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SUMMARY

ENERGINET WORKSHOP ON SYSTEM OPERATION AND BALANCING FOR HYDROGEN – KEY NOTES AND TOPICS

Date:
December 21, 2023

Author:
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Time:

December 7, 2023, from 10:00 to 14:30

Place:

Pederstrupvej 76, Ballerup (Energinet offices)

The system operation and balancing workshop on December 7, 2023, hosted presentations from Energinet's perspective on following matters:

- How to design a hydrogen backbone
- How transportation of hydrogen is effectuated
- The amount of energy "storage" (linepack flexibility) within the backbone at various transport capacity values
- Emphasis on the discrepancies between underground hydrogen storage and backbone hydrogen storage
- Outline of a hydrogen balancing "landscape": What shipper-related factors influence the design of a balancing regime?
- Entry/exit model adoption to the Danish hydrogen system
- Overview of balancing-related definitions and roles
- Potential development of the balancing regime for hydrogen in Denmark
- Group sessions on:
    - Pipeline capacity and linepack flexibility
    - Hydrogen and electricity market interaction

Within the above-formulated perspectives presented by Energinet, various themes were discussed, with the main topics being:

- **System design and operation:** Multiple participants expressed an eager to understand the in-depth technicalities in relation to the system design and operation, particularly addressing pressure limits (both absolute and geographical), the amount of available technical linepack flexibility, and to what extent the system design simulations are coped to incorporate Danish hydrogen consumption (and not only export to Germany).

    - **Energinet comment:** In broader terms, Energinet informs the participants that the upcoming workshop on *Hydrogen quality and grid connection* contains more specifics on pressure limits, quality thresholds for hydrogen, etc. Furthermore, Energinet confirms that the primary system design enforces a uniform pressure distribution. In addition, it is emphasized that the expected Danish hydrogen consumption is included as an integral part to the overall project design.

- **Hydrogen balancing regime development:** The workshop delved into a potential roadmap for the development of the balancing regime, which expectedly incorporates multiple TSO balancing actions and shipper portfolio potentials at different time instances. There was a general agreement among the participants to design and implement a balancing regime, which in an early matureness phase is founded on simple and straightforward principle.

    - **Energinet comment:** Energinet recognizes the need for a "simple" balancing regime in an early matureness level of the Danish hydrogen system. Energinet emphasizes that the TSO needs a combination of balancing tools to influence the within-day positions of shippers, or adequate tools to be able to influence inputs and/or offtakes on the system. However, Energinet strives towards minimizing the intervention in the system from TSO balancing tools, and thereby fostering a balancing regime where the shippers are responsible for effectuating portfolio balancing.

- **Pipeline/transport capacity and linepack flexibility:** Energinet presented different potential scenarios/models for how to bundle/unbundle pipeline capacity and linepack flexibility. Different stakeholder perspectives emerged during the discussions. One spectrum of the stakeholders prefers a model, where transport capacity and linepack flexibility are unbundled commodities (a note: If the hydrogen offtake is "static", there is only a need for transport capacity, and no distinct need for linepack flexibility). Another spectrum of participants prefers a model, where transport capacity and linepack flexibility are procured simultaneously in one distinct bundled commodity.

    - **Energinet comment:** Founded in the participant discussions, it is evident that linepack flexibility is a key cornerstone for the successful design and implementation of multiple electrolysis/hydrogen projects. Linepack flexibility is of high value. Energinet acknowledges that the need for TSO balancing actions should be minimized as much as possible, by allowing the shippers to perform portfolio balancing via multiple methods / tools (i.e., trading capacity, hydrogen, or linepack flexibility between shipper-to-shipper). Furthermore, a decision on individual shipper bands (linepack bands) or a system-wide system band is still to be determined

and will be discussed with market participants and stakeholders during the coming months.

- **Hydrogen and electricity market interaction:** Energinet presented 7 assumptions to the participants within the interplay of electricity and hydrogen market interactions. These assumptions touch upon a wide spectrum of themes ranging from a hydrogen producer's ability to submit operation plans, to what electricity markets the shippers intend to utilize for flexible operation of the electrolysis/PtX plants. Several participants expressed a need for a tight coupling between the electricity markets and a future hydrogen market, to harvest the economic value of operating the electrolysis plants in a flexible manner.

    - **Energinet comment:** Energinet acknowledges that the prerequisite for operating electrolysis or PtX facilities dynamically, is a very close coupling between various electricity markets (forward markets, Day-ahead, intraday, ancillary services) and the future hydrogen market. If implemented, the time instances for realizing capacity bookings, nomination and re-nomination on hydrogen flow, should be directly coupled to the gate closure time (GCT) instances within the electricity market, so specific electricity prices are published at favorable time moments.

Key notes from group work sessions

The following notes are a direct transcript of what was written on the whiteboard during the group work sessions.

GROUP SESSION 1: PIPELINE CAPACITY AND LINEPACK FLEXIBILITY

A) Scenario where linepack and capacity are **independent** of each other:

- Capacity and linepack flexibility are procured separately.

B) Scenario where linepack and capacity are **dependent** of each other:

- Capacity and linepack flexibility are procured simultaneously.
- A specific amount of capacity entails a specific amount of "granted" flexibility

C) A **combination** of scenario A & B

- A specific amount of capacity entails a specific amount of "granted" flexibility
- Additional flexibility can be procured separately

Online group

- Expresses concerns about the immature market. Most participants in favor of separate marketing. Coordination with GE and NL models is important.

Group 1

- It's important to consider that individuals might buy the entire capacity. Beyond that, there is no strong preference among the three options. Emphasizing the necessity of a secondary market.

Group 2

- Favors Scenario B.
- The choice of the system in Germany is crucial; uniformity is ideal across systems. There are different hydrogen consumption profiles in Germany (static, fluctuating, ?)
- Flexibility is most critical at the start due to its potential cost reduction impact.
- The TSO should have in mind that in the start-up phase a limited number of producers can supply hydrogen. A lot of hydrogen is needed in the pipelines before the system can work.
- Scenario B will also require a secondary market for both selling capacity and flexibility. Shippers believes that trading between each other is more favorable than dealing through the TSO.
- Utilize the secondary market platform established for natural gas (is considered to be straightforward). In the initial years, communication between shippers is expected to be the primary method, potentially through direct calls.

Group 3

- Due to production uncertainty, they lean towards option A.
- They argue against purchasing flexibility when operating steady.
- However, option B could provide more certainty for Energinet, as linepack flexibility in model A might not be immediately purchased.

Group 4

- Unable to choose a model but suggests handling flexibility in a way that optimally aligns with the electricity market.

Group 5

- Asserts that Model B is not viable.
- Model A could work.
- Suggests that those who only wants to deliver hydrogen to Germany will only need to buy capacity. Whereas those that will deliver for DK

consumption and those who have a large electrolyzer would be interested in linepack flexibility

- *Group 3 disagree with these suggestions*

GROUP SESSION 2: HYDROGEN AND ELECTRICITY MARKET INTERACTION

Assumption 1: The hydrogen producer can submit its hydrogen production plan the day before the day of operation

Assumption 2: The linepack flexibility in the hydrogen infrastructure reduces the hydrogen producer's need for self-owned on-site hydrogen storage.

Assumption 3: Changes in electricity prices up until the operating hour will affect the hydrogen production.

Assumption 4: The hydrogen producer will provide ancillary services in the electricity market and thus optimize the profit of the electrolysis plant.

Assumption 5: A Hydrogen Purchase Agreement (HPA) is signed between the hydrogen producer and the hydrogen consumer, obligating the producer to deliver a fixed quantity of hydrogen daily.

Assumption 6: A Power Purchase Agreement (PPA) is signed to cover the baseload electricity consumption while the remainder is purchased on the day-ahead and/or intraday market.

Assumption 7: The shipper is also going to be the Balance Responsible Party (BRP) in the electricity market for the hydrogen producer

Online group

- Assumption 1: Will depend on weather conditions.
- Assumption 2: Primarily a matter of pricing.
- Assumption 3: Some uncertainty exists; diverse answers to this question.
- Assumption 4: Dependents on the level of difficulty in participation.
- Assumption 7: Some will be involved in both aspects.

Group 1

- Assumption 1: Yes we can do it, will we do it? No. Maintaining a production plan is challenging, especially without linepack flexibility.
- Assumption 2: Yes; it enhances the competitiveness of exporting hydrogen. Onsite storage is costly.

- Comment: Business cases differs between the present and a decade from now, yet contracts with the TSO are typically of a 10-year duration.
- Assumption 3: Yes, it also differs within the hour.
- Assumption 4: To some extent, yes. Shippers engaged in ancillary services in the electricity market might lower their hydrogen production and then potentially selling their hydrogen capacity to other shippers.
- An increase in hydrogen users is expected to decrease the profitability of ancillary services. Those with Power Purchase Agreements (PPA) have the option to sell electricity instead of producing hydrogen.
- Assumption 5: Varied outcomes depending on the consumer; a mix is anticipated.
- Tenders for German steel producers involve three scenarios: base load, varying load, and backup. The possibility of German consumers building their storage should also be considered.
- Assumption 6: It depends on the HPA, if you have a lot of risk why not try without a PPA.
- Assumption 7: Could be a possibility. Flexibility in the hydrogen market is necessary before such integration becomes feasible.

Group 2

- The extent of overplanting in the upcoming wind farm tenders will significantly impact all the assumptions.
- Assumption 7: Financing may be challenging, especially for those involved in both aspects.

Group 3

- Assumption 1: You can give a plan, but it is important to be able to update it, as it will probably not be accurate
- Assumption 2: Yes. The market model is not intended to underpin a need for local storage
- Assumption 3: They will be in both DA and ID.
- Assumption 4: Depends on electrolyze technology, obtaining financial investment from ancillary services is unlikely, because they can’t guess the price of the ancillary services
- Assumption 5: HPA does not necessarily include a fixed quantity, and thus HPA should not be a problem. They have not signed any HPA at this moment

- Some companies may hire others to handle balance responsibility, allowing them to concentrate only on production.
- Contracts of Difference: They can potentially mitigate certain uncertainties and risks.
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Group 4

- Will engage in ancillary services, however complexities arise in discussions about investment
- Assumption 7 could be an option but is not the only solution.

Group 5

- Uncertainty on value of flexibility makes it difficult to consider in the business case
- Tendency to expose oneself to the electricity price

Additional reflections from participants

- Are the producers and offtakes ready with their terms and conditions for trading with each other?
- Linepack flexibility could be treated as a “pay by usage” product, yielding that the shipper pays per “utilized” MWh linepack. This would incentivise the shippers to exploit every “bought”/”utilized” MWh of linepack flexibility.