NortH$_2$

Plenary Meeting W/MEAC – September 7, 2020

What's NortH2 all about?

Large, Green, Fast, Integrated

Drivers – working back from 2050

- Hydrogen is an essential part of the future energy mix – EU: 13-14%
- Upscaling and acceleration of the green hydrogen value chain is required
  - Paris time frame & targets / reduce costs / underwrite the backbone
- Opportunity
  - Leveraging Strategic location / Centre Green Hydrogen Production

Vision: NortH2 kickstarts the desired upscaling and acceleration and establishes a platform for exponential growth of the NW European H2 market

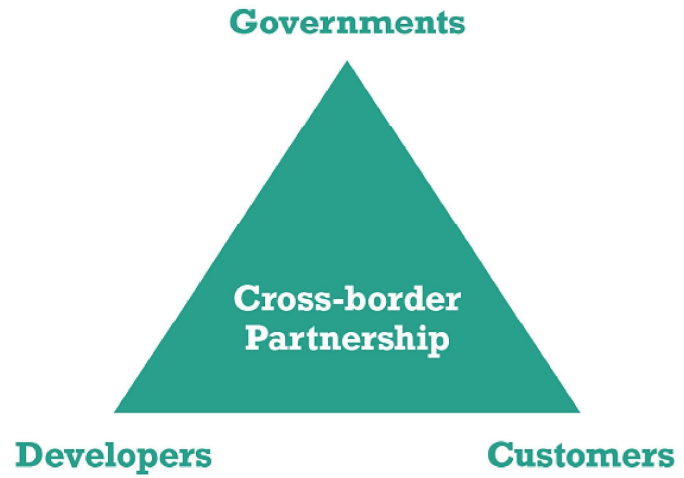
- @2030: backbone / nascent green H2 market / first large-scale green H2 usage in industry / long-term predictable hydrogen policy framework driving change from fossil to green H2 and driving related innovation (production, usage, transport storage)
- @2040: offshore clean H2 production system mature, rapid expansion

Teamwork is required to establish pathways to green hydrogen

- Credible, transparent business case in open dialogue with Governments and customers
- Changeover to Green hydrogen driven and facilitated by targeted government policies, regulations and subsidies … and accepted by customers

Common Objective

Meeting the Paris targets and timeframe to decarbonize sectors at the lowest cost to society



Initial Design Characteristics

Feasibility study assumptions for the first 4 GW to be installed by 2030

Offshore	▸ Base case for wind farm moved from South to North of Gemini ▸ 1 GW per year to be realized in the period 2027-2030 ▸ 12 MW turbines for the first 2GW and 15 MW turbines for the second 2GW ▸ Dedicated offshore power infrastructure to Eemshaven
Electrolyser	▸ Electrolyser located in Eemshaven in 50 to 100 MW modules ▸ Alkaline Water Electrolysis
Compression	▸ For the H_2 transmission backbone currently a pressure regime between 50 and 30 bar is defined
Transmission	▸ Cost of transmission expressed in a hydrogen transportation tariff
Storage	▸ 4 Salt caverns with a total storage capacity of [redacted] (10)(1c)
End-use	▸ Initially targeting industrial segments such as high grade heat and feedstock without carbon requirement

[1] Offshore spatial considerations may result in the use of HVDC offshore power infrastructure. This will impact the economics of NorthH2.

Value Chain Investment – partially optimized – Status Phase 1A

$NorthH_2$ Investment[1] in Billion Euro – Phase I

- Investment in the wind farm (4 GW) is by far the largest required investment)
- Infrastructure to evacuate wind power from North of Gemini to shore accounts for significant CAPEX
- The required investment in the onshore electrolyser is approximately (10)(1c) Billion Euro
- Gasunie estimates an investment of (10)(1c) billion for the H_2 backbone. This CAPEX is outside $NorthH_2$.
- 4 Salt Caverns are required to provide storage for a total investment of (10)(1c) million

1. (10)(1c)
2.
3. Including onshore cable(s) and compression of hydrogen before it enters the backbone
4. Total capacity of the hydrogen backbone will be shared with other hydrogen projects as well, e.g. blue hydrogen production in other industry clusters. To distribute the costs of the backbone fairly among these different projects, a capacity tariff for hydrogen transportation is charged to the project as an OPEX.

Programmatic approach for 4GW E2E value chain to reduce LCOH2

The programmatic approach is a long-term and strategic umbrella program of interlinked projects and components along the H2 value chain that aim at achieving large-scale impacts based on strategic partnerships.

4GW Scale (rather than 4 x 1GW):

(10)(1c)

Integrated program:

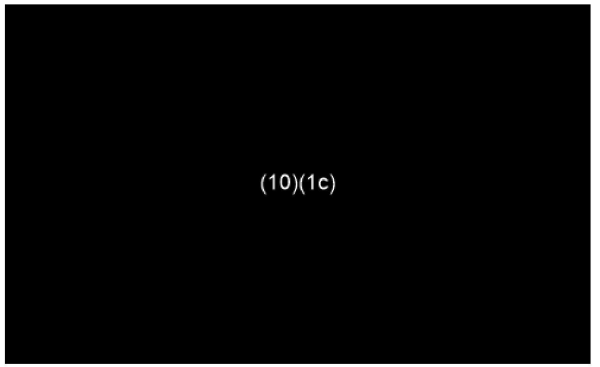
(10)(1c)

Commercial optimization

A electricity grid connection allows for commercial optimization of green hydrogen production by buying or selling additional green electricity, thereby optimizing the load hours of the electrolyser.

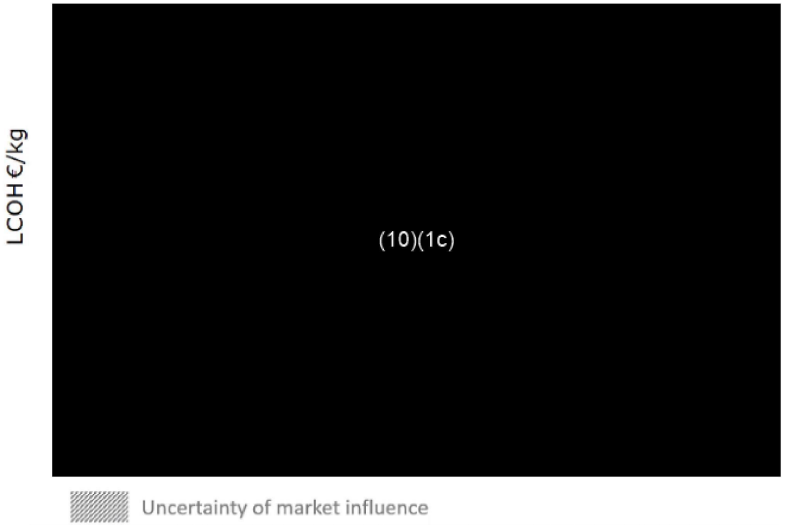
LCOH2 reduction of (10)(1c) through:

- A 1 GW connection, to support the network and without additional grid extensions.
- Buying from the grid if green electricity *and* electrolyser capacity available.
- Selling to the grid if the electricity price is high.



Considerations:

- The combination of available electrolyser capacity and supply of green electricity (PV) currently limits a further reduction in LCOH2.
  - An LCOH2 reduction in the (10)(1c) range rather than the (10)(1c) range could be achieved moving beyond Solar Power from NL
- The impact of the operating strategy and scale of NorthH2 on the electricity market price is not yet known
- Beneficial support of the electricity system by balancing (not quantified)

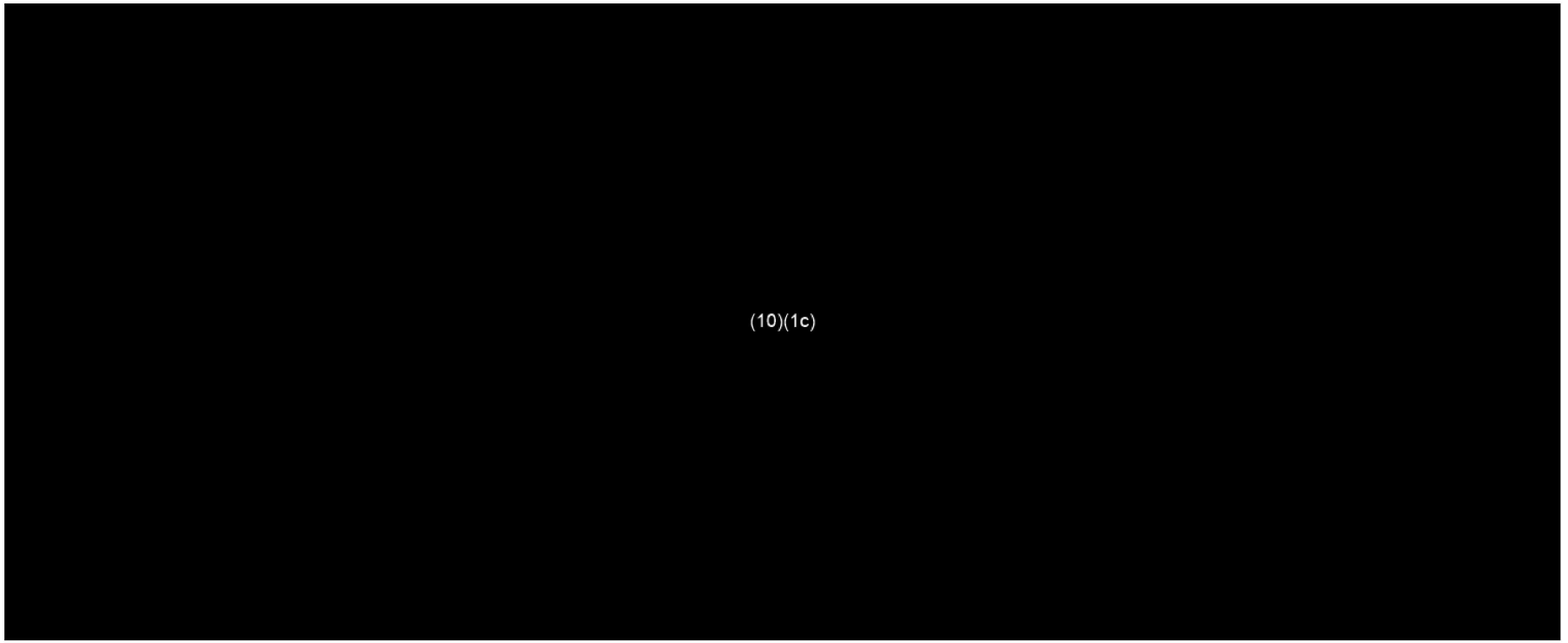


NorthH$_2$

* Calculations based on hourly forecasted electricity prices (PLEXOS with availability of green electricity in 2030-2045)

Optimized Green LCOH2 for NortH2 4GW Program by 2030

Programmatic approach and value chain optimization can reduce green LCOH2 from (10)(1c)

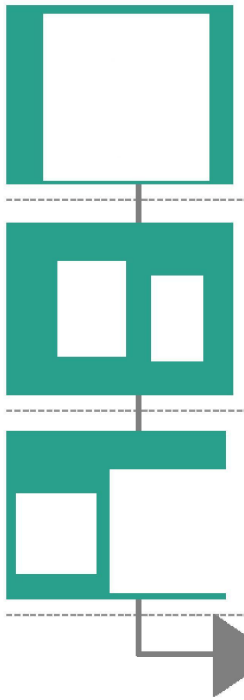


Based on the capital expenditures (CAPEX), operational expenditures (OPEX), lifetimes of the individual assets and efficiencies, the integral cost to produce, transport, store, and deliver a unit of hydrogen (kgH2) is calculated. This cost is expressed as the levelized cost of hydrogen (LCOH). The LCOH is the ratio between the discounted outgoing cash flows over the lifetime divided by the discounted sum of the actual energy delivered.

The LCOH shown in the graph below are in real terms and on an after-tax basis. As such, the LCOH allows for a comparison with present-day prices of competing commodities (e.g. electricity, blue hydrogen, natural gas and carbon capture and storage). @PBL economic criteria

Conclusions Feasibility Phase 1

The NorthH2 approach has potential to meet its ambitions and goals, based on the outcomes of the pre-feasibility study



Technical feasible

- Wind farm developments, green hydrogen production and infrastructure can be realized in the envisioned time frame
- No showstoppers, but innovation and scale required to realize the ambitions

Large technical market potential

- Potential large market for conversion of industrial heating (direct and indirect) from natural gas to hydrogen
- Potential market for H2 as feedstock
- Confirmed by first interviews with the market

Cost levels:

- Main cost components in windfarms, power infrastructure and electrolysis;.
- A programmatic and integrated approach can result in significant cost reductions
- Remaining value gap with fossil + carbon price

High-level Scope Phase 2

- Confirm anticipated cost reductions from a 4 GW programme (bottom-up approach)
- Broadening consortium base (investors and supporters)
- Market development in cooperation with customers and governments
- Dialogue with governments (NL / DE / EU) on key policy asks, e.g.
  - Identification and award dedicated wind for H2 concession (over and above current offshore wind road map)
  - Hydrogen market development policies (e.g. subsidies, mandates, sectoral approach)
  - Level playing field policy offshore power infrastructure (equal to current offshore wind for power generation policy)
  - Hydrogen backbone development and tariff structure for H2 market growth phase