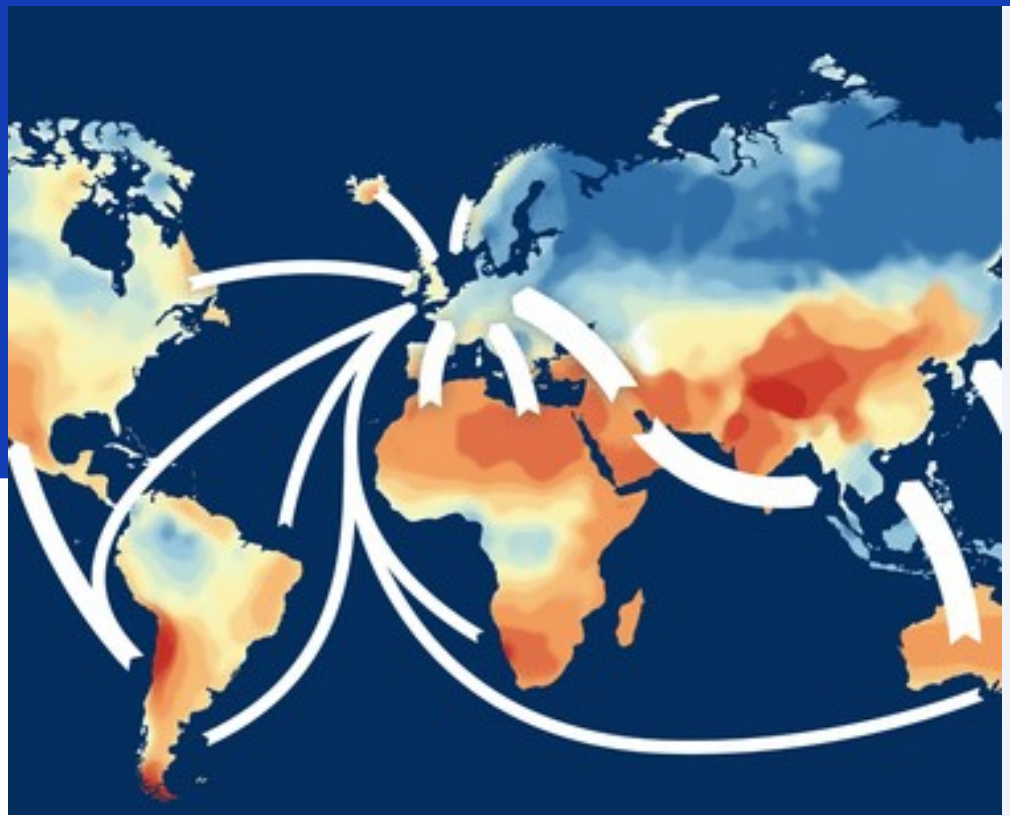
SHIP>NL sessie X

Drs. M.C.M. Rijkers

Start presentation

TNO innovation for life

Agenda SHIP>NL sessie X 15 november



1. Welkom
2. Deep dive: Tender H2Global |
   Justin Rosing, Min.EZK
3. Deep dive: Spotmarktsimulatie HyXChange |
   Bert de Ouden, HyXChange
4. Afsluiting & Borrel

Huisregels

- Telefoon op ‘stil’; laptop gesloten
- Vragen? Steek je hand op!
- De moderator zorgt ervoor dat je vraag beantwoord wordt (eventueel achteraf).
- Slides worden na de sessie gedeeld en zijn te vinden op SHIPNL: Sustainable Hydrogen Import Program Netherlands | Nationaal Waterstof Programma

- We bespreken uiteraard geen marktgevoelige zaken.

- Chatham house rules: De besproken informatie mag gedeeld worden, maar zonder de spreker te onthullen.

Meerjarig kennisprogramma met 5 lijnen

- **In deze sessie:**

1 Technisch economisch	2 Beleid	3 Markt	4 Internationaal	5 Omgeving
▪ Inzicht in importketens productie-conversie-transport-opslag-reconversie-gebruik ▪ Vraagontwikkeling, scenario's ▪ Infrastructuur & systeemintegratie: corridors, benutten bestaande infra. ▪ Technology assessments, R&D	▪ Impact van 'Fit for 55', REDII, Delegated acts, ETS/CBAM, etc. ▪ Impact van certificering en CO2 allocatie: emissiefactoren, LCA ketenanalyse, etc. ▪ Financiering en stimulering (EU & NL): IPCEI, PCI, TEN-E, JTF, EIB, Horizon Europe, MOOI, DEI, MIEK, SDE++, etc	▪ Marktmodellen: bilaterale contracten, vrije handel, waterstofbeurs ▪ Internationale handelsstromen: verwachte vraag- en aanbodvolumes en transportstromen ▪ Importtarieven, trade agreements en handelsbeperkingen, WTO, etc.	▪ Samenwerking met omringende EU/niet-EU importlanden om corridors te ontwikkelen ▪ Concurrentie met omringende EU/niet-EU importlanden ▪ Geopolitieke aspecten: strategische voorraden, afhankelijkheid, politieke stabiliteit van exportlanden	▪ Ruimtegebruik van ketenelementen ▪ Veiligheid: brandbaarheid, zorgwekkende stoffen, risicocontouren, etc ▪ Milieu: stikstof, lekkage ▪ Maatschappelijke acceptatie ▪ MVO / samenhang met SDG's in exportlanden

Actualiteiten | tour de table

Tender H2Global

- Justin Rosing | Min. EZK

Ministerie van Economische Zaken
en Klimaat

NL deelname H2 Global

Presentatie SHIP>NL Platform
15 November, 2023

Justin Rosing

Ondertekening Declarations of Intent

Ondertekening van drie Joint Declarations of Intent gisteren in Noordrijn-Westfalen

- Synchronisatie waterstofinfrastructuur DUI – NL

Verdere ontwikkeling grensoverschrijdende backbone en specifieke benoeming interconnectiepunten.

- H2 Global gezamenlijke tender DUI – NL

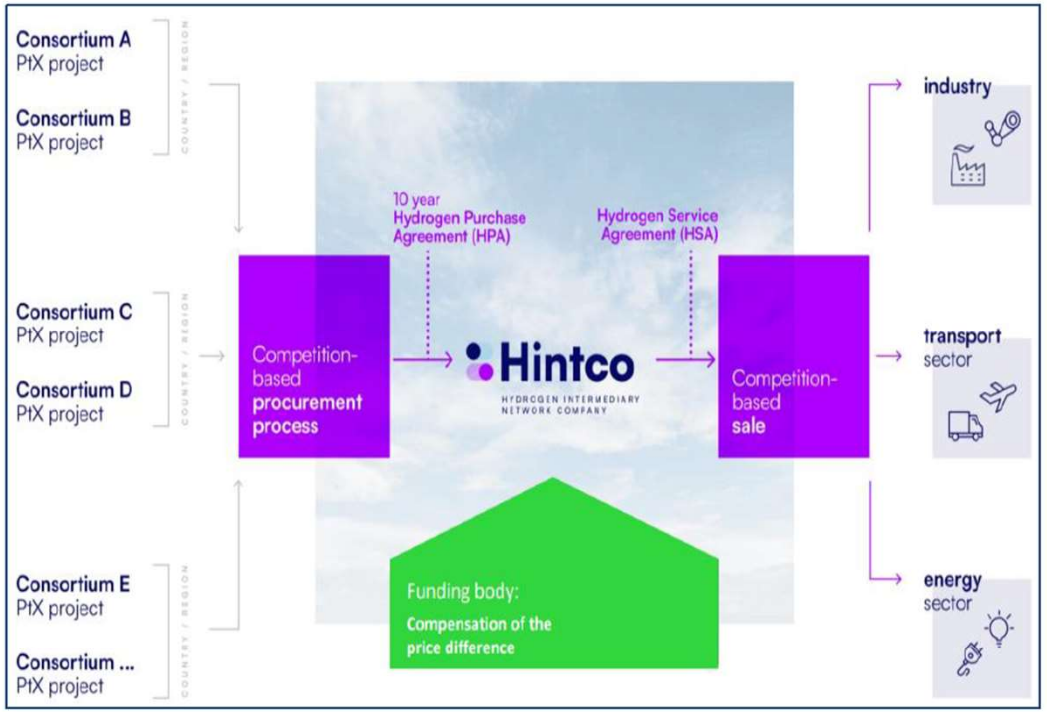
Financiële ondersteuning bijeenbrengen vraag en aanbod

- Delta Rhine Corridor

Politieke steun verdere ontwikkeling DRC [NRW-NL]: afstemming planning, ontwikkelings grenspunten, vergunningverlening (ook CCS)

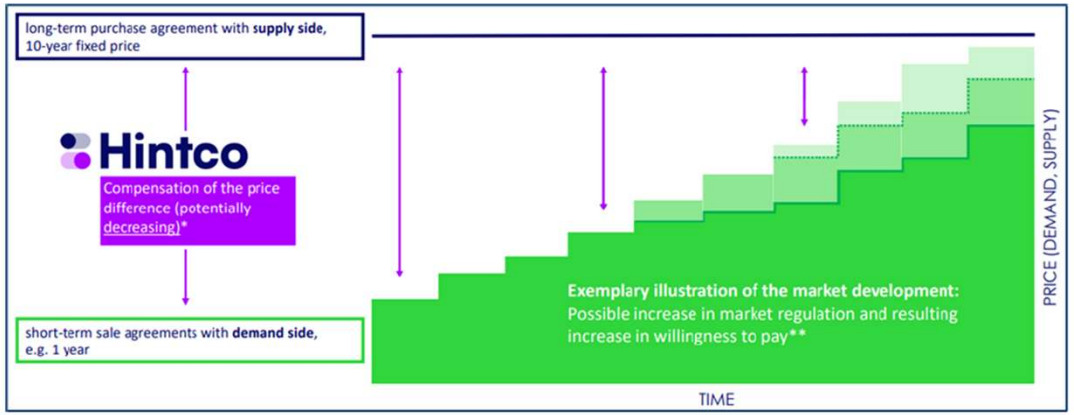
Recap werking H2Global

- Compensatie voor prijsverschil vraag naar en aanbod van hernieuwbare H2
  - Dubbele veilingsystematiek: HPAs - HSAs
  - Carbon Contracts for Difference-principe
    - Afdekken prijsverschil aankoopprijs en verkoopprijs
  - Doel: liquide Europese waterstofmarkt
    - Producenten krijgen prijs- en afnamegarantie
  - Prekwalificatiefase gevolgd door biedingsfase
    - Pre-selectie van geïnteresseerde producenten o.b.v. financieel profiel en expertise (due dilligence)



Recap werking H2Global

- HintCo sluit 10-jarige aankoopcontracten
  - Transactie vindt plaats bij levering point of delivery (haven)
  - Looptijd verkoopcontracten kort (1 jaar)
- Rol EZK
  - Tendercriteria in uitvoeringsovereenkomst (Hint.co – EZK)
  - Betrokkenheid bij concept aankoopcontracten en -verkoopcontracten, niet bij veiling en onderhandelingen
- In principe sprake van 'biedingsplafond'
  - Financiering door BMWK/EZK betreft totaal aankoopbedrag.
  - Verkennen mogelijkheid tot optional volumes (uit inkomsten HSAs)



Beleidsdoelstellingen NL deelname aan H2 Global

- Nederland positioneren als NW-Europese importhub voor waterstof
- Ingebruikname van de Nederlandse (gasvormige) waterstofinfrastructuur
- Kennisverwerving [Pilot]
- Realisering RED-doelstellingen
- Stimulering hernieuwbare waterstofproductie in het buitenland ten behoeve van Nederlandse eindafnemers
- Diversificatie van waterstofimport

Uitgangspunten inrichting NL-DUI tender onder H2 Global

- **Bedrag:** totaal €600 mln. (beide landen leggen € 300 mln. in) voor het veilen van 1 aankoopcontract.
- **Product:** Vector-open. Transportmedium vrijgelaten aan producent. Voorwaarde dat product als gasvormige waterstof op de markt gebracht wordt.
- **Geografisch reikwijdte:** Mondiaal. Producenten uit alle landen mogen meedoen aan tender.
- **Aanlandpunt (point of delivery):** NL en DUI.
- **Verkooppunt (point of sale):** NL en DUI, maar product kan gekocht worden door alle eindafnemers in EU (in Nederland of Duitsland).
- **Contractuele terugvaloptie:** Flexibiliteit in aankoopcontracten. In afwezigheid import/omzettingsfaciliteit mag de vector/drager ook het eindproduct zijn (ammoniak?)
- **Levering product:** 2027-2036
- **Criteria:** IMVO, duurzaamheid, arbeidsomstandigheden, milieu en sociale impact.
- *NB: Alles onder voorbehoud van goedkeuring staatssteun door DG COMP Europese Commissie*

Lopende initiatieven ondersteuning import

- **Initiatieven Duitsland**
  - Lopende tenders H2 Global
    - 3 x 300 mln. EUR voor ammoniak, methanol, e-SAF.
    - Veilingwindow aankoopcontracten gesloten en gesprekken met bieders gestart.
  - Duitsland zal separaat aan NL-DE tender parallele 'windows' onder H2 Global openen voor een totaalbedrag van ca. 3,2 mld. EUR.
    - Verschillende productieregio's
    - Tenders DE deels productneutraal en deels vectorneutraal

- **Europese Commissie**
  - European Hydrogen Bank
    - 800 mln. EUR onder EU Innovation Fund: Veilig fixed premium. Lancering volgende week.
    - Europese Commissie wil EU tender gericht op 3de landen openen onder H2 Global. Vooralsnog echter geen financiering beschikbaar.

Vervolgstappen EZK

- **Lanceren consultatie**
  - Ca. 4 weken geopend. Voornemen om consultatie op korte termijn te openen
  - Input meenemen bij verdere inrichting tender. Vooral ook bedoeld om meer inzicht NL afnemers te krijgen.

- **Staatssteunnotificatie**
  - Gesprekken met DG COMP Europese Commissie gestart.

- **Opstellen subsidiebeschikking/uitvoeringsovereenkomst met Hint.co**
  - Inrichten Special Purpose Vehicle onder Hint.co belast met uitvoering NL bijdrage tender (Hint.co Netherlands)

Streven om NL-DE tender Hydrogen Purchase Agreements eerste helft 2024 te lanceren

Spotmarktsimulatie HyXChange

- Bert den Ouden | HyXChange

H2 Spot market simulation & balancing market

SHIP NL meeting 15-11-2023

1. Main outcomes of simulation
2. Lesson learned and priorities for market set-up
3. Development towards regional spot/balancing markets

Bert den Ouden, Project Director HyXchange
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HyXchange initiative : steps towards realization

Funded by Gasunie and four sea ports

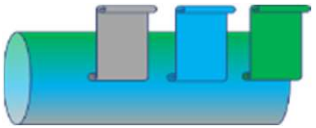
Reference group of over 150 representatives from 70 Market Parties

Global H2 market

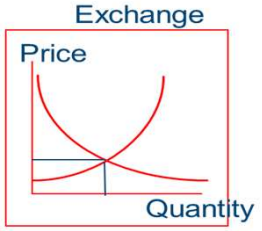
EU Gateway im/exports

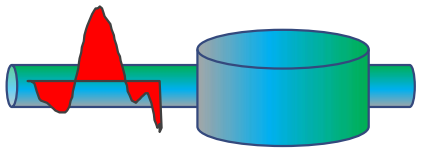
Development plan HyXchange

1. Certificate pilot (2022): certificate system a wish of many market parties. Developed by doing a pilot, awaiting the hydrogen infrastructure.



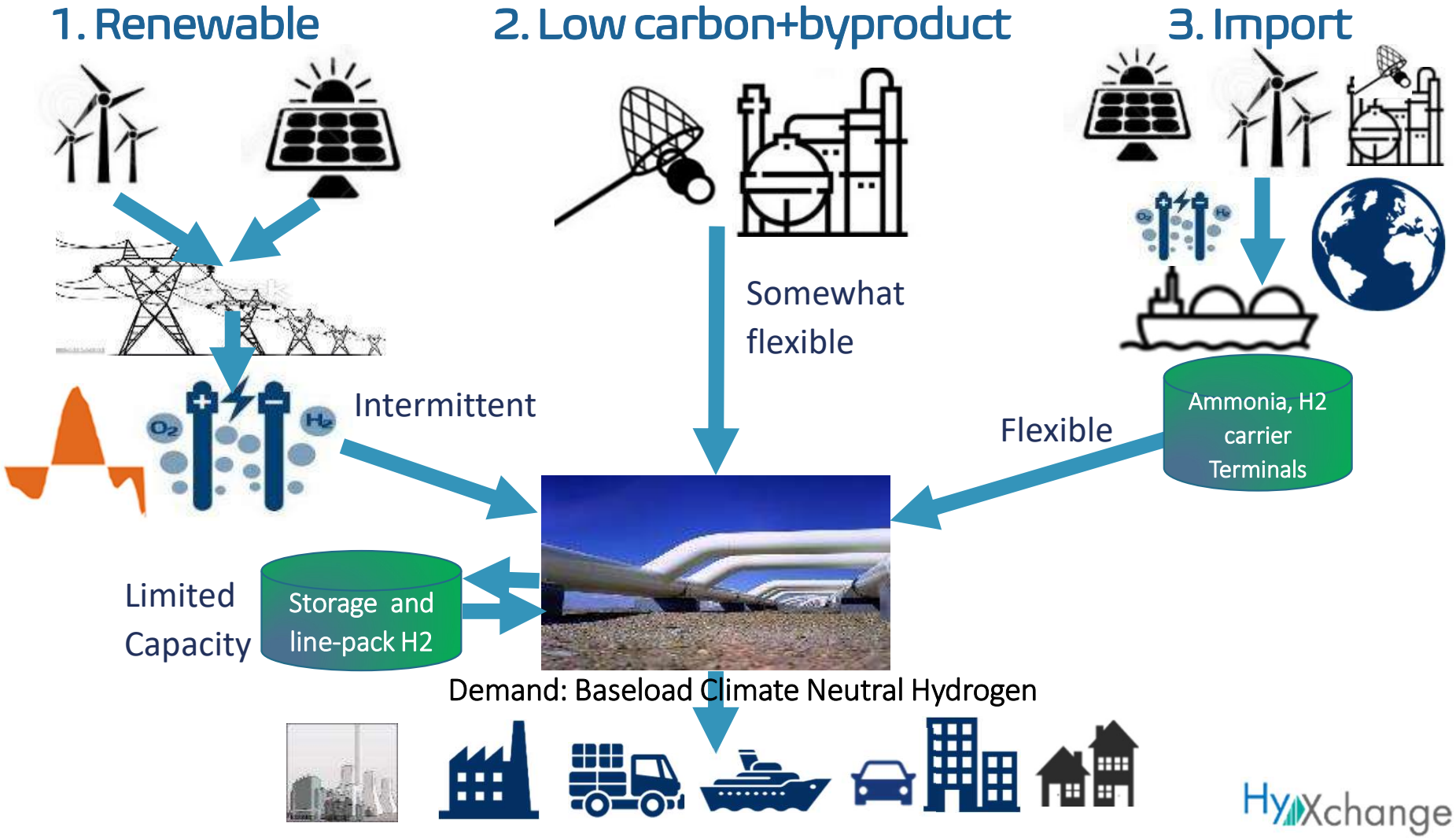
2. Spot market simulation (2022/2023) including balancing: Spot market needed, due to intermittent output of electrolyzers. Simulate the market dynamics, grid balancing and storage.





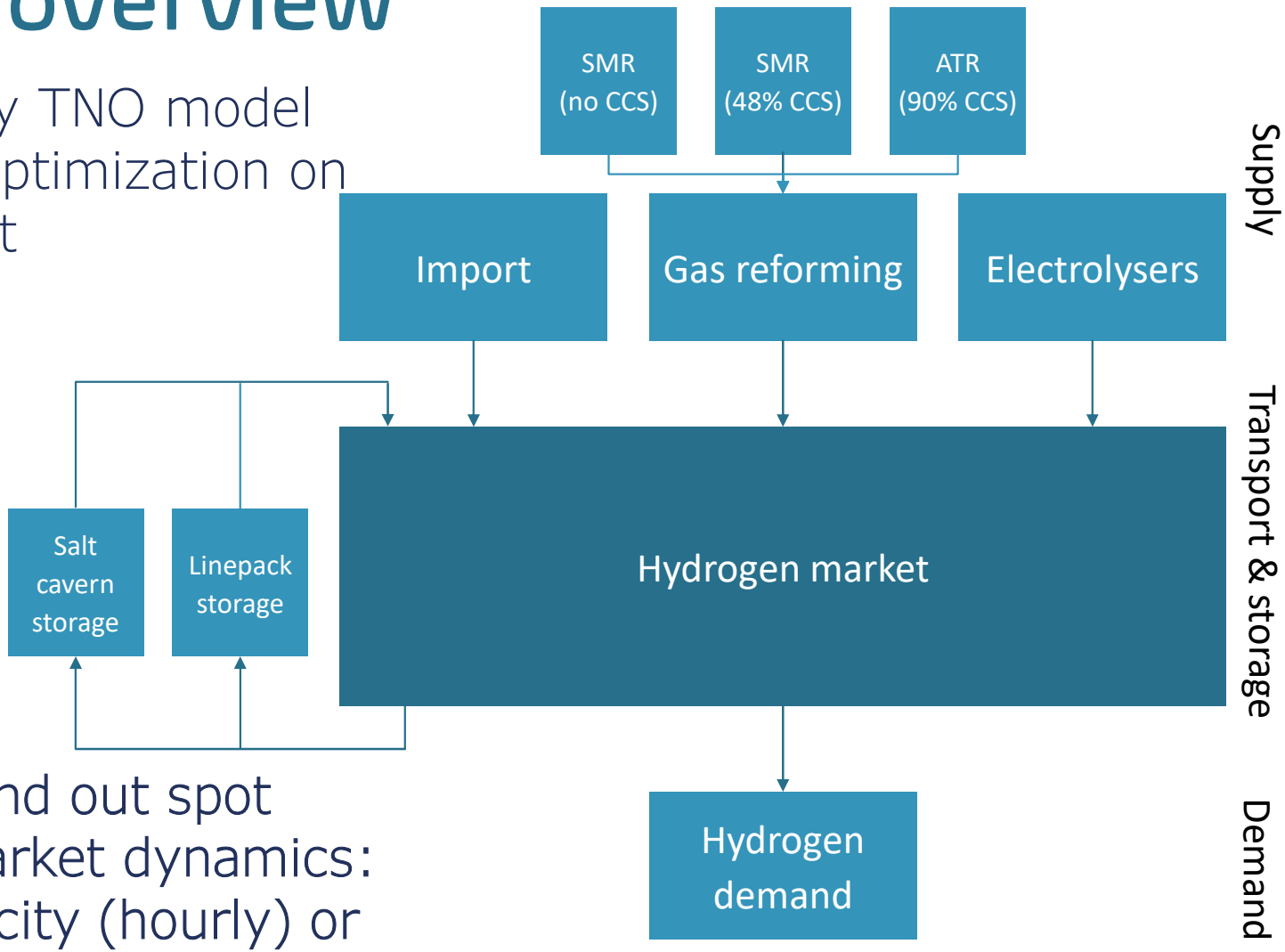
3. Index (2023): this provides a value to the hydrogen and/or certificate, including derivatives. Puts a reference price to hydrogen. Precursor for futures.

HyXchange spot market simulation: find out about H2 market dynamics, balancing, security of supply, pricing



System overview

Simulation by TNO model (I-ELGAS): optimization on marginal cost



Main goal: find out spot hydrogen market dynamics:

- like electricity (hourly) or
- like gas (daily)?

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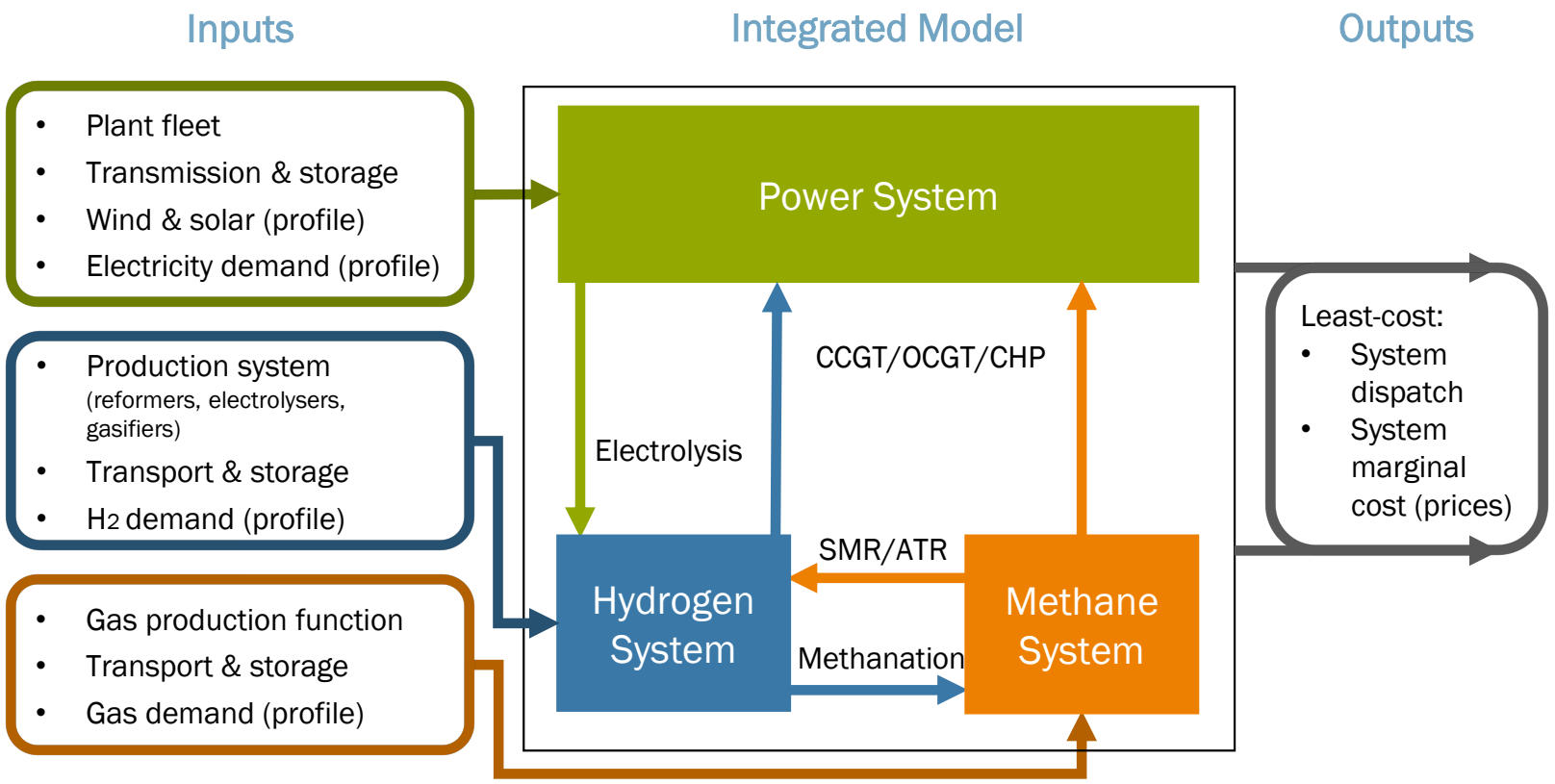
System Simulation on marginal costs

TNO model (I-ELGAS): optimization on marginal cost
Three spot markets with interactions

Main goal: find out hydrogen spot market dynamics:

- like electricity (hourly) or
- like gas (daily)?
- In between?

Not the purpose to predict prices!



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H2 spot market/balancing simulation on a (inter) national hydrogen grid. Unique in the world

- Balancing varying electrolyzer H2 output with flexible H2 output of low-carbon SMR+CCS or import ammonia cracking
- H2 hourly electrolysis overproduction: store or utilize
- Storage: line-pack and salt caverns for balancing – but is that enough?
- Import hydrogen carriers including storage, conversion and flexibility: →additional balancing opportunities.
- In the simulation, we modelled import ammonia (blue and green) for practical reasons
- Connection to Germany, Belgium
- Consumers: in 2030 mainly industry and transportation sector

Main goal: find out hydrogen spot market dynamics:

- **like electricity (hourly) or like gas (daily)? In between?**

Not the purpose to predict prices!

HyXchange

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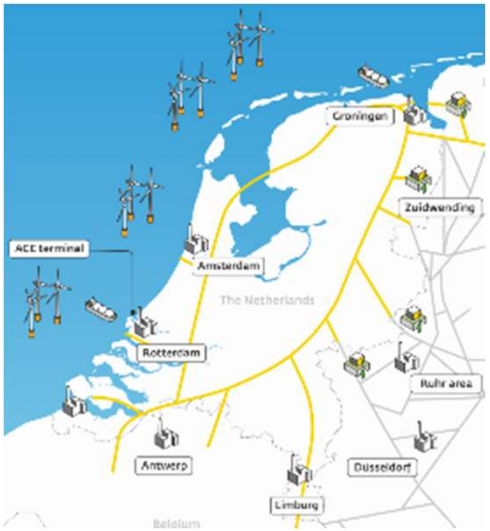
Supply, transp. & storage, demand 2030

Main assumptions

Supply	14 GW
Seaborne ammonia import & cracker • Blue ammonia (Henry Hub) • Green ammonia (MENA)	7.7
Gas reforming • SMR • SMR/CCS • ATR/CCS	6.4 3.5 1.6 1.3
Electrolysers (PEM)	4

Storage	10 GW
4 caverns & line pack	9.5



Market & policy	
Green hydrogen obligation	42%
PEM full load hours (subsidy)	>4200 hours/y**
Market clearing	hourly

H2 Demand *	72 TWh / 8 GW
Netherlands	59 / 6.7
Belgium /Gent	0.5 / 0.1
Germany/NRW	12 / 1.4

** Assumed that half of current ammonia demand is imported directly in 2030, so not produced in NL from H2: H2 demand decrease. Assumed increase H2 demand from others including steel industry*

*** Assumed as a base case: the operation time of electrolyzers is 4200 hours (subsidy criterion 2022)*
As a variant we have also simulated fully free (market-based) dispatch

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The revised H2 infrastructure planning: start in regions

(presented by HNS on 29-6-2023)

This implies: the market will start up in each of the harbour regions separately (Groningen, Rotterdam, Zeeland, Amsterdam) in 2025-2027, to be integrated nationally (including connect to the Hystock storage) in 2028

Market simulation results

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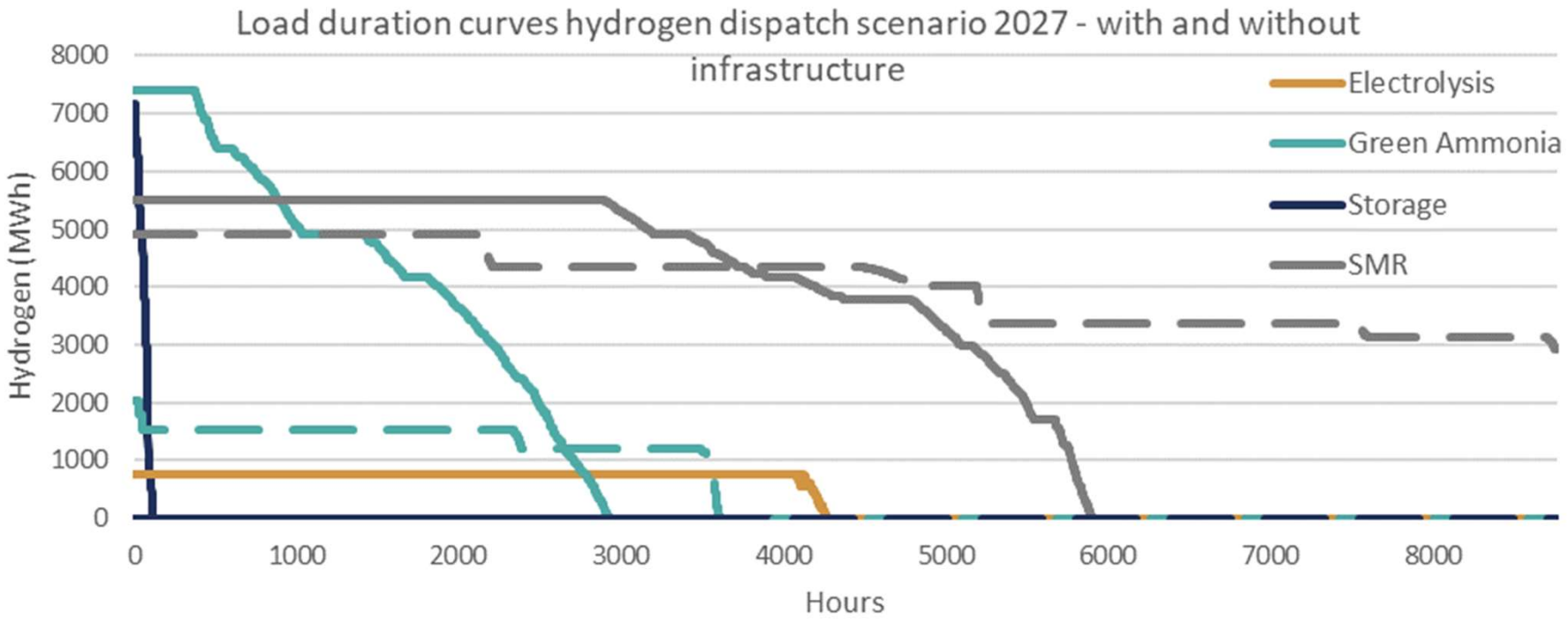
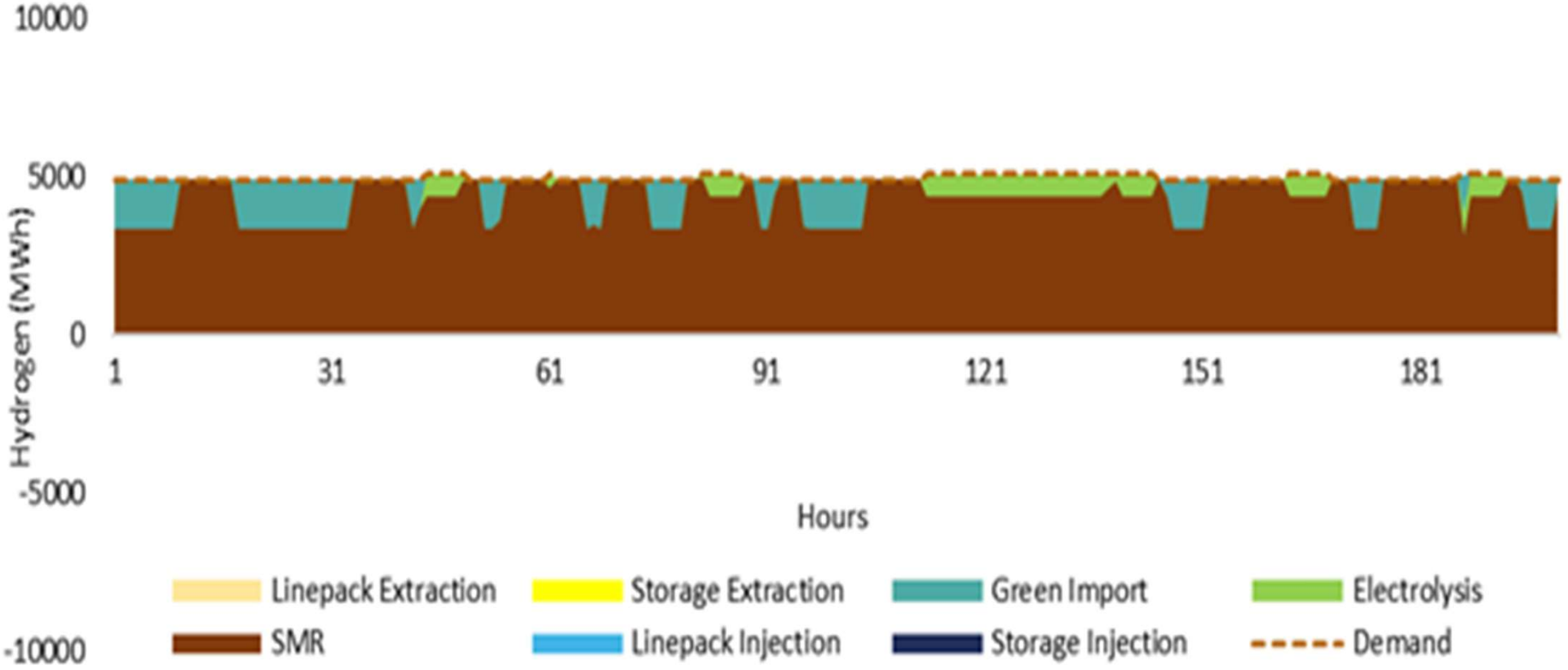
Start H2-system in 2027: connected and disconnected

Full lines a national integrated market for 2027
Dashed lines represent the regional markets, disconnected in 2027



In the regional market (no national infrastructure) we see a main role for SMRs in 2027, providing 81% of the hydrogen in the regional market. Green ammonia imports are also cost-competitive for a significant part of the year, resulting in 12% of total hydrogen supply. Electrolysers are producing at 4200 full load hours (assumed production subsidy), providing 7% of the total mix. Hydrogen storage is only used in sharp peaks for a limited amount of hours in the year for the national market. The regional market has no access to storage.

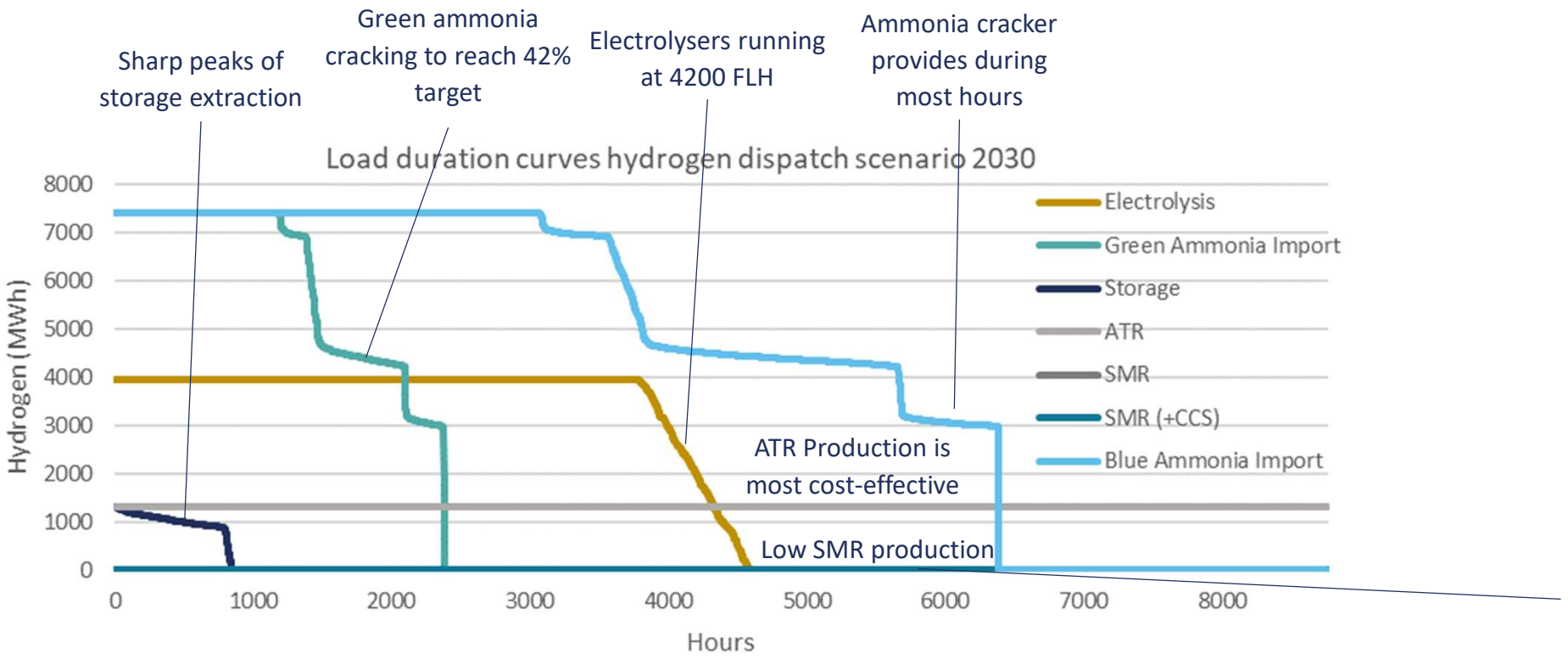
Start backbone 2026/27, regional markets, disconnected, no storage



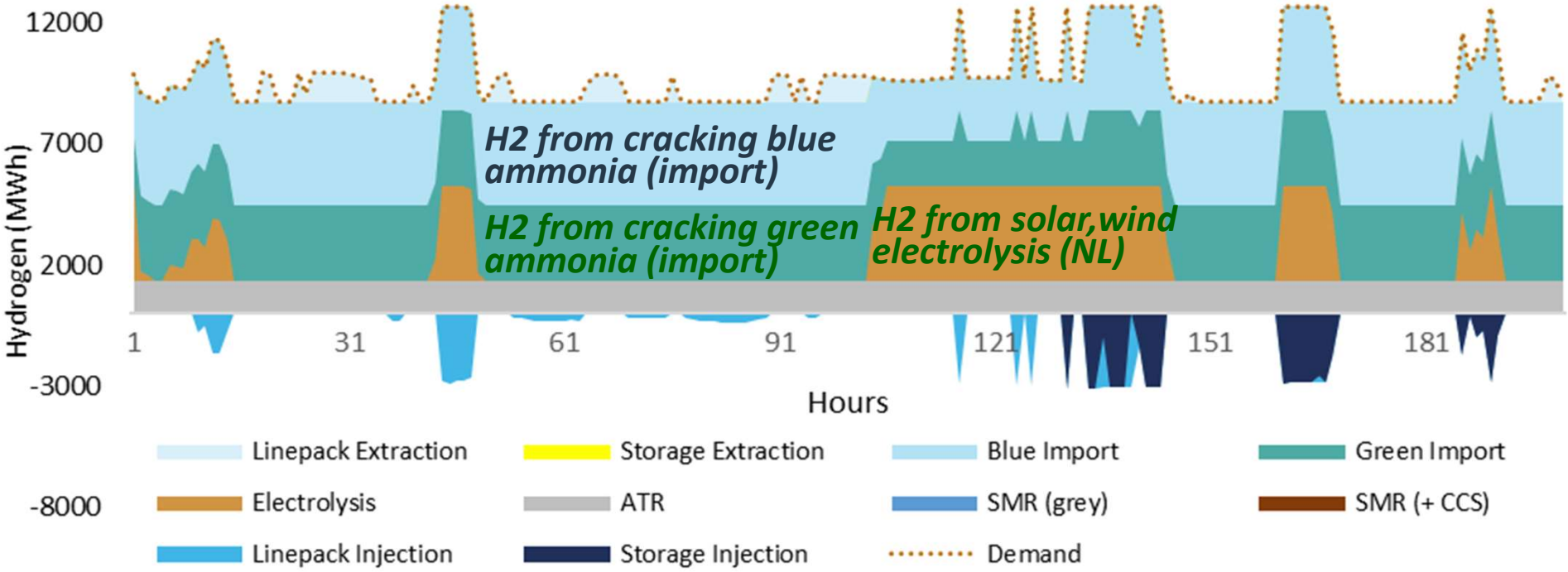
Weekly hydrogen balance for a week in October. The stacked plot shows the hydrogen dispatch per hour.

Integrated hydrogen system, 2030 cheap import case

Note: Assumed is that in 2030 half of the industrial ammonia demand is covered by direct ammonia imports, lowering the hydrogen demand



H2 market simulation 2030 example : October week



Dynamic (hourly) variation pattern by domestic renewable + electrolysis. Demand is baseload, so the gaps are filled by ammonia imports + cracking and/or reforming, depending om price levels of import ammonia and gas.

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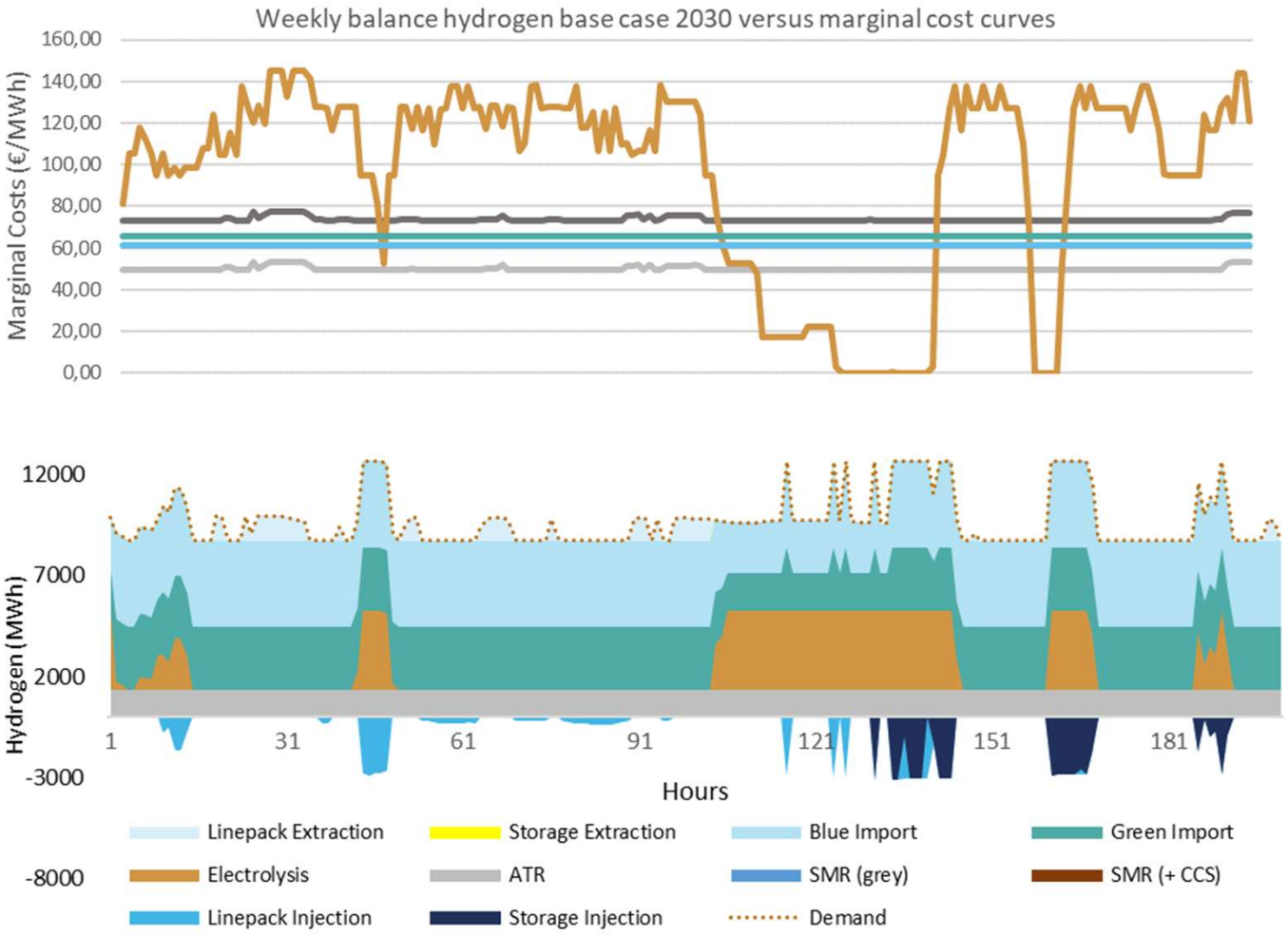
Weekly dispatch base case 2030, week view example

Weekly hydrogen balance for a week in October.



This graph shows the hourly marginal costs.

The stacked plot graph shows the hydrogen dispatch per hour, with production and storage extraction positive, and injection negative.

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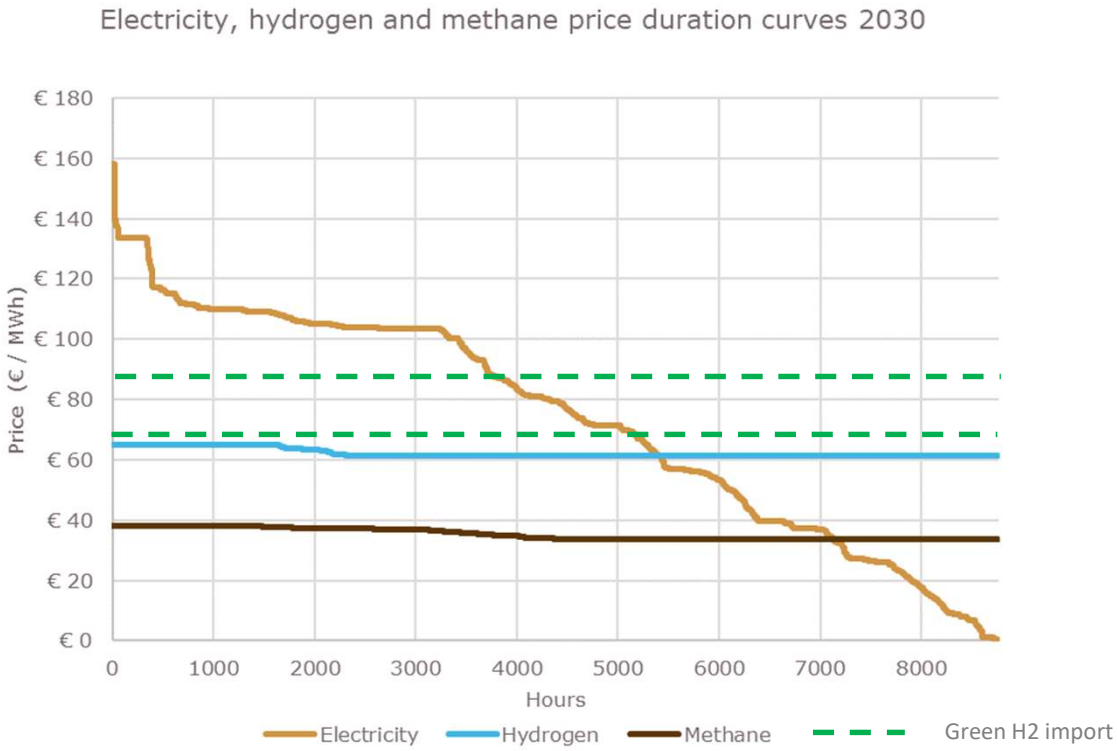
Marginal costs import case 2030

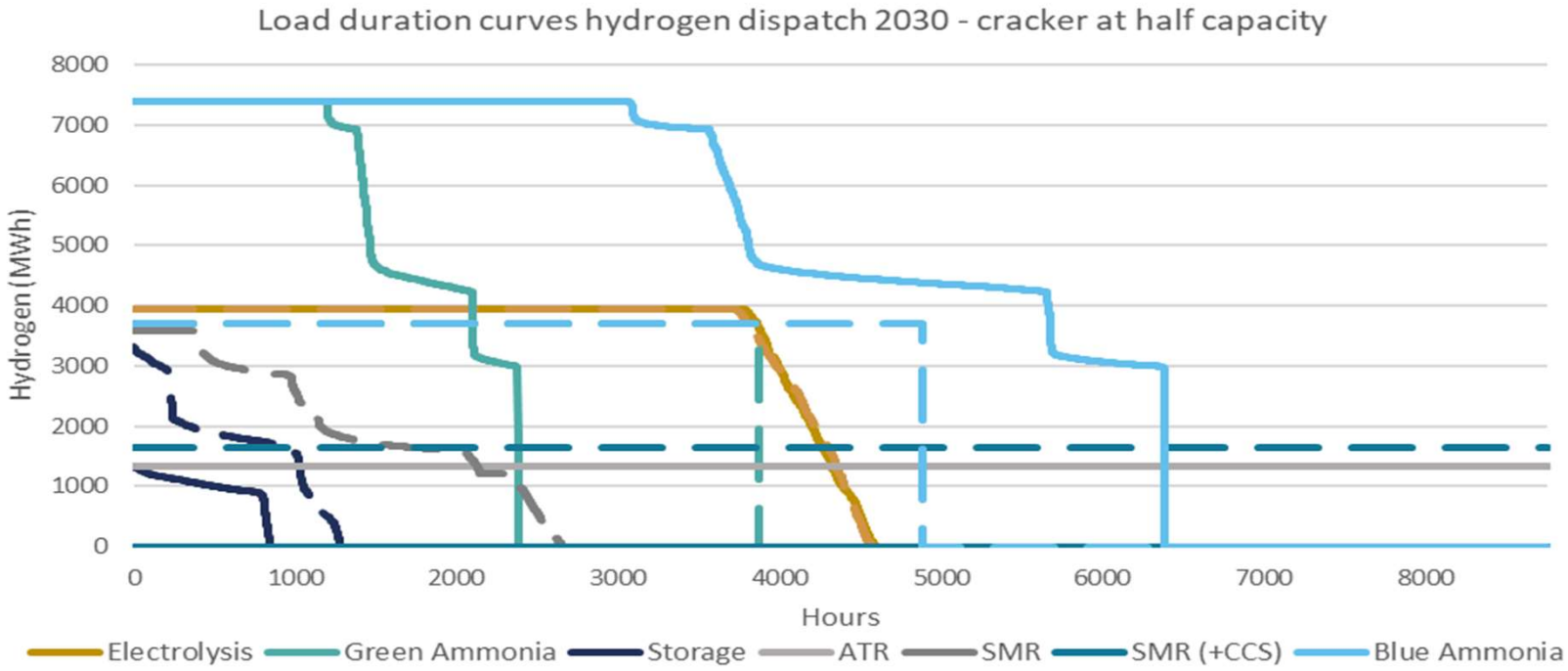
- Hydrogen marginal costs mostly set by two main plateaus in the hydrogen cost curve: one corresponding to the green ammonia import+cracking (low price €66,- /MWh H2; high price price €88,- /MWh H2), and one corresponding to blue ammonia import at €62.- /MWh H2. *Prices in HHV*
- Actual marginal cost of ammonia imports in 2030 will hence strongly affect the market
- A number of scenario variants are run, key among them is % use of ammonia cracker



Scenario Variants

Physical variants	Market variants
A: Low import prices: Assumption of price of green and blue ammonia cracked into H2, marginal price (hhv): - Green: 66 €/MWh H2 - Blue : 62 €/MWh H2	E.1 Import shipping marginal cost analysis – green ammonia cracked into H2, marginal price (hhv): 88 €/MWh H2 E.2 Import shipping marginal cost analysis – LNG cost at Henry Hub price of 35 €/MWh and blue ammonia cracked into H2, marginal price (hhv) €67 /MWh
B. Ammonia cracker analysis – like A, but reduction of capacity of ammonia cracker by 50%	
C. Increased export analysis – increasing hydrogen demand in Germany	F.1 Market based electrolysis dispatch – low green import ammonia cracked into H2: marginal prices (hhv): 66 €/MWh F.2 Market based electrolysis dispatch – high green import ammonia cracked into H2: marginal prices (hhv): 88 €/MWh

2030 variant: cheap green ammonia, cracker at 50% capacity



Lowering the cracker capacity causes it to be running constantly throughout the year, in combination with an increased use of storage. For the remaining demand, there is need for SMR with and without CCS, with the former producing constantly throughout the year. The average marginal costs of the system amount to €85,- /MWh, which is an increase of +27% compared to the base case.

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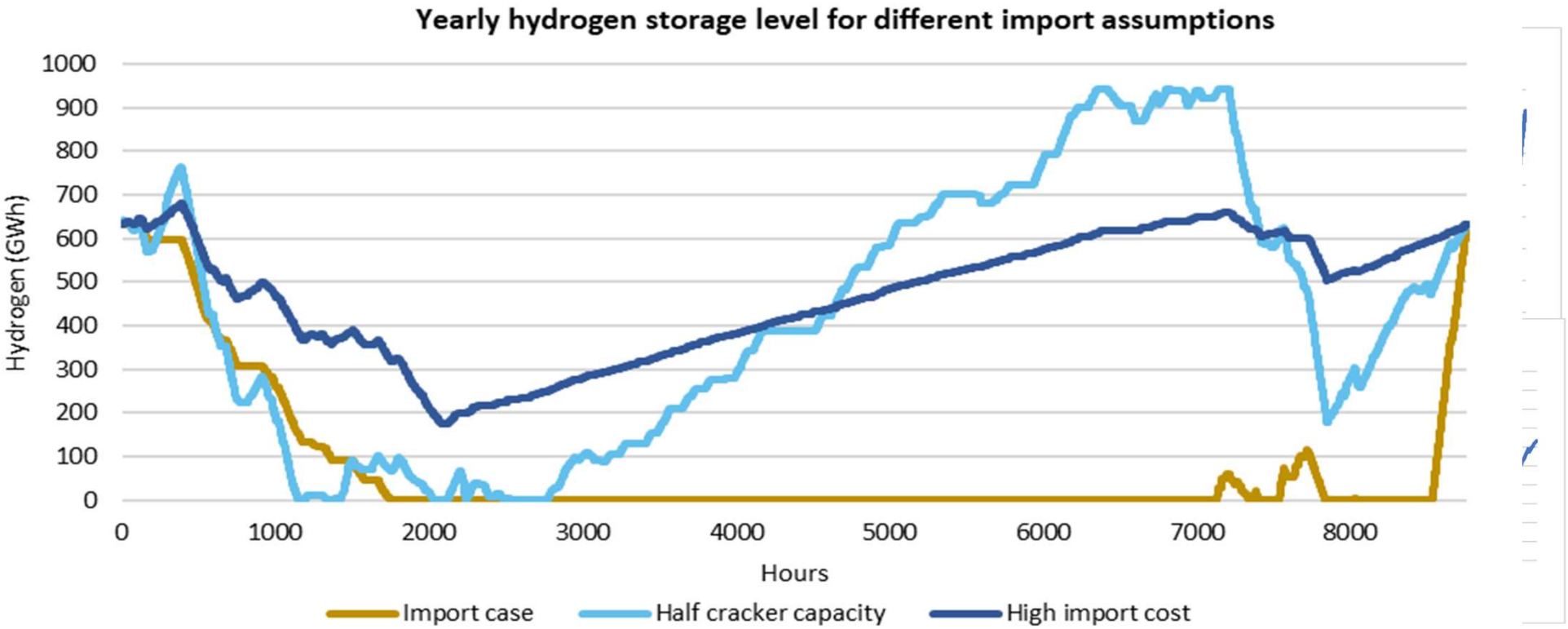
Hydrogen storage in 4 Salt Caverns in 2030: import case 100% and 50% cracker capacity

Note: the simulations were run with the original assumption of 4 caverns in 2030
Current planning is 1 cavern in 2030, +3 in 2032



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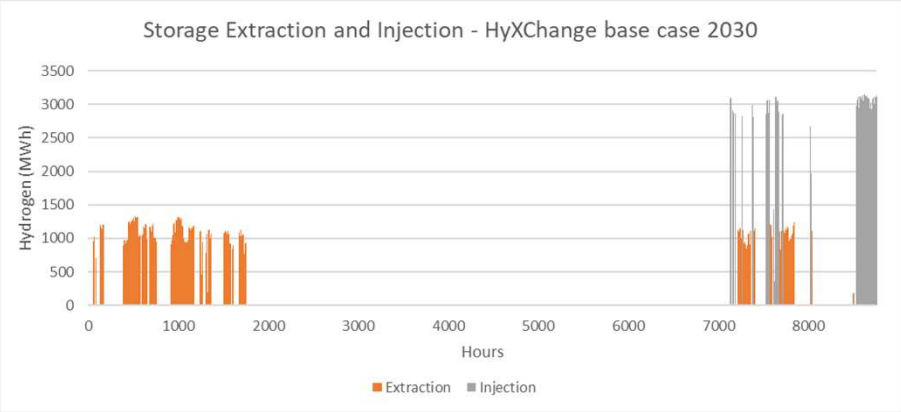

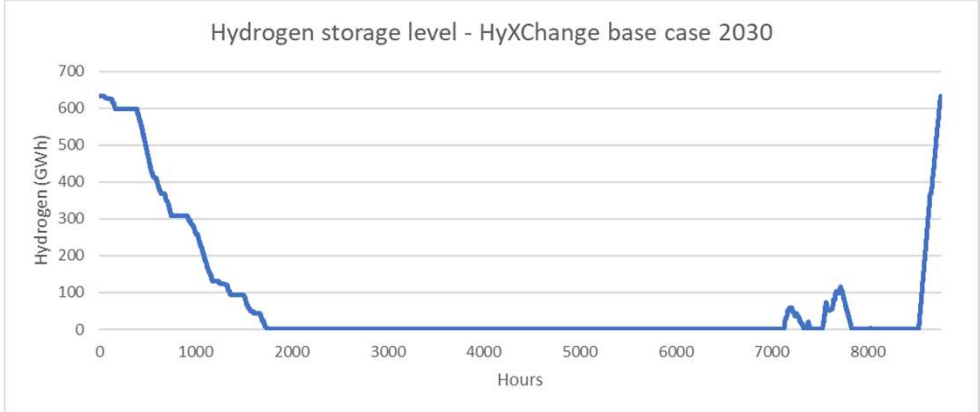

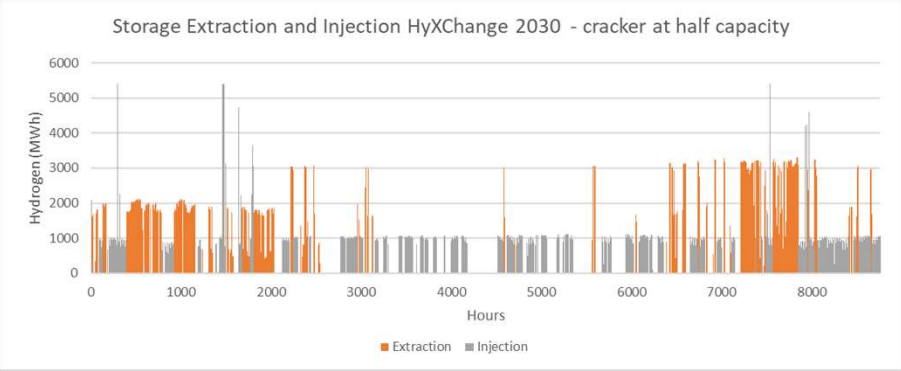

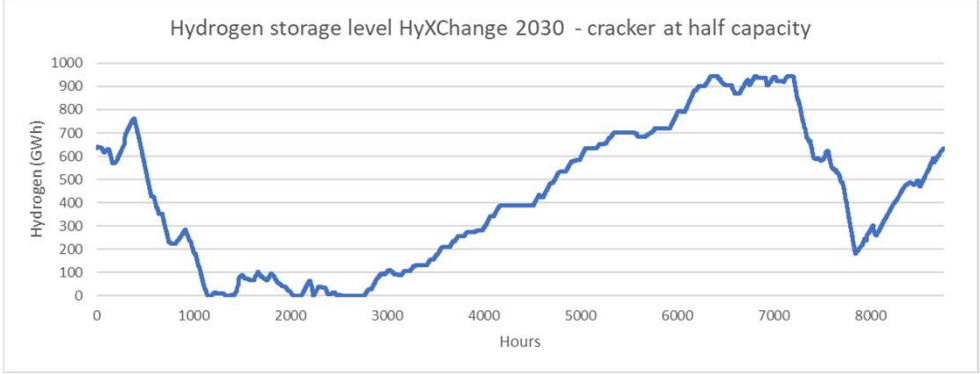

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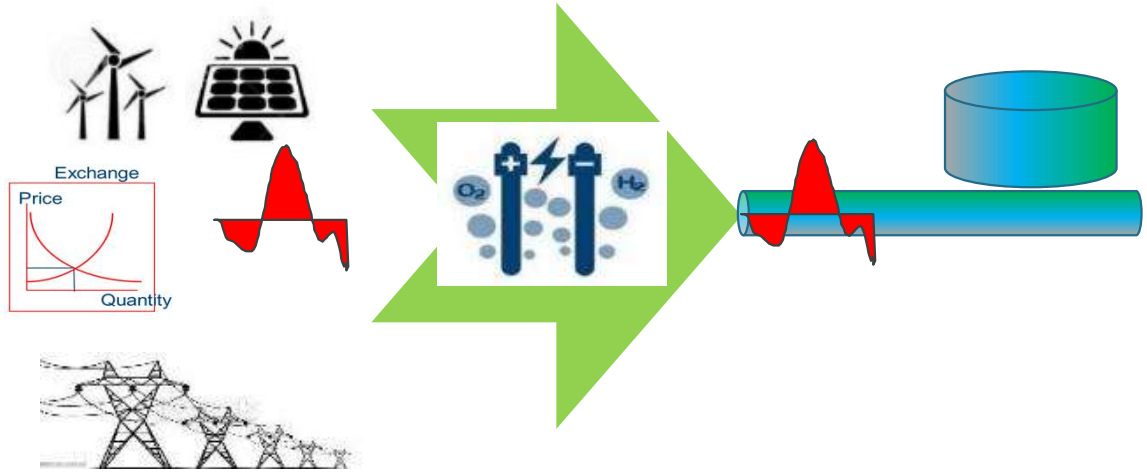
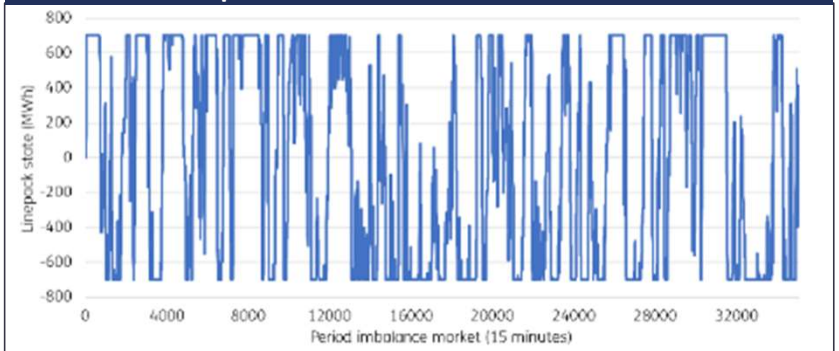
Electrolysers as E-flexibility providers

Effect on the H2 balancing market: need for salt cavern storage

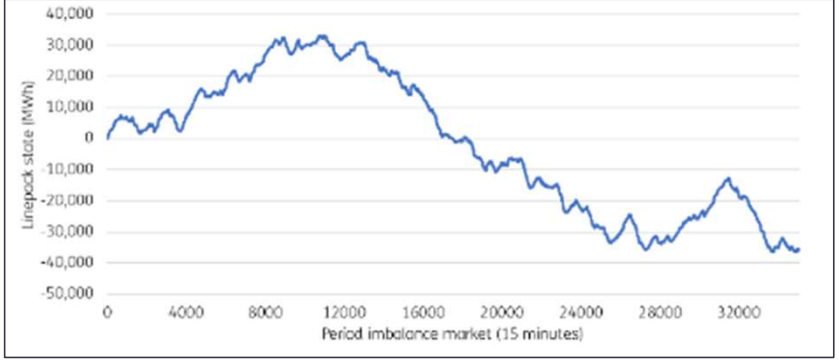
- Electrolyzers can provide flexible response to Electricity market volatility (spot, intra-day, balancing)
- Electrolysers cannot balance the complete E-market with only line pack: salt cavern storage capacity needed



Line pack state with constraint



Linepack state without constraint



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Key findings and implications

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Key findings of project

As learned from market simulation and market parties input in Sim sessions

- **Time unit of the spot, intra-day market: to be hourly**
  - Hourly volume volatility for individual units, driven by weather and storage
  - Price volatility much lower: “slower” sources are always price-setting (import ammonia cracking or SMR/ATR)
- **Day ahead and Intra-day variations**
  - Varying renewable input (wind, solar) in electrolyzers
  - Balancing role electrolyzers on electricity market: well possible.
  - But variations exceed line-pack: cavern storage or other flex needed (SMR/ATR, import ammonia cracking)

Key implications for HyXchange set-up

As learned from market simulation and market parties input in Sim sessions

Balancing and within-day market:

- Important for market parties AND the H2 grid operator
- Balancing, secure supply requires multiple origins H2 (green, low-carbon)
- Need to administrate and transfer green certificates on H2 grid(s) – also during multi-region startup of the market (temporary relaxation of mass balancing rules needed)

Other key findings during sessions regarding Hydrogen carrier imports (e.g. ammonia):

- Ammonia is needed to fulfil 42% renewable H2 industry target: important price driver
- Clear premium of green certificate (difference between blue/green ammonia)

Regional start-up of markets: if enough market parties on TPA H2 infrastructure AND

- Sufficient flex available from Ammonia terminal cracker and/or SMR and/or salt caverns

Spot Balancing development options

06-07-23

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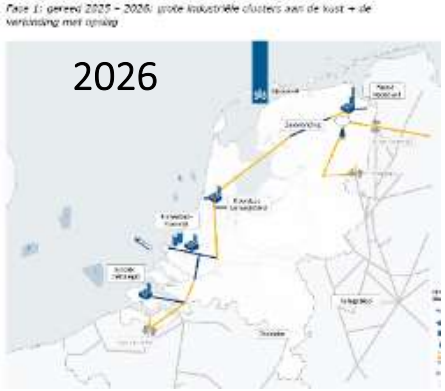
Current challenge: delay national network & storage

The original H2 infrastructure planning: national start
(iBrief Minister EZK aan 2e kamer 29 juni 2022 betreffende ontwikkeling transportnet voor waterstof)

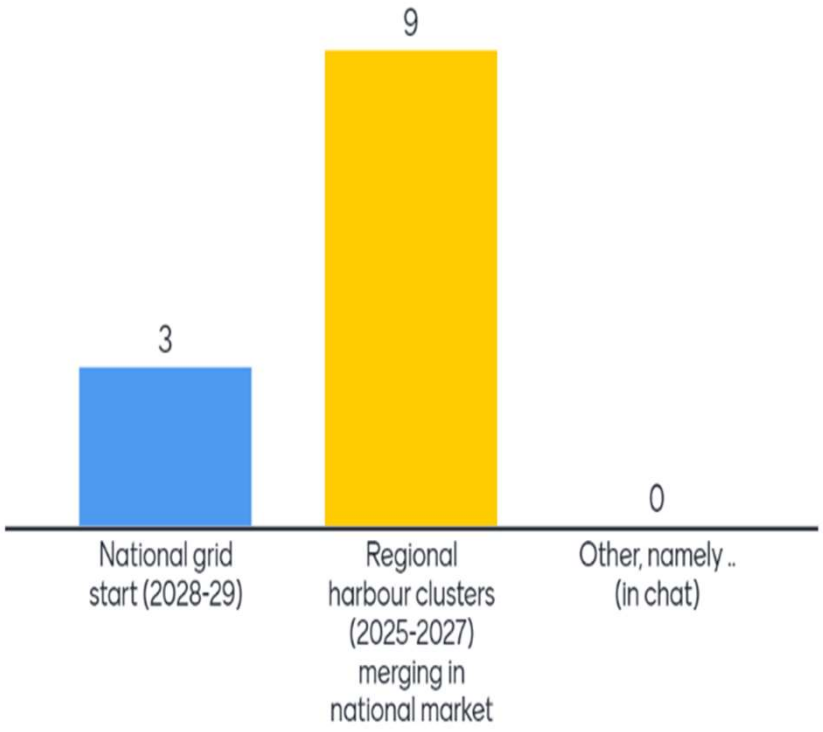


This would have facilitated start of a **national hydrogen market,** connecting main regional clusters in 2026. Even with few parties per region, there would be enough liquidity nationally incl. **exchangeable green certificates**.

The revised H2 infrastructure planning: start in regions (presented by HNS on 29-6-2023)

Now the market will start up in each of **the harbour regions separately** (Groningen, Rotterdam, Zeeland, Amsterdam) in 2025-27, also disconnected for green certificates. To be integrated nationally (incl. connect HyStock storage) in 2028-29

Market parties still prefer startup as early as possible



Advantages of going for market launch 2025-27 in each harbor cluster region

- Keep launch early in one or more clusters as soon as there is enough liquidity.
- Exchange facilities there for market parties, optimizing and balancing
- Get experience in the clusters ahead of the full-blown national market in 2028

This could be regional balancing markets to begin with
Then merge the regional markets into national (incl. storage) in 2028

Start per region in 2026, the picture seems as follows

(According to current information, provisional, to be updated in coming months)

Port Region	Regional H2 infrastructure		Flex type and year	
	Earliest	Latest	Type	Available
Rotterdam region	2025	2026	SMR Import NH3-cracking Import LOHC	Current 2027-2028 2027
Groningen Incl local H2 pipe GSP	2025 2025	2027 2026	SMR H2 import?	Current Unknown
North Sea Port region (Vliss., Tern., Gent, Moerd.)	2027	2027	SMR Import NH3 cracking	Current Unknown
Amsterdam/NZKG incl. plan local H2 grid	2028	2028	LOHC Local SMR+demand	To be investigated

"HNS peilt de interesse in de markt en heeft met een groot aantal bedrijven Expressions of Interest (EoI's) getekend. De EoI's zoals binnen gekomen bij HNS en hier gepresenteerd, zijn nadrukkelijk een momentopname."

Aantal EoI-contracten op 11-03-2022

Cluster	Entry	Exit	Totaal
Noord	6	7	13
NZKG	3	5	8
Rotterdam	6	1	7
Zeeland	10	9	19
Cluster 6	3	6	9
Chemelot	0	1	1
Den Helder	2	0	2
Total	30	29	59

To find out more/better on the number of parties, liquidity and market needs, we will have working groups of market parties, in each region.

Liquidity for market start, balancing and possible solutions: role of H2 Global imports?

Challenge: Limited market liquidity, volatile input electrolyzers: difficult balancing per region in run-up without storage.

- Electrolyzers do not always produce (depending on low price, hourly correlation)
- Demand (industry) is continuous: how to fill the gaps (cost) effectively
- Flex Currently depends on the flexible use of fossil SMRs.
- It's good to have a direct green H2 flex source: green ammonia import + cracking

Possible solution: Dutch version of H2Global for NL H2 flex market needs

- Dutch version H2Global is being considered by Ministry EZK; thoughts to focus that on available H2 for the network as well (if and when possible)
- Ideal for focusing this on the flex need to fill the gaps in NL sustainable electrolyzer production – especially as long as there is no or little storage
- This Market liquidity could also support HyXchange balancing market, available for all: equal access to flexibility in the start-up phase

Thank you for your attention

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15-11-23

Volgende online kennissessie woensdag 20 december

20 december	Agenda
16.00 – 17.00	Financiering van H2 projecten | Dolf Gielen, World Bank

Voorlopige agenda 2024

Datum	
Woe 17 januari	F2F
Woe 21 februari	Online
Woe 20 maart	F2F
Woe 17 April	Online
Woe 15 mei	F2F
Woe 19 juni	Online
Woe 10 juli	F2F
Woe 18 september	F2F
Woe 16 oktober	Online
Woe 20 November	F2F
Woe 18 december	Online

SHIP>NL Sessie X 15 November

Hartelijk dank voor uw aandacht

Vragen? Neem gerust contact met mij op:

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De slides van alle sessies zijn te vinden op:
SHIPNL: Sustainable Hydrogen Import Program Netherlands | Nationaal Waterstof Programma