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DSO's innovation barriers and innovation capacity

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4. Figures

5. Tables

4	DSOs contribution to the main innovation processes
5	Main areas and applicable tools and strategies to increase innovation capability
6	Strategies and their contribution to the innovation processes

6. List of abbreviations

Abbreviation	Definition
CAPEX	Capital Expenditure
CERRE	Centre on Regulation in Europe
DSO	Distribution System Operator
EV	Electric Vehicles
EIT	European Institute of Innovation & Technology
FlexiGrid	Enabling flexibility for future distribution grids with high penetration of variable renewable penetration– FlexiGrid
NRA	National regulatory authorities
OPEX	Operational Expenditure
R&D	Research and Development
T[number]	Task [number]
TIS	Technological Innovation Systems analysis
TRL	Technological Readiness Level
TSO	Transmission System Operator
WP[number]	Work Package [number]

Executive summary

This report constitutes the final deliverable of Task 9.3 DSO's Innovation barriers and innovation capacity of the FlexiGrid project. The main outcome of the report is (1) an analysis of barriers for innovation for implementation of future grids for the project's DSOs, and (2) a description of innovation capability and capacity strategies from the DSO's perspective. The goal is achieved using a combination of literature review and interviews with industry and market experts and project's DSOs, and employing several analytical tools within from systems thinking, innovation management, sustainability transitions, capability management and other related research fields. The focus of the task is on innovations related to flexibility markets, however, when relevant, parallels to other innovation types are drawn.

We identify several emerging factors that will affect the **future market context**, such as weather dependent variable power generation, price of fossil fuel, increased electrification, transmission and distribution grid chokepoints, cyber security vulnerabilities, smart electricity meters and smart homes, electric vehicles.

The following **innovation barriers** are discussed and analysed:

1. *Regulatory*: Price and tariff regime, Revenue caps, Lack of economic incentives, Rigid and inert regulatory background, Unbundling requirements, Inadequate R&D policy, Low emphasis on OPEX in R&D policy, Complicated legal agreements
2. *Economic and market-related*: Inadequate investment and economic incentives, High investment costs and limited access to capital, High operational costs, Unclear business models, Unclear role distribution, Insufficient customer engagement
3. *Technologic*: Lack of appropriate digital and related physical infrastructure, Availability, accessibility, and degree of adoption of technologies, Access to data, Vulnerability to physical and cybersecurity threats, Privacy concerns¨
4. *Organizational*: Insufficient incentive and the lack of a sense of urgency, Lack of experience and capacity to innovate, Absence of collaboration culture, Lack of knowledge and skills

We then demonstrate interconnectedness of the barriers, discuss their future dynamics and relative importance, their effects on the functioning of the innovation system, and the agency of the DSOs to act on each barrier group. We demonstrate that the future barrier landscape will differ drastically from the today's, with technological and regulatory barriers on an improvement trajectory, remaining uncertainties regarding the pace of change, and the rising significance of organizational barrier group.

We conclude that the **main potential for action** lies within strategies that (1) contribute to improving the innovation processes of *market formation, resource mobilization* and *knowledge diffusion*, and (2) aim at bridging the following common capability gaps for DSOs: *inadequate contingency planning, managing an interlinked organization with conflicting objectives* and *lack of agility*.

The following **innovation capability strategies** are then identified within the topical areas of *vision and strategy, organizational structure, knowledge and learning, individual action, resources, collaboration, and processes*:

1. Linking flexibility to the main strategic challenges and opportunities and strengthening portfolio approach to R&D projects

2. Establishing issue-centred interdepartmental working groups, involving several people in innovation projects (targeted involvement), developing differentiated communication strategies
3. Conditional roadmaps and phased investment plans, continuous work on business model development with periodic revisiting
4. Systematically stress-testing the organization against future developments, identifying emerging risks and developing action plans to mitigate them
5. Overseeing procurement and purchasing mechanisms
6. Moving away from transactional towards relational approach to innovation management, through building long-term partnerships
7. Increasing collaboration with actors outside of the traditional lines of the sector
8. Increasing participation in networks with entrepreneurial focus within the sector
9. Initiating regular knowledge exchange with solution providers and other stakeholders
10. Engaging with end-users through understanding their motivations, using price signals and measuring customer response

We point out that increasing the innovation capability requires action on all fronts, from strategic to operational, from little tweaks to culture shifts, from mobilizing people and resources to streamlining processes and adjusting existing structures. While the number of actions might seem overwhelming, it is up to each DSO to figure out which of the actions to focus on, based on the initial assessment of their weaknesses and strengths.

Contents

1. Introduction

This deliverable summarizes the results of the work conducted within Task 3 of Work Package 9 of the Flexigrid project. The objective of the task was to enhance the market impact of the project by (1) looking at the specific obstacles to innovation that the project DSOs are facing and (2) enhancing the innovation capacity and management among partners to increase success-rate in future exploitation. The deliverable features (1) an analysis of barriers for innovation and implementation of future grids and (2) innovation capability and capacity strategies to support solution deployment.

The deliverable is structured as follows. First, the method and process to arrive at the findings is described. A summary of the recent developments affecting the field of flexible grids follows, and acts as an insight into the future market context. Next, the barriers for innovation are described, including regulatory, market and economic, organizational barriers and digital and related physical infrastructure. The barriers are then analyzed to arrive at general takeaways. As the next step, the innovation capability and capacity strategies for DSOs are outlined and analyzed. Conclusions and reflections relevant for future work within and outside the project follow.

2. Method

The chapter contains the description of a framework developed and used to identify, analyze, and discuss the innovation barriers and innovation capability, as well as the description of the accompanying process steps. In addition, links to other initiatives and work packages are described.

Process

The summary of the main process steps employed to reach the objectives is featured in Figure 1. As the first step, the analytical framework was developed. Then, a systematic literature review was conducted that focused on (1) a summary of the main theories used, (2) the main obstacles to innovation for flexible grids, and (3) main strategies suggested to overcome these obstacles. Then, interviews with the DSOs were conducted, with a focus on organizational barriers and ways to overcome them. Several activities ran throughout the task duration, such as exchanges with other tasks and work packages, and general task management. Continuous readjustments to the process were made based on internal and external feedback, information input from other tasks and work packages and human resources availability within the task. These readjustments did not negatively impact the outcome of the task and were systematically reported as part of the periodic reporting process.

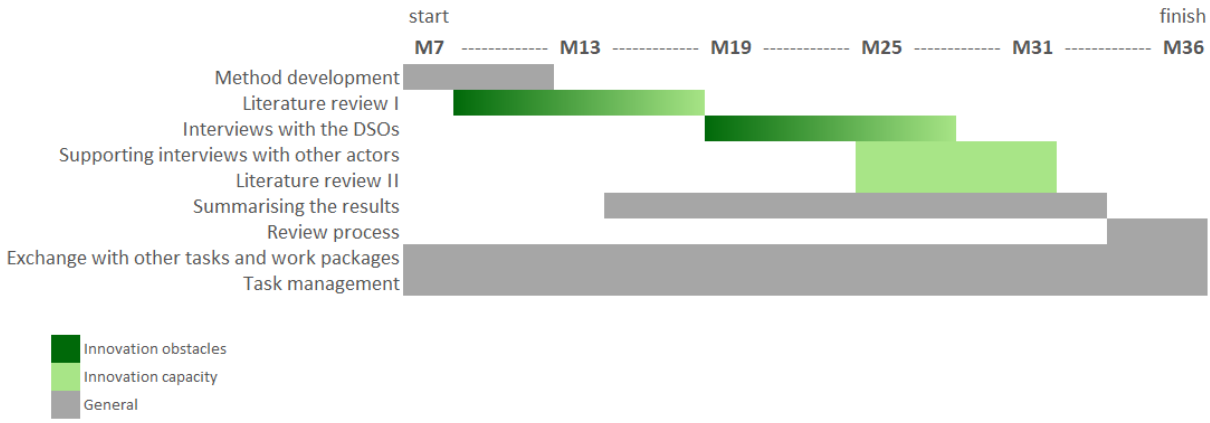

Figure 1 - Main process steps

The literature scan included around 70 sources, ranging from research and innovation project results to governmental and intergovernmental organizations' reports to academic articles to legal documents. More than two thirds of all the sources used are dated 2017 and newer, a third of all the sources are dated 2020 and newer. This was a decision made early on within the task, since it was pointed out during an internal project discussion that reports and articles within the area tend to quickly use their practical relevance due to the fast pace of change. Results of the literature review were summarized using Mural and coded in accordance with the following coding system: barriers, solutions and strategies, categories of barriers, trends, research gaps, theories and frameworks, other. The literature sources were grouped according to their type and corresponding relevant chapter in the report. In addition to the literature, input from the internal meetings, discussions and workshops within FlexiGrid project was constantly fed into the summary sheet.

A total of nine interviews were conducted. The interviews with the participating DSOs aimed to complement the information obtained through the literature scan. These interviews were semi-structured, and the questionnaire can be found in Appendix 1. One of the challenges during the interview process was related to the public availability of this report. It was discussed that the results of the interviews will be anonymized whenever possible, and it was decided that the only identifiable feature which will be used is the country where the interviewed DSO is located. Given the nature of the task and the main objectives, this was not seen as negatively impacting the workflow or the results. The interview results were coded according to the following system: external barriers, internal barriers, solutions and strategies, information about the organization, perceived value of flexibility, expectations about the future, perceived need for innovation. When relevant, the results were fed into the summary sheet on Mural. The interviews with technical and market experts from RISE Research Institutes of Sweden and EIT InnoEnergy represented a later addition to the process. In contrast to the interviews with the DSOs, these interviews were unstructured and centred around the main topic of *trends affecting the field of flexibility markets*. Additional questions varied depending on the expertise of each interviewee.

Links to other initiatives and work packages

Table 1 features the connections of the deliverable to the relevant initiatives outside of the project, tasks within FlexiGrid WP9, and other work packages within FlexiGrid.

Table 1 - Links to other initiatives, tasks and work packages

Initiative or WP	Description of the collaboration
FlexiGrid WP9 Task 9.2	T9.3 provided input to the task regarding the innovation barriers and DSO processes for procurement of services
FlexiGrid WP9 Task 9.4	T9.3 representative acted as a member of the evaluation committee for FlexiGrid business models. T9.3 provided brief input to the task regarding the innovation barriers. T9.3 used results of the business model assessment developed in T9.4. A representative from T9.3 acted as a reviewer for D9.4
FlexiGrid WP2	D9.3, in particular Chapter 4, was supported by the results of T2.1
BRIDGE initiative	Reports developed by members of the BRIDGE initiative are included in the analysis of the innovation barriers
Canada (Nest Net)	Canadian and European barriers to innovation are compared in Chapter 4, Canadian learnings regarding innovation capacity are featured in Chapter 5.
InnoEnergy	Interviews with an InnoEnergy representative were conducted to support work on future market context (Chapter 3).

Analytical steps

Figure 2 features the main analytical steps used to achieve the outcomes of the task.

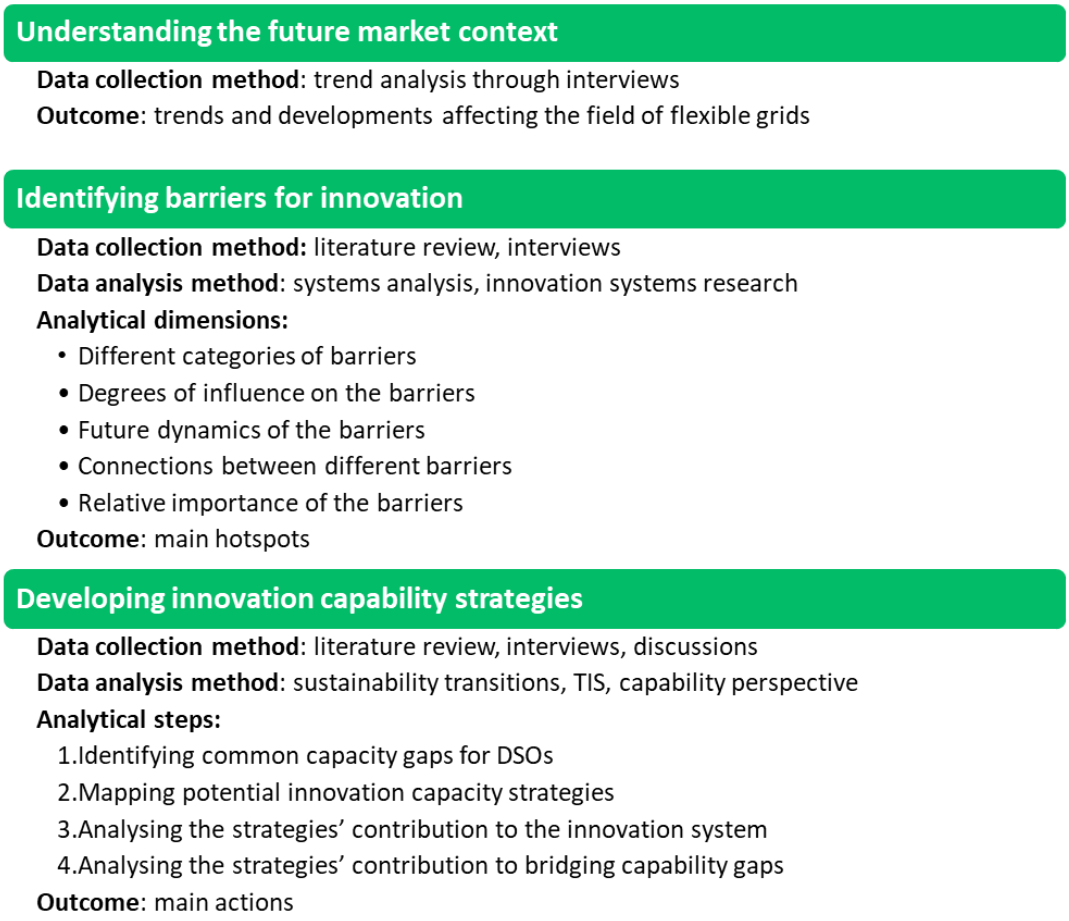

Figure 2 - Main analytical steps corresponding to the required outcomes of the task

The innovation barriers and innovation capacity are discussed within several theoretical fields and areas, not the least sustainability transitions and innovation management. One of the most acknowledged frameworks to assess the ways forward for a technological innovation, Technological Innovation Systems analysis, was used to guide the analysis throughout the task. However, one of the challenges to applying this framework within T9.3 was that the framework is largely technology centered, while the task is stakeholder centered, i.e., focused on the needs and issues faced by one actor within the innovation system - the DSOs. To overcome this challenge, the framework was modified and expanded. For the sake of better flow and readability, the framework and the modifications made are described in detail in Chapter 4. When discussing the innovation capabilities, insights from innovation management and strategic management were used. TIS framework was combined with the capability perspective (discussed in detail in Chapter 5).

3. Understanding future market context: trends affecting the field of flexible grids

The transition towards sustainable power sources at the generation side and increased electrification at the user side calls for more flexibility in both national and local power grids. Current market mechanisms, regulations and technical solutions are not adequate to provide cost-efficiency, reliability, and sustainability suitable for tomorrow's demands.

The years following the start of the FlexiGrid project were characterized by a big number of changes and increasing uncertainties, which affected the playing field for the flexibility markets. One such uncertainty, which could affect several developments, is the longer-term outcomes of the war in Ukraine. Arguably, this development has potential to accelerate the transition towards sustainable energy system and bring to light the significance of technical and regulatory innovation for Europe to become independent from fossil fuels. Such a shift might also be a way to mobilize the consumers into thinking differently about energy usage and flexibility.

Capturing these uncertainties and their effect on the future electricity grids is crucial to understanding the future market context in which DSOs will operate. It is also central to grasping how motivations for DSOs to engage in flexibility markets could evolve. By interviewing technical, market and industry experts, current and upcoming trends have been identified. Some of the main trends, apparent now, point at further increased demand for flexibility services in the short to medium term (up to 5-10 years), while in the longer term (10 years and beyond) technological development and market self-regulation has the potential for decreased demand for specialized flexibility services.

Weather dependent variable power generation

Supply side volatility has been increasing over time, and is expected to continue to do so, as a larger share of the generation units are weather dependent (i.e. wind and solar power). This driver is expected to decrease in intensity in the long term, as a higher share of the installed wind power is planned to be ocean-based, with a flatter and somewhat more predictable generation curve. Several of these ocean-based wind farms will be built where no large-scale power production has been based before, creating a need for new transmission grid access points and possible rebalancing of grid capacity in order to accommodate new electricity flows. It is likely that incentives for expansion of new variable power generation will continue to be stronger than incentives for expansion of grid capacity, thus creating and highlighting new chokepoints (see below).

Price of fossil fuel

Recent years have seen unprecedented oil and gas price volatility, thus affecting the fossil fueled plannable power generation units. Factors such as geopolitical instability and associated sanctions, regulations and cartels limiting production, as well as supply-chain disturbances have pushed the prices to record highs. We have also recently seen negative oil prices for the first time in history, as a result of improved extraction techniques, geopolitical price war and a sudden downturn of the world economy. Economic, security and environmental concerns are driving a move away from fossil fuels, causing a

shortage of biobased alternatives. In the short term, electricity will play a greater role in residential heating, accentuating distribution grid imbalances and increasing peak demand during winter.

Increased electrification

Increased electrification of industry and vehicles is also contributing to higher power peaks and higher overall consumption. Electrification is also happening in geographical areas with little previous demand, for instance EV charging stations away from major power lines, thus creating new grid imbalances.

Increased electrification, specifically controllable demand, also poses a potential remedy to the challenges – pending the right incentives, regulation, and technological solutions. Part of this will probably be self-regulating in the long term, while other aspects will need DSO initiatives and regulatory action.

Transmission and distribution grid chokepoints

Connected to the trend of increased electrification and higher fluctuation in generation and consumption, new chokepoints in transmission and distribution grids are becoming apparent. While in a perfectly plannable electricity distribution system, only capacity to transfer the peak demand effect from one producer to a static set of consumers is needed. That capacity now needs to exist over several routes, thus always calling for redundant capacity, albeit over different routes. This is the case for local distribution grids as well as for national (and international) transmission lines. Since the driving developments have happened in a relatively short period of time, compared to electrical grid investments which span over several decades, these imbalances are expected to remain for considerable time. It is also likely that increased use and innovation of flexibility services will reduce the required investments in a more cost-effective way.

Cyber security vulnerabilities

More and more of the electrical grid components, at the generation, transmission, as well as consumer side are connected to computer-based control system and computer networks. That makes them, potentially, vulnerable to cyber-attacks and computer viruses. Such attacks may be the work of sophisticated hacker-groups, state-sponsored or financially motivated. If a large number of power intensive devices are turned on or off simultaneously it has the potential of disturbing the frequency stability enough to initiate partial blackouts. More and more homes are also being equipped with “smart” electricity meters, that can be monitored and controlled remotely. While this provides the grid owner with a tool for handling grid disturbances, it also provides the above-mentioned hacker groups with a potential target. Flexibility resources with short response times could mitigate these vulnerabilities, by preventing them from reaching critical scale. This also highlights the need for cyber security considerations also for the implementation of flexibility services, to ensure that they are not increasing the vulnerability.

Smart electricity meters and smart homes

More and more homes are switching to real-time or hourly variable electricity rates, thus creating incentives for the users to reduce consumption when supply is scarce, and prices are high. To improve and automate the process of tracking electricity prices and adjust heating or the running of energy intense appliances, a market for this service is developing. While this market today is mainly focused on price savings – it could be used as crowdsourced flexibility resources. This might thus take place at the initiative of the consumers, and a functioning market. It might also be mandated onto consumers by the

use time-based tariffs, where the consumer pays, not only variable rates on energy, but also variable power rates based on available grid transfer capacity. In the short term, the trend of smart homes will likely have a small but increasing effect while in the longer term (10 years and beyond) this is likely to have a profound impact on how electricity consumption is timed.

Electric vehicles

Closely associated with the trend towards smart homes is the possibility of using electric vehicles, when connected to charging poles, as flexibility sources. This provides two different sources of flexibility, demand-response flexibility by choosing when and how to charge the electric vehicle, but also, expected to be more prevalent in the coming years, supply-side flexibility by using the vehicle's battery as energy storage, feeding back to the grid as necessary. This can either be used for residual load flexibility or for grid balancing. There is still a lack of standardized technological solutions as well as regulatory mechanisms – but are likely to be in place within a matter of years. Thus, we will see a small but significant impact within five years and likely a very large impact in the longer term.

4. Barriers for innovation and implementation of future grids

The chapter contains a description of the main barriers for innovation faced by the DSOs, based on the results from the literature review and the interviews with the project's DSOs. In addition, a comparative study is conducted that looks at the situation in Canada. An analysis of the barriers and the main conclusions follow. Throughout the chapter, we focus on innovations related to flexibility markets, but do not limit the analysis to the solutions developed within Flexigrid.

Regulatory barriers

The regulatory barriers facing DSOs are both related to the economic policy and the administrative policies and regulations. Additionally, research and development policy, consisting of both economic and administrative tools, is stated as a category that requires significant changes. These barriers are frequently seen as the main bottleneck on the way to increased uptake of flexibility solutions. Within FlexiGrid project, WP2 looks in depth into policies and regulation. Provided here is a summary instrumental to continued work within the task.

Several general issues related to how the regulation is shaped were pointed out by the interview participants and backed up by the reviewed literature. One such issue is that of *rigidity*. The general perception is that the current regulatory framework is not flexible enough to be able to evolve and adjust to accommodate the constantly changing operating environment. Reportedly, tools such as regulatory sandboxes – multistakeholder arenas for risk-free experimenting with policy measures – are missing. A related issue is *insufficient foresight and the absence of strategic, long-term approach* in the current regulation. It is worth noting that, in a way, flexibility of the regulation and the long-term approach need to be balanced. Providing too much flexibility in the regulatory framework and introducing frequent regulatory changes might create uncertainties for investors in the solutions.

Within the domain of economic policy, prominent issues are related to the price and tariff regime, revenue caps and lack of economic incentives. Adjusted network tariffs to accommodate for distributed generation, and time-of-use tariffs to provide incentives for flexibility are seen by the DSOs as two of the three main enablers when it comes to economic policy instruments (Eurelectric, 2019). It was noted that governmental incentives both for the DSOs and for the end users are required to support market development and investment processes.

When it comes to administrative barriers, the most prominent one is unbundling requirements, limiting access of DSOs to the flexibility markets and restricting the roles DSOs are allowed to uptake. Finally, access to data is, in some cases, a hurdle that could be directly linked to regulation.

Rewarding innovation by DSOs is one regulatory area that is particularly important for low TRL level solutions. Several mechanisms exist to promote innovation, including funding, the aforementioned regulatory sandboxes or policy labs, rule exemptions for trials, measures promoting capacity building. Sources of R&D funding range from funding provided by NRAs to other nationally available public funding, to EU wide research funding.

One hypothesis expressed in the literature is that the closer to the industry the funding sources are, the stronger the learning effects. Therefore, funding provided by NRAs is of particular interest. However, at present, the regulatory mechanisms to promote innovations are scarce on all levels. According to a survey of EURELECTRIC members, the regulatory framework in 13 out of 20 member countries either hampers innovation and R&D activities within the sector, or has no effect on them (Eurelectric, 2016). The mechanisms that do exist address mostly capital expenditure. For operational costs, no support is available in an overwhelming 16 out of 20 EURELECTRIC member countries. Examples of how OPEX support can be organized include covering R&D costs within the distribution network tariff (France) or OPEX allowances for R&D projects (Ireland). An alternative approach is to not make a distinction between CAPEX and OPEX and recognizing both in the allowed revenues, as is the case in the UK.

Currently, the regulatory environment facing the DSOs is undergoing some major changes (albeit at a slower rate than desired), and the future regulatory barriers are likely to be different. The ongoing transposition process for the Directive (EU) 2019/944 is one such change. Among other things, the Directive aims to facilitate increased energy efficiency, integrated electricity markets with clear rules for cross-country exchange and transparent wholesale market. In addition, it lays ground for customer participation through assigning a role to aggregators. Additionally, EU DSO entity is assigned a role in fostering digitalization, data management and protection of distribution systems. Exchange of information between DSOs and TSOs is encouraged. However, the length of the transposition process means that it will take time for the regulation to influence all the actors within the sector, especially on the DSOs (Pollitt et al., 2021).

Market and economic barriers

Closely related to the regulatory environment is market characteristics and economic barriers, such as inadequate investment, unclear business models and insufficient customer engagement leading to reduced market size.

Participation in flexibility markets is associated with major investments in physical and digital assets and infrastructure, as well as staff training and expanding for securing new skills. While financial resources

are a significant constraint, one of the interviewees pointed out that the underlying cause is the lack of prioritization, or a leadership buy in. They stated that it's generally hard to make relevant people within the organization to focus on the issue. Interestingly, this was an issue for both small-sized DSOs and bigger DSOs, and both categories pointed out that the size is one likely explanation for the issue. This is discussed in detail in the next subchapter.

Another issue of unclear role distribution and the lack of appropriate flexibility-based business models. It was argued that flexibility markets are broadly incompatible with the traditional DSO business model. One central question regarding role distribution is one of the nature of the relationship between the DSOs and the flexibility solution providers. Some interviewees stated an opinion that solutions providers will likely only be needed as a transitional, temporary solution, and that, once the DSOs build the necessary capacity and knowledge base, the solutions could be owned by the DSOs themselves.

Insufficient customer engagement and end-user behaviour is another factor limiting innovation and creating uncertainty around the potential of the market. Electricity customers generally do not participate in the electricity market due to incomplete regulatory framework, weak price signals, missing suitable business models and partially technological constraints (Kerscher & Arboleya, 2022, Nordic Council of Ministers, 2017). For instance, in Switzerland, one of the technology-related bottlenecks is the absence of data meters for customers. The newly adopted regulation aims to fix this issue but will only be fully implemented (with a goal of supplying 80% of customers with smart meters) by 2027, effectively stalling the development.

Organizational barriers

Most of the barriers described above have to do with the operational environment of the DSOs and can thus be considered "external". These have been in the spotlight of both the academic and policy effort. However, an equally relevant and often overlooked category is that of "internal" barriers, related to the organisation itself –the way it is structured, the way the internal processes are organized, organizational values and culture, or even individuals within the organization. These are particularly important to consider when looking at innovation capability strategies, since DSOs generally have a higher degree of influence over these barriers.

As previously noted, during the interviews with the DSOs, it was revealed that the underlying barrier to increase the DSOs participation in flexibility markets in the short to medium term had to do with insufficient incentive and the lack of a sense of urgency (Csedő & Zavarkó, 2020). Flexibility markets were generally seen as a peripheric development that would not have a major effect on the DSOs operations within the next 2-5 years. In addition, the perceived level of uncertainty was quite high. Several interviewees mentioned that it was hard to envision the future and plan for it given the existing regulatory uncertainties. They also mentioned that the pace of change is often dictated by stakeholders outside of the industry, with automotive industry/vehicle to grid being one example of a significant external influence. Such was the case in Turkey, where the main driver for the development was related to the national EV policy goals and the projected increase in the number of electric vehicles. In addition, for the DSOs that operate in environments with no significant congestion-related problems in the network, the issue of flexibility becomes purely about long-term strategic opportunity and does not contribute to solving any of the issues facing the organisation in the short to midterm. Limited top-down

support is another stated barrier. Reportedly, even in large DSOs, the leadership is only now starting to understand flexibility and its potential benefits.

The main stated incentive for the DSOs to participate in the FlexiGrid project was knowledge accumulation and knowledge exchange, as well as testing the solutions in a safe and risk-free environment. According to one DSO representative, projects such as FlexiGrid helped to prepare for future scenarios and potentially relevant business models, as well as to be more aware of potential problems which could arrive in the future. When asked whether previous projects led to any tangible changes within the organization, the answer was generally a no.

A broader barrier often identified in literature is that of the general lack of experience and capacity to innovate (e.g. Csedő & Zavarkó, 2020) within the sector. This was linked to the lack of in-house knowledge, the organisational inertia, and a tendency to view innovations strictly from a risk perspective. There are several reasons behind it, and they vary across DSOs, but the traditionally inert nature of the sector is undoubtedly one of them. Zooming in on the innovation within flexibility markets, what often seems to hinder progress is the lack of proactivity internally within the organisation. As one interview participant stated, *"[The DSO] is part of the public sector, and as such, should not be forerunners. Rather, [the DSO] should act as a fast follower and keep an eye on the changes".* The same participant noted that some changes related to the organisational culture can nonetheless be observed, especially compared to five years ago, when the organization was much more conservative.

Another identified barrier had to do with the general absence of collaboration culture, both within the organisations and between the organisations – within the sector and with other sectors. Broader implementation of flexibility is a collaborative effort, and might require involvement of several departments within the DSO, coordinating actions with the TSOs, contracting arrangements with DER and aggregators, and paying more attention to the needs of end users, among other things.

One example of a needed external collaboration is that between DSOs and TSOs. To use flexibility as per Directive (EU) 2019/944, DSOs must coordinate their actions with TSOs not to create network issues in other parts of the electricity system. As pointed out by one of the participants, collaboration with academia is another required but problematic aspect. Participating in publicly funded multistakeholder research projects makes evident that the differences in terminologies used between academia and other parts of the sector represent a significant issue.

An example of a needed internal collaboration, pointed out during the interviews, is between the R&D department, business development department, investment department and network operation department. In general, it was noted that a common problem is the disconnect of the innovation people from both the operational staff and often even the leadership. This represents a clear and drastic shift from the ways DSOs operated to date, and the lack of the experience within the sector will likely require that such collaboration is facilitated by external entities in the beginning.

By comparing the answers of different interviewees one additional dimension of organisational barrier became clear, namely, the vast difference in answers that could be attributed to the differences in the characteristics of a DSO in question, not the least the size. For example, DSOs of smaller size might have bigger problems related to the lack of in-house knowledge and human resources capacity to partake in innovation activity. In fact, according to Pereira et al. (2020), the empiric evidence shows that bigger DSOs are significantly better equipped to adopt innovations and adapt to changing conditions. During

the interviews it was pointed out that, while the value of participating in EU projects is clear, the resources available within small sized DSOs often do not suffice to manage their involvement. This leads to prioritization of smaller scale, more short-term and often less radically innovative projects. One of the DSOs interviewed stated that they only had three people working within the field of flexibility. This, coupled with the lack of knowledge related to IT, data, digitalisation and business analysis, made it hard for the organisation to pull the resources needed to focus on the issue.

Digital and related physical infrastructure

Lack of appropriate digital infrastructure in place is one type of barriers that slow down progress towards flexibility markets. In this regard, it is worth noting that the main technological solutions often already exist, albeit their TRL levels may vary. The issue, to an equal, if not bigger extent, is their availability, accessibility and degree of adoption by the DSO and the whole ecosystem. For instance, European Task Force (2019) mentions that third party ownership of the technologies can often represent a barrier, through limiting accessibility and improvement potential and raising the price of technologies.

Data issues, related to absence of data (such as real time analytics) and poor data quality (such as data on customer demand and supply connections), make it harder to both estimate the business potential and manage flexibility once implemented. Inadequate and outdated IT systems and lack of open standards and protocols for interoperability with DER further aggravate the issue. On the other hand, there is also a growing concern related to the vulnerability of digital infrastructure to physical and cybersecurity threats. Given the conservative nature of the industry and the historic significance of security of supply, these concerns can slow down the efforts to innovate unless addressed preemptively.

Other issues pointed out are linked to the related physical infrastructure, such as current absence of data meters for customers in some places, the related privacy concerns, and standardization processes for technologies. A lot of work is being done in this regard, such as a policy-mandated smart-meter installation in Switzerland, but the change will likely take time.

Barriers to innovation in Canada

Local context

Canada's electricity system is part of the integrated North American market, with electricity regularly traded across the border and Canada being the net exporter. By far the biggest electricity generation source in Canada is hydro, followed by nuclear and natural gas (IEA, 2022).

The national federal and municipal responsibilities in the Canadian electricity system are comparatively limited. Instead, the main actor at the operational side of Canadian electricity grids is provinces (Government of Canada, 2022). They are responsible for generation, transmission, management, and trade within the boundaries of the province, as well as environmental impacts and demand response policies (Hastings-Simon, 2019). Each province is dominated by one transmission provider. Generation, transmission, and distribution functions in the country are unbundled since about a decade ago, and in some provinces, there is a move towards a more competitive electricity system with independent power producers.

The responsibility for innovation policies is distributed across the three levels, with federal level responsible for technology-specific policies and funding innovation research, and municipal and provincial level - for providing subsidies, programs, and targets to support innovation activity.

Main barriers for innovation

While there exists a multitude of barriers for innovation within the Canadian electricity sector, they were recently summarized into two main pivots: (1) risk-averse culture and (2) constraints outstripping support for innovation (Natural Resources Canada, 2020).

One stated issue regarding innovation activity is that of a lack of clear mandate, goals and incentives. Just as in Europe, or, arguably, elsewhere, the market is heavily regulated, and the system operators often lack both the mandate and the necessary incentives to develop and implement innovations. The risk-averse environment of the system was often brought up (Hastings-Simon, 2021). It was stated that, with reliability of the grid being the main priority, the stakeholders are hesitant to make proactive changes. Combined, these factors lead to strong path dependency, with multiple actors continuously choosing the proven and safe technologies.

Another issue brought up in the literature is that of siloed planning and lacking integrated resource planning across energy types, regions and between supply and demand. This corresponds to the lack of collaboration culture, also present in the European context.

Not surprisingly, market barriers were also brought up in Canadian context, namely the lack of market access. Mirroring the developments in Europe, inadequate signals through tariffs, both on the demand and on the supply side, were identified as factors that hinder innovation activity. On the demand side, the need for time-varying rates to incentivize the users to shift their demand profiles was stressed. On the supply side, since the value of new resources provide is not adequately reflected in prices, there was limited incentive to deploy these resources.

Lack of enabling infrastructure, such as smart meters or general spatial distribution of flexibility sources, further hampered the sector's innovation activity. However, as noted by Canada's Tech Network (2014), the main challenges seem to not be technical, but rather relate to how innovation is perceived in different parts of the organizations within the sector. While the sector is inherently, and perhaps rightfully so, risk averse, what seems to be lacking is adequate and efficient processes for assessment of risks and uncertainties and de-risking investments.

In a survey conducted by the Centre on Regulation in Europe (CERRE) among the European TSOs and DSOs, the vast majority of respondents expressed no interest in learning about regulatory developments outside of Europe (Pollitt et al., 2021). This is likely due to the general perception that differences in political, geographic and economic contexts make learnings from one place inapplicable in another context. However, as this subchapter aims to demonstrate, not only are many of the barriers facing the DSOs in Canada similar to those facing the European DSOs, but the underlying causes for these barriers also mirror each other, making a case for improved international cooperation and knowledge exchange.

Analysis of the barriers

The number of innovation barriers facing DSOs can seem overwhelming. To develop effective innovation capability strategies, it is important to understand which of these barriers or barrier groups should be

addressed first. Such prioritization is a multi-criteria decision problem. For instance, one factor of relevance is whether a barrier is expected to persist in the future, or whether it is already being tackled by, e.g., concerted regulatory action. In addition, since the tasks aims to outline strategies that the DSOs could implement, it is important to understand which of the barriers the DSOs have at least some degree of influence over. At the same time, it is also crucial to not exclusively focus on low-hanging fruits, where the DSOs' agency is high, but the impact is low. Finally, it could be worthwhile to identify how different barriers affect each other, to see if there are any leverage points in the system. With this complexity in mind, the prioritization process employed in this study is guided by the following criteria:

1. The connections between different barrier groups (interdependencies)
2. The relative importance of the barriers (impact_present)
3. The future dynamics of different barriers and changes in their relative importance (impact_future)
4. The degree to which DSOs can influence the barriers (influence)

In this subchapter, we illustrate potential interdependencies with the help of a drastically simplified cause-and-effect analysis. Future dynamics of the barriers is assessed based on the results from discussions and interviews within the project. The relative importance of the barriers, as well as DSOs degree of influence over different barriers, is assessed with help of Technological Innovation Systems (TIS) framework. Results from this multi-criteria analysis are synthesized and used to inform the innovation capacity analysis in the next chapter.

Barriers under the current and future market design context

One perspective that is often overlooked when looking at barriers is that of time. As demonstrated in the previous chapter, several changes relevant for flexibility markets, not the least regulatory, are currently under way. Given these developments, the barriers that the DSOs are facing today are likely to be different than the barriers under the future market context. Knowing which barriers will be more prevalent in the future helps develop appropriate and relevant innovation capacity strategies. It is worth noting that within FlexiGrid WP9, particularly T9.4, "future" often refers to five years ahead, where a lot of changes are expected to take place, according to the interviews performed in that task. In T9.3, we adopt a more flexible and long-term approach to discussing the future. However, the five-year timeframe is still seen as an important tipping point for many of the barriers.

Table 2 features an indication of the future dynamics of the main identified barrier groups (color code: green – positive dynamics/likely to get better, yellow – unclear dynamics/no perceived change, red – negative dynamics/likely to get worse).

Table 2 - Main barriers and their expected future dynamics

	Regulatory	Economic and market-related	Technologic	Organizational

Barriers	• Price and tariff regime • Revenue caps • Lack of economic incentives • Rigid and inert regulatory background • Unbundling requirements • Inadequate R&D policy • Low emphasis on OPEX in R&D policy • Complicated legal agreements	• Inadequate investment and economic incentives • High investment costs and limited access to capital • High operational costs • Unclear business models • Unclear role distribution • Insufficient customer engagement	• Lack of appropriate digital and related physical infrastructure • Availability, accessibility, and degree of adoption of technologies Access to data • Vulnerability to physical and cybersecurity threats • Privacy concerns	• Insufficient incentive and the lack of a sense of urgency • Lack of experience and capacity to innovate • Absence of collaboration culture • Lack of knowledge and skills
Future dynamics	A shift from the main bottleneck to a gradual improvement. Whether the pace of change is going to be sufficient remains unclear	Market volumes and interest are likely to increase over time. More CAPEX and OPEX support channels are going to be available. Future dynamics is highly context dependent. Future price dynamics is hard to predict.	Access to technologies will likely improve, as well as the TRL of the required solutions.	The required change is systemic and broad in scope. The underlying industry culture must change, and such processes tend to be slow. This may become the main barrier group in the future

While the assessment above is highly speculative, it demonstrates that the future barrier landscape will differ drastically from the landscape DSOs currently operate in. Several barrier groups will likely improve, notably when it comes to technology and infrastructure, the two areas where the study participants and the literature seemed the most optimistic. In contrast, when it comes to both regulatory barriers and organizational barriers, the main question mark is the pace of change. The complex nature of the electricity market, the growing interconnectedness with other sectors and parts of the economy, and the effects of geopolitical developments mean that the future development of the economic and market-related barriers is hard to predict. While the trend is generally positive, the participants were cautious due to the many uncertainties and the amount of effort required to address the economic and market-related barriers. Lastly, it can be concluded that the organizational barriers are likely to increase in significance, both due to the positive dynamics within other barrier categories, which will affect the relative importance of organizational barriers, and due to the scope of change required, which affects the absolute importance of the barrier group.

Interconnectedness of the barriers

Featured below is a depiction of the main interactions between different barrier groups.

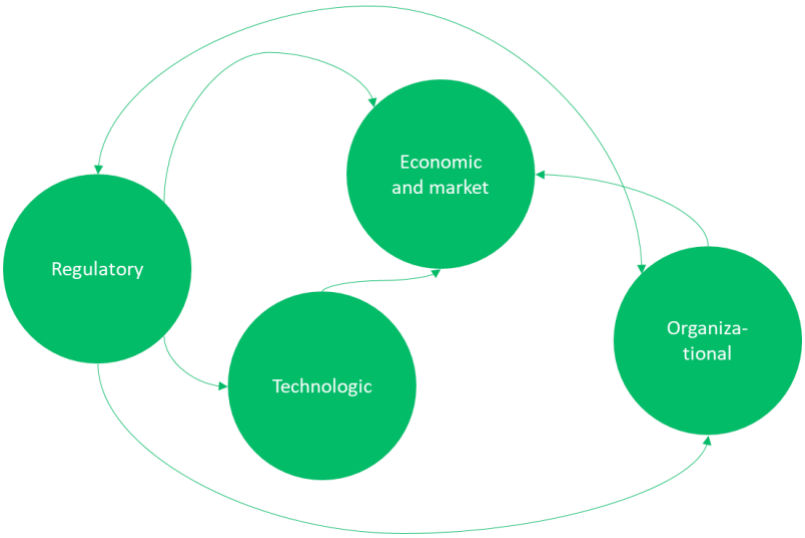

Figure 3 - Interactions between the main barrier groups

The figure serves to demonstrate the interdependencies of different barrier groups but does not depict the full scale of their interactions, which is certainly much more complicated and nuanced. To illustrate one connection, let us consider how inadequate R&D policy affects the landscape in which DSOs develop and implement flexibility solutions. Limited resources designated to support DSOs innovative activities, coupled with virtually unavailable OPEX support, has a direct effect on the operational and capital costs of investing in flexibility solutions. In addition, it has a negative effect on both the degree of adoption and the availability of the enabling technological solutions and contributes to the lack of skills and capacities within the DSOs. Thus, just one barrier within the regulatory category effectively affects all the other barrier groups.

The fact that the barrier groups facing the DSOs are interconnected justifies a more targeted approach when developing strategies to overcome the issues, where improvements in one category might lead to improvements in several other categories. Some barrier groups might be considered particularly strong leverage points for change. In the figure and the example above, this is evident in case of regulatory barriers.

Barriers to innovation within the broader innovation system context

DSOs operate within a broad and complicated innovation system, which involves many actors with different roles, capabilities, and responsibilities. In case of FlexiGrid, at the center of this innovation system is flexibility solutions. Innovation research community often employs the Technological Innovation Systems analysis framework (TIS) to assess how well the innovation system operates, and where the main improvement potential lies. At the core of the framework is the innovation processes, which represent activities required for a success of a certain innovation. Table below features the description of the main innovation processes.

Table 3 - Main innovation processes within TIS framework (Source: Bergek et al., 2008)

Innovation process	Description
Entrepreneurial experimentation	Attempting to develop new solutions and find new commercial applications for the innovations through entrepreneurship practices

Knowledge development and dissemination	Creation of necessary knowledge about the innovations through R&D and learning, as well as its dissemination across relevant actor groups. Knowledge development and knowledge dissemination are frequently separated into two processes.
Guidance of the search	Establishment of a shared vision and broad strategies to define the role of the innovations in the society
Market formation	Creation of price-setting and market developing mechanisms, including public procurement, guaranties, subsidies, business models
Resource mobilization	Attracting the necessary financial, physical, and human capital to develop the innovations
Legitimacy creation	Creation of broad societal acceptance of the innovations and ensuring their compliance with the existing institutions

The application of the TIS framework in this study is two-fold. First, the functioning of each innovation process is evaluated, to understand where the main needs for improvement lie. Then, the DSOs contribution to each innovation process is assessed. DSOs is only one of the many stakeholders forming parts of the flexibility solutions innovation system. It is unrealistic to assume that they can contribute to each process to the same extent, or that their contribution to each process would even be optimal for the success of the innovation system. For example, when it comes to entrepreneurial experimentation, DSOs role is inherently quite limited. It is true that the DSOs could strive to be more active and increase their participation in entrepreneurial activities. But from the standpoint of the whole system, it might prove more efficient if an actor who is better equipped and accustomed to dealing with innovation occupies this niche, while DSOs act as early adopters.

Table 4 summarizes the results of the assessment (color code: green – strong, yellow – average, red – weak). Ideally, the focus of the innovation capacity building would lie within the innovation processes (1) which demonstrate a significant need for improvement – color red or yellow in column 2 and (2) where DSOs have a significant potential to contribute – color red or yellow in column 3.

Table 4 - DSOs contribution to the main innovation processes

Innovation process	Functioning of the innovation process	Assessment of DSO contribution to the innovation processes	Main obstacles to DSO involvement
Entrepreneurial experimentation	Strong, many solutions are being developed through R&I projects	Not likely that the DSOs are the most well-equipped actor to deal with entrepreneurial activities. Can act as early adopters	Organizational
Knowledge development	Growing amount of research	DSOs act primarily as recipients of knowledge; no action is required.	Organizational
Knowledge diffusion	Research doesn't reach relevant organizations and, in many cases, relevant people within the organizations	DSOs can be more proactive while seeking the knowledge, as well as diffusing the knowledge within their respective organizations.	Regulatory, Organizational
Guidance of the search	Slowly improving, but there exist contextual developments that could both hamper and speed up the uptake of flexibility solutions	Flexibility solutions currently play a marginal role in the DSOs overall strategic direction.	Economic, Regulatory
Market formation	Market for flexibility solutions develops rather slowly. Currently, the focus lies on building the knowledge base and figuring out the system	The work with business models for flexibility within the DSOs is insufficient. In addition, more active collaboration with customers and more partnership seeking behavior can be encouraged	Regulatory, Economic
Resource mobilization	Insufficient resource access in terms of financial resources,	DSOs investing in solutions, DSOs collaborating with other actors	Regulatory, Organizational

	infrastructure and physical assets		
Legitimation	Generally strong legitimacy for flexibility solutions, likely increasing with the rising energy prices	Internal discussions within DSOs on the urgency of flexibility solutions are missing, which hampers the pace of change.	Organizational

The table aims to match the needs of the innovation system with the intervention potential of the DSOs, and, by doing this, identify the main strategic areas where DSOs can be more active. As the table indicates, the most potential for action lies within the processes of market formation, resource mobilization and knowledge diffusion. In addition, guidance of the search and legitimation should be considered. This means that the most effective strategies for capacity building within DSOs would be related to these processes.

General takeaways

This chapter looked at the innovation barriers facing the DSOs. The goal of the chapter was not to provide a comprehensive and detailed overview, but rather to gain insight that can be used when developing innovation capacity strategies that the DSOs can implement. Below are the main takeaways from the chapter:

1. Many of the identified barriers are highly context dependent, and manifest differently both with regards to the external environment (e.g. EU versus non-EU countries vis-à-vis regulation) and organizational specificities (small or big DSO, rural or urban). Nonetheless, even in drastically different contexts (Canada vs EU), the underlying factors that limit innovation activity within the sector are fairly similar. Thus, in developing capability strategies in the European context, learnings from other places can be used.
2. Regulatory barriers and access to financing represent a significant hurdle for flexibility markets and DSOs involvement in them. However, several regulatory developments are currently in the pipeline, and as the situation progresses further, other types of barriers will become more urgent.
3. Both academic literature, flexibility related research projects and DSOs themselves tends to pay more attention to the barriers that are external to DSOs, or in other words, barriers that lie outside of the direct scope of DSOs' influence. To an extent, this reflects a historically passive role of the DSOs in change processes within the sector. In this task, and in particular in the next chapter, we choose to look at DSOs as organisational entities, and focus on the things they themselves can improve, to evoke a faster pace of change.
4. Most of the barriers are interconnected. This means that the future landscape, while hard to predict, is likely to be drastically different from today's. The interconnectedness also means that a more targeted approach, with focus on a small number of obstacles, can prove to be effective.
5. Within the innovation system, the innovation processes that the DSOs can focus on improving are those of knowledge diffusion – both externally and internally, market formation and resource mobilization. It is, however, worth noting, that DSOs are only a small part of the innovation system, and their efforts will have to be coordinated and complemented by other actors' efforts, most notably, policymakers.

5. Innovation capabilities and capacity strategies

To accommodate for the fast pace of changes within the sector, DSOs will have to develop – or improve on - several capacities and skills within commercial operations, market management, systems operations and management and network planning, among other areas (Eurelectric, 2019). Future DSOs will have to perform a balancing act between maintaining a reliable grid and enabling a fast-paced transition, all this while keeping the costs reasonably low. To do this, they must innovate and ensure that the innovations flow smoothly from the idea or test stage to the upscaled implementation stage.

Innovation capability and capability gaps within the utility sector

Organizational innovation capability is broadly defined as the ability of organizations to develop and implement innovations (Teece et al., 2001). In this chapter, when discussing innovation capability, we focus on one type of organizations – DSOs, and one type of innovations – solutions related to flexibility markets, with a focus on solutions developed within FlexiGrid when possible. Nonetheless, sector's experiences with other innovations and other parts of the collective utilities sector are considered whenever it is relevant.

To outline which strategies can be deployed to increase innovation capability, it is first necessary to understand (1) the factors that define how successful companies are in dealing with innovations and (2) the main sources of capability gaps. Utility organizations worldwide, including electric utilities, face major capability gaps, manifesting in inadequate organizational structures, lack of know-how and skills (Worch et al., 2013). The challenges they are facing with regards to capability development are both of operational (managing the built infrastructure) and strategic (developing the infrastructure to meet future demands) nature (Dominguez et al., 2009, Schmidt et al., 2012). Generally speaking, there are three ways performance deficiencies are analyzed within the utility sector. The first two are principal-agent approach and transaction cost economics. These are more externally oriented and seek to correct for information asymmetries stemming from the monopolistic position of the utilities through the means of regulation. The third approach, capability-based, is more internally oriented. While it acknowledges the role of regulation and external developments, at the center of the approach is the organizational capabilities of individual organizations.

According to the capability-based approach, the main sources of capability deficiencies within utilities stems from the characteristics of the utility sector (Worch et al., 2013). Depicted below is a representation of the root causes and manifestations of the capability gaps that arise within the sector.

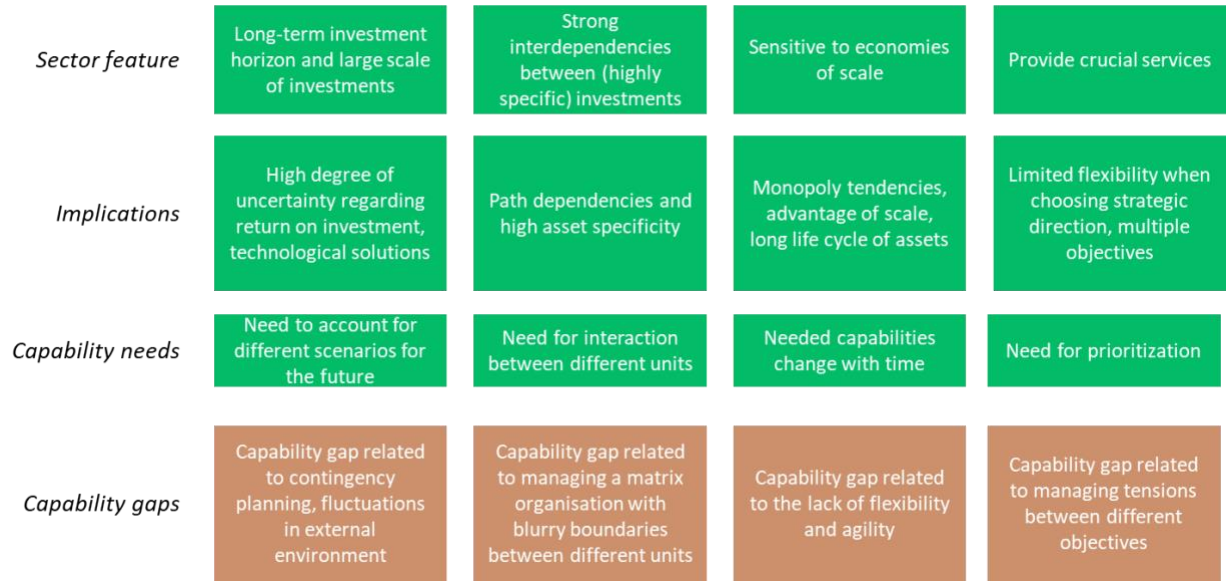

Figure 4 - Sources and types of capability gaps within the utility sector

Source: Own elaboration based on Worch et al., 2013

The features of the sector lead to several implications for the functioning of the organizations. These are high degree of uncertainty regarding investments made and the technological solutions chosen, lock-in effects stemming from long life cycle of main assets, advantage of scale resulting in monopoly situation, and limitations in choosing the strategic direction. These characteristics entail certain capability needs that companies within the sector must possess to thrive in the long run, such as the ability to prioritize and account for multiple futures in planning, as well as the ability to collaborate across the organizational units. In addition, the needed capabilities tend to be constantly evolving. A capability gap, then, represents an unmet capability need within an organization. The common capability gaps are related to inadequate contingency planning, managing an interlinked organization with conflicting objectives and lack of agility. Effective strategies to increase innovation capability of the DSOs should therefore aim at eliminating these capability gaps.

Strategies for increasing innovation capability

Found below is the description of the main strategies to increase innovation capability, identified through a literature scan of academic articles and reports within the fields of innovation and transition management.

Alignment with the organizational vision and strategy

While flexibility-related innovations are currently far from being an urgent strategic issue, a degree of alignment of the solutions with the general vision and strategy of the DSOs can aid the uptake of the solutions. For flexibility solutions to gain top-down support, they must either contribute to solving strategic challenges and issues facing the DSOs or provide a strategic opportunity. One important pre-requisite for this is understanding and communicating internally the value of flexibility for the company. The value categories, or main uses of flexibility, are highly context dependent, and linked to, for

example, the characteristics of the electricity grid, such as the renewables penetration rate, related balancing needs, dimensioning of the network.

One strategy for better alignment with the general strategy is introduction of portfolio thinking for participation in publicly funded R&I projects. Portfolio thinking starts with a mapping of the past and current innovation projects that the company engages in according to their main focus area, contribution to the vision and goals of the organization and the main strategic areas, expected outcomes and follow-up actions. This helps create understanding around the interlinkages between R&D action within flexibility markets and the high-level goals and the general direction of the DSO. Ultimately though, the success of the alignment depends heavily on external factors, such as evolution of the regulatory environment or the pace of change in electrification, to name a few. A more actionable strategy is thus fostering an organizational structure where such links are clear from the beginning.

Favorable organizational structure to promote organizational learning

Elements such as the structure of the organization and the overall innovation culture can significantly improve, or impede, the diffusion of the solutions. The logic of many EU-funded projects implies that the participating companies build enough knowledge to successfully implement the innovations further down the line. However, bridging the knowledge-action gap is often not straight-forward. Knowledge about the solutions, their benefits and constraints, must effectively penetrate the whole organization, from leadership to operation.

One of the frequently encountered structural issues, described in Chapter 4, is weak links between the organizational units dealing with R&D activities, business development activities, finance, and general strategy. Dealing with flexibility solutions exclusively as part of R&D activities builds a solid in-house knowledge base, but the knowledge created is not efficiently disseminated within the company. In contrast, if flexibility solutions are solely dealt with as a potential new business area, not enough fundamental knowledge is created to successfully implement the solutions.

Ultimately, the action boils down to integrating the knowledge into both strategic and operational processes. One key strategy to improve within this area, short of regrouping into a matrix organization, has to do with increasing collaboration between different departments or units, which is not always easily done given the general shortage of resources. However, establishing interdepartmental working groups is one strategy that may prove cost effective, since it does not require permanent changes to organizational structure. Making sure that these groups have a clearly defined focus is important for the success of this strategy.

Involving several people from different parts of the same organization in the innovation projects could help retain the knowledge within the organization in the long run. Establishing differentiated communication strategies, where the information is communicated in the amount and form adequate for the part of organization being targeted, is a helpful supporting strategy to save resources and improve the efficiency of the knowledge dissemination activities. Most of the publicly funded innovation projects have budgets for communication activities which could be leveraged for this purpose.

Supporting individuals that act as promoters and early adopters

While institutionalizing knowledge is crucial for continuity, the contribution of individuals in driving innovation and transition processes should also be leveraged. The topic of individual contributions is frequently overlooked in academic literature on sustainability transitions (Fernqvist, 2021). This is in

stark contrast with the empiric observations, where it is individuals in various positions (often leadership or managerial roles) who tend to initiate the innovation process and act internally as advocates for the change. Particularly in small DSOs, the scope of action frequently boils down to the ambitions and drive of individual employees. However, the nature of the industry, the general resistance to change and risk aversion may make it hard to retain the employees that function as advocates for innovation or intrapreneurs.

According to Fernqvist (2021), some of the barriers for individual engagement in transition processes include software structures, corporate reward system and perceived time and budget pressure. One of the strategies that the author suggests is decoupling entrepreneurial activities by individuals from business development, whereby experimentation is allowed without necessarily directly leading to a new business area or new income stream. Related actions can include inspirational study visits for employees, which can often be financed through external means, such as nationally and regionally available research funding. Encouraging participation of employees in entrepreneurially active networks within the energy industry is another way to help retain entrepreneurial employees.

Mobilizing financial resources

Both small-scale, experiment-based implementation, and large-scale implementation of flexibility solutions require mobilization of financial resources. As demonstrated in the previous chapter, this constitutes one of the most significant barriers for innovation named by the project's DSOs. This issue manifests in several forms. It is not only about the lack of finances and access to funding opportunities as such, but also about the lack of knowledge about funding opportunities, or lack of understanding of the financial implications of implementing a solution (it's potential for cost reduction or revenue increase). Activities performed within Task 9.4 of the project regarding the business models can be considered the first step in building a broad understanding of the financial implications of flexibility markets. Quantifying the gains proved to be impossible at this stage, given that most of the business models are designed as test solutions. However, in the future, even rough estimations can help realize the scope of the potential and communicate financial needs to relevant stakeholder groups more efficiently.

A pre-requisite for doing that is choosing the exploitation path. For DSOs, several potential routes exist for exploitation of technologies and know-how within the project, for example through licensing, internal product development or follow-up R&D projects. The choice of an exploitation path depends on several factors, both internal and external, such as the TRL of the solution by the end of the project, external conditions such as regulation and market, DSOs strategic priorities, resources available. In addition, the exploitation path has to be coordinated with the IPR strategy (see T9.1).

One strategy to minimize risks and increase odds for appropriate timing is through applying a proactive, speculative approach that complements rigid financial planning. The main risks associated with flexibility are those of stranded investments, given that investment and other financial decisions are made in the highly uncertain landscape. Talking about business model innovation is therefore often hard, given that, at present, most of these business models are not feasible given external constraints such as regulation or lack of a viable technological solution. Conditional roadmaps and business models or phased investment plans models are two of the tools that can be used to mitigate this issue. Conditional roadmaps and business models work by linking actions or elements of a traditional business model or a roadmap to a certain assumption about the environment, or a certain external action. This was partially

tested within T9.4 through asking the companies to describe the external conditions required for the implementation of the business models they developed.

A related strategy for mobilizing resources in the face of uncertainty and resource constraint is developing phased investment plans, which start with the low-hanging fruits and continue towards increasingly ambitious measures. In addition to limiting cost exposure and risk of stranded assets in the short-term, phased investment plans can act as a negotiation tool when showed to policymakers, since it demonstrates long-term commitment to the cause.

Future-proofing the organization and streamlining internal processes

Contingency planning is one capacity area that is universally mentioned as needed. Within the utilities sector, there is a long standing tradition of dealing with contingency planning on the operational level, where the main contingencies are relatively easy to predict, model and analyze. However, it is significantly less prevalent on the strategic level, where the main contingencies are often found outside of the boundaries of the sector.

To improve within the area of contingency planning, DSOs may perform stress-testing the organizational capabilities and skills against various lists of required competencies and roles that the future DSOs are expected to uptake. In addition, it can be helpful to understand future developments beyond the energy sector. For each of the identified potential changes in the external environment, it is worth considering:

- The degree of preparedness. Which of the changes the DSO is most/least prepared for? Why?
- Undergoing or planned initiatives linking to the change. Name projects or other initiatives that help the DSO to thrive given the change
- Potential future action related to the change. Brainstorm additional action, conditions for each action (e.g. policy action), resources required to realize the initiative (collaboration partners, financial resources, knowledge)

Another way to boost preparedness is through systematically working with new forms of strategic risk management. Two examples of risks that the DSOs are expected to face and are not always, self-reportedly, sufficiently equipped to deal with are cybersecurity and the risk of stranded assets.

Finally, several improvements can be implemented on the operational side to facilitate the innovation process, from implementing a comprehensive innovation management system to reviewing procurement and purchasing processes. Within FlexiGrid project, the solution providers expressed that a clear bottleneck for their communication with the DSOs was DSOs' unclear processes for buying new services, products and systems, which made it difficult to reach out to the right person with the right information. On the other hand, it could also entail a significant administrative burden and slow down the processes.

Cultivating collaborative culture

While building internal knowledge is an important piece of the puzzle, some degree of reliance on external know-how can be expected. As previously demonstrated, flexibility solutions require involvement of end-users, collaboration with sectors such as mobility and commercial real estate, and collaboration with TSOs. The nature of interactions between DSOs and third parties is changing. While on operational side, technology decisions are often considered to be one-off transactions. The issue with the transactional approach is often lack of trust between the parties and an expectation of strict

planning, not always feasible within the context of innovation projects. The nature of innovation requires more collaborative relationships (de Reuver, 2016). For example, instead of buying a technology, system or other component from a third party, the grid operator may choose to develop the system jointly and opt for shared intellectual property rights. The benefits of a relational approach to governing innovation projects include the possibility to tailor the solutions and build trust between the parties. The required shift from transactional towards relationship approach is especially evident when dealing with end users, where systematic engagement of end user through understanding their motivations, using price signals and measuring customer response is often recommended.

With many of the barriers lying outside of the direct sphere of influence of the DSOs, the benefits of collaboration are manifold. They range from sharing knowledge to pooling resources such as financing and physical assets to aligning the expectations to advocating their interests. Such collaboration can take many forms from coalitions to partnerships to networks. In Canada, an example of a successful collaboration within the sector is that of the Advanced Energy Centre. The initiative was launched with the goal to foster cross-sector cooperation within the electricity sector and bring solutions from pilot scale to commercial scale (Advanced Energy Centre, 2019). The centre brings together several perspectives on electricity sector innovation, such as those of utilities, innovators/solution providers, regulators, government and customers. Several tools are employed to foster the dialogue, such as roadmap and scenario exercises, with the goals to align perspectives and challenge conventional thinking.

One specific issue that demands attention of multistakeholder initiatives is that of the role distribution. The need for clarity on the best way forward when it comes to the role of the DSOs was highlighted both as part of the interviews and in the literature reviewed. This was one of the messages that FlexiGrid communicated to policymakers as part of Milestone 10.

Coordination on policy relevant issues and obstacles to innovation

Gathering forces and advocating for regulatory change lies within the scope of the DSOs' influence and acts as a powerful tool to improve the functioning of the innovation system. Milestone 10 of FlexiGrid project focused on communication with policymakers (Tobiasson, 2021). The following insights were communicated through a number of channels:

1. Roles and responsibilities of different actors must be clarified
2. New incentive schemes and economic regulation framework have to be introduced
3. Capacity building programs should increasingly target small actors
4. Market design must be context-specific and appropriately sized
5. Important policy areas are preventing market manipulation, introducing a degree of standardization

Featured below are the mechanisms through which the recommendations outlined above help foster the functioning of the innovation system (Figure 5).

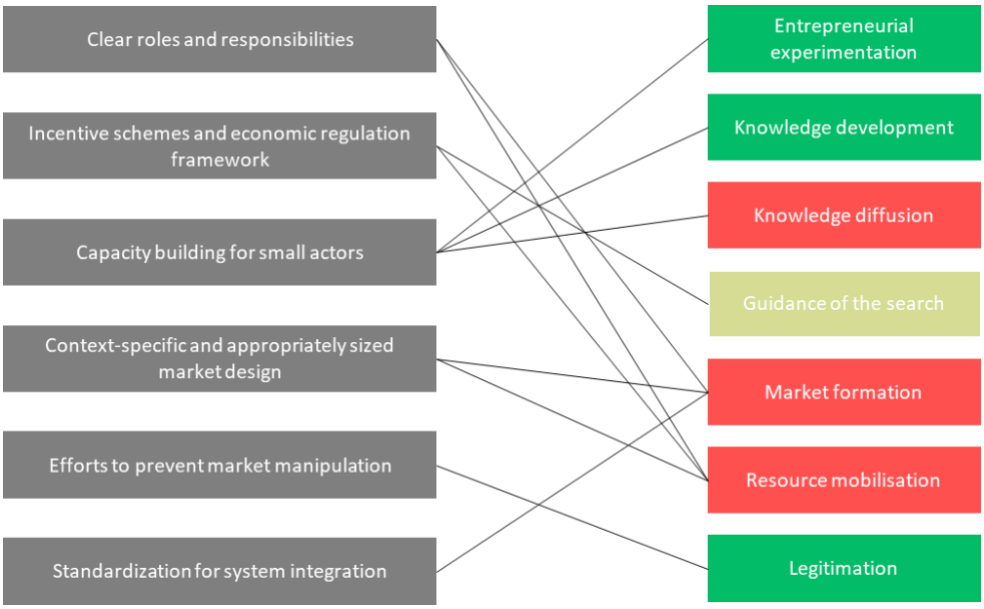

Figure 5 -Policy suggestions and their (main) effects on the innovation system

Establishing the expected roles and responsibilities will bring about the necessary clarity and thus facilitate market formation and long-term resource mobilization. Encouraging participation through economic means will accelerate market formation and increase potential market size. It is also a powerful instrument to guide the investments into the area. While primary effects of capacity building for small actors are on knowledge development and diffusion, capacity building programs act as a way to increase market participation in the long-term and enhance entrepreneurial activity within the area. Context-specific market design helps implement adequate business models that work given the environment, thus accelerating market formation, and ensure the resource mobilization is appropriately scaled. Preventative measures contributed to continued legitimacy of the field. Standards help to interlink different parts of the system, thus creating an overall big market. Overall, several conclusions can be drawn from the figure and the analysis:

1. Policy instruments represent a powerful intervention type to improve the functioning of the innovation system
2. Multiple policy instruments exist that can target market formation and resource mobilization. However, this does not mean that they are redundant. Rather, they target different aspects of these functions and should be implemented in tandem.
3. Related to the previous point, policy mixes approach should be advocated for, since different policy measures target different innovation processes. Synergies between different policies should be analyzed, and trade-offs minimized.

Summary

Featured in Table 5 below is the summary of the main strategic areas and strategic actions within each area that the DSOs can use to enhance their innovation capability.

Table 5 - Main areas and applicable tools and strategies to increase innovation capability

Area	Strategies

Alignment with organizational vision and strategy	Understanding the value of flexibility Linking flexibility to the main strategic challenges and opportunities Portfolio approach to R&D projects
Favorable organizational structure	Establishing issue-centered interdepartmental working groups
Promoting organizational learning and knowledge dissemination	Involving several people in innovation projects (targeted involvement) Differentiated communication strategies
Supporting individuals that act as promoters and early adopters	Allowing for experimentation that does not lead to direct business opportunities Individual based networks with entrepreneurial focus within the sector
Mobilizing financial resources	Conditional roadmaps and business plans, continuous work on business model development with periodic revisiting Phased investment strategies starting with low-capex initiatives
Future-proofing the organization and streamlining internal processes	Stress-testing the organization against future scenarios Identifying new risks and developing action plans Expanding risk management activities to outside the sector Overseeing procurement and purchasing mechanisms
Cultivating collaborative culture	Moving away from transactional towards relational approach to innovation management Long-term partnerships Increasing collaboration with actors outside of the traditional lines of the sector Engagement with end-users through understanding their motivations, using price signals and measuring customer response Using publicly financed projects as a way to communicate the needs externally Regular knowledge exchange with solution providers and other stakeholders

Increasing the innovation capability requires action on all fronts, from strategic to operational, from little tweaks to culture shifts, from mobilizing people and resources to streamlining processes and adjusting existing structures. While the number of actions might seem overwhelming, it is up to each DSO to figure out which of the actions to focus on, based on the initial assessment of their weaknesses and strengths.

Analysis of innovation capacity strategies

As mentioned in the previous chapter, the main potential to support the innovation system surrounding flexibility markets lies within the innovation processes of knowledge dissemination, market formation and resource mobilization. In addition, we conclude that the effective strategies must target the main capability gaps typical of the utility sector, namely, inadequate contingency planning, managing an interlinked organization with conflicting objectives and lack of agility. In this subchapter, we analyze the identified capability strategies through two lenses:

1. Their contribution to the functioning of the innovation system
2. Their contribution to address the capability gaps

Innovation strategies and their contribution to the functioning of the innovation system

Chapter Barriers for innovation and implementation of future grids introduced the three innovation processes (knowledge dissemination, market formation and resource mobilization), where DSOs have an agency to act and an important role to play. The previous subchapter introduced a number of general strategies that can be implemented to support innovation work within DSOs. Table 6 illustrates the connection between the two, namely, it illustrates which of the prioritized innovation processes can be improved by implementing which strategies. For specificity, the strategies are broken down to the action level.

Table 6 – Strategies and their contribution to the innovation processes

Innovation process	Applicable strategies
Knowledge dissemination	Establishing interdepartmental working groups Involving more people internally in publicly financed projects (targeted involvement) Regular knowledge exchange with solution providers and other stakeholders Differentiated communication strategies Linking projects to existing initiatives and strategic priorities
Market formation	Continuous work on business model development with periodic revisiting Increasing collaboration with actors outside of the traditional lines of the sector Overseeing procurement and purchasing mechanisms
Resource mobilization	Phased investment strategies/roadmaps conditional on external actions, starting with incremental, low-capex initiatives Engaging the end user through understanding their motivations, using price signals and measuring customer response Using publicly financed projects to communicate the needs externally

When it comes to knowledge dissemination internally, the main issue to overcome is that of siloed thinking, both within the organization and with other organizations. The main dilemma that the strategies aim to solve is how to ensure broad participation and stakeholder interactions while not dissipating the effort, attention and resources. Within the process of market formation, and in presence of legal and economic constraints, the main dilemma for DSOs is how to advocate for their needs efficiently and to the relevant stakeholders. Within resource mobilization, the problem is the highly uncertain environment and the lack of economic incentives, which together lead to an action paralysis. External changes make it hard to commit and come up with detailed business and investment plans, justifying novel approaches to financial planning.

It is worth noting that the strategies also contribute to other innovation processes. For example, alignment with organizational vision and strategy is strongly linked with the innovation functions guidance of the search and legitimation, while supporting individual action of employees may foster entrepreneurial experimentation/intrapreneurship activities.

Not all the strategies contribute to the selected innovation processes. However, rather than treating it as an indication that some strategies are more important than others, it should be regarded as a limitation of the innovation system approach. Due to the external orientation of TIS framework, it overlooks some of the positive effects of the strategies, which is why we complement the assessment with looking at how they contribute to bridging the previously identified innovation capability gaps.

Innovation strategies and their contribution to address the capability gaps

Figure 6 features the contribution of the identified innovation strategies to address the main capability gaps common among the DSOs, with thick connection lines representing the main gap addressed by each strategy, and thinner lines – additional contributions of each strategy/other gaps that the strategy can help bridge.

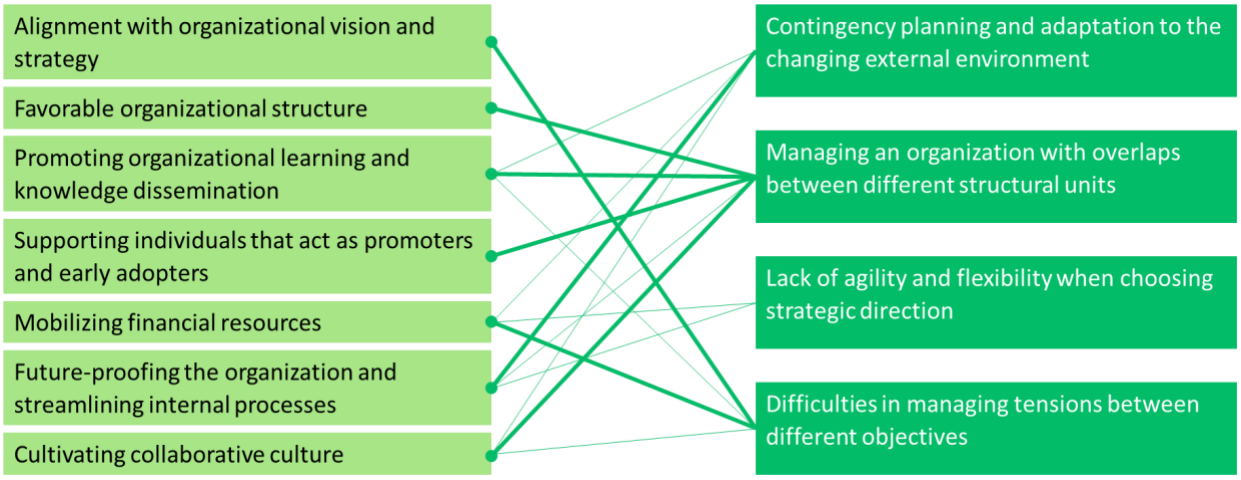

Figure 6 – Innovation strategies and their contributions to address the capability gaps

As can be seen from the figure, multiple strategies can be employed to bridge the common capability gaps. Managing an organization with functional overlaps between different structural units seems to be a gap that is comparatively easy to overcome, with multiple strategies available to correct it. This is partly due to the fact that this gap is the most internally oriented one, and does not involve external parties to the same degree as the other gaps do. One gap area that remains insufficiently addressed by comparison is that of the lack of agility and flexibility when choosing strategic direction. In some ways, and to a bigger extent than with other capability gaps, this is a natural limitation that the sector has to work around rather than address directly. Nonetheless, continuous scanning of the external environment may increase the DSOs' chances that the strategic direction they end up choosing and have to adhere to is a successful one. Actions suggested withing the strategy array of mobilizing financial resources may help maintain a certain degree of flexibility in an otherwise rigid landscape.

6. Conclusions and reflections

In this study, we first looked at the future market context, then proceeded to describe the main innovation barriers facing the DSOs and concluded with the main capacity building strategies that the DSOs can employ to increase their level of success in the rapidly changing playing field.

The identified emerging factors in Chapter 2 demonstrate that the area of flexibility markets is being shaped by a multitude of factors, sometimes of mutually reinforcing and sometimes pointing in opposing direction. The identified developments entail emerging challenges for DSOs, which justifies a need for increased innovation activity among companies in the sector. The analysis of the barriers for innovation in Chapter 3 demonstrates that preparing for a linear future with incremental, easy to predict changes within the system is no longer a viable strategy for DSOs. While we recognize that the DSOs are quite limited in their scope of action, due to the nature of the sector and the political, technological, and economic landscape, it is our strong conviction, based on the reviewed literature and grounded in innovation research, that the future requires a significantly more active stance from this type of organizations.

It is against this background that the main strategies are suggested in Chapter 4. The identified innovation capabilities may serve as a starting point for internal discussions within the DSOs but operationalizing and implementing these strategies will require a lot of effort, often in coordination with other stakeholders, and sometimes directly conditional upon their timely action.

In fact, this study's focus on the DSOs perspective and on actions that fall within reach of the DSOs can be seen as both its strength and a significant limitation. On the one hand, while reviewing the literature, we noted that DSO's perspective is often overlooked, and relatively few studies treat DSOs as organizations operating in a business environment. On the other hand, the challenges facing the electricity markets require concerted efforts from many stakeholders, where different objectives must be aligned, interests considered, and consensus reached. Focusing on the needs of one actor group, then, is to an extent counterproductive. To correct for this limitation, we invite other stakeholder groups, not the least policymakers, to read this, and other similar, studies, to better understand the needs of the DSOs and their point of view, as well as to gain insights into the main hurdles of the innovation policy within the sector. We also invite the research community to bring the much-needed transition perspective into a sector that has long been characterized by rigidity and stability. We hope to have contributed to the broader field of sustainability transitions and innovation research by shedding some light on how individual actors may act to support an innovation system, combining actor-based perspective with system-based perspective on innovation. While we touch upon it briefly in this report, the contribution of individuals within the organizations to achieve the sustainability transitions remains an interesting research area to follow up on.

References

Advanced Energy Centre. (2019). Collaborate to Innovate. Realizing the innovation potential of Canada's electricity system through cross-sector collaboration

AF-Mercados. (2015). Study on tariff design for distribution systems. EU DG Energy.

Anaya, K.L and Pollitt, M.G. (2020), Regulation and policies for local flexibility markets: Current and future developments in seven leading countries. Project Merlin Milestone Three Report, A report for Scottish & Southern Electricity Networks.

Aslani, A., & Mohaghar, A. (2013). Business structure in renewable energy industry: Key areas. Renewable and Sustainable Energy Reviews, 27, 569-575.

Baker, P. (2020), Challenges facing distribution system operators in a decarbonised power system, Brussels: Regulatory Assistance Project.

Behrangrad, M. (2015). A review of demand side management business models in the electricity market. Renewable and Sustainable Energy Reviews, 47, 270-283.

Bell, K., & Gill, S. (2018). Delivering a highly distributed electricity system: Technical, regulatory and policy challenges. In Energy Policy (Vol. 113, pp. 765–777). Elsevier BV.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme for analysis. Research Policy 37, 407–429.

Botelho, D. F., Dias, B. H., de Oliveira, L. W., Soares, T. A., Rezende, I., & Sousa, T. (2021). Innovative business models as drivers for prosumers integration - Enablers and barriers. In Renewable and Sustainable Energy Reviews (Vol. 144, p. 111057). Elsevier BV.

Bouloumpasis, I., Steen, D., & Tuan, L. A. (2019). Congestion Management using Local Flexibility Markets: Recent Development and Challenges. In 2019 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe). 2019 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe). IEEE.

Bray, R., Woodman, B. (2019). Barriers to Independent Aggregators in Europe. EPG Working Paper: EPG1901

Bryant, S. T., Straker, K., & Wrigley, C. (2018). The typologies of power: Energy utility business models in an increasingly renewable sector. Journal of Cleaner Production, 195, 1032-1046.

Cambini, C., & Soroush, G. (2019). Designing grid tariffs in the presence of distributed generation. In Utilities Policy (Vol. 61, p. 100979). Elsevier BV.

Canada's Tech Network. (2014). Why the energy sector must overcome barriers to innovation

Castagneto Gissey, G., Dodds, P. E., & Radcliffe, J. (2018). Market and regulatory barriers to electrical energy storage innovation. In Renewable and Sustainable Energy Reviews (Vol. 82, pp. 781–790). Elsevier BV.

Castaneda, M., Franco, C. J., & Dyner, I. (2017). Evaluating the effect of technology transformation on the electricity utility industry. In Renewable and Sustainable Energy Reviews (Vol. 80, pp. 341–351). Elsevier BV.

CEER (2018). Incentives Schemes for Regulating Distribution System Operators, including for innovation. A CEER Conclusions Paper (2018)

Colle, S., Micaleff, P. (2019:1). How DSOs can keep pace with the fast-moving energy transition. E&Y.

Colle, S., Micaleff, P., Legg, A., Horstead, A., Breakell, J. (2019:2). Where does change start if the future is already decided? EURELECTRIC, E&Y.

Connolly, D., Lund, H., Mathiesen, B. V., Pican, E., & Leahy, M. (2012). The technical and economic implications of integrating fluctuating renewable energy using energy storage. Renewable energy, 43, 47-60.

Csedő, Z., & Zavarkó, M. (2020). The role of inter-organizational innovation networks as change drivers in commercialization of disruptive technologies. International Journal of Sustainable Energy Planning and Management, Vol. 28 (2020).

de Reuver, M., van der Lei, T., & Lukszo, Z. (2016). How should grid operators govern smart grid innovation projects? An embedded case study approach. In Energy Policy (Vol. 97, pp. 628–635). Elsevier BV.

Denicolai, S., Ramirez, M., & Tidd, J. (2014). Creating and capturing value from external knowledge: the moderating role of knowledge intensity. R&D Management, 44(3), 248-264

Dominguez, D., Worch, H., Markard, J., Truffer, B., & Gujer, W. (2009). Closing the Capability Gap: Strategic Planning for the Infrastructure Sector. In California Management Review (Vol. 51, Issue 2, pp. 30–50). SAGE Publications.

Dosi, G., Nelson, R. R., & Winter, S. (Eds.). (2001). The Nature and Dynamics of Organizational Capabilities. Oxford University Press.

E.DSO. (2018). FLEXIBILITY IN THE ENERGY TRANSITION. A Toolbox for Electricity DSOs

EC (2019), Do current regulatory frameworks in the EU support innovation and security of supply in electricity and gas infrastructure? Final Report. Directorate-General for Energy, Brussels: European Commission.

Eid, C., Codani, P., Perez, Y., Reneses, J., and Hakvoort, R. (2016). 'Managing electric flexibility from Distributed Energy Resources: A review of incentives for market design'. Renewable and Sustainable Energy Reviews, 64:237 – 247.

Eurelectric. (2016). Innovation incentives for DSOs - a must in the new energy market development

European Commission. Directorate General for Energy., Tractebel Impact., & Navigant. (2020). Regulatory priorities for enabling demand side flexibility. Publications Office.

European Commission. Joint Research Centre. (2019). Distribution system operators observatory 2018: overview of the electricity distribution system in Europe. Publications Office.

European Smart Grids Task Force (2019). Final Report: Demand Side Flexibility – Perceived barriers and proposed recommendations.

Forouli, A., Bakirtzis, E. A., Papazoglou, G., Oureilidis, K., Gkountis, V., Candido, L., Ferrer, E. D., & Biskas, P. (2021). Assessment of Demand Side Flexibility in European Electricity Markets: A Country Level Review. In Energies (Vol. 14, Issue 8, p. 2324). MDPI AG.

Frame, D., Hannon, M., Bell, K., & McArthur, S. (2018). Innovation in regulated electricity distribution networks: A review of the effectiveness of Great Britain's Low Carbon Networks Fund. In Energy Policy (Vol. 118, pp. 121–132). Elsevier BV.

Frei, F., Sinsel, S. R., Hanafy, A., & Hoppmann, J. (2018). Leaders or laggards? The evolution of electric utilities' business portfolios during the energy transition. Energy Policy, 120, 655-665.

Gerard, H., Six, D., & Puente, E. R. (2015). Innovation by Distribution System Operators: More than a question of remuneration. In 2015 12th International Conference on the European Energy Market (EEM). 2015 12th International Conference on the European Energy Market (EEM). IEEE.

Gonzalez Venegas, F., Petit, M., & Perez, Y. (2021). Active integration of electric vehicles into distribution grids: Barriers and frameworks for flexibility services. In Renewable and Sustainable Energy Reviews (Vol. 145, p. 111060). Elsevier BV.

Good, N., Ellis, K., and Mancarella, P. (2017). Review and Classification of Barriers and Enablers of Demand Response in the Smart Grid. Renewable and Sustainable Energy Reviews, 72.

Günther, O., Politopoulou, S., & Verreth, D. (2017). Innovation incentives for distribution systems operators – a must in the new energy market development. In CIRED - Open Access Proceedings Journal (Vol. 2017, Issue 1, pp. 2791–2794). Institution of Engineering and Technology (IET).

Hall, S., & Roelich, K. (2016). Business model innovation in electricity supply markets: The role of complex value in the United Kingdom. Energy Policy, 92, 286-298.

Hastings-Simon, A. (2021). Barriers to innovation in the Canadian electricity sector and available policy responses. Canadian Institute for Climate Choices

Heinrich, C., Ziras, C., Syrri, A. L. A., & Bindner, H. W. (2020). EcoGrid 2.0: A large-scale field trial of a local flexibility market. In Applied Energy (Vol. 261, p. 114399). Elsevier BV.

IEA. (2022). Canada Electricity Security Policy.

IRENA. (2019). Innovation landscape brief: Future role of distribution system operators.

Jarry, G., Servant, L. (2021). Understanding European flexibility markets. Accenture

Jin, X., Wu, Q., & Jia, H. (2020). Local flexibility markets: Literature review on concepts, models and clearing methods. In Applied Energy (Vol. 261, p. 114387). Elsevier BV.

Johansson, P., Vendel, M., & Nuur, C. (2020). Integrating distributed energy resources in electricity distribution systems: An explorative study of challenges facing DSOs in Sweden. In Utilities Policy (Vol. 67, p. 101117). Elsevier BV.

Kerscher, S., & Arboleya, P. (2022). The key role of aggregators in the energy transition under the latest European regulatory framework. In International Journal of Electrical Power & Energy Systems (Vol. 134, p. 107361). Elsevier BV.

Knezović, K., Marinelli, M., Zecchino, A., Andersen, P.B., Traeholt, C. (2017), 'Supporting involvement of electric vehicles in distribution grids: Lowering the barriers for a proactive integration', Energy, 134: 458-468.

Lockwood, M. (2016). Creating protective space for innovation in electricity distribution networks in Great Britain: The politics of institutional change. In Environmental Innovation and Societal Transitions (Vol. 18, pp. 111–127). Elsevier BV.

Meeus, L. and Saguan, M. (2011), 'Innovating grid regulation to regulate grid innovation: From the Orkney Isles to Kriegers Flak via Italy', Renewable Energy, 36 (6): 1761-1765.

Meijer, L. L. J., Huijben, J. C. C. M., Van Boxstael, A., & Romme, A. G. L. (2019). Barriers and drivers for technology commercialization by SMEs in the Dutch sustainable energy sector. Renewable and Sustainable Energy Reviews, 112, 114-126

Natural Resources Canada. (2020). Navigating Barriers to Utility Investment in Grid Modernization.

Nordic Council of Ministers (2017:1). Flexible demand for electricity and power : Barriers and opportunities. Nordic Council of Ministers

Nordic Council of Ministers. (2017:2). Demand side flexibility in the Nordic electricity market. In TemaNord.

Pereira, G.I., Pereira da Silva, P. and P.A. Cerqueira. (2020). Electricity distribution incumbents' adaptation toward decarbonized and smarter grids: Evidence on the role market, regulatory, investment, and firm-level factors. Energy Policy, 142:111477.

Pollitt, M., Guiletti, M., Anaya, K. (2021). Optimal regulation for European DSOs to 2025 and beyond. Centre on Regulation in Europe (CERRE).

Richter, M. (2013). German utilities and distributed PV: How to overcome barriers to business model innovation. Renewable Energy, 55, 456-466.

Schachter, M. (2016). Flexible investment under uncertainty in smart distribution networks with demand side response. Energy Policy vol 97.

Schmidt, T. S., Schneider, M., Rogge, K. S., Schuetz, M. J. A., & Hoffmann, V. H. (2012). The effects of climate policy on the rate and direction of innovation: A survey of the EU ETS and the electricity sector. In Environmental Innovation and Societal Transitions (Vol. 2, pp. 23–48). Elsevier BV.

Siface, D., Migliavacca, G., Rossi, M., Kockar, I., Morch, A., Gerard, H., Vardanyan, Y. (2019). Policy recommendations to implement and/or overcome barriers and enable TSO-ISO integration

Teece, D. J., Pisano, G., & Shuen, A. (2001). Dynamic Capabilities and Strategic Management. In The Nature and Dynamics of Organizational Capabilities (pp. 334–362). Oxford University PressOxford.

Timeus, K., & Gascó, M. (2018). Increasing innovation capacity in city governments: Do innovation labs make a difference? In Journal of Urban Affairs (Vol. 40, Issue 7, pp. 992–1008). Informa UK Limited.

Van Lancker, J., Mondelaers, K., Wauters, E., & Van Huylenbroeck, G. (2016). The Organizational Innovation System: A systemic framework for radical innovation at the organizational level. In Technovation (Vols. 52–53, pp. 40–50). Elsevier BV

Worch, H., Truffer, B., Kabinga, M., Eberhard, A., & Markard, J. (2013). A capability perspective on performance deficiencies in utility firms. In Utilities Policy (Vol. 25, pp. 1–9). Elsevier BV.

Zabaleta, K., Casado-Mansilla, D., E.Borges, C., Kapassa, E., Preßmair, G., Stathopoulou, M., & López-De-Ipiña, D. (2020:1). Taxonomy of barriers that hinders Local Flexibility Market proliferation (Version 1) [Data set]. Zenodo.

Zabaleta, K., Casado-Mansilla, D., Kapassa, E., Borges, C. E., Presmair, G., Themistocleous, M., & Lopez-de-Ipina, D. (2020:2). Barriers to Widespread the Adoption of Electric Flexibility Markets: A Triangulation Approach. In 2020 5th International Conference on Smart and Sustainable Technologies (SpliTech). 2020 5th International Conference on Smart and Sustainable Technologies (SpliTech). IEEE.

Appendix 1 – Interview questions

Introduction

1. Regarding the solutions developed within FlexiGrid project:
    a. What is the value of them for your organization?
    b. What are the challenges and issues you see, any concerns you have in relation to them?
2. Describe some of the innovations or innovation areas within the field of flexibility markets that you are developing or participating in outside of FlexiGrid (in project or any other form)?
3. What are your expectations about the future state of the flexibility markets? How much do you expect the field to grow in the next 5 years? 10 years? 20 years?
4. How much do you expect your business model to change following this development? Do you see the need for a radical change or rather minor tweaks to how you operate, or something in between?

External barriers to innovation

5. What do you see as the main barriers for flexibility markets in terms of policy and regulation? On the national and regional level?
6. What are the main market-related barriers you face? Consider the following factors:
    a. Pricing structures
    b. Competition
    c. Demand and user involvement
    d. Business processes
    e. Other
7. What are the changes required in terms of consumer behavior and societal norms for flexibility innovations to take off?
8. Describe your role in supporting the development vis-à-vis other actors. Is there a clear division of responsibilities?
9. Are there any other external factors that affect your company's involvement in flexibility markets?

Internal barriers to innovation and innovation capabilities

10. In order to increase innovation activities in the area, what are some of the knowledge areas where you are lacking?
11. Describe the organizational decision-making process regarding innovation. How is the innovation work organized within the company? (e.g. a specific department vs a function across the departments)
12. Do you consider the resources you have to be sufficient to increase your participation in flexibility markets? With regards to resources such as:
    a. Financial resources
    b. Intellectual assets
    c. Access to physical resources such as infrastructure
13. What are some of the collaborations your organization needs to build to successfully develop and implement the flexibility solutions? Some of the valuable collaborations already initiated?
14. Are there any other internal capacity related barriers that you would like to bring up?

Final remarks

15. What are some of the topics you think you would benefit from discussing together with the other DSOs in the project?