System and balance

Workshop 7 December 2023

PLEASE KEEP YOUR MICROPHONE MUTED

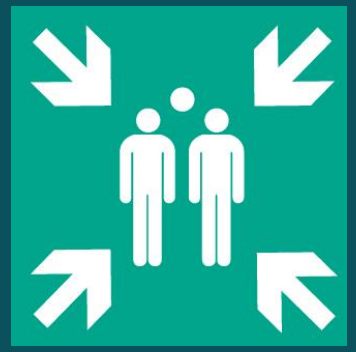
USE THE HAND MARKER OR THE CHAT FOR QUESTIONS AND COMMENTS

THE WEBINAR IS NOT BEING RECORDED

THE PRESENTATION WILL BE SENT OUT AFTERWARDS

Emergency exits

Defibrillator



Assembly point

OBJECTIVE(S) OF TODAY

- To **share** Energinet's status on hydrogen system design and operation and balancing with stakeholders
- To **receive** perspectives from stakeholders on the presented material, in particular the balance model components
- To **ignite** invaluable discussions on the outlined topics/themes in the group sessions
- To **emphasize** that no distinct balancing model have been selected yet

TODAY'S PROGRAMME

10:00 -10:15	Welcome
10:15 -11:15	Subject introduction
	- System operation (30 min)
	- Balance (30 min)
11:15 -11:25	*Break*
11:25 -11:30	Introduction to group session 1
11:30 – 12.00	Group session 1:
	Pipeline capacity & linepack flexibility
12:00 - 12:20	Presentation in plenum
12:20- 13.05	*Lunch*
13:00 - 13:15	Introduction to group session 2
13:15 - 13:45	Group session 2:
	Hydrogen and electricity market interaction
13:45 - 14:15	Presentation in plenum
14:15 - 14:45	Wrap-up and next steps

SUBJECT INTRODUCTION

System design and operation

INTRODUCTION TO THE HYDROGEN SYSTEM

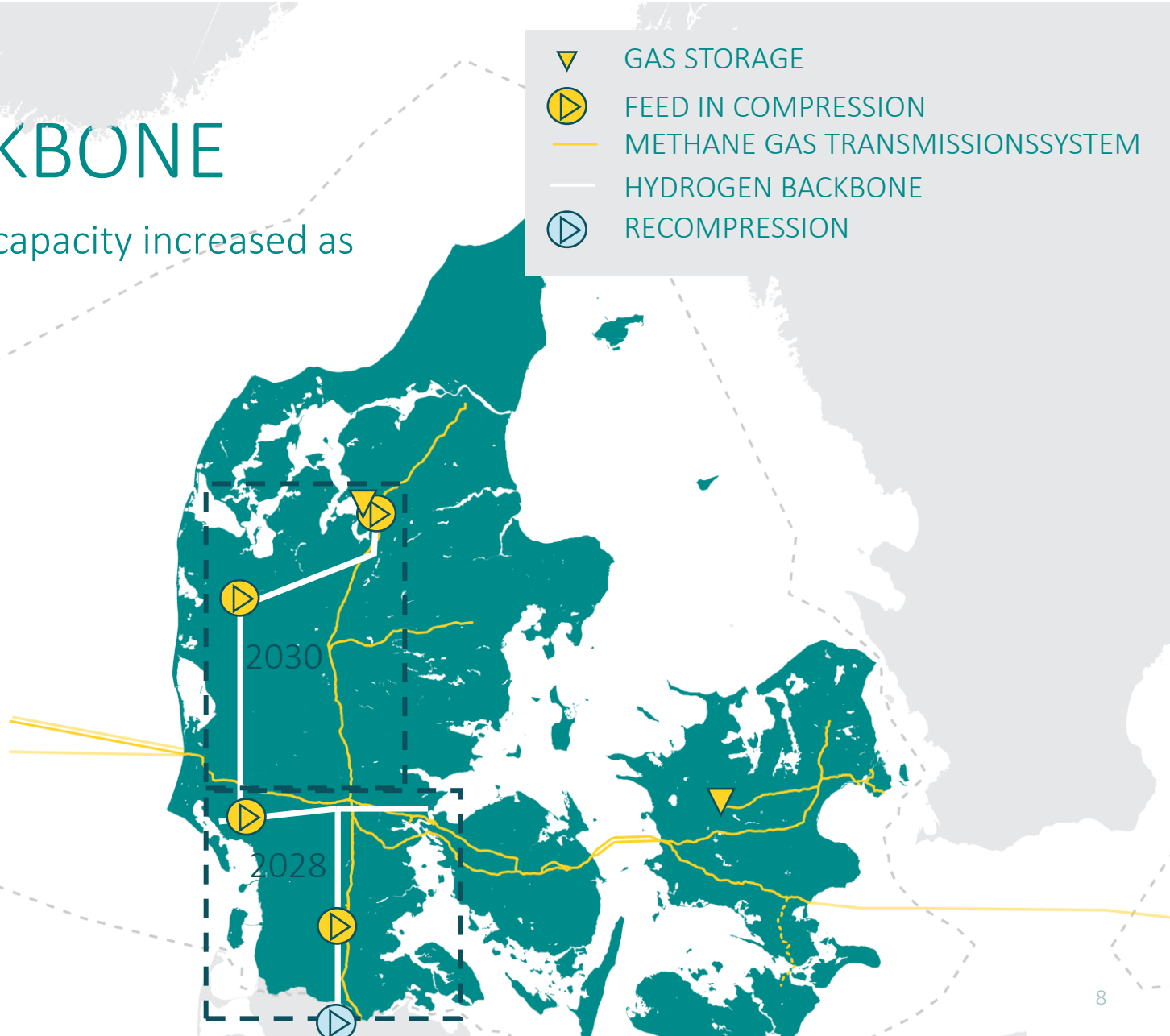
- What are our thoughts behind the design of the hydrogen backbone?
- What can a hydrogen backbone do?

THE HYDROGEN BACKBONE

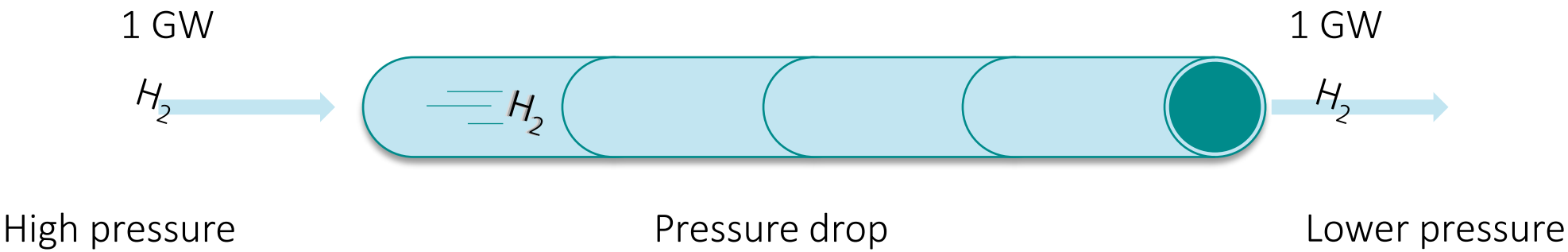
The backbone is constructed in steps and capacity increased as needed

- Backbone constructed in steps – starting from the German border
- Gradual increase in pressure according to the need for capacity
- Feed in compression – possible compression towards Germany to provide sufficient capacity
- Different pipe sizes (diameter 36” or 42”)

Mainly for capacity but also for flexibility



TRANSPORT OF HYDROGEN IN PIPELINES



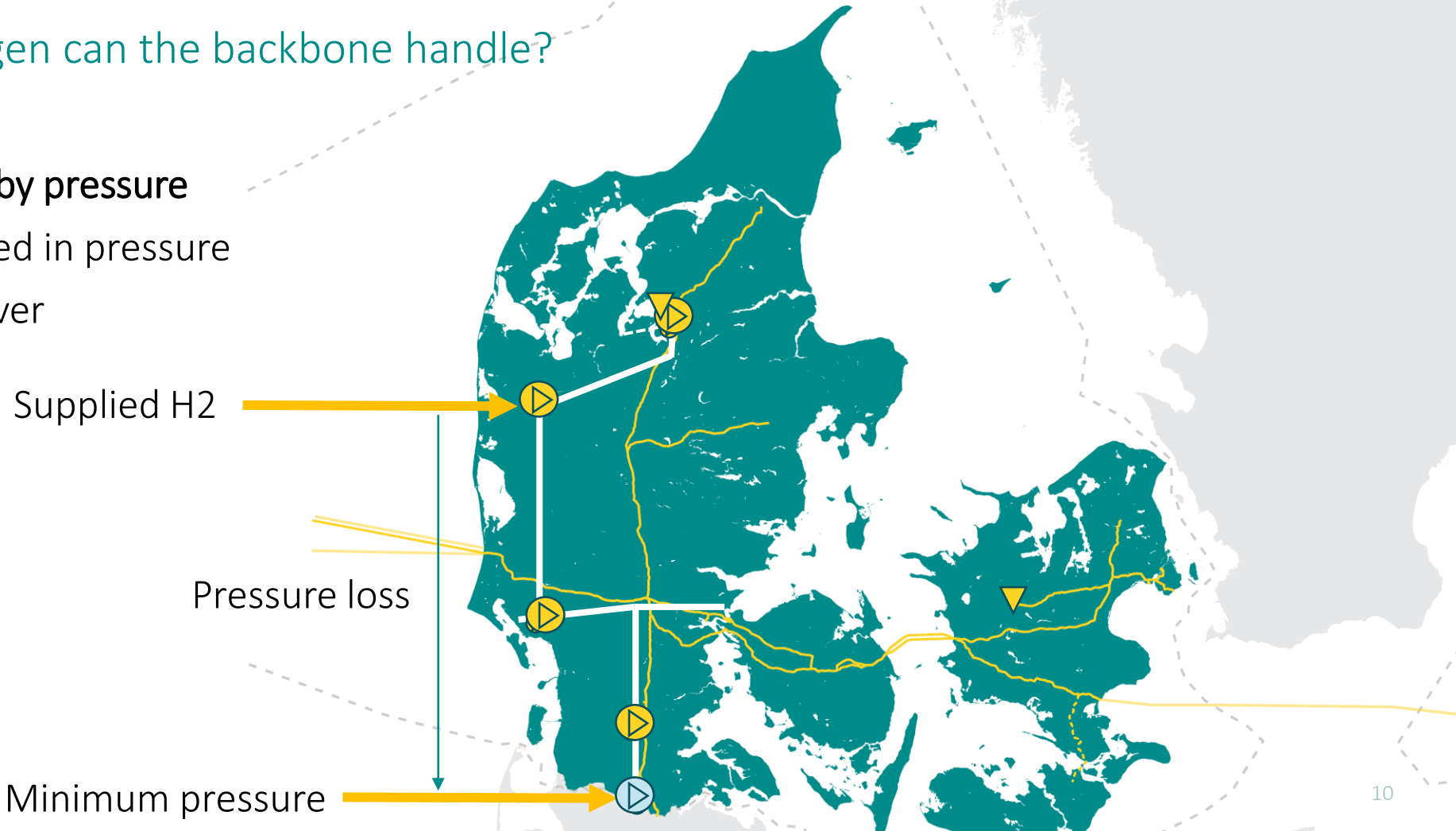
HOW DO WE DETERMINE TRANSPORT CAPACITY?

How many GW hydrogen can the backbone handle?

Hydrogen flow is **driven by pressure**

Maximum pressure is feed in pressure

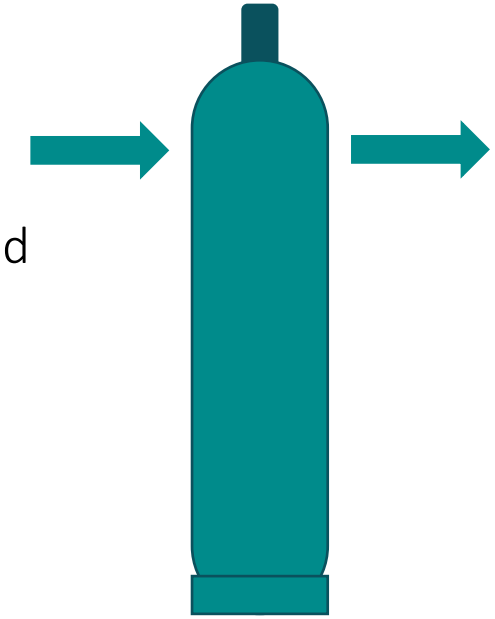
Minimum is set by receiver



THE BACKBONE CAN ALSO STORE ENERGY

By utilizing that the pressure in the hydrogen system can be higher than required for transport capacity – energy can be stored. We call this linepack flexibility

Hydrogen injection
Pressure increases
until max level is reached



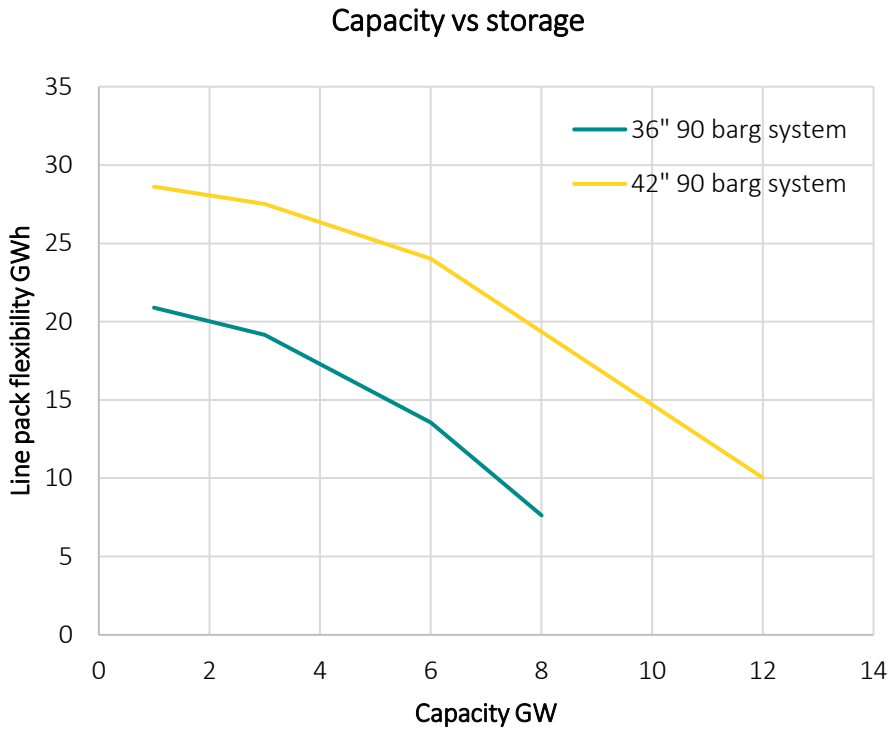
Hydrogen extraction
Pressure decrease
until minimum pressure
is reached

TRANSPORT CAPACITY OR LINEPACK FLEXIBILITY

The amount of storage capacity is a design choice

- We are aiming for a system with 10-20 GWh of linepack flexibility
- The flexibility will only be enough to handle **hours of production** without any export of hydrogen

Capacity and flexibility can both be increased by increasing pipe-size or increasing max pressure. Both are associated with increased costs.



Capacity and heating value defined from lowerheating value 3 kWh/Nm3 or 33,3 kWh/kg

STORAGE FOR FLEXIBILITY

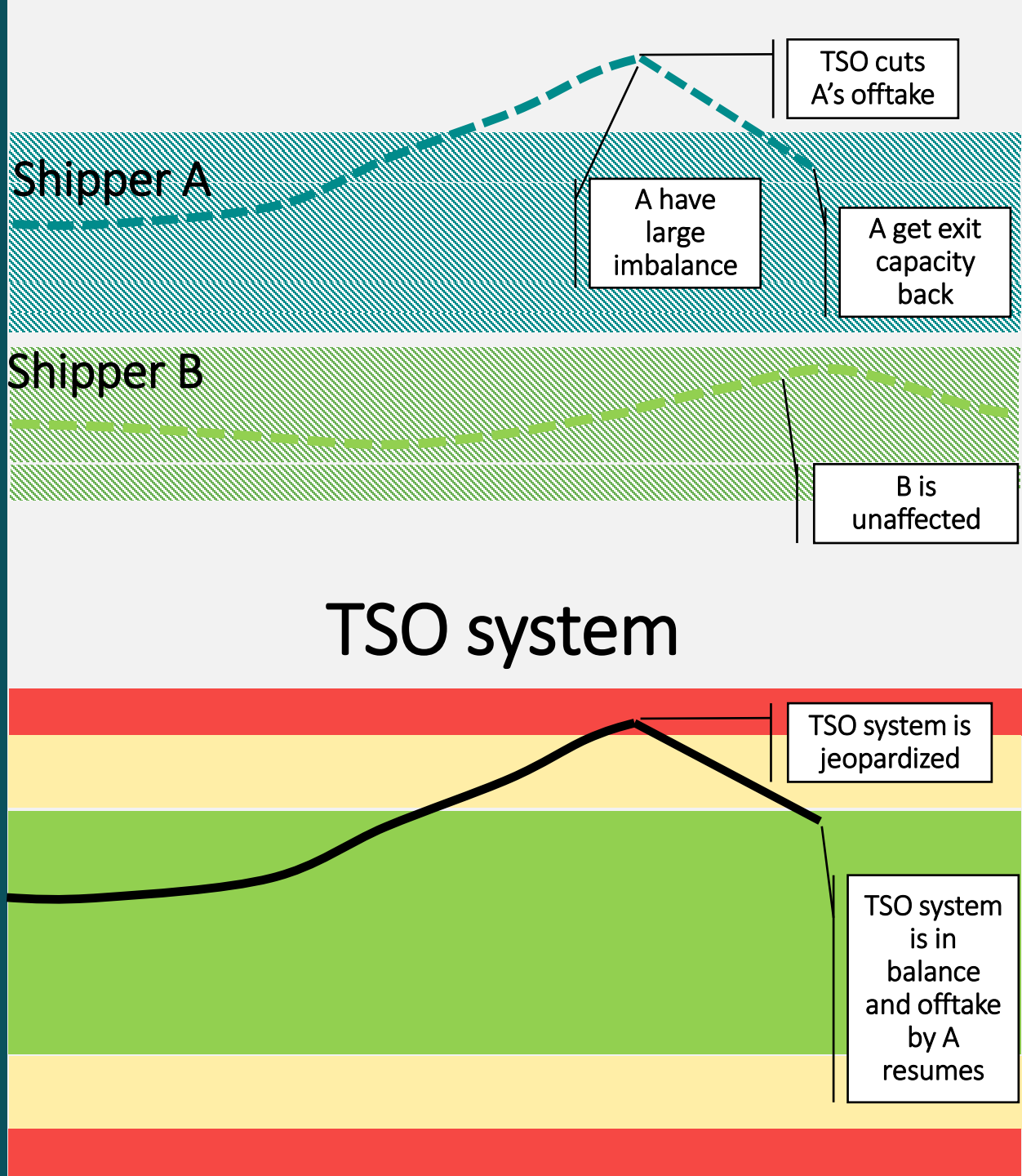
The hydrogen backbone is not alone in providing hydrogen storage

- Hydrogen Backbone 10-20 GWh of storage as Linepack flexibility.
  Hours of storage
  Very fast
  Limited expandability

- Underground storage ~100 GWh/cavern
  Days to months of storage
  Slower injection
  Can be expanded

HOW TO MAINTAIN BALANCE?

- TSO must ensure that the system is kept within the bounds of the pressure band
- Shippers shall have the incentive and possibility to maintain their balance between input and output
- If a shipper imposes too high imbalance to the system, the TSO will intervene
- As a last resort TSO might cut hydrogen offtake from shipper



SUBJECT INTRODUCTION

Balance

SETTING THE SCENE: THE "LANDSCAPE" FOR HYDROGEN BALANCING

ENERGINET

Power purchase agreements

Fluctuating electricity prices

Participation in electricity system ancillary services

FCR

aFRR

mFRR

Grid codes & technical limitations)

(controllable) variation in hydrogen production

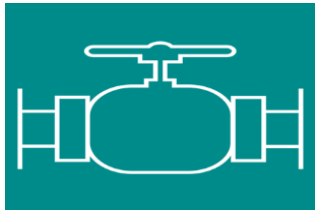
Direct affection on shipper operation

Forecasting "errors" on hydrogen operation

The ability of the shippers to sustain balancing "boundaries"

The "difference" accumulated over a given period

E_{in}



E_{out}

Balancing regime

MWh

Portfolio balancing: utilization of linepack flexibility, storage, trading, etc.

If boundaries are "violated"…

TSO balancing: Design and deployment of balancing actions

Hydrogen purchase agreements

"Market" for hydrogen

(controllable) variation in hydrogen consumption/offtake

Shipper X

Production 1

Consumption 1

Disturbance incident of hydrogen production

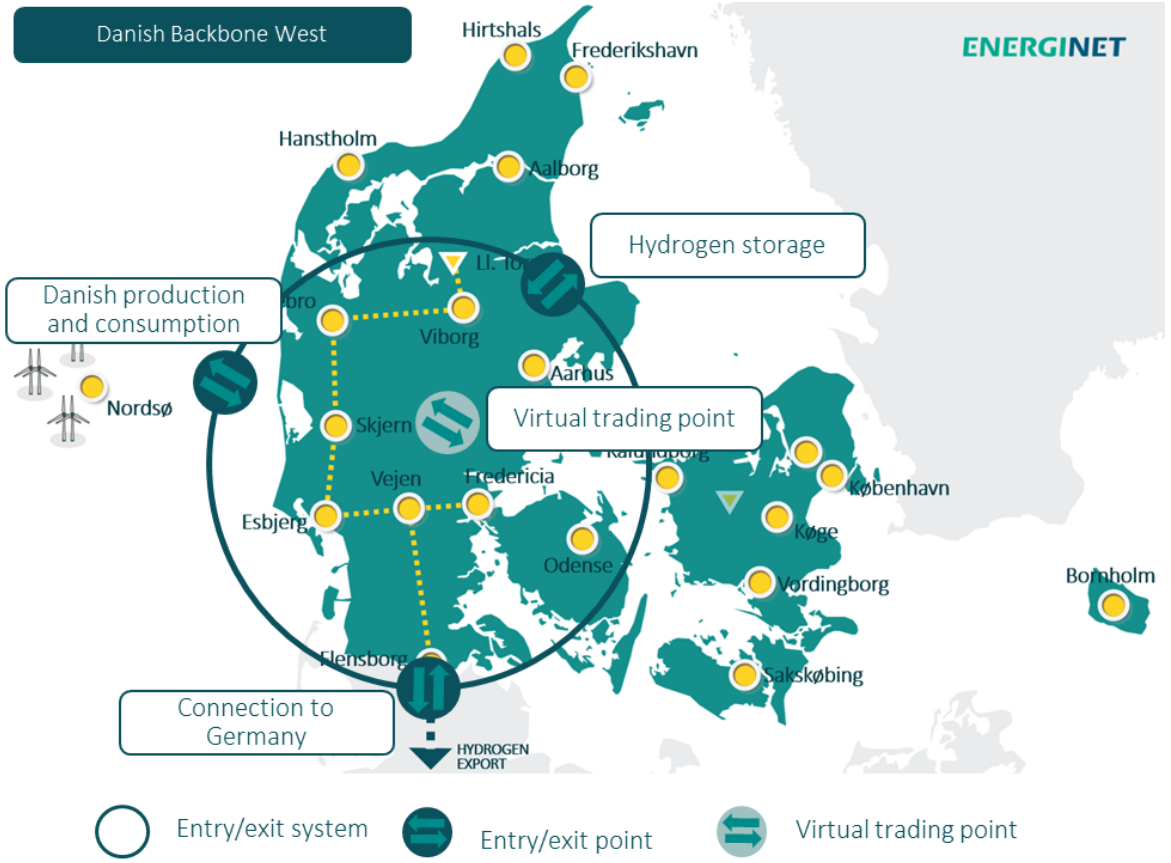
ENTRY/EXIT MODEL

The market model will, from start, be based on an entry-exit system (following EU's gas and hydrogen package, cf. chapter 3).

Today, the natural gas market is also organised as entry-exit systems.

Entry and exit points:

- Danish production and consumption
- Border point between Denmark and Germany
- Hydrogen storage
- Virtual trading point



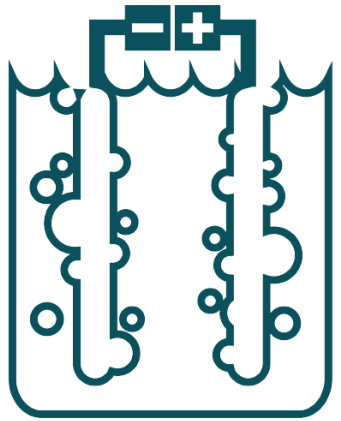
REGULATORY APPROACH TO THE HYDROGEN INFRASTRUCTURE AND MARKET

- Centered in recognized principles from electricity and gas systems: 3rd party access, unbundling, tariff regulation, etc.
- Starting point: Hydrogen value chain is immature
- Stepwise-approach to regulation of market and infrastructure
- Early matureness phase: Flexible utilization of regulatory principles

LEGISLATIVE FRAMEWORK CONDITIONS

1) ***Strive towards harmonization of balancing regimes*** *shall be implemented by Member States*
2) ***Market-based balancing rules****: Fair, non-discriminating and transparent*
3) ***Cost-reflective design*** *of imbalance charges to provide appropriate incentives on network users' appropriate incentives on network users' portfolio balancing*

ENERGINET



DEFINITIONS

Definition of **Balancing zone:** *An entry-exit system, which may consist of more than one system, to which a specific* ***balancing regime*** *is applicable.*

Definition of **balancing period**: *It is a standardized interval of "time", at the end of which network users are financially settled for any deviations, as accumulated over the course of the preceding x time units, between their inputs into and offtakes from the* ***balancing zone****.*

Definition of **shipper imbalance**: *It is the individual network users' difference in injections into the* ***balancing zone*** *and their offtakes form the* ***balancing zone*** accumulated over a given period.

Definition of **linepack flexibility**: *The amount of hydrogen that can be stored in the pipes and made available for balancing purposes, stated in GWh.*

Definition of **transport capacity**: *The given amount of hydrogen which can be flowed through the system under specific pressure conditions, stated in GW.*

Definition of **TSO balancing (tools)**: *The actions undertaken by the TSO to ensure that the system stays within its accepted operational limits.*

ROLES - DRAFT

Energinet: *Owns and operates the transmission system.*

Evida: *Owns and operates the distribution system.*

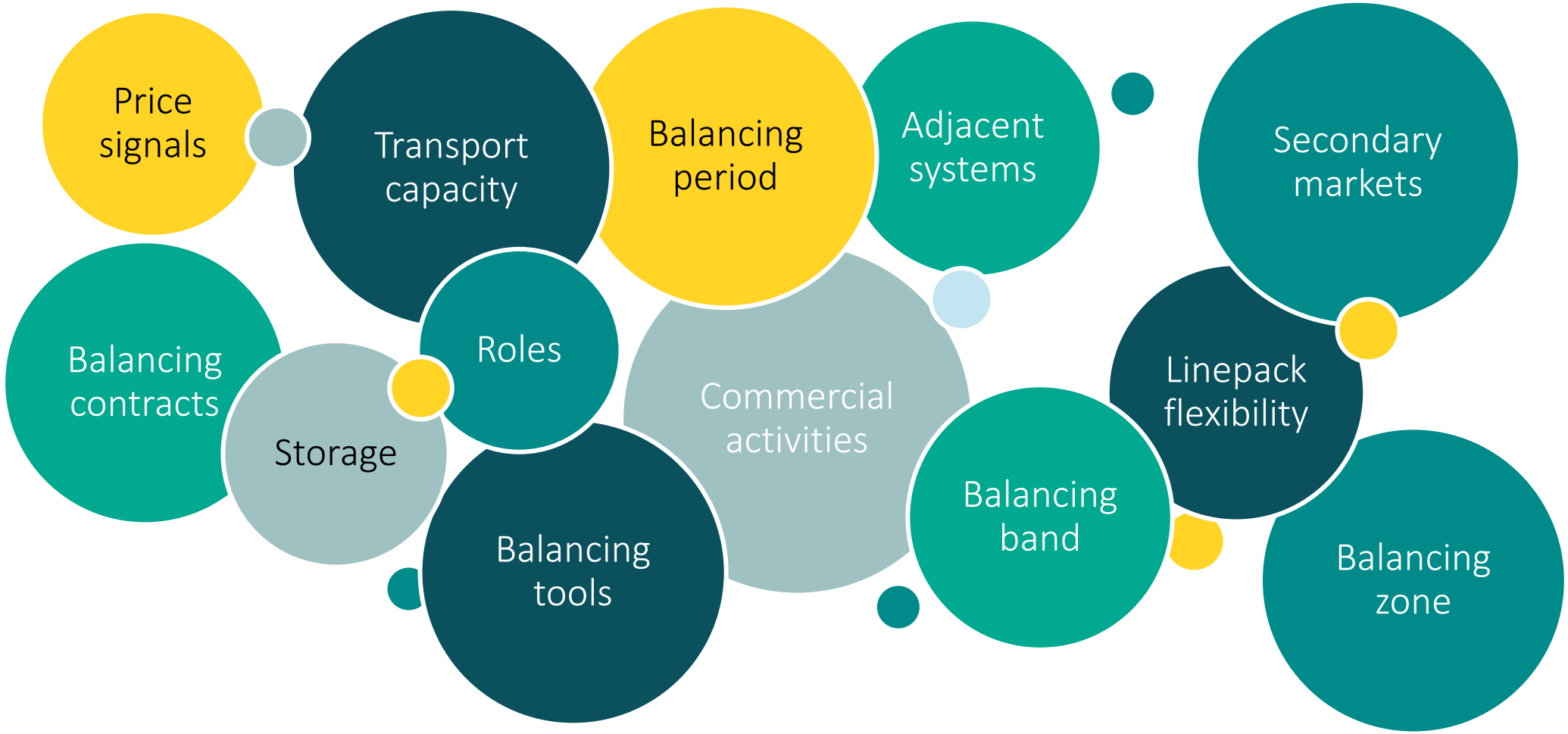
Storage company: *Owns and operates the hydrogen storage facility*

Producers and consumers of hydrogen

Shipper: *Transports hydrogen in the transmission system (from producer, other transport customers or storage) and delivers hydrogen to another shipper, storage customer or towards the end-consumer market. Has balance responsibilities.*

Storage costumer: *Have access to use the storage facilities. Buys capacity, injects and extracts hydrogen.*

WHAT THE BALANCING REGIME CAN CONSIST OF



(POTENTIAL) DEVELOPMENT OF THE BALANCING REGIME FOR HYDROGEN

ENERGINET

STEP

SHIPPER PORTFOLIO BALANCING

TSO BALANCING ACTIONS

Step 0

Cut-off

Step 1

Shippers can perform portfolio balancing on a Wholesale Market

Step 2

Balancing actions are procured via Balancing contracts

Step 3

Balancing actions are procured via a Balancing Platform

Immature market

Bilateral trading between shippers

Portfolio balancing is essential (to avoid cut-offs)

Lack of liquidity on the market

Relatively few large users

Few to several users

Many users

Mature market

High utilization of a wholesale market where parties can trade directly with one another

Transparency and increased European trade to i.e., Germany

Mainly short-term balancing products are used to balance the system, when shippers fail to perform portfolio balancing

EXPLANATION

- Shippers share a priority cut-off list.
- A shipper may be cut-off in case of a large imbalance.

-When market liquidity on the wholesale market reaches a sufficient level, shippers can trade via a digital market.
- The commodity traded can be hydrogen flow (change in position) and/or linepack flexibility (increase/decrease shipper linepack bands)

- Energinet makes a tender for balancing services via balancing contracts, cemented in monthly or yearly obligations.
- Long-term balancing contracts provide adequate response capacity to system imbalances, when shippers fail to perform portfolio balancing

-A trading platform is used to procure balancing services on short-term obligations, where the TSO buy/sell hydrogen (and allocate cost to “polluter”).
- Eventually, this short-term balancing market will decrease the need for cut-off utilization

Break

We will be back at 11.30

GROUP SESSION 1

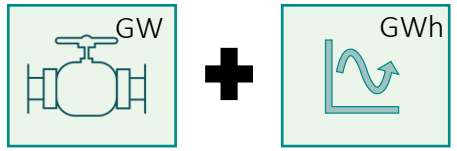
Pipeline capacity & linepack flexibility

(Presentations in plenum at 12)

WHAT MODEL WOULD YOU AS A SHIPPER BE INTERESTED IN?

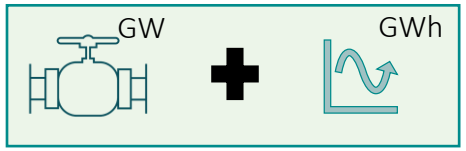
What pros and cons do you see in the models and why do you prefer one model over the other?

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



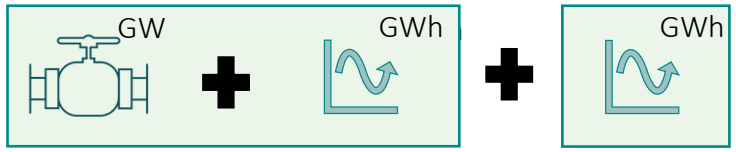
- Capacity and linepack flexibility are procured separately.

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



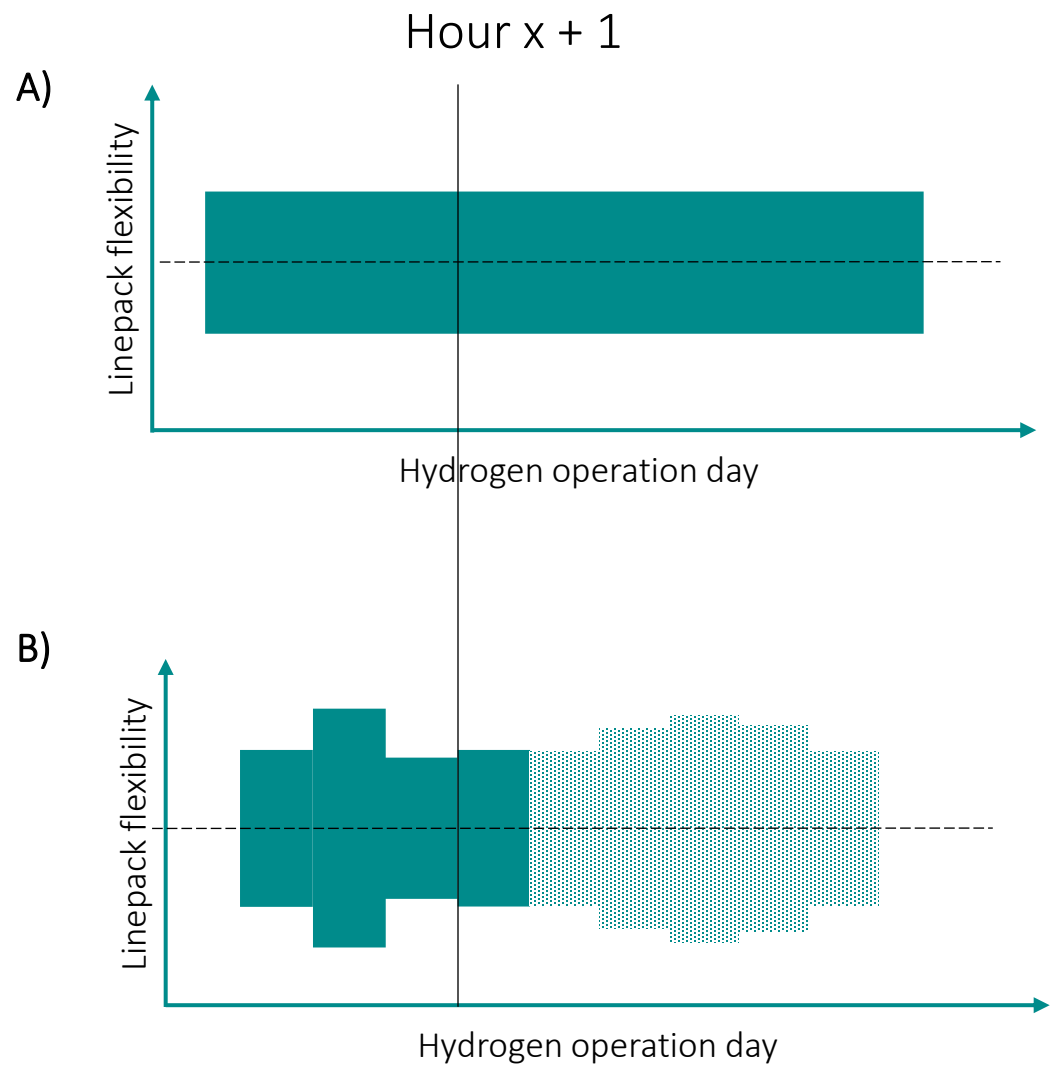
- A specific amount of capacity entails a specific amount of "granted" flexibility
- Additional flexibility can be procured separately

WHAT MODEL WOULD YOU BE INTERESTED IN?

In either model: do you prefer that

A. the available linepack flexibility is presented in the beginning of each day, but is smaller because we need to reserve more for system operation or

B. The available linepack flexibility will be released throughout the day, and it is larger because we know the exact need for system operation?



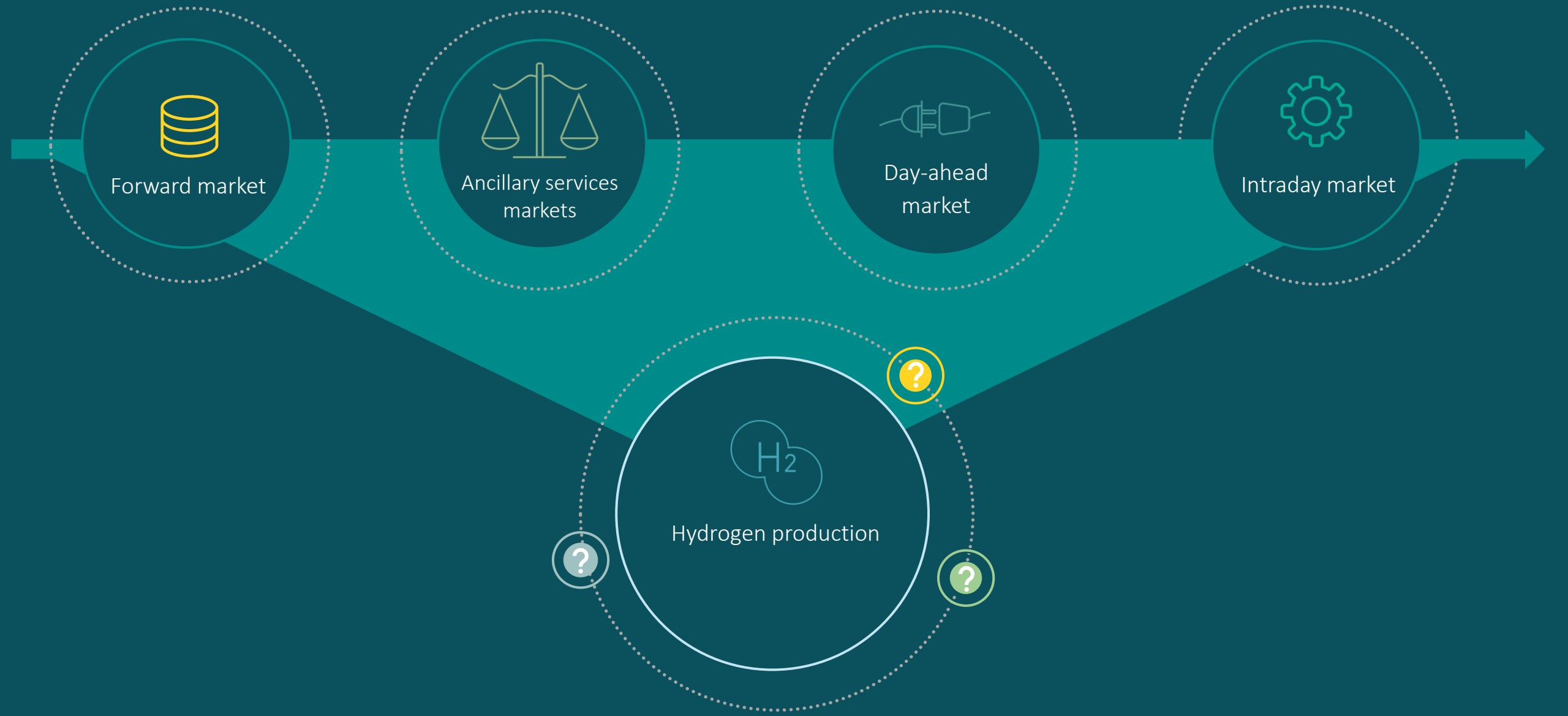
LUNCH

We will be back at 13.05

GROUP SESSION 2

Hydrogen and electricity market interaction

HYDROGEN AND ELECTRICITY MARKET INTERACTION



MARKET PARTICIPATION ASSUMPTIONS

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.

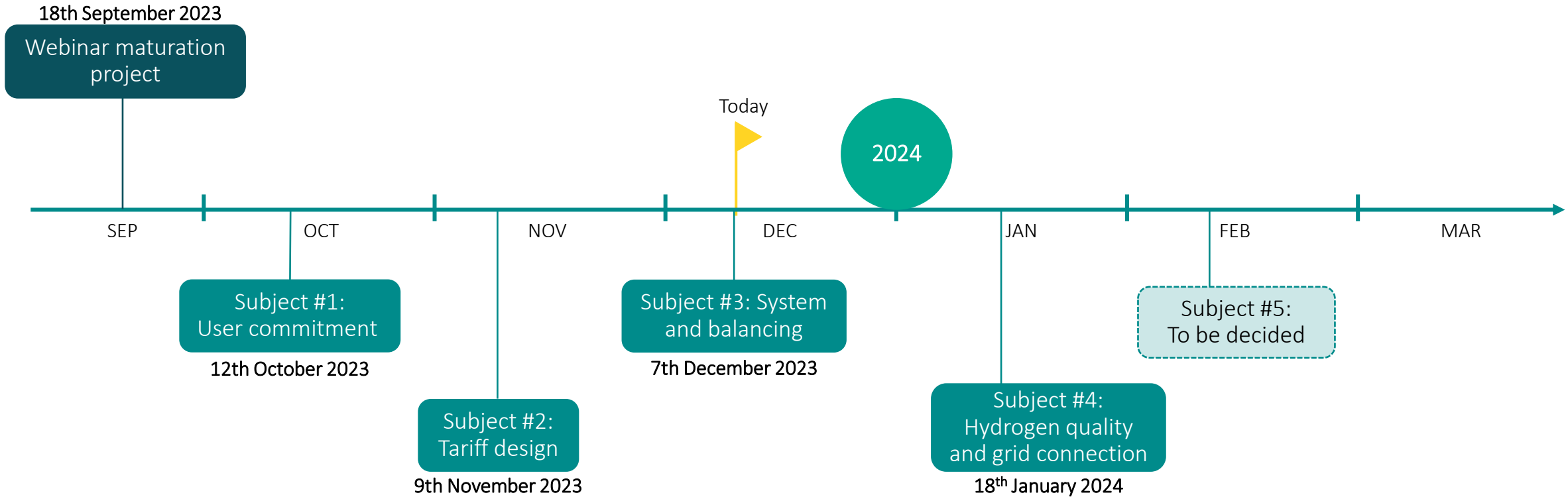
Assumption 7: The shipper is also going to be the Balance Responsible Party (BRP) in the electricity market for the hydrogen producer

WRAP-UP AND NEXT STEPS

DANISH MARKET DIALOGUE

On system operation and balance

- Workshops for coming users of the hydrogen infrastructure.
- **The following events will be published via our homepage:** Frontpage\More\About us\Events\name of event. At the page for events, you can sign up to receive events directly by mail.
- Please mark the dates in your calendar if you want to participate!



QUESTIONS OR REFLECTIONS?

If today's content gave rise to additional questions or remarks, please reach out to SHJ@energinet.dk. We are more than willing to participate in bilateral discussions with regard to system operation and balancing.

THANK YOU!