Use Case 7—Integrated markets for energy and flexibility
Digital workshop 2—May 10th, 2022

Workshop summary

Energy grids of the future – Connecting the dots

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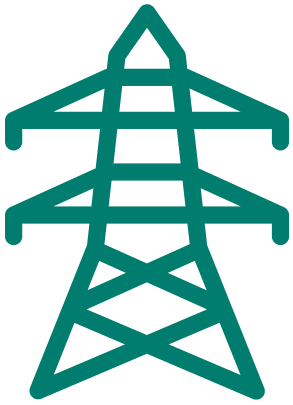
Workshop goal

Identify key drivers and barriers to power grid developments to enable a low-carbon society.

Topics

- What is the status of the power grid as an enabler for the low-carbon society, and what is needed in the coming years?
- What are the main drivers and barriers for the power grid to sustainably facilitate the transition toward a low-carbon society?



Session 1

We presented and discussed research perspectives on the status of the power grid and what is needed in the coming years.

Driving forces for the energy grids of the future
Gerd Kjølle, SINTEF

Business models for flexibility stakeholders in the power grid
Hanne Sæle, SINTEF

Grid development vs. flexibility—ensuring end-users' security of electricity supply
Iver B. Sperstad, SINTEF

Session 2

We organized a panel discussion and group work to discuss key drivers and barriers towards unlocking the future power grid.

Panel discussion
Tor W Stålsett, Elvia
Bjørn-Ove Berthelsen, Trondheim Kommune
Monica Berner, Enova
Ketil Sagen, Energi Norge
Kjetil Storset, Volue

Breakout rooms, followed by a wrap-up

Workshop Summary

The workshop brought together stakeholders across the energy sector for interdisciplinary discussions on the future power grid. The goal was to identify key drivers and barriers for power grid development to enable a low-carbon society, which are listed respectively in Table 1 and Table 2. The drivers and barriers were identified through the presentation of scientific research and discussion among participants in the electricity sector.

The future grid is determined both by the status quo and the trends that are currently shaping society and policies. Climate change is currently one of the most wide-spanning threats, and a major driver for the development of the future grid is in the form of climate change mitigation efforts, where electrification is a major mitigation measure. Several regulatory changes are being made in the power system to reduce carbon emissions, with ripple effects in other sectors of society. Mapping drivers and barriers for future grid development are useful when discussing what to expect of the future power system and how to arrive there.

The electric grid is regulated as a natural monopoly and regulation is not easy to design or adapt in a changing power system. Regulation can both facilitate and hinder grid development, and it is, therefore, a key element to enable the future grid. The regulation defines the role of the different participants in the electricity sector, but the role of aggregators[1] are not clearly defined. There is also a discussion about how current revenue cap regulation for the distribution grid companies incentivizes investment in grid infrastructure versus the development of new flexibility solutions.

Cultural barriers are also relevant. Grid companies are focused on system security and reliability, and their company culture is to develop robust infrastructure. New solutions can be perceived as vulnerable and less reliable than established ones, which could be a barrier to utilising external flexible assets. At the same time, customer culture is equally critical to offer flexibility potential in a local flexibility market, especially if customers have trust issues regarding the external control by grid companies or aggregators on private electricity use.

Flexibility market design faces barriers such as the uncertainty regarding the agent responsible for its implementation and maintenance. Distribution grid companies don't have the expertise to participate in such markets, or even lack the tools to forecast flexibility needs. Other agents may be able to develop and use better tools and knowledge, but there is a lack of common communication protocols, which could facilitate the coordination of actions.

Barriers and drivers for grid development can be organized into layers, from global trends to categories that are external and internal to the grid. Among the megatrends, besides climate change, geopolitics and security of electricity supply are important factors that influence the grid development, as is digitalization which provides new opportunities to monitor and organize supply and demand in the grid. Important external drivers of grid development are political goals and societal trends, technology, and current and future business models.

Political goals and societal trends reflect decisions that are taken by all, and thus society engagement and participation are highly relevant. Knowledge of the problem is equally important as finding the best outcome, and information should be available for customers to understand their role in the grid. Grid companies can also act as facilitators for the adoption of better measures for grid development.

[1] Aggregators are stakeholders that enable more flexibility solutions by coordinating the flexible resources of small customers.

Drivers and barriers

Table 1 and 2 summarizes the identified drivers and barriers for future power grid development that enables distributed flexibility solutions in a low-carbon society. Note that we mention 'regulation' as neither a driver nor a barrier because it can be both, depending on the case.

Table 1 Overview of drivers identified during the workshop.

Drivers	Description
Climate change mitigation	Prompts for changes in grid development and energy consumption and generation, for the electricity grid mainly through more variable renewables and less dispatchable generation.
Digitalization	Digitalization provides the means to monitor and control the electricity system through technology, sensors, and modelling.
Electrification	Electrification is a strong driver for increased electricity consumption and generation, and flexibility will be an important factor to support grid development.
Geopolitics, war, and energy crisis	Geopolitics is important for the security of electricity supply and strategic resources, and its role is enhanced related to future grid developments and flexibility.
Local political goals and societal trends	The perception that decarbonization is a relevant topic for society is reflected in political goals. Societal trends, on the other hand, might be divergent, such as rejection of onshore wind power plants and large transmission lines, or willingness to provide flexibility to the grid.
Technological development	Technology allows for new arrangements and solutions, and it increases the competitiveness of certain generation sources, e.g., wind and solar power.
Business models	Some business models arise spontaneously while others require fostering, nevertheless, they are relevant for the success of the flexibility market and grid development.
Energy system integration and sector coupling	Energy system integration places electricity as the backbone of the energy system. Sector coupling combines the dynamics of other networks with those of electricity. Both trends require more control and security of electricity provision.

Table 2 Overview of barriers identified during the workshop.

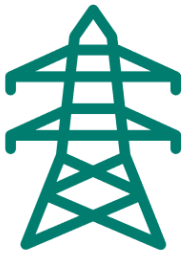
Barriers	Description
Physical or geographic	May relate to limitations regarding the grid itself in terms of providing electricity or flexibility where it is required.
Communication and data management	Participants involved in grid operation and planning use different data management systems and cannot necessarily exchange information.
Limited knowledge and lacking analysis tools	Relates to the distribution grid company not having adequate knowledge on how to coordinate flexibility use, sensor data, and markets. Can also relate to the customer not knowing its flexibility potential or the need for flexibility of the current system.
Uncertainty regarding the aggregator's role	Several issues are combined, which are associated with regulation, trust issues and rational customer behaviour. Also, customers are not a homogeneous group, and this barrier might have a localization component.
Incentives	This can be related to the lack of incentives from the distribution grid company to invest in flexibility measures. The customer also lacks the incentive to offer flexibility in the current regime. There might be a need for incentives to kickstart the flexibility market due to the "chicken-and-egg" problem.
Culture and trust	Culture and the lack of trust might be an important barrier for the adoption of flexibility measures, both by grid companies and users.
Market design	There is uncertainty around which is the best market design for flexibility trading and if there is a need for new regulatory measures. More research and pilot programs are needed.

Workshop overview

Organized by:	FME NTRANS + PowerDig
Number of participants:	63

Participants included researchers and partners of FME NTRANS and FME CINELDI. Researchers and partners from related research centres were also invited and represented, including FME HydroCen, PowerDig, and FME ZEN.

The workshop was structured according to three pillars (sub-topics) related to the "Energy grids of the future":



Driving forces for the energy grids of the future

Business models for flexibility stakeholders in the power grid

Grid development vs. flexibility - ensuring end-users' security of electricity supply

In Session 1, three presentations were given to introduce the three pillars and briefly elaborate on the status of recent and ongoing research.

In Session 2, panellists from different sectors presented shortly the most relevant barriers and drivers to grid development and flexibility markets through their perspectives. After the panellists shared their views, all participants were invited to join three different breakout rooms, organised according to the three pillars. The discussion was facilitated in each breakout room by the speakers from Session 1. Finally, the relevant topics were summarized in the wrap-up

The discussions and input during the workshop are presented in this report summary.

Session 1A

Driving forces for the energy grids of the future

Gerd Kjølle, SINTEF/FME CINELDI

Key takeaway—The driving forces for future grid development can be global megatrends, external, or internal from the grid perspective. The main drivers are decarbonization, digitalization, electrification, societal trends and political goals.

The presentation summarised research that started in 2017 and concluded in 2019, mapping the driving forces of the grid development[2]. The methodology employed, a foresight process is a systematic way of discussing and debating the future. It is multidisciplinary and involves three main steps: (1) identify the driving forces, (2) structure them, and (3) build scenarios.

The driving forces are analysed at different levels, and the topmost level is the megatrends. The most relevant megatrends are decarbonization, digitalisation, and geopolitics. Decarbonization increasingly influences grid development since its effects prompt a more immediate call to action. Digitalisation is also a strong enabler, which has been strengthened by the COVID-19 pandemic. Finally, geopolitics is a megatrend which has been added to the study recently and is related to the energy security crisis which was increased with the war on Ukraine. The original research shows yet two other megatrends, which are globalisation and urbanisation.

The second level of the analysis reflects the external driving forces of grid development. The main external forces are political goals, e.g., electric vehicle policies and policies hindering the development of onshore wind projects. Regulation, standardisation, and societal values such as the acceptance to provide flexibility are also external driving forces. The grid is impacted by technology developments such as artificial intelligence, robotics, improved power electronics, solar facilities, batteries, etc. Finally, weather-related exposure, cyber threats, and business models are also external driving forces. Among all those, political goals, societal trends, external threats and business models are seen as the most relevant drivers.

The final level is the internal driving forces of grid development. Electrification is the strongest one, which requires increased generation that comes from renewable sources due to decarbonization and new types of electricity consumption. Other strong internal forces are the development of flexible resources, security of electricity supply, and cyber security. The remainder of the internal forces are local energy communities, and grid operation and development. Grid-related driving forces are split between grid management, grid performance, and grid customers which are further divided into generation and load.

Other trends and driving forces to be highlighted are: customer orientation, when the customer is the focus of the grid development[3]; energy system integration, where electricity is the backbone of the energy system; and sector coupling involving communication, electricity grids, transport, and other energy carriers such as hydrogen.

What is the role of the small user, such as households, in flexibility provision and the development of the grid?

Households can provide flexibility through the adjustable consumption of electricity intense appliances such as water heaters and electric vehicles. Capacity-based grid tariffs might provide signals for the small users, or to aggregators who would sell the flexible capacity on their behalf. Price sensitivity is not high in today's market, but users that are more technological oriented or oriented towards combating climate change might take part early in the market.

The incentives for a distribution grid company to use flexibility markets are low. Isn't it easier for them to use their customers as flexibility assets?

There are different opinions on that, and besides the grid companies must trust that the development of flexibility markets is beneficial for them.

[2] T. S. Hermansen, H. Vefsnmo, G. Kjølle, K. Sand: Driving forces for intelligent distribution system innovation – results from a foresight process, CIRED 2019, June 2019.

[3] According to etip-snet vision 2050.

Session 1B

Business models for flexibility stakeholders in the power grid

Hanne Sæle, SINTEF/FME CINELDI

Key takeaway—Successful flexibility trading require buyer(s) and seller(s) of flexibility, as well as enabling technology, incentives, and a regulatory framework. The main barriers are lacking incentives for buyers and sellers, lack of technology, as well as a lacking regulatory framework for local flexibility trading.

The use of flexible assets requires the use of enablers, e.g., technology for knowing when and where to use flexibility, and dispatch agreements which for example can take the form of flexibility markets. Flexible solutions consist of the actual flexible resource and the enablers.

A pilot project to investigate the development of flexibility markets was deployed by CINELDI, with the use of a market platform by NODES market[4]. It captures the dynamics of an area placed at the end of a long line, that experiences voltage problems in peak load periods.

Flexibility markets involve two agents: A buyer, which is usually the system operator and/or grid company, and a seller, which is referred to as the flexibility provider. For the market to operate, there is also a need for enabling technology, incentives and a regulatory framework. A market can face barriers, which can be physical and geographical barriers, such as the flexible resource not being located in the same place where congestion is experienced. This might change in the future with increased market participation of flexibility providers. There are also communication and technological barriers, for example, the systems used by grid planners and grid operators are not the same, and the distribution grid company may not have information about actual grid capacities and where there is a relevant grid problem that can be solved with use of flexibility.

Another barrier is related to the role of the aggregator, which can coordinate and represent several small flexibility providers, yet it is uncertain in which manner this will be done. Grid companies also face barriers related to limited knowledge on how to map the potential for flexibility among consumers and have limited expertise in the deployment of flexible resources in planning and operation of the grid. Even within an organization, different sectors might not communicate topics related to flexibility, for instance, between customer centre and grid planning sections.

The regulatory framework can also be a barrier, where the current revenue cap regulation for the distribution grid companies gives different incentives for investment in grid infrastructure versus development of new flexibility solutions. Finally, the grid user might have limited knowledge about their consumption, load profile, and what it means to be flexible. There is a lack of understanding about price formation and the benefits of using flexibility. In some cases, the consumer expects to get paid more than what the grid company is willing to offer.

Concerning the end-user maturity barrier, is it only the lack of knowledge? What about the lack of trust, since the reputation of the industry is not at a high level at those times?
Agree. But there are examples of retailers such as Tibber, that offer help on charging electric vehicles at the lowest prices during the night. They have also contributed to a pilot for fast frequency reserve with a portfolio of electric vehicles. This is an example of how to build trust.

Can you elaborate on the role of the aggregator in a flexibility market?
Larger, industrial customers can give bids directly to the flexibility market. This might not be feasible for the small customer, due to price or technological barriers. So, the aggregator has a role inside the flexibility market by collecting several small customers with flexible resources and participating in the market on their behalf. It is not yet clear which are the correct incentives for the aggregator and the small customers to make possible this arrangement.

[4] K. W. Høiem, V. Mathiesen, I. B. Sperstad og H. Sæle, "Mulighetsstudie om bruk av fleksibilitetsressurser hos nettselskap", Energi Norge / CINELDI, 2021. Available at: https://www.energinorge.no/publikasjoner/rapport/2021/mulighetsstudie-bruk-av-fleksibilitet-i-nettselskap/

Session 1C

Grid development vs. flexibility—ensuring end-users' security of electricity supply

Iver B. Sperstad, SINTEF/FME CINELDI

Key takeaway—Flexibility measures should supplement grid development, not substitute it. Security of supply can be enhanced with flexibility. New types of risks need to be better understood when using distributed flexibility to supplement grid development.

Flexibility measures can be related to grid development or as a measure to improve the security of the electricity supply. These perspectives can be seen as two sides of the same coin.

Whether flexibility is a good alternative to grid development depends on the motivation for grid development. Opportunities to use flexibility depending on whether the need is at the transmission or distribution level, the types of flexibility, measures that are required to use the flexibility, and for how long it must be available.

Flexibility should not be seen as a permanent measure to avoid grid development, but as a supplement to it. Socio-economic benefit analysis could be used to decide which is the best alternative, but non-techno-economic barriers and other operational risks are often ignored using those methods.

The grid serves the primary purpose of ensuring the security of electricity supply to end-users. Security of supply comprises four main aspects: energy availability, power capacity, reliability of supply and power quality. CINELDI has reviewed the impact of flexibility resources on the security of supply[5], and the results are also summarised in a blog post[6].

Some studies are conducted using mini-scenarios: probable events, developments, or actions of significance for the future distribution system. In one such scenario, some end-users might organize in micro-grids, thus providing a local solution for the security of supply. In that scenario, the grid would act as a backup source of electricity. This would create greater relevance for flexible assets.

New types of risk can be introduced when relying on flexible resources. Those risks are related to: the time between request and activation of flexibility; the capacity and time interval that a resource can provide flexibility; and the predictability of resource availability.

Is it likely that end-users will develop the competence for providing themselves with the security of supply?
There are necessary conditions to arrive at such a scenario, and it is seen as a possible future. Examples of those conditions are technological development, lack of trust in the power industry and specific regulation.

Is flexibility a temporary solution and will the benefits one day fade away?
Grid investments are still expected in any time frame, probably by a large amount. Regarding the fading of the benefits, it depends on the scenario. For example, if there is a high increase in load demand due to electrification then flexibility may delay investments for a short time. In other scenarios, where there are microgrids and local energy communities with production, there will be less need for grid investments—in that case, flexibility will have a longer duration, and will not fade away so quickly.

The economic incentive for delivering security for the distribution grid company is the penalty, the cost of energy not supplied. Does this mechanism need to be changed in the future?
Those are questions that are being proposed now. What is the value of the security of supply in the future? It could go both ways. Electrification drives up the value, and self-sufficiency through local production and storage might reduce the value.

[5] I. B. Sperstad, M. Z. Degefa, and G. Kjølle, "The impact of flexible resources in distribution systems on the security of electricity supply: A literature review', Electric Power Systems Research, vol. 188, p. 106532, Nov. 2020, doi: 10.1016/j.epsr.2020.106532.
[6] https://blog.sintef.com/sintefenergy/security-of-electricity-supply-in-the-future-flexible-and-intelligent-grid/

Session 2A

Panel discussion—What are the main drivers and barriers to better coordinate flexibility solutions with grid development?

Tor W Stålsett, Elvia

The main drivers are regulation, sustainability, and technology. EU regulation, in the "Clean energy for all" package, aims for an energy system that is more flexible, more market-based, and better placed to integrate renewables. Sustainability is a driver in itself, and Elvia is looking for ways to reduce negative impacts on climate change and biodiversity without sacrificing the quality of service. Technology is also a driver, especially in the form of devices connected to the internet that can be used to provide flexibility. The main barriers are a fragmented value chain, existing infrastructure, and culture. Many players in the value chain contribute to lesser transparency and legitimacy. The existing infrastructure is of a pre-digital time, and it will take a long time to be replaced. Culture is also a barrier because of legacy ways of solving problems. Finally, the flexibility of the grid must be considered when valuing other alternatives.

Bjørn-Ove Berthelsen, Trondheim Kommune

The projects where the municipality is involved are focused on local energy neighbourhoods and end-user flexibility. From our experience, research for innovation and development is needed at the system level. Norway has 110 years of experience with hydropower, and the system is being surpassed by technology and new needs. There must be a move from a centralised to a decentralised system, and there is a need to deregulate energy markets. A current project in Trondheim is testing deviation from the current regulation. Why do the grid companies need to hold back? Who pays for the costs of local balance and security of supply? The understanding of barriers and the value of flexibility must be connected with possible revenue streams.

Monica Berner, Enova

Enova is a tool for the government to speed up the transition toward a low-carbon society by providing financial support. We are a major part of the development and testing of new technologies, and support for early market introduction. There are different support schemes for pilots and users that apply and introduce new technology. The major driving force seen now is decarbonization. Large industries are reducing their dependency on fossil fuels, especially to replace high-temperature needs. The electricity demand will also increase due to higher carbon prices. Hydrogen production can put a strain on the existing grid. Many buildings and construction sites are set to be fossil-fuel-free. An observed challenge is a growing distrust between the building owners and power system stakeholders. Many building owners make efforts to reduce their dependency on the grid, e.g., installing solar panels. However, from the building owner's perspective, current incentives and grid tariffs do not remunerate them enough for their decreased grid use.

Ketil Sagen, Energi Norge

Energi Norge sees two major drivers, which are climate change and reduced biodiversity. Electrification is the way to handle the need to reduce greenhouse gas emissions. The need to reduce the exploitation of nature means that there must be a reduction in the installation of power lines to not pressure biodiversity. The main barriers are regulatory, technological, and cultural. Grid companies are incentivised to invest in grid expansion rather than increase operational expenses. To utilise flexibility, there is a need for better operational technology, e.g., investments in dispatch centres, and standard communication protocols. The risks must be better balanced between the seller and the buyer of flexibility, e.g., revising how to compensate for the cost of energy not supplied. Cultural barriers are seen in the risk aversion that companies show when refraining from utilising flexible resources. There is a need for pilot programs to learn and build trust between grid companies and flexibility providers.

Kjetil Storset, Volue

Flexibility is not new; it has existed in power systems since the start. What is changing now is that more non-flexible, weather-dependent production is entering the system, and there is no practical way of storing electricity. Then there must be a shift from the production being the traditional provider of flexibility to the demand being the flexible part. The most flexible demand is electrical vehicle charging, and it is valuable for the power system. However, this is a challenge for the local grid and might increase bottlenecks. This can be managed locally by neighbourhood coordination. We must be aware of the overall goals and solve the problems locally. There is a scalability challenge—all the pilots currently are trying to solve a pre-known problem. This must be done dynamically going forward. There is a need for flexibility markets on the distribution level of the grid. There is also a challenge related to data use, and the ability to change and control distributed resources. This all leads to the conclusion that the distribution grid company will not be able to do this innovation alone, it must be driven by consumers.

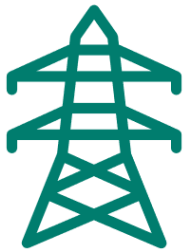
Session 2B

Breakout rooms

Researchers and partners teamed up in smaller groups to come up with their perception of knowledge gaps, and relevant research directions regarding market design for flexibility.

Room #1: Driving forces for the energy grids of the future

Drivers and barriers to flexibility in grid development can be structured around the market participants. For small consumers, a major barrier is the lacking incentives of the distribution companies to use small consumers' flexibility potential. And even if the correct incentives were present, there are other important barriers to consider, such as the lack of a specific technology that allows for the automatic dispatching of the flexible assets, monitoring, and summarizing the energy management.



Driving forces for the energy grids of the future

Flexibility activation can be done by consumers as a price response, through an aggregator, or via direct control by grid companies. There is an issue of trust around the risk allocation between the responsible agent that directly activates and the small consumers with flexible resources. In addition, there is still a lack of knowledge on the different needs and costs that will arise as electricity grids transition towards facilitating a decarbonised energy system. Customers need to know why their contribution is important, but at the same time, the path to action must be an easy one.

For large electricity consumers, the drivers are different as their flexibility product can be large enough to allow direct flexibility trading and/or provision, e.g., through flexibility contracts. Industry participants such as data centres, aluminium smelters, pulp & paper producers, and other power-intensive agents can be flexible and have professional control of their electricity demand. Flexibility, on the other hand, depends on scale and activation time, and many industry participants are not prepared to change consumption patterns on short notice. Another barrier is presented by the electricity-intensive industry that is less flexible, e.g., battery producers.

Electricity generators face limitations and challenges in flexibility supply, and the majority of new renewable sources are non-dispatchable. Flexibility supply by generators can be improved with technology development and battery adoption, leading to the trend of hybrid generation parks. From the grid's perspective, the net grid feed-in is what needs to be controlled. For stakeholders, both consuming and producing electricity, net metering is already giving economic incentives to minimize the grid feed-in and consume the local production on-site.

Room #2: Business models for flexibility stakeholders in the power grid

The drivers and barriers to the implementation of flexibility solutions can be understood from the grid's perspective. Historically, distribution grid companies do not promote flexibility, and therefore, these companies lack the tools to forecast and locate problems regarding its use. There is limited knowledge on how to use the data available from consumers through smart meters, and most real-time information on consumption and production is not available without express consent from the counterpart, which is unlikely to be obtained spontaneously.

As such, if the distribution grid company is to assume a more relevant role in a flexibility market, it is expected to have decision support, e.g., forecasting tools and optimization frameworks, to plan the

use of flexible assets. Flexibility markets could be developed in a similar way that now exists for the transmission grid level.

The distribution grid company's role as a local flexibility market operator is, however, not the only way forward. Other agents, such as independent flexibility market operators (e.g., NODES), could assume this role. In that case, the distribution grid company would keep the duty of connecting customers to the power grid and don't intervene in what happens behind the meter.

Business models for flexibility stakeholders in the power grid

Currently, the distribution grid company has no part in deciding which investment a customer does behind the meter, and it can be even more difficult to properly discern if the customer is asking for the correct capacity when applying for expansions. From the customer's perspective, there is an incentive to ask for more capacity than what is needed, since it can be costly to request too little capacity. In that sense, the distribution grid company is positioned to provide incentives, but not directly control flexible assets. That is a role that can be better suited for an aggregator to perform.

Room #3: Grid development vs. flexibility—ensuring end-users' security of electricity supply

Transmission and distribution grid companies are regulated natural monopolies. This regulation, however, can be a barrier in the transition to a low-carbon energy system. Ideally, the regulation provides the proper incentives for efficient grid development while ensuring the security of supply. Regulation should also support other objectives, such as environmental sustainability, and this is a difficult achievement. It can be a challenge to design a framework that provides cost-recovery, fair cost allocation, and accurate incentives for efficient grid development.

Grid development vs. flexibility - ensuring end-users' security of electricity supply

A previous study interviewed grid companies regarding barriers to flexibility utilisation, but there wasn't a consensus on which barrier was strongest. Not every company pointed out regulatory barriers as the biggest, hence there is not a common understanding of what the current regulation allows or incentivizes. A grid company employee present at the breakout room mentioned that regulation is not seen as a major barrier yet pointed out that a limited budget for R&D expenditures under the regulated revenue cap is a potential point of improvement.

In the United Kingdom, there is an implemented example of local flexibility markets using flexibility resources to the greatest possible extent before investing in more infrastructure. The establishment of the local flexibility market is caused by a low share of flexible generation, which provides strong incentives to use flexibility resources. Small amounts of flexible generation result in mature active network management and the use of conditional or interruptible connection agreements. Those agreements have so far been mostly used for distributed generation rather than for consumption. Most grid companies in the UK provide online maps with available grid capacity, thereby giving a better overview to both grid companies and customers.

In Norway, the number of customers per grid company is increasing, yet it is still much lower than in many other European countries, which leads to challenges in research and innovation. Flexibility

markets have a challenge themselves, in the manner of a “chicken-and-egg” problem, where the development of the market is stalled by the lack of structured flexibility supply and demand and vice versa. A relevant question is whether grid companies should be incentivized to become the first movers. Irrational customer behaviour is also a challenge, which is also reflected in other areas such as nutrition and exercising — customers know the how and why, but don’t do it anyway. Although there might also be a lack of understanding, irrational behaviour must be taken into consideration when designing the interaction between customers and the flexibility market.

Concluding remarks and future steps

The second workshop in "Use Case 7—Integrated markets for energy and flexibility" brought up several key barriers and drivers for power grid development in coordination with flexibility resources. This event provided an overview of different perspectives from different sectors linked to the electricity grid, and several first-hand accounts of the challenges related to grid development in the current and future power systems.

Other workshops will be organized to complement the knowledge obtained in this one and cover the research gaps mapped in the first workshop.

Acknowledgements

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