Explained:

Hydrogen production in Norway

Hydrogen can be an energy carrier where batteries cannot be used. For example, hydrogen storage weighs one-seventh of the battery needed for a speedboat traveling between Trondheim and Kristiansund.

To achieve zero CO2 emissions, the world must decarbonize areas where hydrogen is better suited than batteries. This includes industry, maritime transport, and some forms of energy storage. Figure 1 shows areas of use ranked by performance compared with alternative fuels or inputs. According to the International Energy Agency IEA, the production of hydrogen with low or no emissions must increase 16-fold by 2030 to limit global warming to 1.5 degrees.

Hydrogen is an energy carrier, not an energy source. It can be produced from electricity and water or extracted from natural gas. Greenhouse gases may be released during production, but during use, only water is emitted. Today, hydrogen is used on a large scale industrially and as a fuel in some niche applications.

Hydrogen is usually classified according to its production method:

- **Green hydrogen**, where renewable electricity is used to extract hydrogen from water.
- **Blue hydrogen** from natural gas, where the CO2 is captured and stored. Currently, very little blue hydrogen is produced.
- **Gray hydrogen** from natural gas emits greenhouse gases and accounts for most of today's hydrogen production.

GREEN HYDROGEN

Norway has the prerequisites necessary to produce green hydrogen: cheap renewable electricity, advanced research communities and industrial experience. Production can start on a small scale. It is estimated that the production of green hydrogen can employ up to 15,000 people in Norway.

Significant power demand

The process industry estimates that reaching zero emissions will require 16 TWh of hydrogen, corresponding to 10% of current hydropower production. If the process industry and parts of the transportation system are to be run on green hydrogen at the same time as the society is electrified, Norway will need large amounts of new renewable energy.

Hydrogen

- is an energy carrier similar to batteries
- is necessary to achieve the climate goals
- is produced from renewable energy and water (green), or natural gas with CO2 storage (blue)
- can become a big industry in Norway, but requires support
- needs a market in the EU and expertise from the oil industry

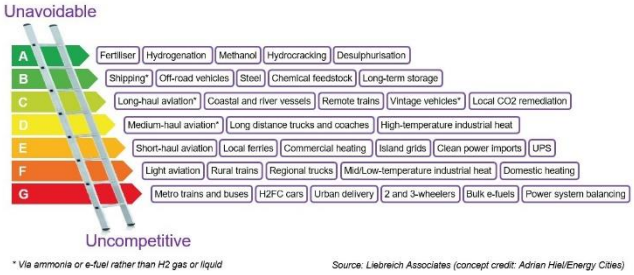

Figure 1: From Liebreich Associates A = more probable areas G = less probable areas

Can regulate renewable energy

The production of green hydrogen can be adapted to the supply of variable energy from wind and solar. Instead of expensive power grid development, green hydrogen can carry the energy.

Mainly export of technology

The core technology for green hydrogen production is the electrolyser, where an electrical potential draws hydrogen out from water molecules. Norway has well-developed industrial expertise in electrolysers, and the global market is significant.

Export of hydrogen from Norway will entail significant transport costs and a domestic market is necessary to develop technology and competence. These will be valuable commodities for the EU and can strengthen Norway's reputation as a green energy nation.

Falling prices, still expensive
When the production of electrolysers is scaled up to industrial level, prices will fall, as happened with solar cells. More renewable power production reduces operating costs, but it is uncertain when green hydrogen will be competitive with alternatives such as blue hydrogen, fossil energy sources and batteries.

BLUE HYDROGEN

Norway has natural gas reserves that can form the basis for blue hydrogen, as well as advantages through the process industry and experience with the handling of gases. Blue hydrogen production is more profitable on a large scale with large developments.

Significant emission cuts and extended value chain
Carbon capture in the production of blue hydrogen will be over 90% efficient, and the emissions are much smaller than if the natural gas is used directly. With stricter emission targets worldwide, natural gas will lose market share. A value chain for blue hydrogen can secure the value of the natural gas reserves.

The production potential is greater than the demand in Norway which provides opportunities for export. Processing of natural gas for hydrogen will be a step up in the value chain for Norwegian industry, and SINTEF estimates that blue hydrogen can employ up to 40,000 people in 2050.

Export of gas, import of CO2
There may be savings in the use of existing gas infrastructure with hydrogen production located in Europe, and subsequent carbon storage in the North Sea. This will move value creation and competence away from Norway.

Carbon capture and storage is the key to price
The cost of blue hydrogen has four components: natural gas extraction, hydrogen production, carbon capture and storage, and handling and transportation. The first two are well-established markets.

Carbon capture and storage is the triggering technology for blue hydrogen. Large-scale projects such as Longship make blue hydrogen cheaper and more attractive.

POLITICAL ISSUES
The Government's hydrogen roadmap sets targets for 2025 for hydrogen hubs, production projects and projects for solutions and technology. It calls for a stronger focus on the development and implementation of the technology, but the industry has higher ambitions.

Can Norway become a pilot country for hydrogen?
According to the IEA, a huge acceleration of the green shift is needed to avoid catastrophic climate change. Conversion of industry and transport to hydrogen requires mature solutions by 2030. Norway can become a leader, but this means that development must be started in 2025 with different types of production (green and blue), transport (compressed, ammonia, etc.), and use (industry, land transport, maritime).

In 2020, Norwegian support schemes used 770 million on hydrogen projects. In comparison, Germany will invest NOK 82 billion in 62 hydrogen projects in the coming years.

Will there be a market for blue hydrogen?
Today, 20% of the EU's energy is produced renewably, with a target of 32% by 2030. It will take time before the EU has enough renewable energy production to produce green hydrogen on a large scale. Nevertheless, there is resistance to blue hydrogen, among others from sunny countries with potential for green hydrogen such as Portugal and Spain. Without the EU market, much of the potential will disappear, as transport costs make other markets less profitable.

Norway can give signals about production and guarantees for blue hydrogen to European customers to influence the issue.

Is hydrogen slowed down by the oil sector?
The competence required for the production and handling of hydrogen coincides with the petroleum industry. Suppliers of the installations, operators, and expertise in gas handling and carbon capture and storage are required. But it is difficult for a new and unestablished industry such as hydrogen to compete against lucrative wages in the petroleum industry. The hydrogen industry needs both expertise and investment, both of which are tied up while the petroleum industry is the most profitable.

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