



ENGINET

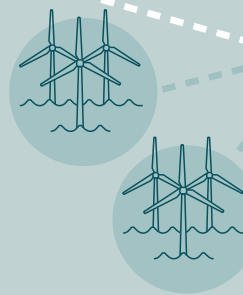
EXECUTIVE SUMMARY

BORNHOLM ENERGY ISLAND'S ELECTRICITY INFRASTRUCTURE

ZEALAND

BORNHOLM ENERGY ISLAND

2 or 3 GW of offshore wind power will be installed in the Baltic Sea off Bornholm and will be distributed through seabed power cables to Zealand and another country. The Bornholm Energy Island must be operational by 2030.



GERMANY

EXECUTIVE SUMMARY

Energinet's business case for the Bornholm Energy Island's electricity infrastructure gives decision makers and other interested parties a picture of the economic value of the energy island's electricity infrastructure and the specific solution which is preferred. It also sheds light on the implications for Energinet's corporate finances.

Together with the Danish Energy Agency's calculations for the overall profitability of the energy island, this business case will make up a significant part of the foundation for political decisions on the further development of the Bornholm Energy Island.

This executive summary first presents a quick overview of the energy islands and the political background and justification for establishing them in Denmark.

It also summarises Energinet's conclusions on the economic calculations for the Bornholm Energy Island's electricity infrastructure, and the recommended solution for the expansion of cables and electrical installations derived from these.

For more detailed information on finances, technical solutions and alternative scenarios, see the various sections in the business case.

Energinet's business case is the decision foundation for establishing electricity infrastructure for the Bornholm Energy Island, and must be approved by the Danish Minister for Climate, Energy and Utilities, pursuant to section 4 of the Danish Act on Energinet.

Energy islands in Denmark

A majority in the Danish Folketing has decided that two energy islands should be established in Denmark. One will be an artificial island in the North Sea. The other is Bornholm, which will serve as an energy island in the Baltic Sea.

What is an energy island?

An energy island is a place where large amounts of energy from offshore wind turbines can be pooled and transmitted to multiple countries via power cables on the seabed or converted to green fuels on the island and transported to other countries. The power cables can also be used to connect the electricity markets of the various countries.

BOX 1



CONCLUSION

Energinet's analyses show that the Bornholm Energy Island's electricity infrastructure is more cost-effective if power from the wind farms is transmitted to both Denmark and Germany, than if it is only transmitted to Denmark. Over the project's 30-year life time, a 9-figure net benefit is expected to be gained from a solution with a connection to Germany, compared to a solution without it.

Energinet emphasises that the calculations are subject to considerable uncertainty, as they are based on as yet uncertain assumptions. Energinet has to assess the isolated economic value of the electricity infrastructure that makes it possible to connect the power from the Bornholm Energy Island to electricity markets in one or more countries. The cost-benefit analysis therefore includes the value of the wind power, but not the costs of constructing the wind farms.

The necessary plant to convert the power from alternating to direct current can be established on the energy island. When the power has been pooled and converted to direct current, it can be transported over large distances without significant energy losses.

Value of energy islands in the green transition

The aim of the energy islands is to accelerate the expansion of renewable energy and ensure that far larger volumes of offshore wind power can supply all parts of society with green energy in the coming years, both in Denmark and in Europe, for the direct electrification of vehicles and heating, and to facilitate the production of hydrogen and green fuels for planes, ships and heavy industry, based on offshore wind power.

Energinet's role in the work with energy islands in Denmark

Energinet is responsible for developing, establishing and operating electricity cables between Denmark, the energy islands and other countries. Energinet must also establish and operate electrical installations on the islands, and connect the renewable energy from them to the onshore energy system.

As part of the preparatory and statutory environmental assessments, Energinet has also been tasked with performing preliminary environmental and seabed studies for both energy islands, the associated cables and offshore wind farms, and onshore installations.

Bornholm Energy Island

Bornholm Energy Island consists of plant at sea and on land. Plant at sea will consist of offshore wind turbines and associated cable grids, substations (if applicable) and cables to bring the power ashore on the south coast of Bornholm.

Submarine cables will be established from Bornholm to Køge Bugt on Zealand and to Germany initially, and possibly other partner countries later.

The onshore facilities on Bornholm will consist of underground cables and a new converter station in the south.

Under the plan, the converter station on Bornholm will support a 60kV connection to the local grid, and large-scale electricity consumption (eg Power-to-X) or generation (eg large PV power plants) in the vicinity will be able to draw or add power directly via the energy island infrastructure.

Possible locations for connecting power from the Bornholm Energy Island to the power grid on Zealand are at Solhøj in Ishøj or Høje-Taastrup Municipality, at Avedøre in Hvidovre Municipality or at Hovegård in Egedal Municipality.

On Zealand there will be underground cables and a converter station with a connection to the existing 400 kV high-voltage grid.

Bornholm Energy Island – a multi-country partnership

In extension of the Danish political decision to construct two energy islands in Denmark, the Danish and German governments have signed a political declaration of intent to investigate and identify possibilities for hybrid projects involving offshore wind power in the North Sea and Baltic Sea.

Energinet has signed a cooperation agreement with German 50Hertz on planning an interconnection between Denmark and Germany via the Bornholm Energy Island.

BOX 2



ENERGINET'S RECOMMENDATION

Energinet recommends making electrical connections to both Denmark and Germany from the Bornholm Energy Island, with two possible time schedules in mind.

Two time schedules make it possible to fulfil the political goal of establishing offshore wind power at the Bornholm Energy Island before 2030, even if it proves to not be possible for the foreign partner to establish their connection to the energy island in time.

Energinet therefore recommends:

TIME SCHEDULE 1: Energinet, in cooperation with German TSO 50Hertz, establishes via the Bornholm Energy Island a 1.2 GW electrical connection between Zealand and Bornholm, and a 2 GW connection between Bornholm and Germany. All onshore and offshore electrical installations and interconnections between countries are ready for operation by the first half of 2029.

Or:

TIME SCHEDULE 2: Energinet establishes a 1.2 GW electrical connection between Zealand and the Bornholm Energy Island, which together with electrical installations in Denmark are ready for operation at the beginning of 2029. At the same time, Energinet and 50Hertz work jointly towards an expected future 2 GW interconnection between Bornholm and Germany, ready for operation in 2030 or as soon as possible thereafter.

BOX 3



CENTRAL ASSUMPTIONS

The economic costs and benefits have been calculated using the following central assumptions:

1. Establishment of 3 GW offshore wind power at the Bornholm Energy Island
2. High-voltage installations and cables must have enough capacity to transmit the connected offshore wind capacity to other locations
3. The Bornholm Energy Island is connected to a new substation at Solhøj on Zealand
4. The Bornholm Energy Island is developed in cooperation with 50Hertz
5. Technical solutions must allow more international connections and more capacity from offshore wind power
6. The Bornholm Energy Island will be a separate bidding zone from Zealand and Germany in the electricity market
7. In line with the political agreement of 1 September 2021, Energinet's net transmission costs will be transferred to the offshore wind farms
8. The 30-year investment horizon in the analysis from the date of commissioning is based on the expected concession period/lifetime for the offshore wind farms connected to the Bornholm Energy Island
9. Solutions exist which make it unnecessary to purchase reserves for outages on the connection between Zealand and Bornholm.

If the assumptions change, it may be necessary to recalculate parts of the business case on an ongoing basis.

50Hertz is a German TSO and Energinet's counterpart in Germany. The agreement involves planning a 2 GW interconnection that connects the Bornholm Energy Island wind turbines and the Danish electricity market with the German electricity market, and a 1.2 GW interconnection between Bornholm and Zealand.

The Bornholm Energy Island is thus an international cooperation on large-scale expansion of offshore wind power in the Baltic Sea, and has the potential to lead to more energy connections to other countries in the Baltic Sea (eg Sweden, Poland and the Baltic states) – possibly via more energy islands in the coming decades.

Connecting Bornholm Energy Island to Germany is most economic option

Energinet has conducted analyses of various interconnections to a future Bornholm Energy Island which are technically feasible.

These show that the Bornholm Energy Island offers a better economic solution if power from the wind farms is connected to both Zealand and Germany via a hybrid electricity connection (alternative 1 in this business case) than if the wind farms are only connected to Zealand (alternative 2).

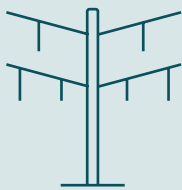
A hybrid interconnection is a cable on the seabed that is used to bring power from the onshore wind turbines ashore, and also connect two countries' electricity markets.

Good economics means that the total economic benefits for generators and consumers in Denmark and Germany exceed the costs of establishing and operating the installations during their lifetimes.

Green power from the Bornholm Energy Island will displace fossil energy consumption in Denmark, Germany and other European countries – directly in existing electricity consumption and indirectly through the electrification of other sectors. The value to society of the Bornholm Energy Island's positive climate effects is also an important part of the cost-benefit analysis.

ECONOMICS OF BORNHOLM ENERGY ISLAND'S ELECTRICITY INFRASTRUCTURE – AT A GLANCE

In this business case, Energinet assesses the economic value of the Bornholm Energy Island's electricity infrastructure by analysing two alternatives: interconnections to both Denmark and Germany, compared to an interconnection to Denmark only.



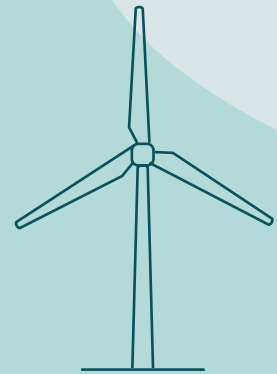
DKK 17
BILLION

Construction costs for the elements of the Bornholm Energy Island's electricity infrastructure which Energinet will build, own and operate.



DKK 20
BILLION*

Connecting the Bornholm Energy Island to both Denmark and Germany achieves a 9-figure net benefit compared to if it is only connected to Denmark.



*There is considerable uncertainty about the specific economic benefit. This uncertainty is due in part to the assumptions in alternative 2, whereby large volumes of wind power are supplied to Eastern Denmark, but demand does not increase in step.

40,000
TONNES IN
DENMARK

Reduction in carbon emissions in Denmark in 2040 as a result of the Bornholm Energy Island (connected to both Denmark and Germany).

3,100,000
TONNES IN EU

Reduction in carbon emissions in Europe in 2040 as a result of the Bornholm Energy Island (connected to both Denmark and Germany).

SIGNIFICANT RISKS

Bornholm Energy Island is to become world's first energy island. The innovation bar has been set high, and the decisions bound by the climate agenda add an external time pressure for the project. Establishment of the Bornholm Energy Island's electricity infrastructure is therefore a project that carries high risk. Three key sources of project risk are listed below:

- **Ambitious time schedule:** Risk of delays if business partners, environmental assessment processes, regulatory approvals, suppliers and supply chains are unable to meet the assumed time schedule.
- **New technology:** Standards for connecting HVDC plant have not yet been developed. There is thus a risk of prices and delivery times for Energinet's plant increasing.
- **Uncertain assumptions:** High uncertainty about future market conditions, particularly in light of the war in Ukraine, ongoing negotiations on shared ownership of the connection to Germany, and the possibility of insuring offshore construction work are examples of uncertain assumptions which could potentially have a major impact on project economics.

WHAT FACTORS COULD AFFECT THE RESULTS OF THE ANALYSIS?

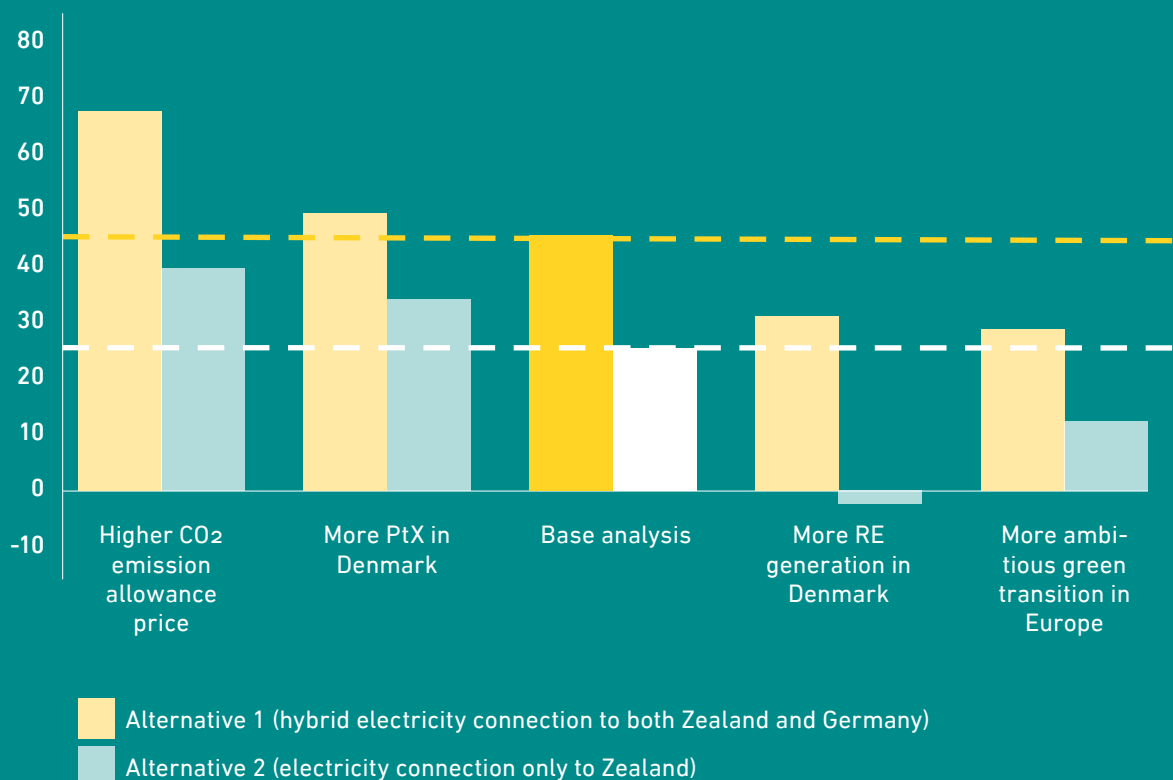
Future development of the energy system could take several paths. These are some of the key elements that could affect the business case for the Bornholm Energy Island's electricity infrastructure:

1. Carbon emission allowance prices are higher than assumed
2. Electricity consumption in Denmark for hydrogen production via Power-to-X is larger than assumed
3. Renewable energy generation in Denmark is higher than assumed
4. The green transition for energy in Europe becomes more ambitious than assumed.

For the developments analysed, the analyses show that it is better for Denmark and Europe for the Bornholm Energy Island to be established with a connection to Germany, as opposed to a pure connection from Bornholm to Zealand.

But the difference in the net benefit between the two solutions varies depending on which path development takes. This is illustrated in the diagram below through a few selected parameters.

Net economic gain without costs of offshore wind power (present value, DKK billions)





ENERGINET

www.en.energinet.dk/Infrastructure-Projects/Energy-Islands