Electrochemistry, Water, Energy: our future for the World

DE NORA TODAY

€856.4m

2023 Revenues

24

Operating companies

+100

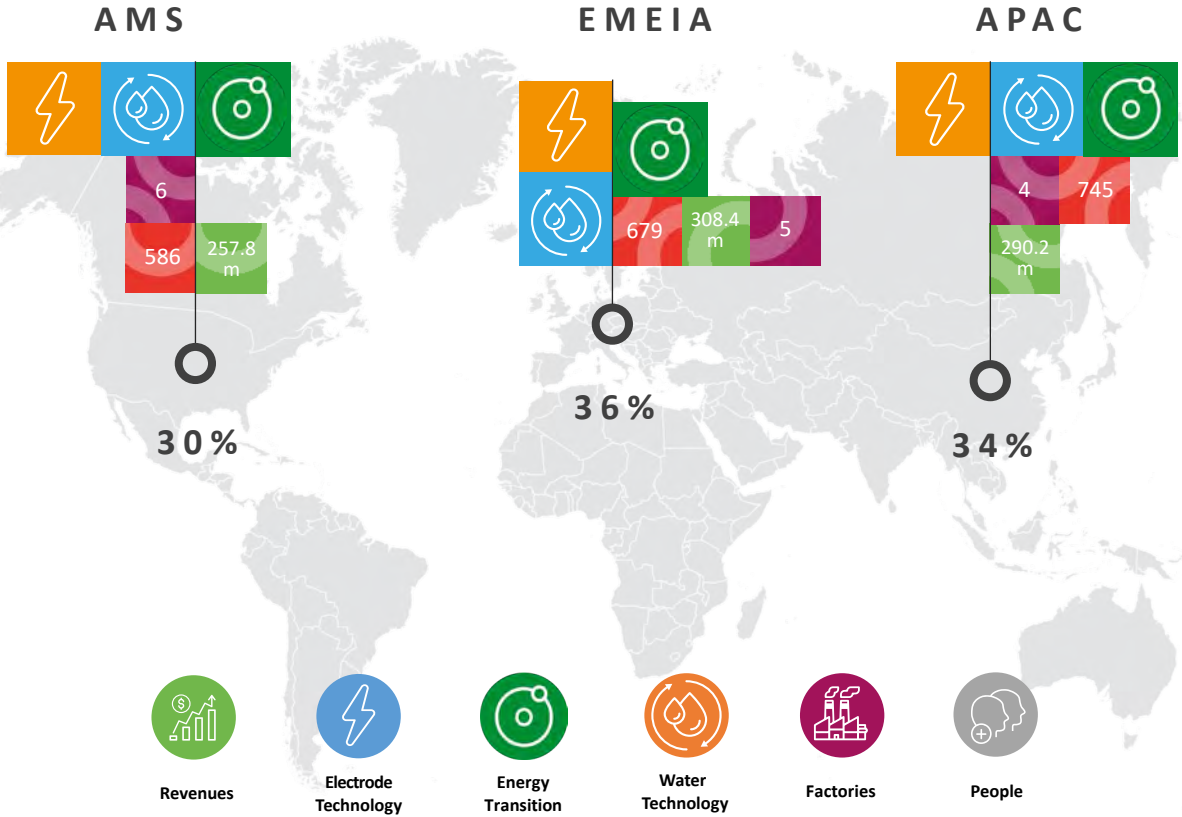
Years of Innovation

281

Patent families

2010

People



Data as of 31.12.2023

…addressing well-diversified end markets and applications while serving a large customer base

Electrode Technologies

Chlor-alkali

Electronics

Mining

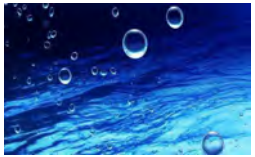
Water Technologies

Swimming pools

Municipal and Industrial water & wastewater treatment

Power and Marine water & wastewater treatment

Energy Transition



Hydrogen production

Hydrogen storage and transportation

Fuel cells

Main Businesses

Electrode Technologies

PRODUCTS AND SOLUTIONS

Anodes, Cathodes, Catalytic Coatings
Gas Diffusion Electrodes

SERVICES

- Electrodes recoating, repair services and spare parts
- Performance upgrades and retrofits

Water Technologies

PRODUCTS AND SOLUTIONS

Electro-chlorination, Disinfection and Filtration Technologies, Marine Water Treatment Technologies, Pool Technologies

SERVICES

- Technical assistance and remote support services
- Analytic services

Energy Transition

PRODUCTS AND SOLUTIONS

DSA® Electrodes for AWE, Electrolysis Cells, Gas Diffusion Electrodes (GDE), Electrodes for Fuel Cells

SERVICES

- Engineering design
- Supply and maintenance agreements

Energy Transition

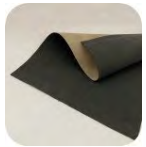
The natural evolution of the Electrode Technologies business

Global leader in solutions for Green Hydrogen Technologies

Electrodes & catalytic coatings for the Energy Transition market and, particularly, solutions relating to Green Hydrogen.

KEY MARKETS

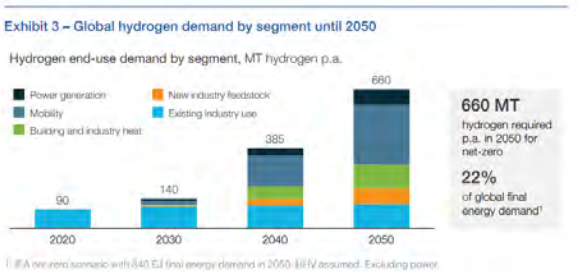
- Heat & Power
- Transport
- Energy Storage
- Chemical Industry
- Petrochemical Industry
- Metallurgy



SECONDARY MARKETS

- Agriculture & Fertilizer
- Food & Beverage

- De Nora's products are used to generate hydrogen through water electrolysis processes and deploy hydrogen to generate electricity in fuel cells.
- Green hydrogen (produced by water electrolysis using renewable energy with zero CO2 emissions) is a key element to achieving "carbon neutrality" and "net-zero emissions".



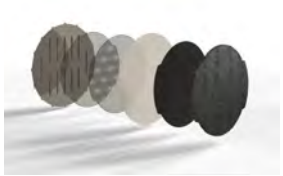
MAIN APPLICATIONS

Green Chemicals

Hard-to-abate

Mobility

PORTFOLIO



Electrodes for Alkaline Water Electrolysis (AWE)

Cells

Dragonfly® system

Gas Diffusion Electrodes for fuel cells

De Nora is tk nucera technological partner for AWE H2 and chlor-alkali solutions

DE NORA

DE NORA — 34%

thyssenkrupp nucera

66% — thyssenkrupp

De Nora value added for thyssenkrupp nucera

- **Technology**
  - ✓ Joint R&D programs
  - ✓ Dedicated coatings
- **Manufacturing of Electrolysis Cells**
  - ✓ >200,000 elements made[2]

Electrodes & tk nucera Electrolysis Cell

World largest backlog of Green H_2 Projects

- **AWE Electrolysers for H_2**
- **Chlor-alkali & Hydrochloric acid Electrolysis**

Electrolysis Module & Plant

tk Uhde value added for thyssenkrupp nucera

- **Engineering, Procurement & Construction**
  - ✓ EPC services
  - ✓ Joint offering of process chains

EPC

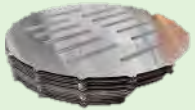
Green Ammonia and Other Green Chemicals

De Nora has a broad product portfolio for H2 solutions

100 years of experience on electrodes and cells with global players on large scale projects worldwide

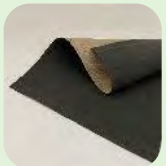
In The Market

Electrodes for AWE (Alkaline Water Electrolysis)



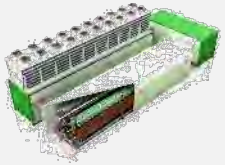
Cells for tkn

Electrodes for fuel cells



Under development

Small size Electrolysers Modules



Other R&D initiatives

- AEM Electrodes
- PEM Components
- Transport & Storage
- Carbon Utilisation

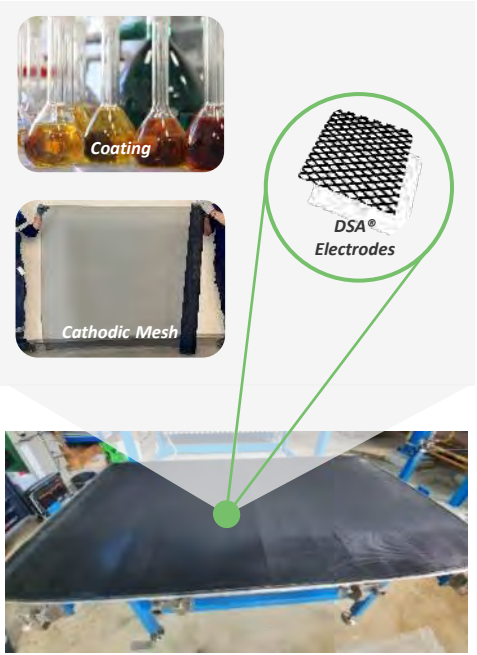
Services

Aftermarket

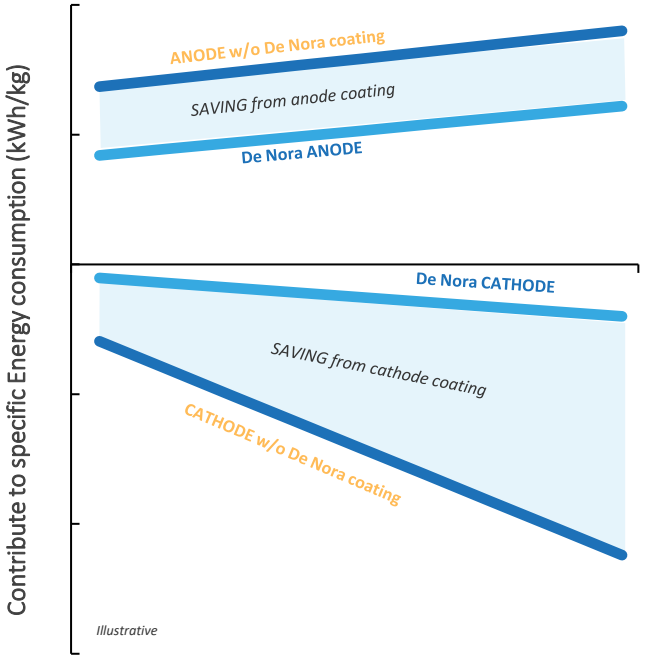
1 2 3 4 5

De Nora electrodes deliver lower LCOH[1]

Coated with proprietary catalytic coatings



Premium Performance



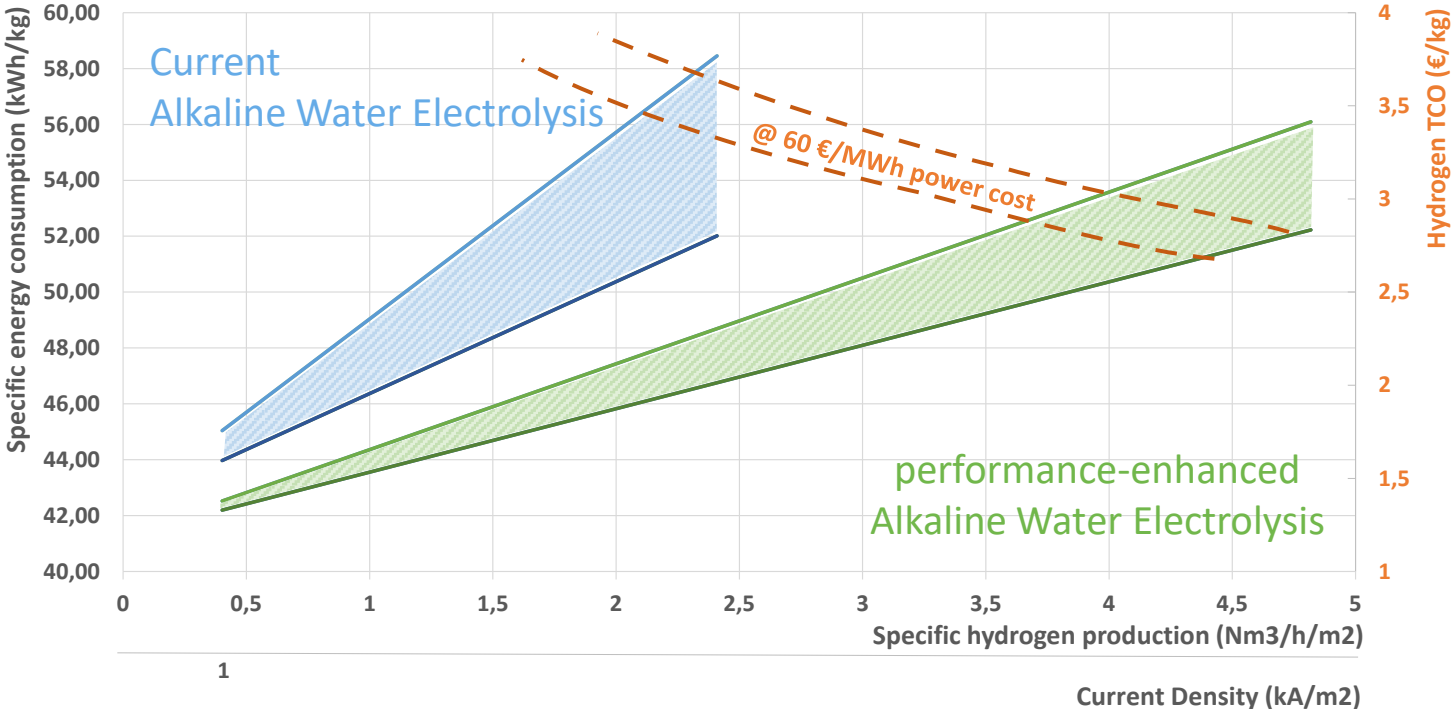
De Nora proprietary electrodes enable **higher hydrogen production** rates at any specific energy consumption

- ✓ **Higher Current Density**
- ✓ **Reduced Power Consumption**
- ✓ **More Compact Installations**
- ✓ **Improved Lifetime and Stability**

 [1] *Levelized Cost Of Hydrogen*

Role of De Nora products

Enabling higher hydrogen specific production at outstanding specific energy consumption, with more compact installations and a lower Hydrogen Cost (LCOH)



Hydrogen production cost reduction (orange curve) at the same time with hydrogen production rate increase with the adoption of De Nora products.

De Nora on leading projects for H2 development

NEOM Project
(Largest Hydrogen Project Globally)

Project Size: **> 2 GW**
tk Nucera project

Hydrogen Holland I Project
(Largest Hydrogen Project in Europe)

Project Size: **200 MW**
tk Nucera project

Casa Grande – Arizona, USA

Project Size: **40 MW**
tk Nucera project

Delfzijl Industrial Park – The Netherlands

Project Size: **20 MW**

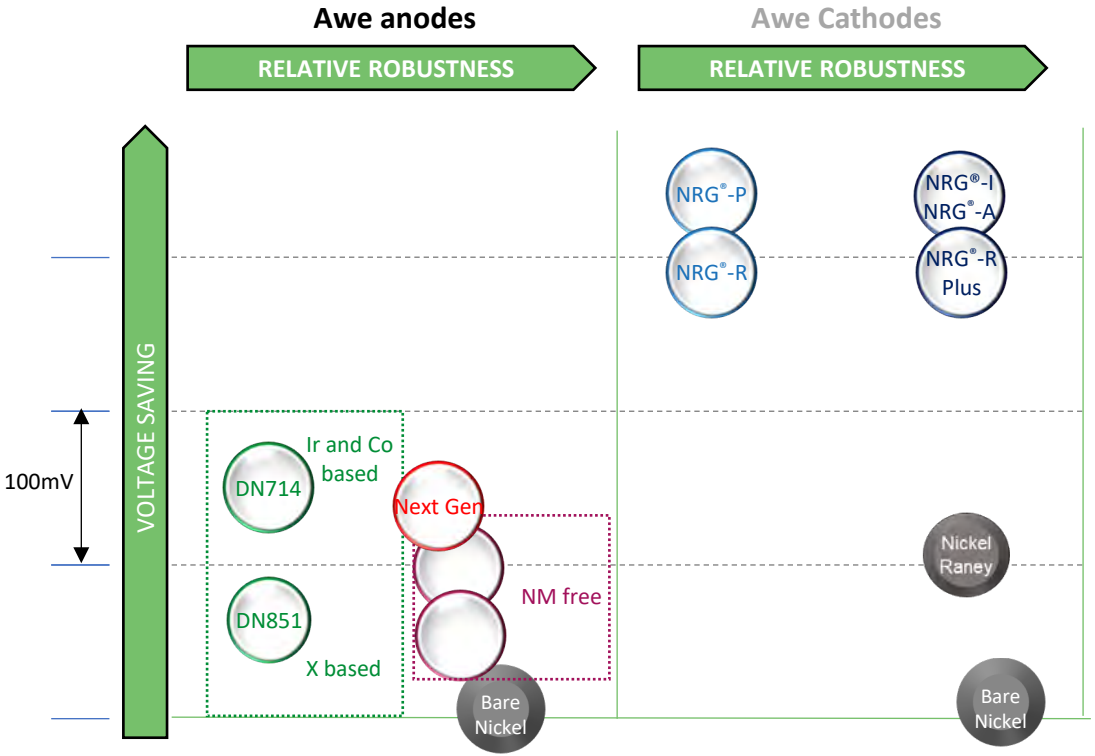
Camacari Industrial Complex
(First industrial-scale green Hydrogen Site in Brazil)

I Phase Project Size: **60 MW**
tk Nucera project

Based on publicly available info

AWE coating portfolio and R&D projects status

Confidential



Thermal based anodes suitable for polarized technologies

Thermal sprayed based anodes, NM free, suitable for intermittent operations

- improved performances compared to bare sandblasted electrodes and DN851 thanks to highly increased electroactive area

R&D focus –ongoing projects

- Trade off between performance and robusteness
- 6 projects ongoing
- Decreasing NM content and dependecy on CRM

With unprotected intermittent operation it is important to consider the interaction between cathode and anode (a.k.a. the electrode package) and the operational model

De Nora role along the value chain

	PRIMARY SCOPE OF SUPPLY	PARTNERS OF CHOICE	Technologies Providers			EPC contractors		Offtakers
			Electrodes	Cell	Electrolyzers	BoP	Plant construc	
	Electrodes and cells manufacturing (AWE)	Joint Venture	De Nora		Thyssenkrupp Nucera			Producer
	Electrodes and packages (AWE)	Electrolyzers OEMs	De Nora		OEM		EPC	Producer
	Electrodes (fuel cell)	Fuel Cell OEMs	De Nora		OEM		EPC	Producer
	Small size AWE electrolyzers	EPC	De Nora				EPC	Producer

Main Projects in Backlog

NEOM, Saudi Arabia,
Largest H_2 Project Globally
part of > **2 GW** tot project
H_2 to Green Ammonia

Green Steel project, Sweden
the 1° large-scale green steel plant in the EU
700+ MW
H_2 to Steel – Hard to abate industry

Dragonfly® electrolyzer- Projects

HyTecHeat
Eu Project with Snam e Tenova
1MW low carbon H_2 for steel production
Funded by EU " Horizon Europe"

CRAVE H_2
Crete-Aegean Hydrogen Valley (Crete)
4 MW - 500 tons/y of Green H_2
co-funded by the EU Commission and the Clean H2 Partn.

Dragonfly® AWE system

An innovative H2 generation system by De Nora based on De Nora Advanced AWE technology

High capacity
High current density, reduced footprint

High-efficiency electrodes
Reduced power consumption

Reduced Stack dimension
New cooling system through special design bipolar plates

Reduced footprint
MW/m^2

Minimized construction costs

Optimized transportation costs
use of standard size containers

Minimized installation costs
plug and play – all utilities on board

Customizable Offer
utilities on board

DRAGONFLY®

Alkaline Water Electrolyzer

DE NORA

Founded in **1923, De Nora** is an Italian multinational company listed on the Euronext Milan stock exchange, specializing in electrochemistry, leader in **sustainable technologies**, and has a vital role in the **industrial green hydrogen production chain.** The Company has a portfolio of products and systems to optimize the energy efficiency of critical industrial electrochemical processes and a range of products and solutions for water treatment.

De Nora has 25 operating companies in 10 countries and 5 R&D centers in Italy, the United States, and Japan, which ensure the **continuous improvement** and enlargement of its proprietary technologies covered by several patent families with more than 2.800 territorial extensions. With its widespread presence and broad product portfolio, the Company can effectively serve customers in 100 countries.

De Nora everywhere

Globally, **De Nora** is the **world's largest supplier of activated electrodes**, serving a broad portfolio of customers operating in chlorine & caustic soda production, components for electronics, and non-ferrous metal refining. De Nora is among the world's leading suppliers of **water filtration and disinfection** technologies (for the industrial, municipal, and marine sectors) and swimming pool disinfection components. Leveraging its well-established electrochemical knowledge, proven manufacturing capability, and a supply chain established over the years, the Company has developed and qualified a portfolio of electrodes and components to **produce hydrogen** through the electrolysis of water, which is **critical for the energy transition.**

Energy Transition

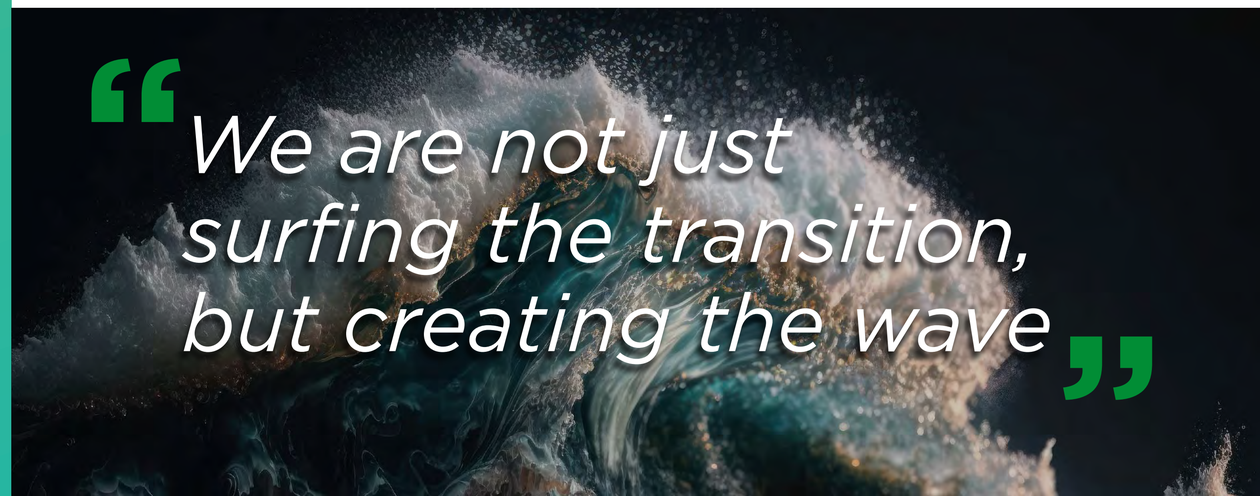
Energy transition applications are the natural extension of the Electrode Technologies business. De Nora's solutions are used to **generate green hydrogen** through water splitting and convert hydrogen into electricity. Hydrogen is crucial for **decarbonizing** many industrial processes; green hydrogen is key to achieving **"carbon neutrality"** and **"net-zero emissions"**.

Sustainability in DNA

De Nora aims to provide new solutions that can contribute to achieving the **United Nations 2030 Agenda** and the **Sustainable Development Goals (SDGs)**.

Boosted Alkaline Water Electrolysis

De Nora has a solid **Alkaline Water Electrolysis** (AWE) background. More than 100 years of expertise in electrochemistry and significant efforts applied in new R&D projects llowed De Nora to develop a new, boosted, alkaline water electrolysis technology. This is today the state-of-the-art technology for green hydrogen generation, ready to contribute to reducing the global carbon footprint in several industrial sectors.



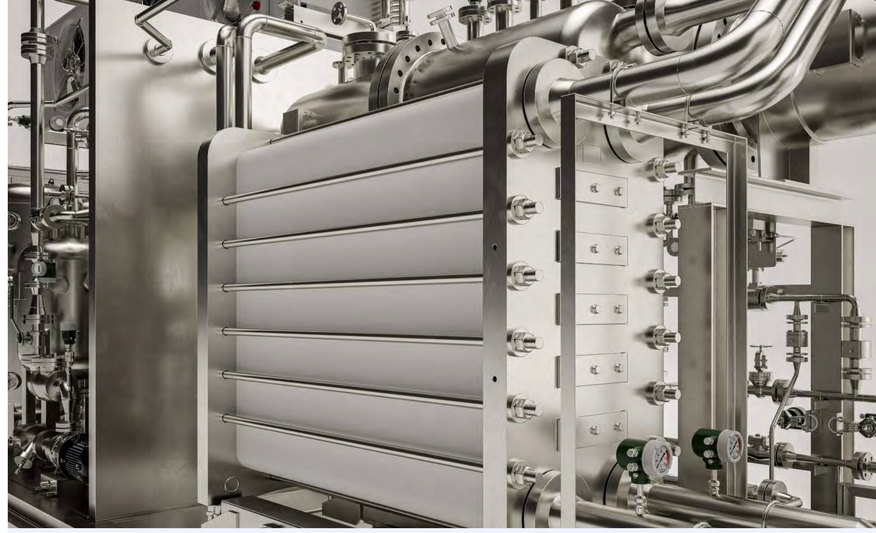
Hydrogen & Electrolysis

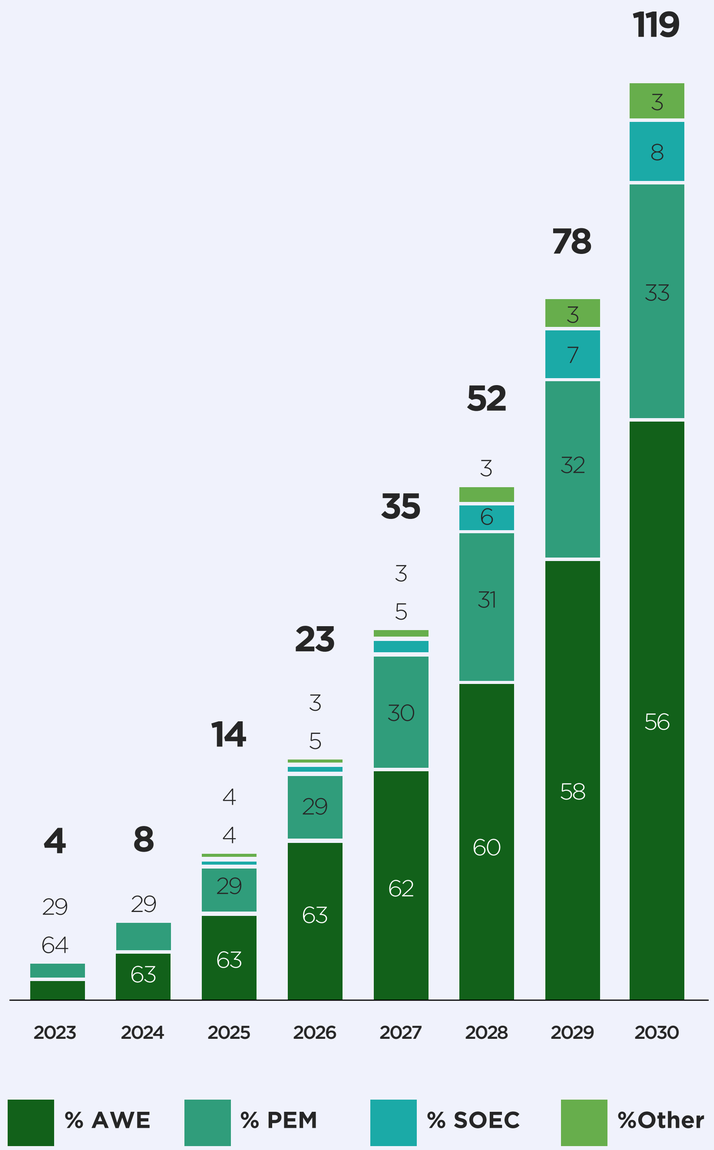
To reach the ambitious goal of net zero carbon emission by 2050 (NZE), the penetration of renewable energy sources will dramatically increase to reach the largest share in the next decades. The intermittency of these energy sources (such as Photovoltaic and Wind Turbines) highlights the necessity to integrate storage systems to balance the energy grid.

In the Energy transition process, **Green hydrogen** is widely recognized not only as a promising option for storing large quantities of renewable electricity over long periods of Power to Power **(P2P)** and as an energy vector for more sustainable **Mobility** (through Fuel Cell Electric Vehicle), but also as a renewable feedstock for a variety of **Chemical Production Power to Chemical (P2C)** (ammonia, methanol, green fuels, ...) and as unique alternative **energy source** for those sectors defined as **"Hard to Abate"** where electrification cannot substitute carbon-based power sources.

Today, the most established technology option for producing Green Hydrogen from electrical power sources is water electrolysis.

De Nora, in recent years, spent substantial R&D efforts in developing what we call boosted AWE, a solution that to maximize its operating current density (CD) and reduce the overall power consumption, pushing this technology toward PEMWE performances but guaranteeing the lower CAPEX investment.
Furthermore De Nora enlarged its ususal scope of supply (Electrodes and Electrode Package) to a full containerized electrolyzer suitable for small and medium scale.
The result of this effort is the De Nora Alkaline Water Electrolyzer **"Dragonfly®".**





* Roland Berger – Project Demetra Report. April 2024

From traditional Alkaline Water Electrolysis (AWE)

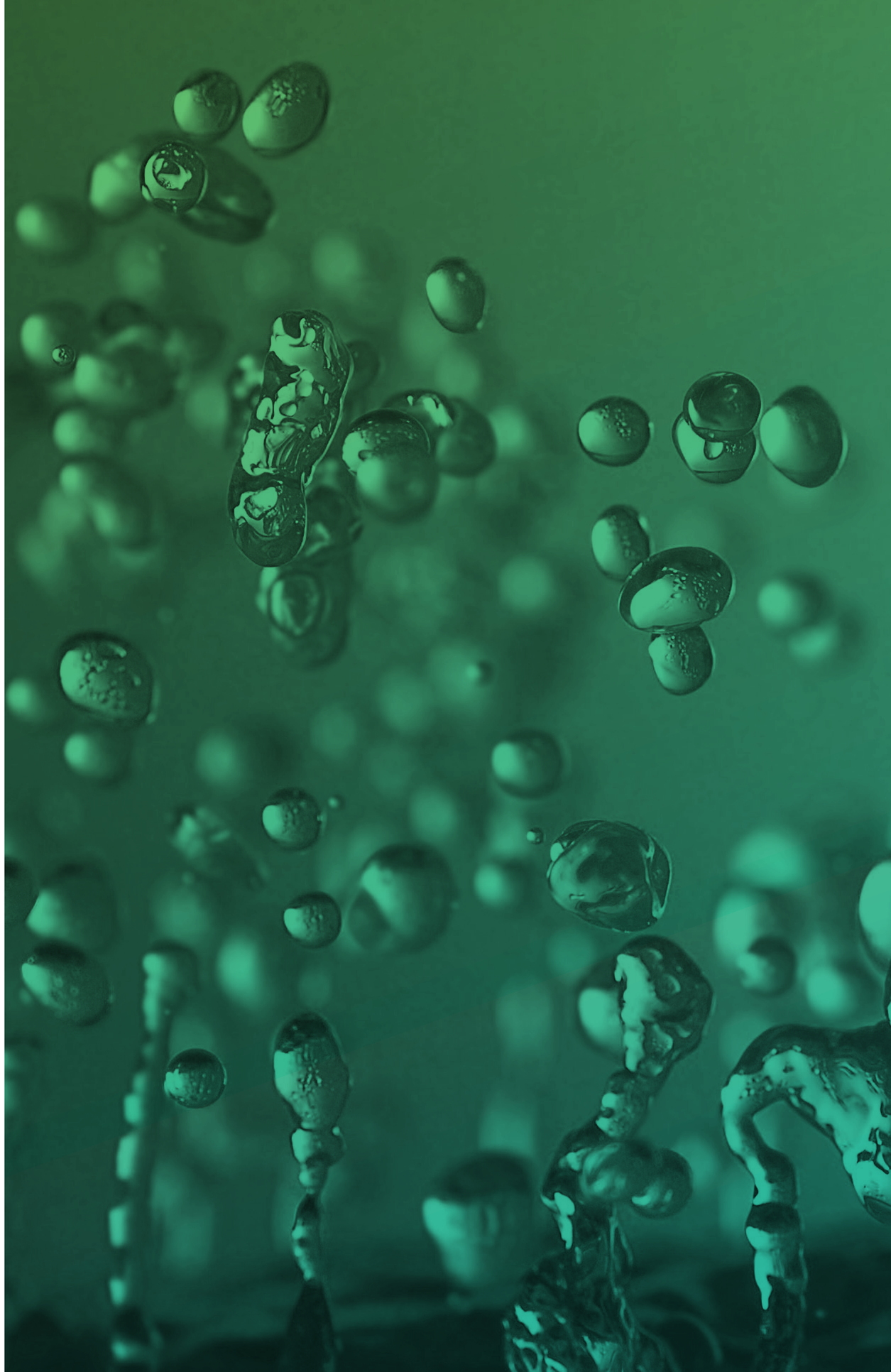
A proven mature technology

The alkaline water electrolyzer is an electrochemical reactor that decomposes water into hydrogen and oxygen gases using electric energy. The reaction takes place in the electrolytic cell, it is composed of two electrodes (anode and cathode) separated by a diaphragm immersed into a liquid alkaline electrolyte (solution of demi water and potassium hydroxide). Hydrogen is produced on the cathode side, while oxygen is produced on the anode surface. During the reaction, the separation of the two gases is guaranteed by the diaphragm that simultaneously allows the hydroxide ions (OH-) transport from the cathode to the anode.

To improve the overall efficiency of the reaction, catalyst layers are deposed on both electrodes.
Alkaline Water Electrolysis is known as the principal process for the water splitting reaction; due to its wide applications, also in large-scale plants, it has proven to be the **most mature** technology that can guarantee **reliable performances** upfront **low initial investment and maintenance cost.**

Nevertheless, AWE technology shows few limitations such as: low current density, slow dynamic response to load variation, limited flexibility and large overall footprint.

De Nora changed the rules, enhancing a consolidated technology. AWE technology evolve into a boosted AWE, allowing a new perspective for the most mature electrolysis process, boosted without renouce to reliability, low maintenance and intitial investment effort.



to... De Nora boosted AWE

A boost to technology, a new evolution

De Nora loves to break the rules, and the new, empowered technology, is a perfect exemple of our approach.
Our target is to facilitate the energy transition through green hydrogen, is to ensure competitive prices too. Initial investment could be a barrier for companies that are thinking to decabornize part/or all their processes, so a mature technology, just like the classical AWE, is the starting point to smash its limitation and push the technological level more than a step forward. The De Nora's technology is the evolution of Alkaline Water Electrolysis.

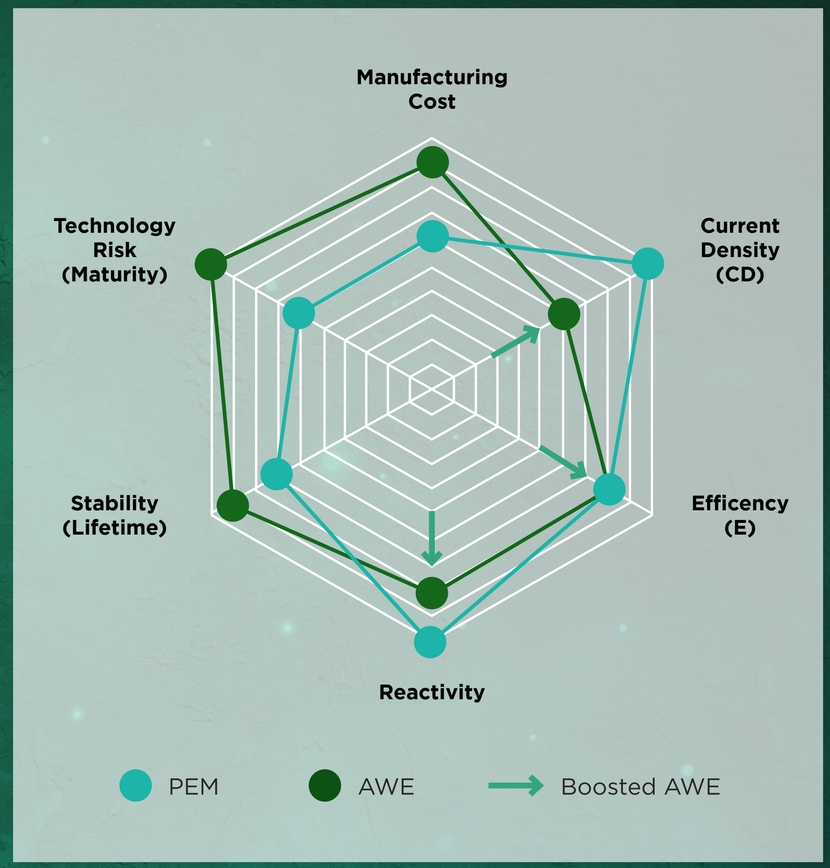
Starting from the alkaline technology strengths such as:

- **Reliability**
- **Efficiency**
- **Moderate initial cost**
- **Low operative costs**

The De Nora's boosted AWE offers other improvements:

- **High efficiency**
  High-performing electrode coatings combined with new cell design increase the reaction efficiency allowing a reduction of the operational cost (energy saving).
- **Augmented Current Density**
  It can be translated into a substantial reduction of the stack footprint and of the initial investment.
- **High flexibility**
  A wider operational range.
- **Rapid Dynamic**
  High capability to respond to load variation, for the coupling with RES.

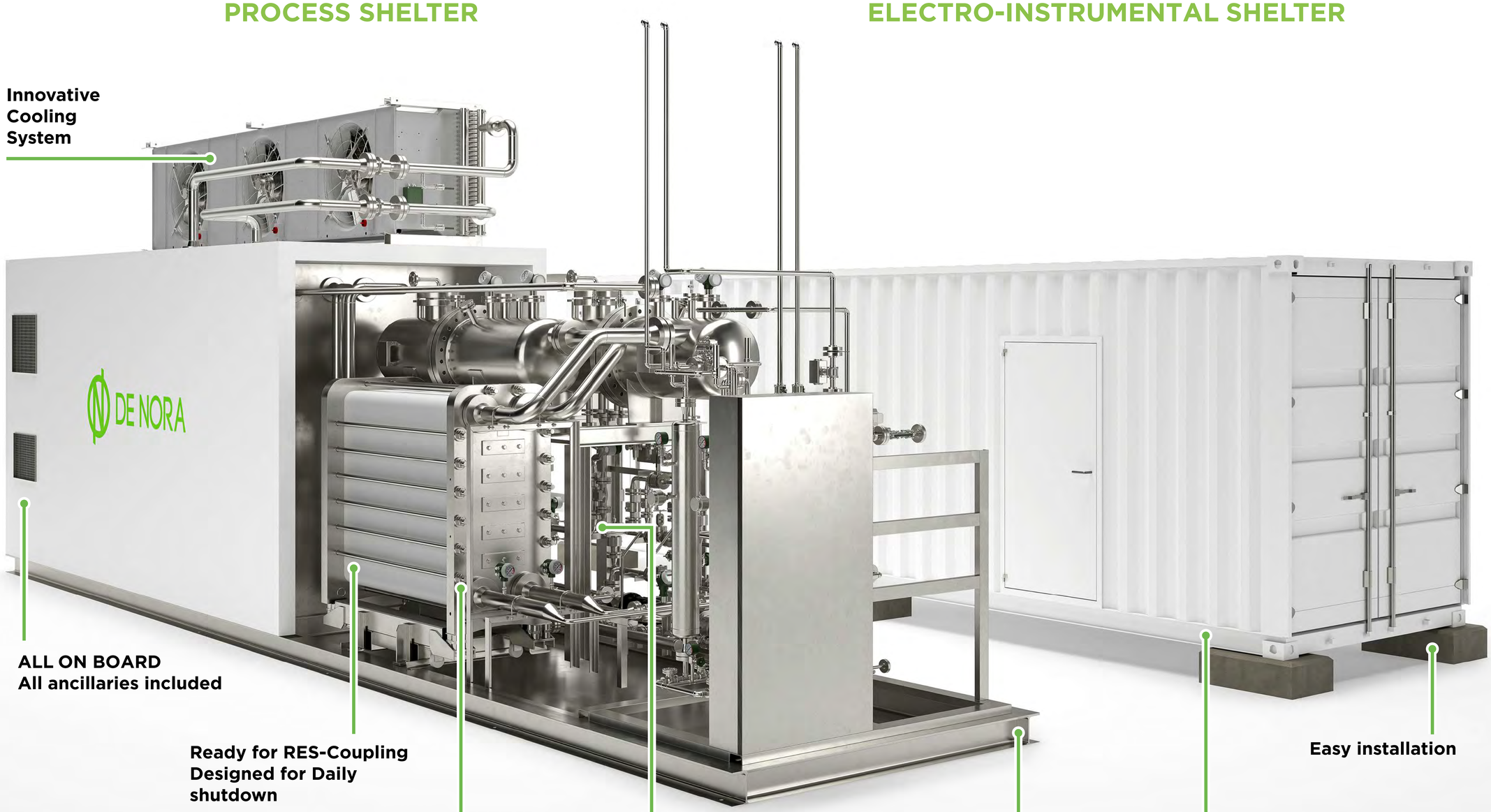
De Nora's high-performing electrode coating technology is completely Noble Metals-free and this allows a reduction of the initial investment cost and of the further refurbishment costs.



Dragonfly® System
Ready to Evolve

PROCESS SHELTER

ELECTRO-INSTRUMENTAL SHELTER



Innovative Cooling System

ALL ON BOARD
All ancillaries included

Ready for RES-Coupling
Designed for Daily shutdown

High Efficiency electrodes for improved energy consumption and wide operational range

Simplified BoP for rapid response to load variations

Shelter with Standard Container dimension for an easier transportation

Easy installation

Dragonfly® System
Evolved turn-key solution

Dragonfly® System is a completely integrated hydrogen generation unit developed by De Nora as a natural evolution of the widespread expertise demonstrated in designing and producing electrodes for the major AWE OEMs. It was born from the need to have an electrolyzer that could fully exploit the potential of the De Nora electrodes and was born responding to the most special needs of customers.

It's a small-sized containerized alkaline water electrolysis unit designed to be easily installed at the user facility and operated even by those users who are not particularly familiar with this type of process. These characteristics make it applicable in all the sectors that require in situ hydrogen generation, such as: fine chemical, pharma, biogas upgrading, oleochemistry, refinery, mobility...

The unit, thanks to its **pressurized design**, can generate H2 and O2 at a design pressure of 30 bar, which is already suitable for most industrial applications without any additional compression step.

"Dragonfly® System" is a **turn-key solution** with all the utilities needed for its operation already included:

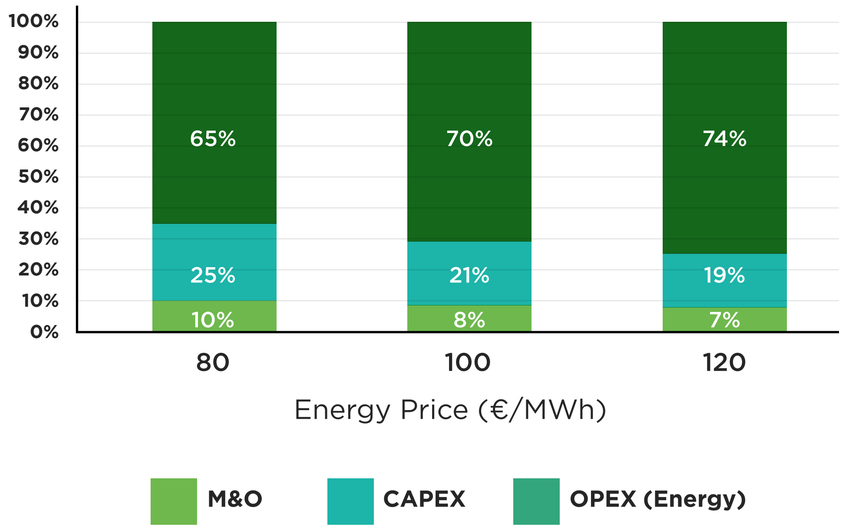
- Transformer/rectifier
- Water Treatment Unit
- Nitrogen generation Unit (for purging)
- Compressed air generation unit (for instruments)
- Dehumidifier
- H2 secondary treatment system (DeOxO) optional
- Cooling system

Power and water: ready to generate hydrogen!
Nothing more than power and water supply is needed to operate the Dragonfly unit.

"Dragonfly® System" is an innovative hydrogen generation unit designed with the aim to reduce the TCO:

- **Initial investment:** Thanks to its high current density and footprint, material consumption can be sensitively reduced. In addition, all the De Nora solutions do not use Noble Metals as a catalyst.
- **Maintenance Cost:** The simplified BoP and EoL electrodes refurbishment reduces maintenance cost
- **Operational Cost:** the high efficiency which characterized the system can be translated into power consumption savings.

TCO main factors



Characteristics

Pressurized
- Design pressure: 30 bar

High current density
- Up to 12 kA/m²

High reliability

High flexibility
- Wider operational range
- Coupling with RES
- Rapid response to load variations

High-efficiency electrodes
- Reduced specific power consumption

Simplified BoP
- Reduced KOH loop
- Dedicated cooling circuit

Fully containerized
- For outdoor applications

Optimized transportation costs
- STD containers

Minimized installation costs
- Turnkey solution
- Low impact civil works

Ease of maintenance
- Minimized maintenance cost
- Electrodes refurbishment service

Customizable
- A bespoke project to satisfy customer needs

Dragonfly® System

High performance containerized Electrolyzer

All Utilities onboard:

- Transformer/Rectifier Unit
- Water Treatment Unit
- Nitrogen Generation Unit
- Instrumental Air Generation Unit
- H2 Treatment Unit (DeOxO) optional
- Cooling System

All Pertaining Safety Systems:

- In line gas analyzers (hydrogen/oxygen)
- Gas leakage detection system
- Forced ventilation unit
- UPS unit for safety system autonomy

Design and performance data

Unit size	1 MW	7,5 MW
Nominal Power for electrolysis (kW)	1000	4000 - 7500
Hydrogen Production (Nm3/h) @ Nominal load	190 – 210*	840 – 1500*
Oxygen Production (Nm3/h) @ Nominal load	95 - 105*	420 – 750*
Hydrogen purity (dry gas basis @ Nominal load)	> 99,8%*	> 99,8%*
Oxygen purity (dry gas basis @ Nominal load)	> 99,5%*	> 99,5%*
Load Range**	20 -120%*	20 – 120%*
Specific Power Consumption (kWh/kg) @ Nominal load	*53,3 – 54,2*	*53,6 – 55,2*
Operating Pressure (barg)	30*	30*
Operating Temperature (°C)	< 90	< 90
Power Supply	MV/LV	MV/LV
Ancillaries Power Consumption (kW)	50 MAX	350 MAX
Operating Current density (kA/m^2)	Up to 12.0, depending on specific needs and characteristics of the downstream sections	Up to 12.0, depending on specific needs and characteristics of the downstream sections

* Depending on System configuration

** Based on hydrogen production rate @ Nominal load

Services

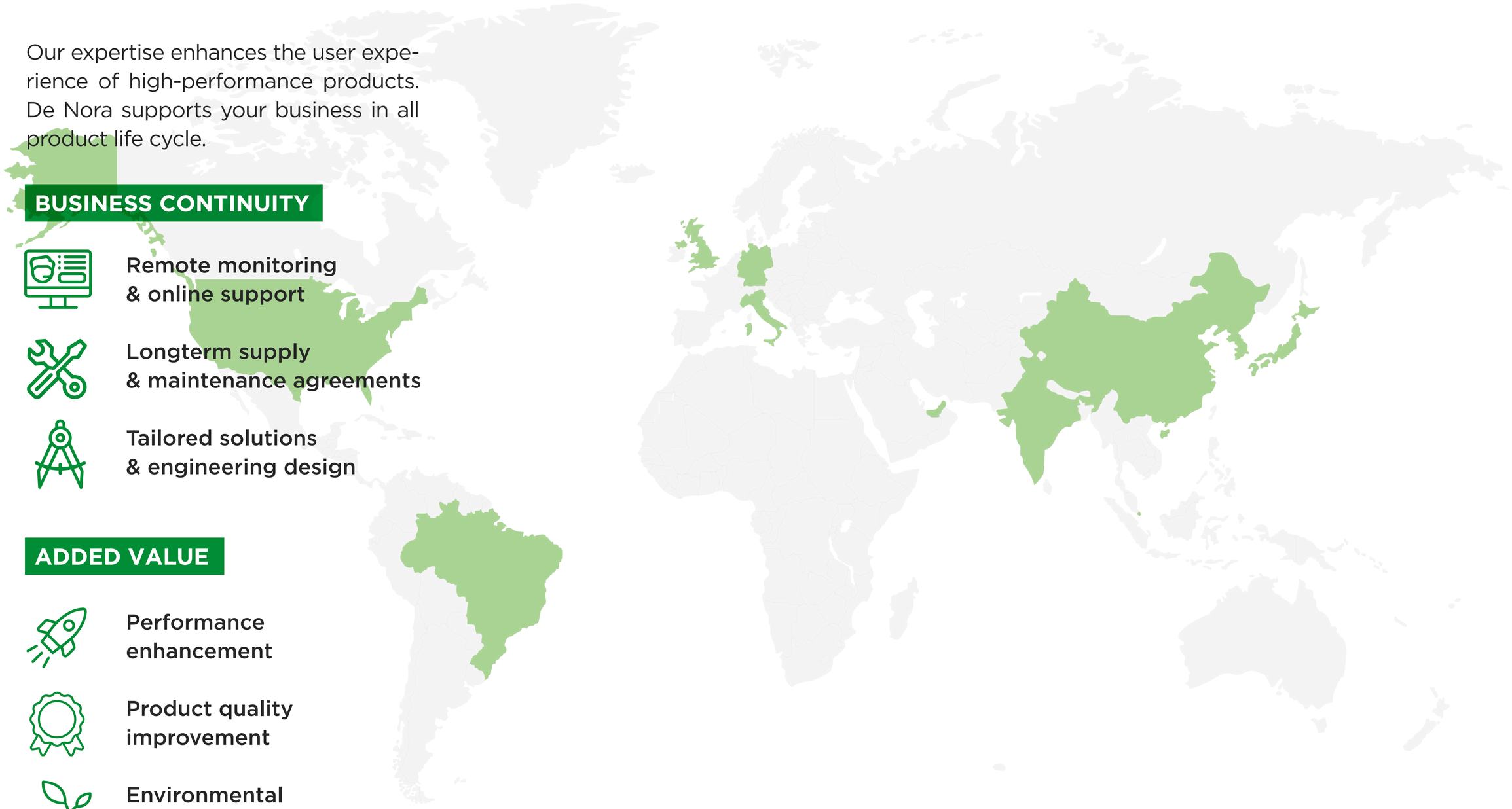
Our expertise enhances the user experience of high-performance products. De Nora supports your business in all product life cycle.

BUSINESS CONTINUITY

- **Remote monitoring & online support**
- **Longterm supply & maintenance agreements**
- **Tailored solutions & engineering design**

ADDED VALUE

- **Performance enhancement**
- **Product quality improvement**
- **Environmental sustainable solution**



Contact Us service.etr@denora.com

DE NORA
discover more

Discover more

Get in touch with us

www.denora.com

Dragonfly® System Brochure
ETR-DF2402001