



Session 5: Impact on Fuel Cells

What are the next steps?

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Hydrogen Quality and Flow Metering for Hydrogen Fuel Cell vehicles

12th of September 2019



Nedstack
FUEL CELL TECHNOLOGY

A

Company

Nedstack fuel cell technology BV

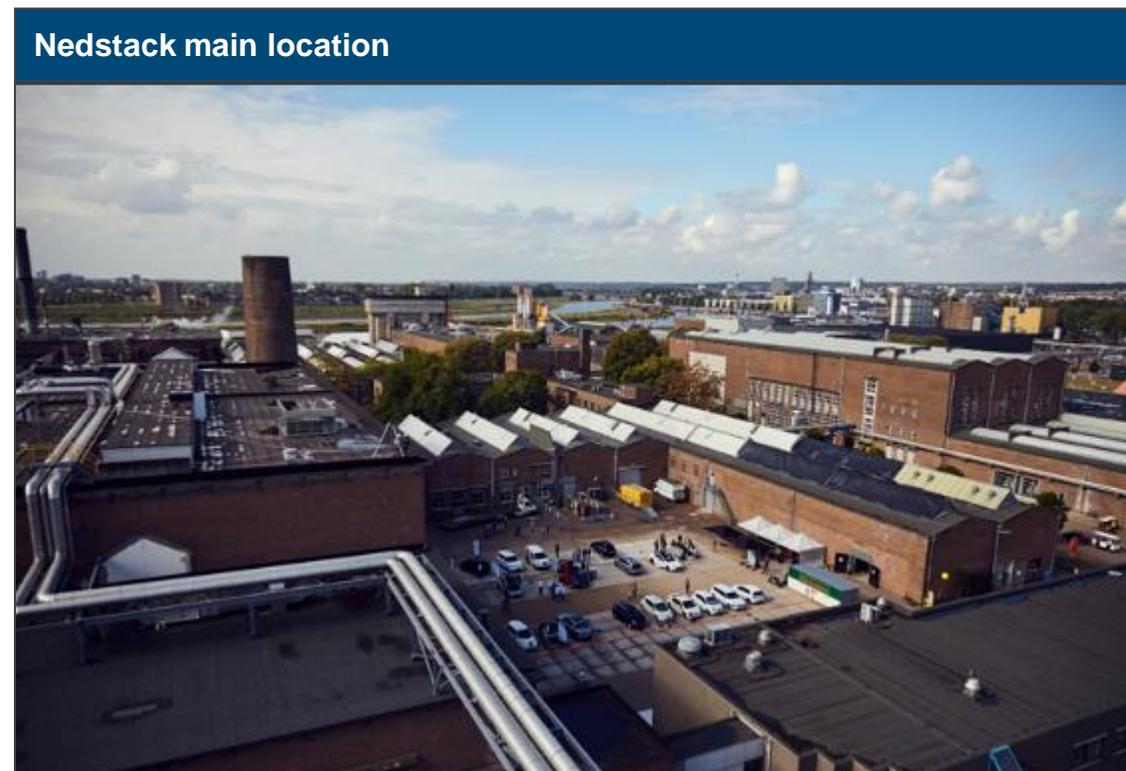


Name	Nedstack Fuel Cell Technology BV
Location	Westervoortsedijk 73, Arnhem, the Netherlands
Founded	1999
Ownership	Private

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

High lights	
	<ul style="list-style-type: none"> • Independent Company since 1999 (Akzo-Nobel spin out); • Leading Global Player in PEM-FC R&D; • In-house Cell plate production and Stack Assembly; • > 700 FC Systems installed-base as per 2017; • > 23.000 Hours in-use Lifetime demonstrated; • Highly competent Application Support team in-house; • Strong footprint in EU and China

Industries Served	
	<ul style="list-style-type: none"> • PEM FC-Power Plants • Commercial Vehicle FC Range Extenders • Marine Fuel Cell Power Modules • Back Up Power Supply Units

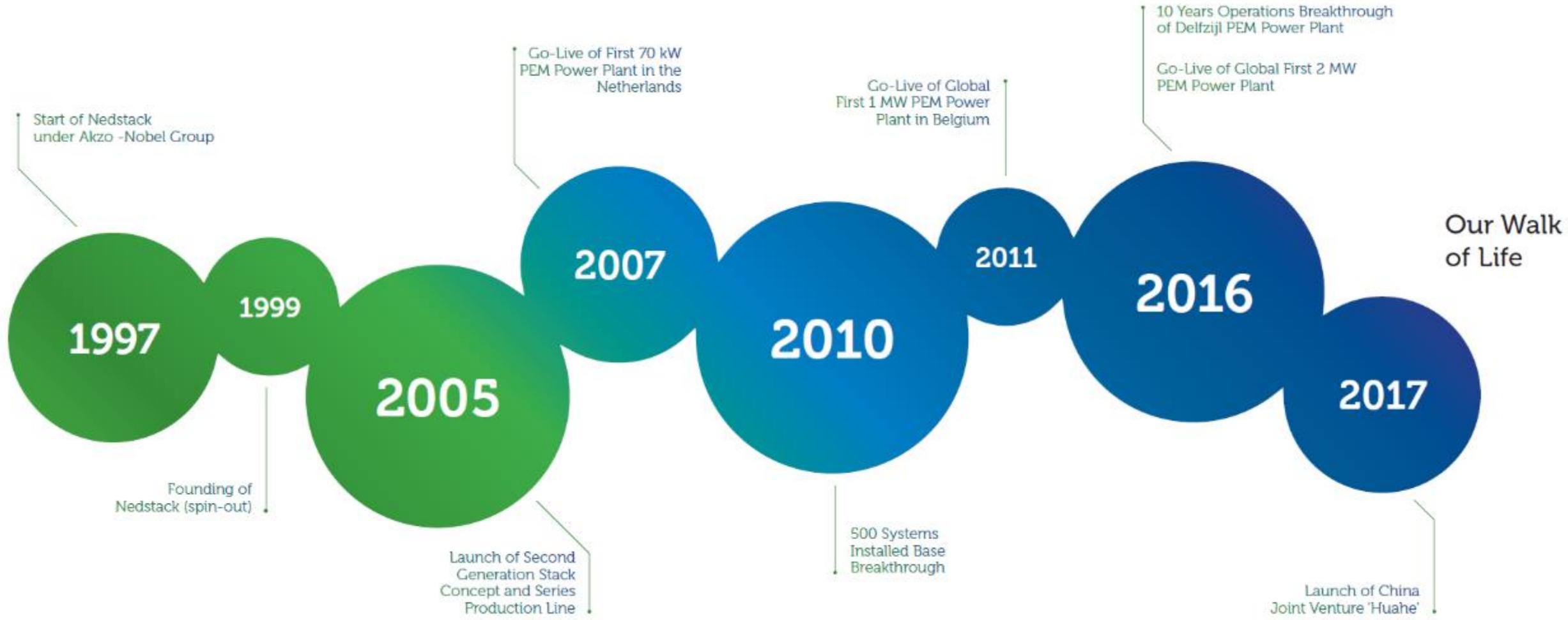


Company

Capabilities

FC Technology

Solutions





Nedstack

PEM FUEL CELLS

B

Capabilities

From Powder to Power



Company

Capabilities

FC Technology

Solutions

Fuel Cell Technology Portfolio					
Fuel Cell Parts		Fuel Cell Solutions			FC Control
BMC's	BPP's	PEM Stacks	FC Engines	Power Plants	SCADA / CVM
Test & Commissioning Engineering Services					Engineering Services Portfolio
Inspection and Maintenance Services					
Application Engineering & Project Management Services					

Project Capacity to Serve Multiple MW size FCPP-projects simultaneously



Company

Capabilities

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Nedstack

PEM FUEL CELLS

C

Technology

Low Temperature PEM Stacks & Systems



PEM FC's use Hydrogen 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	H ₂	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



FC Stack
Certification:



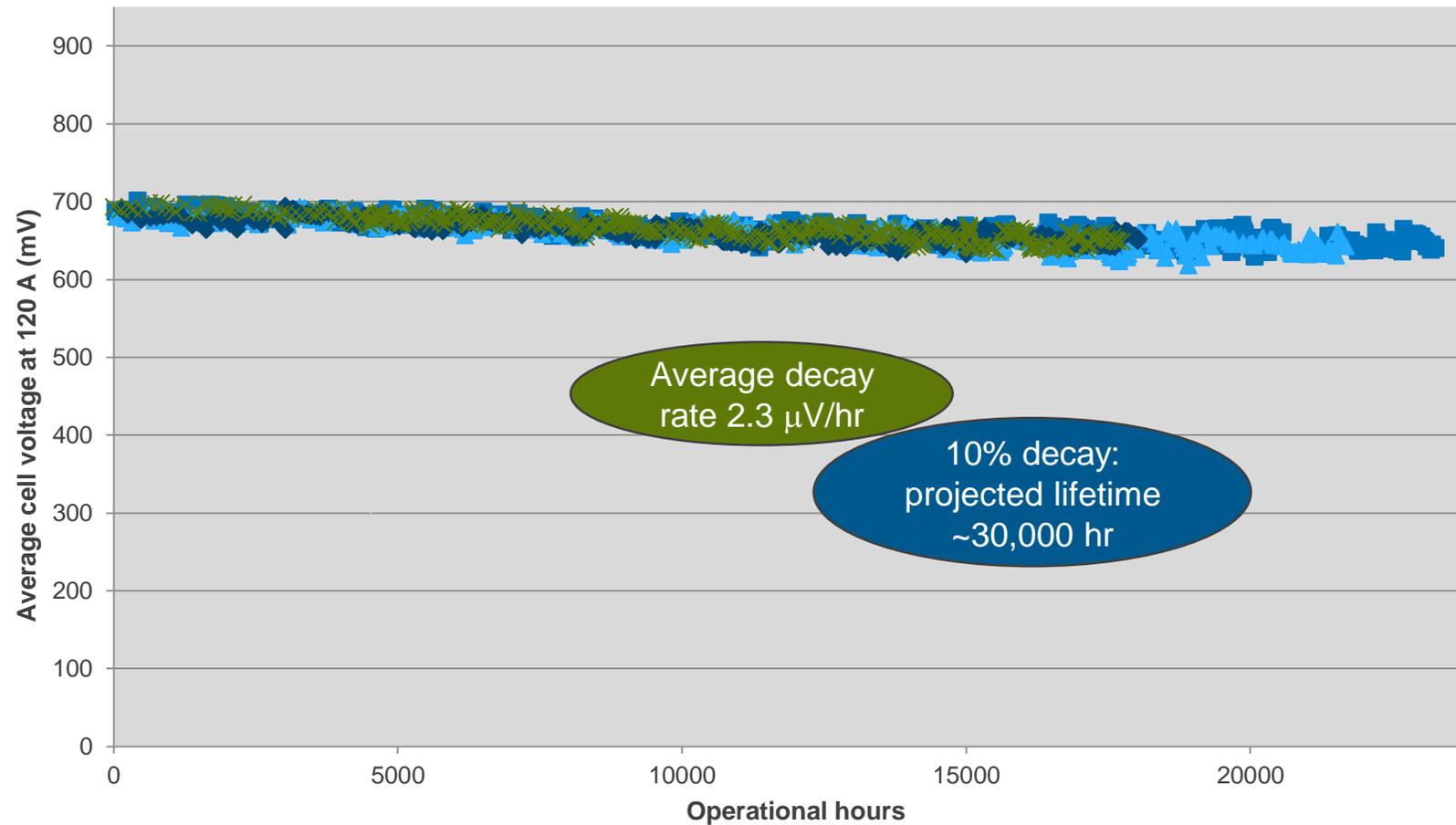


IEC 62282-2 Compliant

Test	Pass
Leakage Test	✓
Normal Operations Testing	✓
Electrical Overload Testing	✓
Electrical Strength Testing	✓
Differential Working Pressure Testing	✓
Leakage Test Repeated	✓
Normal Operations Test Repeated	✓
Fuel Starvation Test	✓
Oxidant Starvation Test	✓
Stack Short Circuit Test	✓
Coolant Starvation Test	✓
Cross-over Monitoring Test	✓
Freeze and Thaw Cycle Test	✓

1) NoBo Report by KIWA (Report Number: 125964 / Project Number: 125964). Dated: December 5, 2011

Performance of XXL stacks in Delfzijl Power Plant



D

Solutions & Markets

Mission Critical High Power PEM solutions and applications





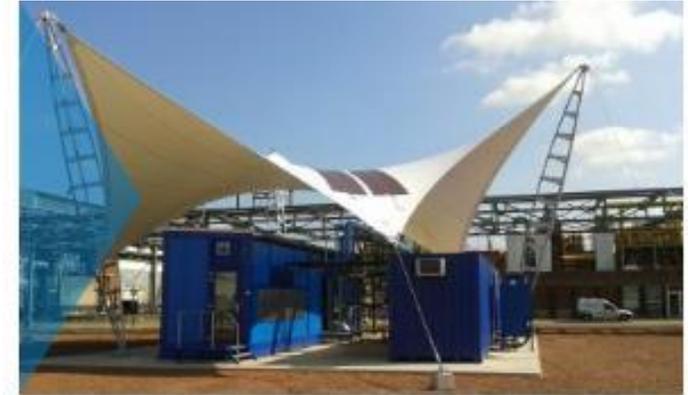
Maritime & Ports

- Ferries
- Cruise Vessels
- Dredging
- Inland navigation
- Fish farming
- Tug boats
- Canal boats



Built Environment

- District heating
- Holiday parks
- Hotels / Conference
- University campuses
- Industry parks;
- Hospitals;
- Shopping malls;



Industry

- Chlor-Alkali industry
- Sodium-Chlorate Ind.
- Semi-conductor



Maritime & Ports

-  Ferries
-  Cruise Vessels
-  Dredging
-  Inland navigation
-  Fish farming
-  Tug boats
-  Canal boats

Challenge

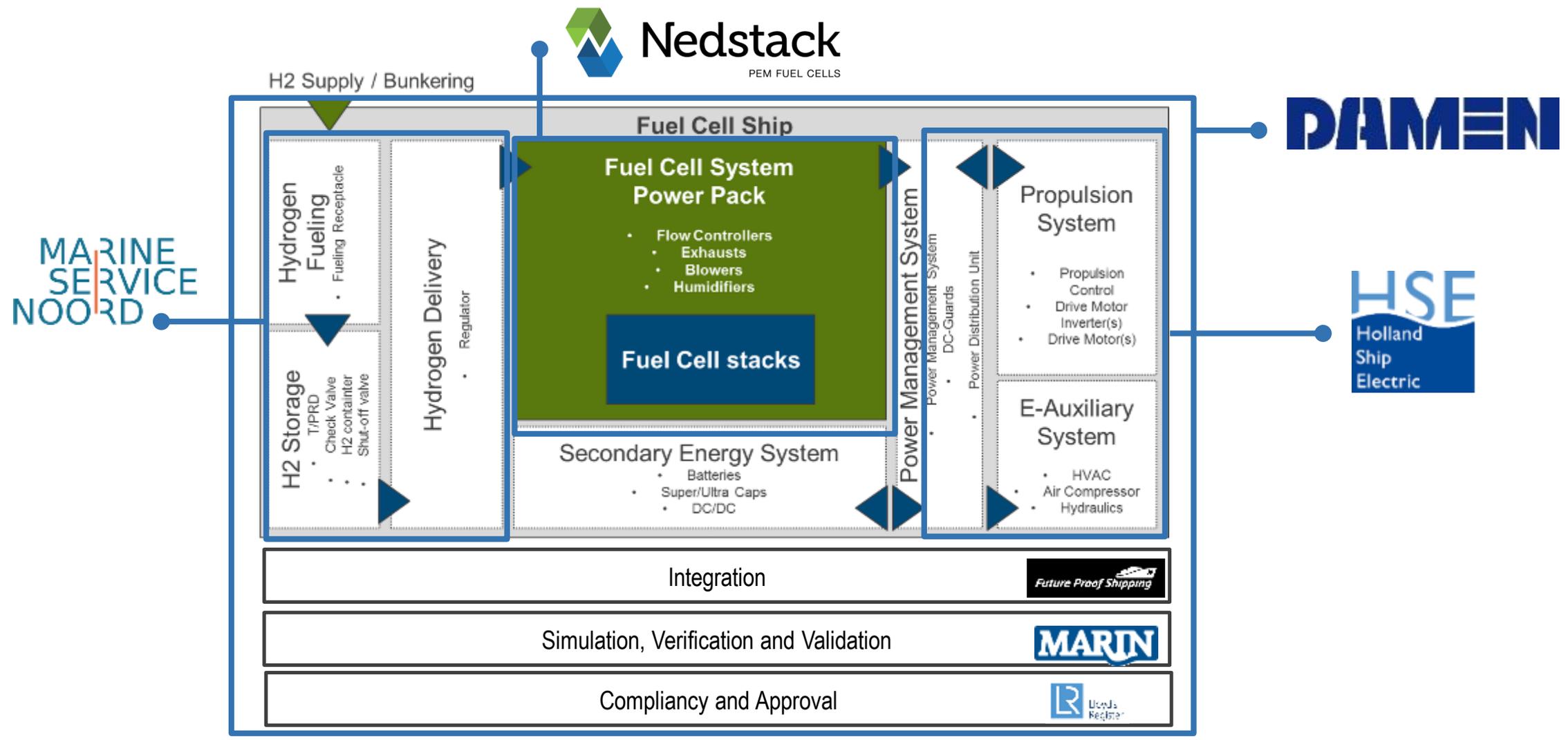
The maritime industry is a massive contributor to global emissions and has recently embraced an enormously ambitious set of emission reductions targets at IMO level. Further local initiatives to establish 0-emission shipping zones push for vulnerable areas;

Value Proposition

The use of hydrogen fuel cells in shipping allow for achieving zero-emission operations while still maintaining endurance at sea, acceptable levels of power densities and rapid turn around times.

Market		Nedstack PemGen fit	
Market Size	Actionable	PemGen Fit	Compliancy
high	starting	high	high

Company
Capabilities
FC Technology
Solutions





Built Environment

- District heating
- Holiday parks
- Hotels / Conference
- University campuses
- Industry parks;
- Hospitals;
- Shopping malls;

Challenge

Decarbonizing the built-environment requires moving away from fossils all together with inclusion of CNG. The Paris climate agreement has been ratified by many and will result in ambitious transition plans. The Netherlands is pursuing a built environment free of CNG in 2030.

Value Proposition

The use of hydrogen allows for buffering between the demand for residential heat and power and the availability of heat and power from green origins. The Nedstack Energie-erf concept allows for harmonizing the energy system from both a heat and power perspective.

Market		Nedstack PemGen fit	
Market Size	Actionable	PemGen Fit	Compliancy
high	opening	high	high

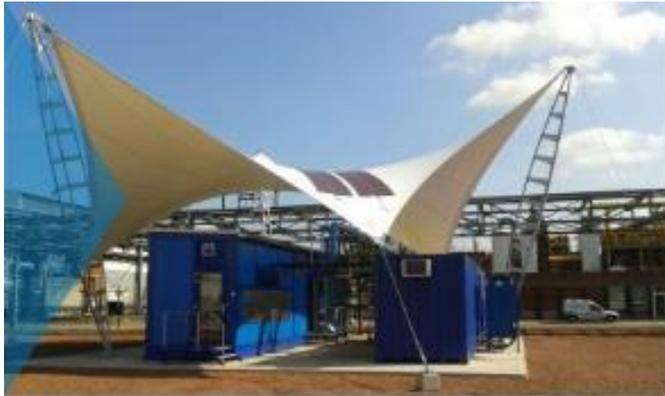
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		Building Blocks Energie-erf			
Energie-erf H2 District CHP		H2 Production	H2 Buffering	E-Generation	Heat Generation
Energie-erf Typologies	Type 1: CNG/CBG Feed Type	Yes, by SMR or equivalent	Yes by compressed storage	Yes, by PEM Fuel Cell Cogeneration	Yes, by PEM FC co-generation and heat pump
	Type 2: Hydrogen Feed Type	None at district level	None or back-up only		By Electrolyser, PEM FC and/or decentral heat pumps
	Type 3: (PV) E-Feed Type	Yes by electrolysis	Yes by compressed storage		



Industry

-  Chlor-Alkali industry
-  Sodium-Chlorate Ind.
-  Semi-conductor

Challenge

Chlor-alkali plants are among the main producers of by-product hydrogen. Worldwide, 50 million tons of chlorine is produced annually. Fuel cell conversion of all by-product hydrogen from global chlorine production alone would yield 3000 MW of continuous power.

Value Proposition

Nedstack PemGen Fuel Cell Power Systems allow for capturing by-product hydrogen and converting it in useful heat and power. This results in up to 20% energy savings on electrolysis costs and avoids massive NOx emissions in the process.

Market		Nedstack PemGen fit	
Market Size	Actionable	PemGen Fit	Compliancy
low	good	high	high

PEM-Power Plants

System Name	1-2 MW Power Plants
FC Type	Long Life - Proton Exchange Membrane Fuel Cell (PEMFC)
Intended Use	Chlorate-Alkali Plants / other Hydrogen Sources



Customer References

Performance Specifications		
Operating Power Range (Net output)	kW / MW	900 p/MW
Thermal Power output (@65°)	kW	700 p/MW
Nominal Electric Efficiency (@80% load)	%	50
Peak Electric Efficiency	% max	60
Peak Combined Efficiency	% max	80
Operating Temperature	°C	65
Lifetime (till stack refurbishment)	Hrs / years	20.000 / 12

Dimensional and Environmental Specifications		
System Size	40ft ISO cont.	3 units
System Footprints	M2 / cont. unit	30
Ambient Temperature	min-max °C	-20 - +40

Inputs and Outputs			
Outputs	Electric Power	Type	380 VAC/ 50 Hz (6kV optional)
	Water	Type	Demineralized water

Standardization and Regulatory Compliance		
Machinery Safety	CE ISO	2006/42/EC Compliant 121001
Low Voltage Directive	CE	2006/95/EC
Emergency Stop systems	ISO	13850
Hazard and operability evaluation	IEC	61882
Electro Magnetic Compatibility	CE	2004/108/EC
Risk Assessment	ISO	14121
Fuel Cell System Safety	IEC-EN	62282-2
Pneumatic Systems EN	EN	983

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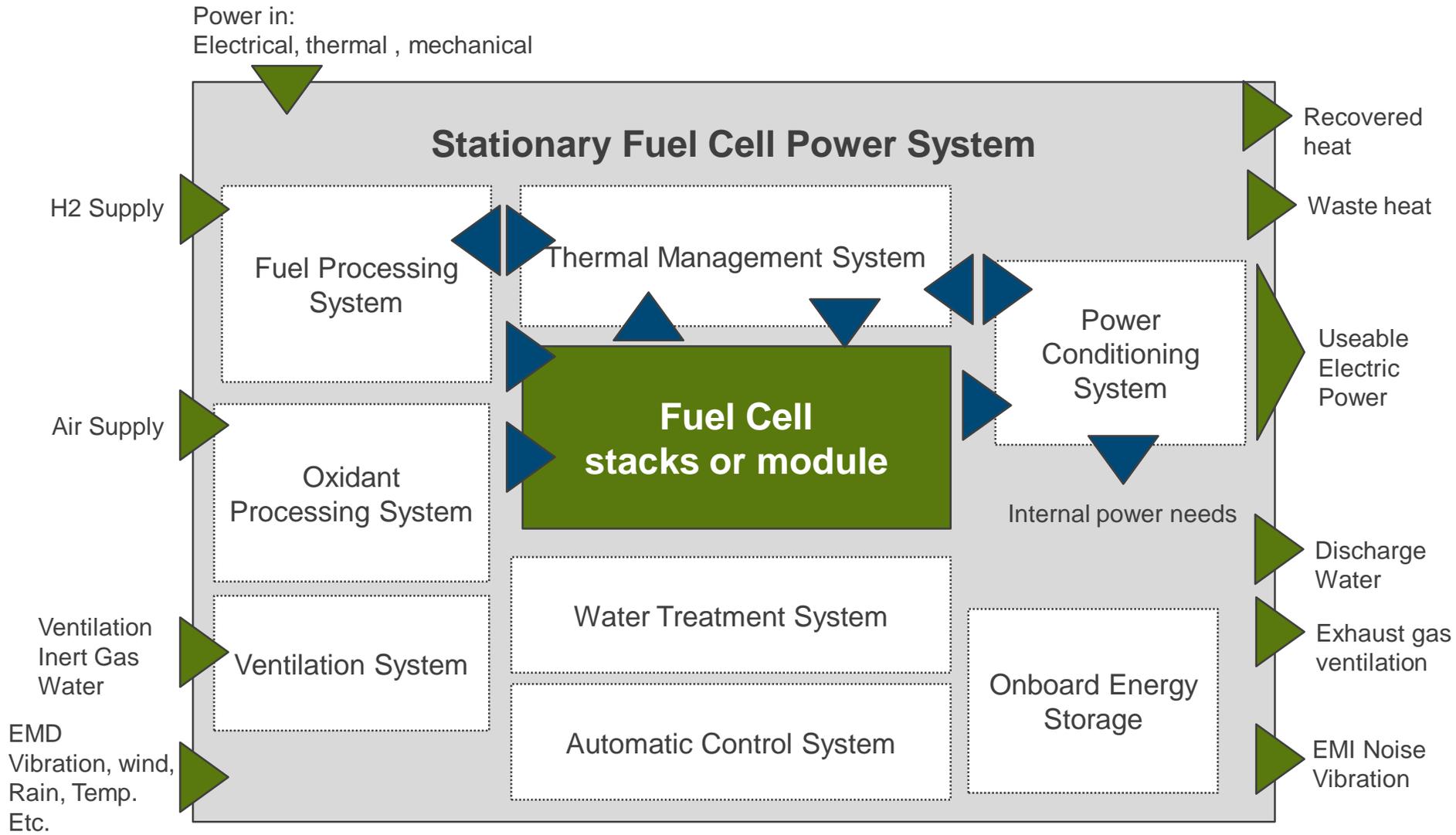


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1) Based on IEC-62282-3

Sources of hydrogen:

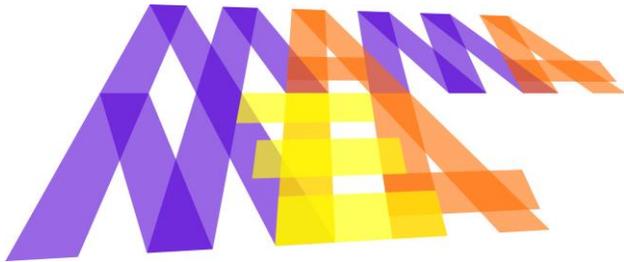
- Steam-(Methane-)Reforming
 - Possible impurities in the product gas: residual CH₄ (or other organic compounds), CO, CO₂, nitrogen and sulphur containing compounds
- Water electrolysis
 - Possible impurities in the product gas: water and O₂. *Alkaline impurities possible depending on the process*
- Chlor-alkaline electrolysis
 - Possible impurities in the product gas: water, chlorine, hydrochloric acid, salt, alkaline impurities

Other sources of impurities

- Hydrogen transport and storage – is what is going in also what is coming out?
 - Possible impurities: particles, airborne impurities (diffusion)
- Hydrogen odour addition
 - Still largely undefined, most options are sulphur based
 - Tolerance or removability?

Impurity	Impact	Method of mitigation
Organic compounds/CH ₄	Known	Known, could be improved further
CO	Known	Known, could be improved further
CO ₂	Known, could be understood better	Known, could be improved further
Water	Known	Known, could be improved further
O ₂	Known	Known, could be improved further
Sulphur and nitrogen containing compounds	Known, could be improved further	Known, could be improved further
Chlorine and HCl	Known	Known, could be improved further
Alkaline compounds and salts	Few studies available	Few studies available

- 🌱 Air quality
 - 🌱 Maritime: salt, soot, etc.
 - 🌱 Residential CHP: few, but depends strongly on the location
 - 🌱 Industrial: harsh corrosive environment
- 🌱 Detection and response to detected off-spec gases
 - 🌱 Reliable measurements of the gases as they enter the system
 - 🌱 How to respond to off-spec gases? When to mitigate ex- or internally and when to interrupt operation



This project has received funding from the FCH JU and European Union's Horizon2020 research and innovation programme under Grant Agreement no. 779591.



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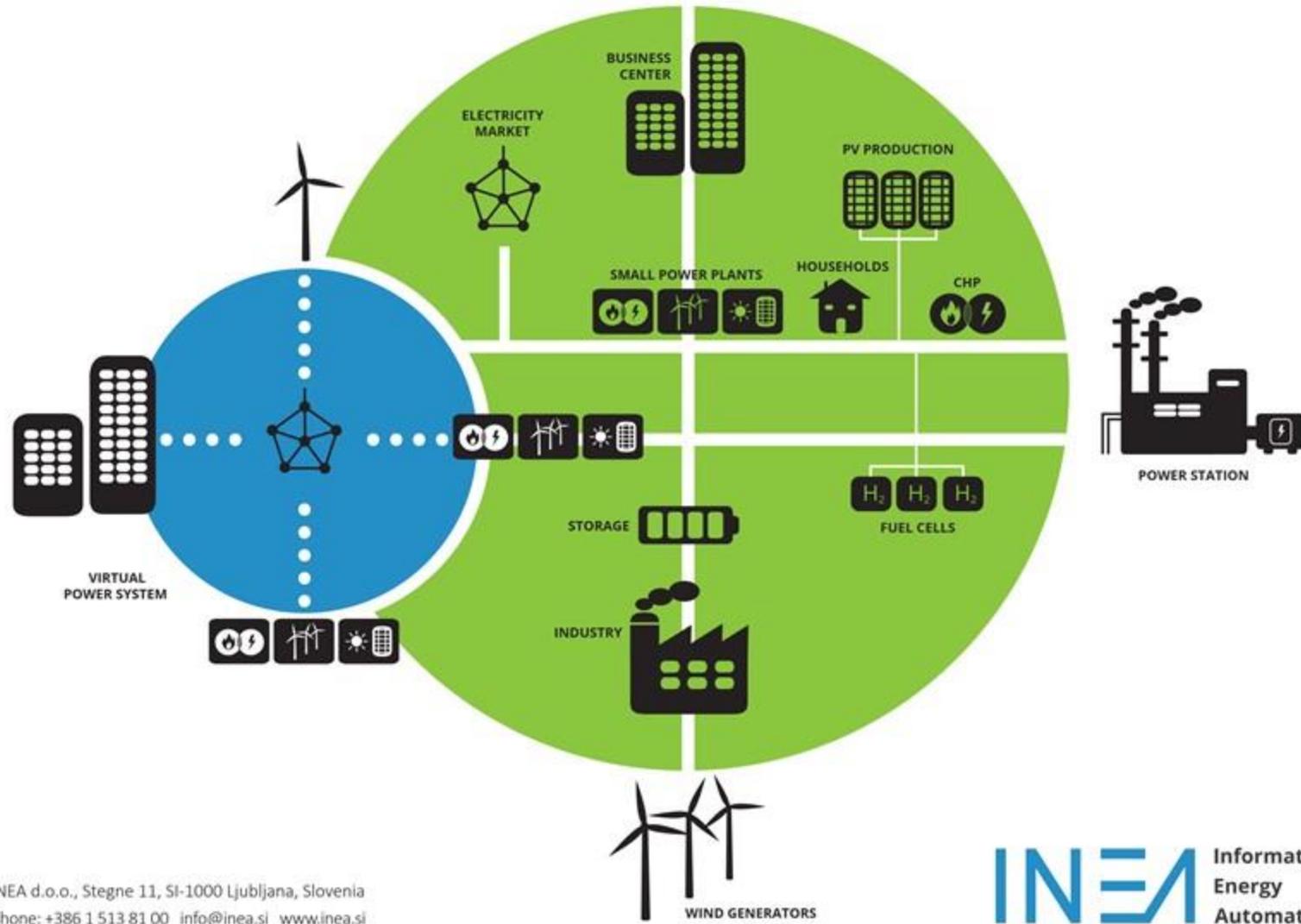


GRASSHOPPER

Grid Assisting Modular Hydrogen
PEM Power Plant



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