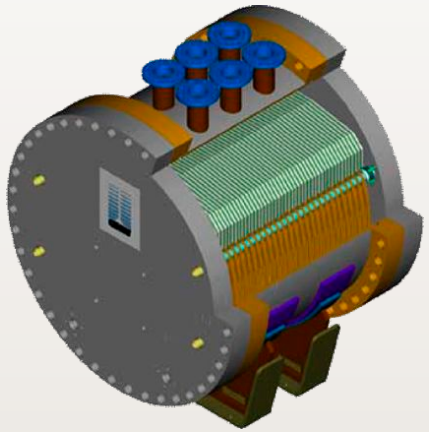
Classification: Internal



Water Electrolysis – Technology Developments

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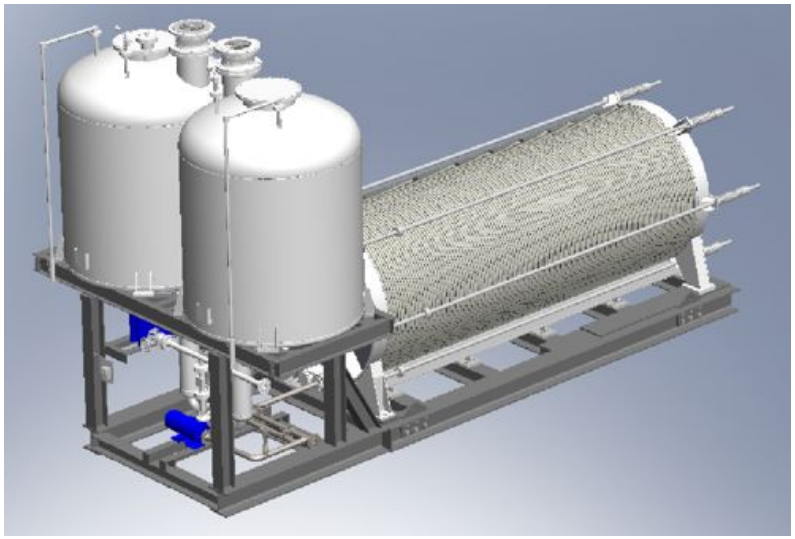
StatoilHydro

Hydrogen Technologies

- Fully owned by StatoilHydro, Norway's largest company with over 29,500 employees, the world's largest deep-water operator, third largest net seller of crude oil and a world-leader in the use of deepwater technology and carbon capture and storage

- We are a small and flexible company with 33 employees, with extensive use of R&D centres of StatoilHydro

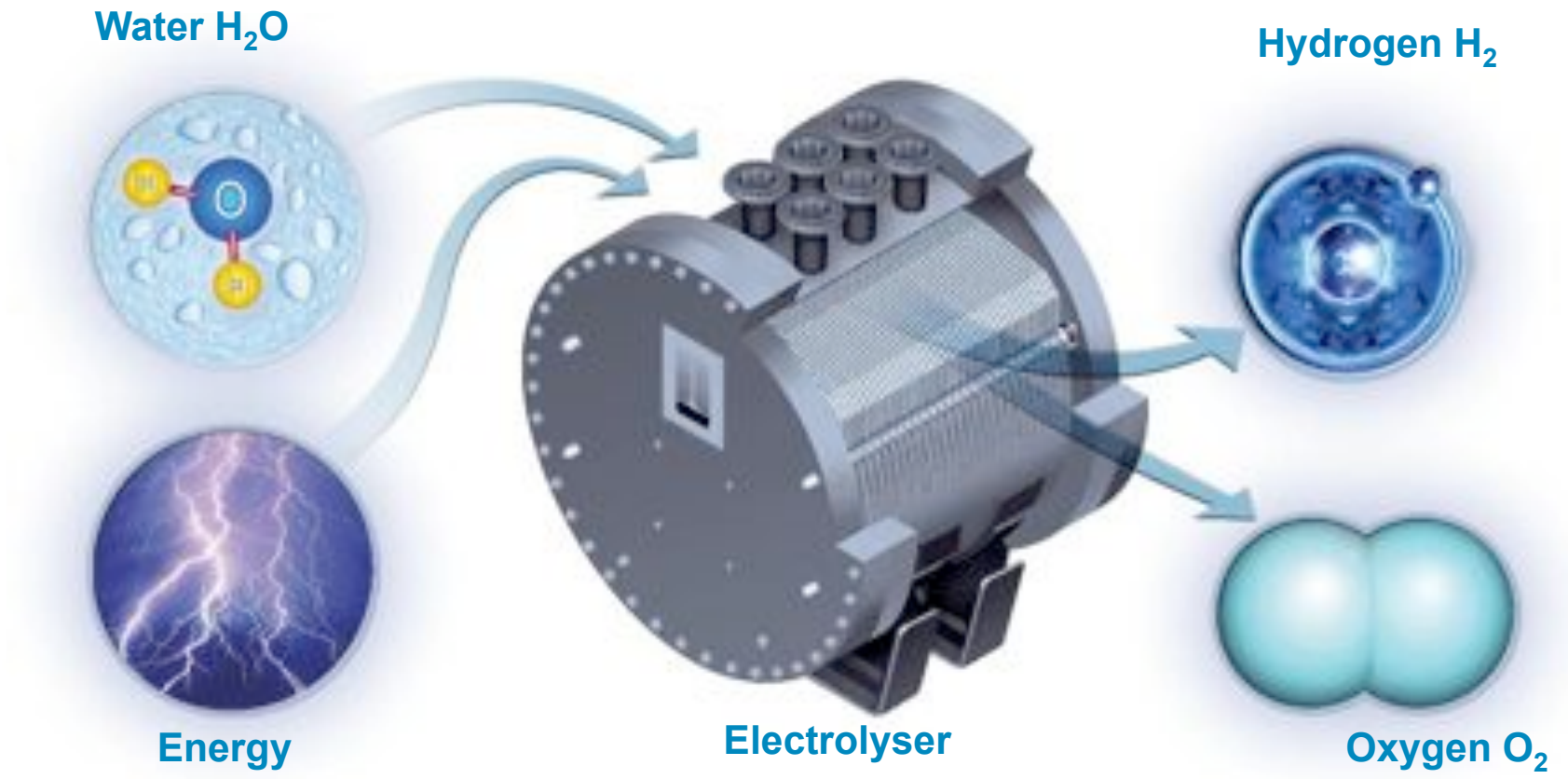
- Have a worldwide net of highly qualified local agents and site personnel



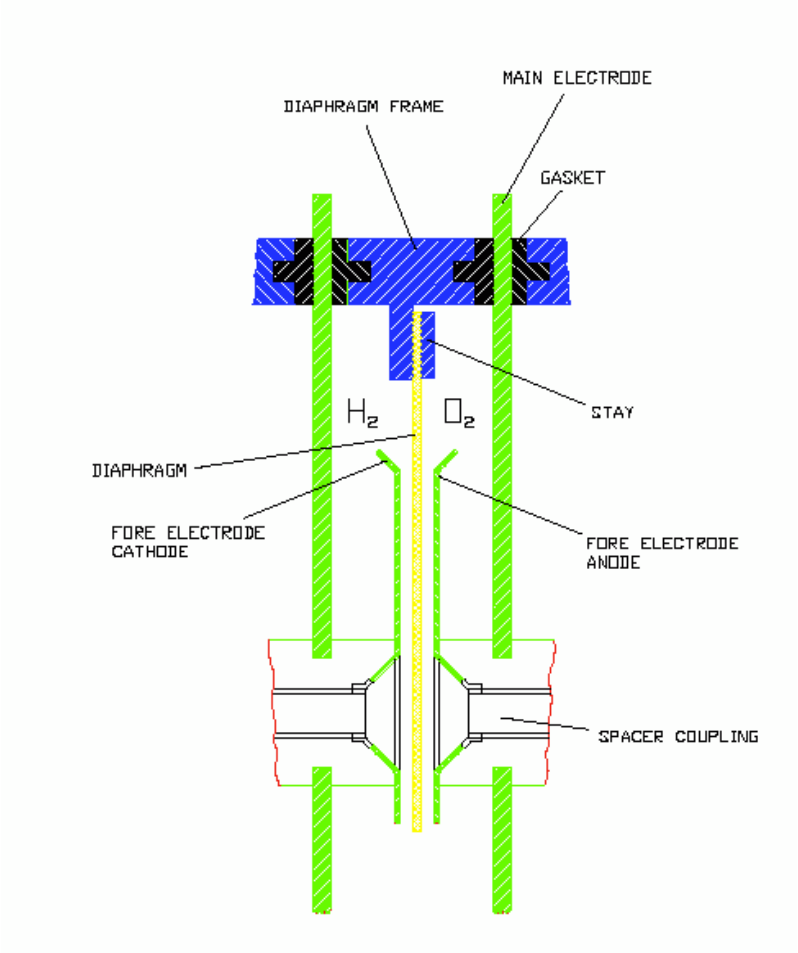
Company background

- A world-leader in water electrolysers – building on 80 years experience back to 1927 for Norsk Hydro's Ammonia plants.
- Constructed the two largest water electrolysis plants in the world with more than 300 electrolysers producing 30.000 Nm3/h at each plant.
- To date we have more than 500 units of electrolysers installed worldwide
- Among the first companies worldwide to develop complete solutions for hydrogen fuelling stations

Water electrolysis – the concept

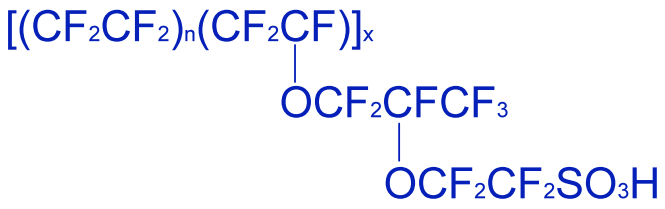


Alkaline Electrolysis - Cell Assembly Cross Section

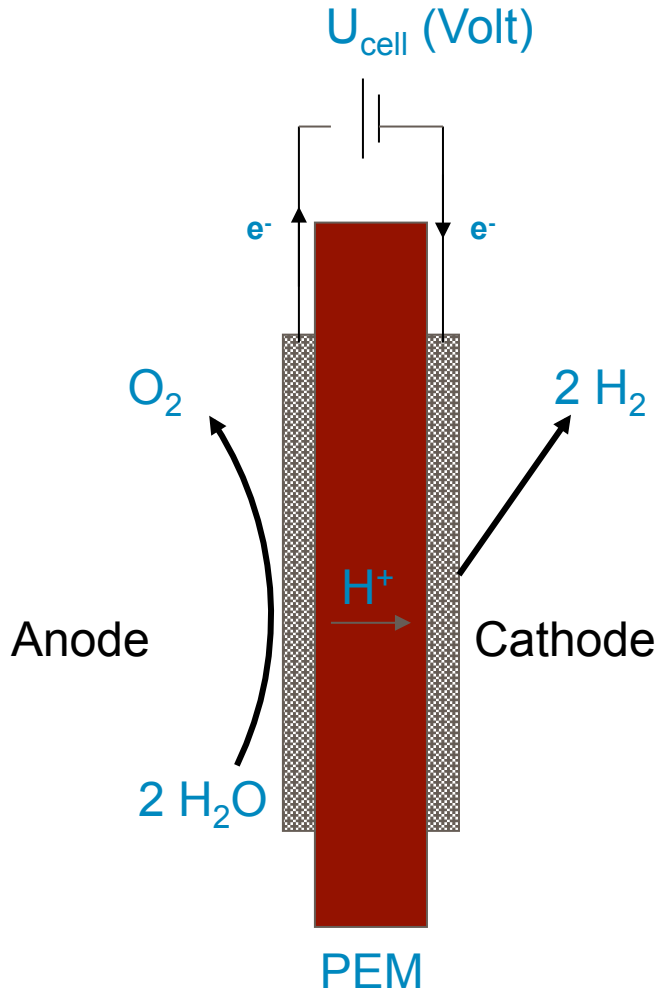


PEM electrolysers
Working principles PEM

- Proton Exchange Membrane (PEM) as electrolyte
  - Acidic
  - High proton conductivity
  - Low permeability towards gases
  - Chemically and mechanically stable



- Noble metals as catalysts

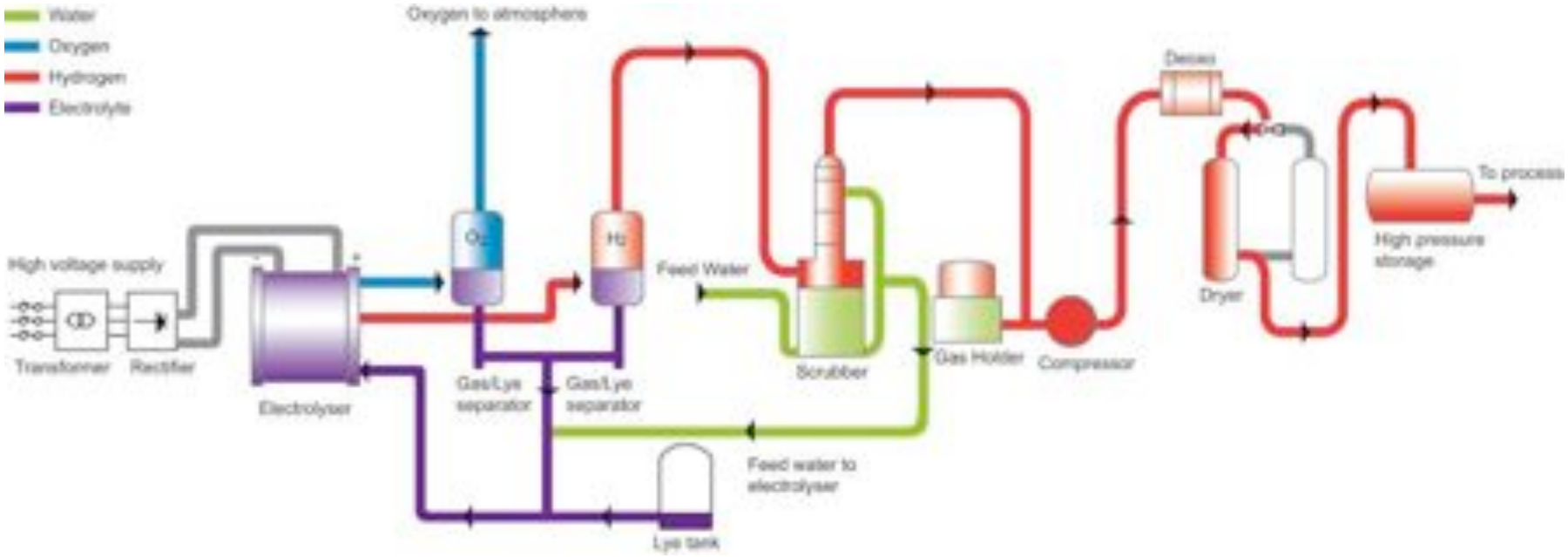


State of the art electrolysers for industrial applications – atmospheric alkaline technology

Benefits of our electrolysers

- Reliability, continuous H2 supply
- Safety
- High gas purity
- Cost-effective solutions
- Minimum maintenance
- Well proven and robust technology

Simplified Flow Diagram



Atmospheric electrolysers - Technical Data

Capacity	
Capacity range (Nm^3 H_2/hr)	10 - 485
Maximum Nm^3 H_2 per cell	2.11
Energy	
Power consumption at 4000 Amp DC (kWh/Nm^3 H_2)	4.1 ± 0.1
Power consumption at 5150 Amp DC (kWh/Nm^3 H_2)	4.3 ± 0.1
Purity	
H_2 purity (%)	99.9 ± 0.1
O_2 purity (%)	99.5 ± 0.1
H_2 purity after purification (%)	99.9998% (2ppm)
Pressure	
H_2 outlet pressure after electrolyser	200 - 500 mm WG
Maximum H_2 outlet pressure after compressor	440 bar g
Operation	
Operating temperature	80 °C
Operation	Automatic, 20 - 100% of max capacity
Electrolyte	25% KOH aqueous solution
Feed water consumption	0.9 litre / Nm^3 H_2

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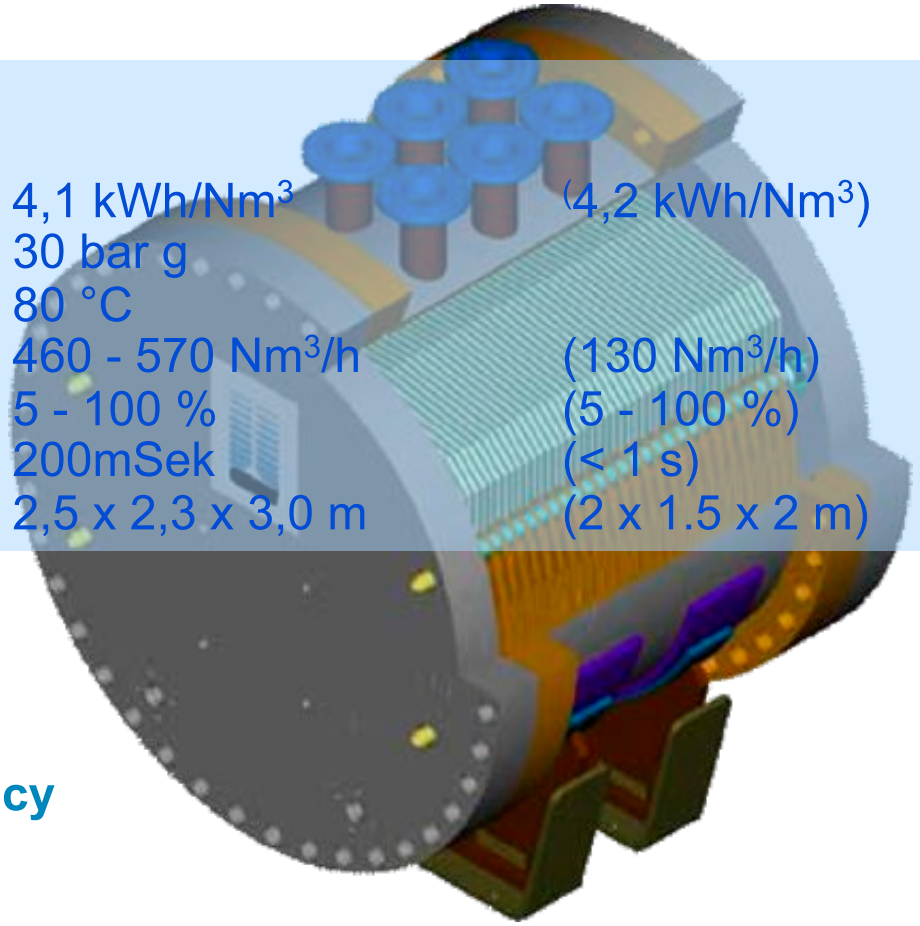
Development trends: 1. High performance electrolysers

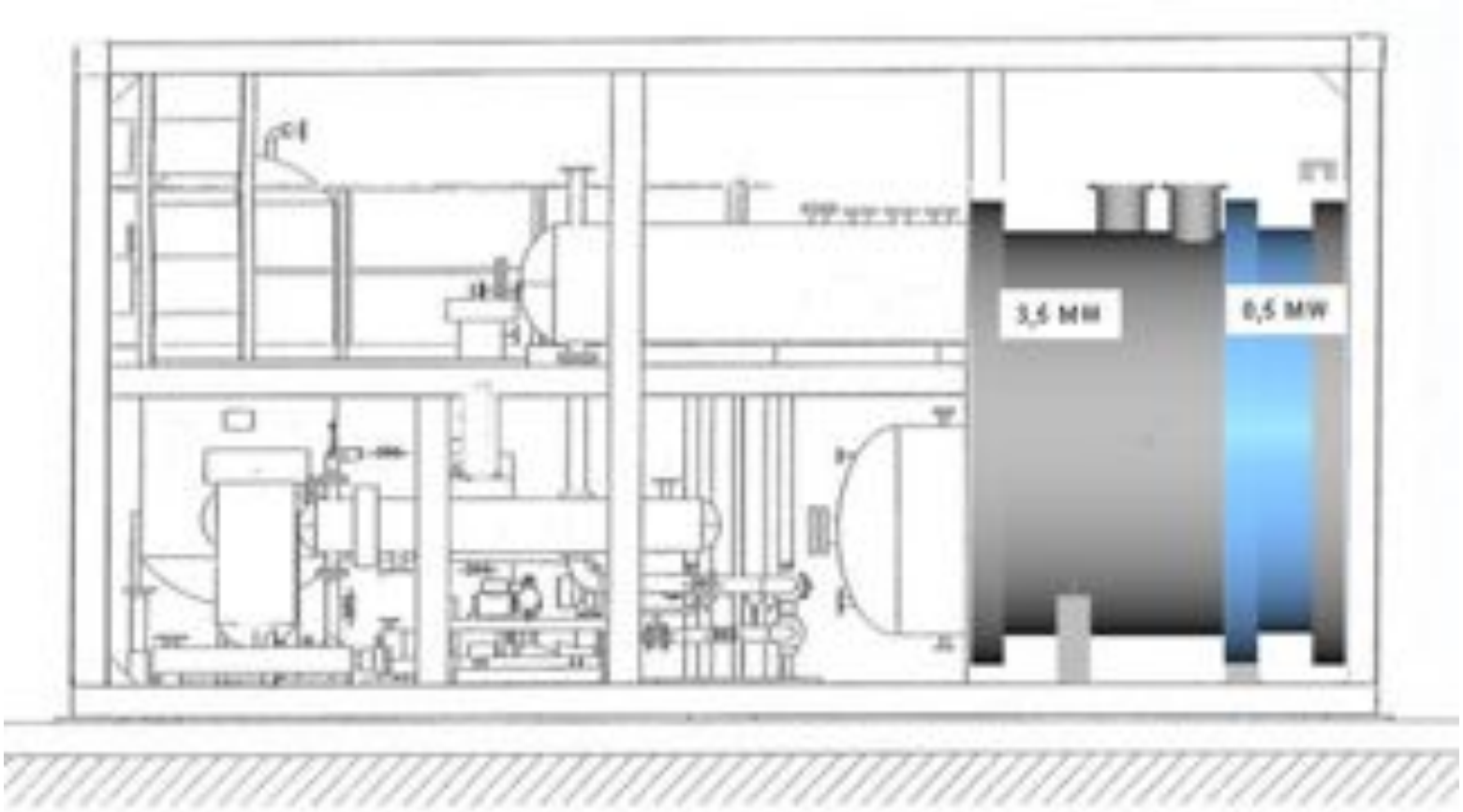
Targets:

Energy consumption	: 4,1 kWh/Nm^3	(4,2 kWh/Nm^3)
Operating pressure	: 30 bar g	
Operating temperature	: 80 °C	
Max. prod. capacity	: 460 - 570 Nm^3/h	(130 Nm^3/h)
Operational range	: 5 - 100 %	(5 - 100 %)
Response time	: 200mSek	(< 1 s)
Foot print	: 2,5 x 2,3 x 3,0 m	(2 x 1.5 x 2 m)



Small footprint, high efficiency

Comparison of the Systems



Comparison of Size / Performance, Old System / New System

Development trends: 2. PEM electrolyser

- Exceptional dynamic range and flexibility
  - Operational range 5 – 100 % of max capacity
  - Ideal for applications with variable power input
  - Response time (5-100%) in the range of milliseconds
- World class performance
  - High current density gives small physical size
  - Low ohmic resistance gives high energy efficiency
- Simple and safe operation
  - Designed to operate in a stand-alone configuration
  - Manual or automatic operation
  - Control system with 100% redundancy for critical safety functions
  - Remote monitoring and control
  - Requires only potable water supply (no lye)
  - No need to place cabinet in area defined as hazardous
- Modular design
  - Simplify service and maintenance
  - Ensures low down-times (estimate 4-6 hours for cell stack replacement)

Utsira - Making an island self-sufficient with renewable energy

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Main components

Wind turbine	600 kW
Hydrogen engine	60 kW
Fuel cell	10 kW
Electrolyser	10 Nm^3/h, 48 kW
Compressor	5,5 kW
Hydrogen storage	2400 Nm^3, 200 bar
Flywheel	200 kW, 5 kWh
Battery	35 kWh
Master synchronous machine	100 kVA

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Utsira – How it works

Electrolysers for renewable energy applications

Requirements based on experiences from Utsira

- Remote operation
- Short start-up time
- Short response time
- Operational flexibility
- Optimised integration of components
- Minimum maintenance

Electrolytic hydrogen as energy carrier

1. Transport

- Providing hydrogen with no greenhouse gas emissions is the only way to fully realise the potential for hydrogen as fuel for vehicles
- Electrolyser technology will be an essential part of the hydrogen value chain for this expanding market

2. Peak sharing / energy storage

- Load balancing today's power plants and tomorrow’s renewable installations.
- Utilising the excess energy capacity to produce hydrogen by electrolysers will offer a solution

3. Isolated energy systems

- Renewable energy + electrolyser + storage + fuel cell
- Bringing energy to isolated areas in the world with no grid connection today

4. Energy independence

- Converting to a hydrogen economy combined with renewable energy
- An ambition in itself for certain nations to become less dependent on import of energy

Capital cost development of electrolysers

1. Incentives for R&D programmes

- Current capital costs must be reduced to facilitate major commitment in a hydrogen economy
- Electrolysers are desired – considerable government funding available for their development
- Substantial R&D programmes ongoing to reduce capital cost for electrolysers

2. Increased volume = reduced costs

- Today's market for electrolysers are limited in number of units – no assembly lines for production
- Large volume increase of electrolysers produced for the Renewable Energy segment will totally re-define the production methods.
- This will enable significant price reductions for electrolysers and auxiliaries

Thank You!

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