



ENERGINET



Energistyrelsen
Danish Energy Agency



MARKET DIALOGUE ABOUT HYDROGEN INFRASTRUCTURE

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BACKGROUND

In the recent year Energinet has seen an increased interest in hydrogen infrastructure in Denmark. PtX-project developers indicate that – in the foreseeable future – they will need access to flexibility and storage from hydrogen infrastructure. A number of these developers have presented project visions for the establishment of GW-sized PtX plants around 2030.

The market dialogue has been conducted in a cooperation between Energinet and the Danish Energy Agency. The results and knowledge from the dialogue are reported here.

Ensuring timely availability of hydrogen infrastructure

In July 2021 Energinet and the Danish Energy Agency launched a systematic process for collecting data to clarify the need for piped hydrogen transport in order to meet the growing interest from Danish PtX developers. For several developers, transport needs are closely correlated with the need for large-scale storage of hydrogen.

The market dialogue has been conducted through an electronic questionnaire after which participating developers have been invited to a follow-up meeting with Energinet and the Danish Energy Agency.

Market developers have had the opportunity to register non-binding expressions of interest in the piped transport of hydrogen throughout Denmark.

The approach of the market dialogue is inspired by capacity demand processes used for expansions in the existing gas system.

It is still ‘early days’

The market dialogue has been launched at an early stage when there is neither regulation nor market model(s) for hydrogen infrastructure in Denmark. Accordingly, responsible operators for any future Danish hydrogen infrastructure has not been identified. The market dialogue is also conducted at an early stage for the reported PtX projects, where many central details are still to be figured out.

The market dialogue has therefore balanced the need to systematically, and in a non-discriminatory way, obtain useful data to get increased knowledge on how the hydrogen market develops.

What is the market dialogue used for?

Energinet and the Danish Energy Agency finds it valuable to gather knowledge to make timely decisions and launch initiatives in relation to market frameworks and future infrastructure needs for hydrogen.

Knowledge from the market dialogue is used as background for the Danish Energy Agency's strategy work as well as work with the analytical assumptions for Energinet. At Energinet, knowledge from the market dialogue will be part of Energinet's holistic energy planning activities.



**The market dialogue was
conducted during the period;
2. July - 31. August 2021**

OVERVIEW OF PROJECT RESPONSES

Reports

In total, 32 project responses have been received from 19 different developers. Of the 19 developers, five have declared more than one project. These five developers account for half of the responses received.

The market dialogue does not rely on a reference network and the developers are thus free to choose a project location. Geographically, the responses are distributed throughout Denmark.

Of the 32 project responses, 12 developers have indicated quantity needs and some have adjusted their volume needs after the dialogue meetings.

Type of projects

The number of projects is relatively evenly divided between the production of hydrogen and the consumption of hydrogen. 11 projects have been declared producers of hydrogen and nine as a buyers of hydrogen. Ten projects declare that they will both produce and consume hydrogen, while two projects do not specify a role.

Several projects have both a producer and consumer role, with hydrogen infrastructure providing flexibility as an alternative to local hydrogen storage.

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Several hydrogen production projects will have flexible production, while the remaining projects have not yet decided.

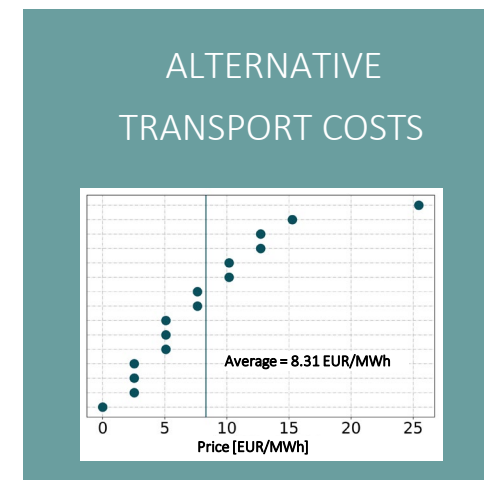
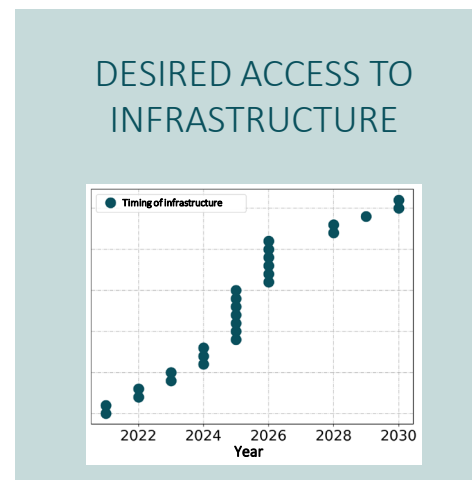
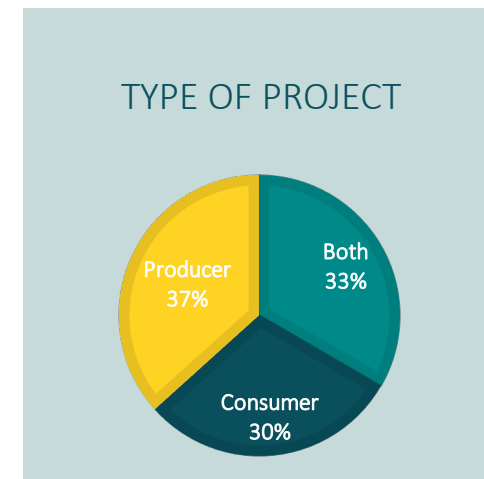
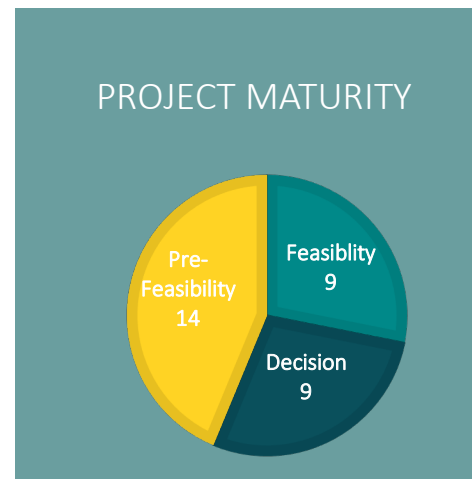
Project maturity and time line

Nine projects have taken an investment decision, while the other projects are in the pre-feasibility or feasibility phase. All projects indicate that they see the need for hydrogen infrastructure before 2030. In the follow-up dialogue meetings, the majority points to the importance of knowing whether hydrogen infrastructure will be established in Denmark in order to further assess the feasibility of the projects.

Alternative transportation costs

The developers list the transport of hydrogen on trucks as an alternative to hydrogen infrastructure. The cost of transporting hydrogen by truck depends on many factors - especially distance and whether the hydrogen is transported in liquid form or compressed. The literature indicates typical transport costs from EUR 0.7/kg up to EUR 7.7/kg. In the market dialogue, operators have indicated an average alternative transport cost of EUR 8,3/MWh (EUR 0,35/kg).

Some answers are not seen as direct interest in piped hydrogen transport, but in other parts of the value chain.



MARKET DEVELOPERS AND THEIR BENEFITS FROM HYDROGEN INFRASTRUCTURE

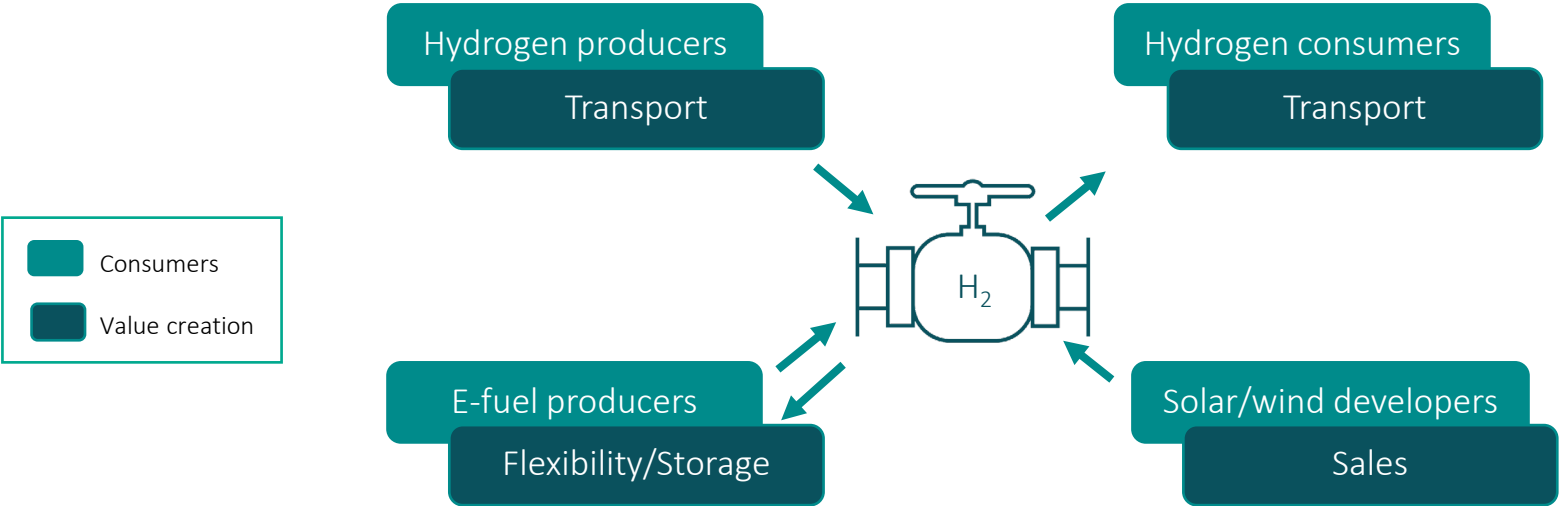
At the dialogue meetings, market developers have been able to elaborate on how they see themselves as potential users of hydrogen infrastructure and what value the infrastructure can create for their projects.

Hydrogen infrastructure users

- *Producers of hydrogen* for a hydrogen market.
- *Solar and wind developers*, who will periodically produce and sell hydrogen when electricity prices are favorable
- *Manufacturers of e-fuels such (process)* as ammonia, methanol, kerosene, etc., who wish to use hydrogen infrastructure to balance their e-fuel production.
- *Hydrogen consumers* who want to replace non-green fuels e.g. in transport and industry.

Value creation for hydrogen infrastructure

- Access to infrastructure gives access to larger markets.
- This will ensure a stable hydrogen supply.
- In the long term, a more transparent market will be created.
- Hydrogen infrastructure can eliminate or reduce the need for local storage of hydrogen.
- Access to infrastructure and storage reduces the risks of scale-up.



INDICATION OF QUANTITIES OG GEOGRAPHY

A total of 15 developers have declared annual volumes for their transport needs. Several of the developers chose to update their declaration after dialogue meetings. Other developers expressed that they were not ready to be concrete in relation to quantities at this time. But also pointed out that lack of quantities did, however, not reflect a lack of interest in hydrogen infrastructure.

The quantity needs of the developers could be attributed as "entry", i.e. the hydrogen quantities that they expect to deliver to the infrastructure (production) and "exit" i.e. the hydrogen volumes that they want to extract from the infrastructure (consumption).

On the map, the declared "entry" annual quantities are shown for different regions. The Region of Southern Denmark stands out and the other two regions of Jutland follow.

Projects have been registered in the Capital Region of Denmark, but without annual volumes.

The quantities of entry and exit declared show a clear majority of "entry", i.e. production (see chart). Several projects have declared roughly the same "entry" and "exit" volumes, which show that hydrogen infrastructure for those projects

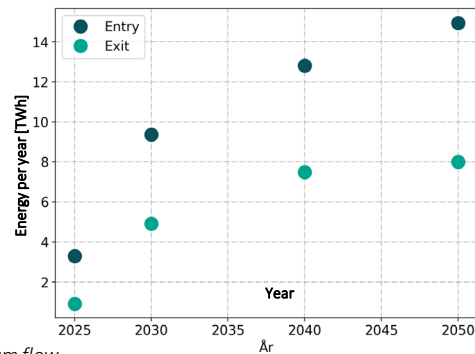
*Load factor indicates the utilization rate of a pipeline, expressed as the average flow in relation to the maximum flow.

is primarily used for storage.

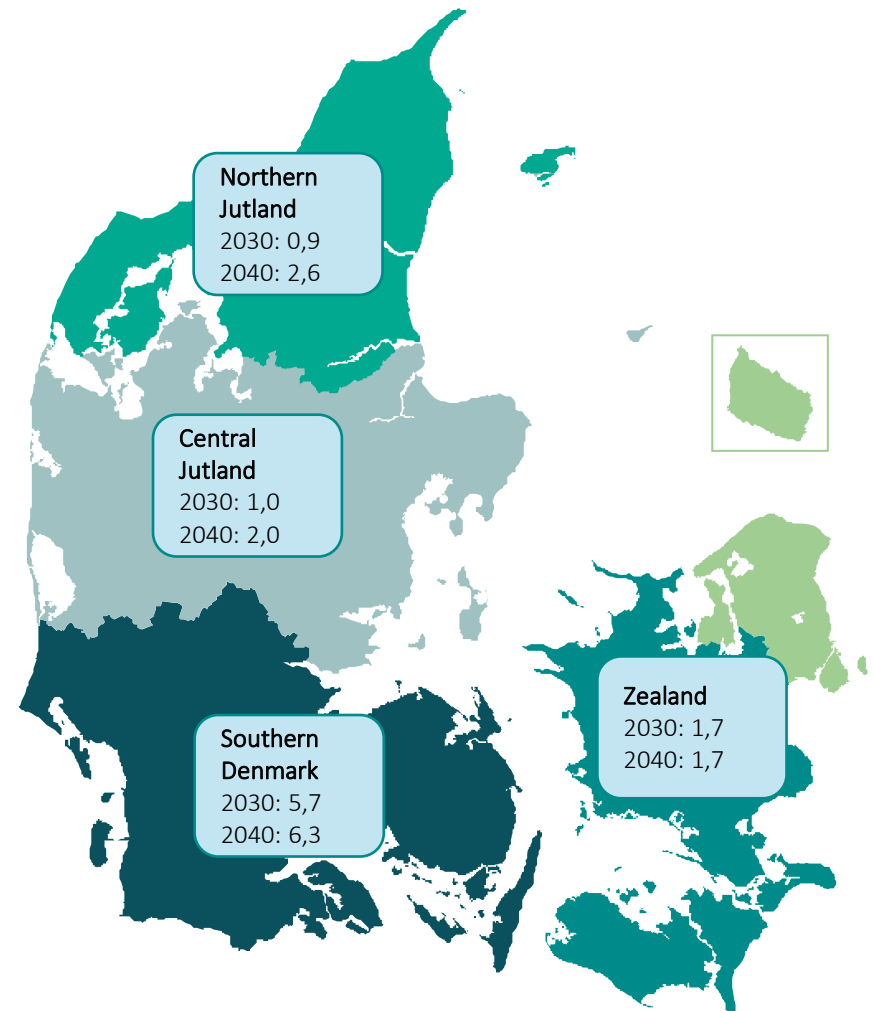
Developers have also enrolled load factor* for each year. It is difficult to say anything very clearly, but the rate of utilization on the production side tends to be high in 2030 and falls to below 0.5 by 2050. For "exit" (consumers), the utilization rate is around 0.6.

The hydrogen volumes declared for 2030 are equivalent to approximately 1.34 GWe (at an efficiency of 0.8). The producers who have declared an interest in the market dialogue represent a significantly greater volume. However, based on the follow-up dialogue, it is clear that many developers, at this early stage, are not ready to provide concrete figures regarding their future transport needs.

There are publicly known PtX project announcements of just over 5 GWe. They also contain projects which do not need infrastructure, or only to a limited extent.



Entry by region in 2030 and 2040 shown in TWh





ALTERNATIVES TO HYDROGEN INFRASTRUCTURE AND DECLARED BARRIERS;

Alternatives to hydrogen infrastructure

Virtually all developers estimate that the alternative to hydrogen infrastructure will be in terms of transport and small scale storage of hydrogen by trucks. The developers see this as both a logistical and probably also an economic barrier for getting projects to full commercial scale. Several developers estimate the transport cost of hydrogen on trucks to be less than EUR 0,5/kg for short-distance transport, and in particular EUR 1/kg for transport as liquid hydrogen over longer distances.

Transport in pipelines will obviously be interesting when it can be made cheaper than the alternative – and preferably significantly cheaper in terms of ensuring competitiveness. Some developers plan to convert most of the hydrogen produced into liquid fuels (e.g. e-ammonia, e-kerosene, etc.) which can be easily distributed via tankers and ships. For these developers, access to a hydrogen network will ensure stable production conditions and be an alternative to local hydrogen storage.

Barriers pointed out by developers

The developers have declared several different barriers that they see for hydrogen/PtX in general as well as for the establishment of hydrogen infrastructure. Summarized below are the barriers that were declared by the majority of developers and were highlighted in the dialogues.

General barriers to hydrogen/PtX production and market demand:

- **Market-driven demand for PtX products** is crucial to get started. Support at the start of projects was highlighted as necessary by several developers.

- **The certification of green hydrogen and e-fuels** was highlighted as a crucial aspect in creating a market for green fuels - within the country as well as when exporting to other countries in the EU.
- **The availability of renewable electricity** was mentioned as a barrier in many projects. PtX requires significant expansion of renewable energy.
- **Electricity tariffs:** Many developers expressed a desire for tariffs that takes the high flexibility of electrolysis into account. In addition, a strong interest in hydrogen production was expressed by the developers on terms similar to “direct lines” in order to reduce production costs.

Specific barriers to the establishment of hydrogen infrastructure:

- **“The chicken and egg” problem:** The infrastructure is seen by several developers as a necessity for scaling up their projects. The majority see the need for hydrogen infrastructure emerging as early as 2030 – and preferably earlier. Some developers point out that in their business cases they assume that they should initially be able to do without hydrogen infrastructure, but for full commercial scaling it will be necessary. The market wants a signal about hydrogen infrastructure and when it will be available. There was a general concern among several developers that Denmark would lose foothold in the competition with other European countries if the infrastructure was established too late.
- **The lack of hydrogen market regulation** was mentioned by several developers as a barrier to, among other things, managing the framework for infrastructure. Some developers also mentioned the need to prepare a real hydrogen market model, taking into account the specificities of hydrogen value chains and the interplay with large-scale renewable energy production.

CONCLUSION

PtX developers see the need for hydrogen infrastructure

Hydrogen infrastructure can create significant value for PtX developers in terms of flexibility as well as access to larger markets, including export to Germany. The majority of Danish projects are still at an early stage, where there is a lack of clarifications on key issues that create great uncertainty about the projects. This has obviously made it difficult for the participants in this market dialogue to be very concrete in terms of hydrogen infrastructure needs. However, in most cases an overall expression of interest has been given, and the signal is that hydrogen infrastructure is interesting in Jutland at first.

It is especially the southern part of Jutland which the developers highlight, where there is concrete interest in the export of hydrogen to Germany as well as access to hydrogen storage.

Relevant and important dialogue

Both the Danish Energy Agency and Energinet have benefited from the dialogue with the project developers, who have provided more clarity on, among other things, the value of hydrogen infrastructure and timing for establishing the infrastructure. However, many clarifications remain to be addressed in close cooperation with market developers.

The Danish Energy Agency uses input from the market dialogue as background information in their current work on the preparation of the national energy strategies, which are expected to be presented by the end of the year.

The market dialogue has also provided important input to the holistic thinking of the energy system, which is central to Energinet's future analysis and planning work.

