ENERGINET

NEW PATHS TO THE ENERGY OF THE FUTURE

ANNUAL REPORT 2017
SHORT VERSION

ENERGINET, TONNE KJÆRSVEJ 65, DK-7000 FREDERICIA, CVR NO. 28980671

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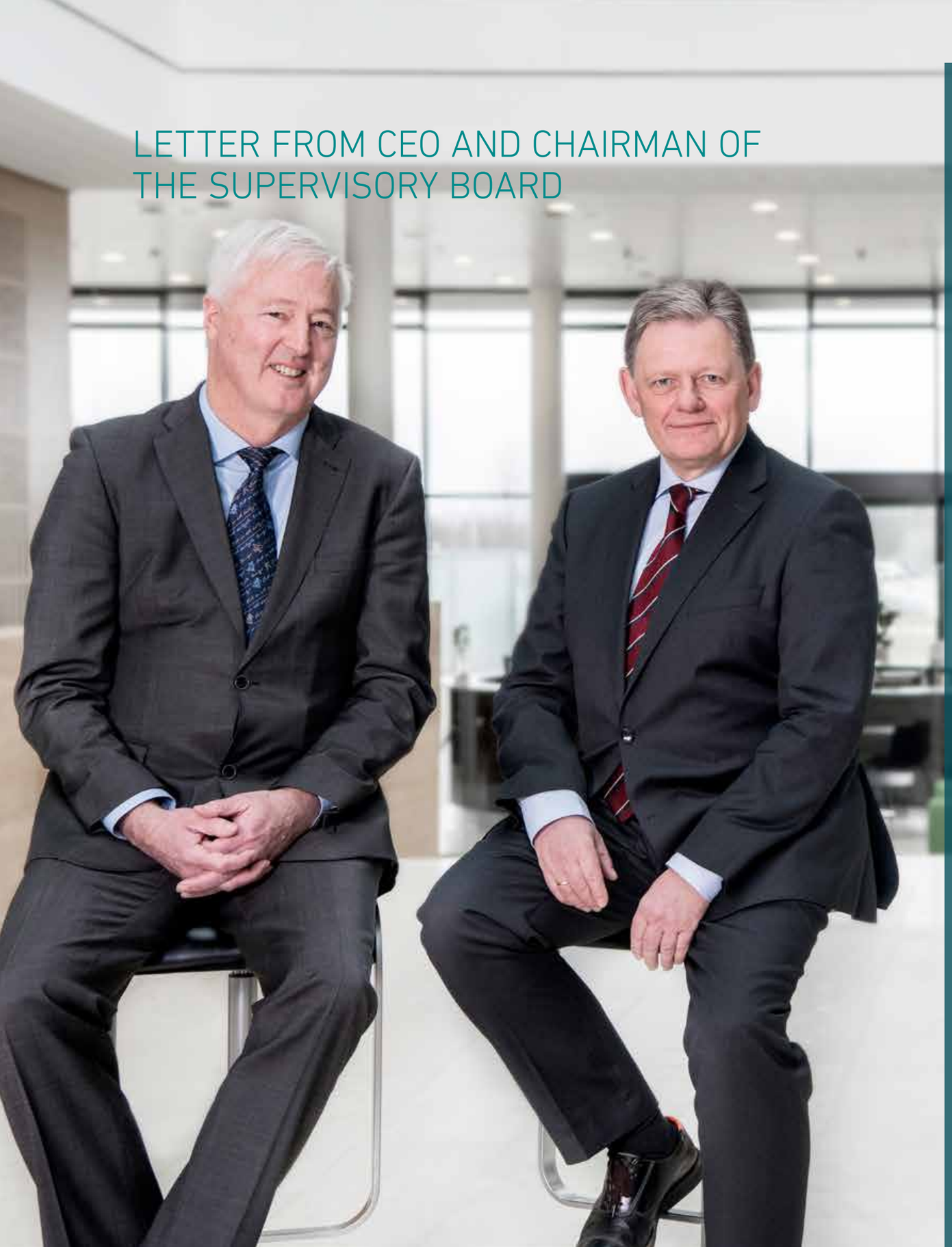
• This is an abbreviated English-language excerpt from Energinet's annual report for 2017. The complete statutory annual report providing an extensive account of the year's activities and financial statements is available in Danish here: https://energinet.dk/Om-publikationer/Publikationer/Aarsrapport-2017

Energinet, March 2018

THE BIG PICTURE

THIS WILL GIVE YOU AN IDEA OF WHAT SORT OF COMPANY ENERGINET IS, WHAT WE ACHIEVED IN 2017 AND HOW WE LOOK AT THE FUTURE.

LETTER FROM CEO AND CHAIRMAN OF THE SUPERVISORY BOARD



STATUS

PATHS TO THE ENERGY OF THE FUTURE

Large parts of the physical infrastructure which are to underpin the green transition of the energy sector in Denmark have now been built or planned.

Ever since the Danish Parliament, Folketinget, established Energinet in 2005, it has been our goal and task to establish more energy connechtions between Denmark and our neighbouring countries.

After years of complex negotiations and investigations, an electricity connection to the UK (Viking Link) and a gas connection to Poland (Baltic Pipe) were finalised for decision in the course of 2017.

We therefore see 2017 as a significant milestone for the expansion of energy connections to other countries.

Viking Link and Baltic Pipe are important projects for the transition in Denmark as sustainable energy is energy which can be moved. Interconnections are of great value to Danish society, because they strengthen security of supply and ensure the lowest possible energy prices for Danish citizens and businesses.

Viking Link creates better opportunities for trading electricity across borders. Electricity, which increasingly comes from wind and solar power, cannot be stored. It must therefore be possible to trade electricity immediately after it has been generated and move it to where the demand and the willingness to pay are found.

Baltic Pipe creates a new supply route for natural gas between the Norwegian fields, the North Sea and the European mainland. For Denmark, the connection entails lower gas prices than previously, and thus also improved socioeconomic utilisation of the existing gas system, which is a valuable aspect for the green transition of the gas sector in the coming years.

From our point of view, 2017 was therefore all about preparing physical infrastructures for sustainable energy.

This was true not only for interconnections, but also for Energinet's task of acquiring and gathering the gas distribution sector on behalf of the Danish state. A task aiming to prepare the existing infrastructure in the distribution link for future green gases.

OUTLOOK

NEW PATHS TO THE ENERGY OF THE FUTURE

Physical infrastructure is just one step on the road towards becoming independent of fossil energy sources. New paths and new partnerships are required when the next step is to be taken.

Energinet was established in order to help solve the trilemma of the transition: providing energy that is green, reliable and affordable for society.

The realisation of the Danish energy policy, which traditionally finds broad support among the political parties in the Danish Parliament, Folketinget, is receiving recognition from international institutions for offering a good solution to the energy transition trilemma.

But new means and new partnership forms will be required in the years to come, if we want to maintain and expand the green transition of the energy sector.

To navigate towards the future energy supply, Energinet's Supervisory Board adopted a strategy in 2017 which applies from 2018 to 2020. The strategy is called 'Energy across borders', because we believe in cooperation across national borders, across technological boundaries and across traditional energy value chains.

Through increased cooperation with the market players in the energy sector, we commit ourselves to exploring and pursuing four objectives: New security of supply framework, Denmark as an energy hub, social responsibility through efficiency, and digitalisation.

Energinet is pursuing the strategy objectives, and in the four focus articles in this annual report, you can gain an insight into selected examples of how we are doing this:

A market without borders for balancing energy between EU countries is an example of a new security of supply framework (page 22). The establishment of data centres is an example of Denmark's great potential as an energy hub (page 26). Energinet is a participant in the development project 'North Sea Wind Power Hub', which is a large-scale vision about wind farms and so-called Power-to-Gas (P2G) far out in the North Sea at Dogger Bank. Read more on page 30. Last, but not least, sharing Big Data in energy for use for innovative business models is an example of digitalisation (page 34).

CEO, Peder Ø. Andreasen
Chairman of the supervisory board, Lars Barfoed

VALUE CHAIN

RESOURCES 2017

FINANCIAL

2.7 DKK BILLION
GRID AND SYSTEM TARIFFS
2016: 2.7

0.4 DKK BILLION
GAS TRANSMISSION TARIFFS
2016: 0.4

26 DKK BILLION
LOANS WITH DANMARKS NATIONALBANK
2016: 24

PHYSICAL

6,956 KM
HIGH-VOLTAGE GRID
2016: 6,913

926 KM
GAS PIPE (TRANSMISSION GRID)
2016: 926

7
INTERCONNECTIONS, 2 GAS CONNECTIONS AND 5 ELECTRICITY CONNECTIONS
2016: 7

6,600 KM
GAS DISTRIBUTION GRID
2016: 6,600

2
GAS STORAGE FACILITIES
2016: 2

HUMAN

1,151
AVG. NO. OF EMPLOYEES
2016: 953

75*
EMPLOYEE SATISFACTION
2015: 75

2.3
% ABSENCE DUE TO ILLNESS
2016: 2.2%

60
DIALOGUE MEETINGS WITH CITIZENS AND MARKET PLAYERS
2016: 60

RESULTS 2017

SECURITY OF SUPPLY

92 SEC.
NON-SUPPLIED ELECTRICITY
2016: 48 SEC.

ZERO
GAS SUPPLY FAILURE
2016: ZERO

3.4 BILLION NM3
TRANSPORTED GAS
2016: 4

3.7
ON THE CMMI SCALE IT MATURITY
2016: 3.6

RENEWABLE ENERGY

43.4
% OF DANISH ELECTRICITY CONSUMPTION COVERED BY WIND POWER
2016: 38

63
% GROWTH IN BIOGAS PRODUCTION
2016: 43

68
% STAKEHOLDER SATISFACTION WITH CONTRIBUTIONS TO EFFECTIVE TRANSITION

EFFECTIVE TRANSITION

5.6
% CHANGE OF ELECTRICITY SUPPLIER
2016: 6%

57
% OF DANISH GAS CONSUMPTION TRADED ON GASPOINT NORDIC
2016: 68

67
% STAKEHOLDER SATISFACTION WITH CONTRIBUTION TO HEALTHY INVESTMENT CLIMATE

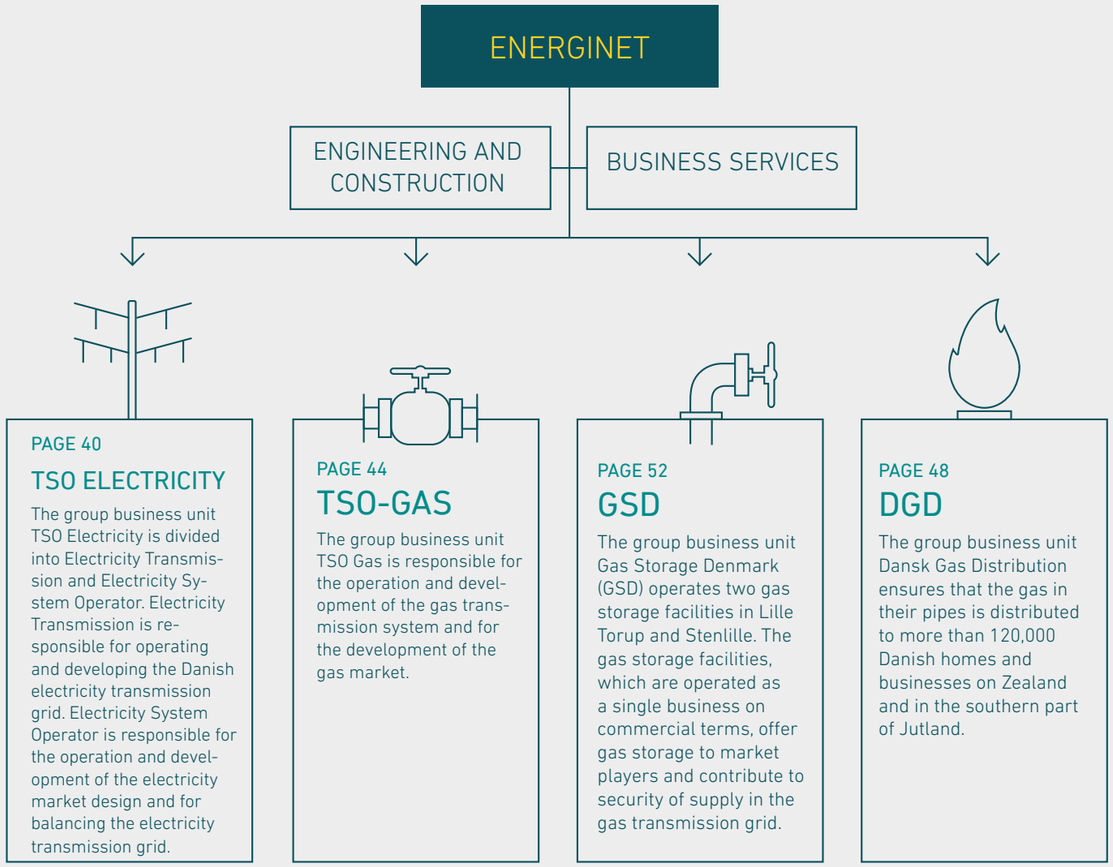
Energinet is charged with integrating renewable energy, ensuring equal access to the grids and ensuring security of supply in Denmark. The above examples of resources and results are intended to provide an immediate idea of what Energinet does. Some results are associated directly with Energinet's activities, while others are more indirectly related to Energinet.

* Employees' assessment of satisfaction is from 2017. Employees answer questions about job satisfaction in a total of nine areas, with the index figure representing the aggregate employee satisfaction score. The model is called 'Global Employee and Leadership Index', which is a recognised and widely used method among Danish and international businesses. Energinet conducts an employee satisfaction survey every other year.

ENERGINET

- We are developing the energy supply of the future

In 2017, Energinet implemented an organisational restructuring and now consists of corporate functions, two business service units and four independent group business units. All group business units are expected to be established as independent subsidiaries within the first half of 2018. Moreover, Electricity Transmission and Electricity System Operator will be spun off as two independent subsidiaries, and DataHub will be spun off from Electricity System Operator and become an independent subsidiary. The organisational restructuring aims to create more transparency and a clearer distribution of responsibility for Energinet's individual and overall activities.



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TSO ELECTRICITY

The group business unit TSO Electricity is divided into Electricity Transmission and Electricity System Operator. Electricity Transmission is responsible for operating and developing the Danish electricity transmission grid. Electricity System Operator is responsible for the operation and development of the electricity market design and for balancing the electricity transmission grid.

PAGE 44

TSO-GAS

The group business unit TSO Gas is responsible for the operation and development of the gas transmission system and for the development of the gas market.

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GSD

The group business unit Gas Storage Denmark (GSD) operates two gas storage facilities in Lille Torup and Stenlille. The gas storage facilities, which are operated as a single business on commercial terms, offer gas storage to market players and contribute to security of supply in the gas transmission grid.

PAGE 48

DGD

The group business unit Dansk Gas Distribution ensures that the gas in their pipes is distributed to more than 120,000 Danish homes and businesses on Zealand and in the southern part of Jutland.

Energinet is an independent public enterprise owned by the Danish state for the purpose of ensuring public control of critical infrastructure for electricity and gas. Energinet was established by the Danish Parliament, Folketinget, by an act of law in 2005, and its ownership falls under the Danish Minister for Energy, Utilities and Climate. Energinet core tasks are to integrate renewable energy, ensure equal access to the grids and ensure security of supply in Denmark.

STRATEGY 2018-2020

ENERGY ACROSS BORDERS

VISION

A BALANCED AND SUSTAINABLE ENERGY SUPPLY

We will find ways of producing reliable and sustainable energy, which is also good business for Danish society.

OBJECTIVES 2018-2020

NEW SECURITY OF SUPPLY

In 2020, we will have helped promote the Danish, Nordic and European cooperation on security of supply, and we will have helped ensure that new players and business models are contributing to a secure supply of energy.

ENERGY HUB

In 2020, Denmark's geographical position as an energy hub between the Nordic countries and Europe will have been strengthened. We will have used this position to create better investment conditions and economies of scale in the operation of the Danish electricity and gas grids.

SOCIAL RESPONSIBILITY

In 2020, we will have realised the potential for efficiency improvements, and we will have assisted in the implementation of a new financial management system for Energinet's group business units.

DIGITALISATION

In 2020, we will have used digitalisation to solve Energinet's tasks in smarter ways, and we will have helped promote innovation in the energy sector.

STANDPOINT

OUR COMMITMENTS

High level of security of supply
Together with the energy sector, we are creating peace of mind that there is energy for everyone.

Efficient transition
Together with the energy sector, we are finding new paths to a green transition which is socioeconomically effective.

Healthy investment climate
Together with the energy sector, we are contributing to a healthy investment climate within the energy sector.

MISSION: RELIABLE ENERGY FOR SOCIETY

Energinet is owned by the Danish state for the purpose of ensuring public control of critical infrastructure.

We must contribute to ensuring a high level of security of supply, integrating renewable energy and well-functioning competitiveness in the electricity and gas markets.

KEY PERFORMANCE INDICATORS

Energinet's corporate targets are indicators for whether our activities create value for society.

OPEX (INDEX)

97/94 ELECTRICITY/GAS

TARGET: 92/100

TSO ACTIVITIES

STAKEHOLDER SATISFACTION (INDEX)

68/67 EFFICIENT TRANSITION/ HEALTHY INVESTMENT CLIMATE

TSO-ACTIVITIES

CAPEX (INDEX)

84

TARGET: 90

TSO-ACTIVITIES

SOLVENCY RATIO (%)

18/33 DGD/GSD

TARGET: 30-40/30-40

DGD AND GSD

REPAIRING EXCAVATION DAMAGE WITHIN THREE HOURS (%)

95

TARGET: 90

DGD

RETURN ON CAPITAL EMPLOYED – ROCE (%)

4.6/-8.1 DGD/GSD

TARGET: 4.0/3.0

DGD OG GSD

NON-SUPPLIED ELECTRICITY (SEC.)

92

TARGET: MAX. 60

TSO ELECTRICITY

EMPLOYEE SATISFACTION (INDEX)

75

TARGET: 76

COMMON CORPORATE TARGETS

GAS SUPPLY FAILURE

ZERO

TARGET: ZERO

TSO-GAS

ABSENCE DUE TO ILLNESS (%)

2.3

TARGET: 2.0

COMMON CORPORATE TARGETS

INFORMATION SECURITY

3.7

TARGET: 4.0

COMMON CORPORATE TARGETS

OCCUPATIONAL INJURIES

6.1 PER MILLION WORKING HOURS

TARGET: 2.0

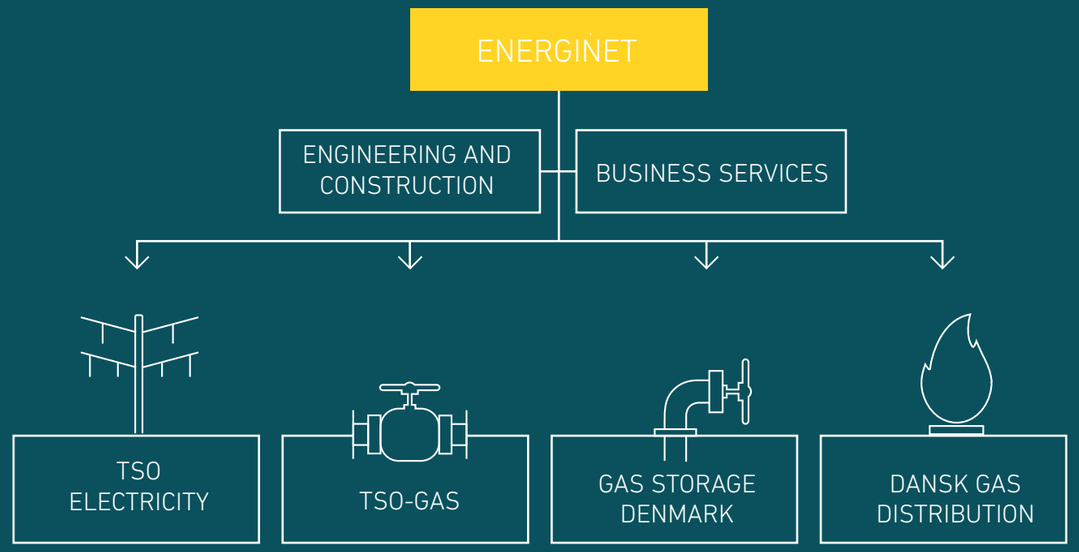
COMMON CORPORATE TARGETS

Energinet's corporate targets have been set by the Supervisory Board in cooperation with Energinet's owner (the Danish Minister for Energy, Utilities and Climate). The graph above shows an overview of the targets and the relevant results for 2017.

OPEX: Operating expenses. The lower the number, the better the result. CAPEX: Costs of capital The lower the number, the better the result. See also key figures and ratios on page 134.

FINANCIAL STATEMENT

The financial statements account for the income and expenses included in the tariffs collected from the consumers.



Energinet is a non-profit enterprise and is based on a break-even principle, which means that income and expenses must balance over a number of years.

NET LOSS FOR THE YEAR, DKKM

-228

2016: -143

Net loss for the year is not satisfactory.

BALANCE SHEET TOTAL

DKK BILLION

45.6

2016: 44.6

The balance sheet total increased primarily as a result of fixed asset investments.

EXCESS REVENUE

DKK MILLION

232

2016: 1,233 IN EXCESS REVENUE

The accumulated excess revenue at 31 December 2017 is DKK 273 million.

The primary reason for this year's negative results is that the value of the gas storage assets was written down by DKK 320 million after tax.

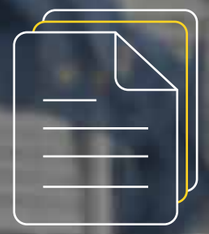
FOCUS ARTICLES

HERE YOU CAN READ FOUR FOCUS ARTICLES ON IMPORTANT PROJECTS UNDERTAKEN IN 2017 WHICH GIVE A PICTURE OF ENERGINET'S VALUE CREATION.

FOCUS ARTICLE

EUROPE'S UNITED SECURITY OF SUPPLY

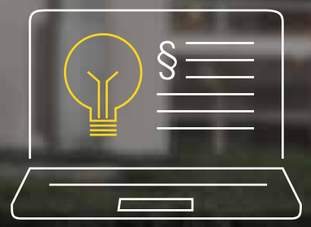
There is an increasing focus on common energy solutions in the European Union, and 2017 was the year in which the last of a number of common network codes for the European electricity market entered into force. The network codes have been adopted after five years of negotiations, and the time to implement them has now come. Martin Høgh Møller from Energinet is spearheading an important part of this work when Energinet and 42 sister organisations are to draw up the framework for a common platform for activation of energy from manual reserves. The market platform is crucial for the ability to ensure cost-effective security of supply in a European energy system with increasing shares of renewable energy. READ MORE »



THE ELECTRICITY BALANCING GUIDELINE
The Electricity Balancing Guideline network code is the legal platform on which the future European balance market is to be based. The network code entered into force on 18 December 2017.

PAN-EUROPEAN BALANCE MARKET
The Electricity Balancing Guideline defines, among other things, requirements, time limits and a preferred design for a common balance market.

Market platforms must be established for exchanging different types of balancing energy, including for manual reserves.



MARKET PLATFORM FOR MANUAL RESERVES
The market platform for manual reserves consists of both hardcore IT systems for activation and settlement of energy between countries and of cooperation and negotiation processes between market players. The processes must result in a level playing field for competition.

The pan-European market platform for activation of energy from manual reserves must be ready for use by the end of 2021. It will be one of the most clear examples of high security of supply being based increasingly on cooperation and sharing of resources across countries. But before we go into more detail about this, we will first explain what manual reserves are.

An electricity system requires a constant balance between generation and consumption of energy. You could say that there must be a constant flow from generator to consumer, and it is not possible to 'shelve' excess energy in the system, the way you can with products in a warehouse or a supermarket. The electricity transmission grid operator's control centre monitors the balance in the grid and initiates measures in the event of imbalances between consumption and generation. In Denmark, this operator is Energinet, and as mentioned above, there are 42 other so-called TSOs (Transmission System Operators) in the other European countries.

In a modern electricity market, manual reserves are a service provided by selected suppliers which the TSO activates in situations where the control centre predicts that an imbalance will occur between consumption and generation, or in situations where grid or plant faults trigger sudden imbalances. Depending on the demand, the service may consist of generating more electricity, or it may consist of stopping the generation or consumption of electricity; businesses may, for example, be paid to stop an electricity-consuming process.

Such balancing services are a necessary tool for maintaining security of supply, and historically, most countries have had their own national ways of safeguarding these services. In the Nordic countries, however, we have had a well-functioning common market for the activation and exchange of balancing services supplied from manual reserves for the past decade. By making this market a cross-border market, major socioeconomic savings have been achieved, and this is what Martin Høgh Møller has now been tasked with replicating for Europe in cooperation with 50 colleagues from the other European TSOs.

Benefits of a pan-European balance market

The pan-European Electricity Balancing Guideline network code entered into force, and thus became part of EU law, on 18 December 2017. One of the provisions in the network code stipulates that a European platform for activation of manual reserves must be established within four years. Four years are a very short time for such a complex project, which not only includes a negotiation process where TSOs and the countries' supervisory authorities (in Denmark, the Danish Energy Regulatory Authority) – with input from the market players – must agree on a large number of ways of fixing prices and trading energy from manual reserves. The project is also a huge IT project, which is to be based on a European algorithm that will make it possible for, for example, Energinet's control centre to request balancing energy and receive the cheapest bid from any market player in Europe at any given time.

"Seeing that four years is not much time for such a complex project, 19 TSOs jumped the gun a bit and started a voluntary cooperation already a year ago, before we were legally obliged to do so," says Martin Høgh Møller and points out that the project "is now the project which has been developed and formally approved by the market committee in ENTSO-E as the project that all 43 TSOs in the EU member states must join". ENTSO-E is the European association of TSOs within the electricity field.

When Martin Høgh Møller heads out twice a week on average to meet with European partners in the project, which counts approximately 50 permanent participants, it is because there are tangible socioeconomic benefits of establishing a pan-European market for balancing energy. In its 'Impact Assessment on European Electricity Balancing Market' report, the European Commission has assessed that exchanging reserves among the member states may result in total annual cost savings in the order of EUR 3 billion for the EU countries. And more specifically, the Nordic cooperation on balancing energy results in a socioeconomic gain among the participating countries of approximately EUR 200 million a year. So the work pays off.

The market supports the green transition

One of the reasons why a pan-European market for manual reserves makes good socioeconomic sense is that far more market players have the opportunity to participate – thereby making it possible to match the demand from the TSOs with a far more diverse offering of balancing energy.

Martin Høgh Møller draws attention to the fact that, although we are used to activating reserves across national borders in the Nordic countries, this is quite foreign to the way of thinking in other parts of Europe: "In some countries, problems with creating balance in the electricity system are solved by having a dedicated coal-fired power plant at the ready which is used to supply flexible generation and balancing energy only – ie to turn the volume up and down as needed. This is neither efficient nor socioeconomically cost saving."

It must be possible for as many market players as possible to participate in the market for manual reserves, says Martin Høgh Møller and provides a graphic example: "Some places have markets for manual reserves in which it's a condition that the market players must be able to submit their bid one month before the time of use. This excludes, for example, a wind turbine owner who doesn't have an earthly chance of predicting how much the wind will blow in one month's time. But if you can wait for the bid until half an hour before the use, for example, the wind turbine owner has a fair chance of participating as well."

The actual market platform for manual reserves must be non-discriminatory towards market players as well as towards consumption and generation technologies. This means that there must be equal access for, for example, wind turbines and power stations based on fossil energy. But, quite logically, the actual need for a cross-border market for balancing energy is larger in energy systems with a high share of renewable energy. The need for flexible balancing of imbalances between consumption and generation most often occurs in weather-dependent energy systems.

One of the most important challenges for Martin Høgh Møller is thus to find compromises between TSOs in countries where the transition to renewable energy has come a long way and TSOs in countries where fossil energy still plays the key role. Already before 18 December 2018, the project must submit a proposal for framework conditions for the common market platform for manual reserves. In Martin Høgh Møller's words: "The time for celebrating is over. Now, it's back to reality."

> For many years, Danske Commodities has developed systems and models in cooperation with our customers, which means that together we are very cost-effective when it comes to the delivery of ancillary services, including manual reserves. We therefore welcome the establishment of a much larger European marketplace, where our customers can sell their products and thereby get extra value from their plants.

Jakob Bendixen, who is Head of Assets in Danske Commodities, is responsible for handling flexibility services from Danske Commodities' customers. The customers are Danish generators and consumers, eg CHP plants, electric boilers, heat pumps etc.

INTERNATIONAL COOPERATION IN THE GAS MARKET

The international and European cooperation is also seeing rapid developments in the gas market. Selected major projects in which Energinet has been involved in 2017 are listed below:

- The European Commission's revised regulation on the security of natural gas supply entered into force in 2017. The regulation proposes that the countries must increasingly help each other in connection with supply crises. New initiatives must be implemented within an 18-month period, and Energinet is looking into how the regulation affects Danish security of gas supply.
- In 2017, Energinet and Swedegas (the Swedish gas TSO) prepared an economic analysis of the balance zone covering both Denmark and Sweden. A common balance zone will increase security of supply in both countries.
- Energinet participates in the Green Gas Initiative cooperation along with six European gas infrastructure companies. In 2017, they published their first status report with recommendations for the development of biogas in Europe.

FOCUS ARTICLE

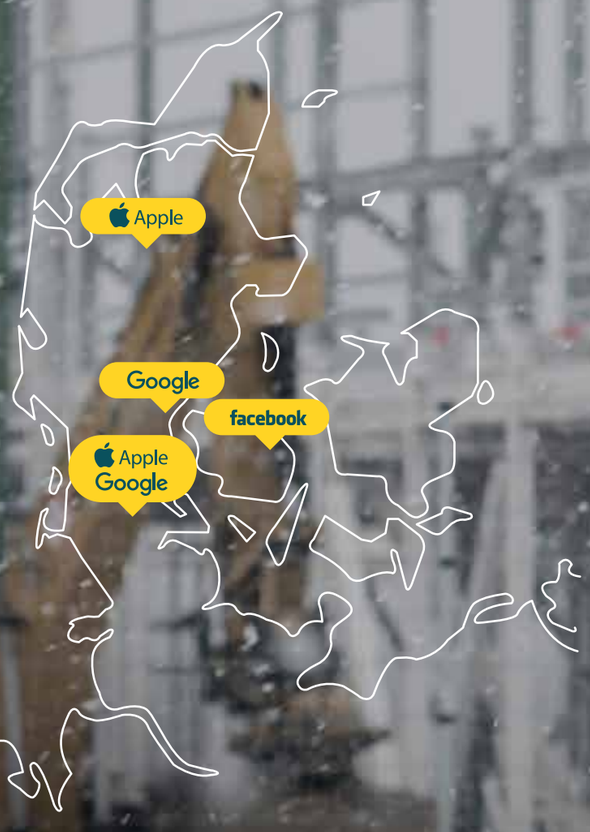
DATA CENTRES

BETWEEN WIND AND WATER

Global companies have discovered that Denmark is a country with access to green energy and high security of electricity supply. Energinet is building the high-voltage substations that are going to connect Apple's and Facebook's data centres to the transmission grid. The location and design of these substations will provide grid connections which are among the most reliable in Europe thanks to Denmark's robust electricity grid and central location in the power grid between wind power on the west coast and hydroelectric power in Norway. Denmark's role as a hub for data centres really took off in 2017. READ MORE »

Many attributes of Odense make it an attractive location for our newest European data center. Among them is the access to the highly interconnected Nordic grid and an abundance of clean energy options across Scandinavia, addressing our needs for both security of supply and the ability to play a role in adding new green capacity to the grid as we move closer to powering all of our operations with 100 % clean and renewable energy.

Vince T. Van Son (to the left) is Commercial Director for Energy & Infrastructure at Facebook.



FIVE POSSIBLE DATA CENTRES ON THE WAY. Apple, Viborg: High-voltage substation built and ready for operation. Data centre under construction. Apple, Aabenraa: A large data centre has been announced, and preparations are underway. Facebook, Odense: High-voltage substation under construction, expected to be completed in April 2018. Data centre under construction. Google, Fredericia: High-voltage substation close to completion. Possible data centre announced, but not decided yet. Google, Aabenraa: Possible data centre announced, but not decided yet.

"The time difference between Denmark and the USA means that Apple was 6-9 hours away. So communication was sometimes quite a challenge," replies Oddleif Nielsen when asked about the biggest challenge in developing a high-voltage substation in Tjele to power the Apple data centre.

Oddleif Nielsen was Energinet's project manager delivering the high-voltage substation for Apple's power supply, which was ready for operation three months ahead of schedule on 28 September 2017.

It may seem surprising that at the top of Oddleif Nielsen's list of challenges were some relatively mundane issues around the time difference between Denmark and the USA. This could just be an excess of modesty, but it could also be an indication that what makes the arrival of data centres in Denmark so new and epoch-making are not the technical aspects of building a modern high-voltage substation.

"The high-voltage substation near Viborg is in a pivotal place in our power system, with connections to Norwegian hydroelectric power and to Sweden, a major link through Jutland to Germany, and a fourth connection to all that wind power from the North Sea," says Oddleif Nielsen, adding "that's what makes it such a great facility in a great location". In other words, security of supply is all about location, location, location as demonstrated by Denmark's robust electricity grid and the growing number of connections to renewable energy sources in Denmark and neighbouring countries.

Denmark's electrical infrastructure makes many regions of Denmark attractive as a potential home for large data centres. This is not just true of Viborg, Odense and Fredericia where the first of several new high-voltage substations funded by private companies are under construction by Energinet. It is about location and about Denmark as a hub for renewable energy.

Data centres and Denmark as a hub for renewable energy

Jesper Storebjerg Jensen has been involved on behalf of Energinet since 2014, when Invest in Denmark came knocking with project development teams from international commercial organisations and global brands to 'kick the tyres' of potential investments as he puts it. In other words, it is not long since interest was first shown in data centres and potential investors came to learn about the Danish electricity system and make decisions on whether Denmark had the right mix of ingredients for supporting investments in data centres.

"At Energinet, it's now commonplace to handle large volumes of wind power in the energy system. In Denmark, the volume of wind power as a proportion of overall electricity consumption sets new records year after year. One reason we can do this is because we have strong international connections, which are set to become even stronger now that the Viking Link to the UK has been approved. Compared to other European countries, we have more capacity in and out of the country than total Danish consumption," says Jesper Storebjerg Jensen, pointing out a possible reason why Apple, Facebook and Google have announced their large data centre investments or preparations for them.

"The new major consumers in the transmission grid all prioritise security of supply, and they're all very serious in their efforts to move forward on the journey towards powering 100% of their operations with renewable energy."

Openness and confidential information

Apple's decision to build a data centre near Viborg as well as the subsequent investment decisions by Apple, Facebook and Google (see fact box) have naturally attracted considerable interest from the media, the public and politicians – both locally and nationally.

The high-voltage substations linking the data centres directly to the transmission grid are paid for by Apple, Facebook and Google, but are owned and operated by Energinet. Working with the consumer, Energinet determines the capacity available to each consumer connected to the grid. Energinet uses this capacity information to plan and operate the grid and ensure security of supply. Information about consumers is subject to commercial confidentiality, and publication could potentially break the law. Energinet carefully uses this confidential information in its planning and operations in order to guarantee security of supply.

Meanwhile, Energinet continually updates and publishes the assumptions used in its analyses, including estimates and projections of future energy production and consumption. Energinet needs these estimates and projections as input in order to meet its grid planning and operating obligations, which require it to keep production and consumption in balance. The analysis assumptions contain an estimate of the total expected electricity consumption from all consuming sectors, but without the possibility of tracking estimates to individual facilities or companies.

As the public gradually becomes more aware of the growing number of data centres, their positive economic impact and the role Denmark can play in supporting their desire to use renewable energy, the media and others have sought information about their future energy consumption. This has prompted a great deal of interest and speculation about how many more data centres are planned and what they will mean for Danish energy consumption.

Energinet's internal estimates of the future energy consumption of large data centres are subject to considerable uncertainty, because the potential number, size, timing and consumption of new facilities are still very uncertain and none are in operation yet.

Michael Refstrup Pedersen, who is responsible for Energinet's analysis assumptions, says: "In layman's terms, we're providing a plug point – the high-voltage substation – with enough capacity to meet the maximum power requirement, but once the connection is installed, it's up to the customer to decide how much to use and when. There's therefore a spread between low consumption and the high consumption which the substation is designed to support. There are no actual operating data available as yet, so our assumptions are more of a best guess at the moment, with a wide range of possible outcomes."

SIZE OF THE HIGH-VOLTAGE SUBSTATIONS

The capacity of the high-voltage substations connecting data centres with the transmission grid can be compared to the fuse in your house. The fuse in your house must be able to withstand a certain amount of power consumption at once before it switches off. But the size of the fuse does not tell you how much electricity you actually use at any given time. Thus, the capacity of a connection does not translate into or imply a particular level of energy consumption.

"Energinet's technical competencies, speed and can-do spirit were essential ingredients in our decision to locate our data centre investment in Odense, Denmark. We value Energinet's professionalism and are confident that we're in good hands in terms of the infrastructure supporting our facility in Odense, now and in the future."

Vince T. Van Son (to the left) is Commercial Director for Energy & Infrastructure at Facebook.

ENERGINET AND DATA CENTRES

- Energinet advises on locations and technical issues when a customer expresses an interest (through Invest in Denmark) in building a data centre.
- Energinet works with the local grid company to decide whether a large electricity consumer (eg a data centre) can be connected to the distribution or transmission grid. The decision is based on socioeconomic factors.
- Energinet consults with all relevant stakeholders to design the high-voltage substations for the right capacity.
- Energinet installs the high-voltage substations connecting the data centres to the transmission grid, and all associated costs are paid by the customer.
- Energinet owns and operates the high-voltage substations.

FOCUS ARTICLE

THE WIND AT DOGGER BANK

Energinet participates in international research, development and innovation projects. Such projects are necessary to pave the way and come up with ideas for the very extensive transition of the energy systems which is under way in these years. However, few of these projects are quite as spectacular as North Sea Wind Power Hub: The vision of having one or more artificial islands or platforms surrounded by thousands of offshore wind turbines at Dogger Bank far out in the North Sea and having interconnections from the 'islands' to and between the surrounding North Sea countries. This is an excellent example of major challenges requiring major visions. Because all scenarios show that the overall generation of wind power in the North Sea must be multiplied many times over, if the European countries are to be able to meet their climate commitments. READ MORE >>

WHAT IS NORTH SEA WIND POWER HUB (NSWPH)?

A vision of having one or more of artificial islands or platforms in the middle of the North Sea which are to harvest energy from thousands of new wind turbines and be the hub for interconnections between the North Sea countries.

A consortium consisting of TenneT (German-Dutch electricity TSO), Gasunie (German-Dutch gas TSO), Port of Rotterdam and Energinet.

6

SQUARE KILOMETRES

The island may have an area of 6 square kilometres, corresponding to 0.02% of the total area of Dogger Bank.

15

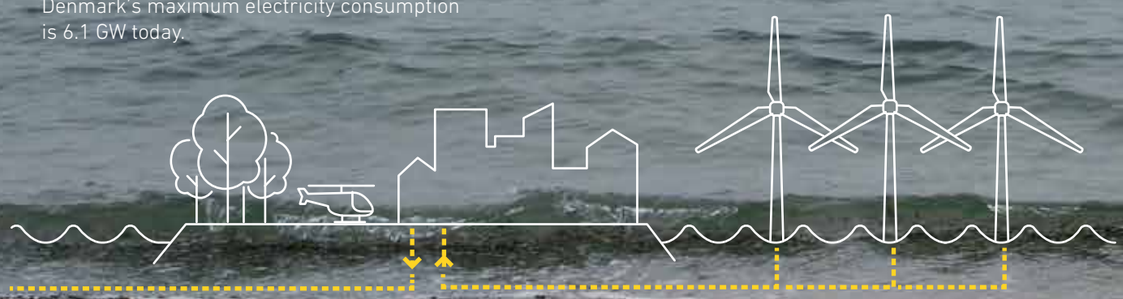
CONVERTER SUBSTATIONS

The island will be able to accommodate 15 converter substations of 2 GW each.

70-150

GW WIND POWER

The island might be able to harvest 70-150 GW wind power in 2040. In comparison, Denmark's maximum electricity consumption is 6.1 GW today.



Peter Larsen is a development consultant and Energinet's project manager in the NSWPH (North Sea Wind Power Hub) consortium. Hanne Storm Edlefsen is head of Department Research and Development and is responsible for Energinet's research, development, demonstration and innovation projects.

Dogger Bank is a shallow area far out in the North Sea between the Northern European countries. Figuratively speaking, it seemed almost as far out when the vision of having an artificial island at Dogger Bank surrounded by thousands of offshore wind turbines broke in the media in early spring 2017. Peter Larsen saw the animated pictures of the vision on his TV in-Brussels, where he, as Danish energy attaché, was working on the design of the European energy union. He immediately got curious, and now he works as Energinet's project manager on the North Sea Wind Power Hub research and development project, which is to investigate whether the vision can be realised.

On 23 March 2017, Energinet entered into the cooperation with the other members of the consortium behind North Sea Wind Power Hub, which so far is a very open and exploratory development project. The investigation of a vision which probably cannot be realised until around 2030 at the earliest. Before a decision can be made to proceed to an actual planning phase, all aspects of the vision must be analysed in detail. In the current phase, the consortium is keeping the project open for new possibilities and ideas that may come up.

From his post in Brussels, Peter Larsen sensed that something "as crazy as an artificial island and thousands of offshore wind turbines capable of generating electricity for millions of Europeans" was exactly what it was all about. Because sometimes major challenges require major visions, and eliminating CO_2 emissions from the European energy supply and reaching zero by 2050 is a huge challenge.

In Brussels, Peter Larsen was used to working on preparing bills: "When the Commission presents a legislative proposal, it's completely normal and appropriate that it subsequently runs into a lot of barriers, when the member states start picking it apart based on the interests they're protecting. But that's also precisely why it was liberating for me to see such a grandiose vision, with nothing detracting from it, but which in fact elaborated further on the overarching European plans regarding the energy union and cleaner energy for the Europeans."

Joining forces on the North Sea winds

One or more artificial islands, complete with harbour and infrastructure for use for harvesting and transmitting electricity from offshore wind farms, perhaps most of all resembles something from a futuristic film. But even though it is a spectacular and long-term vision, it is in many ways a natural extension of the development which has already been going on for a number of years.

An increasing number of offshore wind farms are being established in the North Sea. In step with offshore wind farms being established further away from the coasts, the costs for longer cables and not least for large platforms with converter substations rise, as the electricity from the wind turbines needs to be converted from alternating current to direct current before being brought ashore. It is therefore as such a logical step for many offshore wind farms and more countries instead to partner up with each other and share the costs involved in harvesting the energy and transmitting it from sea to land.

In a way, North Sea Wind Power Hub is a natural extension of the idea of having near-shore wind turbines – only now far out at sea. The electricity from the many wind farms around the island can be transmitted as alternating current 'to shore', meaning to the island. Converters can then be established on the island, which convert the alternating current into direct current and send the current out into a common grid of trading cables between the North Sea countries. In other words, the vision of having one or more artificial islands or platforms at Dogger Bank is both about economies of scale in offshore wind power generation, about the perspectives for cost-effective roll-out and system integration of large volumes of wind power in the North Sea and about a stronger interconnected market.

Energinet's role

Energinet is engaged in a number of research, development, demonstration and innovation projects. In almost all cases, these projects are collaborative projects where several parties from various countries work together on finding solutions for the future energy supply, and, as is often also the case for research projects, they are often financed by several parties, including, for example, via EU R&D programmes.

But why is it important to Energinet to contribute to determining whether the vision of creating one or more artificial islands for harvesting and further distributing wind power in the North Sea can be realised? Hanne Storm Edlefsen heads the department in Energinet which is responsible for coordinating Energinet's participation in research, development, demonstration and innovation projects: "As a TSO, we'll have to integrate quite a bit more renewable energy from offshore wind farms in the North Sea in the coming years, as all scenarios show that offshore wind power generated in the North Sea will be expanded substantially more than it is today. If the North Sea Wind Power Hub vision can be realised, it'll be a significantly cheaper way, from a socioeconomic perspective, of harvesting wind power in the North Sea than if we keep going as today, where the electricity from offshore wind farms is brought ashore in each its own cable, so to speak. This is one of the most important reasons why we in Energinet would very much like to help investigate the vision."

WHY IS NSWPH A GOOD IDEA?

- Offshore wind power from the North Sea plays a key role in Europe's green transition. Somewhere between 70 and 150 GW offshore wind power is expected to be installed in the North Sea in 2040.
- Offshore wind farms become 'near-shore' wind farms. When the distance to shore – the artificial island – is short, it becomes possible to use alternating current technology, thereby reducing costs.
- Submarine cables, which are to carry the electricity from the artificial island to the North Sea countries, can act as both landing cables and as electricity motorways for trading between the countries. This ensures far better utilisation of cable capacity.

POWER-TO-GAS IN NSWPH

The conversion of electricity into gaseous forms such as hydrogen or methane via electrolysis is a promising technology which may come to play an important role in an energy system with increasing volumes of fluctuating and weather-dependent wind energy that cannot be stored in large volumes in the same way as gas. When there is a surplus of wind energy, it can be converted into gas and stored or distributed to consumers. NSWPH may therefore also become a centre for Power-to-Gas (P2G) and for trading with P2G.

"The North Sea is crucial to Europe's green transition and to the transition to fossil-free energy. Denmark has led the way within offshore wind power in terms of technology and price falls, and North Sea Wind Power Hub takes us one step closer to exploiting the enormous potential of the North Sea. A future interconnection of the markets across the North Sea will be of great value to Denmark and Danish industry, including the wind turbine industry, and the project emphasises that we in Denmark are serious about turning the North Sea into the world's Silicon Valley for offshore wind power."

Jan Hylleberg is CEO of the Danish Wind Industry Association, which represents the wind industry in Denmark.

FIVE OTHER R&D PROJECTS WITH ENERGINET AS PARTICIPANT

BEST PATHS: The project is to contribute to overcoming the challenges in connection with the integration of renewable energy into Europe's energy mix. The objective is to develop new technologies that can add capacity and flexibility to the transmission grids and the overall European electricity system.

FUTUREGAS: The project will ensure improved integration of gas into Denmark's energy supply for the benefit of the climate. The project will analyse how gas can best be produced based on renewable energy, and how we can effectively integrate gas into the overall energy system.

PROMOTION: The project is to investigate and develop better technical and regulatory solutions for offshore electricity grids, where electricity from offshore wind farms can be harvested and traded to more countries.

MULTI-DC: The project is to pave the way for an integrated energy system across the Nordic countries. The project will develop methods for optimising the management of electricity connections. The pioneering example for the project is Kriegers Flak, which is a combined interconnection, landing point and connection of offshore wind farms.

SMARTNET: The project is to create the framework for optimising the interaction between transmission system operators and distribution system operators when information for monitoring and utilising ancillary services need to be exchanged. This may, for example, concern reserves and balancing, voltage, control and management of overload – both at national level and in a cross-border context.

FOCUS ARTICLE

OPEN ENERGY DATA

PROMOTE INNOVATION IN THE ENERGY SECTOR

The energy sector needs innovation and new business models if Denmark is to become independent of fossil fuels by 2050. Free energy data can provide consumers with completely new opportunities for understanding and adapting their energy consumption for the benefit of their wallets and the green transition. A more flexible energy consumption which smoothly integrates with green energy production is crucial when Denmark, in the next phase of the green transition, is to successfully harvest the remaining half of the renewable energy. READ MORE »

WHAT IS ENERGY DATA SERVICE?

API – machine-to-machine exchange of data streamlines the use of data in applications and services.

Data guide – overviews, guides and metadata that help the user locate data.

Dialogue forum – online forum where everyone can participate in the dialogue on Energinet's data.

Energy Data Service is an open data portal which regularly publishes energy data from Energinet. Here are three functions in Energy Data Service which you can benefit from.

89,530

PAGE VIEWS at www.energidataservice.dk from June to December 2017.

21

DATA SETS. At Energy Data Service, you can find data sets about electricity production and consumption, the wholesale market, ancillary services, transmission capacity, CO2 emissions and gas quality.

Saturday 17 June 2017. Denmark's Political Festival on Bornholm. Minister for Energy, Utilities and Climate Lars Christian Lilleholt presses a red button with a dramatic gesture. A moment later, a tube filled with confetti explodes, engulfing everyone in a rain of multi-coloured paper. The Minister has just launched Energinet's web portal: Energy Data Service.

Lead project manager Kristine Bock was present at the launch at the People's Political Festival (*Folkemødet*). She remembers the relieved happiness she felt that summer morning on the island of Bornholm:

"I was very pleased and proud, but also aware that we're nowhere near the objective of the project. We had only just started our journey towards setting energy data free."

Energy Data Service will make it easier for entrepreneurs, researchers and businesses to use energy data from Energinet for new services and business models, for the benefit of society and the green transition.

Smarter and greener energy consumption

Energinet has large volumes of data about the energy system at its disposal, for example CO_2 emissions data and consumption and generation data. These data are now available to everyone in Energy Data Service, where users are offered easy access to our energy data. For example, Energy Data Service gives users API access (Application Programming Interface) to all data on the portal. This machine-to-machine exchange of data is essential for the streamlined use of data in apps and data services.

"If energy data are to genuinely benefit society, it must be possible to incorporate them automatically in the products and services that can make our energy consumption smarter and greener," explains Niels Ejnar Helstrup Jensen, market specialist in Energinet, and continues: "Data from Energy Data Service, such as electricity prices and CO_2 emissions, can give consumers the opportunity to play a role in obtaining a cheaper electricity bill or a smaller carbon footprint."

Niels Ejnar Helstrup Jensen sees Energy Data Service as a tool for guiding decision-makers and private citizens towards a greener and more flexible energy consumption. Data about the volume of green energy and the current electricity price may in future give you an indication of when, for example, you should briefly switch off the electrical heating or charge your electric vehicle.

Data for active and flexible consumers

In 2017, 43.4% of Danish electricity consumption was covered by wind power, and in 2050, Denmark's total energy consumption must be covered by renewable energy sources. This requires increasing flexibility in both consumption and generation. And the consumers may get to play a bigger role if they get intelligent automated solutions which ensure that they use energy at times that are best suited to the fluctuating generation of renewable energy.

"Consumers will demand products and services that can help them use the energy when it's cheapest, and reduce energy consumption when this makes sense," says Niels Ejnar Helstrup Jensen.

In 2020, all Danish electricity customers will have a remote-read electricity meter, where consumption is measured on an hourly basis instead of on an annual basis. This considerably increases the volume and the level of detail of energy data, which creates a greater incentive to switch on electrical appliances at times when electricity is cheap.

A platform has been created in cooperation with the users

Energy Data Service has been developed in cooperation with the users of the web portal: entrepreneurs, researchers and businesses. They were involved from the start of the project, and their input has increased Energinet's focus on creating a service containing the functions and data the users request and wish to use.

"When a man chooses to embark on a seven-hour drive, and that in an electric vehicle which needs to be charged once or twice during that drive, in order to help test the portal, you have a highly dedicated user. And we have quite a few of those," says Kristine Bock.

According to the lead project manager, the exchange of experience among users and with Energinet is an important part of Energy Data Service: "We want to ensure that everyone who uses the portal has the opportunity to learn from each other," says Kristine Bock. Therefore, the users can, for example, communicate with each other and Energinet's employees in the portal's discussion forum.

The idea behind Energy Data Service arose from Energinet's Strategy Plan 2014, in which Energinet undertook to build an easily accessible platform with energy data.

Energy Data Service has been launched, but is still being developed. Entrepreneurs, researchers and businesses can now use data from Energinet for new products and services that support the green transition and the digitalisation of the energy sector.

> In future, we'll have more mobile devices, robots and intelligent products in our daily lives. And the free energy data can help to accelerate this development. This gives consumers completely new opportunities for understanding and adapting their energy consumption for the benefit of their wallets and the green transition.

Said Lars Christian Lilleholt, Minister for Energy, Utilities and Climate, after the launch of Energy Data Service.

> Energy Data Service's potential is limitless. I see opportunities for developing businesses based on data from Energy Data Service. Energinet's strong focus on security and accessibility strengthens my belief in the potential of the portal because it's crucial for businesses' willingness to develop products based on your data.

Henrik Bjerregaard, Head of Smart Energy at CLEAN. (CLEAN is a Danish cleantech cluster that communicates knowledge and supports cooperation between large and small businesses, public authorities and knowledge institutions.)

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