A MARKET DESIGN FIT FOR PURPOSE: HOW TO MAXIMISE THE VALUE OF THE NORTH SEA'S WIND RESOURCES

COVER NOTE (PRODUCT A)
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The greening of the Danish and European energy systems has put the unlocking of the North Sea as a powerhouse for Europe at the top of the agenda for many policy makers, developers, and grid planners. At the same time, the significance and complexity of expanding energy production in the North Sea, including new technologies (hydrogen and PtX etc.), to volumes 4.5 times higher than Danish consumption today[1], entails a risk of a too slow and costly roll out. In fact, from a planning perspective, Denmark is trailing behind countries like the Netherlands with respect to offshore hydrogen infrastructure.[2]

When talking about green hydrogen it is important to distinguish between different business cases. Already there are examples of smaller projects looking to produce green hydrogen onshore or close-to-shore. Recent estimates suggest that these projects will provide sufficient electrolyser capacity to supply the Danish market with green hydrogen going forward.[3]

The opportunity to turn the heavy gales of the North Sea into green hydrogen in massive wind farms and electrolysers on artificial islands or platforms 80-100 km from shore on Dogger Banke is, however, a fundamentally different case. We will describe why this is the case in more detail in this note. To put far-from-shore hydrogen production into perspective; of the DKK 100 billion export potential of hydrogen produced on Danish green power resources, a large majority is expected to be generated by far-from-shore wind power.[4]

Copenhagen Economics has been commissioned by the CIP Foundation to identify key challenges to a time-efficient and cost-effective development of the North Sea and the far-from-shore energy production opportunities that it offers and make recommendations for a future market design.

In this work, we have carried out a number of interviews with key stakeholders in and around the North Sea, i.e., developers, energy companies, authorities and grid planners both within Denmark

1 Danish Energy Agency (2022) *Analyseforudsætninger 2022*.
2 Our interviews with TSOs suggest that the focus for hydrogen grid planning in Denmark has mostly been confined to onshore or close-to-shore infrastructure and interconnections to Germany, whereas TSOs in the Netherlands and Germany have gone further in planning e.g., offshore energy hubs and pipelines further out in the North Sea.
3 CIP Foundation (2023) *Markedsvurdering*.
4 CIP Foundation (2023) *Markedsvurdering*.

and beyond, to map challenges as well as the state of play in development of the North Sea. Based on this input and our research, we have synthesised our conclusions and recommendations presented in this note (Product A) and the associated deep dive slide deck (Product B).

1 THE STATE OF PLAY: CHANGING GEARS IN THE EXPLOITATION OF NORTH SEA WIND RESOURCES

The early days of Danish offshore wind

During the 1990s to the late 2010s, we saw a regulatory regime designed for relatively small-scale development of offshore wind farms, driven by the Danish state with economic subsidies to developers and energy companies allocated in dropwise tenders.[5] This was a relatively simple and straightforward scheme where offshore wind was produced in smaller farms close to shore with the purpose of bringing power into the existing grid primarily for domestic consumption. The role of the state in this setup was to de-risk, facilitate and mature offshore wind technology and push out coal from the energy mix.

Then, in 2021, when RWE won the public tender for Thor, the 800-1000 MW wind farm off of Thorsminde in Western Jutland, a turning point was reached. Close-to-shore wind was no longer in need of public subsidies but rather became a source of governmental revenue with an expected concession payment of DKK 2.8 billion during the 30-year concession period.[6,7]

A new era: the rise of energy islands/platforms and offshore hydrogen

In the face of climate change, we are now embarking on a new era. Political ambitions to build Energy islands Bornholm and Nordsøen[8], developing and supporting PtX[9] as well as greening power and heating[10] collectively encompasses a massive potential build out of up to 35 GW in the Danish part of the North Sea towards 2035.[11]

A key difference compared to previously is that the purpose of this far-from-shore power generation will be production and exports of green hydrogen to a market in e.g., Germany, not direct electrification and ingestion into the public grid for domestic consumption, cf. Figure 1. While onshore and close-to-shore wind will remain part of the generation mix for the purpose of powering Danish households and businesses etc. with renewable power, far-from-shore hydrogen production will be a new source of energy exports separated from the existing electricity grid and onshore power market.

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5 AxcelFuture (2022) *Hvordan udbyder Danmark bedst havvind?*

6 Energistyrelsen (2021) *Thor Wind Farm skal bygge Thor havvindmøllepark efter historisk lav budpris*.

7 The Thor process was, however, criticized for primarily two reasons; *1)* the tender requirements pre-defined an upper capacity limit that bidders said they could have surpassed in their design, meaning that the requested design by the authorities was sub-optimal from an electricity production point of view and *2)* the auction was decided by a random draw because several bidders made identical bids. This meant that the winner RWE may not actually be the best amongst the bidders, but non the less the winner.

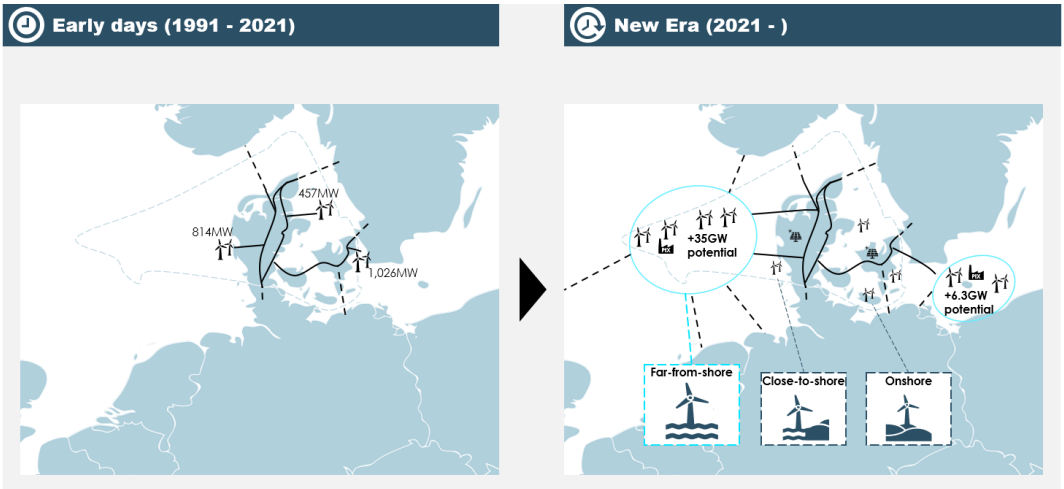
8 Danish Government (2020) *Klimaaftale for energi og industri mv. 2020*, Danish Government (September 2021) *Udbudsforberedende delaftale om langsigtede rammer for udbud og ejerskab af energiøen i Nordsøen*

9 Danish Government (March 2022) *Aftale om udvikling og fremme af brint og grønne brændstoffer*.

10 Danish Government (June 2022) *Klimaaftale om grøn strøm og varme 2022. Et grønnere og sikrere Danmark. Danmark kan mere II*.

11 Energinet (2022) *Systemperspektivanalyse 2022 Udviklingsveje mod fremtidens robuste energisystem.*

Figure 1
Change of gear for exploitation of Danish wind resources



Sources: Energistyrelsen (2023) *Etablerede havvindmølleparker*, Klima-, Energi-og Forsyningsministeriet (2022) *Østersøtopmødet*, Energinet (2022) *Udviklingsveje mod fremtidens robuste energisystem*.

1.1 The far-from-shore hydrogen business case is different

The regulatory needs may well prove to be different for onshore hydrogen infrastructure versus hydrogen infrastructure installed offshore. While a future Danish need for hydrogen is likely to be fully met by onshore production, calling for an onshore common grid of some sort, the case for a detailed Hydrogen Network Operator (HNO) led *offshore* grid development is less clear. Larger transit routes with interconnector properties, like regulated third party access and transparent tariffs, connecting multiple hydrogen hubs in the North Sea to the markets in Germany, Belgium, or the Netherlands, could be a job for an HNO. Point-to-point type pipelines connecting hubs to interconnectors, however, are likely to fall outside the scope of HNOs and are more naturally part of a commercial business case and specific project design.

At the same time, energy infrastructure in the new era will become increasingly complex and require much more co-operation with countries, notably around the North Sea. Energy islands, platforms or hubs, will give rise to multiple value streams (electricity *and* hydrogen or e-fuel) and may have no or several connection points to shore. This is evidently a more complex business model entailing far more risk and with far more exposure to various commercial conditions in surrounding countries than the risk profile associated with replacing coal with wind for use in Danish households and firms. Hence, the 'new era'-case of maturing offshore hydrogen is very different from the 'early days'-case of maturing offshore wind.

In addition, the 'new era' is characterised by a different political and security context. The urgency to improve energy security in Europe by replacing imports of Russian gas, while simultaneously delivering on climate goals at the EU level is evident and emphasises the need for international cooperation and alignment amongst European governments, TSOs and HNOs.
The below quotes illustrate Danish political ambitions and the urgency of the transition. Now the ambitions are to be put into practice by innovation and development, timely decision-making, and conducive regulation.

> Denmark's geography is unique for establishing offshore wind farms. **The parties agree that it is time to begin a new era in the development of Danish offshore wind.** The parties wish that two energy islands totaling 5 GW capacity will be built by 2030. The energy islands will be the very first of their kind and shall future proof Danish offshore wind development.[1]

> The parties agree that Denmark shall **aim to build 4-6 GW capacity of electrolysis by 2030**.[2]

Source: Own translation from original Danish texts: 1) Danish Government (2020) Klimaaftale for energi og industri mv. 2020, 2): Danish Government (March 2022) Udvikling og fremme af brint og grønne brændstoffer (Power-to-X strategi).

2 THE PROBLEMS WITH AN OUTDATED REGULATORY FRAMEWORK

Standing on the verge to this 'new era' where development will (have to) happen much quicker and where projects will become more complex than before, the regulatory framework fit for a simpler past proves insufficient. This is manifested in several ways as observed by market participants:

Too slow development

The development of offshore wind is currently characterised by long lead times in public tendering processes. Average time from staking of seabed of public interest[12], political decision making on the use of a certain area (e.g., for energy islands), tendering, permitting and then, finally, construction and actual production is 10+ years.[13]

This approach is simply too cumbersome to allow for the quick and massive development of new energy infrastructure and production capacity that has been announced from the political side, let alone from the market.[14] Policy makers are increasingly recognizing this problem in Denmark as well as on a European level.[15]

Lack of flexibility for market operators to design the right package

For close-to-shore wind resources that we have practiced exploiting during the early days of Danish offshore wind, we can largely continue with the existing model. In other words, we should let

[12] 'Udpegede områder' in the overall Danish Sea plan (Havplan).

[13] Green Power Denmark (2022) *Forhindringerne skal væk: Den grønne omstilling skal op i fart*

[14] Copenhagen Infrastructure Partners (2022) *'Ørsted and Copenhagen Infrastructure Partners join forces to develop approx. 5.2 gigawatts of offshore wind in Denmark'*.

[15] Danish Ministry of Climate, Energy, and Utilities (2023) *Regeringen etablerer national energikrisestab*, European Commission (2023) *Net-Zero Industry Act*.

developers design projects and bid for an area, transport the power to shore where it can be fed into the grid and consumed either directly by households or by almost closed-system onshore electrolysers for hydrogen production with a very limited need for connection to the TSO electricity grid.[16]

However, the primary case for energy production in the North Sea is different. It rests on exploitation of wind resources far-from-shore (a minimum of 50 km from shore) with the ultimate purpose of producing hydrogen – for consumption in neighbouring countries like e.g., Germany or the Netherlands, not domestically.[17] This requires a much more flexible system where developers have substantial room for manoeuvre in defining the optimal business model. Ultimately, the market is better suited than the Danish Energy Agency (DEA) or politicians to answer questions like *'should we go with a fixed or a floating energy hub?'*, *'what is the optimal level of capacity in a particular area?'*, or *'where are the future customers located?'*.

Unclear mandate and plan for development

While the political ambitions for developing energy islands, Power-to-X etc., are clear and outspoken, it remains unclear to many market participants how these ambitions will be realised when processes remain slow, tenders are postponed or, as most recently, the DEA puts the breaks on the open-door system where developers can apply for exploration rights to areas without subsidy or public support for later development.[18] Also, future high level planning for the North Sea in terms of offshore pipeline infrastructure, interconnectors etc. are lacking behind those of our neighbouring countries like Germany and the Netherlands and no Danish entity has yet been given a clear mandate to plan offshore hydrogen infrastructure for Denmark.[19]

Together this creates uncertainty about the direction of travel and mandate for authorities and grid planners tasked to implement political decisions. Civil servants are making large decisions on the allocation of rights to seabed, revenue, ownership etc. at a high pace and with very professional counterparts. This is obviously non-trivial, and a natural reaction is to be very careful and cautious in order to avoid making decisions that can be criticised for favouring specific firms, conflict with competition rules etc. Ultimately, this leads to a phenomenon of slow and delayed decision making and in turn pushes out investments further into the future. [20]

Outdated view on risk-sharing between public and private sector

Today, the cost of offshore wind has reached a level where close-to-shore wind farms can be constructed without public subsidies and even with a payment to the state as shown by Thor. This illustrates that over time risks have been driven down, through proof of concept and learning effects so that offshore wind today is a much less risky business than it was some 20 years ago.

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16 Copenhagen Economics (2022) *Supporting a cost-effective grid strategy for electrification. Co-location and cost reflective tariffs*.

17 Danish Ministry of Climate, Energy and Utilities (2022) *Press release: Energiø Nordsøen skal bygges forsvarligt og bæredygtigt.*

18 Danish Energy Agency (February 2023) *Press release: Sagsbehandlingen under åben dør-ordningen stilles i bero*

19 In April 2023, nine European gas TSOs have signed a declaration to work on a harmonious development of the North Sea energy resources. Energinet has signed on behalf of the future hydrogen network operator(s) in Denmark. Energinet (2023) *North Sea gas TSOs declaration*

20 Danish Energy Agency (2022) *Press release: Energistyrelsen fastsætter tidspunkt for udbud af Energiø Nordsø og fastholder samlet tidsplan.*, Danish Energy Agency (2023) *Press release: Sagsbehandlingen under åben dør-ordningen stilles i bero*, Danish Ministry of Climate, Energy and Utilities (2022) *Udbudsforberedende delaftale II om udbud af energiøen i Nordsøen*

By the same token, the associated risk with the more complex, multi-product energy hubs 50-100 km from shore is much higher than the now almost business-as-usual, close-to-shore wind farms. By applying the old logic and risk-sharing model of the simple projects to the new, much more complex ones, too much risk will be left with the private investor, which may, at best, slow down development, or deter investments all together.

In commercial projects, private investors will already be taking on all the financial and technological risks, and the state should be careful not to add to this by imposing requirements of upfront concession payments.

3 ELEMENTS OF FUTURE PROOF AND BUSINESS FRIENDLY FRAMEWORK CONDITIONS

To address the issues of the current regulatory framework and administrative processes, market participants have pointed to a number of 'musts' that need to be implemented in a future market design for the North Sea, as well as other far-from-shore hydrogen locations. A more pragmatic approach to regulation is needed on both a strategic and operational level:

Strategic

1 **Clarify mandate of hydrogen network operator and ensure integration into a common European offshore hydrogen grid**
   - Clearly define the mandate for an HNO to plan and develop offshore hydrogen infrastructure in Denmark.
   - Once a mandate has been given to an HNO, offshore planning and dimensioning can and should commence.
   - Danish offshore planning should integrate with existing plans at the European level to ensure that Danish based green hydrogen production can reach future markets in e.g., Germany, Belgium, and the Netherlands. This will be central for market participants to invest in an upcoming market like green hydrogen.
   - A clear scope of work for an HNO should also clarify how *private* operators can build and own hydrogen pipeline infrastructure connecting Danish production sites to markets outside of Denmark, e.g., future main markets in central Europe. Where relevant this can include rules on third party access.

2 **Clarify allocation mechanisms and practices of authorities**
   - Define the 'playing field' by an up-to-date Danish Sea plan, clearly delineating areas of seabed for commercial activities, green hydrogen, energy islands etc., so that it is reasonable for stakeholders to assume that a project falling within a predefined scope would be viable in the given area.
   - Clearly define the process by which seabed will be allocated going forward. It is key that the allocation process ensures a balance between, on the one hand, a public interest in maximising the value to the society of the seabed and, on the other hand, providing sufficient room for manoeuvre for the private operator to define the best possible business model and solution for the area. In particular, the process should allow for flexibility in terms of how much energy and what mix of energy (electricity, hydrogen etc.) should be produced from the area as well as choice of technical solutions to deliver (physical island, platform, hydrogen-in-mill etc.).

- Create transparency in decision making processes and a 'safe working environment' in which public servants can convert political decisions into practice by acknowledging that at the pace we must necessarily travel at, we won't get everything right, but we will be getting somewhere. Decision-making processes should be transparent, predictable, and reasonably quick.

Operational

3 Use 'Open Season-type processes' to de-risk North Sea far-from-shore hydrogen infrastructure investments

- Grid planners should utilise experience from existing Open Season or similar processes to de-risk public infrastructure investments by ensuring there is demand before building the infrastructure and providing transparency and certainty to the market.[21]
- It may be a challenge to use committal forward looking planning processes for infrastructure serving a technology not yet installed and an immature market, but it is a necessary step to get things off the ground at the necessary pace.
- The state or the HNO might be needed to take on limited upfront risk to accommodate capacity in the longer term by building bigger than short-term forward-looking demand suggests in an Open Season process.

4 Develop a long term oriented and cost-reflective tariff system

- Network tariffs can constitute a significant part of costs for hydrogen projects.[22] Hence, a new public hydrogen infrastructure should be governed by cost-reflective and capacity-based tariffs, which incentivise the most efficient use of capacity.
- Introductory tariffs should take a long-term perspective which may imply substantial overcapacity in the built-out phase. Hence, first movers cannot provide short term cost recovery for investments that should be seen in a decade long perspective.
- Tariff principles for hydrogen infrastructure should ideally be harmonized across neighbouring countries around the North Sea to reduce friction.[23]

5 Adopt risk-sharing models between developers and the state

- The future revenues as well as costs from the production of offshore based hydrogen are uncertain, also because competition from other providers of hydrogen outside of northern Europe is likely to become intense.
- High upfront fixed concession payment schemes to the state may deter investments all together because of large financial, commercial, and technical risks. This suggest that public revenues from the allocation of seabed should include elements of risk sharing. This could be in the form of a carried interest or a mandated minority ownership for the Danish State.

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21 Danish Utility Regulator (2015) *Analyse af kontrakter og prisdannelse på det danske engrosmarked for naturgas*

22 This is true both for onshore and offshore projects, and hence geographical closeness of production and consumption of electricity is key to any hydrogen project.

23 Recently, the European Council adopted its position on green hydrogen including draft proposals for regulation and a draft directive, setting out guidelines for third party access, tariffs etc., but with flexibility for the individual Member States to decide. The final regulation remains to be first decided at the EU level and then implemented at the national level, cf. European Council (2023) *Press release: Gas package: member states set their position on future gas and hydrogen market.*

- Inspiration for risk-sharing models could be sought in the existing scheme for oil and gas exploitation in the Danish part of North Sea, where Nordsøfonden takes a dedicated share of ownership for all licenses.
- Concession models could combine a relatively low concession payment in the exploration and development phase followed by a profit-sharing scheme as actual production commences.