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WORLD HYDROGEN FUELS SUMMIT

10-11 MARCH 2020 | AMSTERDAM

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EXECUTIVE SUMMARY



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Foreword

My name is Soizic and I am the producer and programme manager for the World Hydrogen Fuels Summit 2020. I was chairwoman during the Summit and I have synthesized the key insights shared in Amsterdam on the 10th and 11th of March 2020 in the following pages.

In the months of preparation leading to the summit, it was increasingly clear from the research that for Hydrogen, the time for speculation and discussion is over – now is the time to act. Our strapline for this event, international collaboration for real world action, sought to stress the event purpose; **actionable insight and strategic collaboration**. With so many key stakeholders in the room; politicians, oil giants, chemical and legislative experts, we are honoured to create a breeding ground for collaboration and strategic planning that will enable a proactive coordinated shift towards Hydrogen. The resulting insights from the discourse are described in the following pages.

I would also like to make a small disclaimer, I could fill days with the ground-breaking projects, comments, controversies and critical consensus that were exclusive to those present, and the innumerable learning moments of the Summit. Unfortunately these will not fit in a reasonably sized executive summary. I urge those who are serious about the potential for Hydrogen to reach out to me and come to the summit in person in March 2021.

Executive Summary

The Summit begins on a rainy Tuesday morning, in the midst of an unprecedented global health pandemic. The theme of the first half of our summit – Policy and Business – holds a new relevance in the current crisis, as tools for initialising a kick-start of a Hydrogen economy in increasingly challenging times.

Joining by video from Brussels, Jorgo Chatzimarkakis, Secretary General for Hydrogen Europe delivers a hard hitting message to the audience as he opens our summit. For those still in doubt, Jorgo Chatzimarkakis makes sure we are all on the same page from the start – We are now at the slope of enlightenment in the 5 phases of the adoption cycle. The technologies are ready, the coordination is growing and the market is bracing itself for Hydrogen's adoption.

Hydrogen is not a (green) silver bullet. Its unique characteristics however, are undeniable to help us to decarbonise and meet our 2030 and 2050 climate goals with its versatility in use as;

- **An energy vector - transporting and storing (renewable) energy**
- **A Fuel**
- **A Chemical feedstock**

Its more detailed concrete uses for H₂ in the real world are many, these can be found in further detail in the IEA report “The Future of Hydrogen”, where you may find further information on its uses in infrastructure integration, heavy industry, transport and heating among many others.

So Why Now?

David Turk, Executive Director of the IEA enlightens us further. The IEA provides a solution to global complex issues; and it highlights Hydrogen's uses in the integration of renewables, the decarbonisation of steel, chemical trucks and planes as well as the enhancement of energy security through diversification and finally the deployable versatility of green and blue hydrogen.

Climate action, combined with a green deal in sight has increased investor appetite and many stakeholders have seen dramatic spikes in share prices in the sector. As the leading association in Europe for Hydrogen technologies, Hydrogen Europe is well placed to tell us that the technology is ready. The legal instruments are under deliberation and this is the decade of Hydrogen, as we have been hearing for so long.

One country leading a carefully thought out and coordinated Hydrogen Strategy is the Netherlands, our Summit host and long-time renewable energy pioneer. As one of the most forward thinking actors in this historical shift in Hydrogen within the Netherlands and Europe, Noe van Hulst Hydrogen Envoy, Ministry of Economic Affairs & Climate Policy for the Netherlands explains to us the projects ahead and the learnings from their trailblazer journey.

The Netherlands first and foremost focuses on Hydrogen use in hard to abate sectors, the challenge (and indeed for many) remains in the cost which needs to be brought down significantly. In the short term, many projects in blue hydrogen are therefore underway. The Netherlands does need blue hydrogen in order to scale up quickly enough and they believe in this strategy. This is demonstrated in Rotterdam at perhaps one of the biggest CCUS sites – which could allow for megatons of CO₂ to be stored in the North Sea as early as in a couple of years' time.

The Netherlands also anticipate imports of Hydrogen to take place in large volumes, with nations becoming new import and export economies and the birth of new global trade. The Netherlands believes they will also need imports as the volumes needed to decarbonise industry through hydrogen will rapidly double.



... and the costs ?

- H₂ for transport purpose is already at par with Diesel prices
- From a same „mass market level perspective“ fuel cell technology has lower production cost than combustion engine power trains
- Last Hydrogen Council report indicates much faster decrease of green hydrogen production cost than foreseen earlier
- Industry claims green Hydrogen could be available at 1 €/kg before 2030
- Pipeline transportation expected to be at 10 c/kg
- Salt caverns provide a very cost-efficient and vast storage capacity for huge amounts of Hydrogen



How to get there?



Slide: Christian Weinberger

Now is not the time to be passive, setting carbon neutrality goals is not the end of journey. Noe reminds the audience that we need to use the next two years to work very hard with the government and private sector to make final investment decisions that fulfil 2030 scaling up goals.

The Netherlands believes these need to focus on industrial hubs, on ports, using the gas grids, the mobility that is connected to those ports; the freight and development of international trade, and the project underway reflect this.

For the rest of Europe and the world, an autonomous market for Hydrogen that has overcome the supply and demand grid lock is still a while away, admittedly. It will take an initial funding push. This is why the European Commission has set in place the IPCEI (Important Projects of Common European Interest) on Hydrogen, in order to significantly support the EU climate objectives and the security of the energy supply by betting on hydrogen, overcoming the current market failure and reach the cost ranges required to kick-start a massive hydrogen production and utilisation in the EU. This will also improve competitiveness of EU industry because the technologies used in Europe can be used globally to help tackle decarbonisation internationally.



What are IPCEI projects about?

- **Waiver of State Aid restrictions with specific conditions**
- **Project involving 2 or more Member States**
- **Contribution to Union objective(s) and significant impact on competitiveness, sustainability, or value creation across the EU**
- **Environmental, energy or transport projects of great importance for the achievement of EU strategies**
- **Positive spillover effects on internal market/Union/society; benefits not limited to participating Member States & companies**
- **The project can be aided up to 100% of the funding gap on the basis of a large set of eligible costs**

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Slide: Christian Weinberger

Christian Weinberger, Senior Advisor – Advanced Industrial Technologies/Hydrogen Coordinator, European Commission is here to explain what the IPCEI could mean for future Hydrogen societies.

An IPCEI is an instrument of state aid policy, so it's a waiver of state aid restrictions which are typically very harsh in the EU. There are a number of requirements to comply to as you can see depicted, and you will notice Hydrogen for its virtues is a fit.

The opportunity for Green Hydrogen here is huge; the aim is to involve as many projects over as many EU member states as possible to achieve the kick-start. Christian ends on what is needed beyond the European commission, and his message is clear. He highlights an awaited integration of IPCEI, climate innovation, Structural funds, CEF and EU investments.



A broad alliance

- **Climate based initiative – Massive support to the EU emission reduction objectives – Green Deal link**
- **Broad Initiative – cover all MS interested**
- **Combined Initiative – Integrate IPCEI + Climate Innovation + Structural Funds + CEF + EU Invest**
- **Integrated Initiative – spillover effects for the whole EU economy/society**
- **Leveraged Initiative – Create Momentum to promote the further utilization of the technology**

Slide: Christian Weinberger

In time for this call for integrated investments, Shiva Dustdar, Head of Division Innovation Finance Advisory, European Investment Bank (EIB), the proclaimed bank of the European Union, joins by video. As the largest multilateral lender and so far the largest investor of climate action, Hydrogen is a focus of theirs and this is set to increase. 90% of the financing is within the EU and the rest is across the world, primarily in developing countries. In 2019 63.3 Billion Euros were lent to those who fit within the EIB’s 4 priority categories;

- **Innovation 14.4 Bn Euros**
- **Environment 16.5 Bn Euros**
- **Infrastructure 15.7 Bn Euros**
- **SMEs 25.5 Bn Euros**

Hydrogen fits in all these priority areas. The impact objectives of the EIB are improvements in jobs, health, sanitary, energy, transport and digital markets.

100 Bn USD in the last 5 years of investment have gone into mitigation and adaptation in climate action and environmental sustainability. For 2030 1 trillion euros will be used as depicted below.

We need to ensure within the wider investment community that the critical role of Hydrogen in decarbonisation is more widely understood. We are talking about all the energy uses that our critical in all stages of the energy transition; we need to ensure this is also better understood across the wider financial community. The EIB looks for projects that support this transition and in particular green hydrogen.

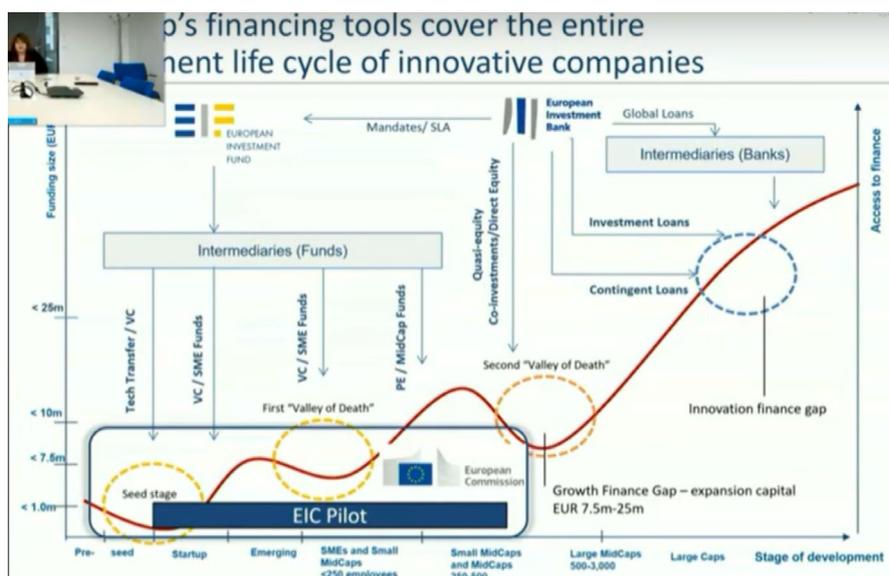
Ambitions for this decade

- **€1 trillion of investments in climate action and environmental sustainability in the critical decade from 2021 to 2030**
- **Increase the share of financing dedicated to climate action and environmental sustainability to reach 50% by 2025**
- **Align all financing activities with the principles and goals of the Paris agreement by the end of 2020**

Slide: Shiva Dustdar, video 02:14

The EIB want to tackle the availability, cost and value chain complexity of Green Hydrogen by;

- **Financing large-scale Hydrogen production projects to help make cheaper Green Hydrogen available**
- **Financing large players in key value chains in Hydrogen adaptation programs**
- **Financing innovative companies with new solutions to Hydrogen deployment**
- **Supporting complex eco-systems through advisory services**



Slide: Shiva Dustdar, video 08:48

The European Investment Bank is also advising the European Commission and provides some upstream advisory support to companies selected for equity and quasi equity investments. This is additional to the numerous financing tools in place, the most relevant for this being Innovation Finance Advisory, Energy Demo Projects (EDP) and another is CEF Future Mobility Facility and Advisory Hubs.

The idea is to prepare these projects with the necessary guidance from the EIB so that they are ready for potential due diligence and they are aware of the financial products that are relevant to accelerate the project. The EIB encourages the community to reach out and looks forward to an increase pipeline of projects; the EIB is ready to support the initiative across the Hydrogen value chain that benefit from the advisory and financing, specifically regarding the availability and costs of green hydrogen. Both the financing and advisory tools the EIB believes will contribute to a successful energy transition.

After a brief coffee break, the European Commission is minutes away from announcing the Clean Hydrogen Alliance as we discuss where hydrogen fits in national and European clean energy policy with Dr Gokce Mete, Afkenel Schipstra and Christian Weinberger.

Dr Gokce Mete, Head of the Knowledge Center at the International Energy Charter first set the scene before the discussion by highlighting some international regulatory and policy considerations.



Other relevant legal questions

- The following issues would also gain greatly from a harmonised approach:
 - Governing law in agreements on hydrogen sales, transmission and distribution.
 - Regulation of cross-border transport of hydrogen.
 - Adequate dispute resolution rules.
 - Applicable regulations for investment promotion and protection
 - Applicability of double taxation treaties.
- Clarification of the obligations and realistic risk allocation would help the market through the legal process of defining adequate terms and conditions.
- A standardised approach would help avoid a fragmentation of the market based on the specific constraints and economic balance of each project.

 COMMON RULES FOR GLOBAL ENERGY SECURITY

3

Slide: Dr Gokce Mete

The Energy Charter is based on a huge multilateral investment treaty with robust provisions on the protection of foreign investments to serve as a foreign investment protection framework. In the context of Hydrogen, the IEC considers potential investments in Africa – a region full of potential for a hydrogen shift – how do we boost investment confidence here? Do we have legal predictability and clarity in this region?

Boosting investor confidence, cost reductions and sector integration are key, so we need to ensure we have a competitive market for clean energy technologies.

For the importance of international cooperation, beyond information sharing and technology, there are also lessons to be learned in terms of frameworks and sandboxing approaches. Natural gas pipelines and storage facilities have harmonised and have internationally accepted standards, these require international consensus so the same for Hydrogen needs to begin now.



International Cooperation

- Information sharing at the international level on technology, regulatory frameworks and standards needs further coordination and attention.
- In particular, a better understanding of re-purposing natural gas pipelines systems could benefit from further learning on technical and economic viability - as harmonised standards for natural gas transport and storage would need to be revised and as international consensus takes time, early action is needed.
- While in Europe it may not be possible to obtain renewably-produced hydrogen at the scale needed, neighboring regions in North Africa, South Africa and Australia can do it thanks to ample sources of sun and wind. International trade in low-carbon hydrogen needs to kick start timely.
- Lessons learned from development of global LNG market can be utilized.

● COMMON RULES FOR GLOBAL ENERGY SECURITY



Slide: Dr Gokce Mete

After a layout of some practical regulatory priorities, considerations and suggestion – a debate ensues with Afkenel Schipstra, an experienced private sector energy professional, alumnus of Shell and Gasunie alongside Christian who steps in as Brussels for the day as Tudor Constantinescu is sadly missed due to travel restrictions. The audience begins to get involved and the discussion flows around some key questions, moderated by Gokce.

So How Does Hydrogen Sit within the European Green Deal and What Resulting Mechanism will Support Hydrogen within the EU?

Ursula von der Leyen pointed out in her unveiling of the Green Deal that Hydrogen will play an important role in the energy transition. Some Directorate Generals of the EU, DGENER, DG MOVE, DG CLIMA, DG GROW and DG Research are all cooperating within the EU commission in order to achieve goals in time.

Do We Have a Concrete Timeline?

Decarbonisation is a broad subject; we have 10 and 20 year timelines. Hydrogen is the most prominent gas outside of natural gas, being used in industry today as we are currently in the megatons. So it's a known entity, some clarifications are needed on certification, which is not clear between renewable and non-renewable, but when it comes to climate the most important element is emissions.

Standards are needed fast. The issue with standards is a status quo first needs to be established so that standard comes out of a reference for reality. So it's a challenge to rapidly come up with standards at the drawing board. If markets don't react as predicted you need to scrap new build standards, here lies a major practical challenge for regulators.

At the moment there are 10 BCM hydrogen productions (all grey) so a relatively big market however the market is not yet fluid. Location determines the cost of hydrogen so the future will be where the market is fluid and for hydrogen pipeline transportation in the most. Gasunie proposes to have a hydrogen backbone so you can transport it from place to place in the future. So the hydrogen market is here already it's just not necessarily green.

What Projections in Demand and Commitments does Industry Expect from Government?

There is a big difference between grey and green hydrogen in costs, so a higher ETS (Emissions Trading System) price will help as you can then calculate the CO₂ emission price – this of course is not solely in the hands of the government. What is also needed is a consistent framework so people know the mid-term and long term expectations, e.g. we have green hydrogen that can be used in heavy transport (transport and trucks) so if the government implement the RED II directive and there is a push from government to have a percentage of green fuels this can be embedded in the price. These initiatives can help improve the market.

The EU - No Customs, No Problem!

Beyond the EU - The advancements of the implementation is not helped by discussion. What's important is to bring projects from viable to tangible. This is our best contributions at international level; if we can demonstrate with the EU – Yes it works! Then we can lead by example to the rest of the world.

What Protection Mechanism is the EU Adopting to Protect the Demand for Hydrogen? How can You Legislate in Line with Permitted Protectionism from the WTO?

It is permissible to use state aid to promote the use of green hydrogen to get over the initial threshold. There is no intention to continue to finance this once we are past this initial market failure. A carbon border adjustment levy has also been discussed for a levy for countries that are not following the same policies – this is something that could be if it's structured to be WTO compatible and this could serve as an incentive. This is not a tax but a compensation mechanism, so if you have another country, like China, that does have some efforts in carbon emission than EU they should only pay half the levy as they are also contributing to achieving our goal. This is an incentive for more countries to invest in a renewable transition rather than pay the levy. The solution is not to blindly protect our industry because this will not ensure we are competitive in the long run but we have a responsibility to take measure to make the necessary adjustments justified within WTO.

There is a very big need to decrease the capex of the electrolyzers, and this is linked to the quantity of electrolyzers which can be ordered in coming years. If we talk about Gigawatt orders for electrolysis it is clear that the industry and all electrolyser producers will get organised and structure to reach maturity and for the cost to drop significantly which is admittedly not the case today.

In conclusion, people cannot imagine there is a learning curve that is steeper than it now seems. The function behind electrolysis is a sheet that bounces and it is extremely repetitive, there is substance behind the claim that the cost can fall “dramatically” and this was the term used by the manufacturer during the Q&A when the claim that these were unreasonable expectations were refuted.

Costs, Techniques and consistent frameworks have been discussed at length. But what we also need is perspective, and this was brought by the brilliant Nienke Homan, Regional Minister for Groningen who took the stage next.

Hers and Groningen's ambition is clear, to provide the rest of Netherlands and EU with green Hydrogen.

The Netherlands is an Iconic Nation of Onshore and Offshore Wind

“The Netherlands are famous for windmills, used for pumping water and milling grain but increasingly it’s now because of wind turbines and offshore winds. We have an ideal situation; many off and shore wind turbines and close proximity to more offshore German wind turbines still. Our history with the wind turbines will also be part of our solution, along with our unique situation with natural gas, as from this we build a future with the wind turbines.”



Extraction of natural gas



Source: [NAM](#)

3

Slide: Nienke Homan

In the last 50-60 years the natural gas extraction of copious amounts to be found beneath the surface led to hundreds of earthquakes. This led to safety and economic risks so the region looked for a new economic perspective. This was found in the pursuit of a Groningen Hydrogen Energy Hub. Because Groningen has the natural gas, this is where the European pipeline begins. So combined with offshore wind turbines in large farms and proximity to German wind farms, as well as the industry formerly based around natural gas, this has provided a unique position to get rid of the natural gas and seismic risk to upgrade the infrastructure and build an investment agenda with government and industry.

The industry and the region were on the same page to push this, and 2.8 Billion euros were dedicated to kick-start this green economy – called Hydrogen Valley.

So the follow through, Shell, Groningen Seaport and Gasunie equipped with millions in investment plus a grant from the European Commission, started a micro ecosystem of green hydrogen.

The Road to Paris Runs Through Groningen

Nienke says “We needed to show this vision that is possible, we already have mobility and industry that use green Hydrogen and since recently, a pilot with a green hydrogen train. So now we have a game changer, a scale higher at 10 Gigawatt from offshore wind produced in Groningen Harbour, Groningen Seaports, used and transported via pipelines and stored in Groningen salt caverns to be used in industry. This is a game changer in the total value chain. Green Hydrogen is the missing link in the energy transition and this motivates us, if we want to reach the Paris goals we need to use it and make it energy efficient, and that is why we say “the road to Paris runs through Groningen”.

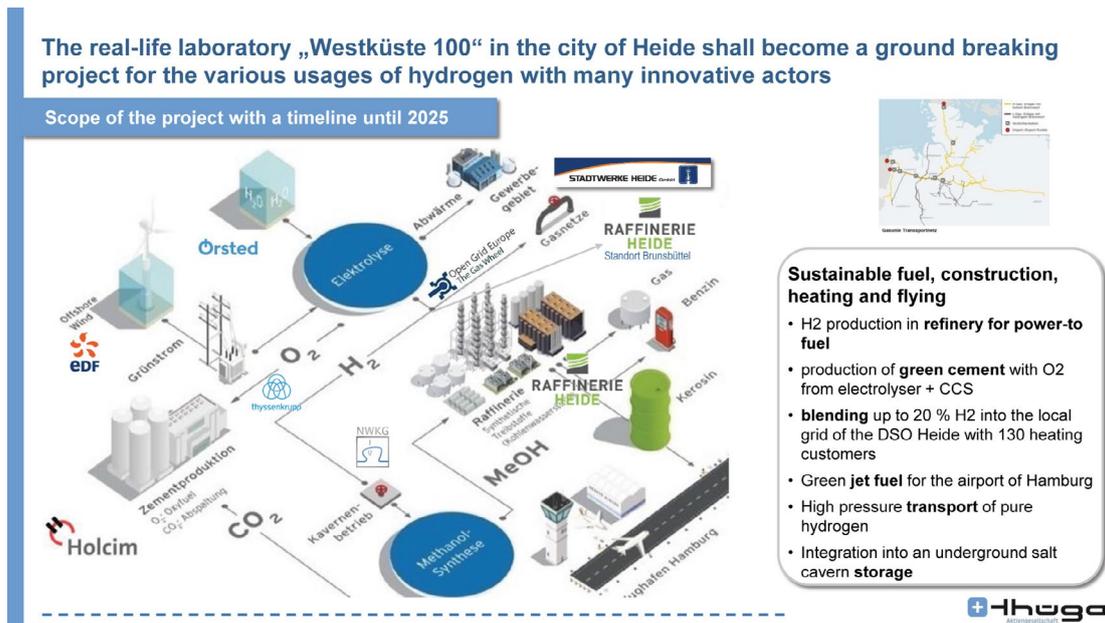
Between Groningen and Paris, we take a very geographically questionable detour via Munich to visit a different Perspective.

Eva Hennig, Head of Department for EU Energy Policy, Thuega gives us a deep dive into the downstream grids and to the end consumers. Thuega is a minority shareholder of about 100 utility companies. Thuega companies range from small to big companies based in places like Hannover and Frankfurt. It's a big group of companies that work together; some have 4.4 million electricity customers and 2 million gas customers.

Thuega have the first power to gas electrolyser injecting hydrogen into the grid of Frankfurt and continue to be active in this field.

In Germany, there are many rumours about the Hydrogen Strategy, which is still under debate. Between the ministry of economy and the ministry of environment they have different takes on H2. The ministry of energy sees blue Hydrogen as a necessity as a transition enabler as we are in the EU gas grid with still a necessary focus of Green with a prediction with 5 Gigawatt of electrolyser up 5 Gigawatt – the Ministry of environment seeing a higher number of closer to 15 Gigawatt.

So Thuega is operating grids up to 80 bars, the biggest customer has 3 billion kW hours. There is a vast range of consumers – paper mills, glass industry, CHP – the decarbonisation of industrial and commercial customers, especially CHP, would have to involve injecting the hydrogen at the distribution level.

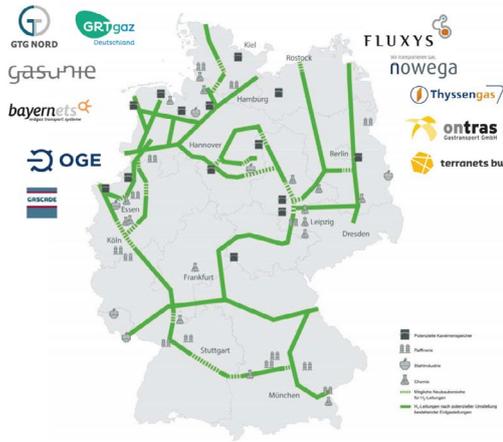


Slide: Eva Hennig

The H21 project in the UK wants to go to 100 % H2 straight away. Thuega however foresees blending in the grid as a first step to decarbonise heating, and this at distribution level and then ramping up Hydrogen to decarbonise over time.

There is a German Government debate on large industry, on steel for instance which is a hard to abate sector, however, heating is not as discussed and this is a mistake. The Green deal will ramp up ambition on the non ETS sectors. It is not possible to electrify the heating sector. We calculated we need to reduce CO2 emissions by 50% for 2030, so we will need renewable gases in the heating sector to chip in to the effort.

Decarbonising industry, transport, Power-plants, CHP and individual heating is only possible with molecules transported through grids – transmission and distribution



11 German TSO published a hydrogen strategy for the conversion of existing pipelines into a H2 backbone. It encompasses 5.900 km of pipeline of which 90 % are existing natural gas pipes. This hydrogen grid connects industrial clusters, fuelling stations for mobility on land and water as well as distribution grids. The TSO are actively working on technical solutions and the details of the grid planning.

This hydrogen infrastructure shall become part of the National development plan NEP 2020-30. To achieve this the rules have to be expanded to include hydrogen next to the existing H/L-Gas. The TSO and DSO are calling to the German government and the NRA to swift change of the existing German legislation. Without the gas pipeline infrastructure the German hydrogen strategy cannot be successful.

Disclaimer: Bei der Karte handelt es sich um eine schematische Darstellung, die hinsichtlich der eingezeichneten Speicher und Abnehmer keinen Anspruch auf Vollständigkeit erhebt.

Source: FNB Gas

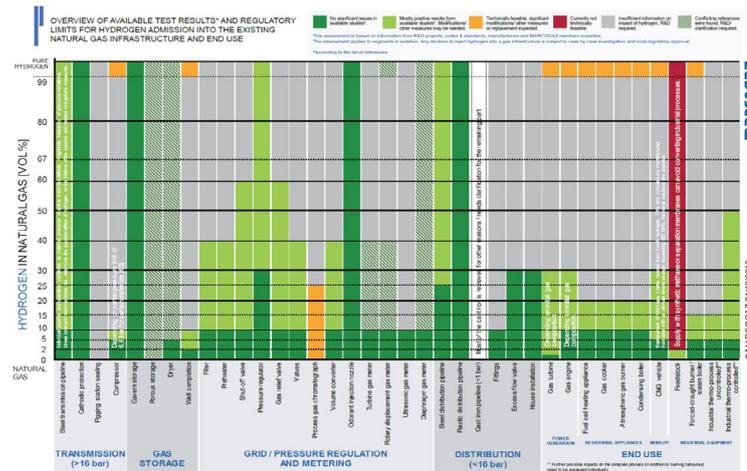


Slide: Eva Hennig

In 2019 Thuega thought it was necessary to say we are in favour of a renewable gas quota of 25% for 2030 and common CO2 price for all sectors. Thuega's ambitions are to increase the percentage in the gas grid, with power to gas to be increased up to 5 Gigawatt, and to push for Hydrogen to be recognised in building legislation in an initiative involving a number of other companies.

Regarding materials, there are many different types of steel. At some point all the DSOs will say we need material which is 100% safe as blending is just a short term phase.

For many years research has been done in Europe, US and Asia on the effect of H2 on different materials. Now the tests expand further into the various grid components.



The available data is huge and every week new intel is added worldwide. A very open and cooperative atmosphere between grid operators in Europe helps to disseminate the knowledge faster and learn from best practices.

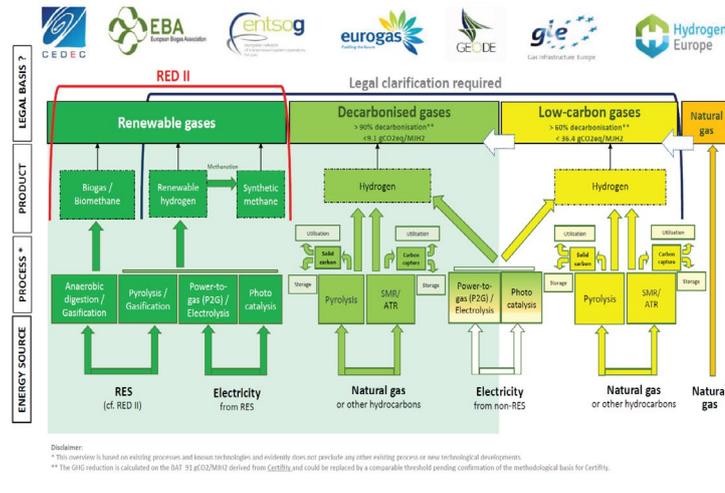
The Task Force in Marco-gaz studied in detail 63 reports from all over the world. The results for DSO was very positive: PE components are safe up to 100 %.



Slide: Eva Hennig

There is a constant exchange between DSO and TSOs to work together and learnings are more accessible and international thanks to the international gas union.

In the last Madrid Forum the 7 gas associations presented a proposal for definitions. Important was the very ambitious threshold of 9,1 gCO₂equiv./MJ_{H2}



- Clear definitions are important to:
- enable free trade of the different gases in Europe
 - give investors signals for their technology choices
 - build the basis for the needed changes in the different legislations e.g. gas directive and regulation, ETS and non-ETS, Network Codes,....
 - Help design potential incentive schemes

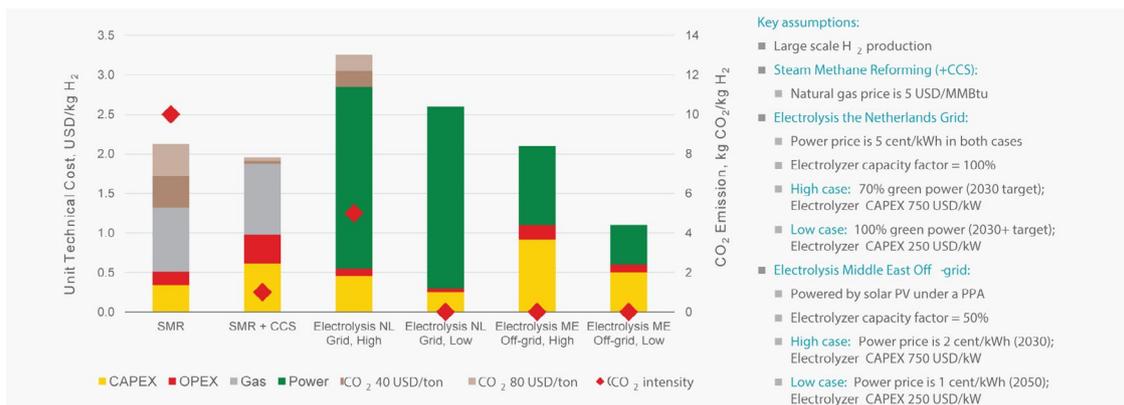


Slide: Eva Hennig

90% of infrastructure is hydrogen ready, and like many things the end goal is within reach through collaboration and shared knowledge. With the recent announcement of Nort H2, Mattijs Slee, Hydrogen Commercial Manager – Europe at Shell was tasked with presenting to our audience and answered the many questions that were posed by the Hydrogen community.

The keynote included further details on Nort H2 and H2 mobility in Germany as well as R&D projects underway on the liquid hydrogen value chain from Australia to Japan. Shell is focusing on liquid solutions for energy short markets in Japan, EU and US. In the future these markets will require exports and Shell want to start working on this in next ten years.

Unit Technical Cost of H₂ after 2030



Source: IEA, McKinsey
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February 2020 10

Slide: Mattijs Slee

The audience was curious how Shell sees Hydrogen as it is investing also in electric mobility and bio-LNG, and Shell responded it seeks to build a palette of solutions. Mattijs explained that the reality is there will be competition within the portfolio and that they do not envisage a winner takes all situation. Transportation is likely to be more saturated than in the past but as we can't predict how the segmentation will take place, and there will be different solutions for different segments according to Shell, and within time constraints versus market maturity now, there are more LNG trucks available than H2 so both are being developed.

After a long lunch in the hotel restaurant with views over the river Ij and some very strong coffee, the crowds spilled back into the room to hear from our gas infrastructure session welcomed back by session chair Nurul Nashwar bt Mohd Taib, Exploration Business Development, MPM, Petronas.

Chiyoda opens with our distinguished speaker joining us from Tokyo, Mr Setsuo Iuchi, Senior Vice President & Executive Assistant to the President. Chiyoda's current business portfolio includes the following, with the Hydrogen value chain now sitting within green energy.

Current Business Portfolio

Gas Value Chain

- Gas Processing (Onshore/Offshore)
- LNG (Onshore/Offshore)
 - Liquefaction
 - Regasification
 - FLNG/Platform & Nearshore LNG
 - FLNG Power Generation



Petroleum Refineries

- Clean Fuel
- Chemical Refinery Integration
- Heavy oil upgrading



Petrochemicals & Chemicals

- Olefins
- Aromatics
- Synthesis Gas/Fertilizer
- Methanol
- Specialty Chemicals



Pharmaceuticals

- Pharmaceuticals
- Tissue Engineering (iPS cell)
- Laboratories



Green Energy

- Solar Energy
- Wind Power
- Biomass Power Generation
- Energy Storage
- Hydrogen Value chain



Environment

- Flue gas desulfurization
- Acid gas/CO2 capture and storage
- Energy conservation
- Industrial Water Management
 - Waste Water Treatment + Recycling
 - Produced Water Treatment



Metals & Mining

- Metallurgical Refining and Smelting



Infrastructure

- Airport
- Transport



General Industry

- Electronic materials
- Food processing

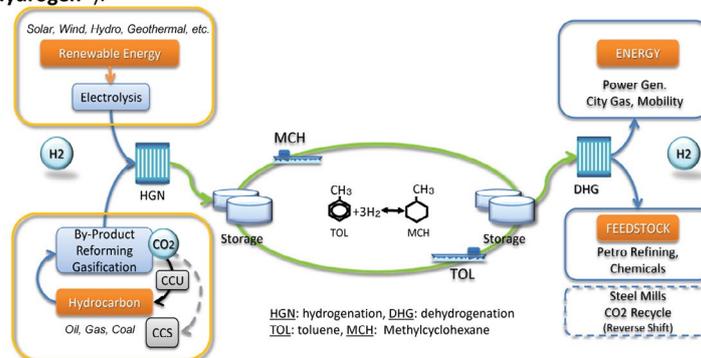


Slide: Setsuo Iuchi

The new ambition is to develop a hydrogen supply chain with a large and efficient Hydrogen storage and transportation system. Methylcyclohexane (MCH) is a hydrogen carrier which remains liquid in normal temperature and pressure.

Hydrogen Supply Chain Technology Overview

- Chiyoda has established a large and efficient H₂ storage and transportation system.
- Methylcyclohexane (MCH), an H₂ carrier, remains a liquid under normal temperature and pressure (SPERA Hydrogen®).



Key Technology is a New Dehydrogenation Catalyst .



Slide: Setsuo Iuchi



The New Hydrogen Compound is Called Spera, from the Latin Word for Hope

So Chiyoda bought the ambition to demonstration, with the support of NEDO, building a plot in Brunei in Darussalam.

Technology Development : Phase 3 (Demonstration)

- Chiyoda and partners established the Advanced Hydrogen Energy chain Association for technology Development ("AHEAD") and initiated the world's first global hydrogen supply chain demonstration project

Description	
Scale	210 tons/year (maximum)
Duration	One (1) year (January 2020 - December 2020)
Hydrogen Supply	Brunei Darussalam (Hydrogen Production)
Hydrogen Demand	Kawasaki City (fuel for gas turbine power plant)
Transportation	ISO tank container (container ship/truck)
Business Scheme	Establishment of the Association for Technology Development. NEDO Funded Project*



* Technology Development for the Realization of a Hydrogen Society (funded by NEDO)
Demonstration of the Hydrogen Supply Chain by the Organic Chemical Hydride Method Utilizing Unused Energy



Slide: Setsuo Iuchi

The first cargo has arrived in Japan and awaits power generation. Chiyoda, Mitsubishi Corporation, NYKLine and Mitsui & Co established "AHEAD" to launch the world's first hydrogen global supply chain project funded by NEDO who believe Spera Hydrogen will be widely used in the real world.

Marc Van der Linden, CEO, Stedin brings us to a DSO perspective back to the Netherlands. In the 50s when the Netherlands found natural gas reserves in the north we began to roll out a fine meshed gas network throughout the whole country. Over 90% of all Dutch residents are connected to the gas network used for cooking and heating in the home.

Grid operators have to plan for the next decade now and continue to innovate in keeping with the rapid rate of change. Stedin will carry out a trial on a small area of houses, 14 houses, which are ready to be demolished. Stedin are using this opportunity to innovate, to install Hydrogen boilers and heat pumps using existing gas infrastructure to carry out tests and learn what the effects are on the gas infrastructure. He also tells us more about Stad Ann't haringvliet, an area with many windmills and solar energy, a neighbourhood of 550 houses, which is being considered to switch to 100% H2 between 2024 and 2025.

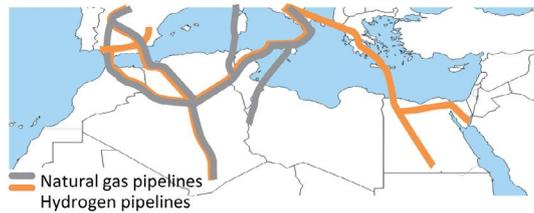
Stedin recognises the task ahead and strive to be realistic, to consider the entire value chain and facilitate innovation with policy.

- To be realistic
- To consider the entire value chain
- To facilitate the innovation with policy

Could Energy Security and Economic Development Come Hand in Hand?

Paul van Son outlines a Hydrogen future for North Africa and an increased impetus in climate strategy in the region in recent years. He also highlights a quote from Frans Timmermans who aspires to build a partnership between the EU and North Africa as allies into the renewable Energy transition, and Hydrogen is a big part of this. North African countries have ambitions in Hydrogen exporting with Morocco holding strong projects ahead.

Existing and new Gas Infrastructure Eventually to be used for hydrogen



Existing gas infrastructure from Algeria and Morocco could be converted to a hydrogen infrastructure (grey-orange lines)
A "new" hydrogen transport pipeline to be realized from Italy to Greece, crossing the Mediterranean Sea to Egypt (orange line).

© Dii Desert Energy

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Slide: Paul van Son

Presenting on behalf of Frank Wouters too, Paul tells us more about the Middle Eastern hydrogen market and quotes Frank who notably said when presenting on the topic of H2 in the Middle East; Hydrogen is the new oil. Saudi Arabia and the UAE have shown heightened interest in hydrogen, and these regions are developing technologies to tackle water scarcity. One option is used water - treated sewage water and another is desalination with technologies to remove minerals needed in the hydrogenation process.

Anton Tvelenev, Global Petrochemicals Director at KBR reinforces the notion that premium land economies may seek to import renewable energy carriers rather than generate in situ. He presents an in depth case study undertaken by KBR on local readiness for Hydrogen adoption in Singapore. The crucial insights of this presentation were far too numerous for this report; but Anton highlights evolving carbon pricing and other disruptive green routes will help pace hydrogen economy adoption.

Climate Change Momentum - a Tailwind for Green H₂



1992 Rio Earth Summit – UNFCCC, Principle 13:
Develop national law regarding liability and compensation for the victims of pollution and other environmental damage.



2005 EU ETS
First emissions trading system, covering 45% of EU greenhouse emissions



COP21-CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE

2015 Paris COP 21
Nationally Determined Contributions (NDCs) to keep global avg. temperature rise to below 2°C relative to pre-industrial levels by 2050



2019 European Fin Giants divest from fossil fuels
ING, BBVA, BNP Paribas, Société Générale and Standard Chartered pledge to be aligned to COP21



2020 European Green Deal
European Climate Law proposals for further emission cuts by 2030



Glasgow COP 26
All nations to present detailed plans to cut carbon emissions. Further EU Green Deal detail?

5 | Proud history, bright future.

Proud history, bright future.

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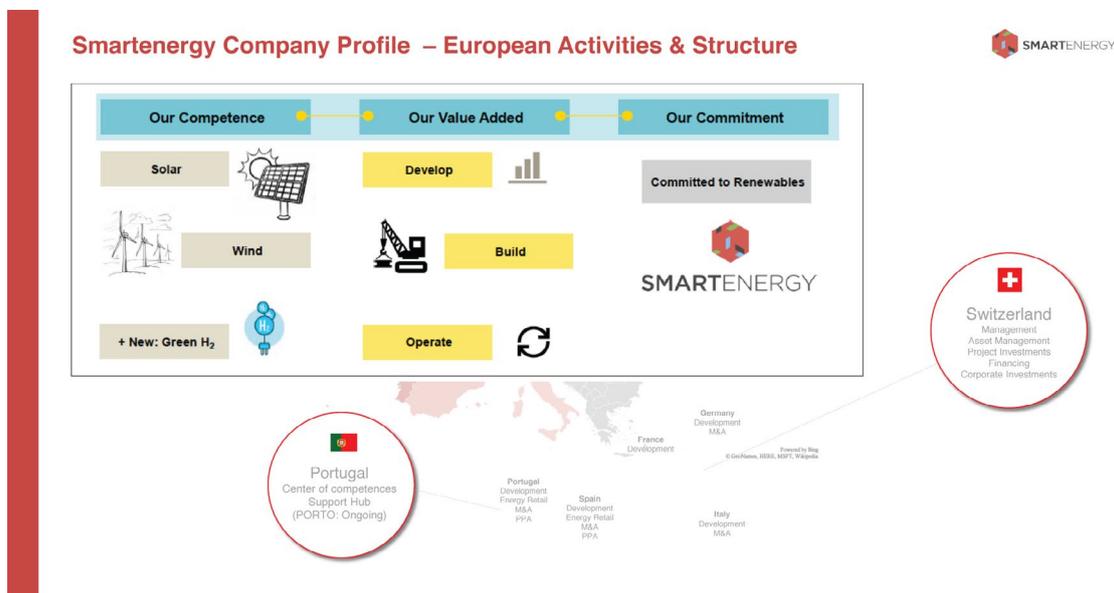
Slide: Anton Tvelenev

THE FIRST DAY OF SUMMIT REACHES A CLOSE.

Opportunity in the Challenge

His Excellency João Galamba, Deputy Minister and Secretary of State for Energy, Portugal, is here to greet our returning audience for the opening of our second day of the summit, setting out an ambitious National Energy and Climate Plan to contribute to the decarbonisation of Portugal and the rest of Europe. The Deputy Minister recognises Hydrogen as a missing link in their former energy strategy, and with its new draft it has become an enabler across sectors and objectives that unleashes economic potential. The Deputy Minister turns challenge in to opportunity, leveraging carbon neutrality to promote growth, investment and employment opportunities within the nation, in an exemplary vision which could pave the way for many future solar energy economies.

Christian Pho Duc, Managing Director, Smart Energy Projects follows by walking us through the reality we face within the energy transition, and hydrogen's role in decarbonisation. Christian highlights the cost reality and the best paths ahead for Hydrogen and makes a call for the support of the public to drive the market with heightened societal acceptance. He highlights it is our mission to educate the public and get their support and create a widespread understanding for hydrogen beyond the hydrogen community.



Slide: Christian Pho Duc

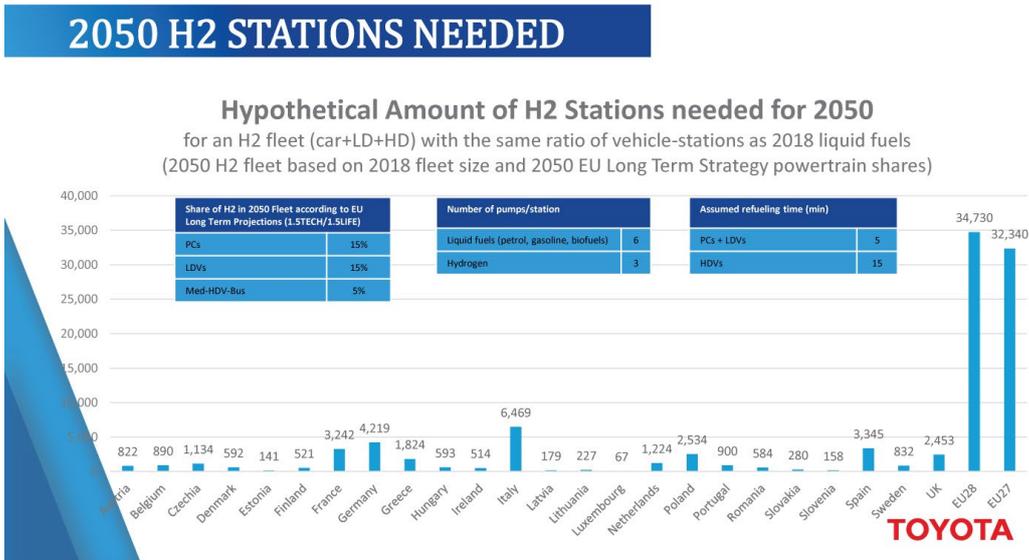
Dennis Hayter, Deputy Chair, UKHFCA moderated a unique panel we were lucky to hold with Guy Janssens, Chief Corporate Affairs Officer, The Port of Antwerp, Eduard De Visser, Director Strategy and Innovation, The Port of Amsterdam and Cas König, CEO, Groningen Seaports NV.

This is an opportunity to look at the transportation of Hydrogen in the maritime sector, with major ports authorities present to consider the vast opportunities for hydrogen within the sea land interface, which led us to innumerable key points. The group discussed location of industrial activities, commercial and residential land use resolution, vessel operations, and the handling of cargo. What do ideal hubs and clusters look like in the maritime sector? Through the discussion the complexity of maritime sectors' Hydrogen ambition deepens and collective efforts are more needed than ever to achieve this.

Dr Anita Sengupta, CFO & Chief Product Officer, Airspace Experience Technologies and Jasper van der Vorst, Senior Research Engineer, NLR – Royal Netherlands Aerospace Centre, Netherlands recognise we are still a long way away from a hydrogen solution for aviation and walk us through the commercial and research developments in operations, policy and infrastructure. A discussion ensued from a member of the audience on the viability of aviation as a market for liquid hydrogen, considering significant technological delay and costs, which

costs. When you introduce a disruptive technology which simultaneously reduces operational and maintenance costs you reduce one of the biggest challenges in commercial aviation, but the investments have to start now for this to become real life.

Undeniably, mobility is evolving, and Hydrogen stations are the most above ground visible evidence. Dr Lars Rontzsch, Head of Department for Hydrogen Technology, Fraunhofer IFAM moderated a joint discussion with Dirk Schaap, Coordinator Hydrogen, Ministry of Infrastructure and Water Management, Didier Stevens, Senior Manager, European & Government Affairs, Toyota Motor Europe and Dr Ward van den Berg, Principal Consultant, AFRY on the topic of mobility infrastructure, hydrogen vehicles and refuelling stations.



Slide: Didier Stevens

David Sanders, Managing Director, Global Clean Energy Practice, FTI Consulting and Florent Baudu, Sales Director, Heavy Industry Market, McPhy discuss the engineering and supply of refuelling stations and electrolyzers with some early insights on the Djewels Projects.

DJEWELS project

CONSORTIUM MEMBERS

A PROJECT SUPPORTED BY:

- McPhy is member of the Djewels consortium**
- McPhy will supply the eletrolyzer technology for the first 20MW unit dedicated to renewable methanol in Europe**
- Djewels project will allow to validate at real industrial scale McPhy's pioneering electrolysis technology**

Slide: Florent Baudu

Emanuele Taibi, Power Sector Transformation Strategies, International Renewable Energy Agency (IRENA) shares some insights on role of green hydrogen in the energy transition by video contribution.

Ministerial Roundtable on Green Hydrogen



"In addition to power sector, there are other sectors which are very important, iron and steel, chemicals, and so on, and hydrogen can be very important there to decarbonize those so-called hard to abate sectors."
Fatih Birol
 Executive-Director of IEA

"Green hydrogen is gaining unprecedented political and business momentum, with the number of policies and projects expanding rapidly around the world."
Francesco La Camera
 Director-General of IRENA

"The first thing which I feel is that costs of electrolyzers have to come down."
Claude Turmes, Minister of Energy of Luxembourg

Slide: Emmanuele Taibi

As he joins virtually, he highlights comments from Dr Fatih Birol, Francesco La Camera and Minister Claude Turmes who backed hydrogen at the ministerial roundtable during IRENA’s annual assembly and urges the community to focus on a few key messages;

- The recognition of Hydrogen as a key solution to decarbonisation
- Increased ramping up of green hydrogen production
- Accelerate the deployment of renewables
- Take advantage of new global trade of low carbon commodities

John Williams, Principal Consultant, AFRY Management Consulting moves us on to production, storage and distribution technologies with our first speaker, whom he crowns the conference’s best hydrogen related name!

Siying Huang, Senior Business Development Manager, Hydrogenious talks about LOHC technologies and their role in distribution so that many countries can take advantage of the international green hydrogen trade. This is crucial to enable safe and efficient transport in ambient conditions for industrial, mobility and energy end users. Siying claims that proprietary research shows their chosen carrier, thermal transfer oil, is the most suitable one for the commercialisation of their technology. With a number of cost and chemical analyses, Siying goes on to share more on the large-scale hydrogen storage in LOHC at the H2 Mobility refuelling station in Erlangen for 2020 as depicted below.

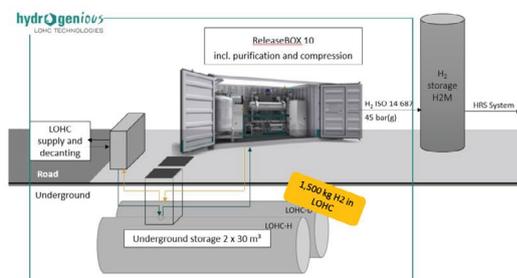
Hydrogenious LOHC will demonstrate large-scale hydrogen storage in LOHC at the H₂Mobility refuelling station in Erlangen in 2020



Project description

- Implementation of first German LOHC HRS in Erlangen
- Worldwide first 1.5 t hydrogen underground storage by LOHC
- Dehydrogenated with ReleaseBOX 10
- Delivering hydrogen according to ISO 14 687-2

Key Partners



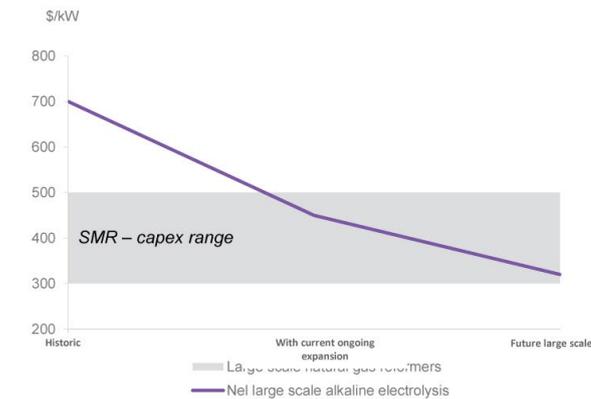
Slide: Siying Huang

Luc Graré, VP Sales and Marketing, Nel Hydrogen Electrolyser opens by sharing Nel are working very hard on the CAPEX to bring costs down for electrolysis. He points out a missing element in the hydrogen market, a hydrogen ecosystem. We are missing a range of developers, engineering officers, EPCs, construction and more need to see the Hydrogen opportunity in order to achieve this.

Electrolysers reaching same capex levels as large scale steam methane reformers

The H2 opportunity

CAPEX of electrolysers set to reach parity with SMR in 2020 & drop below in foreseeable future



- SMR – “steam methane reforming” is dominating hydrogen production today, using natural gas and steam
- Nel is establishing a new manufacturing plant targeting a >40% cost reduction
 - Expect to see further reduction in capex with increased production volume, and further size scaling of products
- Nel foresees capex to drop below SMR over time
- Electrolysis expected to be the preferred production method if opex (i.e. power prices) are low enough (or at parity) with the alternative production methods

nel • Source: Nel

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Slide: Luc Grarae

Nel are famously delivering technology for Nikola the American truck builder, with over 14,000 in pre-orders. Nel are also supplying the HYBRIT Development, a SSAB LKAB and Vattenfal joint venture for a 4.5 megawatt alkaline electrolyser, a significant step for the decarbonisation of the steel industry.

John Williams sums up key challenges and opportunities to consider for the development of a hydrogen project from renewables and a discussion with Siying and Luc ensues.

The Chairwoman thanks the audience and the speakers as we bring the World Hydrogen Fuels Summit 2020 to a close. In historically unusual circumstance, hundreds contributed to an extraordinary triumph of an event whose insights I hope will ripple across the value chain for a stronger, more consolidated market.

HELP SHAPE THE FUTURE OF HYDROGEN

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TO WELCOMING
YOU NEXT YEAR
MARCH 2021**

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