GEODE
The voice of local energy distributors across Europe

Distribution Grids:
The Energy Transition's Backbone

MAY 2023

Introduction

Distribution grids are at the core of the energy transition which takes place at the distribution grids. Covering 10 million km in electricity[1] and 2 million km in gas[2], distribution networks are the backbone of the energy system in Europe. Therefore, the ambitious decarbonisation objectives and policies set by the EU must inevitably prioritise them.

Just mentioning a few of the targets announced in the 2022 **REPowerEU** plan[3] helps to better understand the scale of the challenge for the distribution grids:

- 45% RES target by 2030 (eventually set by the revision of the Renewable Energy Directive at 42,5% plus a 2,5% additional top-up that EU countries can voluntarily add)
- 320 Gigawatts (GW) of solar photovoltaic (PV) capacity installed by 2025 rising to 600 GW by 2030
- Double the number of heat pumps in use to 10 million by 2027
- 10 million tons (Mt) of renewable hydrogen domestically produced and 10 Mt imported (REPowerEU) by 2030
- 35 bcm biomethane by 2030

2030 – which is only few years away from now – is therefore the key milestone date for the evolution of the EU energy system – a crucial intermediate step towards the mid-century climate neutrality goal[4].

While the role of distribution networks to achieve these ambitious objectives is largely acknowledged, it is important to understand how, and under which conditions they can contribute to this transformation. The latter highlights **the aim of this paper: explaining the current challenges faced by Distribution System Operators (DSOs) in the daily operation of their grids, and how they are enablers of the changes in an evolving energy system.** Case studies from GEODE members are also included to showcase best practices and concrete projects happening now.

[1] **Distribution Grids in Europe - Facts and Figures 2020**, Eurelectric (2020). The number refers to Europe (including countries beyond the EU Member States), https://cdn.eurelectric.org/media/5089/dso-facts-and-figures-11122020-compressed-2020-030-0721-01-e-h-6BF237D8.pdf

[2] **Gas Factsheet**, ACER. The number refers to the EU, https://www.acer.europa.eu/gas-factsheet

[3] **REPowerEU: affordable, secure and sustainable energy for Europe**, European Commission (May 2022), https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/repowereu-affordable-secure-and-sustainable-energy-europe_en#documents

[4] **EU Regulation 2021/1119 establishing the framework for achieving climate neutrality ('European Climate Law')**, Official Journal of the European Union (30 June 2021), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32021R1119

Key messages

- DSOs – both for electricity and gas – stand at the core of an unprecedented transformation taking place in the energy system. DSOs are ready to play a more active role in the operation of their grids.
- Decentralisation, democratisation and digitalisation trends are making DSOs the crucial actor in the electricity system.
- DSOs are best placed to enable decarbonisation by facilitating the integration of hydrogen and biomethane.
- It is essential to establish a proactive adequate regulatory framework acknowledging the role of DSOs and supporting and anticipating the necessary investments for upgrading and expanding the existing distribution grids, procurement of flexibility services and for strengthening its digital and data capabilities. Grid controllability and observability is crucial.
- Measures for faster and simplified permitting procedures for new grid infrastructure are also needed.
- DSOs require a toolbox of solutions to operate a future electricity grid fit for purpose.
- To further promote flexibility, DSOs must also be able to have control options amongst their responsibilities, including the use and operation of system-serving storage.
- DSOs, as neutral market facilitators are the ideal partner for energy communities, who can benefit from DSO expertise in grid management while providing flexibility to the grids.
- Beyond investments, network planning will be increasingly more important for making distribution networks more resilient and fit for a new system.
- Many DSOs initiatives and projects are already taking place in Europe by DSOs to proactively transform their networks and equip them for their new role in the energy transition.

Electricity networks

Europe's targets and measures towards decarbonisation have led to the following transformative trends in the electricity sector: decentralisation, democratisation and digitalisation.

DECENTRALISATION

It is not a secret that the sharp increase in Distributed Energy Resources (DERs) is resulting in a more decentralised energy system. The penetration of solar PVs, EVs, heat pumps and batteries will have a strong impact on distribution networks. While promising for decarbonisation, this trend poses **very complex challenges for the management of the grids**, at least in relation to the following aspects:

- *Capacity:* grids' ability to accommodate new variable loads is limited.
- *Resources:* the growth in connection requests is not matched by adequate capacity to accommodate all the demands (See Figure 1).
- *Financial feasibility:* while delivering economic benefits in the long run, transitioning towards a more decentralised network does not come for free and the question on how this can be financed inevitably arises.
- *Permitting:* the permitting processes to reinforce or build new capacity necessary to integrate additional renewables' generation is extremely lengthy.
- *Efficiency:* electricity grids have become increasingly more efficient over the years. A steep and sudden integration of DERs – while increasing the presence of renewables – might lead to the paradoxical outcome of a less efficient network if not managed correctly and if our grids are not smartly prepared in advance.

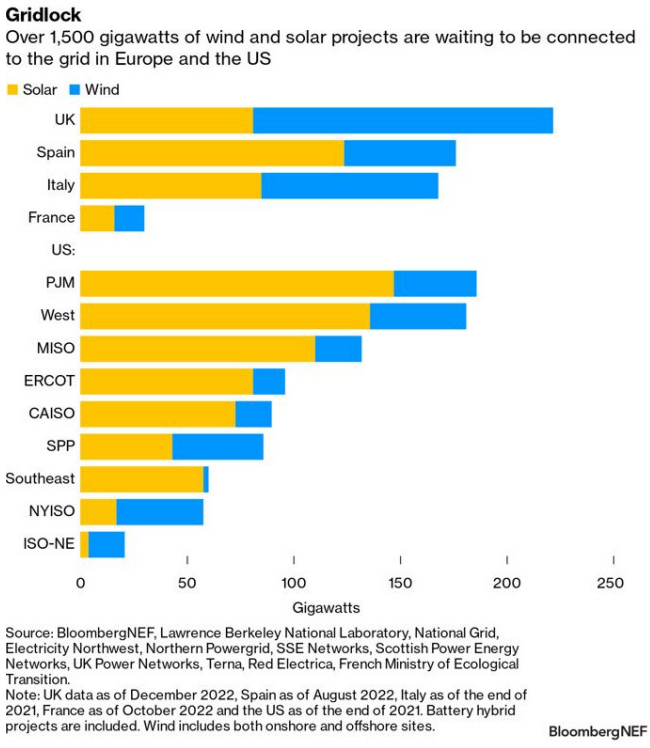


Figure 1

These challenges make the DSOs' task to integrate renewable energy resources extremely complex, leading to the question on whether granting network access to every DER should always be technically possible. To overcome this situation, **DSOs require a toolbox of solutions to operate a future electricity grid fit for purpose.**

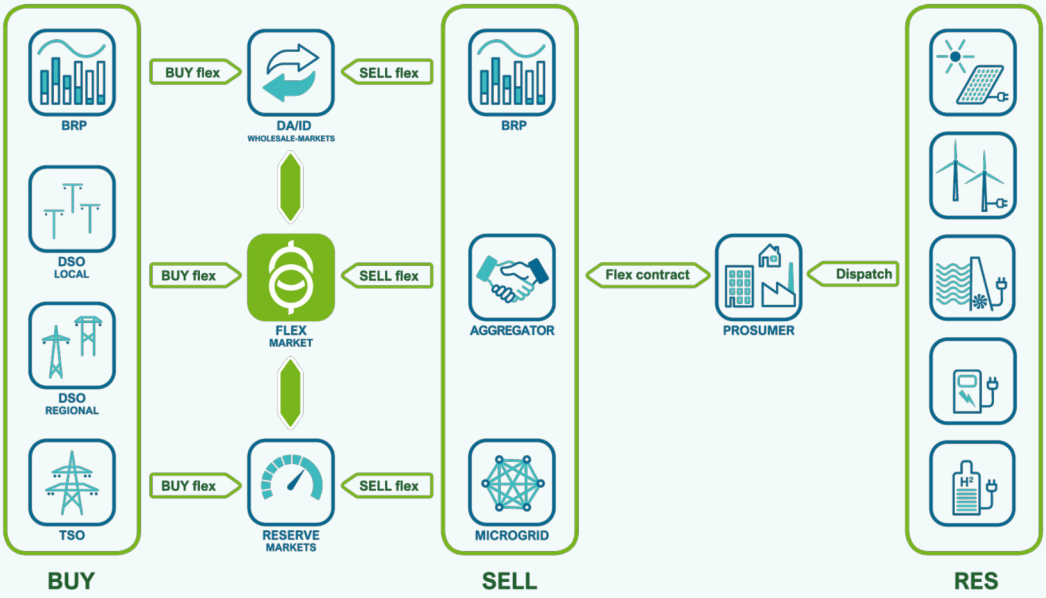
Flexibility is certainly one of these tools, and there are a wide range of technologies available to deliver it, such as **energy storage** and **demand response**. **These solutions can only be guaranteed if distribution networks become 'smart' in the way they are operating.** The digital transformation of the grids is already underway through different solutions, such as the physical installation of new intelligent control, automation and adjustable network topology equipment, better monitoring equipment, such as Smart Meters and intelligent sensors, and new business models, such as flexibility markets. To further promote flexibility, DSOs must also be able to have control options amongst their responsibilities, including the use and operation of **system-serving storage.**

Case study:
Å Energi (NO)

Å ENERGI

Norflex – Demonstrating NODES local energy marketplace in distribution grids

The main objective of the Norflex project[5] is to **incentivise and facilitate the use of distributed flexible energy resources through a market-based approach.** All accommodate the need for more capacity in the electricity networks due to the energy transition. Two DSOs, one TSO, 8 aggregators and the NODES market platform form the framework of the project.



In the Norflex project the main goal has been to establish an independent market platform and common language so that the DSOs can develop tools and methods while using marked based solutions for congestion management purposes, provide the TSO with new aggregated resources for balancing the power system and help aggregators to develop and test their own unique business models while offering flexible resources from their customers.

Throughout the project period the **NODES platform has provided 31470 trades with a total volume of 1.39 GWh from over 4400 assets.** The project has equipped the DSO with automatic solutions for both flexible asset approval, forecasting, optimisation, and trading. This has made the DSO able to predict when, where, how much and for how long a problem in the distribution grid will exist and provided new market based instruments for an efficient, secure and reliable operation of the grid. For the end users the project has provided an opportunity to 1) get compensated for voluntary change in energy use even with small volumes (>= 1kW), 2) make available capacity for new customers and 3) optimize the value of flexibility or return of investment.

[5] **Norflex**, Nodes, https://:nodesmarket.com/norflex/

DEMOCRATISATION

Another trend is "democratisation", commonly intended as a more active participation of consumers in the energy system. **Energy communities (EnCs)**, legal entities based on open and voluntary participation who can be engaged in different activities such as generation, distribution, supply, consumption aggregation, storage, energy efficiency services and charging services for electric vehicles are a good example of consumers engagement.

DSOs, as neutral market facilitators with expertise in grid management, **are the ideal partner for energy communities**, who can benefit the grids by providing flexibility.

However, democratisation does not only mean enabling the participation of active customers. **Network operators hold the duty of ensuring equal grid access and conditions to all consumers, both active and non-active.** This point is crucial to avoid the risk of granting unconditional and uncontrolled access to the grid which, in turn, would lead to a suboptimal energy system. The latter refers to a situation where active customers – having the financial means of installing DERs (especially PVs) – reap all the benefits of democratisation at the expense of passive customers who do not have the possibility or knowledge to actively participate in these processes. These imbalances may worsen by promoting net metering, instead of more cost-reflective capacity-based charges[6].

[6] **GEODE Recommendations on Electricity Distribution Tariff Structures,** GEODE (May 2023), https://www.geode-eu.org/wp-content/uploads/2023/05/GEODE-Recomm-Electricity-Distribution-Tariff-Structures.pdf

Case study: **ENERCOOP (ES)**

COMPTEM

The COMPTEM Energy Community initiative[7] is a collaboration between the energy cooperative Enercoop and the municipality of Crevillent (Alicante) to develop a village-wide energy community (30.000 inhabitants). ENERCOOP promotes collective self-consumption facilities in public and private buildings, small PV plants in the periurban area of the village and EV charging stations. A mobile APP is available to its members to maximize their electricity self-consumption and thus lower their electricity bills. Digital panels in buildings and public places with the municipality's energy information have also been implemented to support the education and engagement of the citizens. To lower the participation barrier for citizens, no initial individual investments are needed, instead investments come from Enercoop; ultimately members make their investments by repaying the cooperative through the reimbursement of the rebates in the electricity tariff. The energy community produces energy savings of about 15-20% for the involved households.

At the beginning of 2023, COMPTEM has 600 kW of PV installed in public roofs, 242 kWh of ESS, 4 EV charging stations and 2 information panels within the municipality, with the objective of substantially increasing the capacity of renewable generation and storage of the community in the next years.

The planned activities for the energy community imply the development of flexibility assets and services that will give the opportunity to the DSO to improve the operation of its network, these activities include energy storage systems, participation through demand response schemes, development of an energy aggregator and incentivation of energy consumption within solar hours.

[7] **Comptem,** Grupo Enercoop, https://:www.grupoenercoop.es/conocecomptem/

DIGITALISATION

In broad terms, DSOs consider digitalization as the necessary tool to optimize system operation while improving the experience of customers, who should be able to interact with the energy system in a "plug & play" manner. Digital solutions can also help DSOs to facilitate the integration of renewable energy and other DERs, support the deployment of flexibility services and better deal with cybersecurity issues. Promising developments in this area include the design at EU level of Smart Grid Indicators and the development by DSOs of **digital twins**, virtual replica of the physical network used to run simulations and test the impact of DERs' integration.

To grasp these opportunities, DSOs must make significant investments in their digital and data capabilities to ensure an efficient operation of their grids and security supply for consumers. However, and while data is key, its use is not always the easiest due to existing data protection regulations, which can (in practice) result as barriers. Grid controllability and observability is also crucial.

Case study:
LINZ NETZ GmbH (AT)

LINZ NETZ
Ein Unternehmen der LINZ AG

Digital Twin Pilot Project

Due to the lack of detailed information in the low-voltage grid, traditional grid planning methods rely on worst-case assumptions that are applied when examining the influence of additional photovoltaic systems on local voltage levels and the loading of lines and transformers. Since both the voltage levels and the loadings must be kept below certain limits, the detection of exceeding these limits in the planning process often leads to the initiation of a costly grid expansion. The usage of measurement data, however, gives a more detailed insight into the actual reserves in a low-voltage grid. A measurement-based planning approach holds the potential for more economical use of existing grid infrastructure than a worst-case planning approach.

LINZ NETZ GmbH started a pilot project to gain experience using existing measurement data in the grid planning process. In a small area of the low-voltage grid, available measurements of transformers, inverters, and customers are used as input in load-flow calculations by which it is possible to calculate the influence of newly attached photovoltaic systems on voltage and loadings based on the individual reserves of the corresponding grid section.

Gas networks

Decarbonisation policies and recent geopolitical developments are redefining the role of gas in the European energy system. Despite the phase out of Russian natural gas imports politically agreed by EU Member States, **gaseous energy will continue to play a relevant role in the EU's mix for the foreseeable future.** Both in the form of alternative natural gas imports and through the penetration of new solutions, such as renewable hydrogen and biomethane, the EU energy system will continue to rely on molecules. In this context, the role of DSOs will remain crucial in contributing to the decarbonisation of EU gas system. This is rather straightforward if we look at some numbers:

- The EU is home to an articulated and efficient gas network consisting of more than **2 million km of distribution pipelines**[8] transporting large quantities of energy.
- **100%** of residential consumers and **99%** of industrial and commercial gas end users[9] are connected to local gas distribution grids.

DSOs are therefore best placed to enable decarbonisation by facilitating the integration of hydrogen and biomethane.

BIOMETHANE

Given its properties, biomethane can directly be injected into existing natural gas grids with minor adjustments. This makes biomethane an extremely promising short-term solution for DSOs, who are ready to contribute to the objective of 35 bcm of biomethane in the EU by 2030 as established by the REPowerEU strategy.

The injection of biomethane into existing distribution networks has been a reality in Europe for decades and even more now in 2023, as demonstrated by the case study below:

[8] **Gas Factsheet**, ACER, https://www.acer.europa.eu/gas-factsheet

[9] **Report – Part 02. The value of local hydrogen distribution networks in a decarbonised Europe,** ready4H2 (February 2022), https://www.ready4h2.com/projects-3

Case study: **Evida (DK)**

Biomethane in Denmark: Strategic distribution grid planning – A key to fast energy transition

The Danish gas distribution system operator, Evida, is owned by the Danish government. Evida operates, maintains, and constructs the gas distribution grid across the country as part of Denmark´s critical infrastructure. **Evida is responsible for the injection of biomethane into the distribution grid and has in few years connected 56 biomethane production plants reaching a share of about 34 % biomethane by end 2022.** The level of 100 % biomethane in the grid is expected to be reached around 2030.

Evida plays a major role when it comes to the green transition of the Danish gas grid, including integrating biomethane into the grid. **Evida, as the national Gas DSO, is responsible for the strategic network planning, a key tool for securing a sustainable roll-out of biomethane.** Due to the nature of the production and grid injection of biomethane, and especially the fast-moving development in biomethane production, Evida is among many other initiatives increasing its efforts in strategic grid planning.

Biomethane cannot flow freely across the full distribution grid which results in imbalances when the local biomethane production is greater than the local consumption. To handle imbalances grid reinforcements are needed. Grid reinforcements can be handled in four different ways:

1. Line pack
2. Connecting different grid sections
3. Building back flow compressors (at "higher" DSO or TSO grid levels)
4. Modeling market incentives

With these four approaches in mind, Evida uses strategic guidance when handling biomethane roll out - each grid section (36 in total) should be operated with one of the following guidelines in mind:

1. Small distribution sections should be left without biomethane producers – only connect to larger sections to reduce investment costs in grid section connections.
2. Connect grid sections where possible to reduce the need for back flow compressors.
3. Grid sections where back flow compressors will be needed.

This strategic approach in grid planning for biomethane is key to secure an efficient green transition in the gas grid. The DSO's will play an important role in this work, as they have expertise and practical knowledge on how to plan and balance the local distribution grid. Evida explores further development on how to strengthen biomethane implementation strategically, e.g., whether specific market driven models can contribute with additional incentives when planning the grid development.

For now, the speed and expansion of biomethane in the Danish grid is remarkable, why swift reactions are needed. Local 'ownership' and strong strategic coordination seems to be fundamentals for success – two aspects that illustrate why DSO's play an important and central role in the green energy transition in the EU.

HYDROGEN

Over **1 million km** of European distribution pipelines are ready for hydrogen[10]. This makes DSOs an important actor in the scale up of hydrogen. Depending on the local circumstances, hydrogen can be better supported by repurposing existing gas pipelines or building new ones. Blending is also an alternative to consider helping the market ramp up in the initial phases.

While being a more long-term solution, it is important to emphasize that DSOs are already participating in hydrogen projects. This clearly emerges from the Hydrogen Infrastructure Map[11], which shows that **dozens of hydrogen distribution projects are being developed right now across Europe.**

Case study:
Wiener Netze & Netz Burgenland (AT)

WIENER NETZE
netz BURGENLAND

H2 Collector East

The purpose of the construction of the hydrogen pipeline[12] by the DSOs Wiener Netze, Netz NÖ, and Netz Burgeland as well as the TSO Gas Connect Austria is to alleviate the strain on the electricity grid infrastructure caused by the increase of volatile PV and wind generation and to lay the groundwork for the future of hydrogen in Austria. This also ensures a substitution of renewable hydrogen for natural gas consumption. New construction of the DSO level lines, and conversion of the TSO line are included in the project.

The objective is to produce renewable hydrogen through the expansion of renewable energy in order to supply industry, which has an urgent need for renewable hydrogen. Similarly, this can enhance the flexibility of both sectors.

The construction of a new hydrogen line from Burgenland to Vienna will supply renewable hydrogen to future hydrogen customers. Specifically, the gas power plant in Vienna will benefit from this implementation and will also serve as a renewable backbone of the volatile renewable power generation in the electricity sector in the future.

[10] **Report - Part 01. Local gas networks are ready to convert**, ready4H2 (December 2021), https://www.ready4h2.com/projects-3

[11] **Hydrogen Infrastructure Map**, ENTSOG, GIE, EUROGAS, CEDEC, GD4S, GEODE (December 2022), https://www.h2inframap.eu/

[12] **H2 Collector Ost: Wasserstoff marsch für Ostregion!**,Gas Connect Austria (28 March 2023), https://gasconnect.at/aktuelles/news-presse/news/detail/News/h2-collector-ost-wasserstoff-marsch-fuer-ostregion

The answer: investments and network planning as the DSOs' allies

How can DSOs support all these transformative trends? In our view, **network investment and planning** are priorities to make grids more resilient and fit for a new energy system.

An adequate regulatory framework for **network investments** is necessary to embrace all these transformations as it is estimated that at least *"about EUR 584 billion of investment in the electricity grid will be required, between 2020 and 2030, in particular in the distribution grid"* to achieve the Fit for 55 and REPowerEU objectives for renewables and energy efficiency[13]. To this end, it is important to support a comprehensive approach towards investments, including the **physical expansion, reinforcement and maintenance of the grid, the procurement of flexibility services and digitalisation.** The latter must be considered as a relevant investment voice since the transformation towards a distributed system will require smarter networks. An enabling and **proactive framework for investments** – anticipating the upcoming needs, volumes and loads (e.g. EVs, heat pumps) – can be ensured only if the following elements are considered:

- **Regulatory certainty** based on a certain, clear, and stable regulatory model allowing DSOs sufficient economic return (WACC) to make investments on first place, having a sustainable flow of revenues in return.
- **Easier and faster permitting procedures** to reinforce and expand grids.
- Support **capacity-based network tariffs** to better reflect the costs of grid operations, maintenance, and investments. This tariff structure provides customers with incentives to optimize their consumption and production, encouraging them to participate in demand response while improving the overall efficiency of the system.
- A more balanced approach between operational (OPEX) and capital (CAPEX) expenditure in DSOs' remuneration.

Together with predictable and stable flow of investments, another crucial element is network planning. The latter – mandated and regulated at EU level by the Electricity Directive (Article 32)[14] – is implemented in different degrees of effectiveness across Member States. While the Directive's provision has not been transposed in some Member States, best practices exist in other countries, as described in the case study below from Finland which also shows the importance of customer engagement in the process.

[13] **Digitalising the energy system - EU action plan**, European Commission (2022), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022DC0552

[14] **EU Directive 2019/944 on common rules for the internal market for electricity**, Official Journal of the European Union (5 June 2019), https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32019L0944

Case study: **Elenia (FI)**

Elenia Avoin – Public Consultation Platform for Network Development Plan

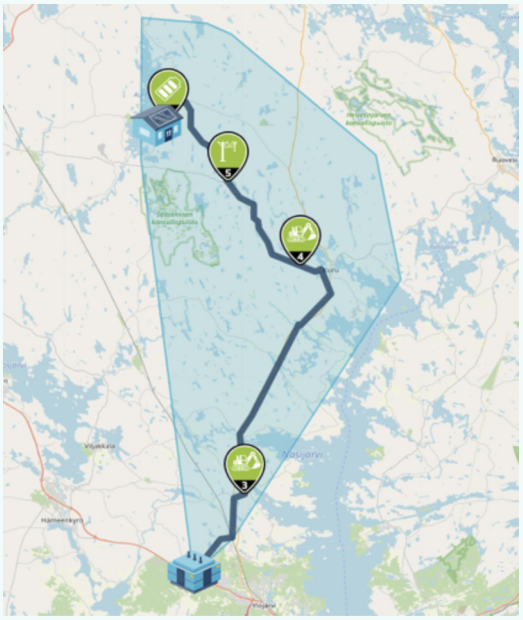
WHAT IS IT ABOUT?

Since 2014, Finnish DSOs like Elenia have been obligated to form their network development plans (NPDs). In 2021, a new demand of a one-month public consultation for the NDPs was introduced.

The NDP itself is a complex topic, a pile of documents full of engineering jargon and economics. Publishing it as a pdf-file in Elenia's webpage would not create value for customers nor Elenia. The company therefore wanted to enable customer engagement with a digital, interactive solution. With the primary goal to enable way of sharing the NDP and gathering feedback in an efficient and understandable way that strengthens the customer relationship and builds customer insight.

Elenia innovated a concept and a map-based platform for the public consultation of Elenia's NDP. The platform was named **Elenia Avoin**[15], meaning Elenia open/transparent.

People must first understand the fundamentals of the grid to be able to give feedback on the NDP. Also, the NDP must be put to the context of the person whose reviewing it, "what's in it for me?". **Elenia Avoin platform explains the basics of how the grid works** and includes an interactive map which allows the user to input any address in Elenia's network area and see insights such as: Where does my electricity come from? What is the coverage, structure, age, and outage history of the network serving me? What is the security of supply -status of the network serving me? What are Elenia's plans for this area according to the NDP?



Elenia Avoin platform makes it possible to explain network management to the public in a personalized way. DSOs are the ones enabling green transition and securing the supply in any circumstances. According to Elenia's NDP, substantial investments will be made to drive these themes. This will have an impact on customers' network service fees and customers need to understand the reasons for the investments and agree on their appropriateness. Increasing transparency and raising public's awareness contributes to the acceptability of a DSO's operation.

[15] **Elenia Avoin**, Elenia (2 May 2022), https://www.elenia.fi/uutiset/tutustu-elenia-avoin-palveluun-ja-vaikuta-sahkoverkon-kehittamiseen

On the gas side, **the integration of biomethane and hydrogen into the grids will also require a sound network planning**, as clearly explained in the case study by Evida in the previous section. In this context, DSOs must be realistic in their planning and consider the specific needs of the areas in which they operate. As such, all network evolution options must be considered, ranging from decommissioning, repurposing and building new pipes. Decommissioning will inevitably take place in those countries where clear political decisions on the role of natural gas have been made (e.g. The Netherlands, Austria). For instance, in January 2023, the city of Vienna decided to phase out the use of natural gas in households' heating by 2040, and instead bet on district heating and heat pumps[16]. Such decisions preclude the use of gaseous alternatives to natural gas and lead to plans for decommissioning.

In countries and regions where it will be assessed that gaseous solutions will continue having an important role in energy systems, network planning will be an essential tool for DSOs to better understand how to adapt their grids for the integration of biomethane and hydrogen.

Network planning is therefore a crucial tool to better assess the challenges for DSOs and identify the most suitable option to decarbonise the energy they distribute. An interesting example of such a strategic approach comes from our German Member Stadtwerke Schwerte.

[15] **Raus aus Gas - Wiener Wärme und Kälte 2040**, Stadt Wien (February 2023), https://www.wien.gv.at/stadtentwicklung/energie/wissen/waerme-und-kaelte-2040.html

Case study:
Stadtwerke Schwerte (DE)

"Zukunftsstadtwerk Schwerte"- A customised decarbonisation strategy to make the municipal utility company of Schwerte fit for the future

The project "Zukunftsstadtwerk Schwerte" aims to **identify a decarbonisation strategy for the energy system of Stadtwerke Schwerte.** Together with the BBH group, Stadtwerke Schwerte wants to answer a key question: What is the future role of the municipal utility company Stadtwerke Schwerte – in 20 to 30 years?

As part of the company's philosophy is being in the driver's seat to address all current challenges – decarbonisation being one of the crucial – there is the urgency to answer that key question and also take into account all the regional peculiarities in Schwerte.

The project started in January 2022 and will be finished by June 2023. The results are recorded in a roadmap to achieve climate neutrality, setting out the vision for the next 20 years from 2023. To this end, the following steps were necessary:

- Analysing historical data and examining the current revenue situation in the respective segments (electricity, gas, heating)
- Identifying the potentials in Schwerte
- Devising a model of the future role as supplier under consideration of individual parameters
- Optimising the entire energy system under consideration of individual subsegments
- Evaluating the regulatory framework conditions and carrying out an economic assessment of the future development

The key question should be asked by every distribution system operator and answered considering the individual parameters. In the end, only a stable and proactive planning is beneficial to users.

Conclusion

The path to transform distribution networks and make them fit for the new decarbonisation era is still long and challenging. Beyond a paradigm shift in the way DSOs operate, concrete actions are needed in this journey, starting from simplified permitting procedure to expand and upgrade grids, sound network planning and more investments.

On behalf of its members, GEODE calls on EU and national policymakers to create the right conditions to enable the transformation of the distribution networks for the benefit of the entire energy system.

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