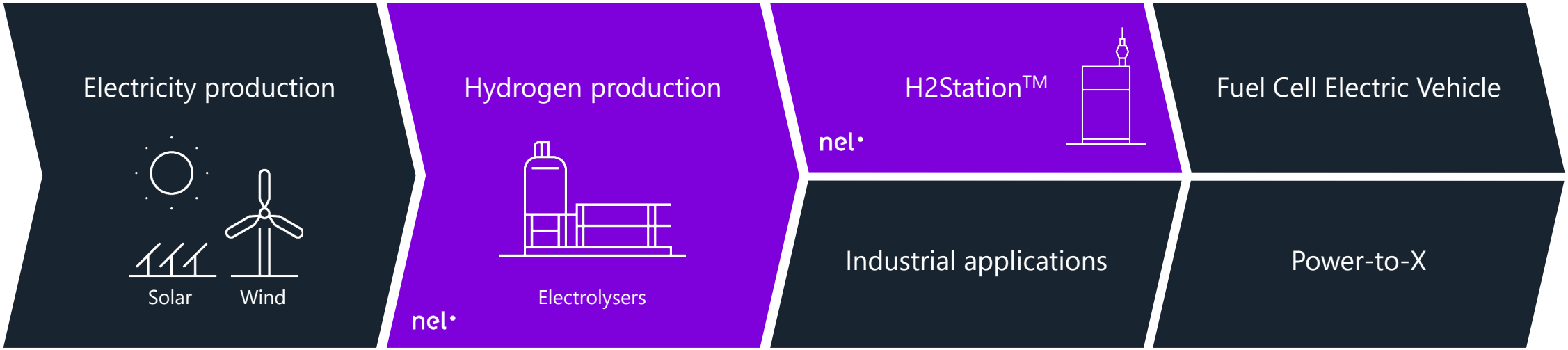
Nel: Taking electrolysis to large-scale

Manufacturing Capabilities and Technology Pathways

Nel is a global, dedicated hydrogen technology company that delivers optimal solutions to produce and distribute hydrogen from renewable energy



Electricity is generated from wind or solar

Electricity is used to split water (H_2O) into hydrogen and oxygen

Hydrogen is compressed and cooled in the H2Station™ ready for fueling through the dispenser

Hydrogen fueling is relevant for both light duty vehicles (LDV) and heavy-duty vehicles (HDV)

Green hydrogen has a massive potential to decarbonise industries, i.e. ammonia and steel

Hydrogen is expected to become relevant within all forms of industry, energy storage, heating, energy export and new applications

500+ Employees, Listed (NEL.OL)

PEM water electrolysers

Wallingford, CT USA

Systems delivered: **3,000+**

Nameplate capacity: **50MW/year**

Experience: **25+ years**

Capacity ready for 150MW/y

Alkaline water electrolysers

Notodden/Herøya, Norway

800+

500MW/year

90+ years

Expandable to 2GW/y

Hydrogen refuelling stations

Herning, Denmark

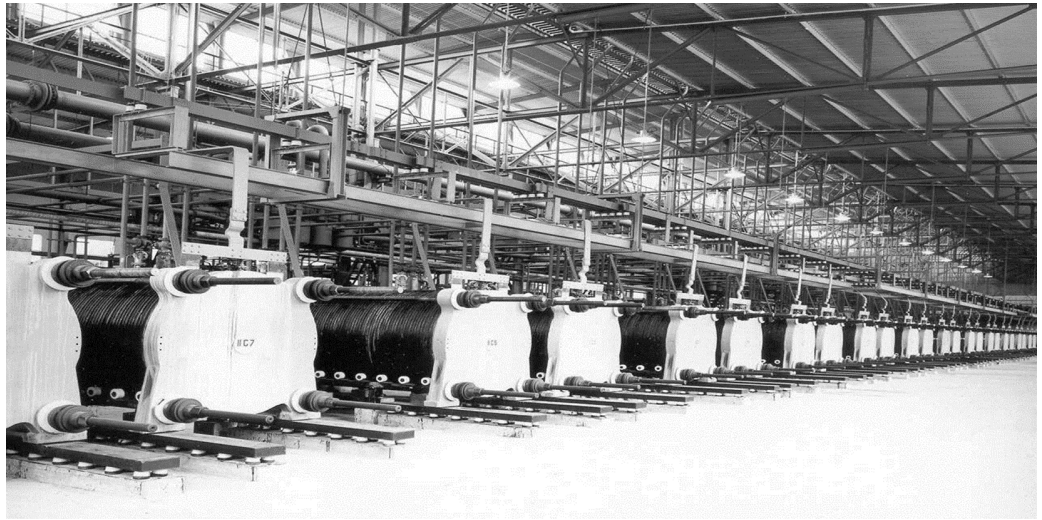
110+

300 HRS/year

17+ years

Nel Herøya plant

- Production of alkaline electrolyzers
  - Developed for industrial applications
  - 100 years of experience
  - Designed for low cost and efficiency
  - Demonstrated at 100+ MW
- 500 MW production line
  - Scalable to 2 GW with additional lines



150 MW plant
1953-1991

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OUR UNIQUE ELECTROLYSER SOLUTIONS

Broadest product portfolio in the market

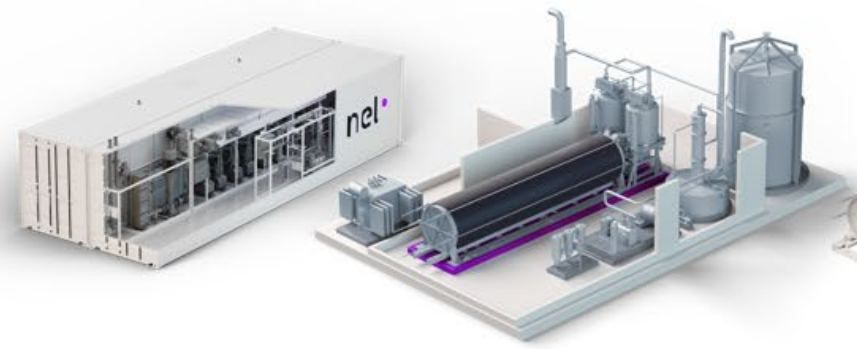
Nel Alkaline and PEM electrolysers

Wide proven experience
Alkaline electrolysers since 1927 and PEM electrolysers since 1996

Scalable design
from 1 to 10,000+ kg/day production in standard plant designs;
Scalable to 100+ MW systems

Designed for high volume manufacturing
to achieve large scale plants with fossil price quality

3 kW – 174 kW



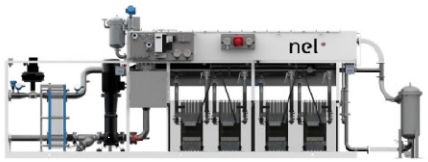
1.25 MW – 25 MW

> 50 MW & 100 MW

From kW- to multi-MW industrial hydrogen production plants

H2Station™ | Standardized hydrogen fueling

- Turn-key standardized hydrogen fueling station with dispensers for cars, busses and trucks.
- Station capacity unlimited back-2-back, depending on customer supply setup.
- Fueling speed according to SAE J2601 – 1/2, total fueling time depends on tank size of vehicle.
- Flexible configuration of hydrogen storage and fueling capacity – very compact total footprint.
- Can connect to various hydrogen supply sources e.g., onsite production or trucked-in delivery.


Electrolyser


Supply Compressor


Supply Cabinet

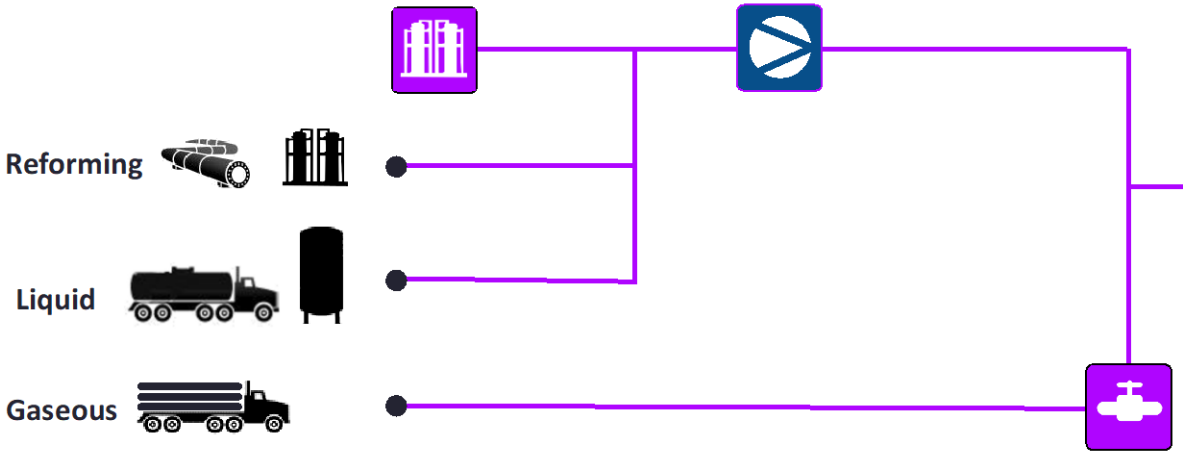

Supply & Fueling Storage

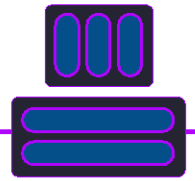

Station Module

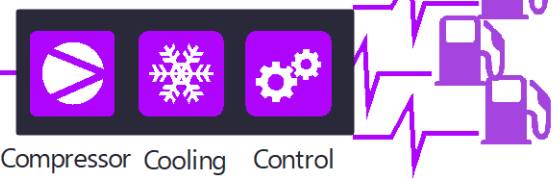




Dispenser 35/70MPa




20MPa and
45MPa storage



- *Fueling from one dispenser at a time.*
- *For simultaneous fueling capabilities additional station modules are required.*

Nel deliverables

3rd party/Nel deliverables

The Future of Nel's PEM Manufacturing

New plant will be fully automated for stack manufacture

- Actively specifying equipment for manufacturing scale up
- Site selection and plant layout complete by end 2022
- Exploring parallel expansion in other strategic markets
- Building capacity for 2 GW PEM, 2 GW alkaline

NATIONWIDE COLLABORATIVE INNOVATION WITH DOE COMPLEX & PARTNERS

10+ years driving new realities

2009 — ARPA-E Grids: Transformative Renewable Energy Storage Devices on Neutral Water Input

2010 — DOE Bipolar Plate R&D: High-Performance, Low-Cost Hydrogen Generation from Renewable Energy

2012 — DOE/EERE SBIR Phase 1/2/2B: Economical production of Hydrogen Through Development of Novel, High Efficiency Electrocatalysts for Alkaline Membrane Electrolysis

2013 — DOE/BES STTR Phase 1/2: Low Noble Metal Content Catalysts/Electrodes for Hydrogen Production by Water Electrolysis

2018 — DOE/EERE FCTO2018: Advanced Electrode Manufacturing to Enable Low-Cost PEM Electrolysis

2019 — DOE/EERE H2@Scale2019: Interface and Electrode Engineering for Durable, Low-Cost Alkaline Anion Exchange Membrane Electrolyzers

DOE Award for fueling of heavy-duty hydrogen vehicles (SuperTruck3)

2020 — DOE/EERE H2@Scale2020: Enabling Low-Cost PEM Electrolysis at Scale Through Optimization of Transport Components and Electrode Interfaces

DOE/EERE H2@Scale2019: A Novel Stack Approach to Enable High Round Trip Efficiencies in Unitized PEM Regenerative Fuel Cells

2021 — ARPA-E Open 2021: High capacity electrolyzers based on Ultrathin Proton-Conducting Oxide Membranes

Contract for 1.25 mW containerized PEM electrolyzer for installation at a Nine Mile Point nuclear power plant in NY

Los Alamos NATIONAL LABORATORY

EPRI ELECTRIC POWER RESEARCH INSTITUTE

BERKELEY LAB

DE NORA

OAK RIDGE National Laboratory

KODAK

NREL Transforming ENERGY

- Execution of multi-million $ programs, leading to successful commercialization
- Strong relationships with DOE Labs – CRADAs and other collaborative projects
- DOE R&D Awards in 2012 and 2021 at Annual Merit Review
- Technical advisor to many DOE consortia
- Service on Hydrogen and Fuel Cell and Basic Energy Sciences Advisory Committee

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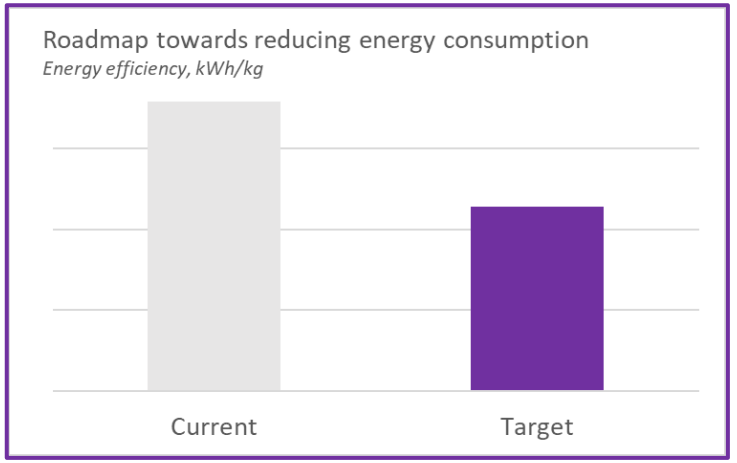
Standardization reducing system cost & technology development



Electrolyer system cost today

Excludes Civil/Building

Technology

Advanced designs and materials, including process development to enable automation & continuous processing

Engineering

Standardizing large-scale offerings: 20 MW to 100 MW

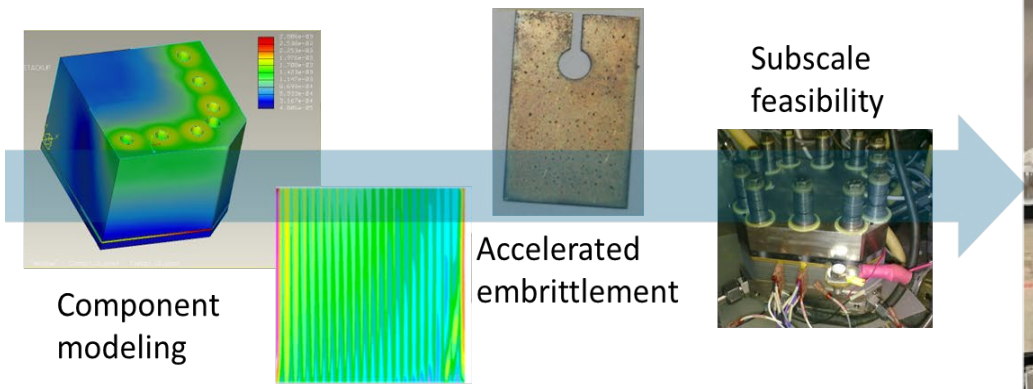
Standardized design and pre-fabricated skids reducing time and cost for commissioning and installation

Procurement

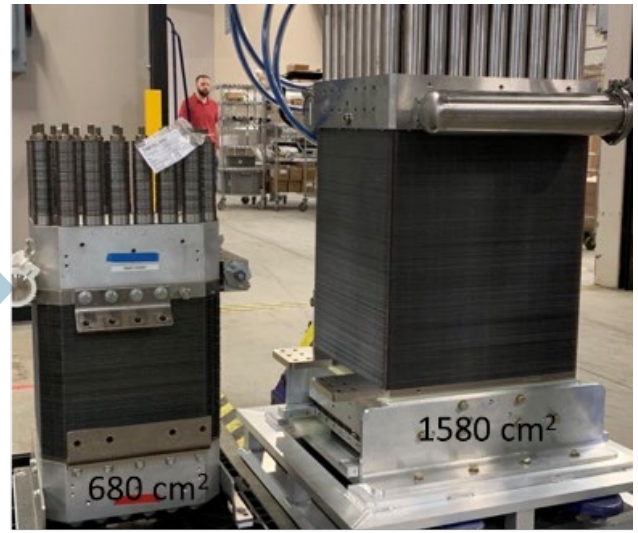
Continuous improvement of supply chains and framework agreements

Reduced cost

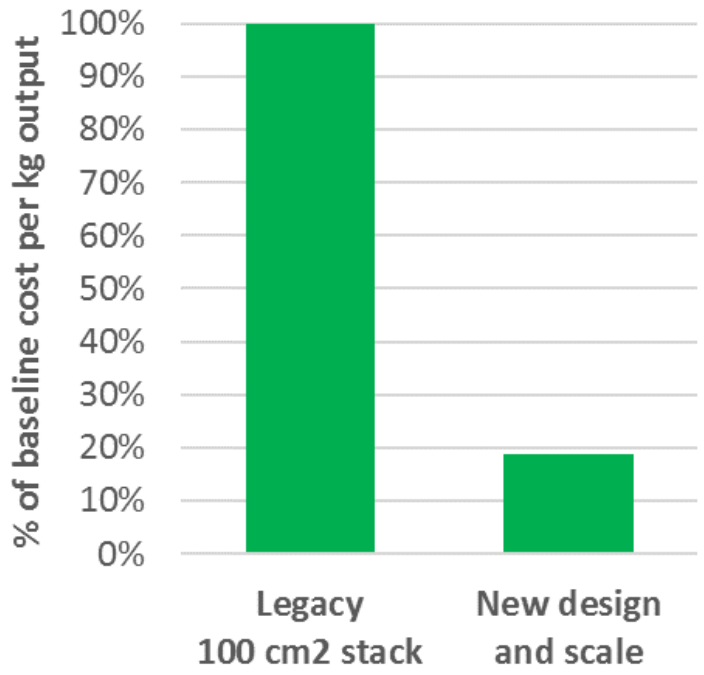
Example of targeted cost reduction



Comprehensive program led to commercial implementation in 2016

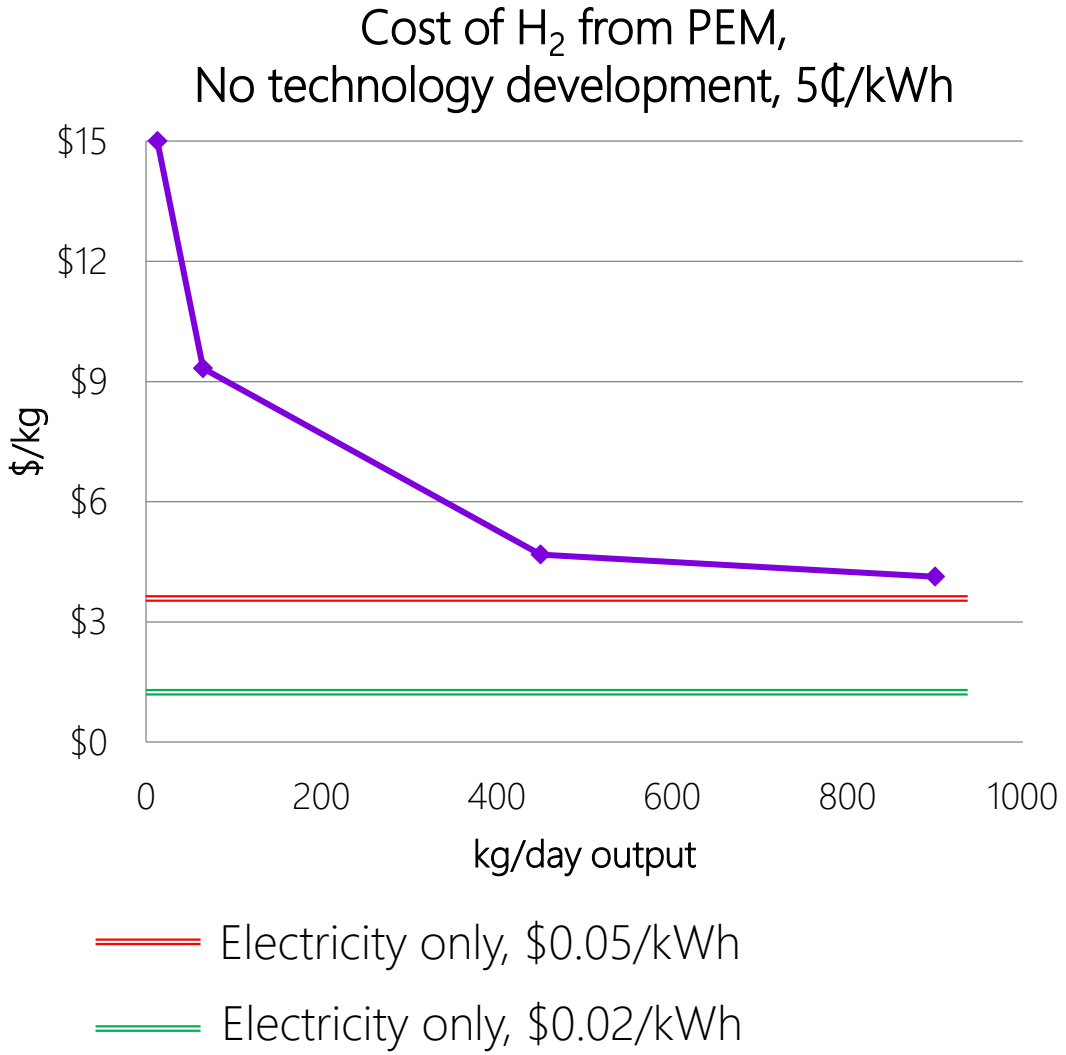


10,000s of cells produced



>80% component cost savings

Can we get to the $/kg goals?



- Traditional electricity model asymptotes above $3/kg based on $0.05/kWh pricing
- Need inexpensive renewables to make business case

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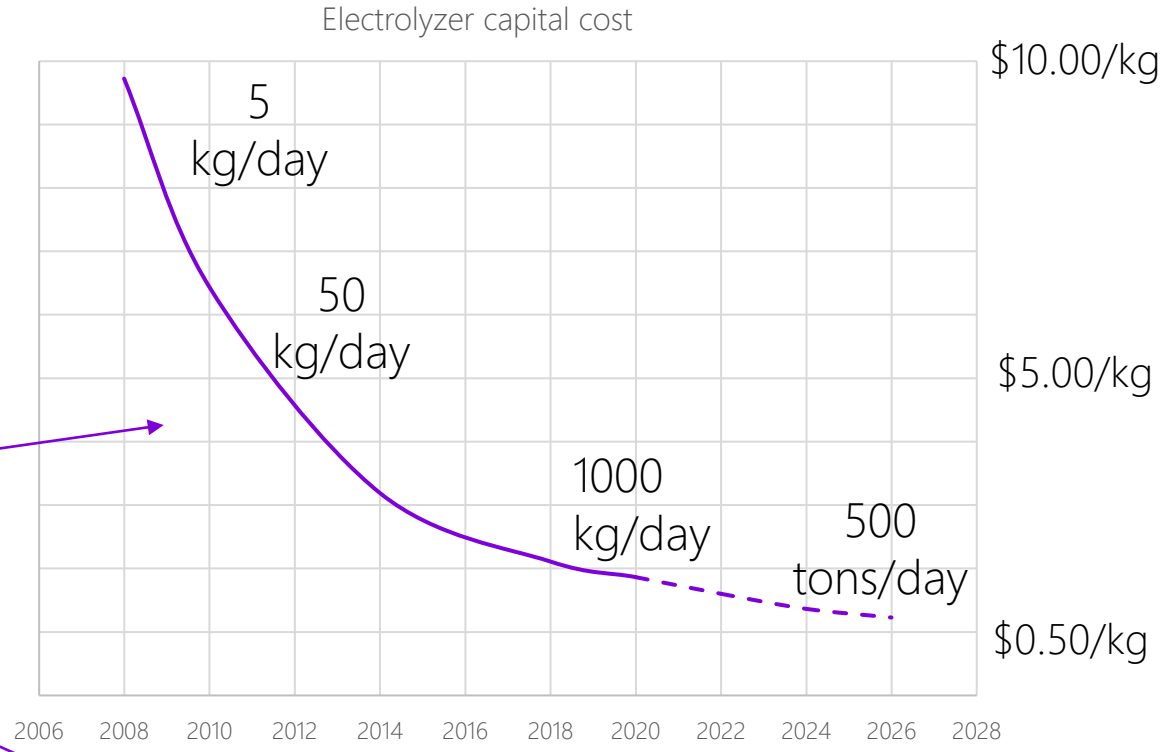
Progress towards $1-2/kg H_2

- $2/kg H_2 target is major step to meet business case
  - Energy comparison: 1 gallon gasoline ~ 1 kg H_2
- Approaching $2/kg with current technology
  - Capital cost has dropped with scale
  - Solar and wind reaching electricity costs
  - Capacity factor (% usage) plays a role
- <$2/kg needed to replace all fossil fuel based H_2
  - SMR plant directly onsite process facility is cheaper at current cost of natural gas

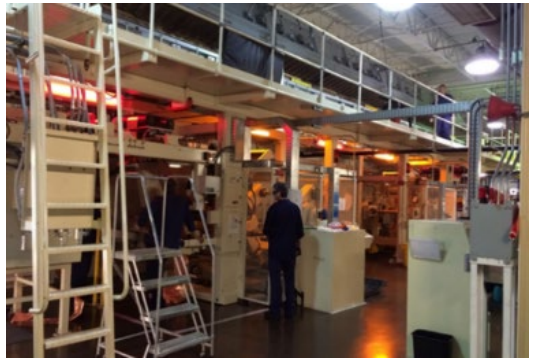


Cost, $/kWh	$/kg OPEX
$0.06	$3
$0.04	$2
$0.02	$1

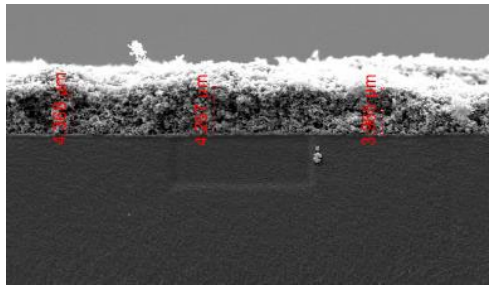
Available in some power markets today

Cell Components

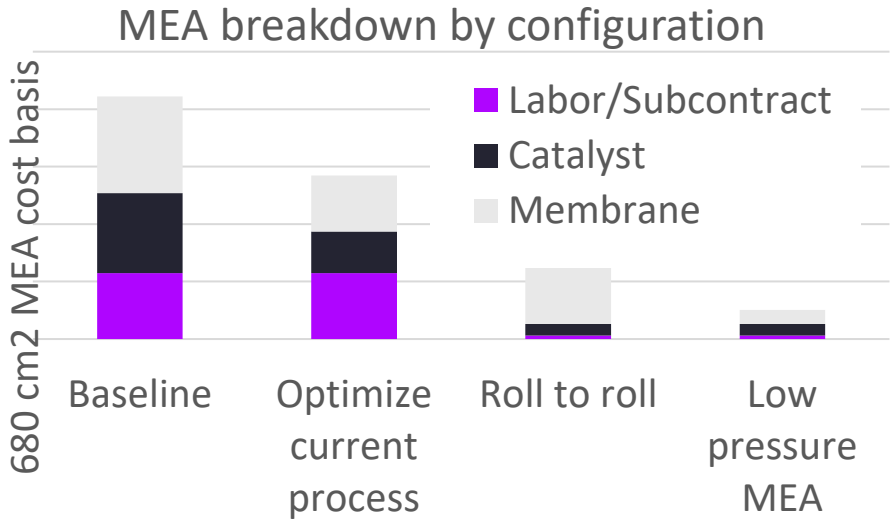
MEA: move to roll to roll processes



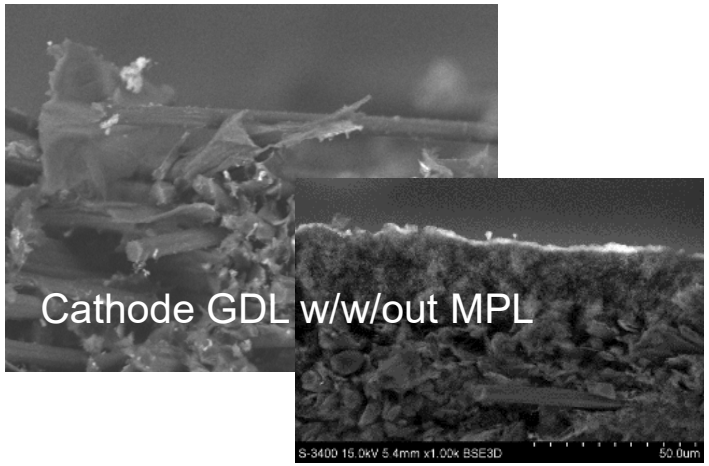
Automated manufacturing reduces labor



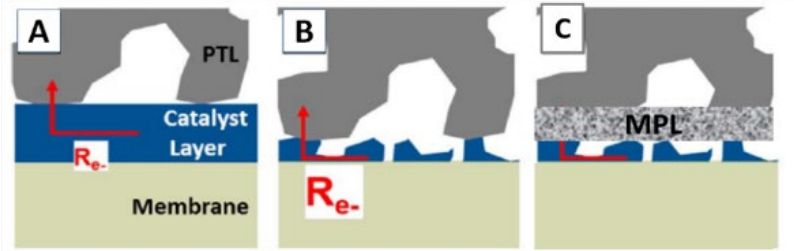
Enables uniformity at lower loading



Porous transport layer: improve structure/interface – enables above and supports thinner membranes

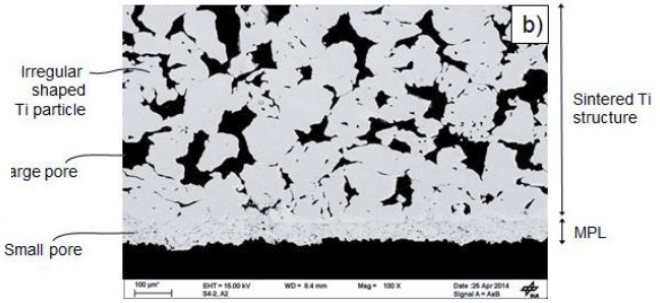


Gasteiger, ECS 2018



A – Thick electrode catalyst layer has lower resistance to the porous transport layer
B – Thinner electrode catalyst has very high resistance to porous transport layer
C – Microporous layer effectively contacts catalyst layer

Friedrich, J. Power Sources 2016



Summary

- Nel has the longest history in the world in producing and installing electrolyzer equipment
  - Proven reliability in varying environments
  - Understanding of field impact on performance
- Roadmaps are defined and being executed for further advancements
  - Technology
  - Manufacturing
- Large scale projects are being deployed and developed