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Natural Gas to Blue Hydrogen and Ammonia – Transportation to markets and Decarbonisation in multiple sectors

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REINERTSEN New Energy AS

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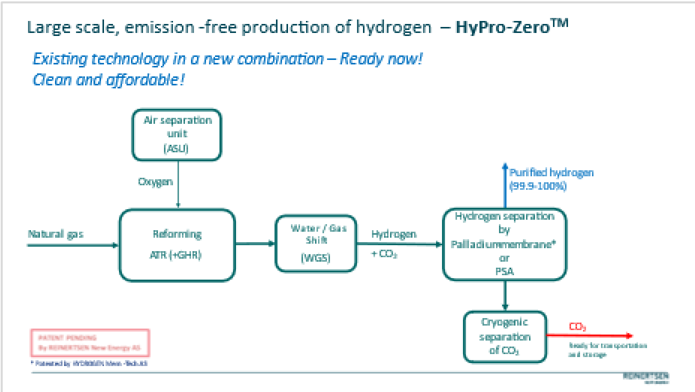
.... Developing Clean Energy Solutions

Natural Gas to Blue Hydrogen and Ammonia – Transportation to markets and Decarbonization in multiple sectors

Electrification is the most important tool for decarbonization of Europe but will be limited by insufficient renewable electricity production capacity and flexibility. In addition, Hydrogen and CCS will play an important role in decarbonization. However, hydrogen produced clean, in large volumes at a competitive cost will be needed.

Until recently, EU's hydrogen strategy is focused on producing green hydrogen from scarce renewable energy. An obvious alternative would be to produce large volumes of blue, competitive hydrogen, emission-free from natural gas (not LNG?). The CO2 biproduct will have to be transported to a safe storage facility. The EU could get access to large volumes of blue hydrogen and ammonia by import from Norway and other regions.

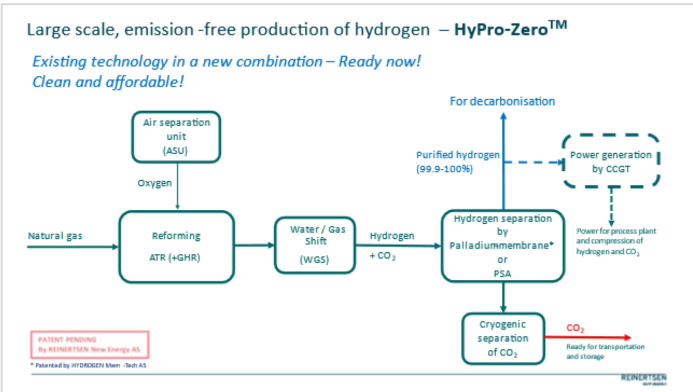
We have investigated the feasibility of blue hydrogen and ammonia production in Norway, storage of the CO2 close to the production site, as well as the transportation of hydrogen and ammonia to the market, and the use of it for decarbonization in multiple sectors.



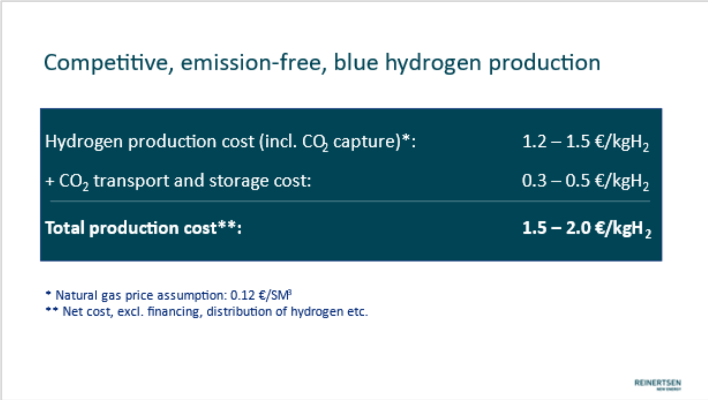
New and cleaner processes have recently been promoted by REINERTSEN New Energy and others. We have developed a process named HyPro-Zero™ based on Autothermal Reforming (ATR), fed by oxygen from an Air Separation Unit (ASU), Palladium membrane or PSA for H2 separation, and cryogenic separation of CO2.

The process solution has been further developed to an ultrahigh CO2 capture rate of close to 100% and no need for import of renewable electricity. The technology is proven and can be built, now! Ready now!

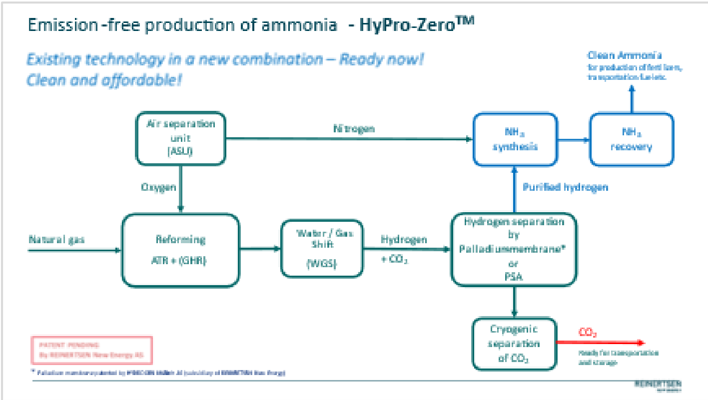
If renewable power is not available, a hydrogen power plant can be added.



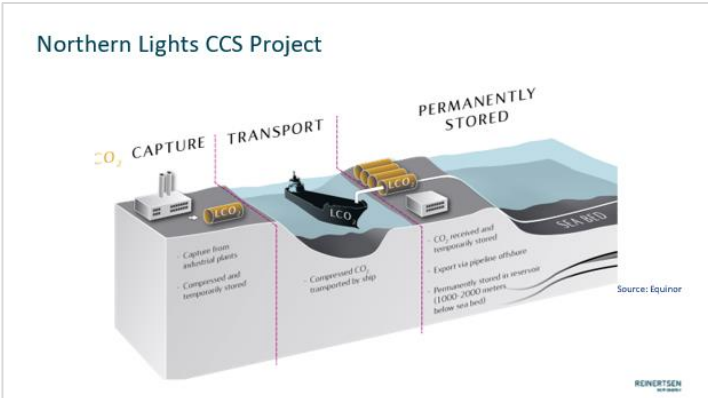
The hydrogen production cost, including CCS is estimated to 1.5 – 2.0 Euro/kgH2, the higher figure is valid for ultra-high CO2 capture rate and no power import. The production cost of blue hydrogen is less than half of green hydrogen!



The process (HyPro-Zero) can be extended with a "Bolt on", standard ammonia production plant. Again, the CO2 capture rate is very close to 100%!

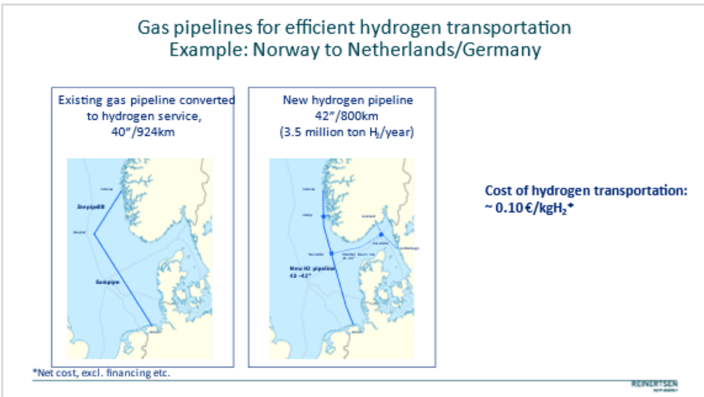


Although we have developed our HyPro-Zero process, we are a product and technology independent engineering company that will work out the best solutions for our client's projects.



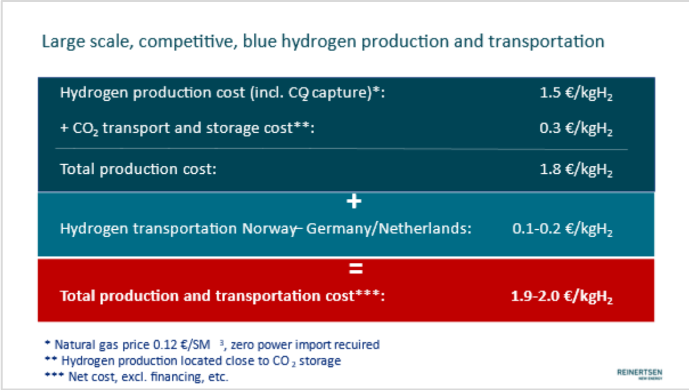
CO2 storage is a prerequisite for clean hydrogen production from natural gas and several projects are being developed in Norway, Netherlands, UK, US and other countries.

Several projects are being developed for transportation of hydrogen, 100% or blended in new or repurposed gas pipelines and networks. The H2 transportation cost for such systems may be very competitive. Studies of a repurposed 40-inch gas pipeline from Norway to Germany or alternatively a new 42-inch pipeline indicate a transportation cost as low as 0.1 Euro/kg H2! The main cost element is the energy for compression.



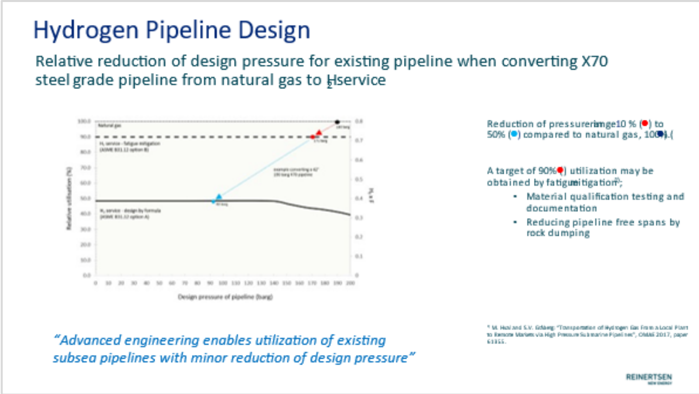
We have been involved in pipeline design, H2 compressor station design (potentially the world's largest!), and H2 de-blending/extraction station at the landfall.

The production and transportation cost adds up to about 2.0 Euro/kg H2, delivered onshore in Netherlands/Germany!



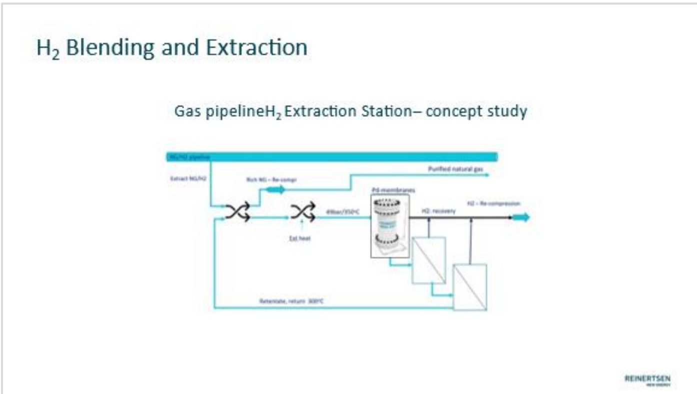
Examples of studies:

Advanced engineering enables utilization of existing subsea pipelines with minor reduction of design pressure.



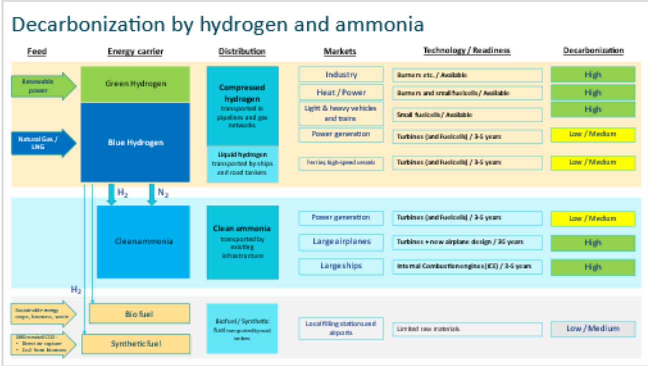
Hydrogen compression study! The world's largest!

Our proposal for de-blending/extraction station at the landfall, using Palladium membrane technology.



Sorry about this busy picture, but in summary, hydrogen can most economically be transported and distributed as compressed hydrogen in pipelines, or as ammonia by ships or road tankers.

The most relevant markets for compressed hydrogen will be industry, heat&power and transportation. For clean ammonia the main markets will be marine shipping and possibly aviation. For clean ammonia, the existing ammonia infrastructure and logistics can be used and expanded.

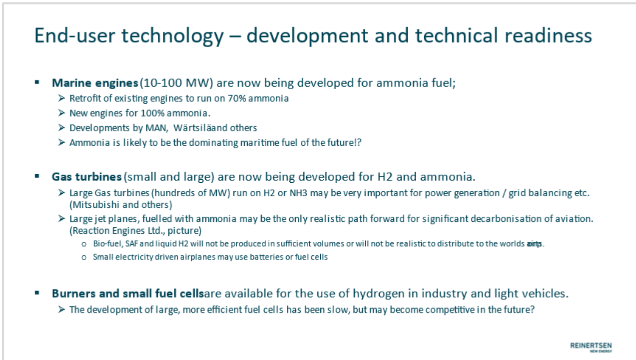


Both compressed hydrogen and ammonia may be important for power generation and powergrid balancing.

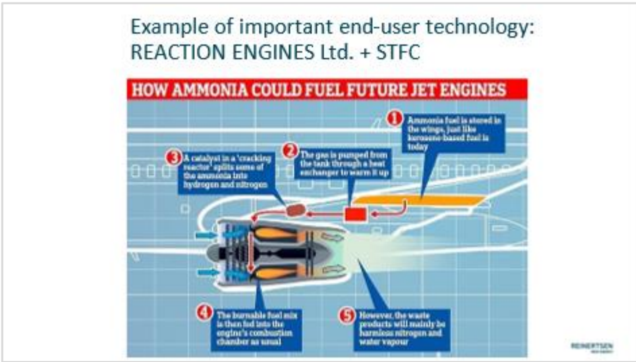
For liquid hydrogen we see a marginal market, only.

End-user technology and TRL

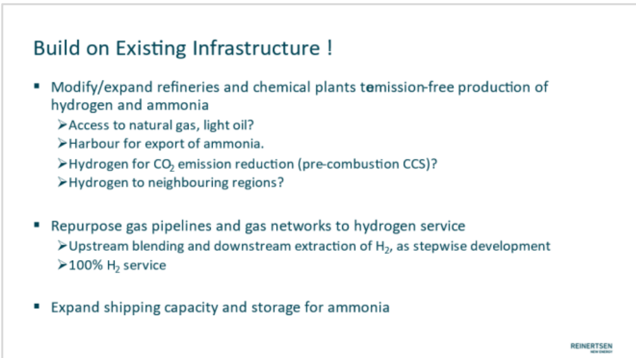
The most important, end-user technology developments for the next years include turbines and internal combustion engines (ICE) run on 100% hydrogen and ammonia. (Fuel cells are currently available, but the capacity is very limited.)



The development ICEs (diesel engines) are important for the maritime, power generation and compression. Wartsila, MAN and others are developing engine modification packages for up to 70% ammonia fuel, and new engines for 100% ammonia.



The ongoing development of turbines is important for power generation, compression and probably for aviation (jet engines). NOx emissions need to be controlled at an acceptable level. (Mitsubishi and GE).



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Thank you for your attention!

We find it most motivating to develop low carbon technology and solutions for a clean planet (for all) and we want to involve the next generation in the transition!