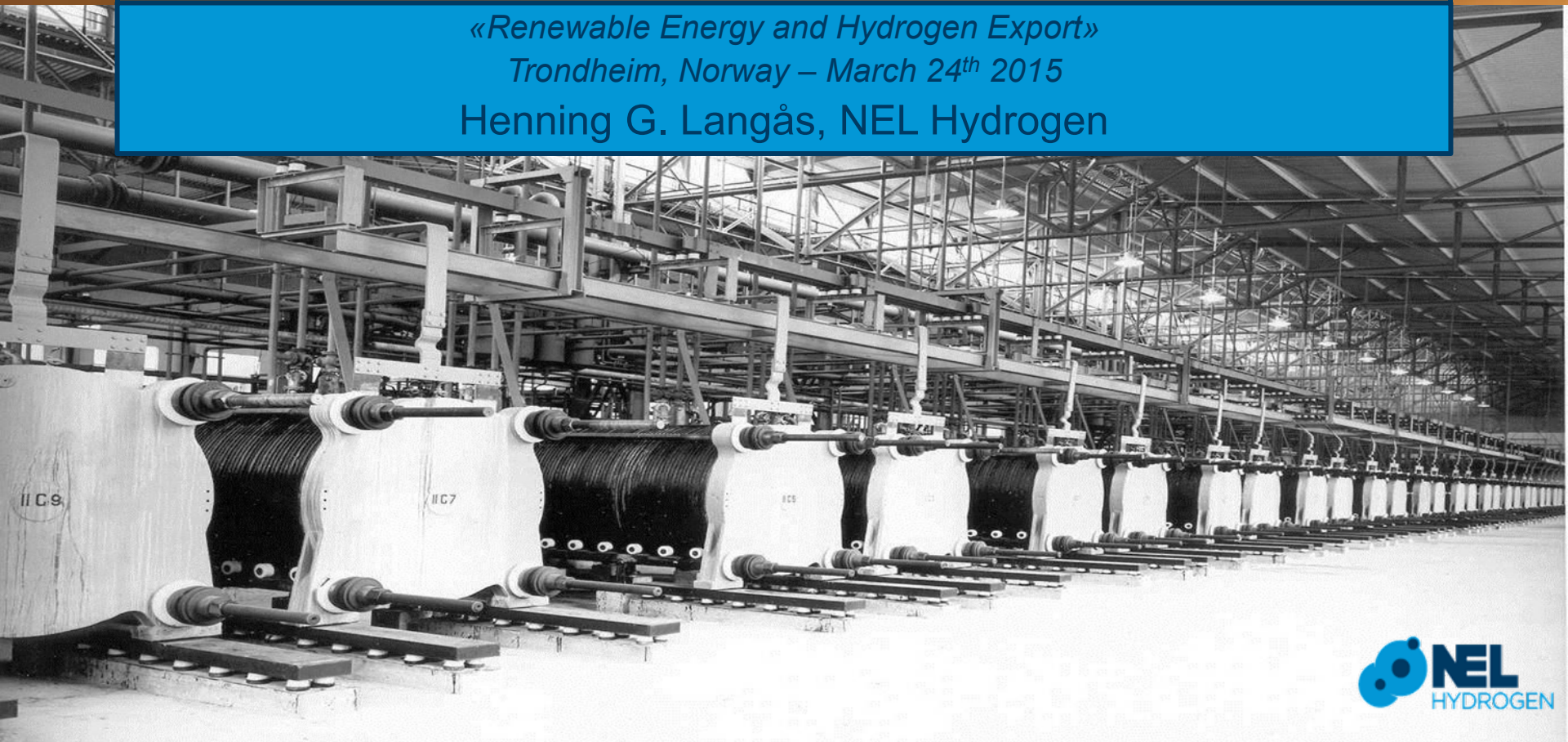
LARGE SCALE HYDROGEN PRODUCTION

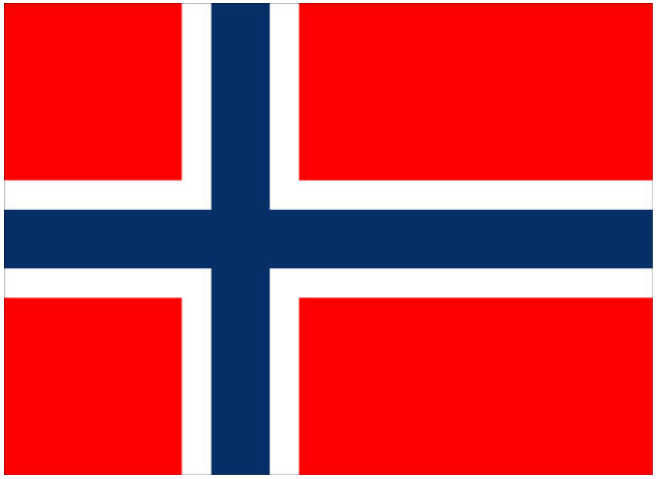
«Renewable Energy and Hydrogen Export»
Trondheim, Norway – March 24th 2015

Henning G. Langås, NEL Hydrogen



NEL HYDROGEN

NEL HYDROGEN - KEY FACTS



- Private Norwegian company, listed on Oslo Stock Exchange
- ~ 25 employees
- Business: water electrolysers
- Worldwide presence with customers in more than 50 countries
- Financials 2014;
  - Revenues 69,3 MNOK
  - EBIT 14,5 MNOK

COMPANY HISTORY

1927

Norsk Hydro started up electrolyser technology for **large scale H_2 production** at its ammonia fertilizer plants in Rjukan, Norway

1974

Commercial sales of water electrolysers commenced in the 1970's

1993

Spin-off, Norsk Hydro Electrolysers (NHEL) established as a separate and limited company fully owned by Norsk Hydro

2007

Statoil becomes the owner of NHEL as a result of the Statoil-Hydro merger

2011

The company leaves Statoil and has a new ownership, name and logo

2014

NEL Hydrogen listed on Oslo Stock Exchange

ELECTROLYSER IN HISTORICAL CONTEXT

COAL GASIFICATION

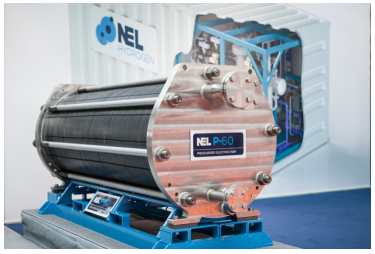
1800's – 1920's

WATER ELECTROLYSIS

1920's – 1960's

GAS REFORMING

1950's – TODAY



H_2 ECONOMY?

2010 –

NEL HYDROGEN

REVITALISATION OF GREEN H_2 PRODUCTION

H_2 ECONOMY

+

H_2 MOBILITY /
FUEL FOR TRANSPORT

ENERGY STORAGE /
POWER-TO-GAS (PtG)

= NEED FOR ELECTROLYSERS

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H_2 MOBILITY / FUEL FOR TRANSPORT

2010:

«A portfolio of power-trains for Europe» - *fact based analysis*

COMPANIES:

BMW, Daimler, Ford, GM, Honda, Hyundai, Kia, Nissan, Renault, Toyota, Volkswagen

ENI, Galp, OMV, Shell, Total

EnBW, Vattenfall

Air Liquide, Air Products, Linde

Intelligent Energy, Powertech

Nordex

ELT, Hydrogenics, NEL Hydrogen, Proton

European Climate Foundation, FCH JU, NOW

- Future power trains a combination of ICE*, BEV*, FCEV* and partly PHEV*
- Early stages of FCEV; government stimulus required for build-up of infrastructure
- 25% FCEV by 2050; 800 retail stations in 2020, 5.100 by 2030, 18.200 by 2050
- 30% on-site electrolyser in 2020, and 15% on-site + 15% central electrolyser by 2050

*ICE = Internal Combustion Engine
*BEV = Battery Electric Vehicles
*FCEV = Fuel Cell Electric Vehicles
*PHEV = Plug-In Hybrid Electrical Vehicle

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ENERGY STORAGE / POWER-TO-GAS (PtG)

2015:

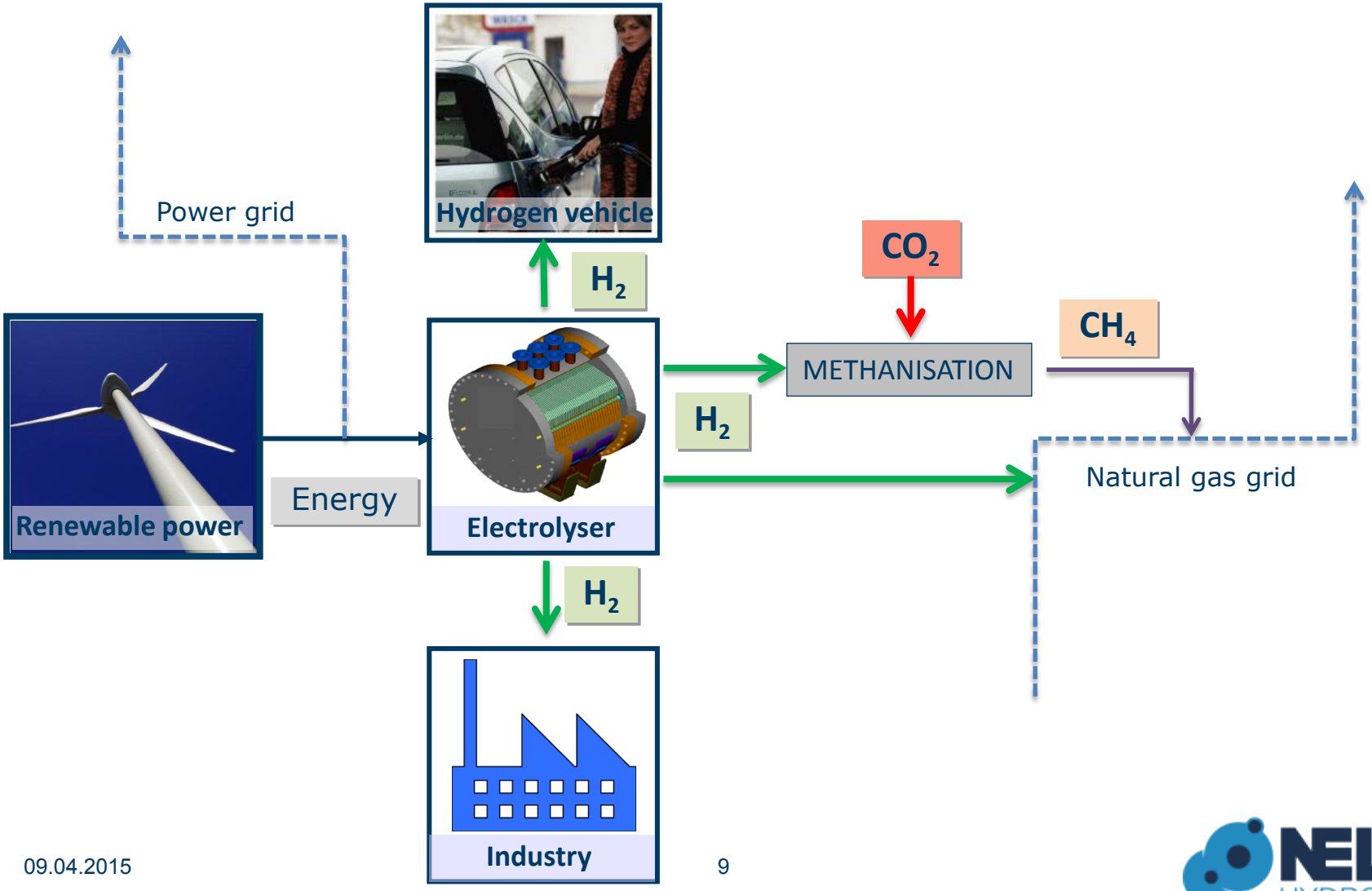
«Commercialisation of Energy Storage in Europe» - *fact based analysis*

COMPANIES:

- Future increase in RES* *(2020: 36%, 2030: 45-60%, 2050: > 80%)* will required flexibility
- Flexibility not solved by traditional solutions, energy storage technologies required
- Conversion to H_2 by electrolysis is the only technology enabling full utilization of all excess energy
- Positive business case for PtG by 2030, but need to offset H_2 to local industrial consumer for short term solutions

*RES = Renewable Energy System

POWER-TO-GAS
- UTILISING EXCESS RENEWABLE POWER



KEY CRITERIA'S

- How to enable a business case for PtG and H_2 mobility with focus on water electrolyser technology?

- CHALLENGE?
  - Minimize Capex
  - Long term reliable technology
  - Minimize Opex

HISTORICAL LARGE SCALE PLANTS

Rjukan, Norway; 1927 – 1970's

Glomfjord, Norway; 1953 – 1991

- Two largest electrolyser plants worldwide
- Capacity: 30 000 Nm^3/h each
- Energy consumption: approximately 135 MW each
- Supplied by renewable hydro power

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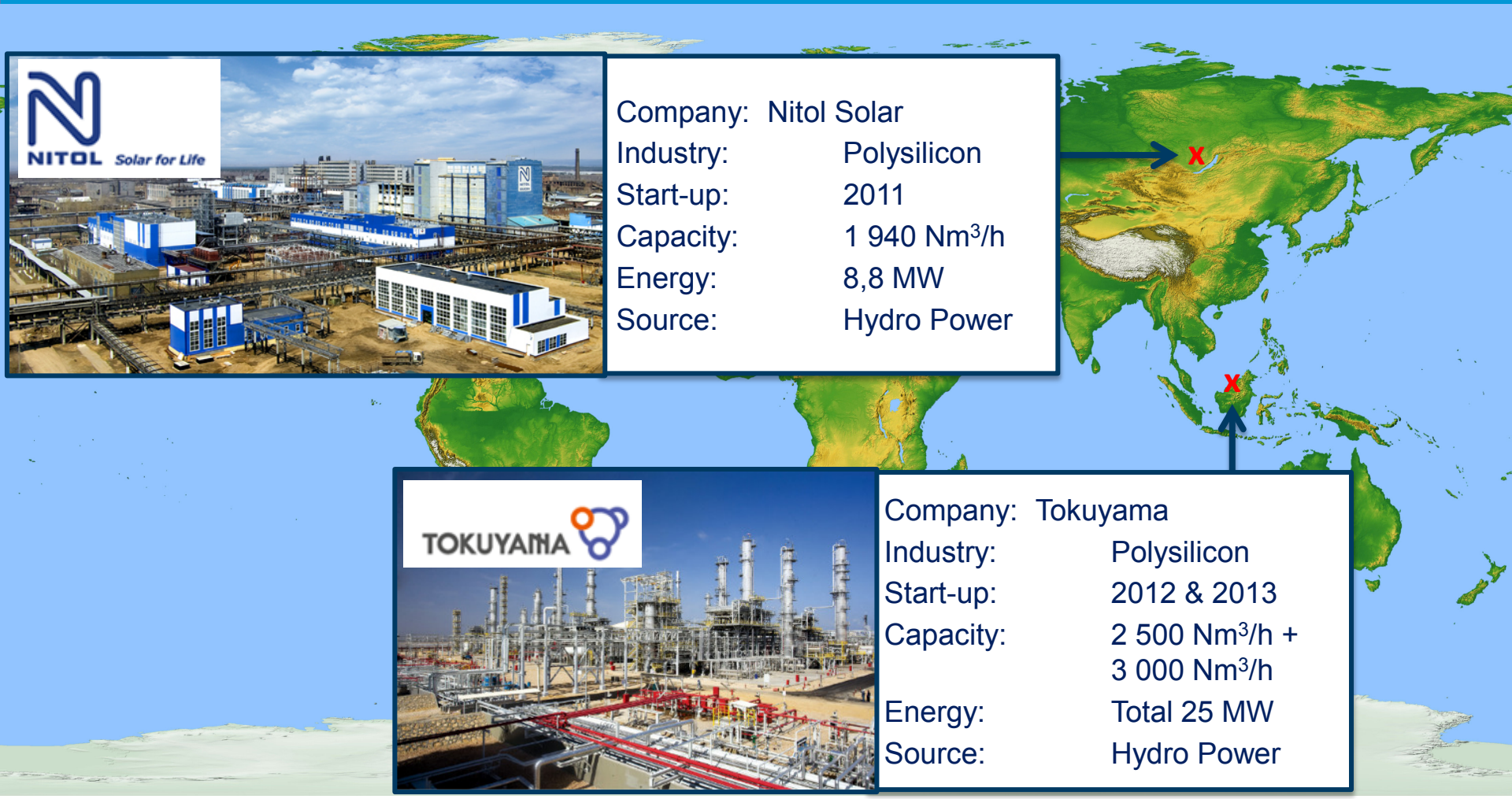
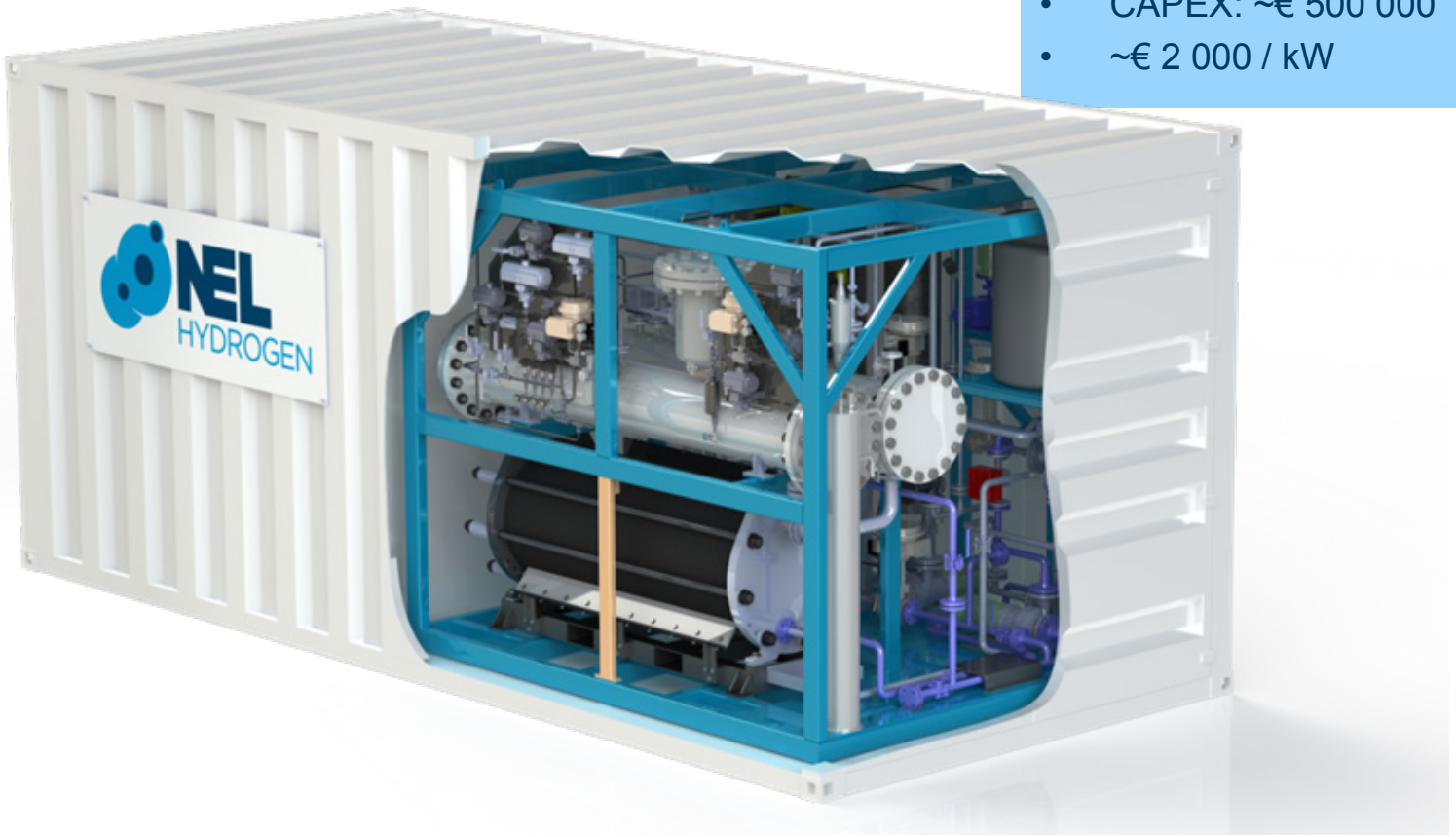
NEW LARGE SCALE PLANTS



Company: Nitol Solar
Industry: Polysilicon
Start-up: 2011
Capacity: 1 940 Nm^3/h
Energy: 8,8 MW
Source: Hydro Power

Company: Tokuyama
Industry: Polysilicon
Start-up: 2012 & 2013
Capacity: 2 500 Nm^3/h + 3 000 Nm^3/h
Energy: Total 25 MW
Source: Hydro Power

250 kW PLANT (50 Nm^3/hr)



- Typical size for demo-projects
- CAPEX: ~€ 500 000
- ~€ 2 000 / kW

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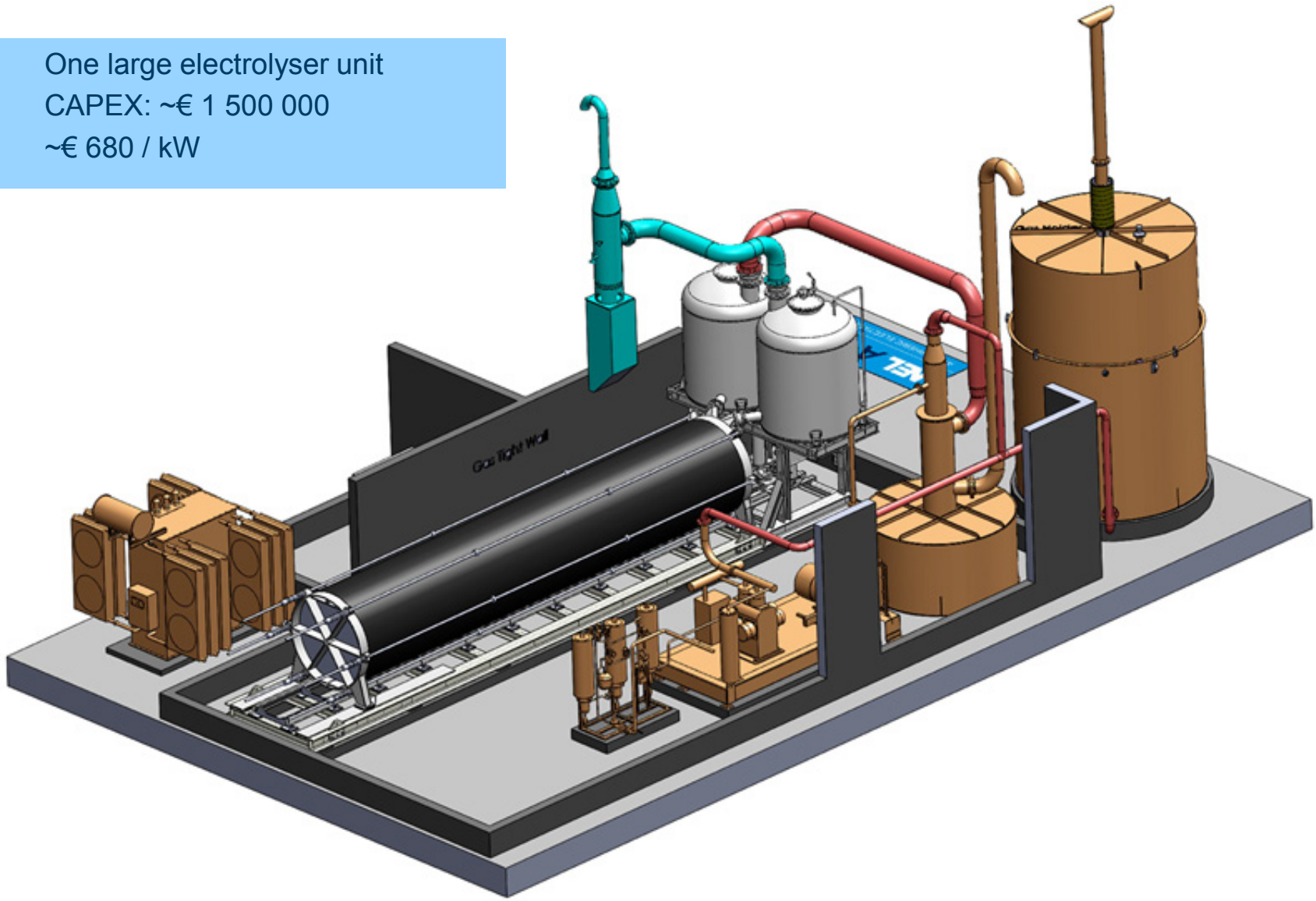
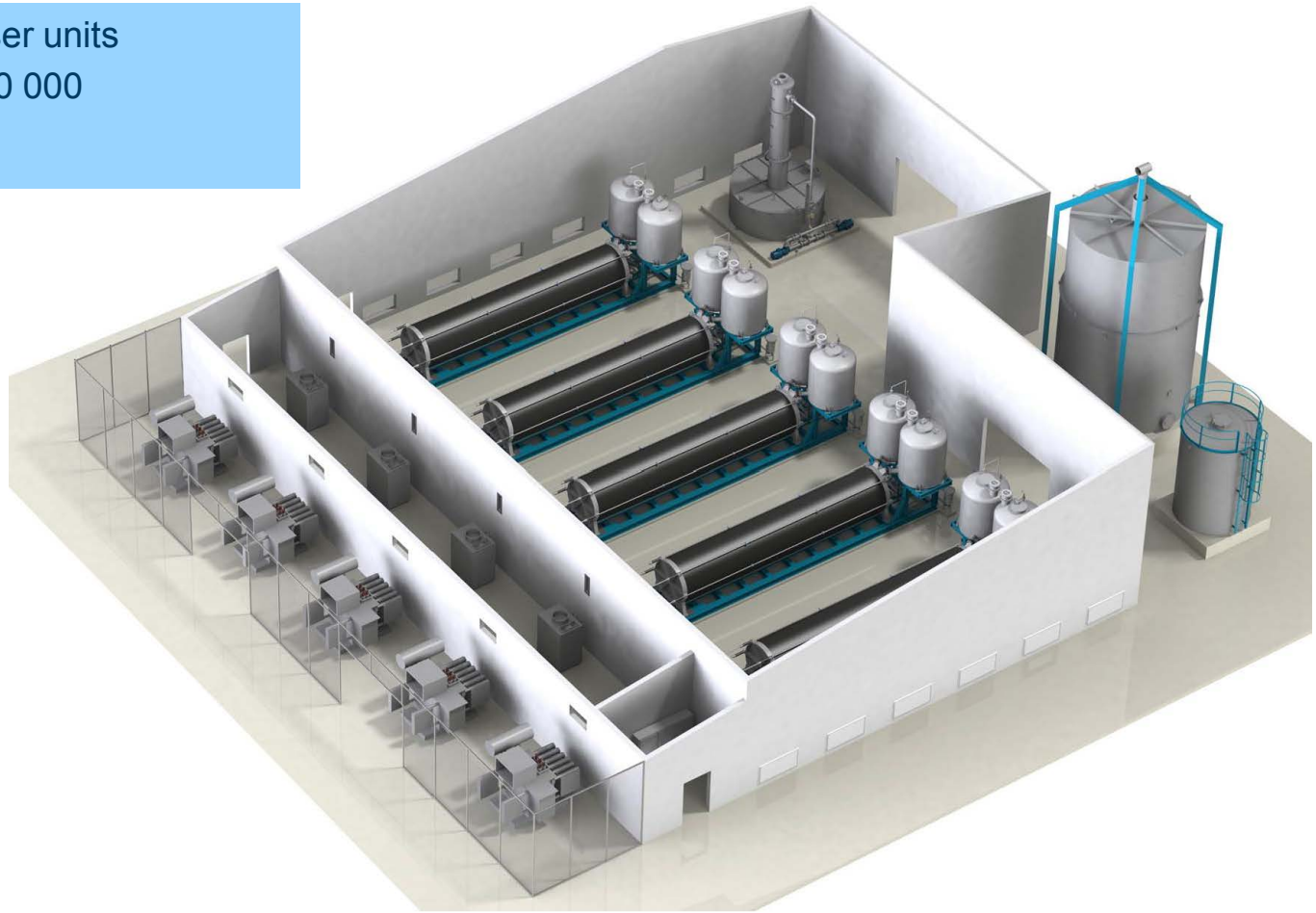
2,2 MW PLANT (485 Nm^3/hr)

- One large electrolyser unit
- CAPEX: ~€ 1 500 000
- ~€ 680 / kW



10 MW PLANT (2 250 Nm^3/hr)

- 5 large electrolyser units
- CAPEX: ~€ 5 500 000
- ~€ 550 / kW



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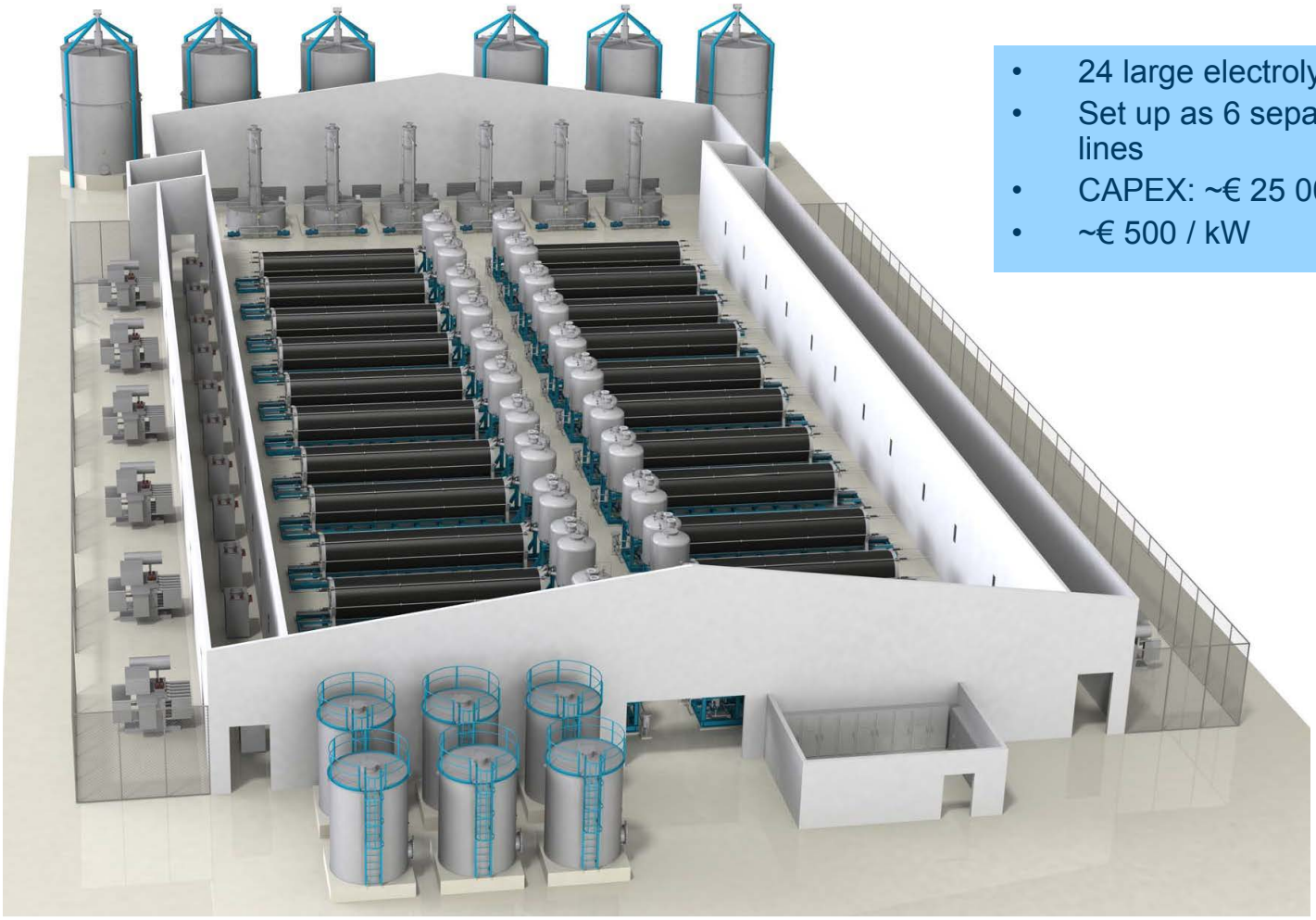
50 MW PLANT (10 800 Nm^3/hr)



- 24 large electrolyser units
- Set up as 6 separate production lines
- CAPEX: ~€ 25 000 000
- ~€ 500 / kW

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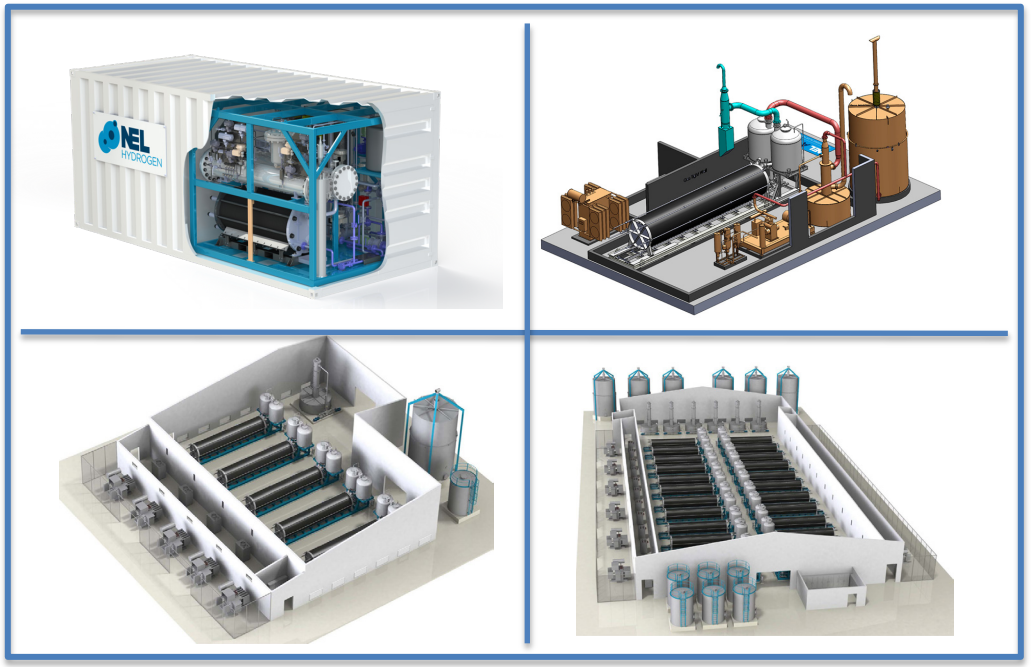
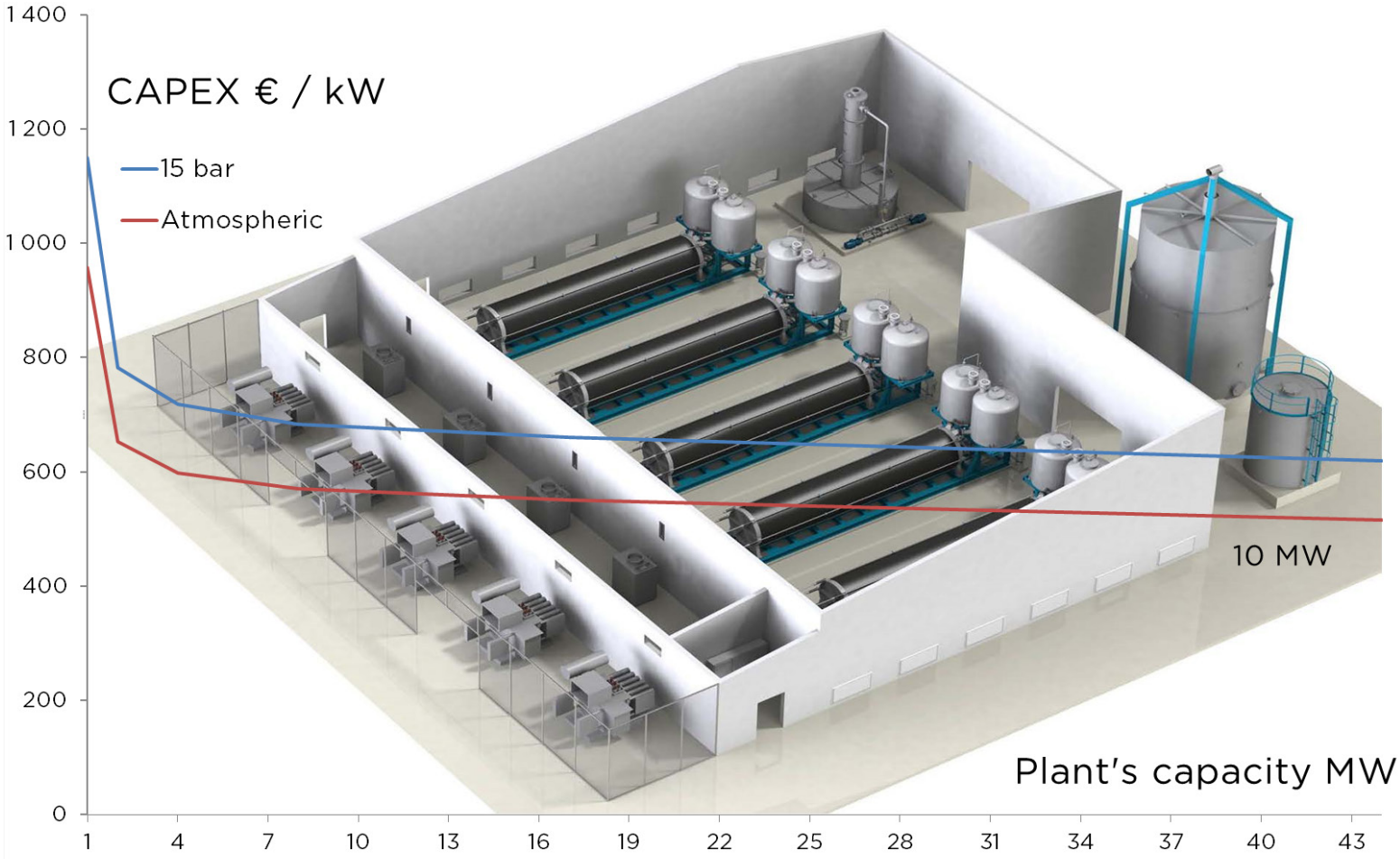
CAPEX SUMMARY

- Today's demo-projects not representative
- A need to go large scale to reduce CAPEX
- Reduction to about 1/4 of initial CAPEX
- Not much to gain on going from 10 to 50 MW (but somewhat untapped potential?)



CAPEX COSTS LARGE SCALE



COST; OPEX

1. Get right technology!
   - Stable operation
   - No shut-downs
   - Minimum maintenance
   - Long lifetime (cell stack & plant)

2. Focus on energy efficiency
   - If technology is right; energy cost is > 90% of OPEX


NEL A
ATMOSPHERIC
ELECTROLYSER
KEY FOR SUCCESS:
1. Go large
2. Reliability & efficiency

THANK YOU!