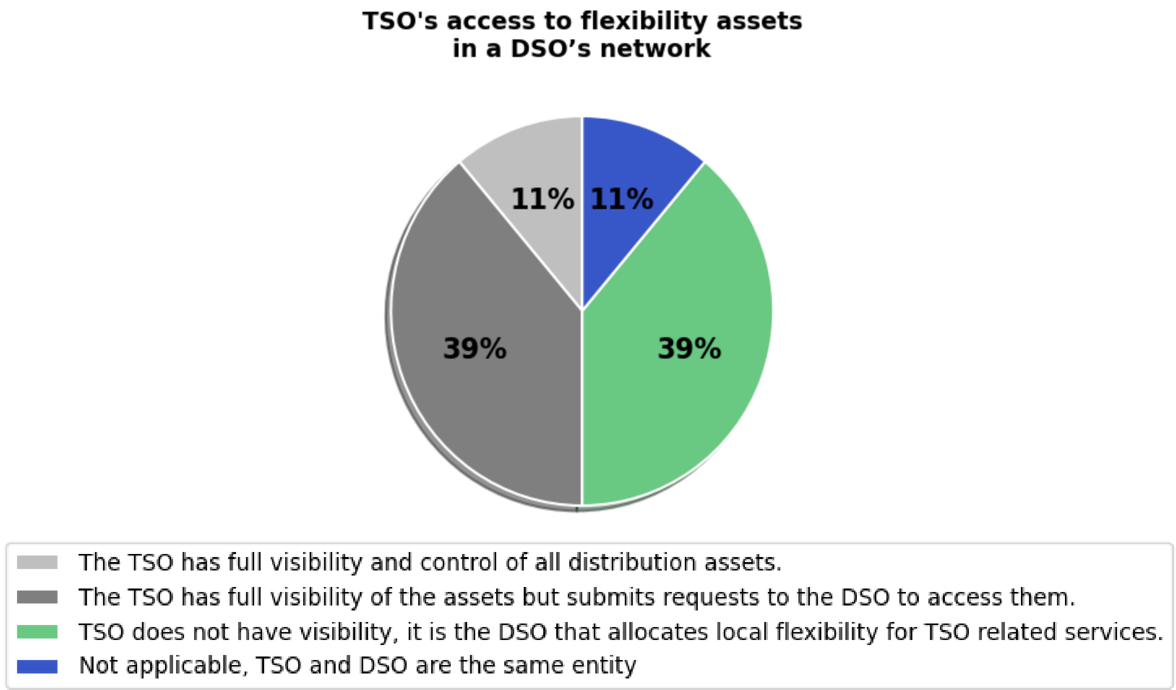


Figure 14 Overview of TSO accessibility to DSO assets

Furthermore, additional explanations were provided to provide context. In one case, it was indicated that TSO may have access through an open market within which the assets are located in a DSO area. In this case, it was mentioned that the DSO is not involved in the chain, however, the inclusion of DSO- level constraints in utilizing the flexibility requires the implementation of new solutions. Additionally, it was indicated that this is possible through markets in which the DSO-connected flexibilities are supported by an IT system which enables or facilitates TSO-DSO coordination. In other cases, it was indicated that the TSO has visibility of aggregated assets at the DSO boundary and has the ability to provide direct instruction to the asset. Lastly, it was indicated that Full visibility and coordinated TSO/DSO procurement and dispatch is implemented, and possible.

3.8. Data exchange platforms and methods

To obtain an overview of existing data exchange platforms as well as to identify the interest for adopting a universal format for data exchange, the following two questions were posed:

- Is there a Data Exchange Platform adopted in your country?

- Is your country interested in using a universal standardized format for exchanging Data between stakeholders?

The responses to these questions can be seen in Figure 15 and Figure 16 respectively.

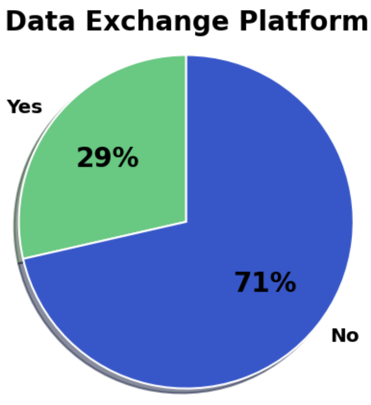


Figure 15 Overview of data exchange platforms in various countries

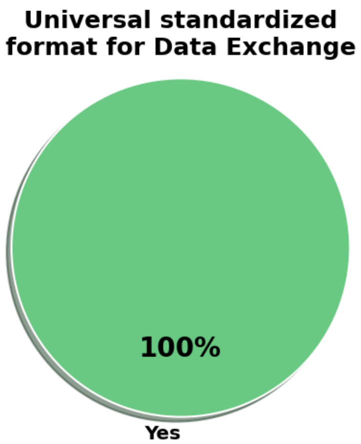


Figure 16 Overview of interest in using a universal standardized format for data exchange

As can be seen in Figure 15, 71% of respondents indicated that there is a no data exchange platform existing in their respective countries, while 29% of the respondents indicated that there is. Thus, this indicates that there is significant potential to utilize these platforms to facilitate the exchange of information to increase stakeholder interaction. Furthermore, there is a unanimous interest amongst respondents for a universal standardized format to further enhance this interaction as shown in Figure 16.

When considering additional approaches to how the data is shared between system operators within the respective countries, the respondents highlighted the following approaches:

- Direct contact between TSO-DSO
- Availability of information via websites of the respective institution and shared via APIs
- Datahubs (initially used for historical customer and billing data, and as flexibility registers in the future)
- Asset registration data
- Information is shared with the regulator

- Data Exchange Platform for metering data exchange
- SCADA systems are used for sharing of operational data exchange. Communication between system operators is based on the current system operation guidelines.
- Redispatch actions are communicated when it affects neighbouring grids, e.g., in maintenance situations
- European Network of Transmission System Operators for Electricity (ENTSOE) database
- Cross-Regional Coordination of Transmission Operators has a platform to share the data from TSO/DSO in each region.
- Sharing of long-term development data
- Provision of daily load curves

When considering the access of system/ network operator data through third-party access the respondents were able to indicate whether this is the case or not, through a yes/no response. The responses are summarized in Figure 17.

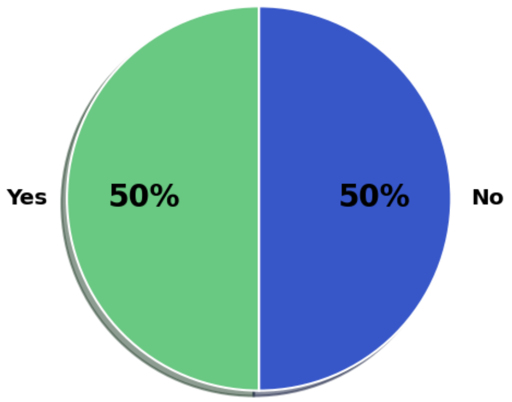


Figure 17 Overview of whether third party access to network operator data is possible

3.9. Change in the roles of stakeholders when considering the use of flexibility

In most cases, the respondents consider that the role of various stakeholders will change in the future. In particular, a more active role will be required of the DSO, managing all distributed resources efficiently, while ensuring the secure operation of distribution system and reduce carbon emissions. Respondents see an increasing significance of decentralized controls and the integration and service provision of flexibility at the DSO level.

The development of various flexibility registers and coordination platforms will be needed to utilize the available flexibility. It is expected that these platforms would enable the prequalification of resources for all system operators and the joint optimization of all the bids for all needs. The use of these asset registers and TSO-DSO coordination tools is demonstrated in various R&D projects to evaluate the roles and requirements for each of the stakeholders. Within this context, the DSO is expected to have an increased active role when enabling the flexibility provision and coordinating with the TSO. In other cases, it was also mentioned that prosumers will become more active with respect to on-peak load reduction and flexibility services, both residential as small and medium-sized enterprises.

In addition, the flexibility procurement is highly expected in case of an emergency such as a natural disaster in the near future. From the regulatory perspective, in some countries, there are ongoing discussions and there a formal process to address the work on the definition of policies and rules which will allow for the integration of flexibility services from distributed resources to the current flexibility market scheme. Although these changes are in inevitable, it was mentioned that the timeline for these changes will not happen in the near future, however it is expected to take place within the next decade.

4. Projects and initiatives

This section aims to gain insight into how flexibility projects are implemented based on the perspectives of respondents from various sectors and geographical locations. With the survey, information from 37 projects with representation from 17 countries are accounted for. A summary of the projects and initiatives can be found in the Appendix. The geographical distribution in Figure 18 reflects the countries from which the project information was collected. it should be noted that the considered projects also present international collaboration and an in-depth analysis should be conducted in the scope of future work.

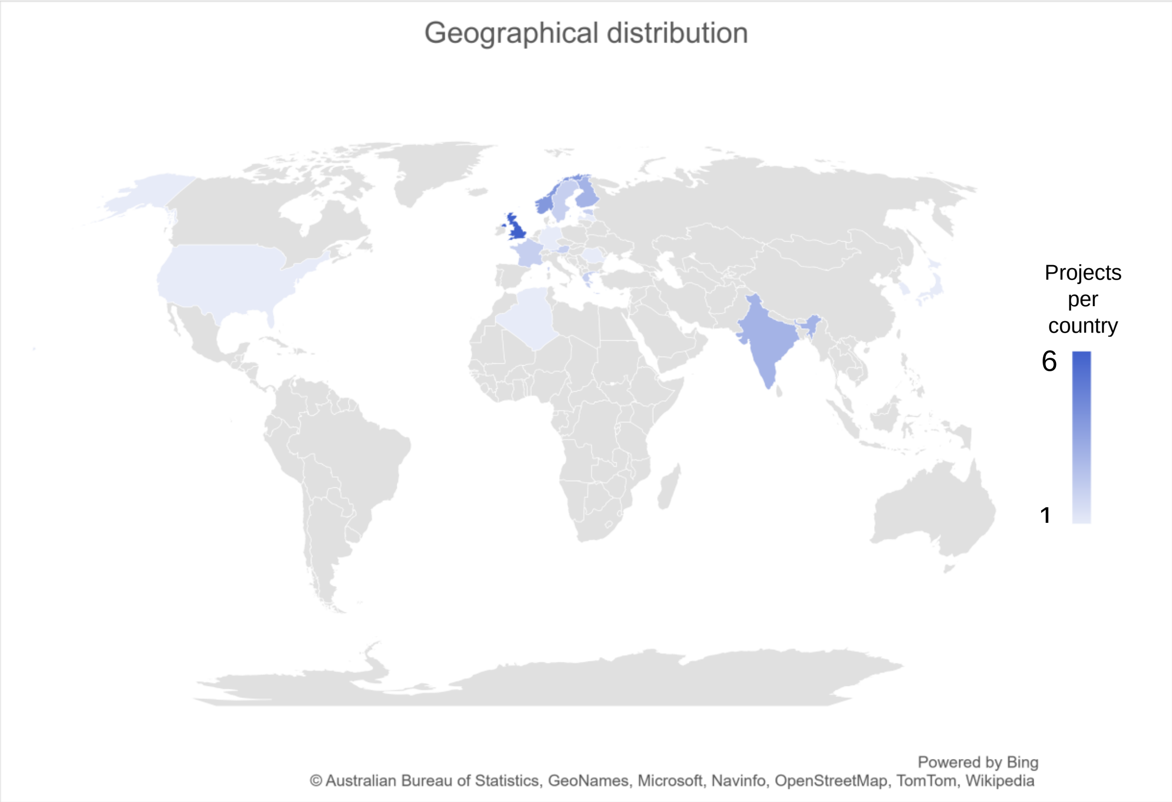


Figure 18 Geographical distribution of collected project responses

The next sub-sections provide an overview of the basic statistics of the characteristic of the collected projects.

4.1. Network levels where the projects are active

Figure 19 presents one overview of the network levels in which the collected projects are active. There are four main levels considered:

- Local – for projects which cover small network areas (including mostly those projects which are in an early stages)
- Distribution level – covering projects that only apply to the distribution level of the networks, marginally considering the impact at transmission level
- Transmission level – covering projects that only apply to the transmission level of the networks, marginally considering the impact at distribution level
- Both – covering projects applied on all network levels considering both the impact at distribution and transmission level

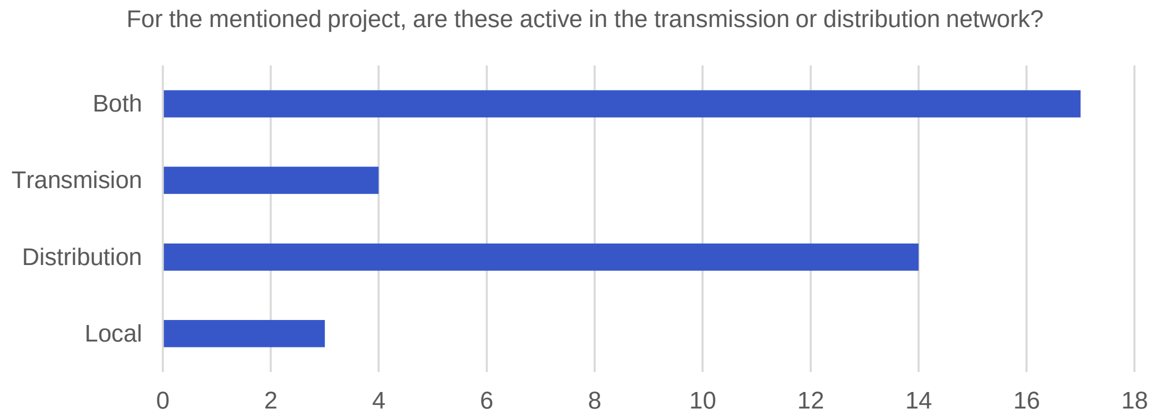


Figure 19 Overview of the network levels in which the collected projects are active

As can be seen, there are many projects that are both at the transmission and distribution network levels. When considering the network levels individually, it is clear that the distribution level has received a lot more attention when compared to the transmission level. This is encouraging to observe, since many DSOs are currently interested in exploring the possibility of increased flexibility integration, for the benefit of both the DSO and the flexibility owner. Contrary, there are currently fewer active projects within the local network level and thus offers an opportunity for future projects to be investigation within this domain.

4.2. Technology mixes used in the projects

Figure 20 offers an overview of the main technologies considered in the collected projects.

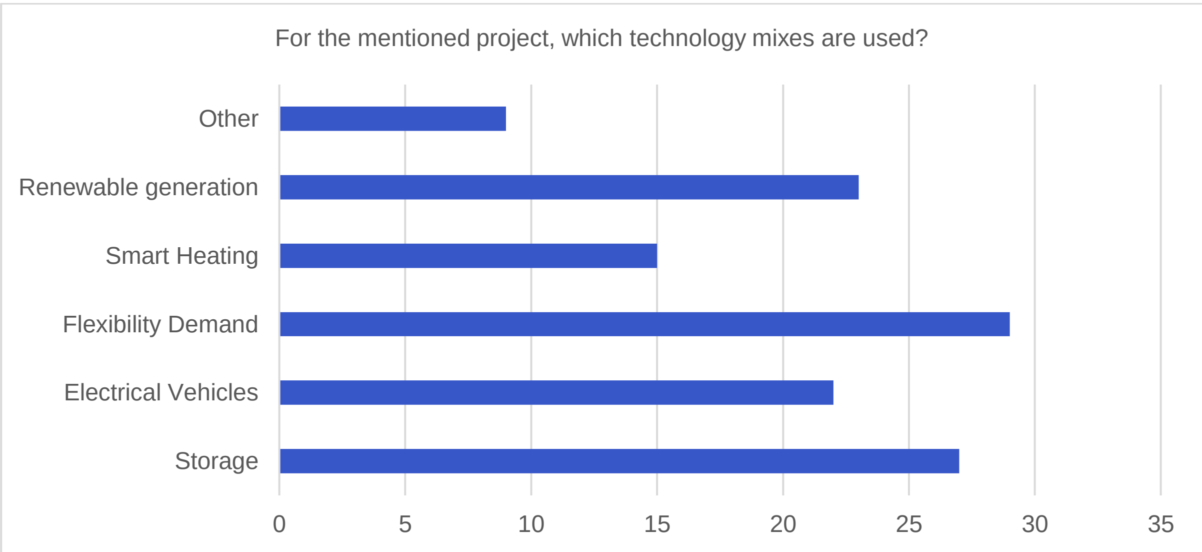


Figure 20 Overview of the main technologies considered in the collected projects

As can be seen, many projects are currently dedicated to the integration of flexibility demand, storage and renewable generation. As expected, these projects are currently considering those technologies which are expected to receive increasingly more attention and acceptance from a wide range of stakeholders and, prosumers in particular. Interestingly, the use of smart heating for future integration is also currently being investigated based on the received responses.

4.3. Funding type

Figure 21 gives an overview on the type of funding for the considered projects. Government funding covers the highest proportion of the projects followed by private/industry investments. Based on the figure, one can conclude that flexibility related projects have reached a reasonable level of maturity and are starting to be implemented in the networks. In order to get a more accurate impression, the data below should be considered and analysed alongside the data regarding the maturity level of the projects.

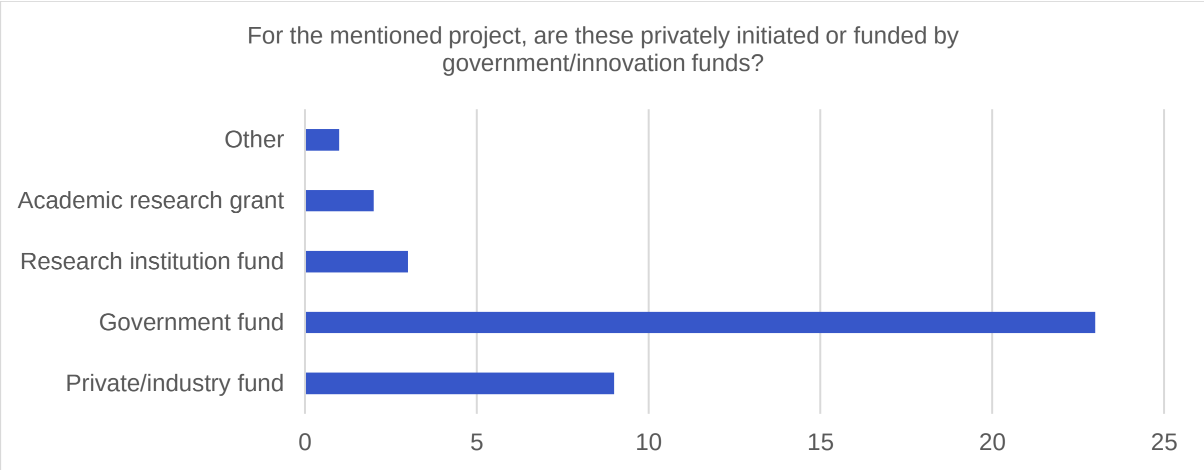


Figure 21 Overview on the type of funding for the considered projects

4.4. Current development status

Figure 22 presents the maturity level of the considered projects. One can observe that the majority of the projects are in a pilot stage with new projects being in the research and development stage. Further correlation of these results with the funding provides an enhanced understanding of the vectors pushing the implementation of flexibility related business cases in real world scenarios. As can be observed, most of the projects are in a pilot stage. This means that flexibility solutions have reached a reasonable level of maturity. Since many projects are currently in the research phase, new solutions are still being developed, which mean there is still room for improvement. Market solutions are also starting to gain momentum leading to the implementation of flexibility markets.

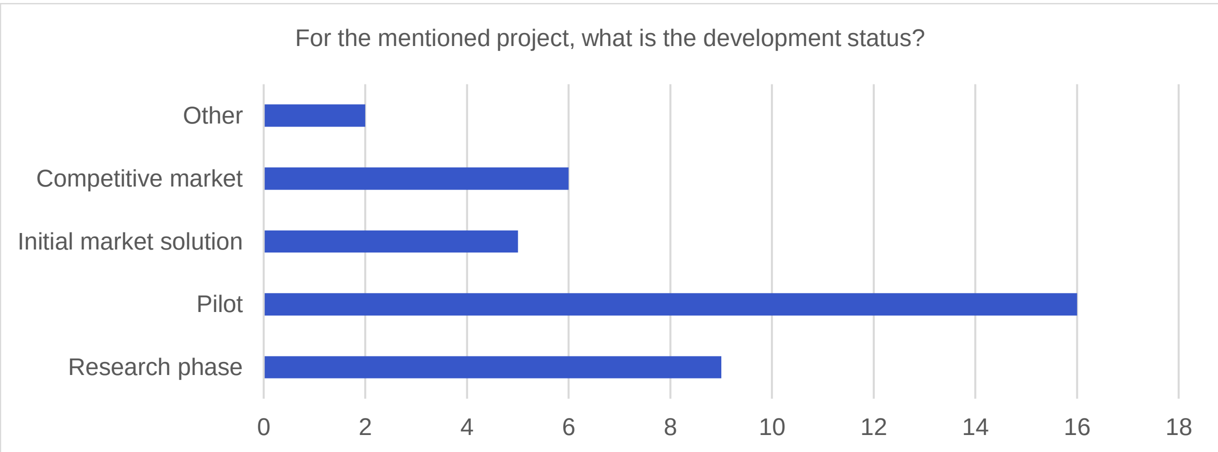


Figure 22 Maturity level of the considered projects

4.5. Services that are being targeted or considered

Figure 23 provides an overview of the main services for which flexibility is being considered. The data needs to be corelated with the different network levels where the projects are applied. Constraint management is one of the main services which is of interest for the proposed projects. Flexibility services may allow network operators to tackle grid constraints in all timescales, maintaining reliability and quality of service and maximizing integration of distributed energy resources. An efficient and transparent method could lead to a better use of the existing grids and to reduced investments in new grid assets.

Another important service targeted by the proposed projects is peak demand provision. Power consumption peaks are important in terms of grid stability, but they also affect power procurement costs: In many countries, electricity prices for large-scale consumers are set with reference to their maximum peak-load. The reason is simple: the grid load and the necessary amount of power production need to be designed to accommodate these peak loads. For distribution network operators, peak shaving is a beneficial solution to keep the costs of network expansion low. An efficiently operating network requires less copper installation in the form of power lines and distribution points. Uniform power generation and consumption is the ideal scenario, leading grid operators to create an incentive for reducing peak loads, especially in light of increasingly volatile feed-in from wind and photovoltaics.

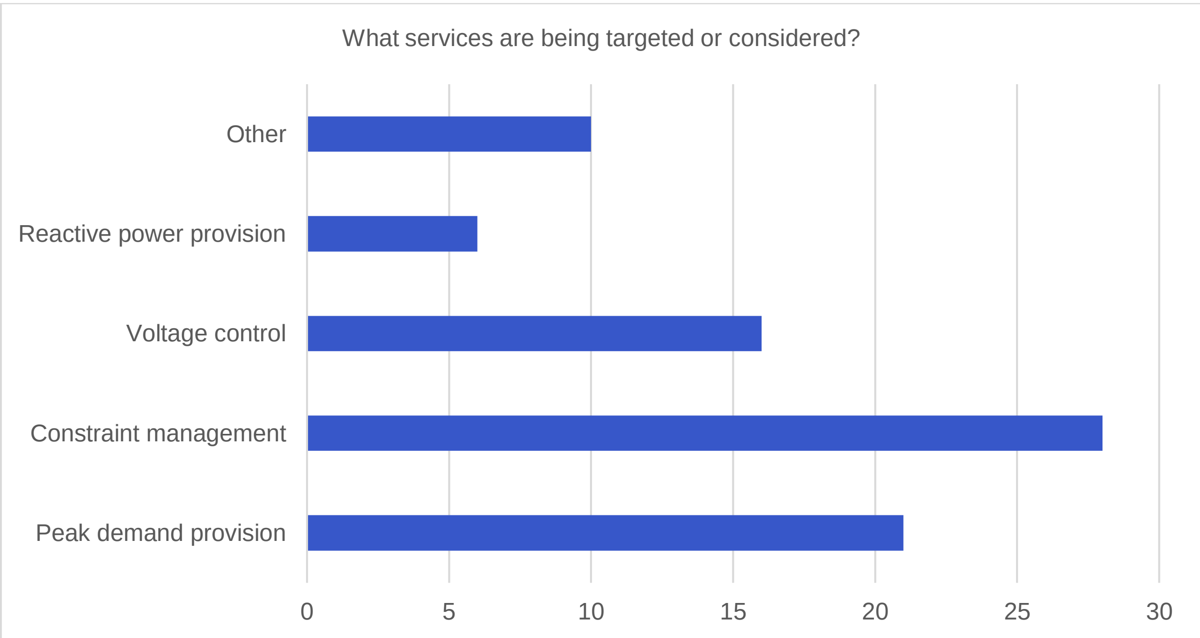


Figure 23 Overview of the main services for which flexibility is being considered

5. Workshop

On the 14th October 2021, ISGAN Annex 6/9 hosted an online workshop as a side event to the ISGAN ExCo 22. The workshop attendees included numerous ISGAN members, in addition to invited participants. During the workshop an introduction to the respective Annexes as well as previous work conducted was presented to provide context to the proceedings. Thereafter, the initial results of the survey were presented based on a high-level summary of information received to date. The aim of the presentation was also used to facilitate and promote/encourage additional participation in the discussion sessions. A panel of experts were invited to share their background experiences and knowledge on various topics related to flexibility and stakeholder interaction. Each panellist was posed three key questions, to which they could respond to, along with additional questions posed by the audience/participating members. Thereafter, various discussions, which highly active participants was conducted.

Challenges from the perspectives of the Netherlands was discussion and mentioned that flexibility is used by the users of the networks to adjust their demand and supply for the networks of the DSO. One particular challenge that was highlighted is how the DSO manages to deal with the integration of renewable energy generation such that it is able to keep up with the enormous amounts of penetration into the grid. Further challenges include the limited transport capacity of this energy flow within the network. Additionally, peak power of RES generation occurs a few times within one year, which creates problems, but the number of these occurrences is too low to justify the high investment cost of grid development.

A regulatory framework is being set up to bridge the need for more grid capacity in order to avoid peak loading of the network through the use of incentives which could be a promoter of the flexibility market. DSOs are putting in increase effort towards flexibility solutions in addition to traditional grid reinforcement methods.

The consideration of customer engagement and participation when new markets are created are noted to be highly challenging. It was acknowledged that not all the capacity requested was able to be offered to potential providers. Aggregator's business needs are still to be developed. Some countries are considered to be more advanced: UK and The Netherlands are already incorporating these concepts, while in other countries there still needs to be a clear definition of the roles of aggregators and the development of the market itself. New markets need to be simpler so that they can provide a more long-time signal; bilateral contracts; and certainty for some years. Later on, as the markets and services mature, it can move to short term contracts for daily business to procure flexibility for balancing purposes.

ISGAN has been very active on the concept of regulatory sandboxes. A community of practice has been established. In Europe, a new network code for demand side flexibility is currently being developed. Recommendations on these challenges need to be made, which should be addressed to tackle the barriers from the regulatory point of view.

The initial results of the survey which were presented at the workshop showed that there was no response which considers CO_2 reduction as a priority; this was perceived to be understandable from the discussions with regulators; it is not their priority. Currently, their priority in the short-term it to follow the recommendation to protect the customers with price signals; climate goals are not one of their priorities for the moment.

Further discussion evolved toward the technical requirements to facilitate flexibility markets. One of the key conclusions was that data needs to be shared among the different actors. One possible source of that could be the smart meter rollout. It was expected that smart meters would solve all problems however, there is a sense of disappointment in the approach, because the problems are not solved; The data is valuable for DSOs but not all problems are solved by it. Smart meters only provide information in Spain, as is the case for most countries (e.g., hourly tariffs), and it is possible for customers to monitor this but in terms of controllability tools, these are not yet available.

There are many projects which have considered new business models of the electricity market using the next generation of smart meters. Current smart meters do not really provide the technical requirements for enabling flexibility markets. New smart meters were developed: smart home add-on was developed; that was the most important step, and second-generation smart meter can act as an access point for behind the meter equipment capable of providing flexibility services. There perceptions among participants suggested that the next generation of smart meters will surely have more technical capacities.

6. Conclusion

In general, the electrical energy system is transitioning in the way that electricity is generated, transmitted and distributed. Due to these changes, system operators are faced with various challenges (technical, ICT, regulatory and economic) to accommodate new technologies due to the drive toward modern power systems. However, these changes have also allowed for the increased opportunity for system development and the inclusion of new market players. Flexibility will provide network operators (together with other stakeholders such as prosumers, aggregators, etc.) with the possibly to increase the stability of the electrical system and ensure the safe, secure and reliably of supply. Stakeholder interaction is key to facilitate and enable the integration and utilization of flexibility in future power systems.

Overview of the survey

The purpose of this survey was to collect information and stakeholder perspectives on how flexibility is understood and deployed within various countries/regions, how system/network operators and other stakeholders perceive the impact of flexibility and their interaction on the electric network and collect international experiences and research projects related to flexibility in the power system.

23 countries	42 responses	9 sectors	37 Projects/initiatives

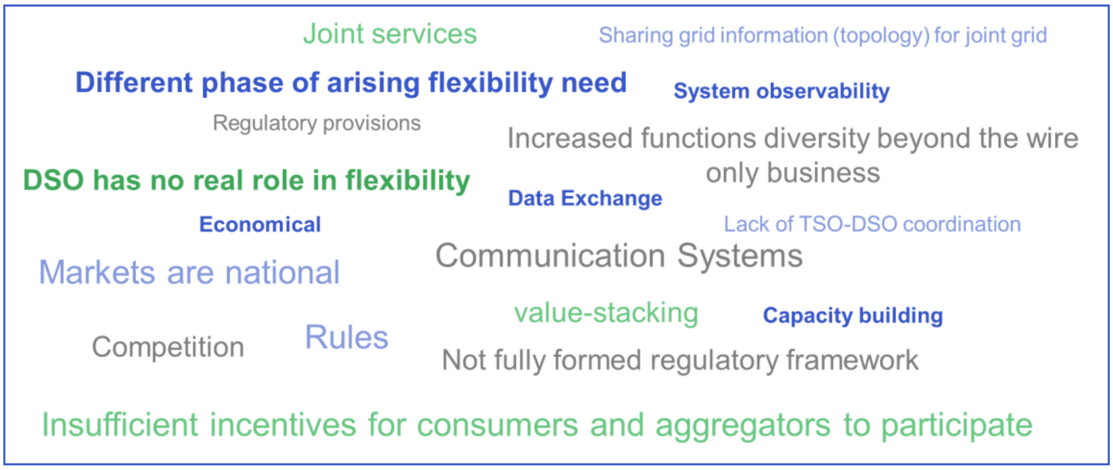
The numbers above show an overview of the distribution of respondents. The majority of respondents were from the DSO, TSO, and research sectors.

Discussion and key findings

Transmission-connected generation and large industrial loads were identified as currently the most drawn upon flexibility resource. Conversely, distribution resources (generation, storage, or loads) were the least likely to be used, with the general exception of some European countries. When used, load flexibility was frequently deployed to satisfy transmission capacity needs, followed by frequency regulation, transmission-level economic dispatch, and contingency reserve services. Utilizing load flexibility for voltage regulation (non-reactive power support) or economic dispatch within distribution/local energy markets was the least mature (i.e., mostly under consideration or not pursued).

When considering the value of increased customer involvement, the respondents (with at least one representation from each sector) have indicated that ‘awareness, acceptance and customer responsibility’ plays the most significant role, while ‘faster innovation’ the least. The global goal to decarbonize the energy system and thereby efforts towards ‘CO_2 reduction’ was ranked in the middle. This is linked to the consideration for the usage of increased integration of renewables and thus improved local air quality. Furthermore, the role of cost reduction for end users is also considered to be an important aspect especially since it may provide additional incentives and initiatives for the adoption and implementation of flexible devices. Naturally, from the perspectives of network operators, ‘grid support and congestion management’ becomes highly valuable for the safe and secure operation of the network and therefore, increased customer involvement, through the use of flexibilities can be beneficial for network operation as well as cost deferral in the case of network reinforcement requirements.

Within the various geographical areas, there are several barriers which have been identified which may result in limited TSO-DSO interaction with respect to flexibility integration and activation. In many cases, it was identified that a major barrier lies in the fact that the roles and responsibilities of various stakeholders in the energy sector are not clearly defined. In some cases, the DSO has no role when it comes to flexibility, since the assets are currently market-based, while it was also mentioned that the reason for the lack of (or limited) flexibilities is the lack of a meaningful business case for market participants. From the consumer perspective, insufficient incentives for consumers and aggregators to participate proves to be a barrier in many countries due to limited integration within the regulatory framework. These regulatory frameworks, in some cases, do not facilitate the procurement of flexibility from resources located in the distribution system.



Overview of barriers to TSO-DSO coordination with respect to flexibility

Industrial and commercial users were considered to be the most important flexibility provider in various countries. Local energy communities also play an important role in the future, however, less so. Nonetheless, it is expected that a wide range of flexibility providers will begin to play increasingly important roles within the energy system in the future.

Most of the respondents indicate that currently, DSOs do not contribute to congestion management and prequalification of flexibilities. In some countries, however, the contribution of DSOs toward congestion management does play a role and thus indicates that these methods are implemented successfully and have significant potential in future power systems.

The development of various flexibility registers and coordination platforms will be needed to utilize the available flexibility. It is expected that these platforms would enable the prequalification of resources for all system operators and the joint optimization of all the bids for all needs. The use of these asset registers and TSO-DSO coordination tools is demonstrated in various R&D projects to evaluate the roles and requirements for each of the stakeholders. Within this context, DSO is expected to have an increased active role when enabling the flexibility provision and coordinating with the TSO. In other cases, it was also mentioned that prosumers will become more active with respect to on-peak load reduction and flexibility services, both residential as small and medium-sized enterprises.

In addition, the flexibility procurement is highly expected in case of an emergency such as a natural disaster in the near future. From the regulatory perspective, in some countries, there are ongoing discussions and a formal process to address the work on the definition of policies and rules that will allow for the integration of flexibility services from distributed resources to the current flexibility market scheme. Although these changes are likely inevitable, the timeline for them was mentioned, specifically that they will not happen in the immediate future but are expected to take place within the next decade.

An overview of numerous projects and initiatives from respective respondents was collected and indicated that there is indeed added value attained from them. It was shown that these projects extend across all network levels and thus take into account the perspectives of all stakeholders. Many of the projects and initiatives are currently in their pilot phase, which allows for the adequate testing and evaluation of flexibility and stakeholder interaction concepts prior to large scale rollout and implementation. In this regard, various services are being targeted, mostly in the area of constraint management, and include a wide variety of technology mixes such as renewable generation, electric vehicles and storage.

Final thoughts and closing remarks

Although the topic of flexibility and stakeholder interaction is receiving increased attention, this survey reiterates the current perception amongst various stakeholders from different sectors from various locations. From the survey, it is clear that flexibility has a different meaning depending on the stakeholder; a new definition, or use of definitions tailored to the application, may be appropriate. Currently, transmission assets, either generation or industrial loads, are likely to be deployed for flexibility whereas distributed resources are often not yet utilized; this is consistent with current grid service applications, which are currently focused on transmission level needs. However, the survey has shown significant interest by respondents in capturing DER flexibility, with power capacity and location currently important factors and rebound, granularity of control, customer behaviour, and duty cycle in need of more study.

From the perspective of stakeholder interaction, it is clear that there is an increased value pertaining to increased customer involvement. The customer premise is therefore receiving increased attention as network operators endeavour to provide adequate incentives to increase active participation. This is particularly important as the awareness, acceptance and customer responsibility was ranked the highest. As expected, there are a wide range of barriers associated with stakeholder interaction. Primarily, the concept of data exchange, lack of/limited regulatory frameworks and the definition of the roles and responsibilities of stakeholders were the most identified amongst respondents. Challenges, mitigations, and benefits for current and future stakeholder interaction were also investigated, and it was indicated that a strategic approach to the formulation of future networks is needed. It was shown that challenges occur in various domains (technical, ICT, economic and regulatory). Despite this, it was acknowledged that there are adequate benefits to flexibility integrations provided there is adequate stakeholder interaction and accessibility. Given the maturity level of these solutions, there is a need to push for the provision and implementation of meaningful flexibility related business cases for different stakeholders. Value stacking of the solutions could provide for different stakeholder needs.

The hosting of a workshop allowed for the presentation of initial results and facilitated a wide range of discussions from experts in all areas. Based on the outcome of the workshop, it was emphasised that data needs to be shared among the different actors and that there are ongoing projects that address the concepts of new business models of the electricity market using the new technologies.

Recommendations

Based on the outcomes of the survey and the workshop, the following key findings and recommendations are noted:

- Due the wide range of perspectives, the term flexibility has a different meaning, or implication, to different stakeholders. Therefore, it is worthwhile to explore an agreed upon all-encompassing universal definition which can be recognised on a global scale.
- Load flexibility has potential to be further deployed to provide distribution and local energy market services. Simultaneously, there is a need to further study DER characteristics, e.g., rebound and granularity, to better understand their potential.
- There is scope for the deployment of more flexibilities for grid services and therefore all relevant stakeholders should endeavour to encourage further deployment as far as possible, while ensure a safe and reliable electricity framework.
- As expected, increased customer involvement is key to the successful operation of future networks. Therefore, it is important to encourage increased awareness, acceptance, and customer responsibility as pillars for improved customer participation. These aspects should be considered within the regulatory framework.
- The increased integration of flexibilities within the electrical system calls for the increase in stakeholder interaction. Since a major barrier lies in the fact that the roles and responsibilities of various stakeholders in the energy sector are not clearly defined, stakeholders should continue to define and develop a framework to provide clear guidance to facilitate the increased interaction among stakeholders and that use of flexibilities are complementary (as opposed to conflicting) to the respective needs of all stakeholders.
- System observability, communication, data exchange and regulatory frameworks play a significant role in stakeholder interaction. Therefore, system enhancements should be made to facilitate the inclusions of devices and methods. This possibly includes a universal standardized format to further enhance interaction.
- The concept of value stacking based on the design of joint products such that the same flexibility can be used simultaneously for different system needs should be further explored and developed.
- New markets need to be simpler so they can provide a more long-time signal and certainty for several years. Later on, as the markets and services mature, they can move to short-term contracts for daily business to procure flexibility for balancing purposes.
- A near-term recommendation is to prioritize the active participation of the customers with price signals; climate goals are not one of their priorities for the moment.
- Next-generation smart meters can act as an access point for behind-the-meter equipment capable of providing flexibility services. Next-generation smart meters, therefore, should have more technical capabilities.
- Projects, especially those with pilot demonstrations, allow for the development of new concepts alongside real life implementation. These projects are highly valuable, since they all for the testing and evaluation of these concepts prior to large-scale role out. Funding agencies should, therefore, continue to support such initiatives.

The results of this survey provide an overview of flexibility and stakeholder interaction based on the various perceptions from a wide range of respondents from different geographic locations and sectors. The survey highlights the current status of the related topics and allows for the opportunity to identify concepts, such as challenges and opportunities, which require increased attention by all stakeholders in modern power systems of the future. This work can provide a foundation for future work which will be conducted in the next phase within of ISGAN Annex 6 and Annex 9.

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8. Appendix

A summary of the list of projects and initiatives obtained from the survey.

Name	Link
4D Heat	https://www.theade.co.uk/news/policy-and-regulation/4d-heat-project-could-provide-substantial-savings-to-electricity-consumers
CoordiNet	https://coordinet-project.eu/
Crossbow	http://crossbowproject.eu/
X-Flex	http://xflexproject.eu/
EU-SysFlex,	https://eu-sysflex.com/
FLEXIMAR	https://www.vttresearch.com/en/news-and-ideas/need-demand-side-management-electricity-increases-piloted-marketplace-would-enhance
HONOR	https://honor-project.eu/?page_id=5
Industry4Redispatch	https://www.nefi.at/en/industry4redispatch/
INTERRFACE	http://www.interrface.eu/
OneNet	https://onenet-project.eu/
ReFlex Project	https://reflex-project.eu/
Smarter Network Storage	https://innovation.ukpowernetworks.co.uk/projects/smarter-network-storage-sns/
ebalance-plus	https://www.ebalanceplus.eu/
Electric Nation	https://electricnation.org.uk/
"Feasibility study for further utilization of distributed energy resources "" New Energy and Industrial Technology Development Organization"	https://www.meti.go.jp/shingikai/energy_environment/energy_resource/pdf/013_05_00.pdf
Flex+	https://www.flexplus.at/
Flexible Plug & Play Networks	https://innovation.ukpowernetworks.co.uk/projects/flexible-plug-and-play/
FlexiGrid	https://flexigrid.org/
Low Carbon London	https://innovation.ukpowernetworks.co.uk/projects/low-carbon-london/
Market based flexibility procurement	https://www.enedis.fr/co-construction-flexibilite-locale
Smart Otaniemi innovation ecosystem	www.smartotaniemi.fi
Virtual Power Plant demonstration project" Agency for Natural Resources and Energy	https://www.meti.go.jp/shingikai/energy_environment/energy_resource/pdf/016_06_00.pdf
NGESO Power Responsive for Immediate through Reserve	
ERC Sandbox: School & Temple	

ERC Sandbox: TU University Campus	
Eureka	
FME CINELDI	
ForTa - Future capacity-based grid tariff	
Gredeg	
ERC Sandbox: 3 residential villages	
Thermostat and water heater Demand Response programs established through utilities and enabled by 3rd party services (e.g., EnergyHub)	
Power Trade West (Effekthandel väst)	
Large scale demonstration project on flexibility - Strømflex	