



ENERGINET

POSSIBLE SOLUTIONS FOR ELECTRICITY NEEDS

Energinet's long-term development plan 2022 –
Solution catalogue

POSSIBLE SOLUTIONS FOR ELECTRICITY NEEDS – NOW AND IN THE FUTURE

The green transition is picking up pace and presenting challenges for the Danish electricity transmission grid, which must adapt and develop if it is to avoid becoming a bottleneck in the climate transition. This requires wide-ranging decisions and timely solutions.

This solution catalogue provides an overview of many of the solutions and tools Energinet is working on to address identified needs in the power grid. The catalogue will be used as a basis for close dialogue with stakeholders, and new solutions and tools can be added to the examples here to produce a common draft list of possible solutions. This draft list of solutions is also intended to guarantee coordination of the best solutions across the electricity and gas sectors.

More renewable energy requires a bigger toolbox

Energinet is always trying to expand the toolbox it has at its disposal to address the needs. In the following pages we describe a range of solutions designed to meet the needs of the future: construction solutions, operational solutions and market solutions as well as dialogue-based initiatives and third-party solutions. The list is not exhaustive, but is a good starting point for dialogue and cooperation around the opportunities, constraints and effectiveness of the solutions.

The green transition will be visible in the landscape

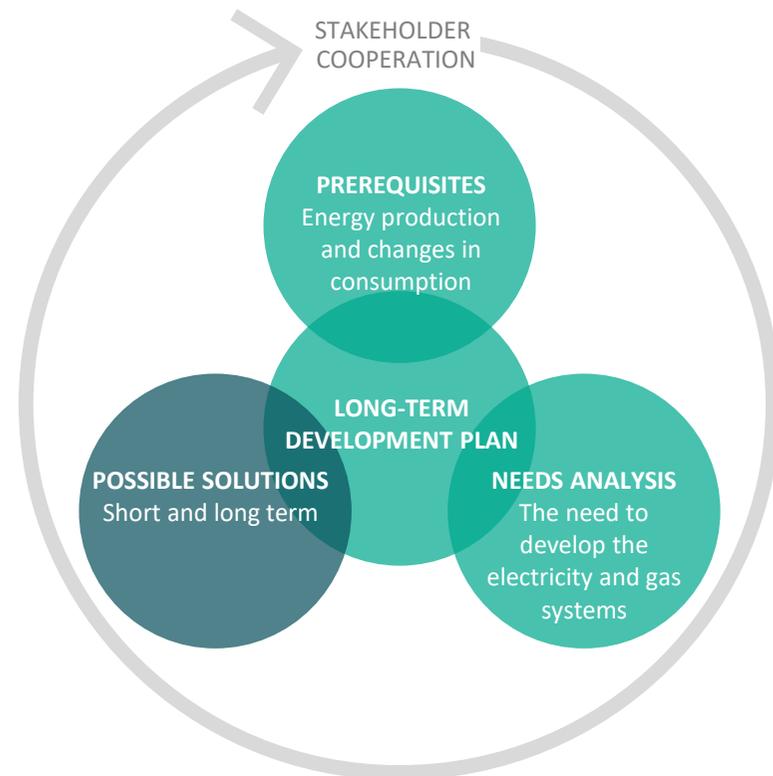
As the green transition picks up speed, renewable energy will become more visible in the landscape, and Energinet has the important task of ensuring that the new solutions cause as little inconvenience as possible to people and to nature. Energinet is also working hard to resolve the energy trilemma: converting the electricity and gas systems to run on green energy; maintaining a very high level of security of supply; and keeping it affordable for consumers and society.

Where can you find out more?

Discover more about the needs identified in the power grid and find background material at

Needs analysis for the power grid: www.en.energinet.dk/power-needsanalysis2021

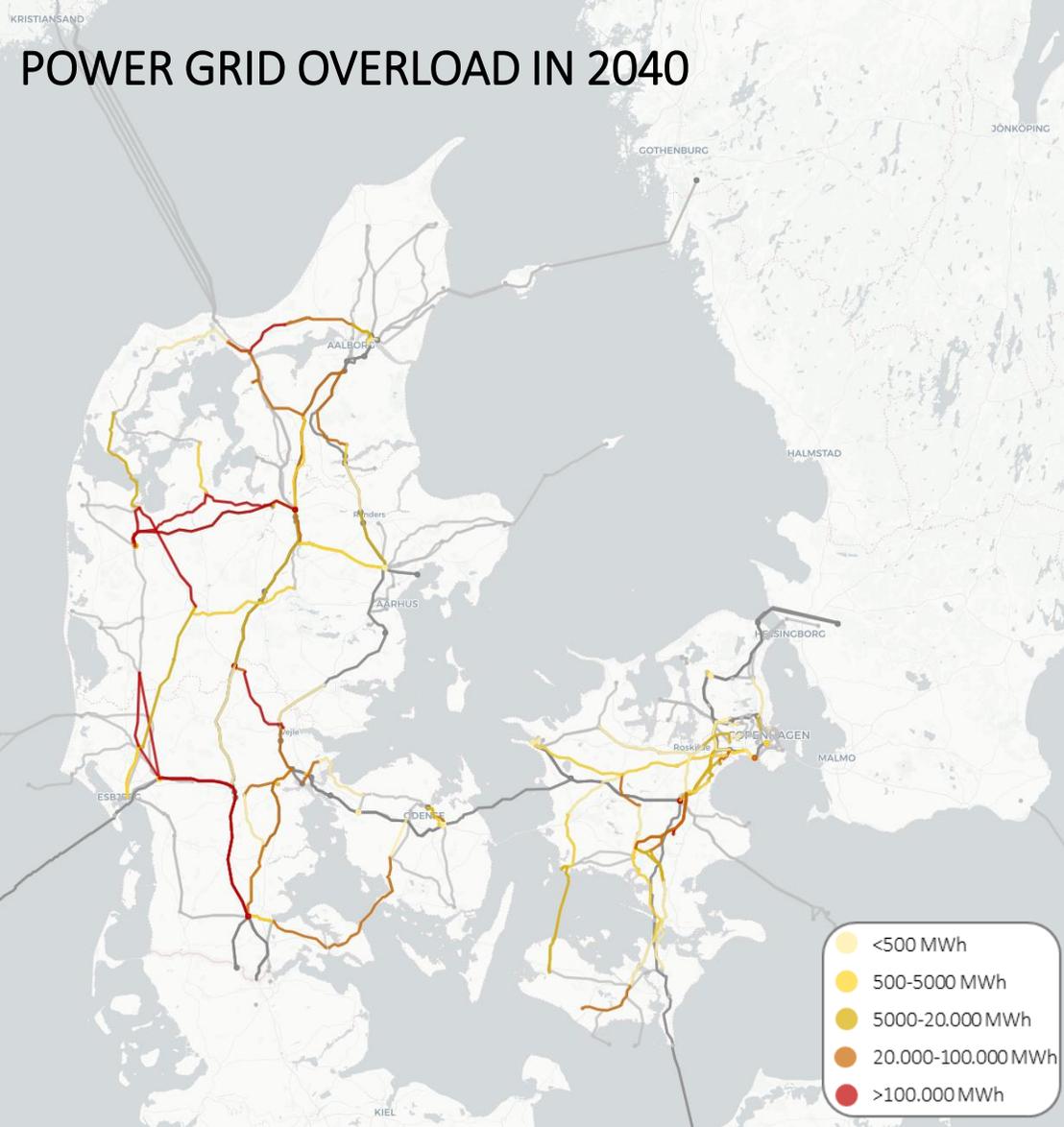
Background material for the power grid: www.energinet.dk/el-baggrund2021 (in Danish)



Energinet's long-term development plan

The solution catalogue is an important part of our long-term development planning. In line with the assumptions used, the needs analysis forms a basis for investment decisions and thus for the solutions which are intended to guarantee a high degree of security of supply now and in the future. There are many unknowns and therefore the process is iterative, meaning that we revise and update our plan as we go if the assumptions change, and new needs arise.

POWER GRID OVERLOAD IN 2040



ENERGY OVERLOAD

The map shows the volume of energy that must be relieved on a connection if no other measures are taken. It is determined by simulating the electricity spot market over a year. The energy volume will be larger if the overload occurs frequently, or if the component is transferring a lot of energy.

POWER GRID OVERLOADING MAKES NEW INITIATIVES NECESSARY

With an anticipated development of consumption and generation, for example, we can present the most likely scenario for the need for initiatives that will be needed in the power grid as a result of the green transition. In this context, 'needs' means that there is overloading in the power grid due to existing capacity not being sufficient to transmit the energy through the system which the analyses predict will be necessary. There are big geographical differences in how pressing the needs are and what developments are driving them. You can read more about the assumptions used and the identified needs here: www.energinet.dk/el-behovsanalyse2021. In the pages that follow, we present various solutions to the needs set out in the needs analysis.

Renewable energy must be transported to where it will be used

Even today, certain parts of the country generate more electricity than they consume. As a result, the excess power has to be transported out of the region and either delivered to consumers or exported. This trend is expected to grow over time because renewable energy facilities tend to be installed in areas with low consumption. Examples of such regions include Lolland-Falster, South Zealand, West Jutland and North Jutland. In many parts of the country there is particular interest in installing PV power plants, and this could make the needs more pressing than indicated by the analyses here.

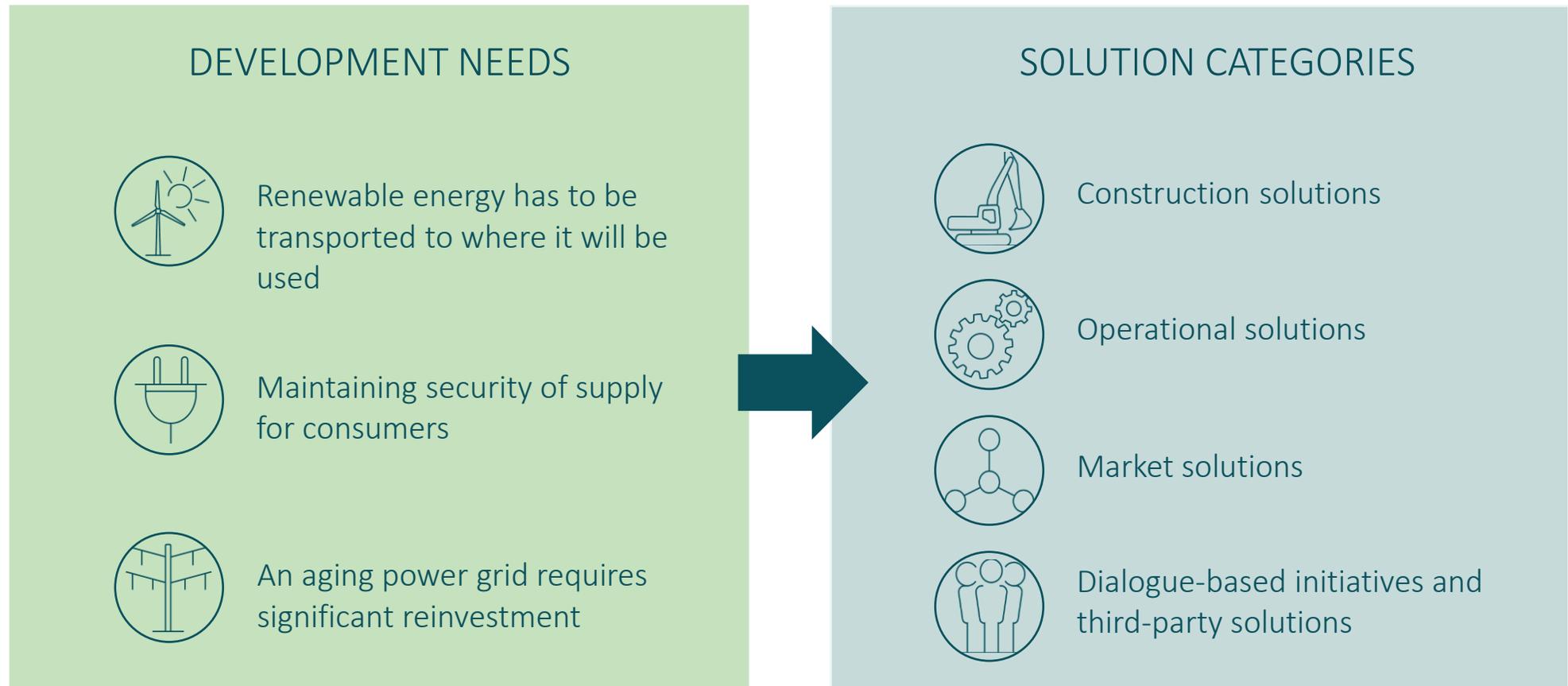
Maintaining security of supply for consumers

Increasing consumption means more power will have to be delivered to the consumers. Electricity must be available from the wall sockets, to charge the electric vehicle, or to heat the house. Electricity consumption is also expected to grow significantly from technologies with the potential to improve flexibility in the system. Examples include electric boilers and heat pumps in the district heating sector, and PtX plants.

It is mainly in the densely populated areas that increasing consumption will determine power grid development needs. These include the areas around the major cities of Copenhagen, Aarhus and Odense, the east coast of Jutland and the Triangle Region. In many parts of the country, there is potential for bigger increases in consumption than predicted in the analyses here. If more of these potential increases is realised, the needs may exceed the forecasts in the analyses.

WORK ON SOLUTIONS IS BASED ON THE DEVELOPMENT NEEDS

Energinet spends a lot of time mapping and analysing the development needs of the power grid, aiming to develop the power grid in a way that supports a future with fluctuating energy sources such as solar and wind. The needs analysis supports this process by providing an overview of the challenges and needs facing us. The types of development needs we identified are summarised in the headings below on the left. You can read more about the assumptions used and the identified needs here: www.energinet.dk/el-behovsanalyse2021. Energinet is always working with several types of solutions, and the four main categories of solutions are on the right below. Solutions are described in more detail on the following pages. The needs analysis and solution catalogue form the basis for a dialogue about how possible solutions – both old and new – can be used to address the identified needs.



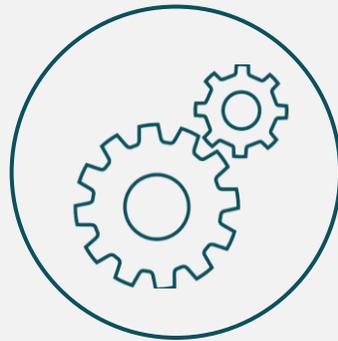
DIFFERENT SOLUTIONS TO ADDRESS DIFFERENT NEEDS IN THE POWER GRID

The four main categories of solutions which Energinet works with are described below. The four categories will be described in more detail on the following pages.



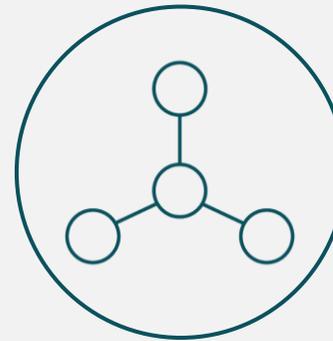
CONSTRUCTION SOLUTIONS

Construction solutions allow the existing power grid to be developed, either by building new connections and substations or upgrading existing ones. Developing and maintaining the power grid is essential in order to transport energy from where it is produced to where it is consumed.



OPERATIONAL SOLUTIONS

Certain challenges can be tackled within the system by making operational changes. An operational solution could increase the amount of energy or move the energy around the system more easily – removing the need to invest in new facilities or power lines or to implement a market solution.



MARKET SOLUTIONS

Market solutions can ensure that energy is produced and consumed in a flexible and intelligent way. As such, they can refine production and consumption in a way that makes the best possible use of our transmission grid. This could reduce and/or postpone the need for construction solutions.



DIALOGUE-BASED INITIATIVES AND THIRD-PARTY SOLUTIONS

Energinet does not always have the best solution. Other market players can contribute with a solution, such as market solutions in which Energinet compensates producers or consumers, or clever solutions in which addressing a need could be a business idea for a third party. For example, new consumers could use local surpluses of renewable energy.

THE MOST COMMON CONSTRUCTION SOLUTIONS

Construction solutions allow the existing electricity transmission grid to be developed, either by building new connections and substations or upgrading existing ones. Developing and maintaining the power grid is essential in order to transport the energy from where it is produced to where it is consumed. This page summarises some of the various types of solutions available to Energinet in order to expand the power grid. There are many different construction solutions, but the solutions described below are the most common. Different voltage levels can address different needs and perform different functions in the overall power grid, and that is why they are described separately.

TRANSFORMERS

When renewable energy is produced and connected to the existing power grid, the aim is to convert the power to a higher voltage as close as possible to the point of connection. Changing to higher voltage levels reduces losses and improves the energy mix in the meshed power grid. This enables better use of the existing power grid, and grid reinforcements can be postponed by installing transformers.

HVDC CONNECTIONS

HVDC connections are used to transport large amounts of power over long distances from point to point. This solution cannot be used for meshed power grids and can be thought of as a motorway without interchanges.

400 KV CONNECTIONS

400 kV connections are used for transporting and distributing large amounts of energy over long distances. 400 kV connections are generally built as overhead lines, but are underground where technically possible.



220 KV CONNECTIONS

220 kV can be used if new RE generation is to be connected to the existing power grid via radial connections. Examples include Horns Rev 3 and Kriegers Flak. 220 kV connections are not part of the meshed power grid like the 400 kV and 150/132 kV connections.

150/132 KV CONNECTIONS

150/132 kV acts as a regional electricity grid which integrates renewable energy generated onshore and distributes energy to consumers. New 150/132 kV power lines are normally always built as cables.

OPERATIONAL SOLUTIONS

Some challenges in the power grid can be handled by altering or adjusting the way it is operated. An operational solution could increase the available capacity or move the energy around the power grid more easily – removing the need to invest in new facilities, power lines or a market solution. Energinet is constantly seeking to develop new operational solutions to support an efficient power grid. The operational solutions currently in use are outlined below.



PRODUCTION SYSTEM PROTECTION

In a green electricity system based primarily on power from solar and wind, very high electricity generation is expected to occur for a few hours each year – on sunny days with strong wind. In this situation, the production system protection can ensure that generation facilities are automatically disconnected in the event of a simultaneous critical outage of a grid component.

This takes away the need to expand the grid to accommodate all this power while a grid component is out of operation.

DYNAMIC LINE RATING

DLR is an operation philosophy that makes the best possible use of existing and new facilities. For example, it is possible to utilise the inherent overload properties of an overhead line in favourable weather scenarios.

DLR, including wind cooling, can increase the transmission capacity of overhead lines by 25-50% in situations with high wind power generation. Here, the high wind speed guarantees effective cooling of the overhead line.

GENERAL MARKET SOLUTIONS

Energinet is constantly working with many types of solutions to meet the development needs in the power grid – including market solutions. We distinguish between general market solutions, which are applied to the entire power grid, and specific market solutions, which are applied more locally to address specific needs. The general market solutions have the potential to change the development needs and the long-term grid structure – and are often coordinated with possible construction solutions, reducing or postponing the need for grid expansions.

NEW MODEL FOR THE GRID TARIFF

A new model for the grid tariff will include a capacity payment element, which could provide an incentive for the customers to pay attention to capacity needs. Time-differentiated tariffs could also help move consumption away from peak periods, which can be the determining factor for grid capacity, thereby reducing the need for expansion. Finally, Energinet and the DSOs are jointly working on a model in which the grid tariff is not collected from the end users, but from the DSOs, thereby sending price signals that can support effective grid development.

CO-LOCATION

This initiative explores how Energinet can encourage the co-location of new electricity generation and consumption in the electricity transmission grid, for example by examining whether it should be made easier to become an autogenerator in the TSO grid. Effective co-location, where appropriate, will help to make the best possible use of the existing electricity infrastructure.

FEED-IN TARIFFS

The climate agreement of June 2020 indicates that the legislation must be changed to permit the introduction of a geographically differentiated connection contribution and feed-in tariffs for generators. Geographical differentiation will provide a price signal to RE developers that encourages more appropriate locations in the grid.

BID ZONES

At present, the Danish electricity market is divided into two bid zones (price areas) – Eastern and Western Denmark. Dividing into more bid zones could provide market participants with a clearer price signal, encouraging them to take account of limitations in the power grid when choosing locations for new production or consumption. Dividing into more bid zones will be part of a regional process, reducing the scope for Energinet to make active use of this tool.

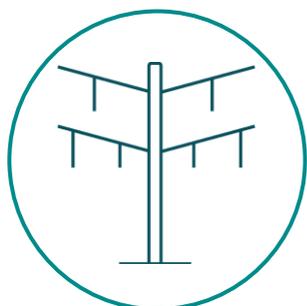
LIMITED NETWORK ACCESS

Energinet has registered the “Limited grid access” product for approval by the Danish Utility Regulator. This grid product will allow large consumers directly connected to the transmission grid to choose to be interruptible, in exchange for a reduced tariff. Energinet and the DSOs are also investigating whether a similar product could be offered to large customers in the DSO grid.



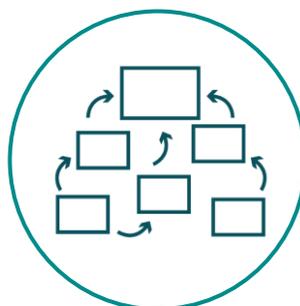
SPECIFIC MARKET SOLUTIONS

In addition to the general market solutions, we at Energinet are also working on developing more specific market solutions. They often only concern a single project and are implemented locally or regionally where there is a need to mitigate a specific operating situation. The specific market solutions can be applied temporarily (e.g. during planned outage times), or they can be used in addition to construction solutions, which could be scaled back or postponed as a result.



PROCUREMENT OF ADDITIONAL RESERVES

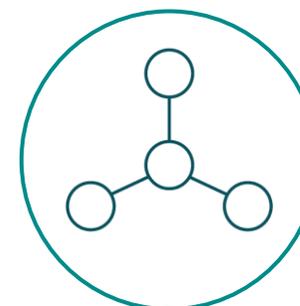
The procurement of additional reserves exploits the ability to purchase downward regulation reserves in specific areas. The market players with generation that will overload the segment are incentivised to stop generating – they are compensated in advance of the day-ahead market through the purchase of their potential generation as a reserve. Predicting the overload is a market philosophy in which a potential overload is avoided through the procurement of additional reserves. As such, the electricity markets do not see the grid congestion directly, but may be made aware of it through offers in the reserve capacity markets.



COUNTERTRADE

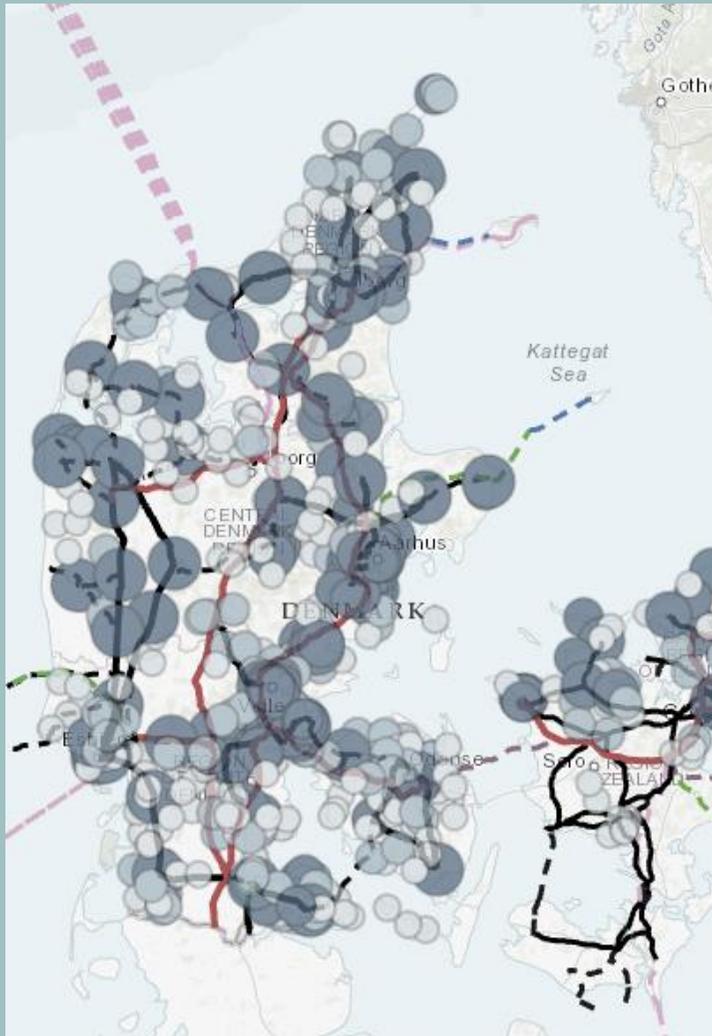
In countertrade, the control centre handles overloads by means of upward or downward regulation on both sides of the overloaded segment. At present, structural countertrade is in substantial use at the DK1-DE border, but as a result of a new EU regulation, the need for countertrade is expected to increase at the other borders too. In countertrade, some or all of the activation takes place abroad.

The necessary countertrade volume is known (as an approximation) from the calculations of the expected overloads and from the requirements in the EU regulation.



LOCAL FLEXIBILITY

Local flexibility is a variation of the special regulation which is already being used. Special regulation is implemented by activating bids for upward or downward regulation of generation or consumption in the regulating power market. Local flexibility means that the special regulation is geographically separated. In other words, upward and downward regulation takes place precisely in the overloaded area.



CAPACITY MAP

Energinet has joined with the Danish Energy Association and the DSOs to publish a capacity map as a tool for dialogue with renewable energy stakeholders. The capacity map focuses attention on good locations for new renewable energy facilities from the point of view of the transmission and distribution grids, and aims to streamline the planning of necessary grid reinforcements.

Find out more at www.kapacitetskort.dk

19/08894-7 Offentligt/Public

DIALOGUE-BASED INITIATIVES AND THIRD-PARTY SOLUTIONS

Dialogue is important if we are to achieve the goal of 100% renewable energy in the power grid by 2030.

Dialogue-based initiatives are therefore an important focus area and play a crucial part in our future work on electricity system development. The dialogue will not directly affect the financial incentives in the way that market solutions do, but will be an important add-on to the other solutions. The dialogue will enable us, among other things, to create an overview of potential challenges in the power grid, and how they can be met. The capacity map, www.kapacitetskort.dk, developed jointly by Energinet, the Danish Energy Association and the DSOs, is a good example.

Third-party solutions are an important part of the toolbox

The solutions presented in this catalogue are not an exhaustive list – there may be other good solutions from outside Energinet. The aim of this solution catalogue, and the dialogue flowing from it, is to create a bigger toolbox in order to identify the best possible solutions for a 100% transition of the energy sector.

GLOSSARY

Day-ahead market

Through their balance-responsible parties, electricity suppliers and producers trade in the day-ahead market to cover production and consumption for the following 24-hour period. The day-ahead market is the largest market in the Nordic region, and more than 70% of total Nordic electricity consumption is traded there.

Meshed power grid

A meshed grid means a grid which is designed to be supplied from at least two sides – for example in a ring structure. This means that regardless of where in the ring a fault occurs, supply will continue to all the substations.

Differentiated connection contribution and feed-in tariffs

The costs associated with connecting and feeding power from a PV power plant, for example, into the power grid will vary depending on the geographical location of the facility. Consequently, the connection contribution and feed-in tariffs to be paid by the developer will be lower if the facility is located in an area requiring little or no grid reinforcements.

Inherent overload properties

Some components such as a transformer or an overhead line have the characteristic that for short periods or under specific ambient conditions, they can be subjected to more than 100% of their rated load.

Downward regulation reserves

Production of energy that can potentially be stopped/reduced in order to balance the relationship between consumption and production.

Production system protection

Production system protection means that when certain events occur (e.g. a fault in a 400 kV connection), a particular generation facility will be disconnected. The facility will no longer feed power into the system, taking the load off the system in the event of a fault. With a production system protection, disconnection occurs quickly and automatically, as opposed to downward regulation, which must be activated manually.

Radial connections

Unlike the meshed grid, this is a connection between two points. For example a radial connection between a wind farm and a point of connection (a substation) from which the power is fed into the meshed grid.

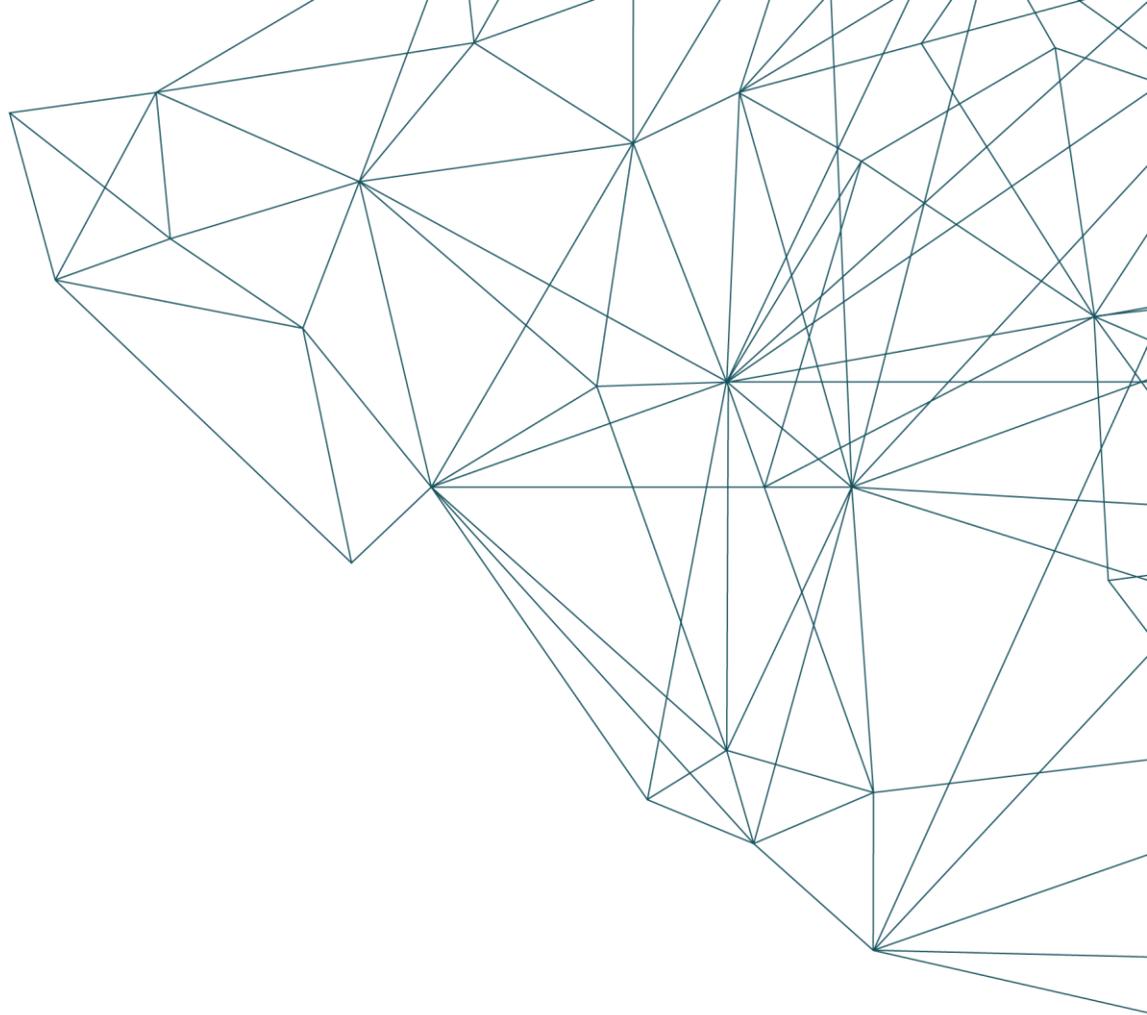
Regulating power market

On the regulating power market, Energinet buys/sells power (regulating power) from/to the players in the delivery hour on the basis of bids for upward and downward regulation submitted to Energinet by the players.

ENERGINET

Tonne Kjærvej 65
7000 Fredericia
Tlf 70 10 22 44

info@energinet.dk
www.energinet.dk



Energinet is an independent public undertaking owned by the Danish state.

This means, that publication etc. Published by Energinet is an reflection of the professional assessment of Energinet alone. These assessments are not necessarily shared med the Danish minister of Climate, Energy and Utilities, who handle the ownership of Energinet on behalf of the Danish state.

Energinet strives to be an open and transparent company, where assessments and analyses are made available to everyone.