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

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

nel

Number one by nature

Company Overview

Public Company, Pure H_2 Play

3 Manufacturing Sites

3,500+ Electrolyzers Installed

40+ H_2 Fueling Stations

90+ Years Experience

USA (Wallingford, CT)
PEM Electrolyzers

Denmark (Herning)
H_2 Fueling Stations

Norway (Notodden)
Alkaline Electrolyzers

Company History

1927 — MW Alkaline Atm. Water Electrolysis

1993 — Norsk Hydro Electrolysers (NHEL)

2007 — Hydro Oil & Gas Statoil Merger

2011 — Management buy out + Investors

2014 — Oslo Stock Exchange

2015 — Acquires H2 Logic

2017 — Acquires Proton Onsite

2003 — H_2 Fueling Station

2009 — 1st 350bar Fueling Station

2011 — 1st 700bar Fueling Station

1955 — PEM Pressurized Water Electrolysis

1996 — Industrial / RE Systems

2003 — H-Series 2-6Nm³/h

2010 — C-Series 10-30Nm³/h

2014 — M-Series 200-400Nm³/h

Size matters! Scale drives down cost…

Largest single electrolysis plant ever built

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

"We're looking at a total contract volume which is many times higher than the current annual production capacity at Notodden. 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.

Source: Nikola

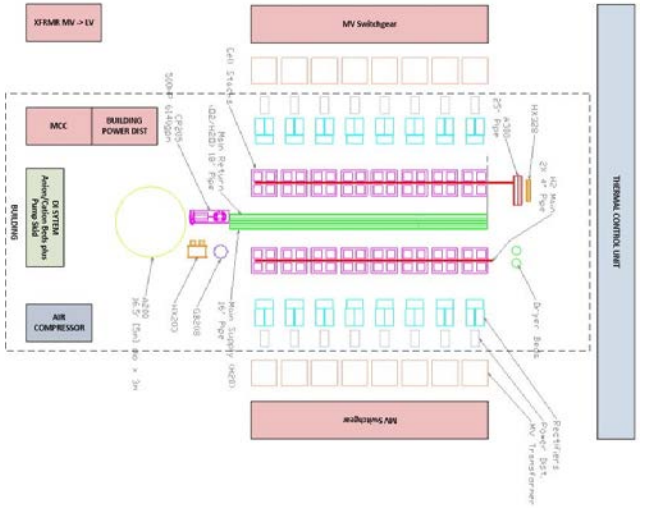
How do you build 1 GW of alkaline electrolysis stacks?

Nel Hydrogen Electrolyzer Factory in Notodden

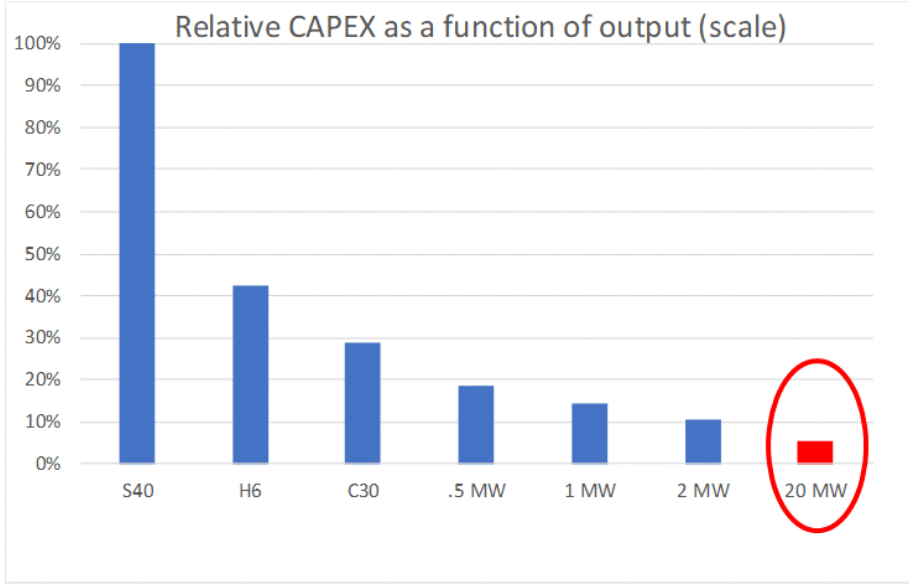
- Nearby building purchased for future manufacturing expansion
- Volume justifies investment in automation
- Working with supply chain to assure they can meet demand
- Installation and commissioning resources must be carefully planned as well
- A 40% reduction in stack cost is huge, as this represents 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

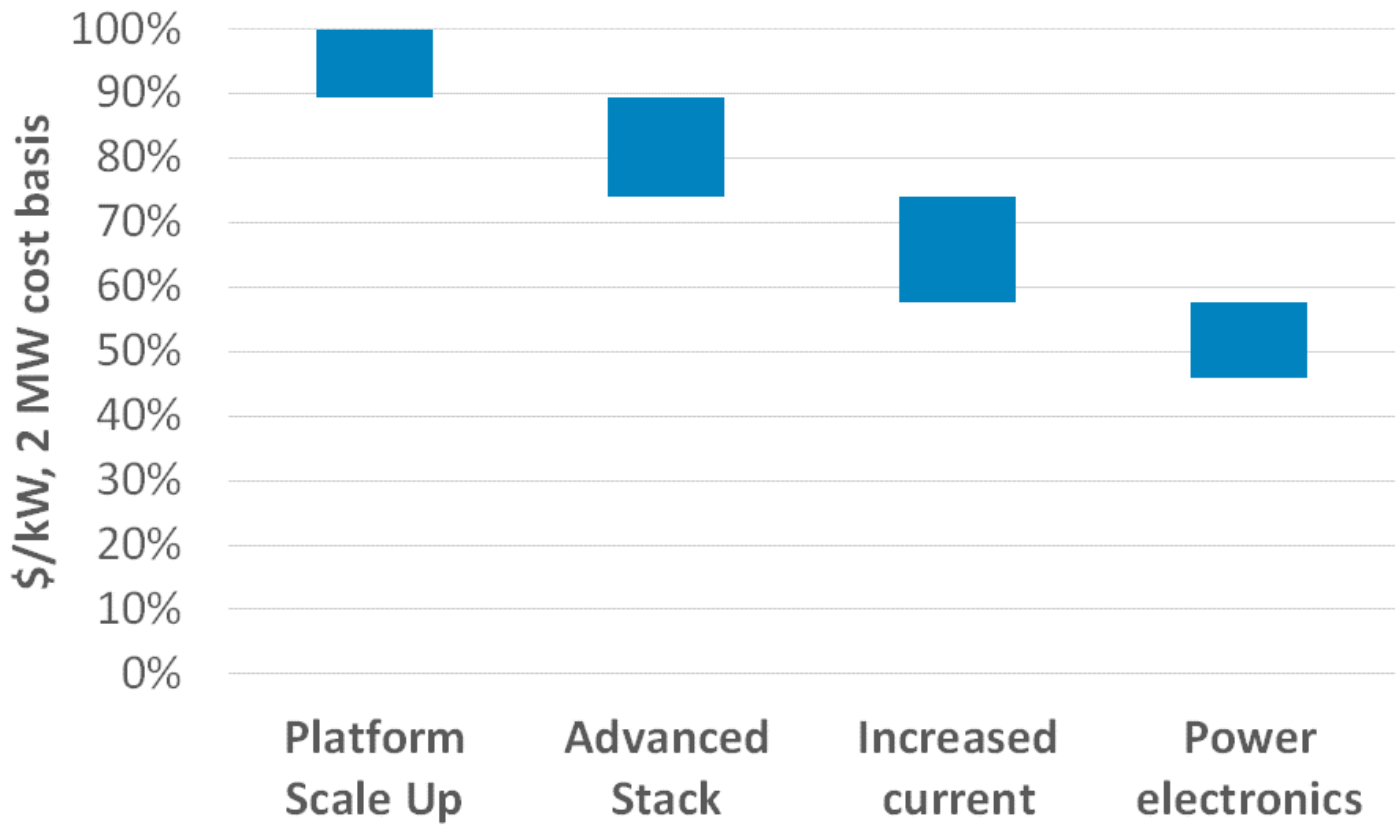
- PEM Electrolyzers benefit from scaleup as well:
  - Stack scaleup by ~ 5X
  - Consolidate balance of plant components to achieve a 20 MW system configuration
- Scaleup is straightforward from a design standpoint
- Challenges remain in manufacturing and test:
  - Process equipment for larger formats
  - 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.



20 MW array conceptual layout



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