Nedstack
PEM FUEL CELLS

Nedstack Company Profile

Nedstack Company Profile

High-Power & High-Use PEM Technology Leadership

Name	**Nedstack Fuel Cell Technology BV**
Location	Westervoortsedijk 73-VB, Arnhem, the Netherlands
Founded	1999
Ownership	Privately

Website	www.nedstack.com
Industry	PEM Fuel Cells & PEM Power Solutions
Logo	Nedstack PEM FUEL CELLS

- **Company Highlights**
  - AkzoNobel spin-out. Independent since 1999
  - Global Leader in High-Power / High-Use PEM-FC Technology
    - World's Longest PEM Power Plant in Operation > 10 years
    - World's First MW Sized PEM Power Plant
    - World's Largest PEM Power Plant > 2 / 3.6 Mwe
  - In-house stack assembly – systems with co-makers on Nedstack IP
  - PemGen® proprietary PEM Power Plant portfolio
  - Application Centers for:
    - Stationary & CHP
    - Maritime & Ports
    - Temporary Power

TÜVRheinland CERTIFIED Management System ISO 9001:2015

WE SUPPORT UN GLOBAL COMPACT

Nedstack Heritage

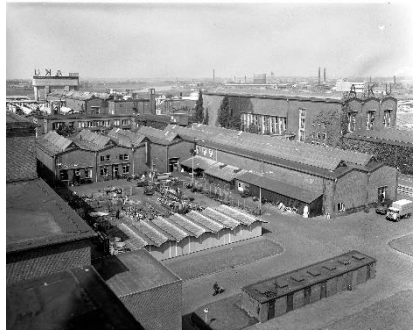
>20 years of PEM Fuel Cell Excellence

Nedstack PEM FUEL CELLS

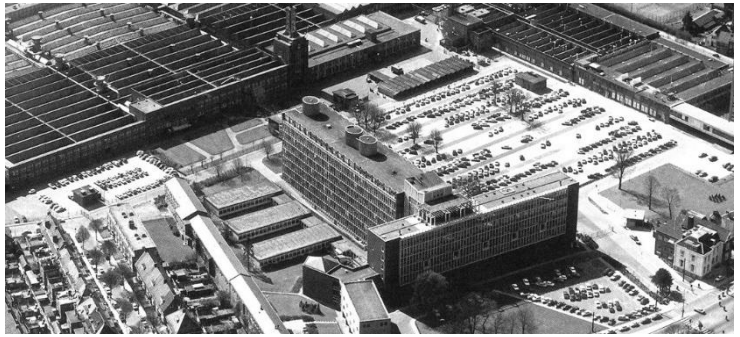
NedStack fuel cell technology BV

Nedstack

- AkzoNobel and ECN jointly established Nedstack, combining AkzoNobel applied chemistry products with the fundamental PEM Fuel Cell expertise that was vested in ECN. In doing so they created a global first PEM-FC player with a commitment to high-power / high-use type PEM-Fuel Cell Applications.



AkzoNobel – IPKW (current Site)



Akzo Velperweg Arnhem (first site of Nedstack)

Process & Systems Engineering

AKZO NOBEL

Akzo Engineering

- PEM Power Plant Process & Instrumentation Design
- HAZOP & Safety Concept definition for PEM-FC systems in industry
- Process Engineering Capacity

PEM Fuel Cell Expertise & Technology

ECN

Energieonderzoek Centrum Nederland (ECN)

- PEM-FC Engineering & Test Expertise
- PEM-FC Testing laboratory
- Electro-Chemical Engineering Capacity
- Applied Membrane expertise

■ PEM Fuel Cell Building Blocks from AkzoNobel Group – Advanced Chemicals

KETJEN

Ketjen

- Carbon & Graphite Expertise

NOURY

Noury

- Catalyst Expertise

GLANZSTOFF Enka

Enka Glanzstoff

- Polymers & lamination Expertise

AKZO

Akzo Zout

- Electrolyte Expertise

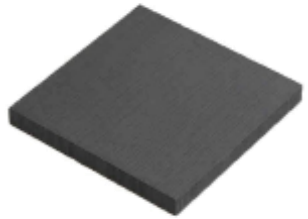
sikkens

Sikkens

- Coating Technology

Technology & Engineering Services Portfolio

PEM Fuel Cell Excellence from Powder-to-Power

Fuel Cell Parts			Fuel Cell Solutions		
BMC's	**BPP's**	**CVM**	**PEM Stacks**	**Power Plants**	**FC Control**
					

Application Engineering & Project Management Services

Field Engineering Services (commissioning / Inspection)

Maintenance & Support Services

Engineering & IP-ownership by Nedstack / Built Process by Co-Maker

Flagship Demonstrators – Globally Unique Recognitions

Leadership in the High-Power / High-Use Domain

Longest Running PEM Power Plant

- **AkzoNobel Delfzijl (NL) Plant**
- Live since 2007
- Using H2 from Chlor-Alkali
- 70k Running hours accumulated

First MWe Sized PEM Power Plant

- **Solvay Antwerps (Be) Plant**
- Now transferred to Martinique (Fr)
- Installed in 2011, under transit
- Using H2 from Chlor-Alkali

Largest PEM Power Plant

- **Ynnovate Yinkou (PRC) Plant**
- Installed in 2016
- Developed in DemcoPEM Project
- Using H2 from Chlor-Alkali

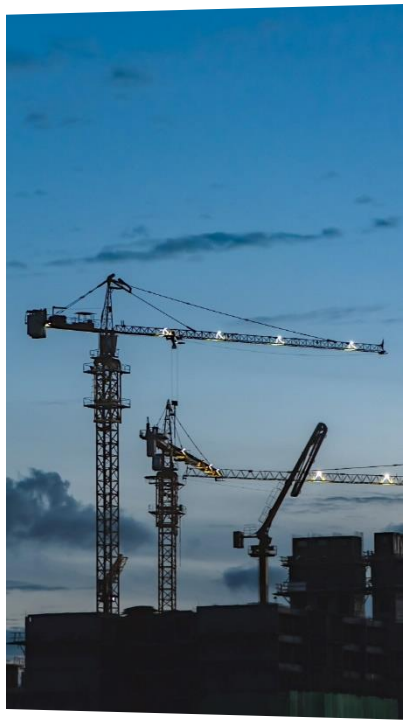
1) DemcoPEM has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement no. 621265

PemGen Focus Markets

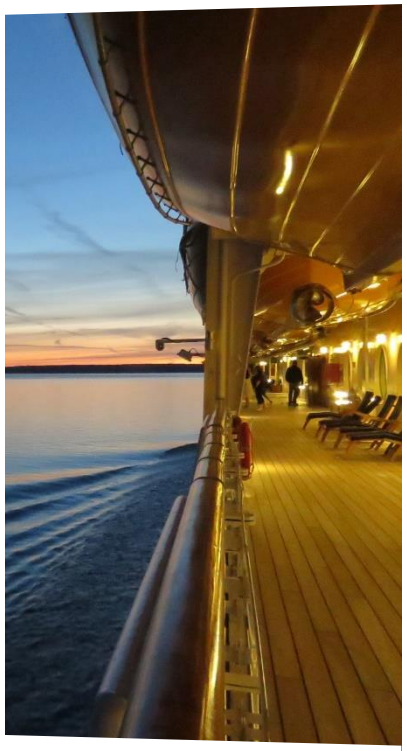
Servicing the High-Power / High-Use Domain

Industry

Utility Power to Power



Distributed Power / RAPS



Maritime & Ports

PemGen - Focus Markets

- PemGen focus markets are focused at delivering technology and cost (LCoE) leadership for high-power / high-use markets.
- PemGen® pursues leadership at the utility scale level with power plants intended for 20 years in the field, having advanced safety concepts.
- The PemGen portfolio is tuned for either land-based use (in compliance with EC directives and IEC standards) or maritime use (in compliance with IMO codes, maritime Class Rules and IEC standards).
- The PemGen® business model assumes configure-to-order type technology delivery models where customer value is maximised.

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PEM-Technology

PEM-FC's are Low Temp Catalytic Electro-Chemical Reactors

Using H2 as a fuel and a PEM membrane as electrolyte

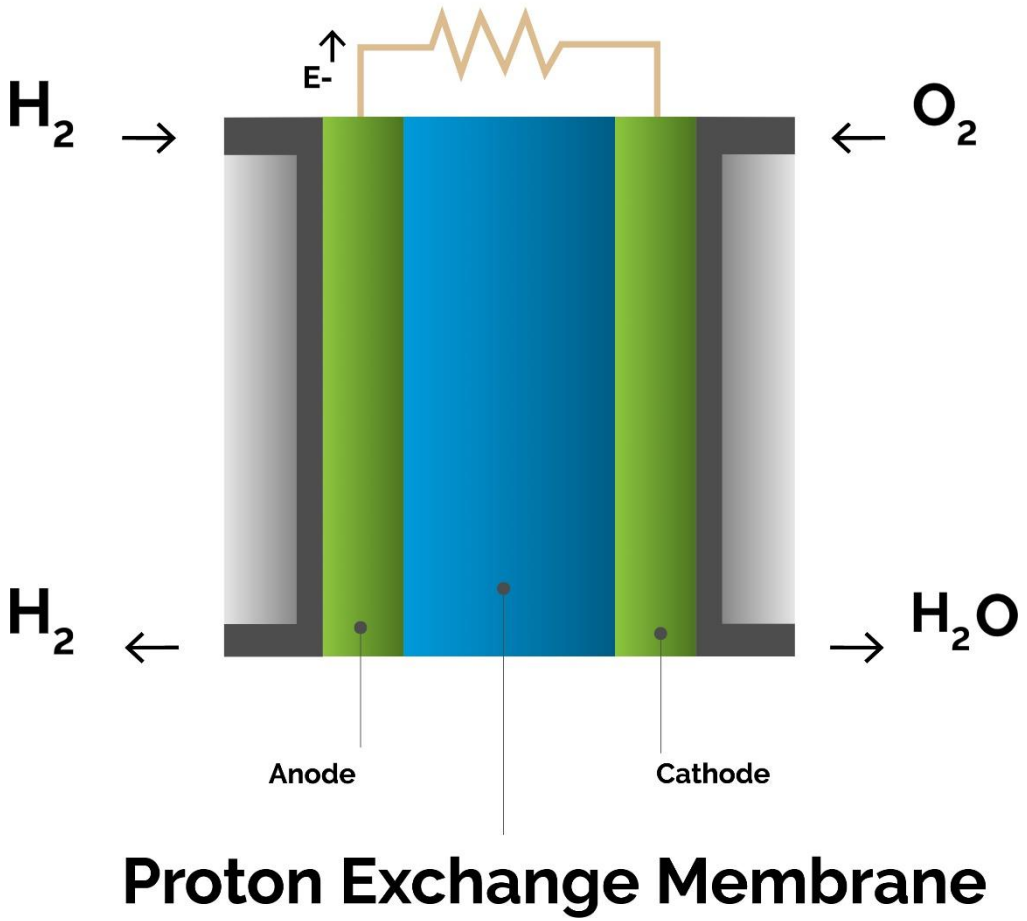
	Operating temp (°C)	Fuel	Electrolyte
PEMFC	40-90	H_2	Proton Exchange Membrane
AFC	40-200	H2	KOH
DMFC	60-130	Methanol	Proton Exchange Membrane
PAFC	200	H_2	Phosphoric Acid
MCFC	650	CH_4, H_2	Molten Carbonate
SOFC	600-950	CH_4, H_2	Solid Oxide

- Noble metals
- Noble metals/ non-noble metals
- Non-noble metals

Nedstack PEM FUEL CELLS

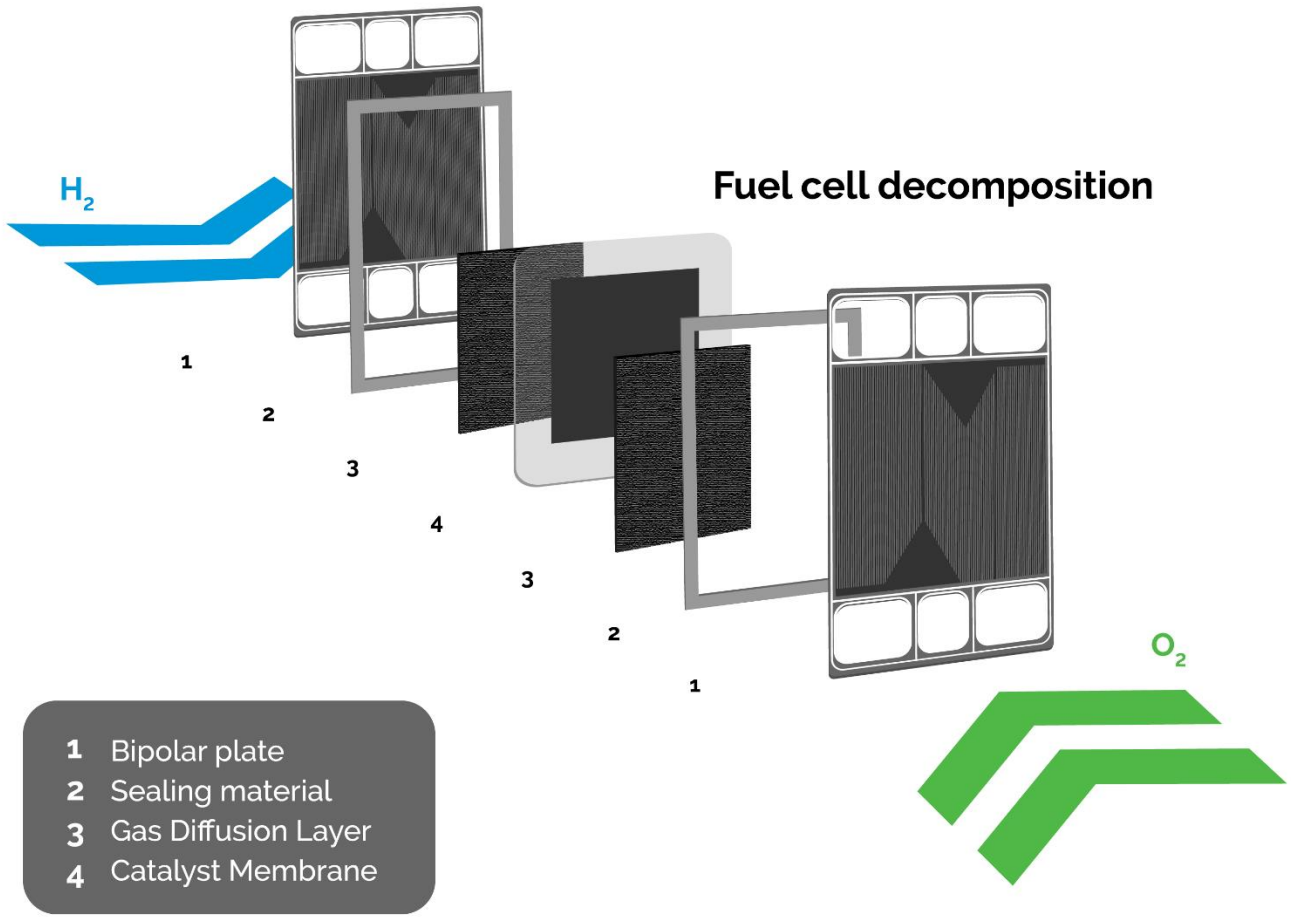
Membrane Electrode Assembly facilitates proton transport

PEM Cells produce Current, Water and Heat



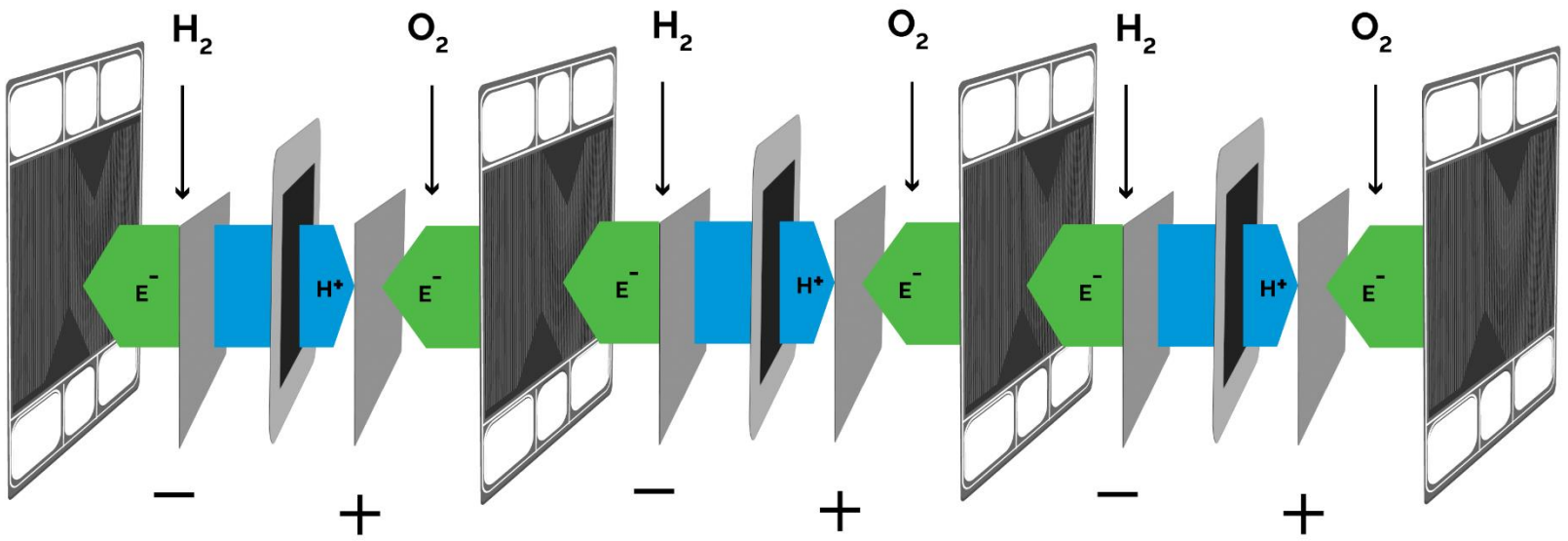
An MEA together with Flow Plates and Gaskets builts a Cell

Each PEM Cell is an electro chemical reactor



A Stack is a daisy-chain of PEM-Cells

Accumulating voltage while maintaining constant current



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LT-PEM Stack Label – Extended Long-Life PEM Stacks

Nedstack signature cassette type design

Technology Highlights

- Portfolio of LT-PEM Fuel Cell stacks intended for extended long-life and high-power applications
- Designed to provide the lowest possible LCOE within boundaries of absolute reliability, availability and safety
- Proprietary long-life graphite composite bipolar plate technology and proprietary bulk moulding compounds
- IEC 62282-2 Compliant design, production and Exit factory inspection
- Integrated safety system by Nedstack CVM Assembly (safety цС) and voltage pick up assembly

Nedstack Capabilities

Graphite Composite Plate Manufacturing

PEM Stack Assembly

PEM Stack Testing & Exit Factory Inspection

PemGen Label and Signature Features

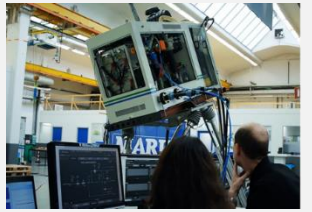
Fuel Cell Power Solutions Optimized for LCoE Leadership

Technology Highlights

- At Nedstack we have developed a portfolio of power systems around our extended long life (XXL) PEM-FCS stack platform
- Rationalized over the lowest possible levelized cost of energy (LCOE) within boundaries of absolute reliability, availability and safety
- The PemGen platform is based on the Nedstack Central BoP philosophy for extreme plant life and superior serviceability
- Configurable to customer requirements

Nedstack Capabilities

PemGen Assembly Docks



PemGen Testing Station

PemGen commissioning Support

1) PemGen is a Nedstack European registered trademark. Registered at EUIPO under NO. 018036949 / Registered at USPTO under NO. 6,054,999

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Product Market Combinations

Target PMC-1:

Industry H2 By-Product Capture

PUBLIC VERSION

Application Value Proposition

- At Chlorine sites where hydrogen by-product is not used, a combined total of 40% of costs of electrolysis are escaping in the form of hydrogen by-product.
- Using a Fuel Cell Power system to capture such hydrogen and convert it back to useful heat and power allows for a significant cost reduction and reduction of environmental impact by avoiding flaring of hydrogen (and forthcoming NOx and H2 abatement).
- PemGen® power-plants capture by-product hydrogen and convert this into clean energy and heat which can be used to **reduce the costs of electrolysis by about 20%** and save heating expenses for pre-heating the brine.

Technology Offering

- PemGen CHP Portfolio
- Power Conversion Systems
- Coolers

Palmares (PEM)

- **Worlds Longest Running**
- **Worlds First MWe Sized**
- **Worlds Largest**

Target PMC-2:
Zero-Emission Shipping

Application Value Proposition

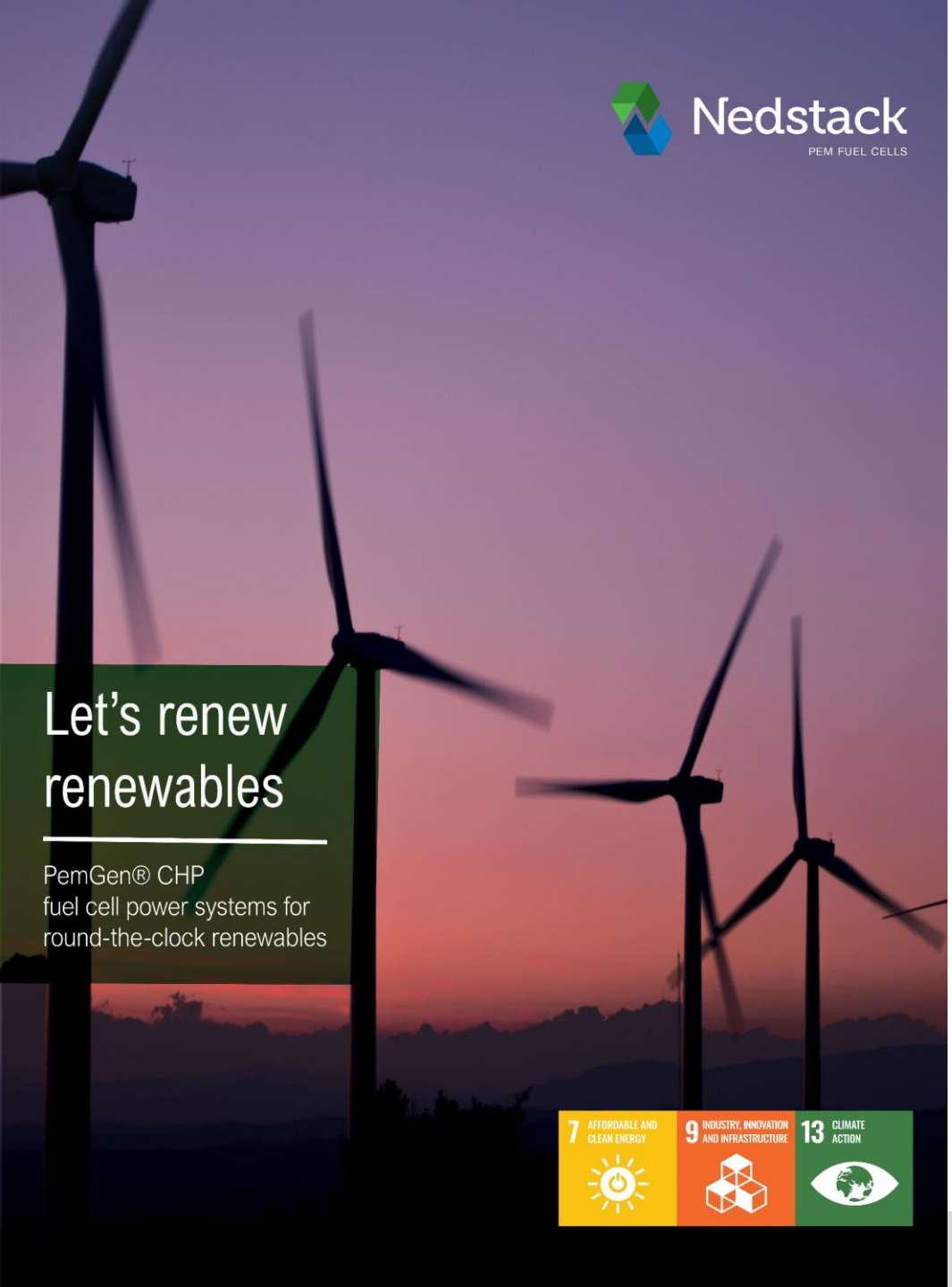
- Zero-Emission shipping requires fuel and power conversion that allows merchant fleets to maintain sufficient endurance-at-sea to complete their missions without sacrificing unacceptable levels of payload capacity.
- Nedstack PemGen MT series is designed for meeting the most extreme maritime requirements such as Class Rule compliancy, rough sea fitness and 5 year dry-dock periods;
- The PemGen LCoE optimized layout in the merchant marine markets pay-off by significant operational savings and increased vessel utility.

Technology Offering

- PemGen MT Portfolio

Palmares (PEM)

- **Worlds Second Class Approved MT-FC System;**
- **Lead of FELMAR Consortium;**



Target PMC-3:
Round-the-Clock Renewables

Application Value Proposition

- When buffering renewables, round-trip efficiency is critical to minimize marginal costs of energy and for achieving dispatch priority in the merit-order stack.
- PemGen systems are designed to integrate with utility scale power conversion systems to meet grid requirements and have the lowest possible level of LCoE. Hence, PemGen at utility scale offers both the lowest possible LCoE and allows for revenue generation both in active power, but also grid-support markets.
- Upon going live in Q4 2021 the Nedstack PAG Power-to-Power system is expected to **be worlds largest H2FC based Power-to-Power system.**

Technology Offering

- PemGen CHP Portfolio
- Power Conversion Systems
- Coolers

Palmares (PEM)

- **Worlds Largest H2 Power-to-Power system in Production.**

Target PMC-4:
Zero-Emission Temporary Power

Application Value Proposition

- Zero-Emission off-grid power requires clean fuels and efficient power conversion with high levels of safety and robustness.
- Batteries alone are often too limited in their endurance and cannot be 'refuelled' in an ordinary fashion. Hence, temporary power markets with above back-up endurance requirements are targeting hydrogen fuel cells for their transition strategies.
- The Nedstack MPU portfolio leverages Nedstack's first movers advantages (2008 with Bredenoord Purity) to establish a series-production ready platform and take advantage of early adoption scale-up effects.

Technology Offering

- PemGen MPU Portfolio
- Pressure Regulator Stations

Palmares (PEM)

- **Worlds First Fuel Cell Genset (with Bredenoord)**