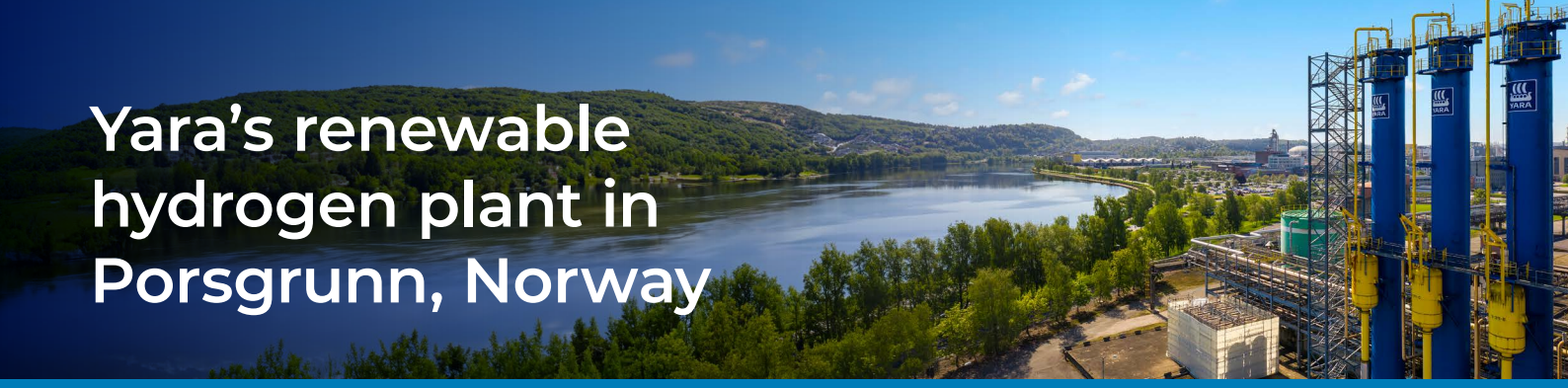
Yara's renewable hydrogen plant in Porsgrunn, Norway



Electrolyser:	**24MW PEM electrolyser from ITM Power (England)**
Delivery:	**Hydrogen >99% (residual water) at 30 bar**
Area of use:	**Ammonia production**
Hydrogen capacity:	**10 tonnes per day, no intermediate storage of hydrogen**
First hydrogen produced:	**September 2023**
Status:	**In stable production, not full capacity**
Ammonia production:	**20,000 tonnes per annum**
CO_2 reduction:	**41,000 tonnes per annum** For comparison, CO_2 reduction from road transport was 110,000 tonnes from 2021-2022 in Norway.
Enova support:	**<40% (max 283 MNOK)**
Final Investment Decision (FID):	**December 2021**
Design (Engineering):	**Linde Engineering, Dresden**

Largest challenges

- Scaling up of technology
- Early industrialization of PEM
- Very many components, several things can go wrong

Aim of the project

- Qualify the system PEM electrolysis + Haber Bosch (analyse for degradation products)
- Qualify new rectifier setup (IGBT)
- Qualify scale
- Developing and building markets for green products

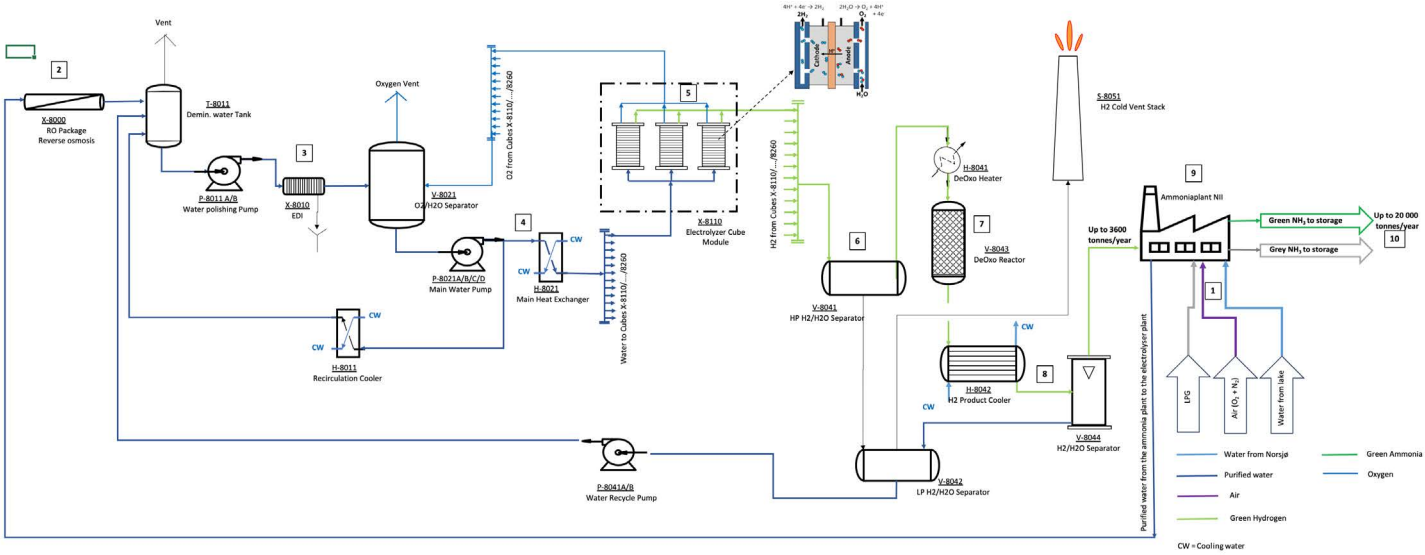
Key suppliers and place of production

- Electrolyser: ITM Power (England)
- Transformer: TMC (Italy)
- Rectifier: Danfoss (Lithuania)
- Water treatment plant: Suez /Veolia (Spain)
- Hydrogen separation: Silica (Germany)
- Plastic pipe: Plasticon (Poland/Germany)
- Build: Bilfinger (Norway)
- High voltage: Herøya Nett (Norway)
- Ventilation: GK Norge (Norway)

Renewable Hydrogen Process Description

Skrei Project

24 Mw
4800 Nm³/h (432 kg/h)



1. Feedstock (LPG (Ethane/Propane/Butane), air and water are fed into the ammonia plant.
   • Water from lake Norsjø is purified and sent to the electrolyser plant.

2. Purified water is further purified utilizing reverse osmosis.

3. The purified water mixed with recycle water from the process is purified. Ions are removed by means of EDI filters (electrodeionisation).

4. Purified water is pumped through the main heat exchanger and led to the 12 electrolyser cubes.

5. Each cube contains 3 electrolyser stacks consisting of multiple electrolyser cells.
   • Each cell is divided by a membrane.
   • Direct current electricity is supplied to the cells and ultrapure water is split into oxygen and hydrogen.
   • Hydrogen is formed on one side of the membrane, at the cathode, and oxygen is formed at the other side of the membrane at the anode.
   • Oxygen, together with excess water, is sent to the oxygen water separator.

6. Hydrogen from the cubes is sent to a separator, where water and hydrogen is separated.

7. There are traces of oxygen in the hydrogen. This oxygen is removed by utilizing a catalyst, where the oxygen traces are forced to react with hydrogen to form water.

8. After the DeOxo reactor, the hydrogen is cooled down and water is subsequently removed from the hydrogen stream prior to sending the hydrogen in a pipeline to the ammonia plant.

9. In the ammonia plant, the renewable hydrogen is mixed with synthesis gas (mixture of hydrogen and nitrogen). The gas mixture is compressed and led to the synthesis reactor where the hydrogen reacts with nitrogen to form ammonia.

10. The ammonia is fed to the ammonia grid/storage tanks to be used to produce fertilizer. It can also be used as an emission-free shipping fuel, for power generation or as an energy carrier.