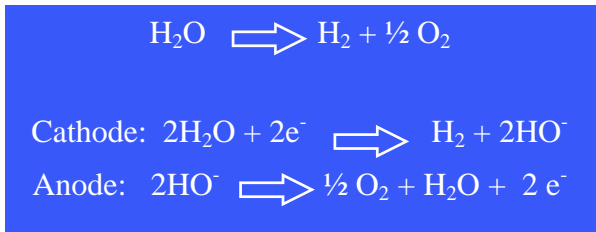
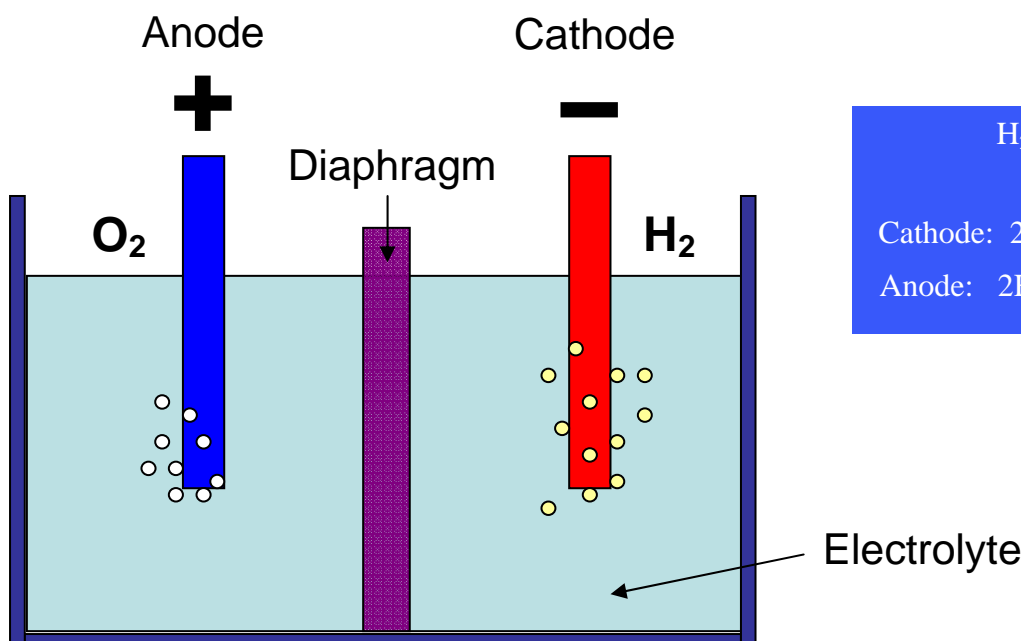


# Alkaline Electrolysis

## Process Principle



### Current status :

Alkaline electrolysis is a mature process: suitable electrolyzers are industrially manufactured. If the electricity is generated by CO<sub>2</sub>-free processes (renewables, nuclear), alkaline electrolysis is a sustainable way to produce hydrogen.

### Advantages :

- Mature process
- Low temperature (~ 80-90°C)
- High purity of the products (>99.8 % H<sub>2</sub>)
- Modular process

### Challenges :

- Electricity consumption
- Wholesale electrolyzers manufacturing

## Alkaline Electrolysis

**Process description:** Water decomposes at the cathode to hydrogen and HO<sup>-</sup>. The latter migrates through the electrolyte and a separating diaphragm, discharging at the anode liberating the O<sub>2</sub>. The electrolyte is an aqueous solution containing either NaOH or KOH.

**Energy:** Electricity

**Conditions:** 80-90°C and 0.1 to 3 MPa

### Materials:

Electrodes: nickel-coated steel

Diaphragm: asbestos or asbestos-free polymer

**Efficiency :** ~ 70 % LHV for the water conversion (electrolyser)

**Cost evaluation:** ~ 3 €/kg (for a 40 €/MWh<sub>e</sub> electricity price). The hydrogen production cost is highly dependent on the electricity price (~ 75 % of the final cost)



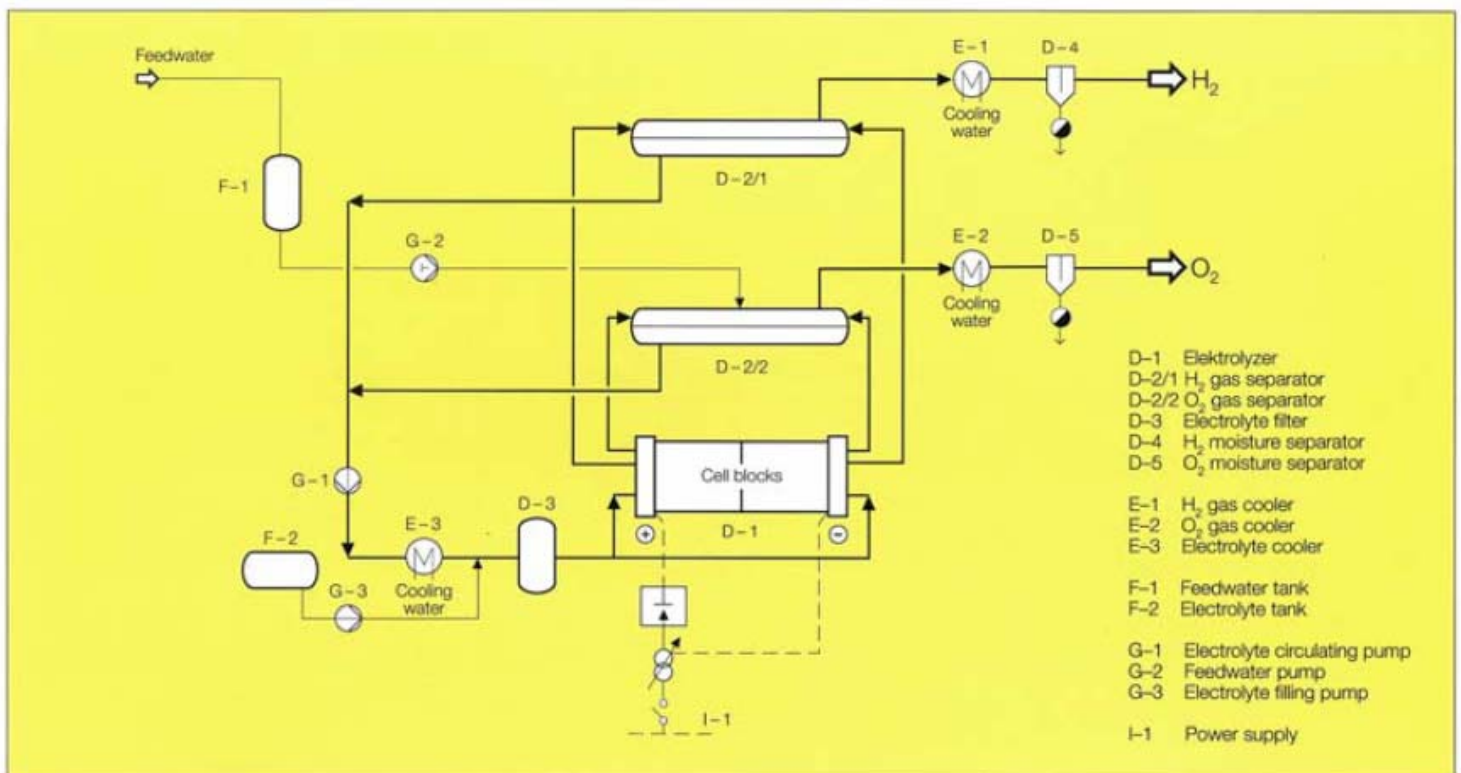


## IEA/HIA TASK 25: HIGH TEMPERATURE HYDROGEN PRODUCTION PROCESS

### Flow-sheet

In addition to the electrolyser, the overall plant comprises:

- transformer/rectifier,
- feedwater system,
- electrolyte station,
- gas and electrolyte coolers.



Flowsheet of pressure electrolysis plant

Source: IHT, Lurgi system

### Existing systems

The largest electrolyzers that are currently available for massive scale hydrogen production are provided by NorskHydro (485 Nm<sup>3</sup>/h; electrolyser pressure: 0.1 MPa - production pressure: 3 MPa) and IHT (Lurgi concept: 760 Nm<sup>3</sup>/h; electrolyser pressure: 3 MPa).

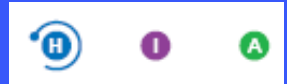
Other manufacturers choose to commercialize smaller units producing hydrogen with a higher purity or to a higher pressure (Teledyne, Hydrogenics/Stuart Energy, Accagen, Avalence).

Source: IHT,  
Lurgi system



Source:  
NorskHydro



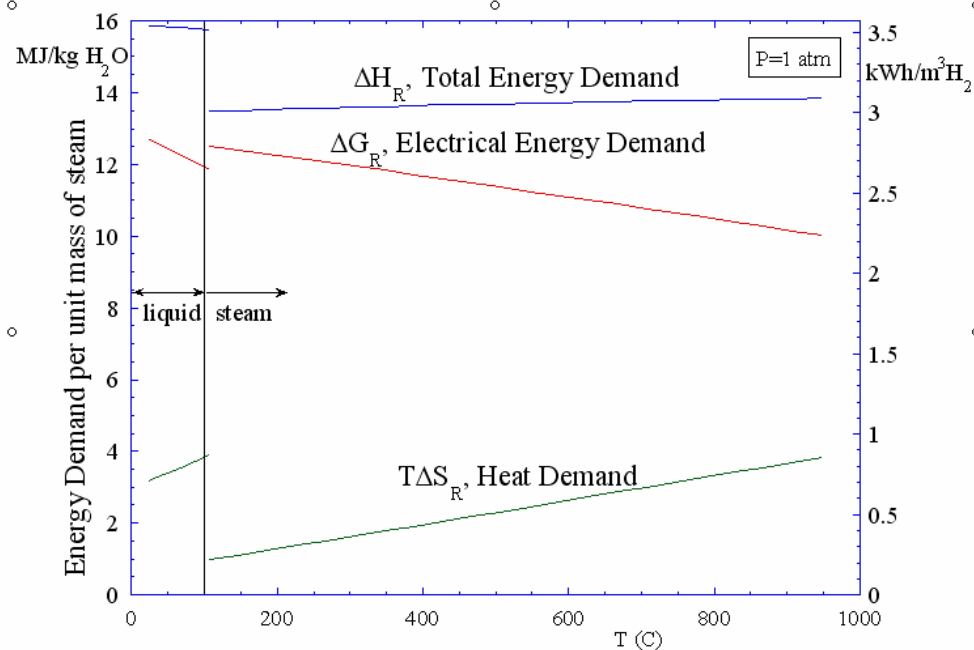


## IEA/HIA TASK 25: HIGH TEMPERATURE HYDROGEN PRODUCTION PROCESS

### Efficiency

The ideal reversible cell potential needed to split the water molecule is 1.23 V at 25° C which corresponds to a theoretical dissociation energy of 286 kJ/mol (15.9 MJ/kg) or an electricity demand of 2.96 kWh/Nm<sup>3</sup>H<sub>2</sub>. However, typical cell voltages are 1.80 to 2.05 V. Electricity requirements are then from 4 to 4.5 kWh/Nm<sup>3</sup>H<sub>2</sub> depending on the design and lead to an efficiency of around 65-75 % (Low Heating Value). High pressure electrolysis working at pressures up to 3 MPa allows a saving on the compression energy when hydrogen is stored as a pressurized gas or transported in pipelines.

Electrolyzing water steam instead of liquid water diminishes the electrical energy demand. Moreover, ohmic losses lessen when increasing the temperature. This explains the growing interest in high temperature electrolysis.



### Cost evaluation

Electrolysers are industrially manufactured. Current electrolyser investment costs range from 700 to 1300 €/kW (based on Low Heating Value). The overall cost taking into account the complete installation is around 50 % for a single electrolyser and decreases to ~10% for large plants (~100 electrolyser units).

The hydrogen production cost is very dependent on the electricity price ( ~ 75 % of the final cost). Therefore electrolysis plants take advantage of low electricity prices (off-peak periods, hydro power, ...).

For an electricity price of about 40 €/MWh, hydrogen production cost could be of ~3 €/kg. Hydrogen production costs are also tightly related to techno-economic models.



## IEA/HIA task 25: High Temperature Hydrogen Production Process

### Alkaline Electrolysis

#### Acknowledgements:

An IEA/ HIA Task was devoted to electrolytic production (task 4). It was completed in 1988 (see <http://www.ieahia.org>)

<https://www-prodh2-task25.cea.fr>

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