Renewable Hydrogen from Electrolysis: How do we get to a relevant scale?

H2@Scale Consortium Kick-Off Meeting, 8/1/18
Company Overview

**Public Company, Pure H₂ Play**

3 Manufacturing Sites

3,500+ Electrolyzers Installed

40+ H₂ Fueling Stations

90+ Years Experience

USA (Wallingford, CT) PEM Electrolyzers

Denmark (Herning) H₂ Fueling Stations

Norway (Notodden) Alkaline Electrolyzers
Company History

MW Alkaline Atm. Water Electrolysis

Norsk Hydro Electrolysers (NHEL)

1927

1993

Hydro Oil & Gas Statoil Merger

Management buyout + Investors

Oslo Stock Exchange

Acquires H2 Logic

Acquires Proton Onsite

H₂ Fueling Station

1st 350bar Fueling Station

1st 700bar Fueling Station

2003

2009

2011

PEM Pressurized Water Electrolysis

Industrial / RE Systems

H-Series 2-6Nm³/h

C-Series 10-30Nm³/h

M-Series 200-400Nm³/h

1955

1996

2003

2010

2014
Size matters! Scale drives down cost...

Largest single electrolysis plant ever built

Nel (Norsk Hydro)
Glomfjord / Norway
1953 – 1991

135MW
(30,000Nm³/h)
Large Scale Renewable Hydrogen Case Study

Nikola Motors supply agreement will drive automation, scale-up, and cost reduction

- Nikola Class 8 trucks
- Several thousand pre-orders
- Hydrogen included in lease
- 800 to Anheuser-Busch
  - Up to a 750 mile range
  - Fueling time: ~10 min
  - Rollout: 2021
- Target: Hundreds of HRS in the US
- Represents more than 1 GW of electrolysis
- Production capacity is > 500 tpd H2

“While we have not reached any conclusions on an expansion to accommodate the order, we want to reiterate our plans to develop the Notodden facility into the world’s largest electrolyzer stack manufacturing facility, aiming at a cost reduction of around 40 percent,” Jon Løkke, CEO.
How do you build 1 GW of alkaline electrolysis stacks?

Nel Hydrogen Electrolyzer Factory in Notodden

- Nearby building purchased for future manufacturing expansion
- Volume justifies investment in automation
- Working with supply chain to assure they can meet demand
- Installation and commissioning resources must be carefully planned as well
- A 40% reduction in stack cost is huge, as this represents about 30% of the total system CAPEX
- High volume will reduce other system cost elements as well
Similar cost reduction opportunities exist for PEM: 20 MW array concept in development

- PEM Electrolyzers benefit from scaleup as well:
  - Stack scaleup by ~ 5X
  - Consolidate balance of plant components to achieve a 20 MW system configuration
- Scaleup is straightforward from a design standpoint
- Challenges remain in manufacturing and test:
  - Process equipment for larger formats
  - Supply chain limitations for materials
  - Being able to test full scale stacks
- Ultimately, volume will drive justification for automation and major retooling.
- The 20 MW array concept in conjunction with technical advancements, can achieve a net $/kW cost that is about half of our current 2 MW system cost.
- This design approach helps address larger grid scale applications better suited for PEM.
PEM Cost Reduction is Achieved from Focused Efforts in Several Areas
In Summary…

- Scale and volume are key cost drivers
- Focused R&D is needed in several areas:
  - Manufacturing processes for high volume
  - MEA cost reduction for membrane-based electrolysis
  - Power electronics for integration with renewables
  - Materials for higher temperature operation
  - Porous transport layers and supports designed for electrolysis cells
- Investment will come when business cases are validated (e.g. Nikola case study)
- We need to get bigger faster!
Stephen Szymanski
sszymanski@protononsite.com
+01.203.678.2338

number one by nature...

www.nelhydrogen.com

Number one by nature