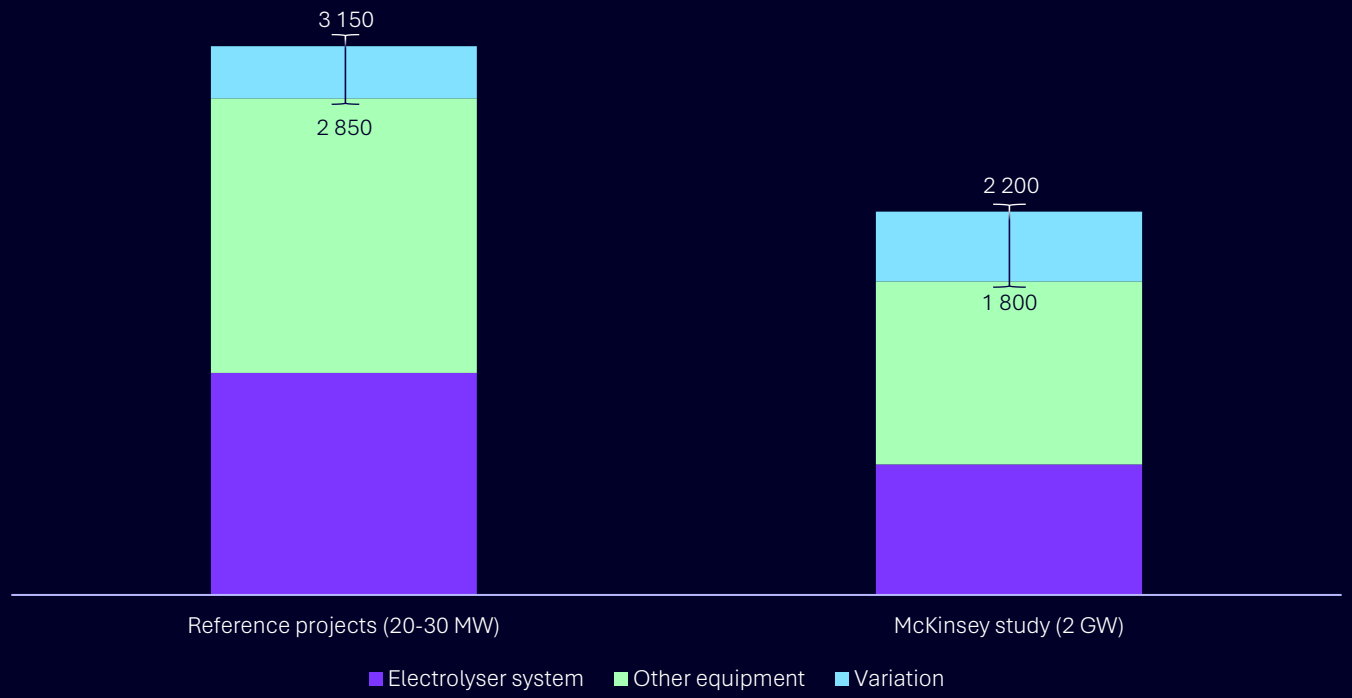
The next-generation pressurized alkaline electrolyser

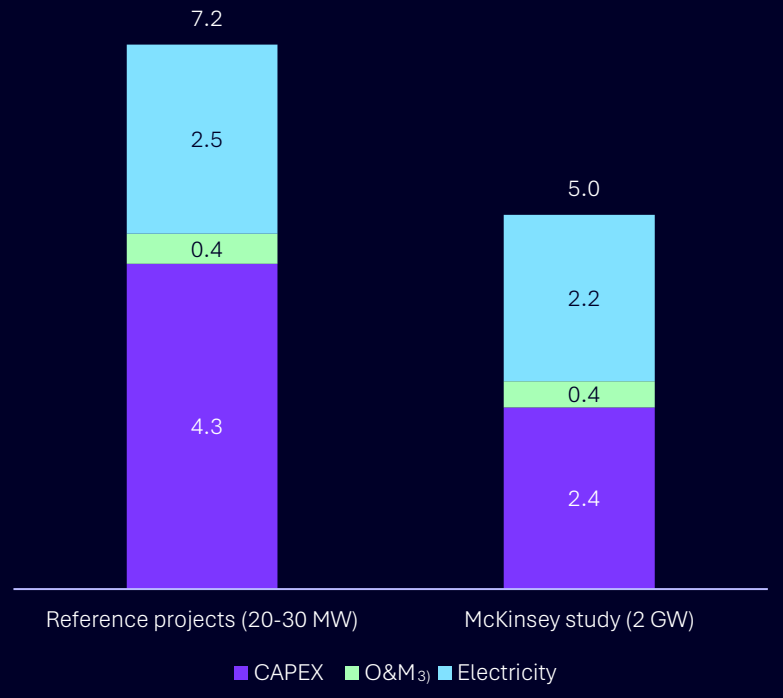
Marius Løken, CTO, Nel ASA

Total project cost must decline to unlock more projects

Full turn-key system CAPEX[1] assumptions in current market (USD/kW)



LCOH[2] (USD/kg)



1) Capital Expenditure (investment cost)
2) Levelized Cost of Hydrogen (lifetime cost of hydrogen per kg)
3) Operation and maintenance

Source: McKinsey & Company

How Nel approaches the challenge

We fundamentally rethink the large-scale electrolyser
– designed for cost and efficiency

NEXT GENERATION ALKALINE SOLUTION

Highlights from the design brief

- Improve energy efficiency
- Minimize system footprint
- Remove the building
- Dramatically reduce project engineering hours
- Dramatically reduce site works
- Enable a wide operating range
- Design for dynamic operations

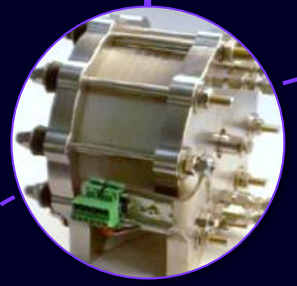
NEXT GENERATION ALKALINE ELECTROLYSER

Eight years of development is behind this event

2018

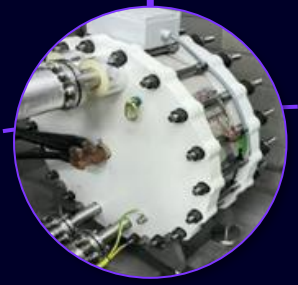
Small single-cell

2019



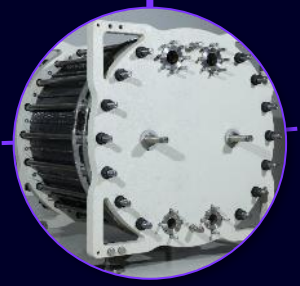
Small cell-stack

2020



Short stack
10-cell

2023



Short stack
50-cell

2025

Full-length stack
230-cell

2026

Commercialization

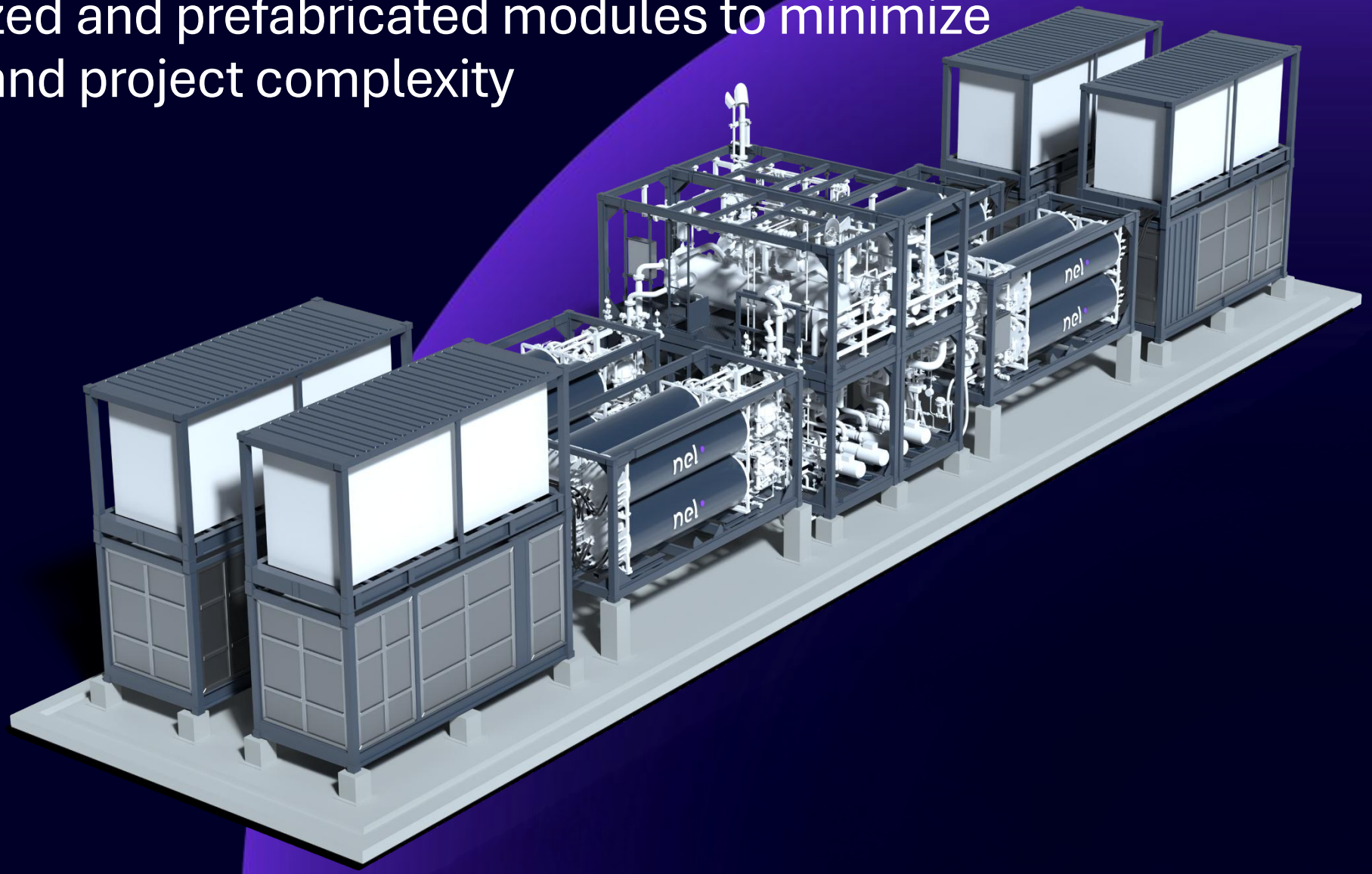
Introducing...

NEXT GENERATION ALKALINE ELECTROLYSER

The next-generation Pressurized Alkaline electrolyser

NEXT GENERATION ALKALINE ELECTROLYSER

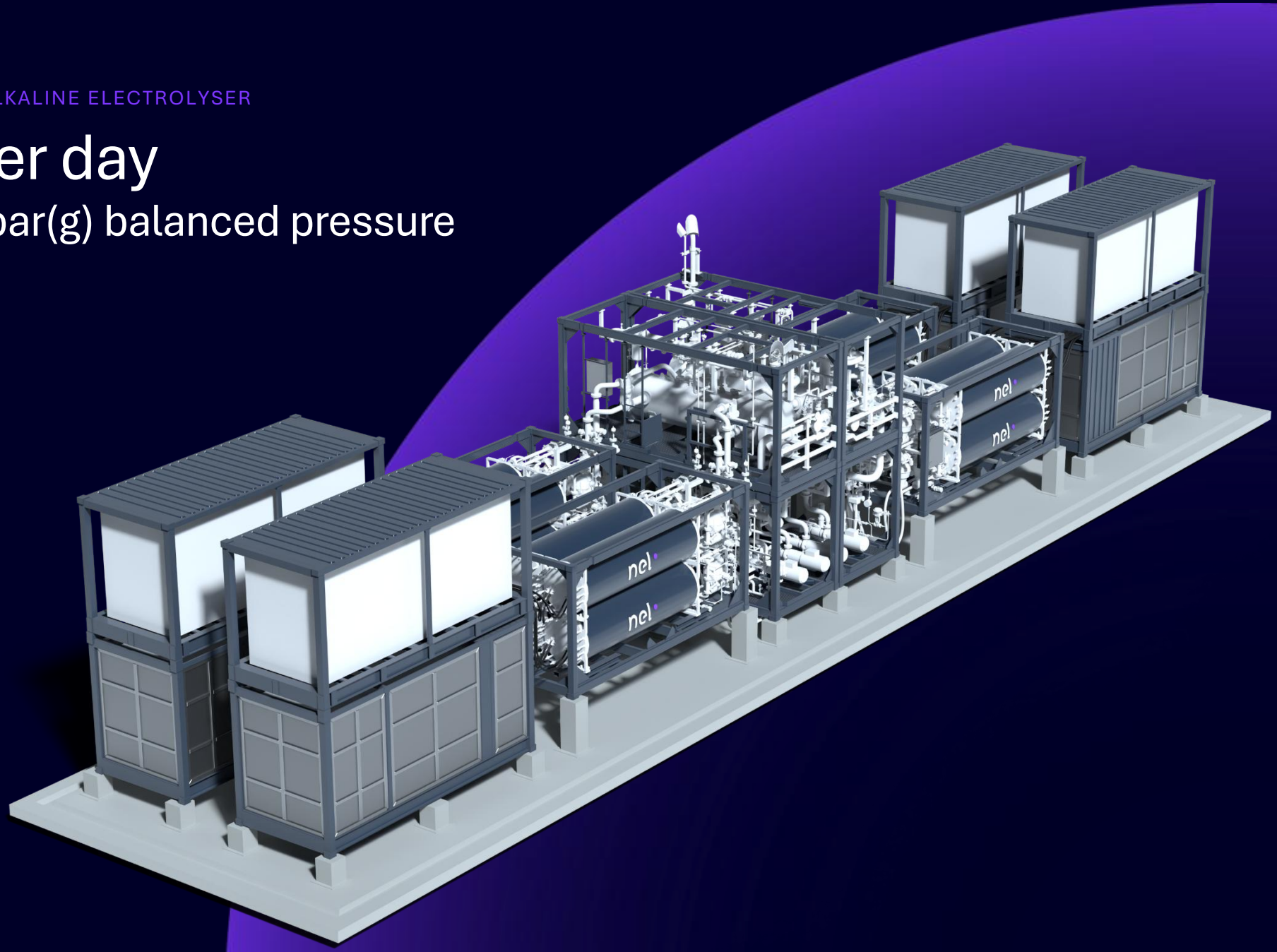
Standardized and prefabricated modules to minimize site work and project complexity



NEXT GENERATION ALKALINE ELECTROLYSER

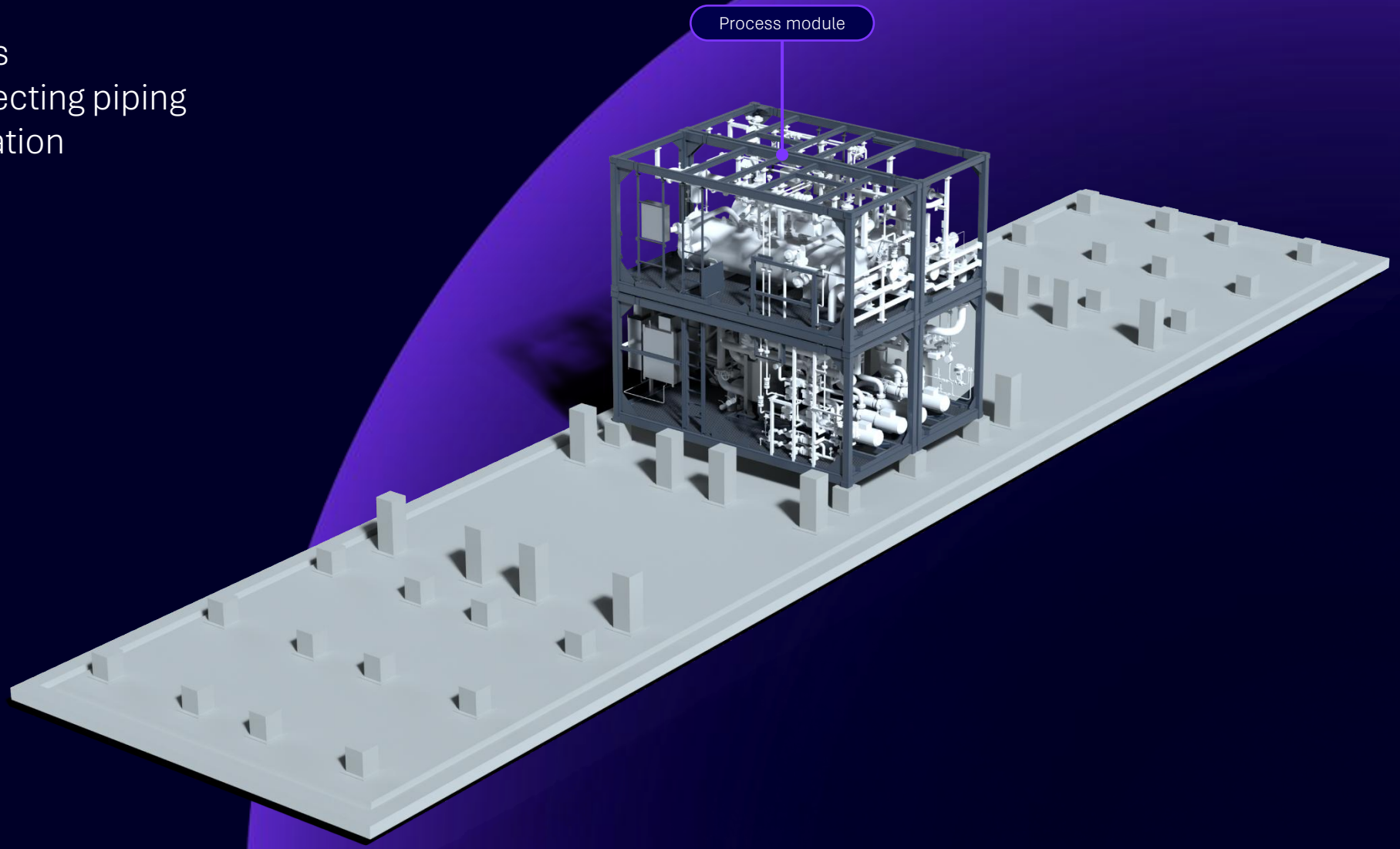
10 ton per day

25 MW, 15 bar(g) balanced pressure



Process module

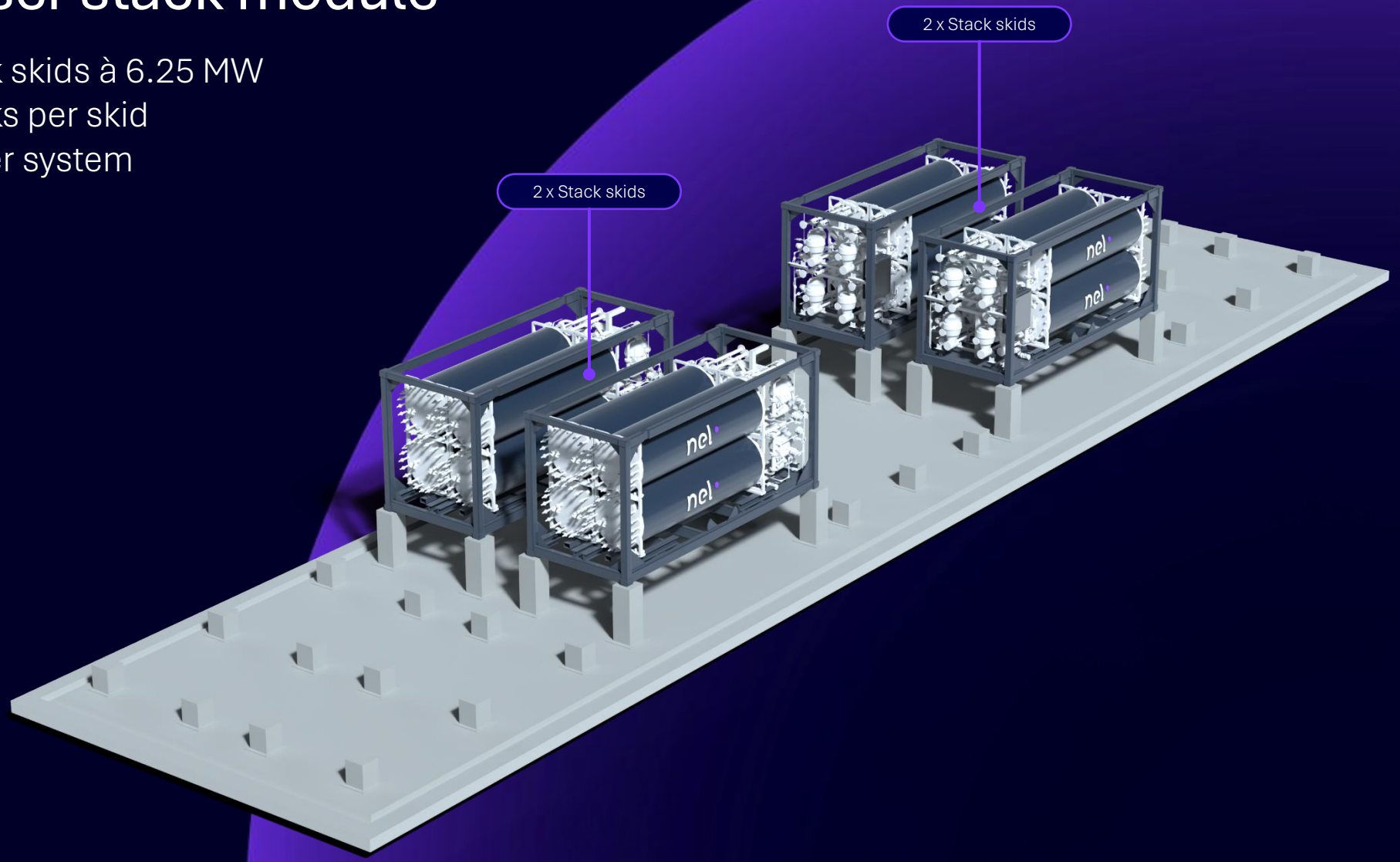
- Separators
- Interconnecting piping
- Lye circulation
- Vents
- Controls



NEXT GENERATION ALKALINE ELECTROLYSER

Electrolyser stack module

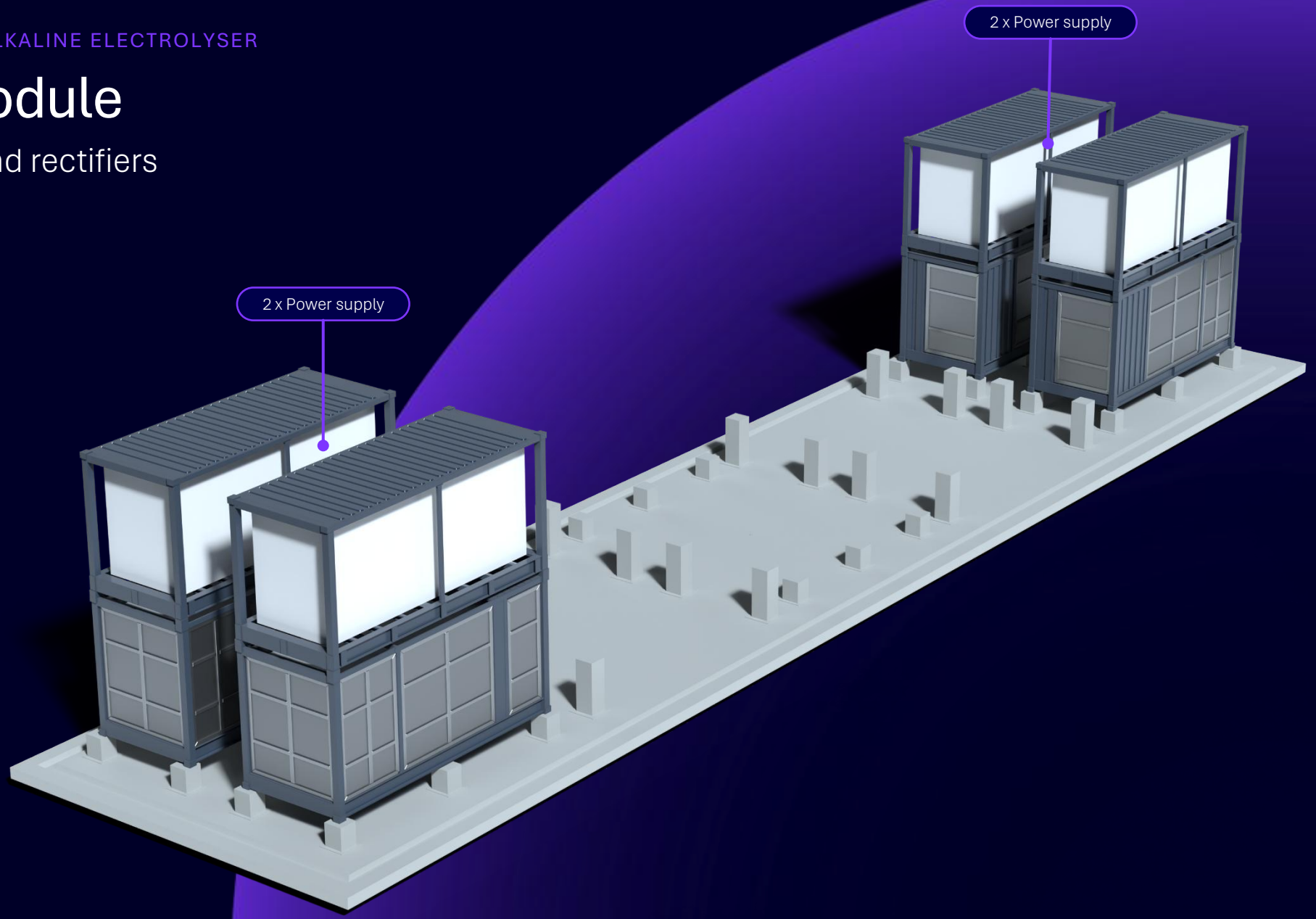
- Four stack skids à 6.25 MW
- Four stacks per skid
- 25 MW per system



NEXT GENERATION ALKALINE ELECTROLYSER

Power module

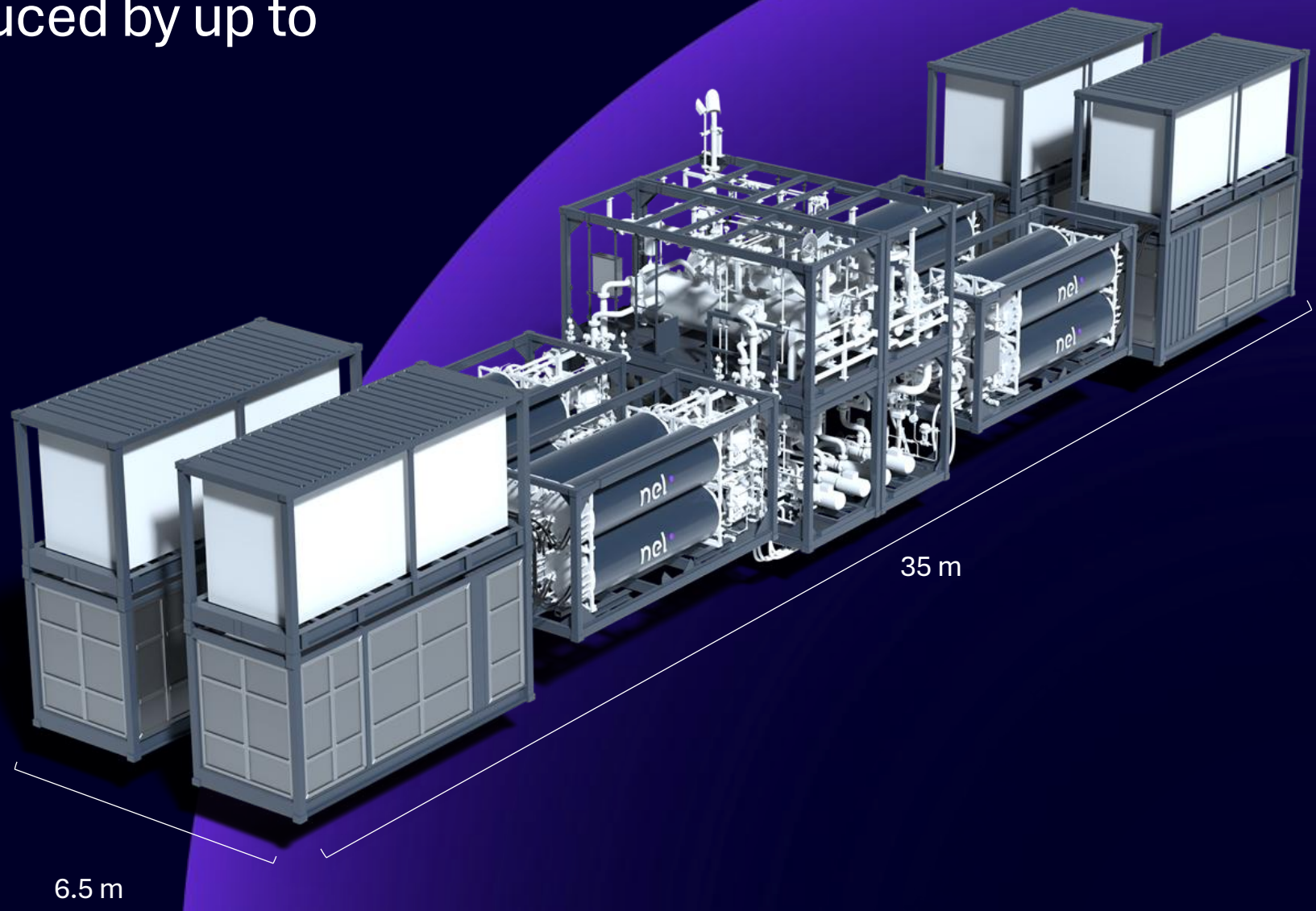
Transformers and rectifiers



NEXT GENERATION ALKALINE ELECTROLYSER

Footprint reduced by up to

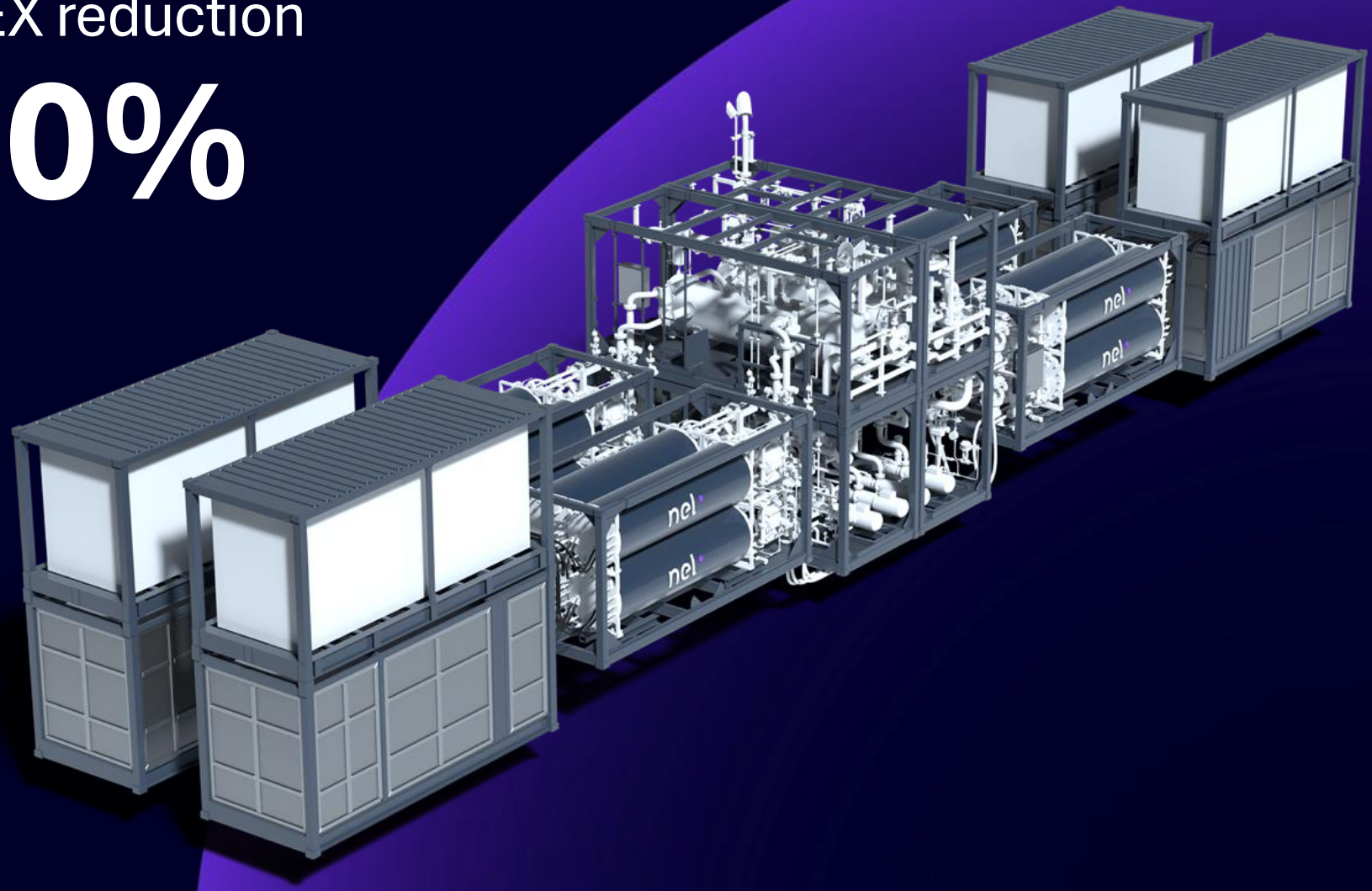
80%



NEXT GENERATION ALKALINE ELECTROLYSER

System CAPEX reduction

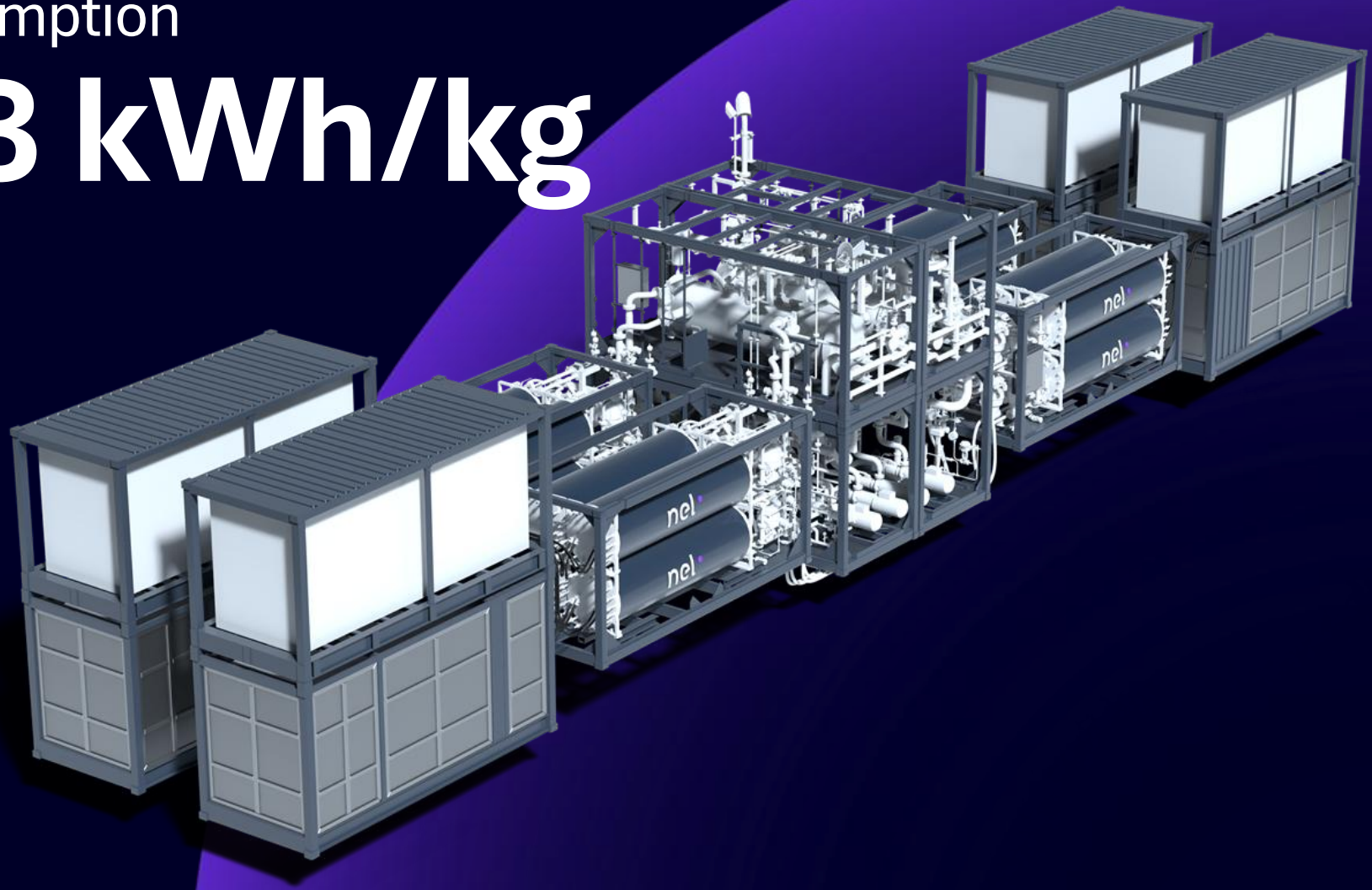
40-60%



NEXT GENERATION ALKALINE ELECTROLYSER

Energy consumption

51-53 kWh/kg



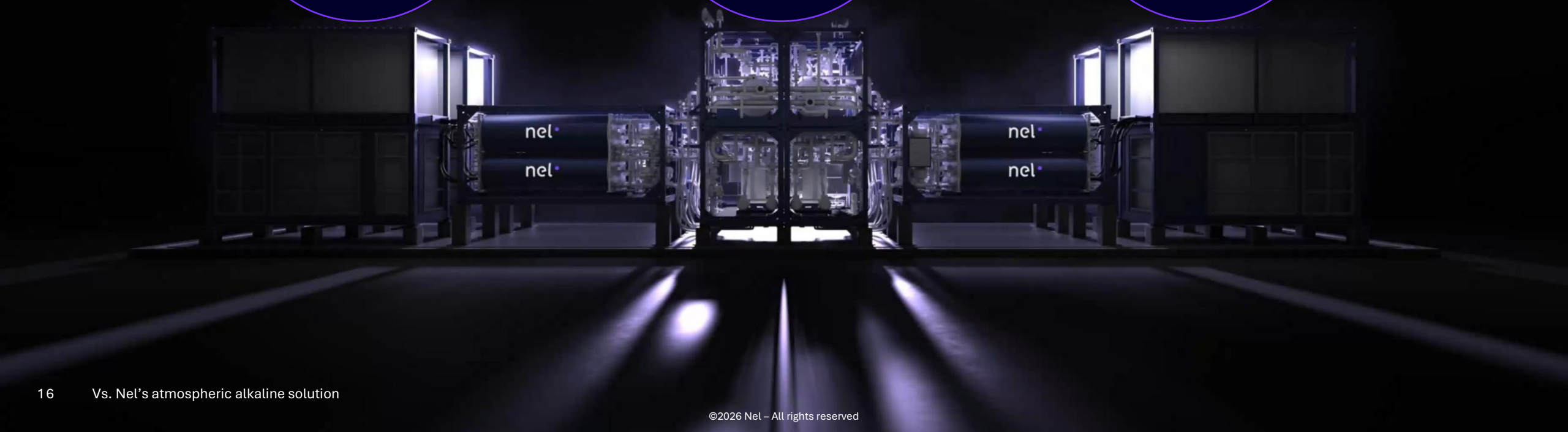
NEXT GENERATION ALKALINE ELECTROLYSER

The next-generation Pressurized Alkaline electrolyser

Footprint reduction 80%

System CAPEX reduction 40-60%

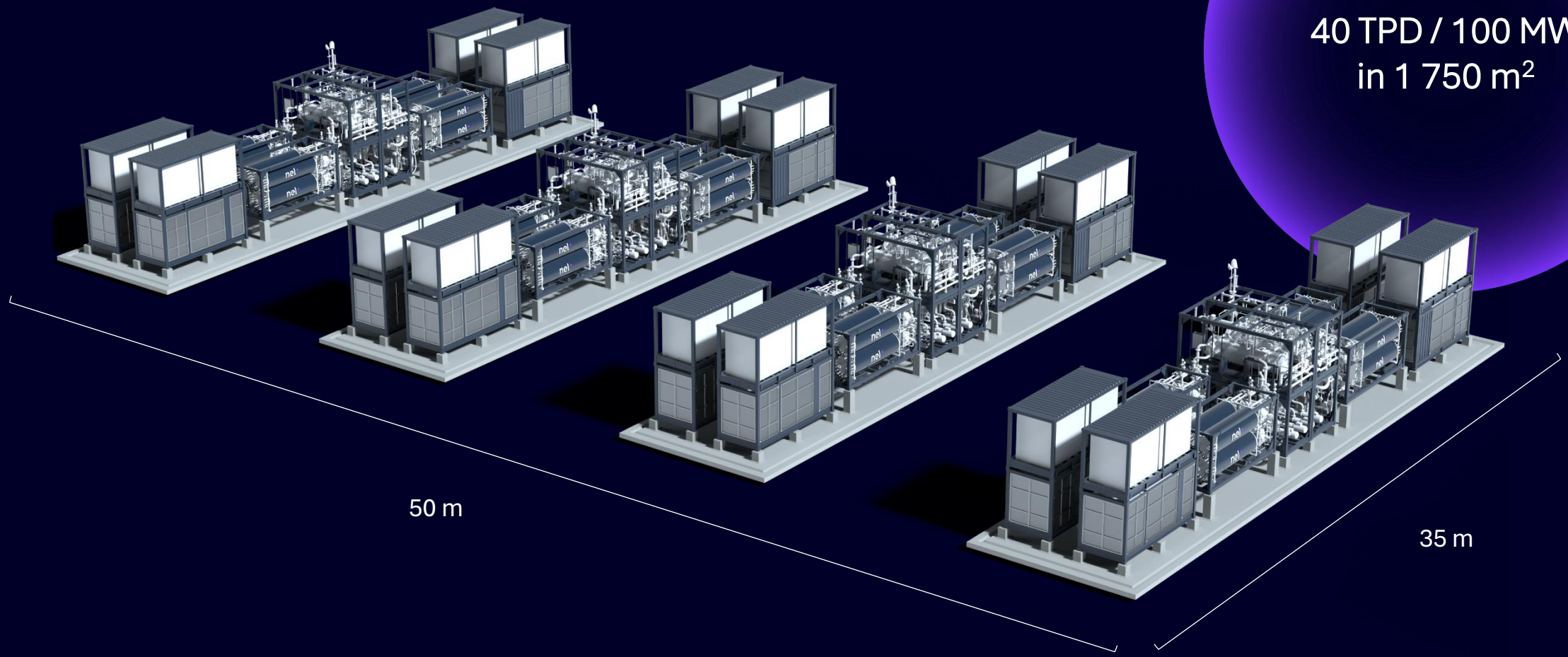
Energy consumption 51-53 kWh/kg



Vs. Nel's atmospheric alkaline solution

NEXT GENERATION ALKALINE ELECTROLYSER

25 MW building blocks scale to larger plants



Plant plot includes transformer, rectifier, electrolyser, gas management at 15 bar output
Excludes sub-station, water purification, coolers, purging and compression above 15 bar

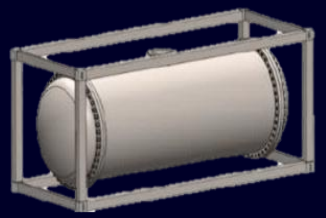
Selected design features, benefits, and key metrics

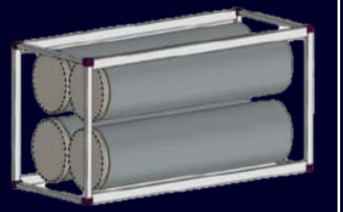
NEXT GENERATION ALKALINE SOLUTION

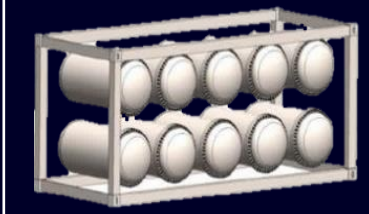
Key stack metrics

- Stack efficiency: 48.8-51.2 kWh/kg
- Degradation: 1-1.4 pp/yr
- Load range: 20-100% (system level 12.5-100%)
- Pressure: 15 bar(g), balanced
- Hydrogen purity: >99.5%
- Dynamic response: 2 sec/pp
- Design lifetime: 80 000 h / 10 yrs
- Factory assembled and factory tested

Key stack design features







Cell diameter [cm]	1 800	**950**	750
Cell width [cm]	25	**20**	16
Number of cells	160	**920**	100
Flow [kg/day]	1 479	**2 500**	1 630
Effect [W]	3 400	**5 750**	3 749

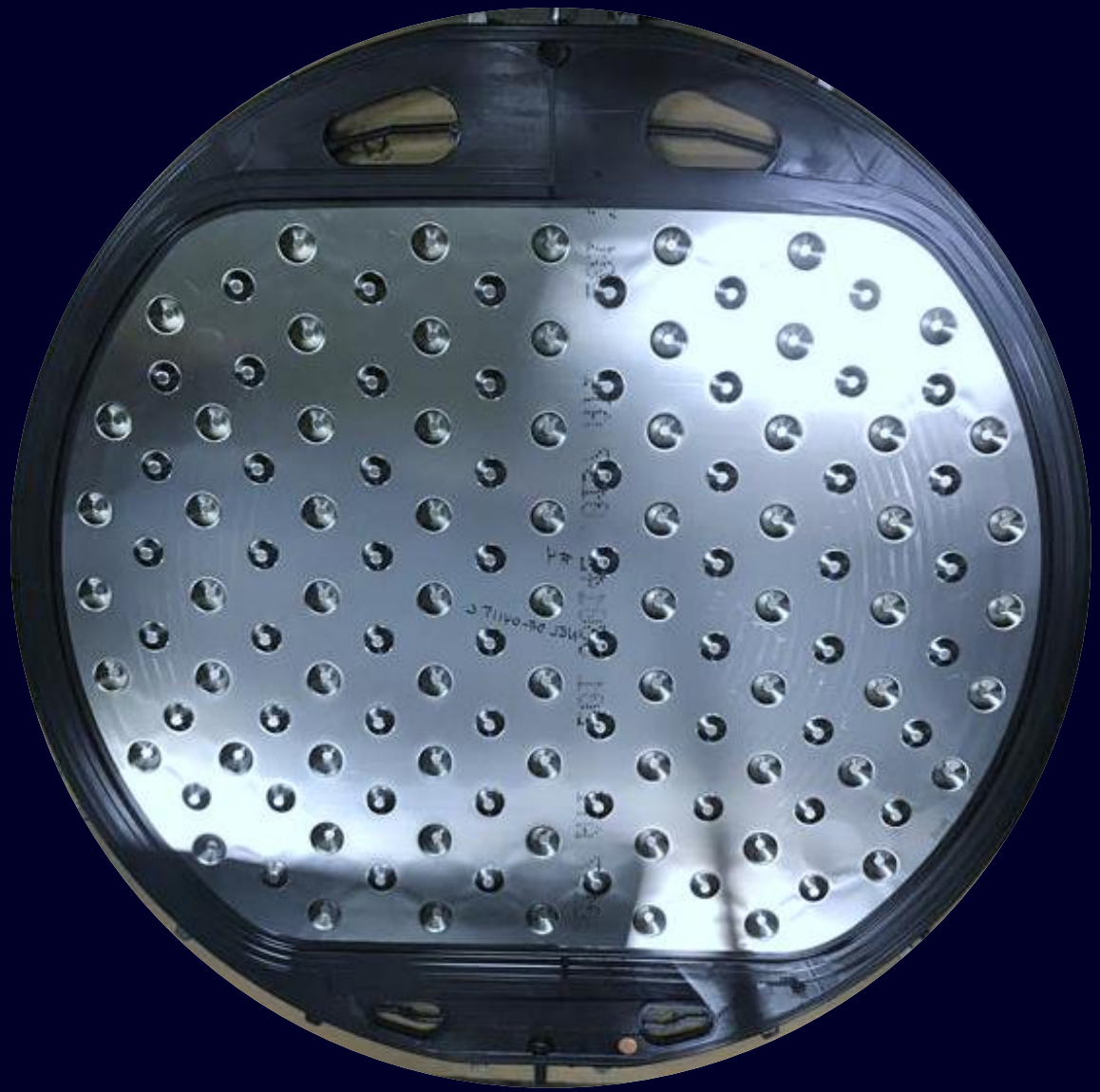
Selected concepts

- 20ft ISO-skid eases handling
- Maximize gas flow per skid
- Allows injection moulded cells
- Avoid diaphragm and nickel sheet size limitations
- Reduces end-plate forces

NEXT GENERATION ALKALINE SOLUTION

Key design features for injection moulding

- Gasket free cell design
- Patented double-seal concept
- Manifold design to minimize shunt currents
- Short cycle times with frame, structural core and goffer plate integrated in one moulding step
- Future-proof to support various catalyst and diaphragm options



Shunt currents

a historic blind spot of pressurized alkaline electrolysis

What are shunt currents?

In an electrolyser, electricity is supposed to flow through the cells – splitting water into hydrogen and oxygen.

Shunt current is the electricity that doesn't follow the intended path.

Wasted energy
Current not passing through a cell produces no hydrogen. It just generates heat - a direct efficiency loss – or even worse – produce the wrong gas in the wrong place.

Corrosion
Stray current flowing through metal pipes and fittings causes electrochemical corrosion - eating away at the hardware from the inside.

Cell imbalance
Some cells receive more current than intended, others less. This causes uneven wear and can shorten the life of the entire stack.

Nel’s approach to shunt currents

Injection moulding enables the design freedom behind our patented manifold and cell architecture – unlocking a unique approach to reducing shunt currents, thereby improving system efficiency

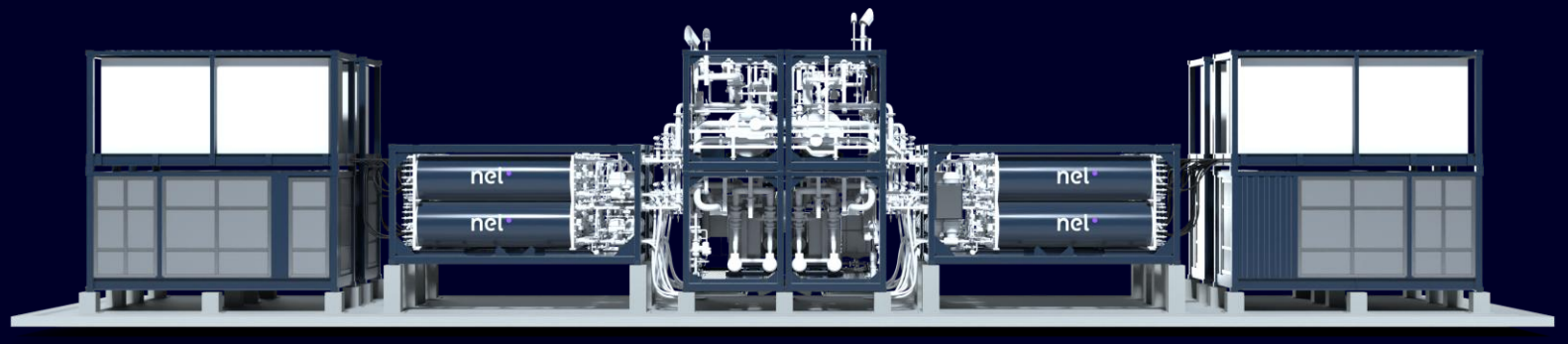
Price estimate for a turnkey system

NEXT GENERATION ALKALINE SOLUTION

Estimated total system price below USD 1 450 /kW

Normalized to 30 bar(g), 99.99% purity

25 MW system	USDm	USD/kW
HW as illustrated	24.2	966
Nel services	3.1	123
Other HW and services	8.7	346
Total	36	~1 435



HW as illustrated include (ex. works)
- Stack module
- Process module
- Power modules (transformer and rectifier)
- Standard Nel warranties

Nel service include
- Engineering support
- I&C supervising

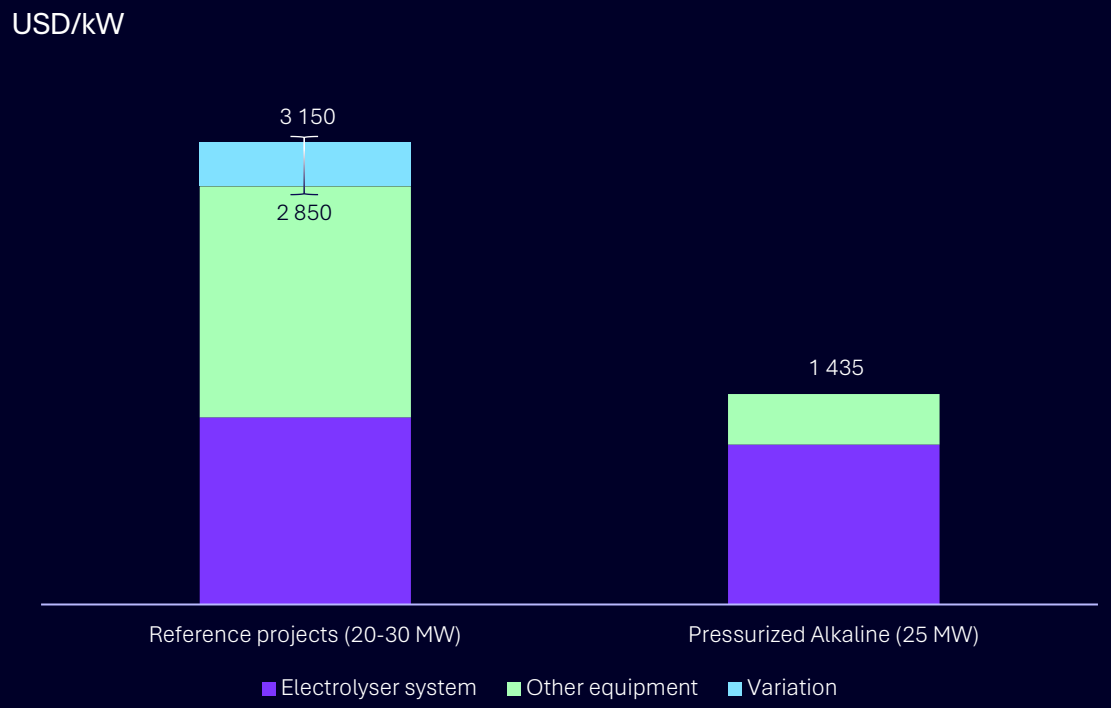
Other HW include
- Water purification
- Dryer/purification
- Compression 15 to 30 bar(g)
- Coolers
- Instrument air
- Nitrogen

Other service
- Delivery/freight
- I&C scope
- Civil works and site preparations
- KOH, EPC services

NEXT GENERATION ALKALINE SOLUTION

...enabling supply of hydrogen at a significantly lower price

Full turn-key CAPEX comparison



Full turn-key LCOH comparison

Given 95% system utilization, 50 USD/MWh power price, 30 bar (g) output pressure, 20-year lifetime

The future belongs to the front-runners

Next-generation electrolyser production capabilities

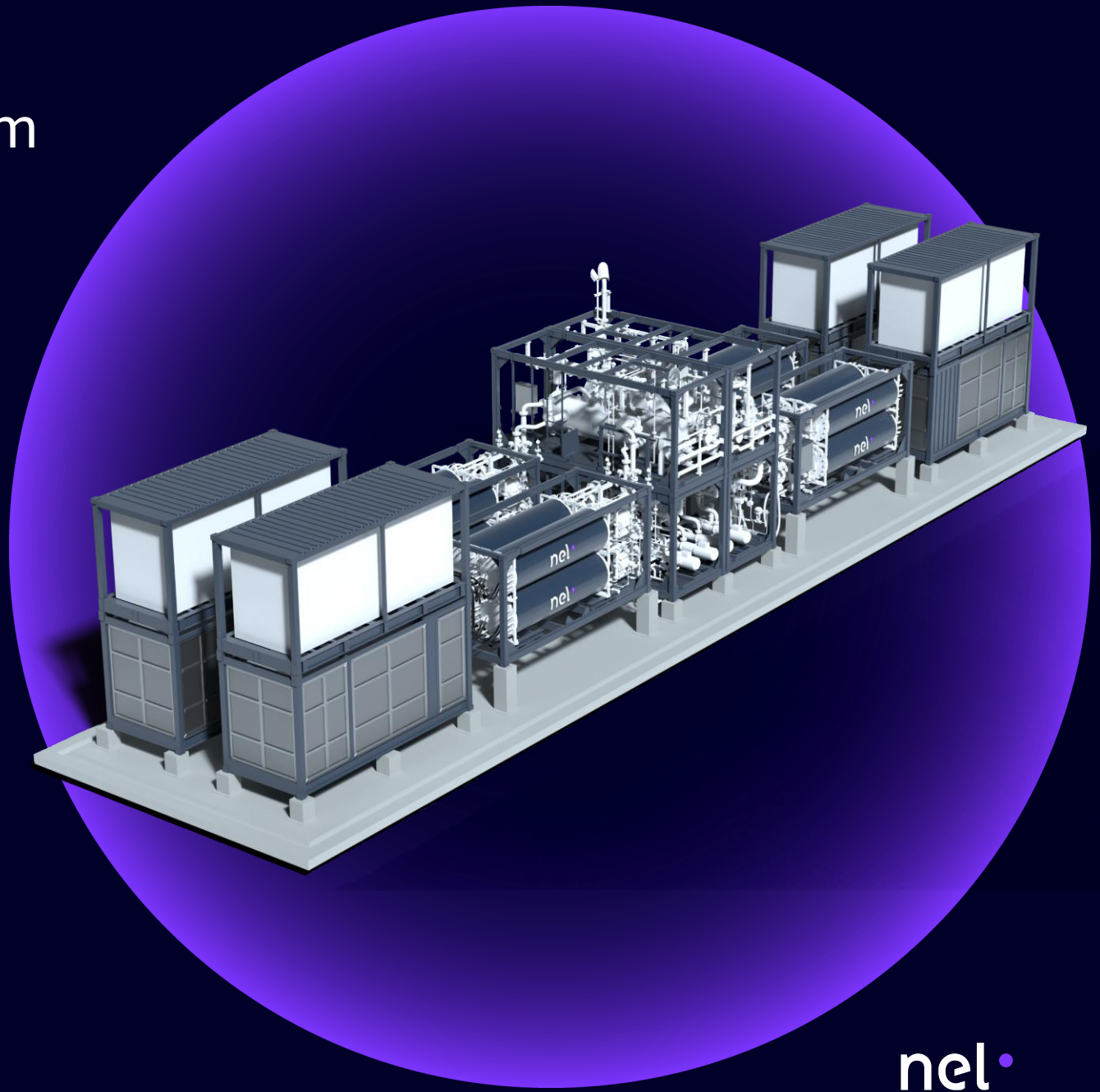
Mats Bohman, VP Alkaline Operations

Funded by the European Union
Emissions Trading System
Innovation Fund

NEXT GENERATION PRODUCTION CAPABILITIES

The new pressurized alkaline platform designed for manufacturing

- The produced units are part of a modular system with well-defined interfaces in order to minimize installation at site
- The stack is a standard product fully fabricated at Nel production plant
  - Designed for high volume production
  - FAT at Nel site
  - No engineering work between projects is needed



NEXT GENERATION PRODUCTION CAPABILITIES

The journey of industrialization

Design for manufacturing
Design & process

Validate maturity
Design & processes

Apply learnings
Tolerances & assembly

Process validation
Serial line and tools

Build the roadmap
Scalable volume ramp-up

NEXT GENERATION PRODUCTION CAPABILITIES

Manufacturing concept

1 Standardized assembly

A clearly defined sequence ensures Quality, Repeatability and Just In Time Delivery

2 Make vs buy

Driven by Nel's core technology weighed against complexity, flexibility and total cost

3 Manual vs automated

A clear separation between manual and automated processes, selected based on flexibility/maturity, quality and total cost

4 Capacity by scalability

Production Line concept is planned for scalability

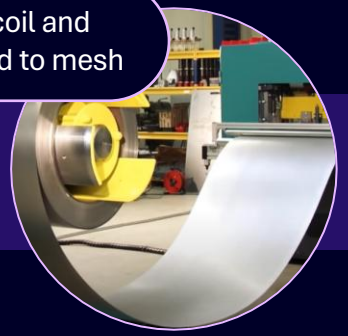
NEXT GENERATION PRODUCTION CAPABILITIES

Process overview: Supplier scope

Electrodes

Nickel sheet

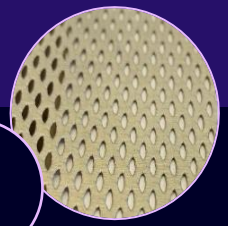
Decoil and expand to mesh



Manufacturing of Cathode electrode

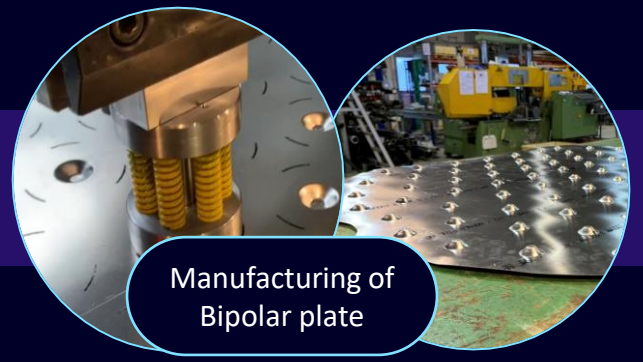
Coating Cathode

Manufacturing of Anode electrode



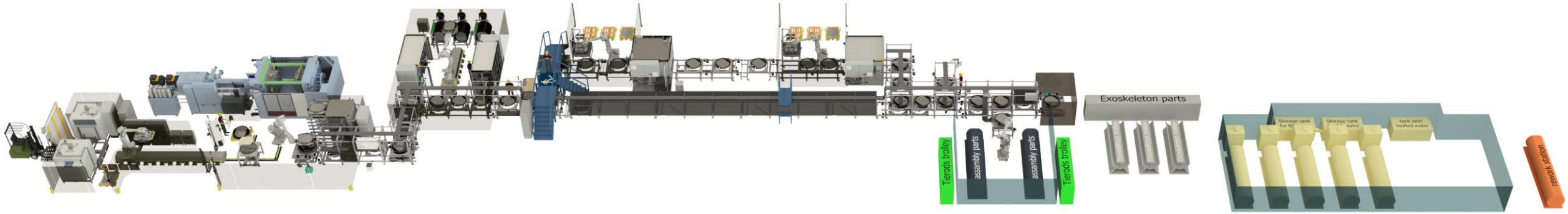
Bipolar plate

Decoil and slit cut



Manufacturing of Bipolar plate

Steel core frame manufacturing



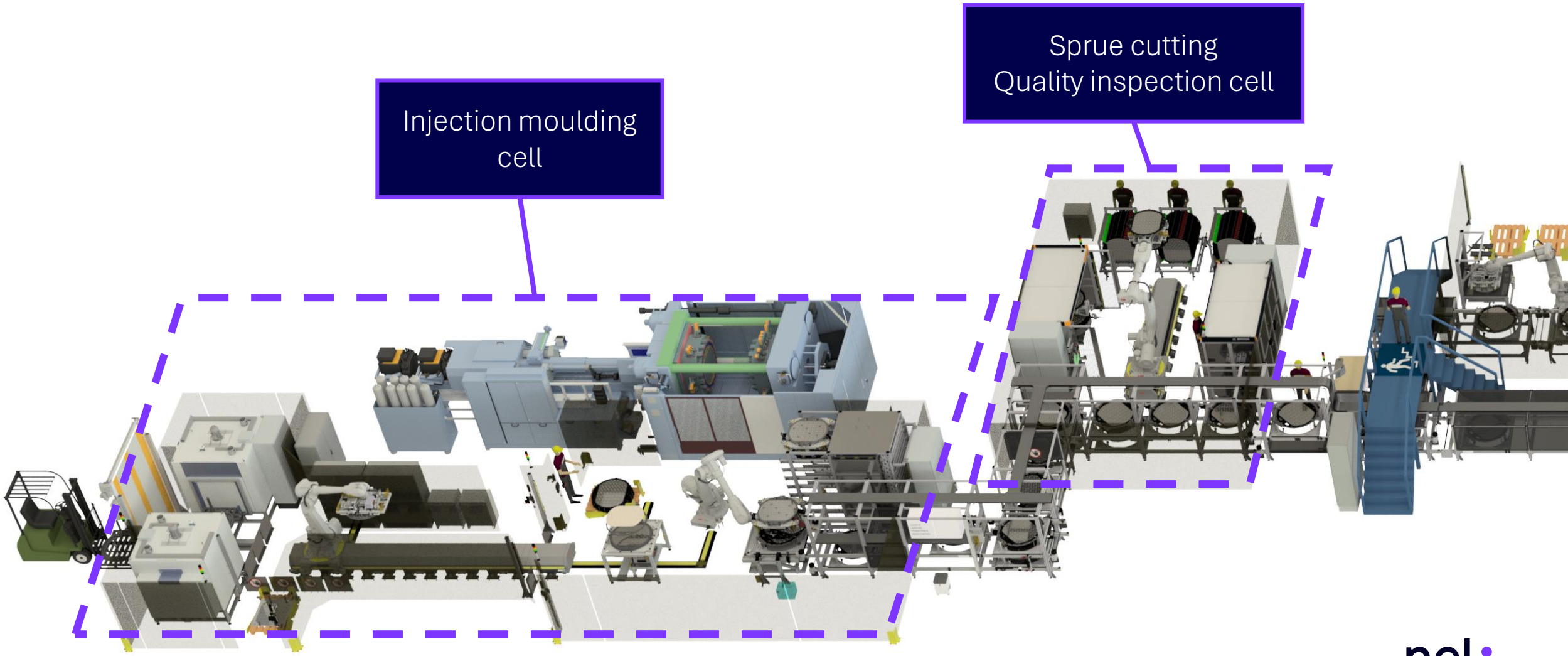
The new production line

500 MW

nel

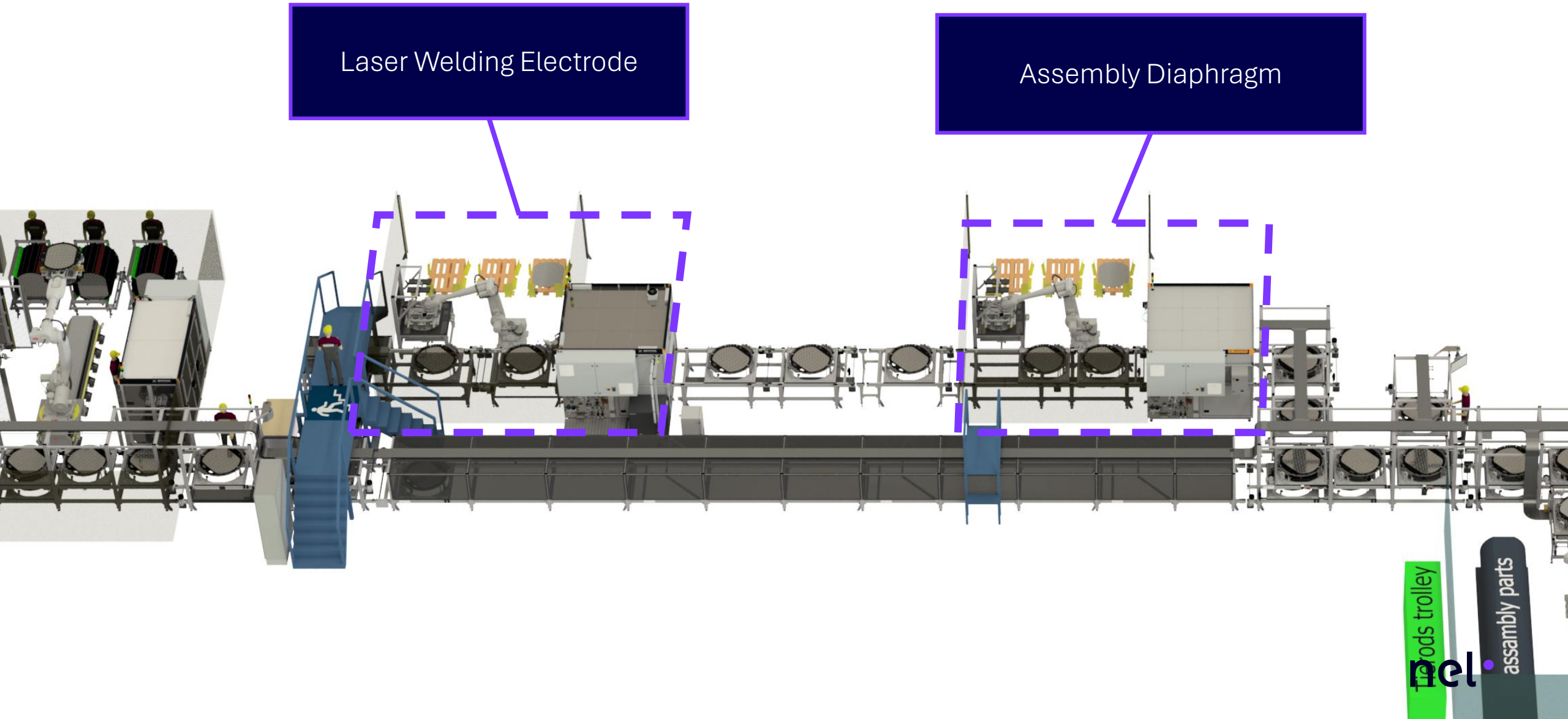
NEXT GENERATION PRODUCTION CAPABILITIES

The new production line



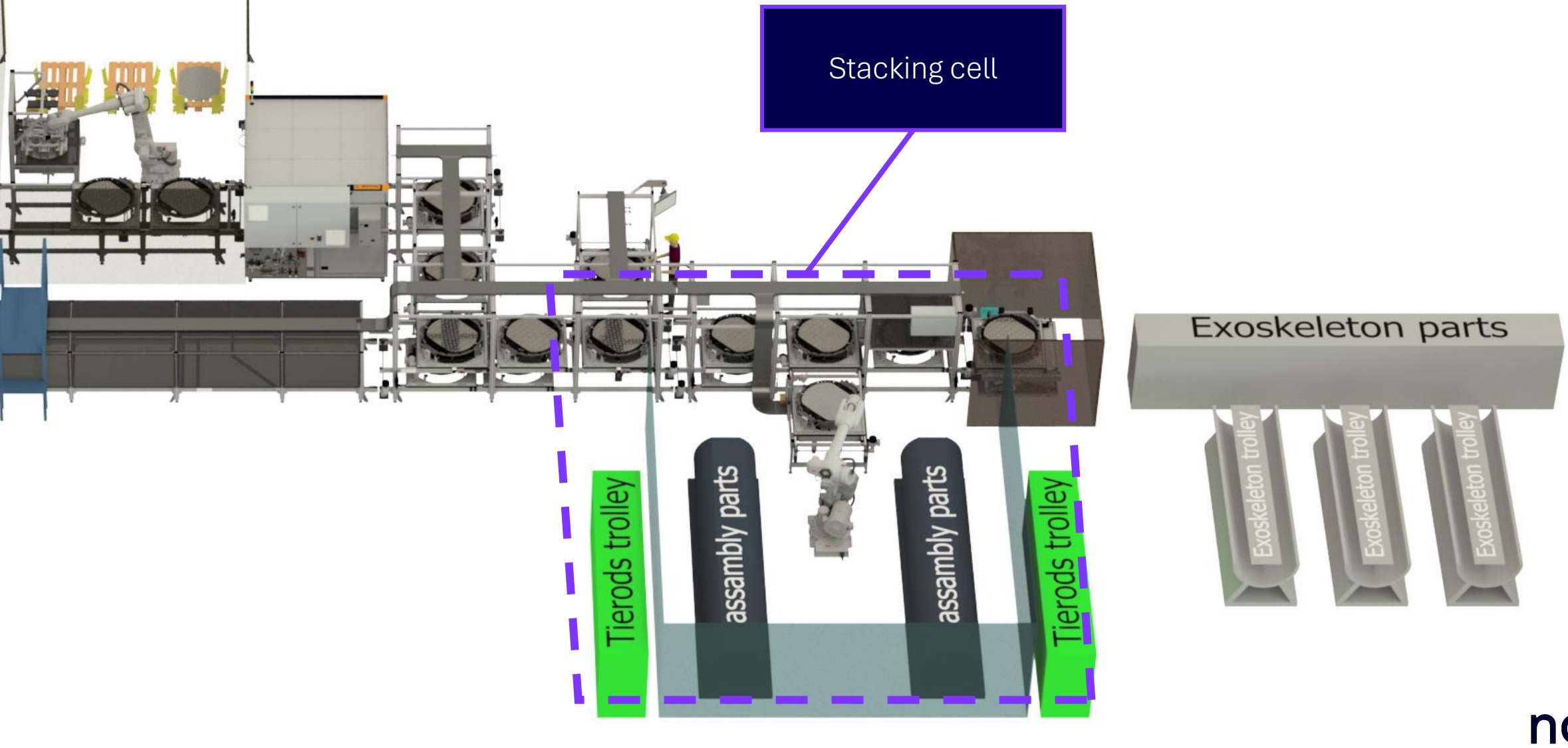
NEXT GENERATION PRODUCTION CAPABILITIES

The new production line

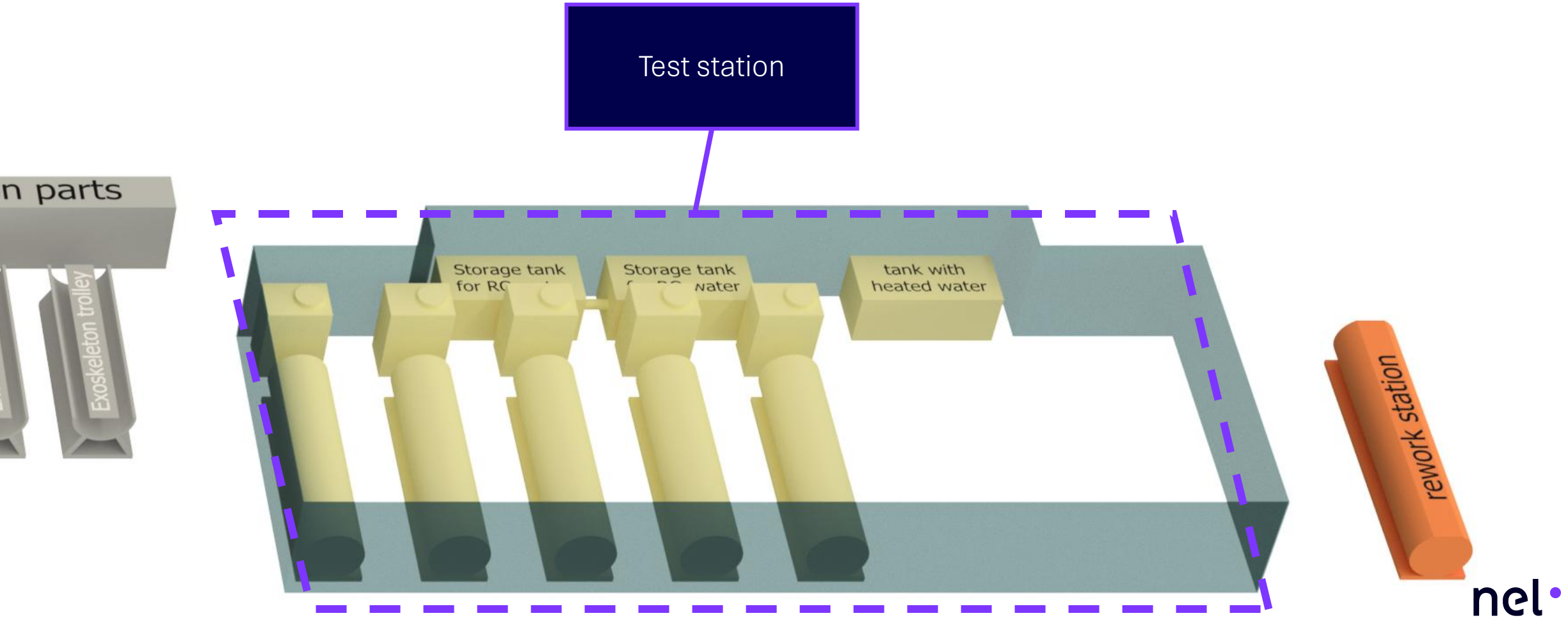


NEXT GENERATION PRODUCTION CAPABILITIES

The new production line



The new production line



The product

NEXT GENERATION PRODUCTION CAPABILITIES

Quality in every step

1 Built-in quality

PA is designed for robust Quality from the very beginning by combining design, processes and equipment.

2 FMEA in every step

Every process step is analyzed in detail to identify and mitigate risks before they occur in reality.

3 Data builds quality

Data is collected during manufacturing to optimize the process during and after production.

4 Full traceability

Every component and critical process parameter is traceable – assuring full traceability from system to process parameters to raw material.

5 Result

Stable, predictable product quality at scale.

NEXT GENERATION PRODUCTION CAPABILITIES

Supply chain & Sourcing strategy

1 Designed for resilience

Supply chain built to reduce risk while supporting long-term growth.

2 Early supplier involvement

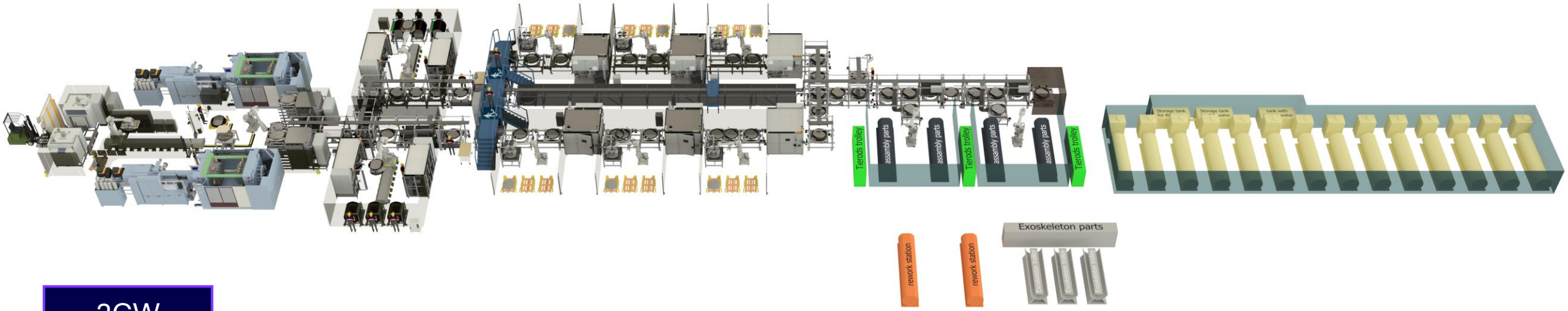
Suppliers engaged early to ensure manufacturability and robust quality.

3 Global + regional balance

Qualified suppliers worldwide balance cost, quality, availability and lead time.

4 Result

Scalable supply chain enables volume ramp-up without compromising quality.



2GW

Scaling the system

from launch to volume

- Standardized line concept enables short lead-time for expansion of production capacity
- Pressurized Alkaline system designed for stepwise capacity increases in 500 MW increments
- The design of the line ensures pull flow and a stable, predictable production pace
- The ramp-up capacity and quality is assured by validating the line capacity/quality

NEXT GENERATION PRODUCTION CAPABILITIES

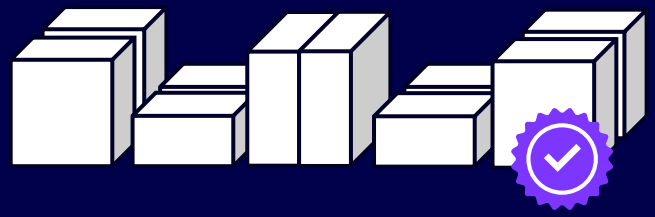
Support from the EU Innovation Fund to de-risk production capacity growth

Funded by the European Union
Emissions Trading System
Innovation Fund

Total funding up to

EUR 135 million

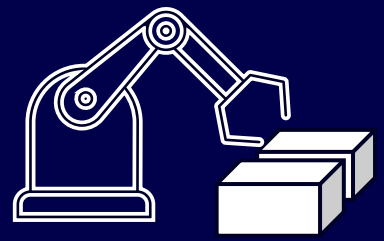
To commercialize and produce the next-generation electrolyser



Manufacturing capacity built in phases

1 GW ready by 2027

Further scale to 4 GW in the second phase

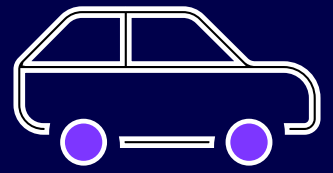


Total GHG emissions avoidance

33.5 Mt CO_2

=

8 million



gasoline cars

The future belongs to the front-runners