Draft Nordic TSO strategy on sector integration and wind power development
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ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

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1 Background and objective

In the autumn of 2020, the four Nordic transmission system operators (TSO) launched their work in drafting an updated common strategy for meeting the expectations for wind power development and sector integration. The work will be finalized and made public in the spring of 2022 as part of the next Nordic TSOs' joint Solutions Report. The time span for the strategy work covers the next ten years up to 2030.

Energy transition is changing the electricity landscape. Transmission system operators welcome this development and are positive to enabling the transition to a cleaner energy system. Electricity and the increase in its use have been addressed by the EU as being key to meeting the Union's climate targets. The region needs more clean electricity, which onshore and offshore wind power can generate.

To meet national expectations, each Nordic TSO faces the challenges of energy transition. The four TSOs see a need to adopt a common approach to ensure efficient integration of wind power to our power system and to support and utilize the integration of energy sectors to help reduce greenhouse gases.

The strategy will comprise a Nordic vision and actions for reaching this vision. It will also recognize and consider the developments and requirements taking place at the EU level and in surrounding regions such as the Baltic Sea and the North Sea regions.

Integral to these efforts are the knowledge, plans and objectives of the energy sector stakeholders. They are key to this strategy work and their input and views will be sought in the process through webinars (the first in March 2021 and the second in autumn 2021), consultations and meetings.

2 Nordic challenges

2.1 Sector integration

- How much, where, and when will sector integration increase the need for electricity? Where and when should grid infrastructure (electricity lines or gas pipelines) for new and increasing needs (electrification of heat and gas production, e-mobility) be built? How can the Nordics harmonize and optimize plans for electricity and gas? How can load variation estimations be ensured for years? How can flexibility potential be utilized in grid planning?
- How should different control centers coordinate with each other when sectors are strongly integrated? How can load variation estimation for hours and seasons be ensured? How can adequate and relevant data needed for flexibility forecasts and availability (e.g., access to electrical vehicles - EV charging data) be ensured?
- How can market mechanisms steer the location of electrolyzes? What kind of incentives (e.g., price signals, suitable products, supportive taxation for energy conversions) are needed to enable more flexibility from different sectors? How can consumer aggregation (in buildings) be made more attractive?

- How can the electricity tariff structure be reconstructed and how can the heat and gas tariff structure be harmonized with electricity tariffs? What tariff structure is needed to incentivize EVs to provide reserve services? What tariff structure is profitable for prosumers (V2H)?
- How can data exchange be organized between different sectors to understand the behavior of new flexibility resources?
- How can adequate long-term storage capacity be ensured? What are the most feasible solutions to support (e.g., P2G)?
- How can regulations be changed to support climate goals and to incentivize investors to also invest in flexibility when implementing new sector integration solutions? How can TSOs mitigate or prevent regulatory barriers (preventing the SI progress)?

2.2 Wind power

- How can grid capacity and points of connection be provided in time and in the proper locations to support the exploitation of wind power?
- To hasten the process, implement new technologies in order to optimize the performance of the existing grid.
- Onshore and offshore wind have different technical characteristics that must be considered in developing the grid and connections.
- There is a higher degree of experience in handling onshore wind than offshore wind.
- Are the scenarios and the planning methodologies appropriate with regard to potential future development?
- The potential for exploiting wind power in the Nordics is high but varies in the four countries.
- How can it be ensured that wind power can participate in the balancing market and ancillary services?
- How should we cooperate with stakeholders to find solutions that are for the common good of the power system?
- How to ensure security of supply? The massive increase of wind power challenges also the security of supply, which has been on high level in Nordic electricity system in recent decades. Wind power units do not contribute to the inertia and this can lead to operational situation with less inertia in the electricity system. In low inertia system frequency variations are more rapid and possibly also larger. The combination of frequent low inertia situation with single high-power nuclear units and HVDC connections increases the probability for disturbances with large frequency change.

3 The Nordic strategy

3.1 The elements of success - joint Nordic storyline

Electrification is a tool for competitiveness and climate neutrality.

- Electricity can replace fossil fuels when producing heat for buildings and industry. Electricity can also be used in place of fossil fuels as a direct or indirect fuel (electricity->hydrogen->liquid fuels) in the transportation sector. Furthermore, electricity can be used to produce clean hydrogen which can then be used directly in industry or be further processed to serve several purposes. Assuming affordable electricity prices in the Nordics, thanks to well-functioning electricity markets and good wind conditions, electrification can also lead to an efficient and competitive energy system. Climate neutrality is a consequence of moving from fossil-based fuels to clean and renewable electricity.

Wind power is a Nordic resource for electrification, but its variability is a challenge.

- With geographically extensive rural areas for onshore wind, long coastlines with shallow water for offshore wind and excellent wind conditions, the Nordics have great potential to exploit wind power. The power system in the Nordics has an exceedingly high degree of climate-neutral energy that attracts stakeholders whose business models prioritize clean energy. However, wind power production is naturally variable and, to some extent, season-dependent, with cold winter days with little wind. Therefore, substantial amounts of connected wind power will cause great fluctuation in power production, affecting prices and the stability of the power system. This means that with each new connection of wind power to the power system, countermeasures must be taken that ensure the stability of the whole system.

Flexibility enables wind integration and improves system security.

- Flexibility pertains to the ability to react to the fluctuating needs of the power system while continuing to secure supply. There are several sources of power system flexibility such as electricity generation, loads, storage and transmission lines between the areas. In the event that wind power variability does not mirror the variability of load, flexibility may be needed to balance momentary consumption and generation. Flexibility can also be used to limit short-term power flow peaks in the grid. The more flexibility there is, the better the possibility of integrating large-scale wind power generation to the system without compromising system security.

Sector integration enables flexibility, electrification, and business opportunities.

- By integrating other energy sectors (e.g., heating, gas, transportation) into the power sector, new electricity loads with new flexibility potential will be available. For example, an electrolyzer using electricity for clean hydrogen production can be used as a source of power system flexibility. Sector integration not only enables electrification, it often leads to it. In other words, it is not possible to electrify heat and gas production and road traffic without sector integration. New services and technologies will be needed for sector integration. For instance, flexibility resources will need to be coordinated from the system point of view and optimized from the resource owner point of view. Such needs will lead to new business opportunities.

3.2 Vision

We have laid out the vision in a vision house. Each of the components are described below.

Vision statement (the rood of the house): **Clean and affordable electricity enabling a climate-neutral, secure and integrated energy system in the Nordics**

- **Clean**: Electricity from carbon-free and renewable electricity generation
- **Affordable**: Refers to the cost-efficiency of renewable power generation, such as wind power, without subsidies

- **Enabling**: Addresses the role of TSOs in this energy system transition mainly as enablers and facilitators, but also as responsible for maintaining electricity infrastructure.
- **Climate-neutral**: Refers to the common European target
- **Secure**: Emphasizes the TSOs' key responsibility to maintain adequate quality and secure supply of electricity
- **Integrated**: Refers to sector integration as well as cooperation between Nordic TSOs
- **Energy system**: Energy rather than power. Addresses the aim to harmonize and optimize the energy system as a whole
- **In the Nordics**: Nordic TSOs work for the Nordic energy system. However, offshore wind power may be located somewhere between the Nordic system and another system.

<u>Elements (pillars) of the vision with explanations:</u>

"**Optimized energy system"** Optimized Nordic energy ecosystem where infrastructure is based on the potential of climate-neutral electricity, incorporating the needs of stakeholders.

- An optimized Nordic energy ecosystem means a system where energy is generated, converted, stored, transferred, exported, and consumed in the form, way and location that is the most favorable for the society, while keeping national differences in mind.
- Infrastructure covers not only the electricity grid but also the gas grid, EV's charging infrastructure, district heating infrastructure and all infrastructure needed to facilitate clean energy generation, consumption and transmission according to stakeholder needs.

"**Harmonized market and secure power system"** Harmonized Nordic market design supporting coordinated flexibility on a cross-border level and secure system operation with a level playing field for all technologies.

- At the least, market rules and design should be harmonized in the Nordic region to enable easy access and utilization of all (flexibility) resources by the Nordic markets. This also prevents conflicting incentives and enables efficient coordination of flexibility resources on a cross-border level.
- In the long run, all energy markets (not only electricity markets) should be harmonized to enable complete integration of energy sectors on the market level.
- A level playing field for all technologies guarantees a neutral and fair position to any technology that may support power system security.

"**Adequate infrastructure"** Adequate transmission capacity within and between countries enabling an integrated Nordic market for renewable resources as well as direct and indirect electrification.

- Adequate transmission capacity means that predefined security of supply criteria and market needs have been achieved at an optimized cost-benefit level, taking available non-grid solutions into consideration. Adequate transmission capacity produces an optimized cost-benefit level.
- Here, transmission capacity not only refers to electricity transmission but also that of gas and heat.
- The purpose of adequate transmission capacity is to fulfill all customer and market player needs. However, renewable resources are addressed here because of their importance in electrification and their role in transitioning to a clean energy system.

- Indirect electrification means that electricity is used indirectly for decarbonization. For example, clean hydrogen is produced with electricity. The hydrogen is then used by the end user or further processed into clean liquid fuels for heavy transport, ships, etc.

The foundation of the vision house refers to prerequisites.

To be able to enable the sector integration and to exploit large amounts of wind power, some prerequisites need to be fulfilled. In this sense, the conditions in the Nordics are very favorable. Nordic TSOs have a long tradition of successfully cooperating and closely communicating. This entails cooperation on all organizational levels, finding and implementing harmonized solutions, sharing resources and sharing a joint position within Europe. The conditions for on- and offshore wind power in the Nordics are excellent and advanced electricity and reserve power markets are easily accessed. National-level political and economic conditions are stable. The already high degree of climate-neutral power and, to some extent the geography and climate, attract new innovations, businesses and investors such as an electrified transport system, fossil-free steel production and large data centers. There is also a long tradition of engineering and research and development in many business sectors.

3.3 Roadmap for sector integration

The Nordic TSO roadmap for sector integration presents strategic milestones for reaching the 2030 Nordic vision (*Clean and affordable electricity enabling a climate-neutral, secure, and integrated energy system in the Nordics*). The milestones are classified according to the TSOs' internal working streams: market development, integrated system operation and system planning. In addition, sub-vision *Optimized energy system* is considered in all three working streams, *Harmonized market and secure power system* belongs mainly within market development and integrated system operation while *Adequate infrastructure* is housed under system planning.

The roadmap timeline is indicative. Further analyses are required to better define how to best prioritize efforts. It may be urgent to achieve some milestones, while others can be afforded more time. Also, the TSOs have limited resources at their disposal and will therefore need to prioritize and cooperate. Some of the tasks are most relevant for TSOs while the others require the cooperation of stakeholders to be completed. On a high level, i) TSOs have to prepare for the substantial change sector integration will cause in their operations and ii) TSOs are committed to enable and support the positive development of sector integration. In the latter of the two goals, stakeholder participation is a prerequisite.

Although we have separated the roadmaps into Nordic sector integration and wind power development, we have a common strategy with a joint vision. Furthermore, it should be noted that several Nordic and national development projects related to this Nordic strategy are already underway. As such, we are already moving down the path towards a climate-neutral, secure and integrated energy system. In the following paragraphs, we will describe the overall aim of the roadmap milestones.

In the area of **market development**, the key actions are to enable market-based flexibility where a new type of distributed energy resources (DER), consumption or production has a common market design and easy access to local markets as well as the Nordic reserve power and balancing power markets. In addition, all energy carriers will have a level playing field, there will be clear price signals for market players and the grid tariffs will incentivize customers to connect and use their resources in a way that benefits the whole energy system. Finally, efforts must continuously be made to identify possible barriers to sector integration development. In short, TSOs would like to ensure that new potential flexibility, coming from different energy sectors, would be available in the markets when needed. This requires knowledge about business opportunities and real added value for market players when investment decisions (for flexibility) are to be made.

In the area of **integrated system operations**, it is necessary to manage data and information to maintain real time situational awareness and to develop short- and long-term forecasts. TSOs are responsible for the entire power (and gas) system, but data is provided by the stakeholders of different energy sectors. Sector integration brings a new type of load to the power system whose behaviors are not yet known. Also, the development of new technologies and their flexibility potential, as well as volumes, geographical locations and timing of investments, should be known as early as possible to prepare for the change. Finally, new types of flexibility resources may have new features (opportunities and limitations) that should be taken into consideration in new (connection) requirements. Here, cooperation is required if we are to understand the possibilities (for TSOs) and benefits (for resource owners) of new technologies related to flexibility.

In the area of **system planning**, the main goal is to develop grid planning toward holistic planning of all energy sectors i.e., power systems, gas systems, heating systems and road transportation. This will also require new knowledge about the modelling of new types of technologies and processes. There may be a need to redefine the roles and responsibilities of different actors. Close cooperation with the stakeholders responsible for different energy systems planning is needed early on in the process. Part of the optimization between planning, infrastructure building, and systems operation is a possibility to incorporate new secure supply options for new types of flexible and interruptible loads. This is a new element to be considered in holistic energy system planning.

3.4 Roadmap for wind power integration

The Nordic TSO wind power roadmap presents strategic milestones that need to be achieved in order to reach the 2030 Nordic vision (*Clean and affordable electricity enabling a climate-neutral, secure, and integrated energy system in the Nordics*). The milestones are classified according to TSOs' internal sectors or working streams:

- Research & Development (R&D) and Technology
- Planning
- Markets & operations
- Infrastructure

The short-term milestones are already ongoing or have been initiated and are important to finalize. The long-term milestones are the top three most important milestones per sector. In identifying all the milestones that need to be achieved, there are naturally a lot more details.

The timeline is only indicative and further analysis is needed in order to set priorities and a more detailed timeline.

It may be urgent to achieve some milestones, while others can be afforded more time. Also, the TSOs have limited resources at their disposal and will therefore need to prioritize and cooperate to contribute most effectively. Some of the tasks are most relevant for TSOs while the others require the cooperation of stakeholders to be completed. On a high level, i) TSOs have to prepare for the substantial change sector integration will cause in their operations and ii) TSOs are committed to enable and support the positive development of onshore and offshore wind power.

Although we have separated the roadmaps into Nordic sector integration and wind power development, we have a common strategy with a joint vision. Furthermore, it should be noted that several Nordic and national development projects related to this Nordic strategy are already underway. As such, we are already moving down the path towards a climate-neutral, secure and integrated energy system. In the following paragraphs, we will describe the overall aim of the roadmap milestones.

In the area of **(R&D) and Technology**, the key actions are to optimize performance of the existing system and assess the viability of expanding the grid technology mix. Performance optimization of the existing system is particularly an effect of gaining speed in providing capacity and connections in the grid. The current fact is that the timeframe of the physical expansion from idea to actual delivery is long, particularly the legal processes. Introducing large amounts of wind power, presumably clustered in geographical areas, will create a need to introduce new technologies to the grid, not only existing technologies that have not yet been implemented in the Nordics but also completely novel solutions that are harmonized and interoperable between vendors.

In the area of a **planning**, there is a need for more holistic planning methodologies and to take factors outside the power system into account. Wind power will drive the power system to no longer be a standalone planning problem but rather to be a part of optimizing the energy system. The TSOs also need to reflect on the appropriate assumptions concerning how wind power will develop in the Nordics over the next decades. These scenarios based on these assumptions are the foundation for long-term planning of the system. Close communication with stakeholders is necessary to discover the right scenarios and make the right plans. Both TSOs and stakeholders will benefit if we all strive for the common good of the total system.

In the area of **Markets & operations**, the key actions will be to improve short-term forecasting, enabling proactive balancing. With large amounts of wind, how can we predict the weather and thereby the amount of wind power produced so that we can adapt. So far, the wind power sector has not needed, or has not had the opportunity, to participate in balancing markets and ancillary services. In this area, barriers that hinder wind power from contributing need to be discussed as well as what wind power can or should contribute for the common good of the system. Offshore wind is a relatively unexplored area. Therefore, offshore market design needs to be investigated and discussed to reach a joint Nordic view.

In the area of **Infrastructure**, the main milestones are to build the identified grid to meet capacity needs within and between countries and to streamline connection to the grid ("reduce time to implementation"). The focus is for TSOs to be swift and exact in providing the right solutions, at the right time and at the right position in order to fulfill the needs of wind power providers. To be fast and efficient, TSOs believe that success is dependent on close cooperation and making use of the total amount of resources in the Nordics. Therefore, any solution that simplifies the use of Nordic resources and can save days or weeks in the implementation process (from identified demand to delivery) needs to be explored and evaluated.

3.5 Role of TSOs in sector and wind power integration

Grid is the platform that connects electricity producers and consumers. Hence, TSOs have a central role as enablers in sector and wind power integration. TSOs provide access to the grid and markets for both consumers and producers. The objective is a system where users and producers have competitive conditions to invest in the Nordics. While the investments in clean generation and demand facilities themselves will be carried out by other companies, TSOs will play a role as enablers to make those investments possible. With the rapidly progressing energy transition and upcoming electrification, this needs to be done at an unprecedented pace, while simultaneously ensuring that the future system will be secure. This requires good cooperation and communication between TSOs and stakeholders.

The wheel does not need to be reinvented, but the design needs to be improved. A substantial part of needed TSO actions will still be related to core TSO business – e.g. connecting new generation and demand, optimizing the performance of the existing power system, building planned grid investments, facilitating players' access to the common markets, and operating the system in a secure way. At the same time, new demand, generation, storage and grid technologies, as well as market mechanisms related to sector integration, require R&D and other development activities.

4 Appendix

Definition of sector integration

First, some definitions for sector integration-related vocabulary:

- Energy sectors: different sectors where energy is *consumed*, e.g., industry (electricity, gas and heat used by industry), transport (electric/gas vehicles) and buildings (heating and cooling).
- Energy vectors: different forms of energy, e.g., gas, heat and electricity
- Energy carriers: a substance (fuel) or sometimes a phenomenon (energy system) that contains energy that can later be converted to other forms of energy. Examples are electrical batteries, capacitors, pressurized air, dammed water, hydrogen, petroleum, coal, etc.
- Sector coupling: often refers to integration of electricity and gas systems (power to gas)
- Sector integration: to be discussed further below.

There are several definitions of sector integration available. The European Union defines sector integration in its strategy for system integration (published in July 2020) as follows: *Energy* *system integration – the coordinated planning and operation of the energy system 'as a whole', across multiple energy carriers, infrastructures, and consumption sectors*. Fingrid[1] and Hydrogen Council[2] offer other definitions.

Regardless of the definition of *sector integration*, integration may occur in several ways. First, the generation, storage, transmission, and consumption of *energy vectors* can be connected into one integrated system. This can be done at the system level, the (energy) end-user level, or both. Second, different *energy* (usage) *sectors* can be integrated into one energy system. In this report, sector integration covers all aspects described in this paragraph.

[1] Sector integration means bringing the various energy sectors together to enable them to balance out each other's consumption and generation peaks. Electricity, heat, gas and transport will be interconnected to provide mutual support to one other.

[2] Sector integration means the integration of the power sector with the transport, industry and heating and cooling sectors via the use of all energy carriers, such as electricity and hydrogen, to achieve European climate and energy goals.