The Hydrogen market boosted by Ammonia: *feed, standards & balancing*

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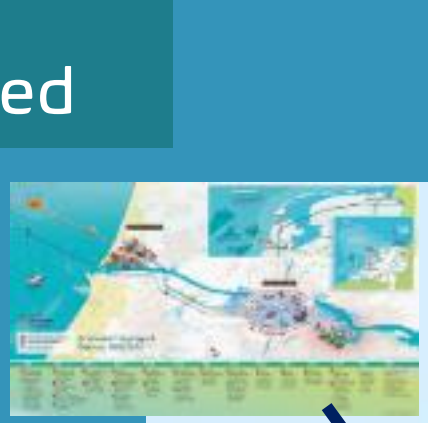
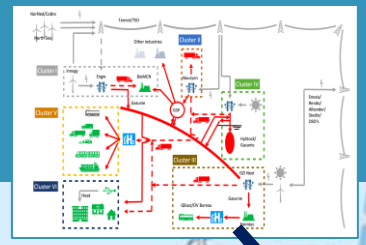
HyXchange

About HyXchange

Initiative by Gasunie TSO and 4 Sea Ports. 60 Market parties involved

One strand of multi-pipeline gas network in NL repurposed for H2. First stage 2026; Completed in 2030 Including salt cavern H2 storage





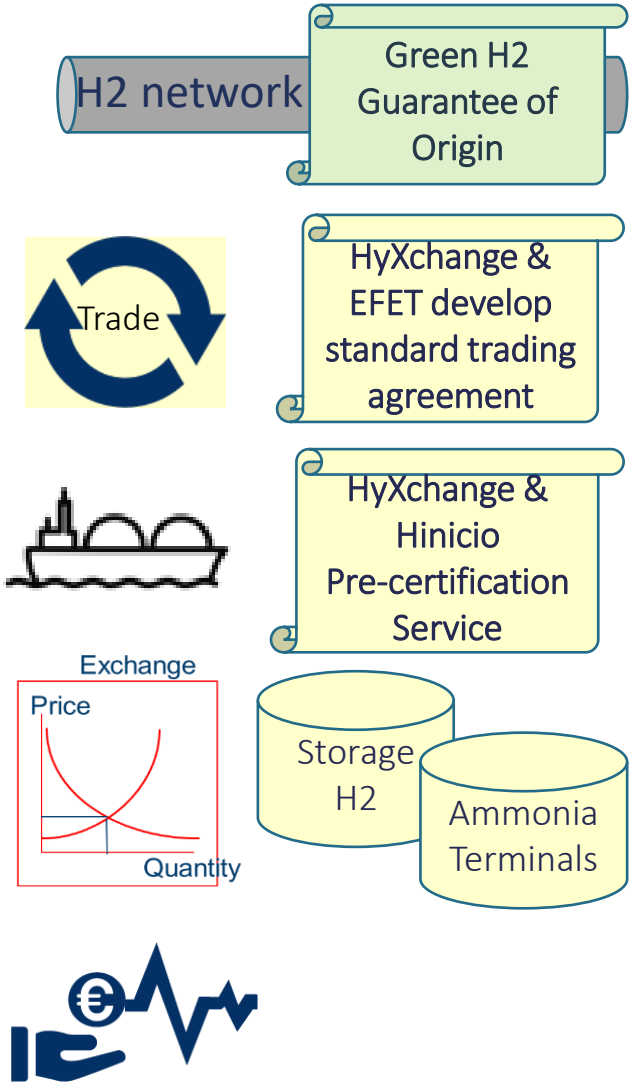
Salt Caverns

Global H2 carrier market

EU Gateway im/exports

Development activities HyXchange

- ❖ Pilot preparing Green Hydrogen Guarantees of Origin (GOs) now available in NL
  - ○ Standard contract for trading of Hydrogen GOs
- ❖ Pre-certification hydrogen carrier imports into Europe
  - ○ Simulation hydrogen spot market on national H2 grid
  - ○ Exploration of a price index product



❖ *These activities conducted in co-operation with Hinicio*

The Dutch H2 / ammonia market

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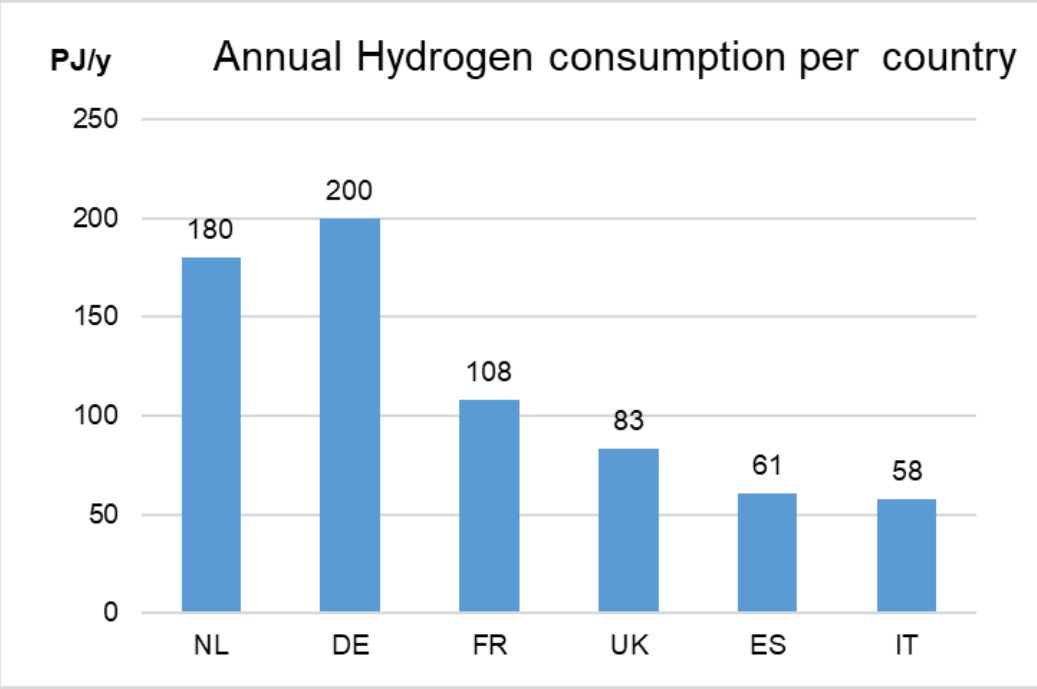
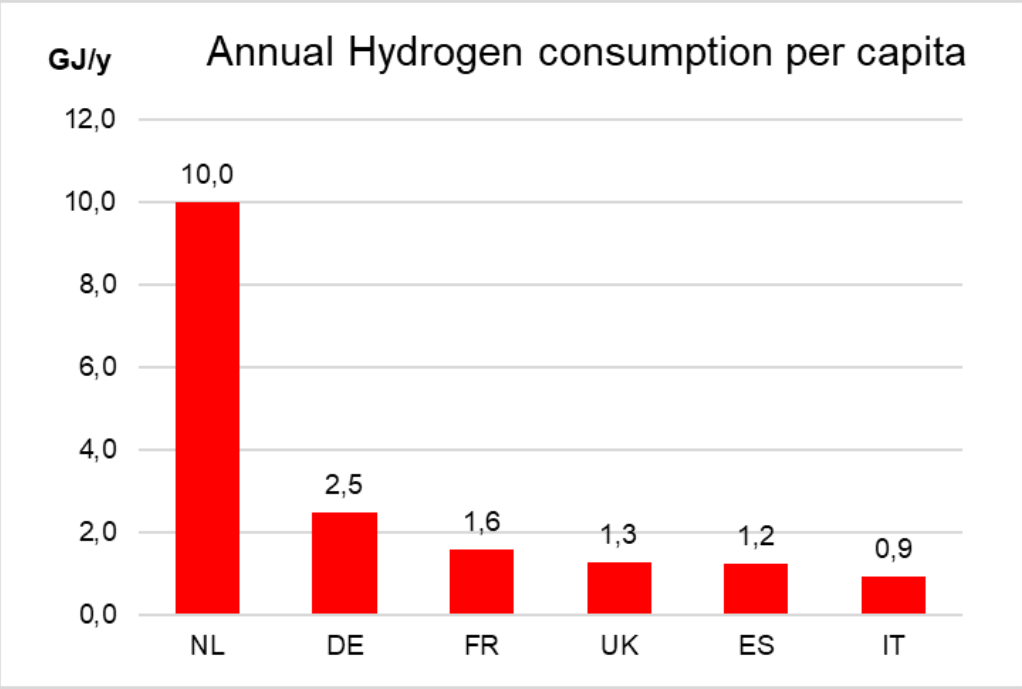
Netherlands: biggest Hydrogen use per capita today

- Annual hydrogen consumption EU: Germany 200 PJ, Netherlands 180 PJ*, mostly grey
- Netherlands: 10 GJ per capita, by far the highest in the world.
- Annually 4 billion m3 natural gas (10% of total use) to produce 110 PJ hydrogen (Until rec
- Almost half of the hydrogen used for ammonia production: for fertilizers and chemicals





* Data source: "Contrasting European hydrogen pathways", Oxford Institute for Energy Studies and University of Cologne, March 2021

Target EC: industrial H2* 50%- 78% green by 2030

* Except refineries. Original target Fit for 55: 50%. In RepowerEU, this is 78%

- Current industrial H2 demand Netherlands: 116 PJ (excluding H2 for refineries)
- In 2030: bigger due to H2 for steel industry: 200 PJ

Renewable hydrogen demand Netherlands	GW	hours	TWh	PJ H2	Kton H2	Pattern
78% industrial H2, current		8760		90	**750**	Continuous
78% industrial H2, 2030		8760		156	**1300**	Continuous
Possible sources:						
10 GW offshore wind 50% base electrolysis, OR 	5	6000	30	74	**600**	Intermittent
10 GW offshore wind 50% peak electrolysis	5	3000	15	37	**300**	Intermittent
Import liquid Ammonia (2 ships/week) a 80.000m3 (partly used as ammonia, partly converted in H2)* 				108	**900**	Continuous

Difficult to cover the target fully with (additional) renewable power in the Netherlands:

→ **Import of renewable hydrogen / ammonia: certainly needed to fulfil the target**

→ **This has been speeded up now after invasion of Ukraine /energy crisis (high gas prices)**

* Part of current H2 demand is for ammonia production. Imported ammonia can fill that directly

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The Dutch green Hydrogen guarantee of origin system:
- HyXchange pilot early 2022
- Go live October 2022

The EU certification challenge -Import Pre-certification initiative

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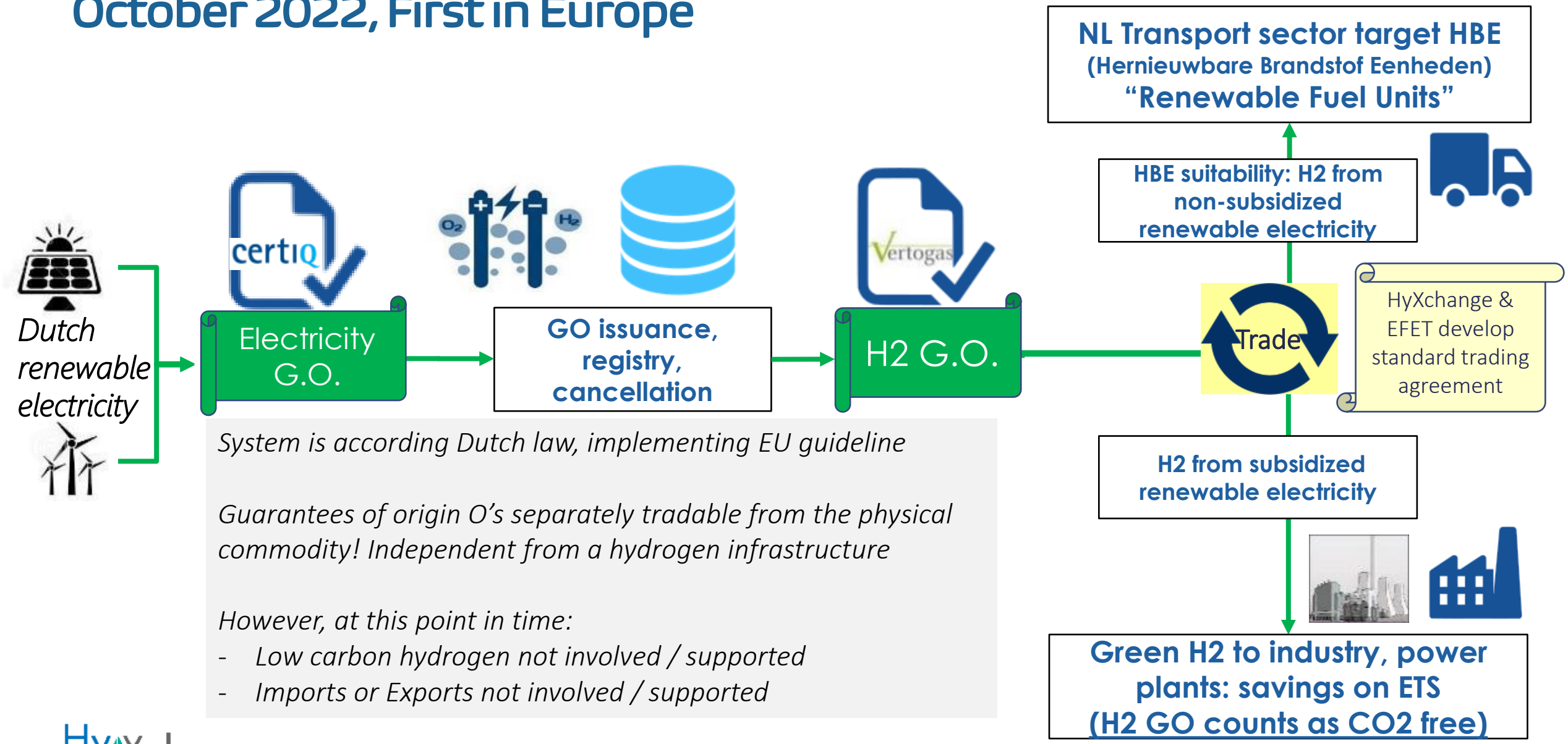
HyXchange H2 certificate pilot: 18 parties, 3 months dry run End report finalized. Findings used to improve live system.

- January – May 2022, conducted by HyXchange assisted by Hinicio (Certifhy designer)
- Dry run new H2 GO system by Vertogas, certifying body (biogas, now also H2)
- GO test for green hydrogen, prepare go-live of system based on Dutch law
- GO low-carbon hydrogen: same format
- Pilot included registration, cancellation, splitting and trade
- Findings into live system operational now

Report on Website: Hyxchange.org

Dutch law GO system: After pilot, system started recently October 2022, First in Europe



System is according Dutch law, implementing EU guideline

Guarantees of origin O's separately tradable from the physical commodity! Independent from a hydrogen infrastructure

However, at this point in time:

- *Low carbon hydrogen not involved / supported*
- *Imports or Exports not involved / supported*

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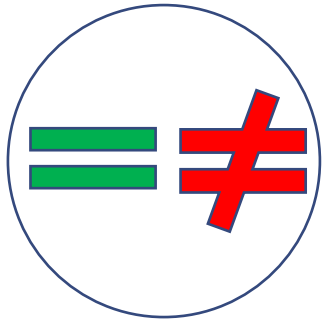
International (EU) system: EU certificates based on RED2 Renewable Energy Directive: draft Delegated Acts

Delegated act on "Additionality": long discussion on strict demands "what is Green H2"

- **Temporal correlation**: time matching of renewable supply and electrolyzer
- **Geographical correlation:** renewable supply and electrolyzer in same area
- **Additionality requirement:** H2 only from renewable power built recently



Draft, much debated, downvoted in EU parliament: "relax requirements!" Still in discussion.

AND

Delegated act on carbon footprint requirement: -70% (versus H2 from SMR)

- Not much debated, widely accepted
- Whole chain: renewable, electrolyzer, conversion into carrier, transportation, conversion from carrier (e.g. NH3) to H2

→ IMPORTANT FOR IMPORTS INCLUDING AMMONIA

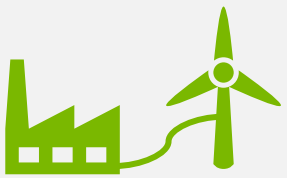
Why is this a problem? It doesn't need to be!

Many H2 imports are from semi-autonomous windfarms and solar farms. EU acceptance should be easy

Delegated Act (DA)

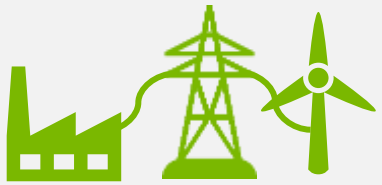
Case 1
Partial renewable hydrogen

- Renewable share of grid



Case 2
100% renewable hydrogen

- New renewable installation



Case 3
100% renewable hydrogen

- Additionality
- Temporal correlation
- Geographical correlation

- < 3,4 kg CO_{2eq}/kg H_2 consumed

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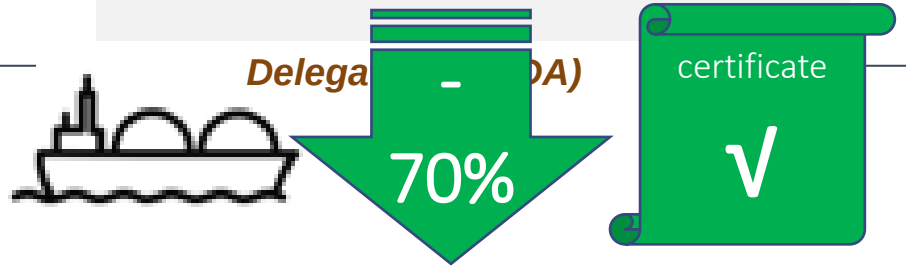
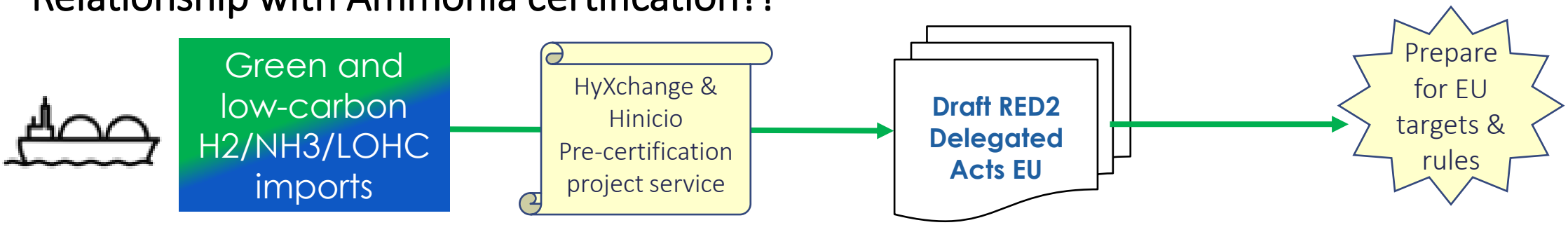


Pre-certification project service by HyXchange & Hinicio

- Certification key enabler for international imports, trading of hydrogen counting for:
  - targets for RFNBO hydrogen
  - targets for percentage of renewable hydrogen in the industry
  - exemption from CBAM charge
- Pre-certification: doing the homework for important projects – ahead of the final rules
- We enough about the draft rules to prepare for readiness; then hit the ground running
- Both green and low carbon Hydrogen (with same -70% criterion), Certifhy based
- Taking into account steps in between like ammonia conversion & transport
- Project service, first parties signing up ..
- Relationship with Ammonia certification?!



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Hydrogen spot market simulation, now ongoing

- Hydrogen network and storage
- Balancing role of ammonia

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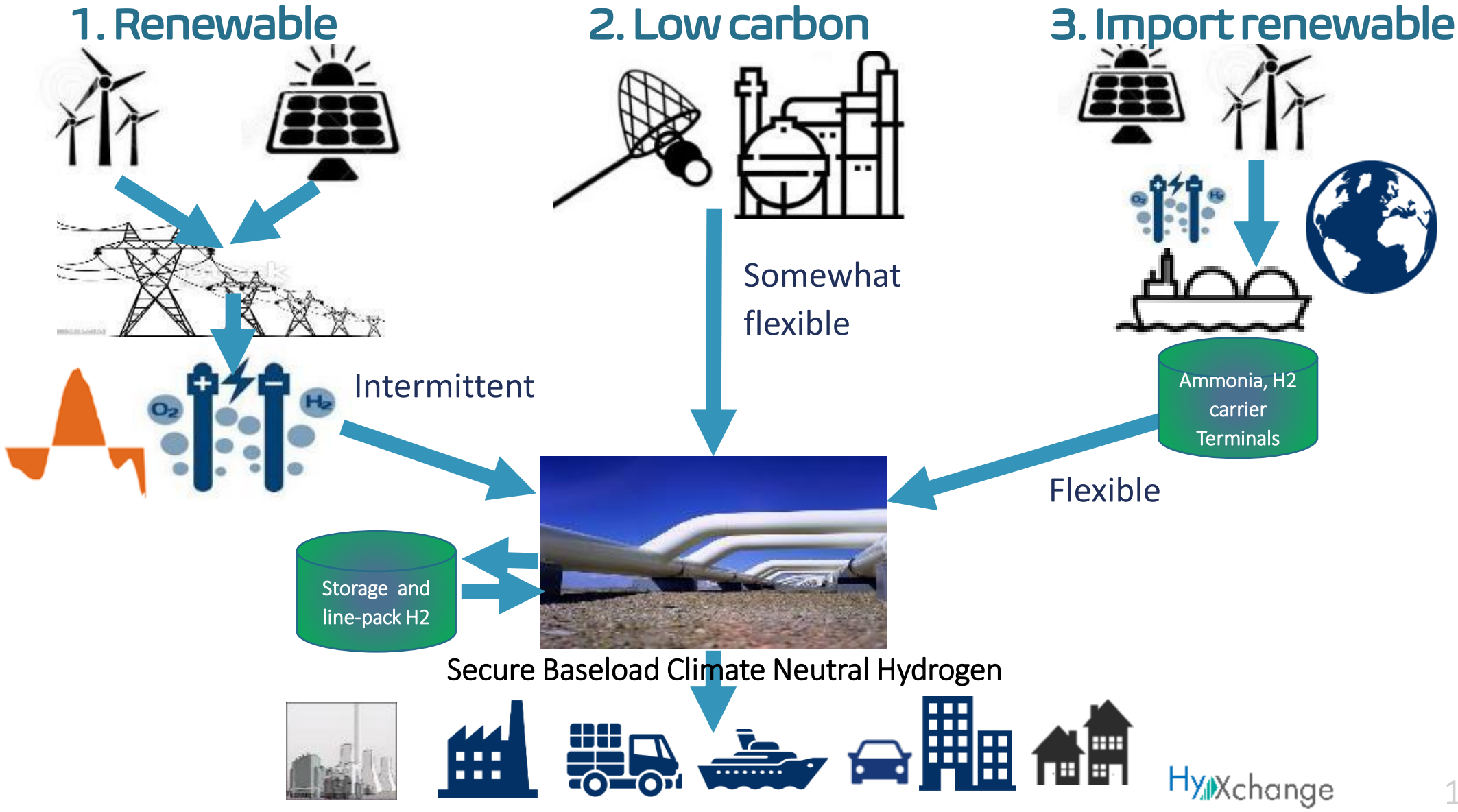
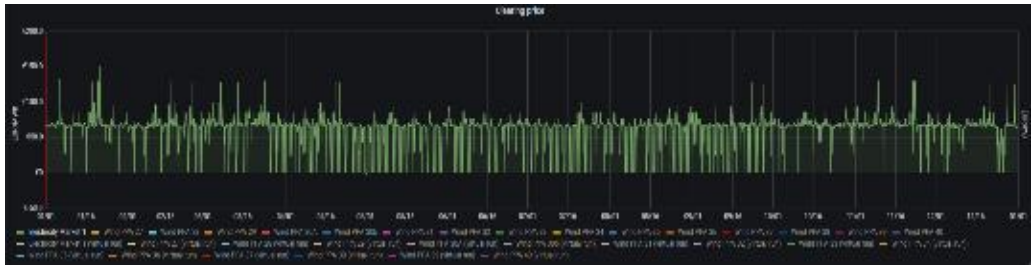
H2 spot market/balancing simulation on a (inter) national hydrogen grid. Unique in the world

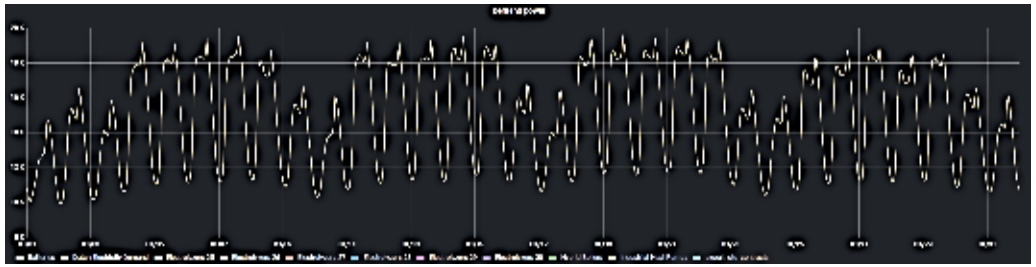
- Balancing varying electrolyzer H2 output with flexible H2 output of low-carbon SMR+CCS.
- H2 hourly electrolysis overproduction: store or utilize in gas power plants
- Storage: line-pack and salt caverns important for balancing
- Import hydrogen (ammonia, LOHC, liquid H2), each with storage, conversion and flexibility: →additional balancing opportunities
- Connection to Germany, Belgium
- Diversity of consumers: industry sectors; housing; transport; each with their own demand patterns.

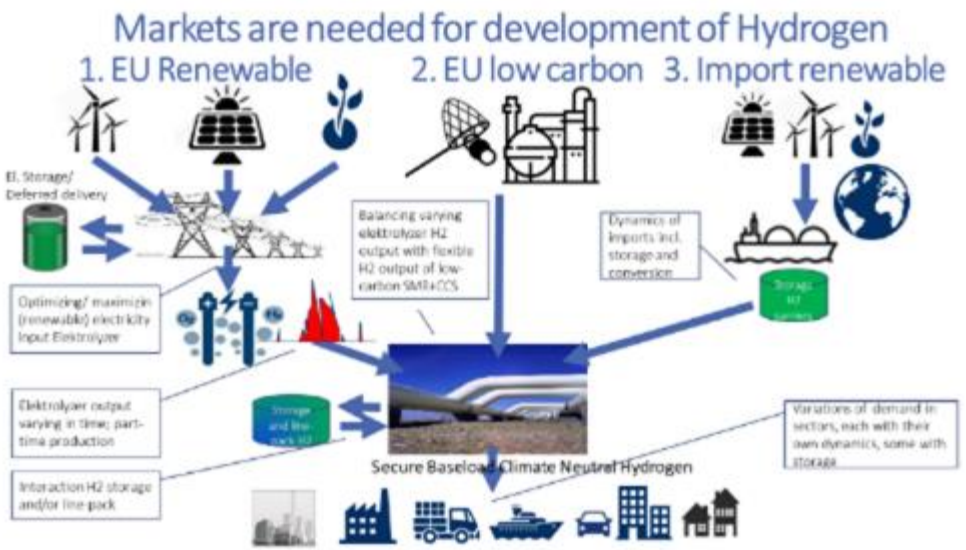
HyXchange simulation of Hydrogen spot market
Different sources, patterns, balancing



Hourly Clearing prices and volumes simulated







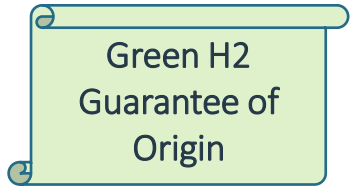
Subsidized by Dutch government gas technology program

Step 1 Model (dispatch) simulation, Dutch techn. institution

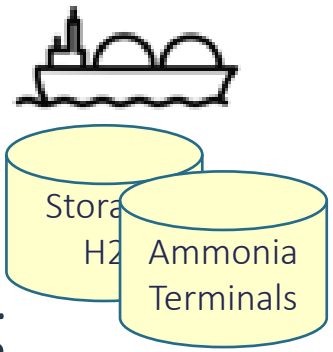
Step 2 Game (spot market) simulation with market parties

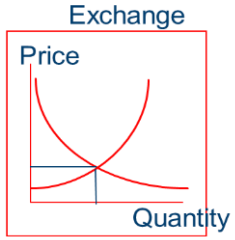
SUMMARY & CONCLUSIONS

1. HyXchange kickstarted H2 Guarantee of Origins
   Trading starting up, market parties involved



2. We need H2 carrier (NH3) imports into NW-Europe:
   - for volume feed to achieve H2 targets,
     and as an antidote for the energy crisis
   - for balancing the H2 grid: HyXchange simulation ongoing





3. Time is of the essence; industry needs standards to decide on FIDs
   - Speed up solutions by pre-certification of import H2 carriers
   - Opportunity for involving (draft) Ammonia certification standards

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Thank you for your attention

If you want to contribute to the HyXchange program or join the initiatives:

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Visit our new web site: www.hyxchange.org

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