

TSO2020: Activity 5

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TSO2020: A Future Vision...then...

2016

- The initial small PEM electrolyzers were being deployed to c. 500kW
- Isolated mobility demonstrations were proving the technical concepts
- Regional hydrogen policy in the Northern Netherlands and many other regions was in its infancy.
- Hydrogen was seen as offering potential which was difficult to grasp in terms of technology, cost and position within energy value chains
- National governments were supportive but cautious to avoid wasting public money and avoid backing the wrong horse...
- The case needed to be made on how and where hydrogen could play a role in delivering an energy transition



Activity 5: Scaling Up to Mass Application

Key activity 5 project elements:

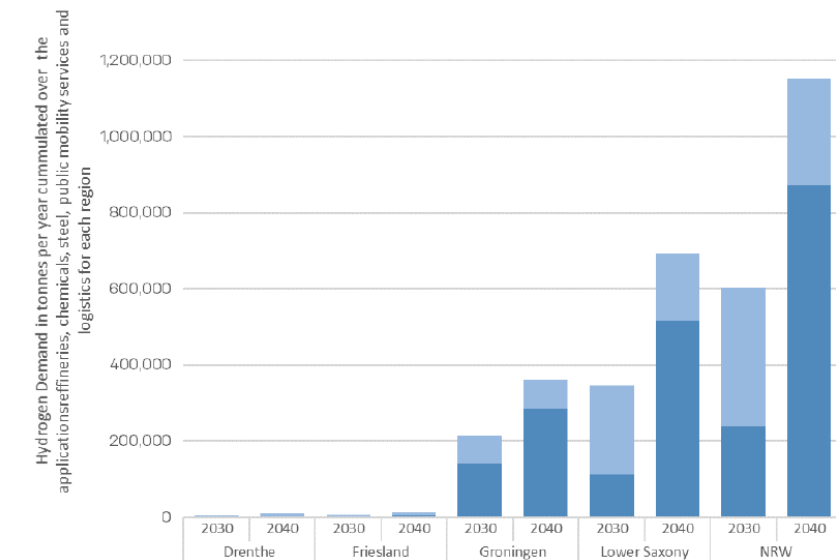
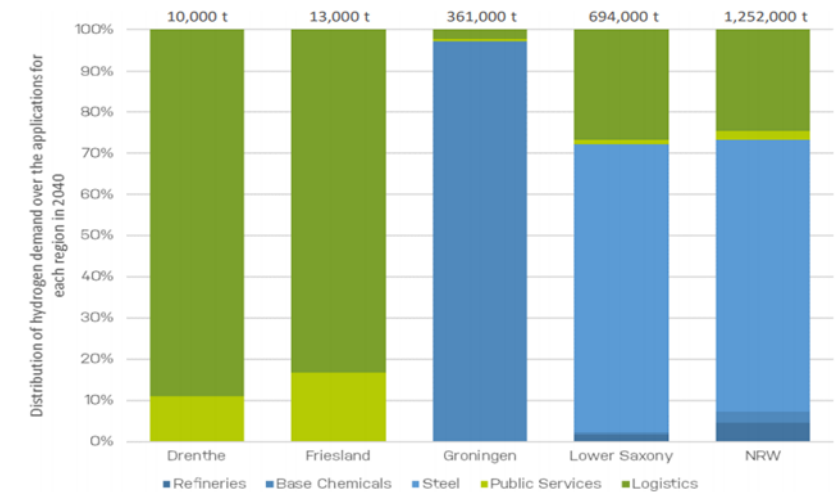
- Scaling up of electrolyser supply for local, regional and national H2 distribution
- Analysis of current and future hydrogen demand in the northern Netherlands and its adjacent regions
- Identification and assessment of the best synergistic locations for hydrogen roll out where energy infrastructure and TEN T corridors intersect
- Existing national hydrogen policy comparisons and future business model development



Hydrogen Demand/Energy Infrastructure Interfaces

Industrial Demand Driver

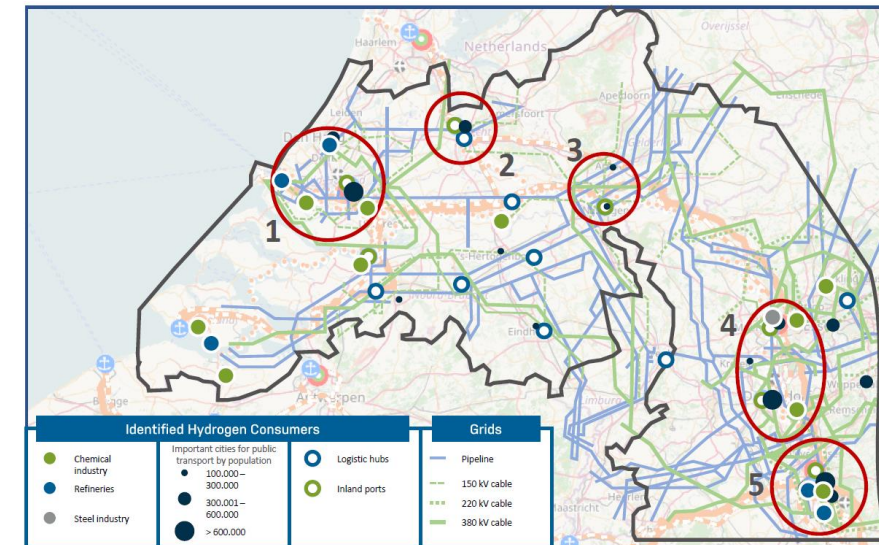
- During the period of the TSO2020 project a need and drive has developed for the acceleration of large-scale decarbonisation of industry
- Activity 5.2 identified significant industrial hydrogen demand within the regions of the Northern Netherlands and the neighbouring German ones which will drive future demand
- Drenthe and Friesland are more rural and will be focussed on mobility and public services for their hydrogen applications
- Hydrogen is now expected to play a key energy connecting and storage role in the energy mix in all EU countries
- The industrial demand of Groningen and Lower Saxony will be directly connected to these coastal renewable energy hubs
- NRW requires interconnection via distribution systems. Local renewables is not expected not scale sufficiently to meet local NRW demand



Hydrogen Demand/Energy Infrastructure Interfaces

Mobility Demand Driver

- Over the project life period hydrogen mobility began to focus more on heavier vehicles this will align more closely with major highway infrastructure and therefore initial roll out along TEN T corridors is expected
- Utrecht and Nijmegen – like Friesland and Drenthe – where mobility applications will lead hydrogen demand
- They combine well with other more industrial geographies which provide volume to enable their mobility hydrogen demand to develop (Activity 5.3)
- Activity 4 is a prime example of this with the envisaged Hydrogen Hub and trailer distribution initiating the hydrogen mobility sector via by-product hydrogen in Delfzijl
- Other regions such as Cologne, Duisburg and Rotterdam are felt to have sufficient local enablers to drive the development of their own local hydrogen system

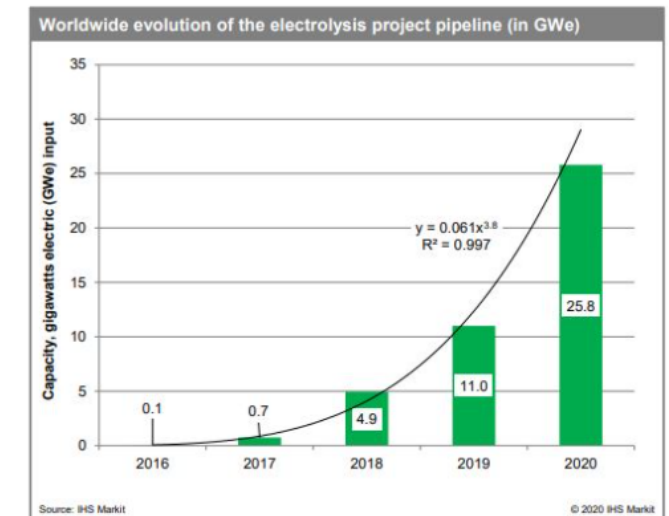
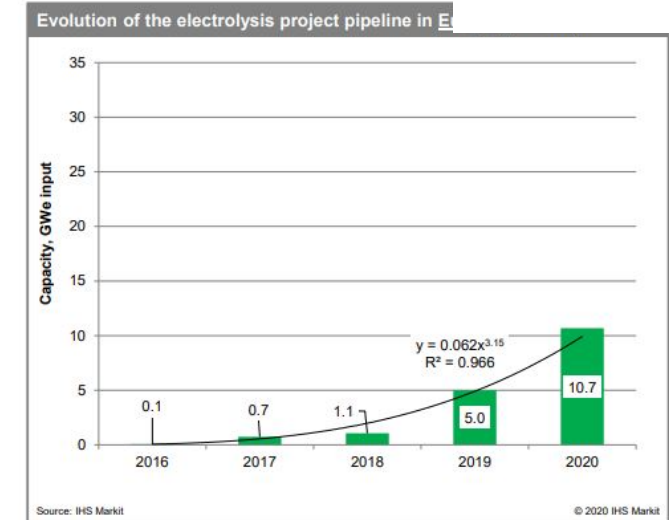


Energy Engineers Activity 5.3 Report

Electrolysis Scale-Up

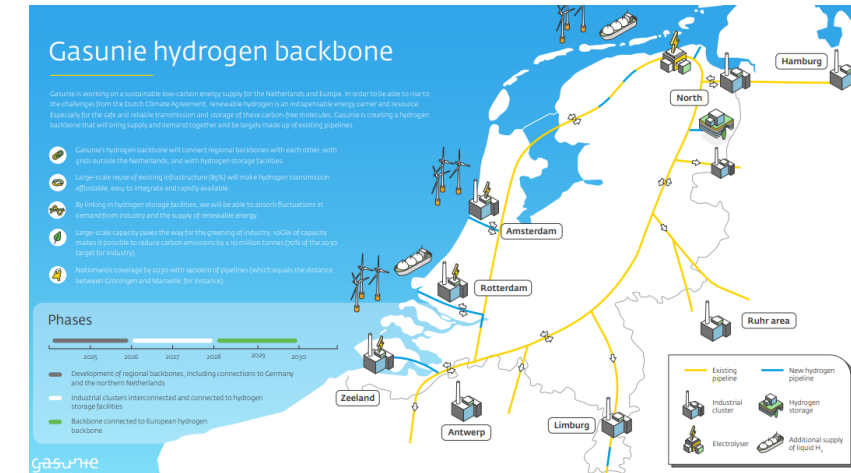
- Electrolysis technology has been rapidly maturing over the project period - no longer talking in the scale of KWs, but MWs and GWs...
- Large-scale renewable production will either be based off-shore or close to key demand nodes for the Netherlands and Germany with land-based renewables expanding but at a reduced rate
- Here are some of the Dutch projects:

County	Project	Description	Size (MW)	Dev. Date
NL	HEAVENN	Design and FEED study for 1GW North Sea based electrolyser (Engie)	1000	2020 - 2025
	NorthH2	Green hydrogen production from GW windfarm in north sea.	Up to 10000	2020 - 2040
	Hydrogen Delta	Plans to design 1 GW hydrogen factory in Zeeland. Powered by several GW scale offshore wind farms	1000	2019 >
	H2.50	Hydrogen factory stationed in the Port of Rotterdam. BP to use the hydrogen to desulphurise products	250	2019 – 2022 (FID)
	Westereems	Westereems wind farm to add 100 MW electrolyser located on site of RWE-Eemshaven power plant.	100	2019 >
	Hemweg hub Amsterdam	Hemwegsite powerplant as part of a fossil free hub. Providing electricity, heating and fuels for Amsterdam.	100	19 >
	HyNetherlands	Electrolyser in Eemshaven to help balance electricity system from local wind farm.	100	2021 – 2022 (FID)
	H2ermes	Hydrogen plant development for Tata Steel in Amsterdam	100	2019 >
	Crosswind	Eneco and Shell project with an electrolyser growing to 200MW on the Tweede Maasvlakte - operational by 2023	200	2020-2023



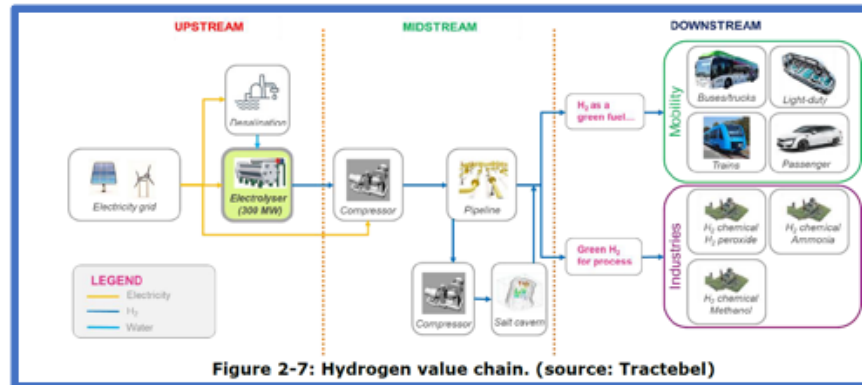
Connection of Application and Demand

- Most initial projects will be delivered via road by trailer
- Activity 4 provides a model and examples of this method of hydrogen distribution
- The cost effectiveness of hydrogen distribution methods are key to successfully migrating demand to green hydrogen
- An extensive hydrogen transmission network is therefore required by the Netherlands to realise the goal of a truly booming hydrogen economy
- Hydrogen Backbone is a plan championed by Gasunie together with a number of energy and hydrogen players across Europe to showcase how dedicated hydrogen infrastructure can be created
- The plans envisage an interconnected cluster in the Netherlands, Germany and Belgium, which could enhance benefits of various hydrogen initiatives, including co-located electrolysis-plus-wind farms and blue hydrogen plants on the supply side, and hydrogen refuelling station deployment and industrial demand sites on the demand site
 - Delivering the vision begun by TSO2020....



Complete Hydrogen Model

- Pulling all this activity together we see
 - TSO2020 partners have delivered the complete business model case for upstream and midstream when looking at this P2G CBA task 1 graphic



- Final cost at the customer will depend on distribution method

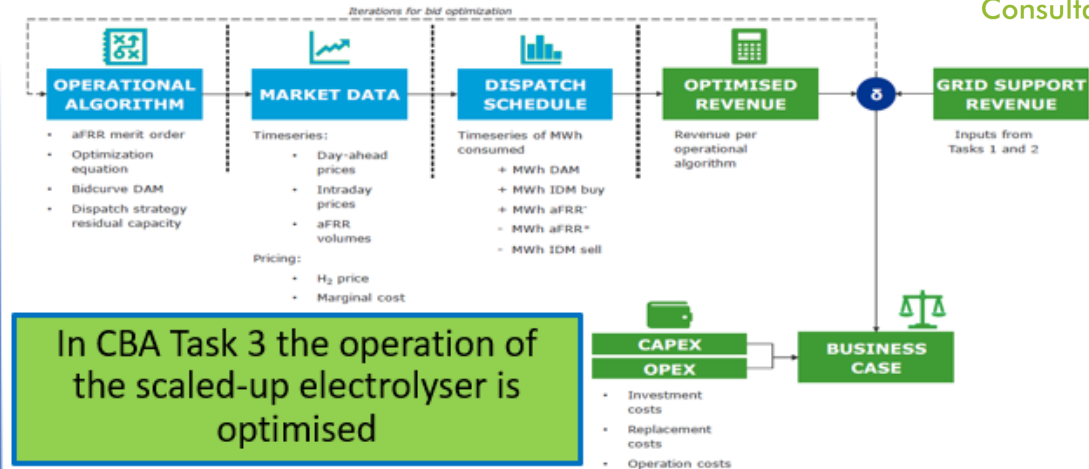
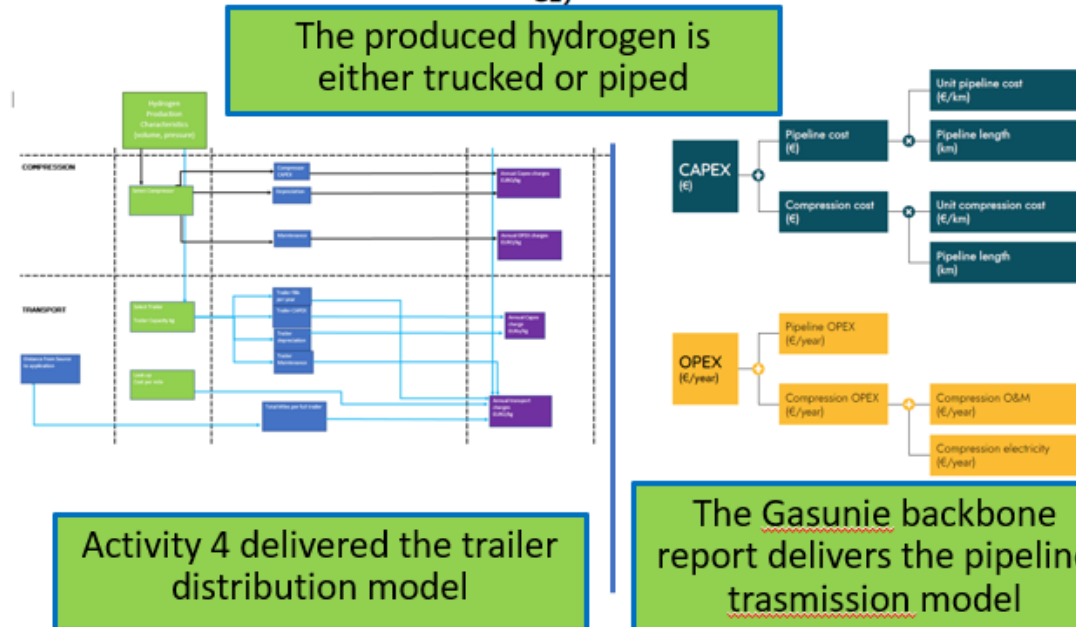


Figure 3-1: Optimisation and economic modelling scheme for the electrolyser. (source: DNV GL)



Activity 4 delivered the trailer distribution model

The Gasunie backbone report delivers the pipeline trasmission model

TSO2020: A Future Vision...now...

2021

- Over the period of the project the world has come to focus on hydrogen
- Integrated regional production and application planning for hydrogen enabled energy transition is occurring (in northern NL = HEAVENN)
- Large-scale coastal electrolysis systems are being planned
- Industry will lead demand with mobility added based on co-location of need and infrastructure
- Mobility will be based on heavier vehicles (trucks, trains, boats, planes)
- Green hydrogen still requires funding and support to achieve parity in the market
- National hydrogen strategies have been announced and energy transition goals have tightened
- The EU positioned hydrogen centrally in its COVID recovery plans confirming its importance
- Public and private investment has become available for larger energy transition project finance
- Multiple projects are now coming to market in the TSO2020 region



TSO2020's legacy is it has played its part in ensuring hydrogen will enter the energy value chain



Thank you for your attention