EUROPEAN GRID PERSPECTIVES

How system operators see the future

Renewables Grid Initiative

About RGI
The Renewables Grid Initiative is a unique collaboration of environmental NGOs and transmission system operators from across Europe. We promote transparent, environmentally sensitive grid development to enable the further steady growth of renewable energy and the energy transition.

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www.renewables-grid.eu

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EXECUTIVE SUMMARY

The transformation of the European power system to one based on renewables is necessary if we are going to halt climate change. This will require a shift in how the electricity grids, the backbone of the power system, are developed and operated. To help understand what this future could look like, RGI collected the personal perspectives of senior managers from European electricity grid operators, discussing topics from technology and regulation, to future roles and responsibilities. RGI did this in order to identify where there is significant consensus and to inform the wider society of the personal perspectives of grid operators. This is core to RGI's mission to increase transparency, to build coalitions and to jointly show the path to a decarbonised power system.

From the discussions we identified **six common perspectives** which are detailed in this report. From these perspectives, we have drawn a **set of main findings,** these are:

- **Electricity grid operators believe that the energy transformation is feasible and want to be proactive in enabling it.**
- **There is consensus on many of the technical solutions the system needs to enable the integration of very high shares of renewables.**
- **Electricity grid operators often described the relationship between themselves and the public in adversarial terms. This mindset is unhelpful and may compound negative perceptions.**
- **Electricity grid operators expressed technological non-discrimination, although personal preferences or involvement in hand-picked pilots may put this position into question.**
- **Grid operators both see their future as market and digital platform facilitators. Increased cooperation should take precedent over gaining competitive advantage.**
- **Effective communication of the options available to society must be enhanced to increase transparency of the decision-making process.**

The main positive finding is the consensus among participants that the transformation to renewables is achievable and that they as grid operators should and will play a proactive, enabling role in this change. That being said, it was also evident that grid operators still face significant barriers both in how they themselves communicate and involve stakeholders in defining the need for high voltage grids and how they are regulated and incentivised as a business. Work therefore needs to be done to improve how grid operators can further open up to a diverse range of interested groups and for regulators to find innovative ways to progressively incentivise grid operators to make the investments required to enable a renewables-based energy system.

INTRODUCTION

At the centre of the monumental shifts we are seeing in the power system are the operators of both the high voltage and lower voltage networks.

The grid operators who own and/or manage these networks are the backbone of the system. They have the responsibility to keep the lights on and the whole system balanced and secure. Their success is crucial for progress in the energy transformation, as a major blackout could undermine public confidence in the overall project.

Their traditionally static role is, however, becoming more complex. A number of trends are driving the need for grid operators to become more proactive and to be responsive to complex technological changes, societal expectations and environmental standards. They are also vitally placed to be an enabler of, rather than an obstacle to, society's mission to decarbonise and democratise the way we use energy.

In this context of complex and rapid change, RGI interviewed **22 system operator senior executives (16 TSOs and 6 DSOs) from 16 different European countries.**

We wanted to understand their perspectives on the most pressing topics facing the power sector. We did this in order to:

- **Find where outlooks on the most important issues are common.**
- **Provide transparency by collating the personal perspectives and expectations of decision makers.**
- **Help set the agenda for priority topics for attention and future discussion.**

Before looking at where perspectives are common, participants identified a number of main intersecting trends which impact their current and future operations.

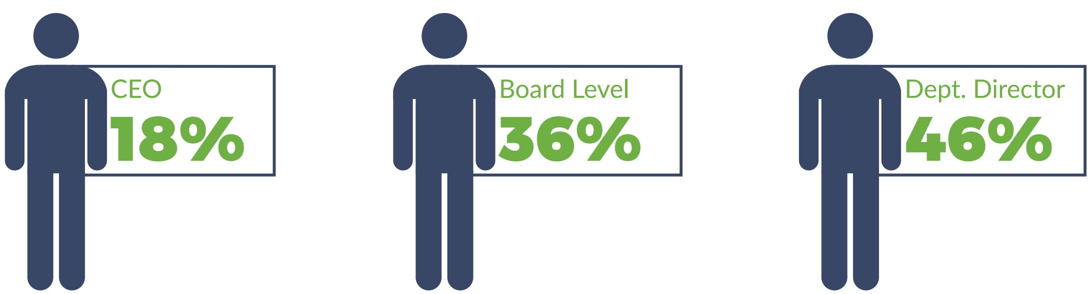

Fig. 1: Seniority of participants

Fig. 2: Countries of participants

THE DRIVERS OF CHANGE

Shifting public opinion and policy

Participants initially identified a common hierarchy of drivers, changes and impacts (Fig 3). The public and civil society organisations especially have put increasing pressure on governments to take action to reduce CO2 emissions and promote renewable power generation. This shift in public opinion has been coupled with a top-down drive at the national and European policy levels. From this, a range of subsidies, regulations, public sector investments, new market designs and commitments to various multilateral targets have been put in place. Many of these policy tools have prioritised renewable technologies and incentivised other disruptive behaviours. Additionally, the policies enacted at the European level to build an independent, secure and integrated power system for Europe was given, especially in its role in prioritising cross-border interconnection projects.

Reduced technology costs

The rapid reduction in technology and project development costs was also considered a key driver. The learning curve of the major renewable technology types has brought down project costs, lowering their levelised cost of electricity, with the market responding, driving further deployment of the technology. Two examples given by participants were the large cost reductions in offshore wind and the fall in the cost of PV panels.

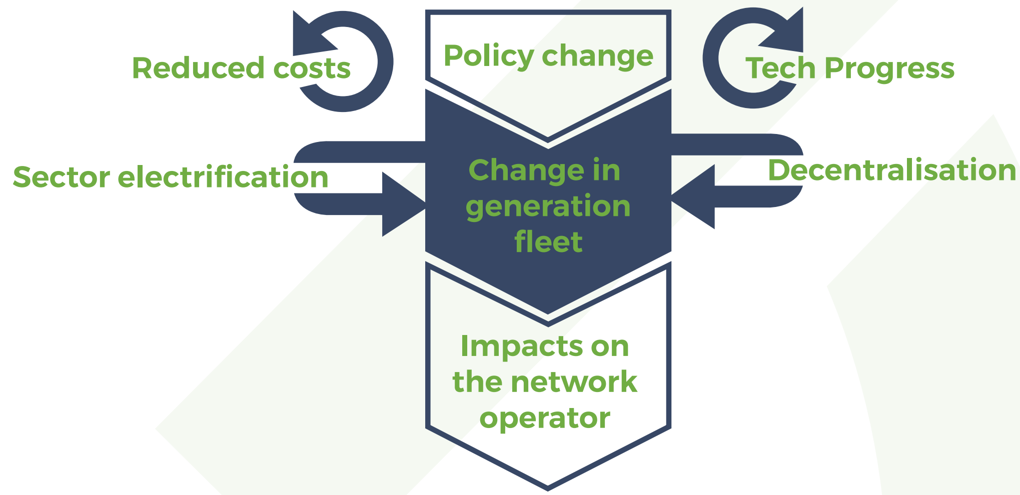

Fig. 3: Hierarchy of drivers, changes and impacts identified by particpants

Technological progress

Technological progress was considered a key driver in several ways: firstly, in terms of advances in both existing and emerging generation (especially offshore wind) and storage technologies; secondly, our growing ability to electrify other sectors such as transport and heating; and finally, the huge advances being made in our ability to collate, manage and interpret data. **The ability to use data to automate processes, to understand consumer behaviour and to build more complex market products are all driving new business models.** Such data management opens up opportunities to offer a more diverse set of technologies and services to the market.

WHAT IS CHANGING

Generation types and location

The drivers listed previously were linked by participants to a fundamental change in how and where we produce and consume electricity. We are moving to an increasingly spatially distributed pattern of generation and away from a limited number of large thermal power plants. **Politically mandated deadlines for the phasing out of major parts of the thermal fleet (both coal and nuclear) were mentioned by several participants and were considered to be accelerating change.** Also, the growth in large scale onshore and offshore wind means that more energy is produced at a regional scale where these resources are present.

Electrification of other sectors

Advances in technology and cheaper electricity have the potential to open up new options for the electrification of other sectors. So far, this electrification has been relatively limited. There was therefore some uncertainty from participants as to the extent and speed to which these sectors of the economy will electrify. This uncertainty was compounded by uncertainty as to how these newly electrified sectors will behave and impact the system at large. It was nonetheless clear from participants that the expected changes over the next decades are fundamentally impacting upon how they plan the grid today.

More complex demand

Demand, as we experience it today (standard household and industrial applications), was assumed to stay relatively flat by most participants, with rises moderated by energy efficiency measures and the continued decoupling of demand growth from GDP. Although this was (sometimes cautiously) believed by most participants, the impact of the electrification of other sectors on total demand was considered to have the potential to be very substantial. The extent of this increase is poorly understood, with many participants looking to develop their forecasting tools to understand this better.

Additionally, driven by changes in markets, new technologies like smart meters and the need to find flexibility in a system high in renewables, participants pointed to a significant growth in the sophistication of demand response. This will change how consumers interact with the market and the system and will also change the profiles of energy use across time, maybe in unpredictable ways.

THE IMPACTS OF CHANGE ON THE SYSTEM OPERATORS

These changes present grid operators with a complete paradigm shift. Below are the most prevalent high-level technical challenges that the network will face, as identified by participants.

- **Increased complexity:** The number of diverse actors in the system will increase, with their behaviour becoming less predictable. All will produce data to be managed, organised and acted upon.
- **Planning from an "all energy" perspective:** Electrification of sectors means that the grid operator must engage and cooperate with multiple other sectors when planning and forecasting.
- **Operating at the limit:** High amounts of variable renewables coupled with the phase out of thermal units (coal, nuclear) in some countries will mean that the grid will be pushed to its technical limits.
- **Internationalisation:** National operators of the high-voltage grid particularly will have to increasingly cooperate across borders to help balance the system, to define joint standards and participate in cross-border markets.
- **"Flexibility, flexibility, flexibility":** The need to find flexibility for a system high in variable renewables is paramount.

These changes and their drivers create huge new technical challenges for grid operators, but they also open up new opportunities to deliver a secure and decarbonised energy system. To go deeper, the following chapter provides the **common perspectives** that operators expressed.

SIX COMMON PERSPECTIVES

I. "REGULATORY BARRIERS AND LOW PUBLIC ACCEPTANCE WILL HINDER THE NEEDED GRID DEVELOPMENT"

In order to **overcome the increasing misalignment between generation and transmission or distribution infrastructure, some new lines are needed.** In this context, participants pointed to a number of common issues which currently hinder this expansion.

Regulatory barriers

Some elements of the current regulatory environment in which grid operators work were considered by participants as barriers to grid development, both at the national and European scale. Some common themes were:

- **Laborious and overly complex project permitting procedures.**
- **Regulatory pressure for cost reductions whilst the requirement for new in - vestment increases.**
- **The lack of regulatory cost recognition for additional environmental and social mitigation and compensation work to improve acceptance rates.**
- **Lack of consideration by regulators of the costs of not developing the grid (e.g. re-dispatch costs).**
- **Lack of regulatory foresight to incentivise system flexibility in order to integrate larger quantities of renewables in the near future.**

In a related point, some participants also commented on **the lack of planning alignment at the European level.** This has the impact that national grid planning (and national energy strategies more broadly) are not always complementary to the plans of neighbouring countries. Such misalignment creates real-world problems. One example is the contradictory desire of most countries to gear their systems towards being net electricity exporters.

Low public acceptance

Low public acceptance was given as the main challenge by the majority of participants. Grid operators expressed that they currently face problems with low rates of public support across the whole range of project types: Overhead lines (OHLs), underground cables, line upgrades and associated infrastructure (substations etc.). Additionally, "public acceptance" was sometimes used to mean low levels of acceptance from national and local politicians. With some stating that local politicians in particular use opposing grids as a "populist rallying cry", making issues of acceptance and permitting more complex. As lower voltage lines can often be buried, they have fewer visual and environmental impacts. This means that public acceptance was seen as a much more minor problem by lower voltage distributors.

Several other causes for the low levels of public acceptance were speculated on by participants. One example was the increase in the complexity of stakeholder value systems. **Transmission lines are no longer seen by citizens as the tolerable signs of development that they once were.** This change is magnified by the apparent paradox that a distributed renewables revolution actually requires expansion of the centrally controlled transmission and distribution networks.

Box 1: The DSO Perspective – Challenges to grid expansion

DSO participants mentioned some additional issues affecting the distribution grid:

- **Lack of knowledge and capacity** at the local regulatory level to make important decisions and incentivise development.
- **Poor or inaccurate planning by larger customers** on future consumption makes forecasting and planning of new infrastructure difficult.
- **Overly cautious privacy rules for customer data** hamper their effective use for grid analyses, making optimisation of existing infrastructure more difficult.

II. "THE RIGHT HARDWARE, AN IMPROVED BUSINESS CASE AND ENGAGED CONSUMERS ARE PRECONDITIONS TO EXPAND DISTRIBUTED DEMAND RESPONSE"

Distributed demand response (DR) techniques are ways by which smaller scale consumers can change their demand to match the supply of electricity and to assist the grid operator in maintaining network security. Participants had a generally positive outlook on distributed DR and mentioned several pre-conditions for it to develop further.

Distributed DR has great potential but is underdeveloped

There was overwhelming consensus from participants on the positive impact that distributed DR could have on consumers and on the system. For consumers, there was thought to be potential for decreasing household bills by shifting consumption to lower cost times and for them to earn revenue by selling services to the system. For the system, by providing flexibility to prevent grid congestion, DR has the potential to help avoid some investments in grid infrastructure and increase the share of variable renewables on the system more securely. Although the current sophistication of existing demand response schemes varied across the countries of participants, **the flexibility offered by distributed DR was universally perceived as underdeveloped.**

Pre-conditions for expanding distributed DR

When discussing how to expand DR, participants referred to a mixture of both implicit DR (potential of consumers to react to market prices) and explicit DR (the contracted form traded on markets). In this context, participants pointed to several interlinked pre-conditions for a significant expansion.

Hardware

- **Smart meters/data availability:** Smart meter rollouts are complete or almost complete in most of the countries where participants operate. Availability of, and clear rules for, the use of data are necessary for providers to offer services (see business case below).
- **Growth in electric vehicles and electric heating:** Greater electrification of transport and heating needs will increase the benefits of DR, both for the consumer and for the system.
- **Smart appliances:** Some considered this "the missing link". Through third party control, smart appliances will allow consumers to be more price responsive with less effort (see "engaged consumers").

Business case

- **Short term market price variations:** Short term prices were currently not considered (by some) to be volatile enough to incentivise DR in households and businesses with low consumption.
- **Appropriate market products:** Many participants saw a growing role for aggregators and other market intermediaries in the future. These players need access to appropriate market products and data to facilitate the participation of small scale consumers in the market.

Engaged consumers

- **Ease of use:** Very few people wish to actively manage their electricity use. "Energy as a service" packages, which bundle consumer consumption, generation and storage into one service will be required (see appropriate market products above).
- **Link to the local context:** Some participants pointed to the importance of inspiring consumers by **linking their consumption patterns to the local community context,** such as through community energy cooperatives.

III. "THE SYSTEM WILL NEED BOTH SHORT AND LONG-TERM STORAGE. GRID OPERATORS SHOULD BE PROACTIVE BUT TECHNOLOGY NON-DISCRIMINATORY"

Participants had the common perspective that storage will be needed in the future system to provide the needed flexibility. All believed that a number of technologies will be needed for different applications and timeframes. This being so, the majority believed that **grid operators need to play an enabling, but technologically non-discriminatory role.**

Short-term storage

The majority saw the need for short-term storage to help solve a number of developing grid issues caused by changes in the system. This includes moderating peaks in demand and helping to resolve national and local congestion. **The technology considered to have the most impact was distributed lithium-ion batteries.** According to most participants, these batteries will most likely enter the market as part of a package with electric vehicles (EVs) and rooftop PV. There were some variations in the expected speed of growth in EV numbers. This depended on a country's wealth (the richer, the more battery packs/EVs), the urban-rural character (EVs less attractive in rural settings) and the incentives in place (tax-breaks and subsidies). **There was some doubt as to whether battery storage as a standalone offering (just buying a Tesla Powerwall for example) will have the business case to happen without a "package offering" of EVs and PV, and without changes in how small consumers are allowed to take part in markets.**

Long-term storage

The common perspective was that long-term storage (covering days and weeks) is likely required with a very high share of renewables in the system. The outlook on specific technology types for long term storage was more mixed, depending on the local context of the country. Participants stressed the potential of power-to-x technology and the expansion (and refitting) of pump-storage. The majority saw the need for long-term storage as a mid/long-term issue (>10 years), but an issue that nevertheless should be addressed now in the form of research and development (R&D) and pilot projects.

Role as technology neutral enablers

The significant majority believed that technology development of both long- and short-term storage needs to be market led. Which technology offers the service was considered not as important as the effectiveness of the service these technologies can offer. Participants stressed that **these services need to be accessible, reliable and cost effective.** Due to their non-discriminatory position, system operators were wary of trying to pick winners in terms of technology. Nonetheless, **many expressed a desire to continue to invest in R&D, participate in multi-partner pilot projects, help define standards and act as a technology accelerator.**

Some participants saw the need for longer-term "seasonal" energy storage (covering months) as limited to rare years with an atypical climate (i.e. sustained periods with little wind). Such limited use would likely make such units unprofitable, potentially requiring non-market interventions.

IV. "DIGITALISATION WILL BE BENEFICIAL TO GRID OPERATORS AND CONSUMERS, BUT ENSURING DATA PRIVACY WILL BE KEY"

Digitalisation was considered the "hot topic" by most of the interviewed grid operators and was considered to have a number of clear benefits both for the system operator and the consumer.

Observability and automation

With regards to **data derived from advanced monitoring of the networks,** advanced sensor technology and algorithms will give a real-time picture of what is happening on the grid. Participants believed that this will enable new techniques like real-time measurements of the line's thermal rating (dynamic line and asset rating) and automated N-1 compliance to actively manage (and increase) the capacities of lines. It was considered likely that these types of techniques will be complimented by advances in Artificial Intelligence (AI) to create an increasingly automated system. A related point that several participants mentioned was that the growth in the number of sensors will also improve their ability to monitor their assets in real time, improving fault detection and maintenance scheduling.

Breaking down data silos

A range of technical, organisational and legal barriers currently exist that can make data management and exchange between parties inefficient. Participants agreed that advances in sensor technology and data management will help to overcome at least some of these barriers. Participants were divided on whether this should be based on a data-hub model or a direct exchange model between parties, e.g. SCADA to SCADA.

Market optimisation and consumer empowerment

Participants considered the consumer empowered vision of the future energy system reliant on improving the efficient bi-directional flow of data between multiple parties. This data must also be simultaneously reconciled with data from other market participants. Such a web of data exchange was considered by some participants to be highly complex and only possible with the continued penetration of digital technology.

Data privacy and consent

Properly ensuring data privacy in a highly digitalised energy system was considered key. Although current systems of data management varied between participants' respective countries, both TSOs and DSOs stressed two common points with regards to data privacy: **First, consumers remain owners of their data, which is not shared with third parties without explicit consent; and second, consumers can easily access their own data in full.**

Box 2: Cyber security - More smart units = more access = higher risk
Apart from agreeing that it is a key issue, participants were reluctant to talk in much detail about the specific security steps that they are taking to secure data and their systems from hackers. Nonetheless, participants identified a growing risk as more physical sensors and controls on the infrastructure (such as in substations) and smart meters in homes provide potential hackers with more physical entry points that they can exploit to harm the system.

V. “GRID OPERATORS OF THE FUTURE WILL INCREASINGLY FOCUS ON MARKET FACILITATION, EDUCATION AND GAINING ACCEPTANCE”

Market facilitation

According to participants, grid operators will play an expanded role in hosting power and ancillary service markets. Many of the changes discussed in this paper so far, require an increased level of market sophistication and transparency, especially at the local level. Decentralisation especially will lead to an increase in transactions that need to be confirmed and settled. The aggregation of data will supply insights into patterns of consumer behaviour and allow for more parties to design service offerings which are desirable for consumers and which can supply flexibility to the system. The grid operator, as a non-discriminatory actor, was seen by participants as the party who has the overview of the system to facilitate such services and markets in the future.

Inclusive strategic planning and gaining acceptance

Some participants pointed to the changing nature of how they conduct their strategic planning processes. These processes are done to understand future grid requirements, both to guide planning and to inform national grid plans. Many participants pointed out that, in the future, **operators will need to further open up their strategic planning to garner input from a broader range of stakeholders.** Although this will make the process more complex, the involvement of a broader range of groups was seen by many participants as vital if they are to build a broader base of consensus on what system is required and gain future acceptance.

Educating market participants

The future role of **educating market participants (generators, retailers, aggregators etc.) to allow them to better understand the opportunities of new market structures and the products on offer was seen as an opportunity by many.** As markets become more complex, grid operators will have to become more proactive in this role, especially as a more diverse “non-expert” group of players (energy cooperatives etc.) becomes more active on the markets. It was generally believed that this should be done with a consumer focus, **enabling participants to offer the best solutions to bring down prices and meet consumer needs.** The importance this could have for large industrial consumers was mentioned, as they could realise the market value of their flexible resource if they were made more aware of the market products on offer.

Box 3: The DSO perspective - The future of the DSO

The future of the DSO’s role in particular was seen to be experiencing a profound shift from a passive to an active role. This included a shift to becoming:

- **Active system manager:** Increased active coordination of feed-in from generators and load on the local distribution network.
- **Local market facilitator:** DSO coordination and procurement of services for flexibility from commercial parties on their network.
- **Data handler and ensuring customer privacy:** Data from smart meters is already a responsibility for many DSOs. Handling the expanded data flow and ensuring security and privacy was seen as a major future core competency.

VI. "GRID OPERATORS CAN ENABLE THE ENERGY TRANSFORMATION BY ENSURING SYSTEM RELIABILITY, UNLOCKING FLEXIBILITY AND ENACTING THE PUBLIC WILL"

Most participants expressed reservations about system operators taking an overt position when it comes to being "pro-renewables", stressing the non-discriminatory position of the operator. This being said, participants appeared eager to demonstrate commitment to the decarbonisation of the system.

System reliability

A traditional core mandate of the grid operator is to keep the entire system balanced and secure. Many participants felt that, by demonstrating that the system can be reliable even with higher penetrations of renewables, the operator is in effect demonstrating by doing. It was commented that, if a major blackout was to happen, the conversation in society could shift to issues of energy security and away from the important task of decarbonisation. It is the role of the operator to prevent such a conversation shift by ensuring system reliability.

Unlocking flexibility

Operators cannot accurately predict or control the exact future development of the system. They can, however, be proactive in providing flexibility to the system itself (through grid development and optimisation) whilst opening up the system to source flexibility from a wider pool of actors. This includes not only connecting and managing new sources of flexibility on the system (generation, storage, EVs and electric heating, interconnectors etc.) but also enabling pilot projects and helping to define more progressive rules, procedures and standards (e.g. market products).

Enacting the "public will"

As regulated monopolies, grid operators must interact with governments in complex ways. This interaction thus touches upon the "public will", which the government represents. Participants interpreted how the "public will" should be defined in two ways. Some participants referred solely to their interaction with policy makers and regulators. This interaction defines the "public will" accordingly, as being expressed through the democratic institutions of the state and subsequent policy.

A minority of participants provided a broader definition of "public will" that included NGOs and consumer organisations. This also involved including such groups in the decision-making process of jointly defining the energy system of the future, beyond what is strictly required by regulators.

SIX COMMON PERSPECTIVES

MAIN FINDINGS

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Electricity grid operators believe that the energy transformation is feasible and want to be proactive in enabling it.

There is consensus on many of the technical solutions the system needs to enable the integration of very high shares of renewables.

Electricity grid operators often described the relationship between themselves and the public in adversarial terms. This mindset is unhelpful and may compound negative perceptions.

Electricity grid operators expressed technological non-discrimination, although personal preferences or involvement in hand-picked pilots may put this position into question.

Grid operators overwhelmingly see their future as market and digital platform facilitators. Increased cooperation should take precedent over gaining competitive advantage.

Effective communication of the options available to society must be enhanced to increase transparency of the decision-making process.

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