Clean hydrogen for a market ramp-up and for climate-neutral steel

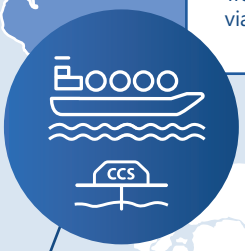
H2morrow steel

1. Natural gas supply

Production, transport and import of natural gas from Norway using existing infrastructure

5. Offshore CO_2 storage

Transport of captured CO_2 – for example via ships and offshore storage in Norway

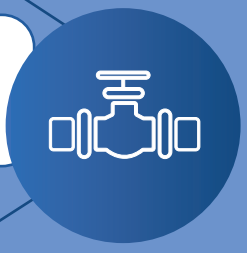


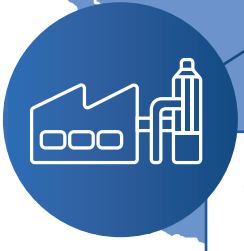
2. Hydrogen production

Natural gas reforming and CO_2 capture at a site on the German or Dutch coast

3. Hydrogen transport

Transport to site of consumption via pure hydrogen pipelines





4. Production of climate-neutral steel

Production of climate-neutral steel in Duisburg by utilizing hydrogen

thyssenkrupp

equinor

OGE

H2morrow steel

Norwegian energy company Equinor, natural gas transmission system operator OGE and steel producer thyssenkrupp Steel Europe (tkSE) have concluded a joint feasibility study by the end of 2020 evaluating a suitable model of producing and transporting blue hydrogen to the largest German steel mill in Duisburg.

Blue hydrogen is obtained from natural gas reforming in combination with carbon capture and permanent offshore storage (CCOS) of CO_2 under the seabed of the Norwegian part of the North Sea. CCOS allows for a 95 percent reduction of the carbon footprint. Another major advantage is that large quantities of nearly climate-neutral hydrogen can be produced using proven and available technology and at competitive prices. Hence, the industrial hydrogen demand can be met in a short time frame. Blue hydrogen is thus a complementary solution to other hydrogen production methods: It enables the relatively fast transition into a clean hydrogen economy and is available in high volumes 24 hours a day and 7 days a week.

Project Layout

At this stage in the project planning, it is expected that natural gas from Norway will be transported via the existing pipeline grid to an autothermal reforming plant (ATR) located on the North Sea coast. A potential production site on the Dutch coast in Eemshaven and two other potential sites on the German North Sea coast are principally suitable. The plant is contemplated with a capacity of up to 800,000 Nm^3/h of hydrogen (~2.7 GW), of which 200,000 Nm^3/h (~0.6 GW) is envisioned to be provided to third parties. The remaining roughly 600,000 Nm^3/h of hydrogen (~2.1 GW) will serve the steel production of thyssenkrupp Steel Europe, providing energy for up to 7 million metric tonnes of climate-neutral steel per year. Based on market forecasts by renowned external market analysts, the study estimates a price for blue hydrogen of approximately 2.1 €/kg (corresponding to 58 €/MWh) based on a long-term average natural gas price of 23 €/MWh. The H2morrow steel project concludes that the complete proposed value chain could begin operations in 2027 the earliest. The produced hydrogen will be transported from the ATR by pipeline to industrial sites, such as in North Rhine-Westphalia. For this transportation, a combination of existing German and Dutch gas pipelines converted to hydrogen and a 37 km new-built connection to the Duisburg steel mill are to be utilized.

At the ATR, the CO_2 separated in the reforming process will be captured. With regard to the transport and storage of CO_2, the study has investigated potential CO_2 storage sites with the Northern Lights project in Norway and other storage options, e.g. the Porthos project offshore of Rotterdam, of which the Northern Lights project is most advanced. Northern Lights a joint venture between the energy companies Equinor, Shell and Total, is to a large extent funded by the Norwegian State. The full-scale CCOS project captures, transports and safely stores CO_2 below the seabed off the Norwegian coast. To reach its final destination in the subsurface of the Norwegian North Sea, the liquified CO_2 will be transported by ship to a receiving terminal on the Norwegian west coast and from there onwards by a 120 km pipeline to an offshore injection point where the CO_2 will be injected into the storage reservoir more than 2.600m below the seabed. CCOS is a well-proven technology that has been used offshore Norway for more than 24 years. The CO_2 deposits are monitored closely, and no CO_2 leaks have been observed or detected during this period. The CCOS technology is firmly established in Norway and is supported by the state and society at large.

In summary, blue hydrogen can enable an efficient transition into a clean hydrogen economy by providing high and reliable volumes for the industry. However, regulatory changes regarding the transportation of hydrogen in public grids, the acknowledgement to transport CO_2 by ship as well as a compensation mechanism to neutralize additional costs for climate-neutral steel are necessary preconditions for the project realization.

- **Targeted reforming capacity of up to 800,000 Nm^3/h (2.7 GW)**
- **Thereof, 600,000 Nm^3/h of hydrogen (2.1 GW) for thyssenkrupp Steel Europe, 200,000 Nm^3/h to be provided to third parties**
- **Up to 7 millon tons of climate-neutral steel per year**
- **H2morrow steel enables up to 11 million tons of CO_2 savings per year (currently: 18.5 million tons of yearly CO_2 emissions)**
- **thyssenkrupp Steel's long-term goal: Full climate neutrality (10 million tons of climate-neutral steel per year)**