Intensification of alkaline electrolysis

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Loen, 12 June 2019

Your partner in essential chemistry for a sustainable future

AkzoNobel
SPECIALTY CHEMICALS

Nouryon

We are experts in electrochemical production

Active in electrochemistry since 1899

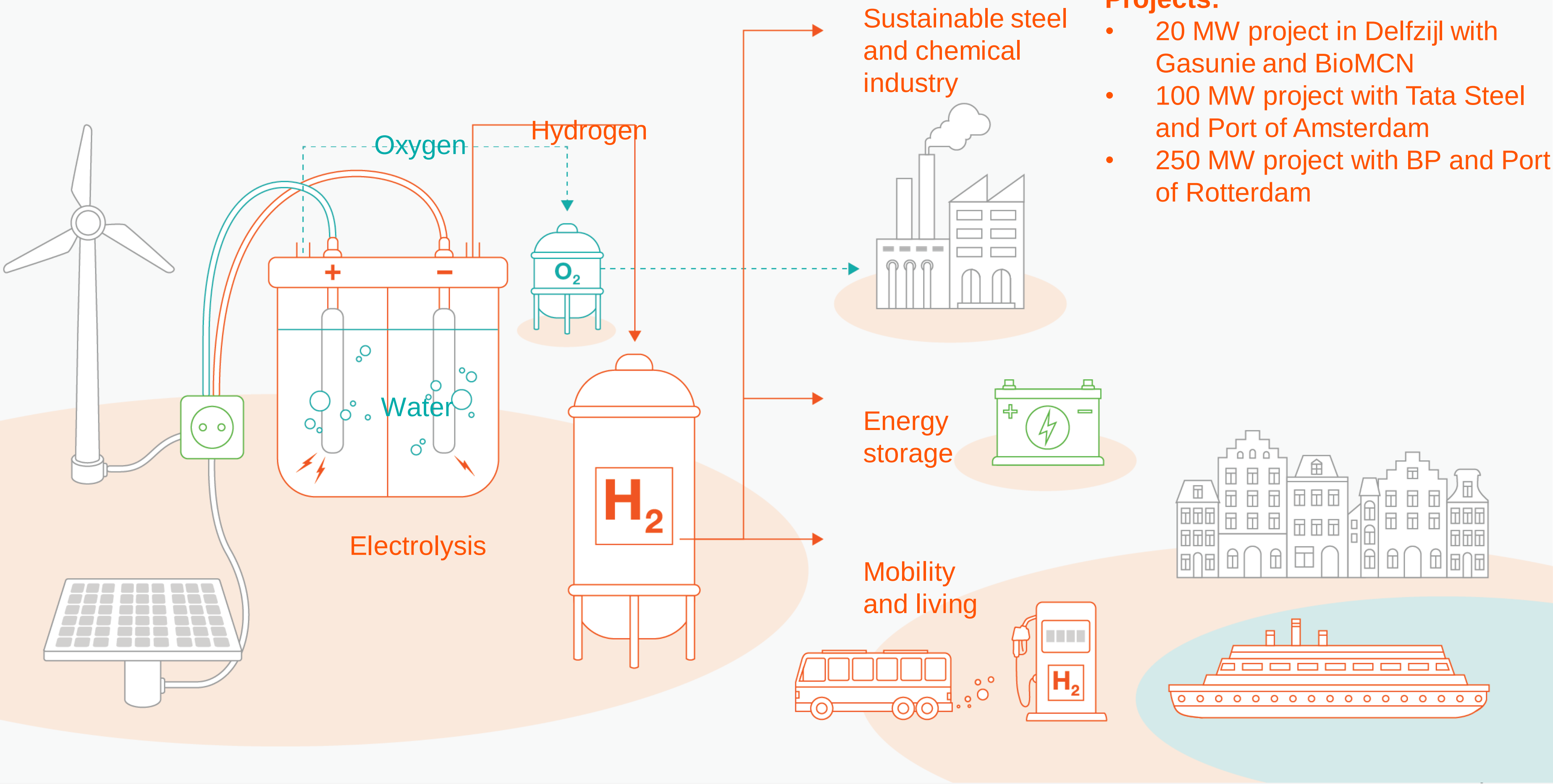
Water electrolysis since 1940

46% share of renewable energy

Chlor-alkali	Sodium chlorate	Water electrolysis
		
Installed capacity: 380 MW **H_2 production: 38 kta**	**Installed capacity: 620 MW** **H_2 production: 62 kta**	**Installed capacity: 8 MW** **H_2 production: 1.2 kta**

Nouryon operates 1000 MW of electrolysis capacity

Leading the way for green hydrogen

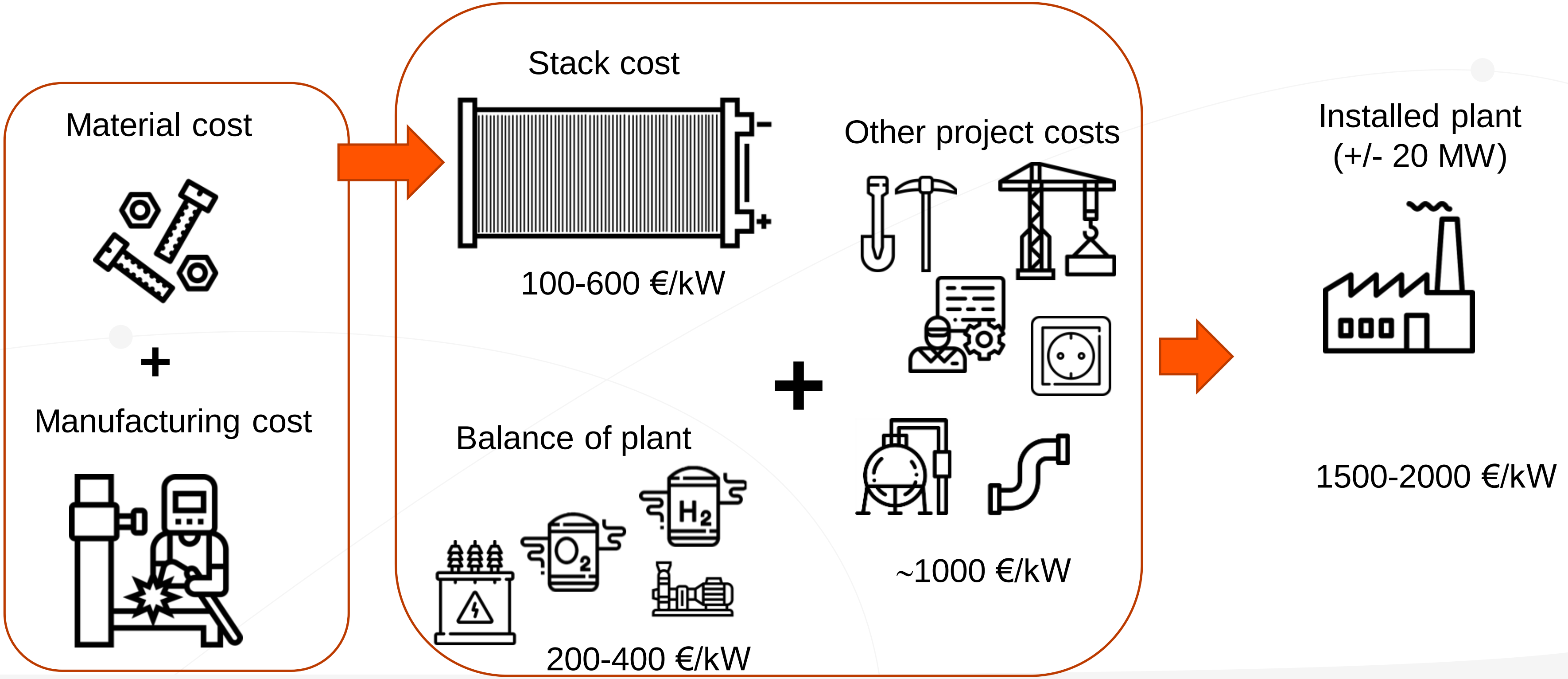


Projects:

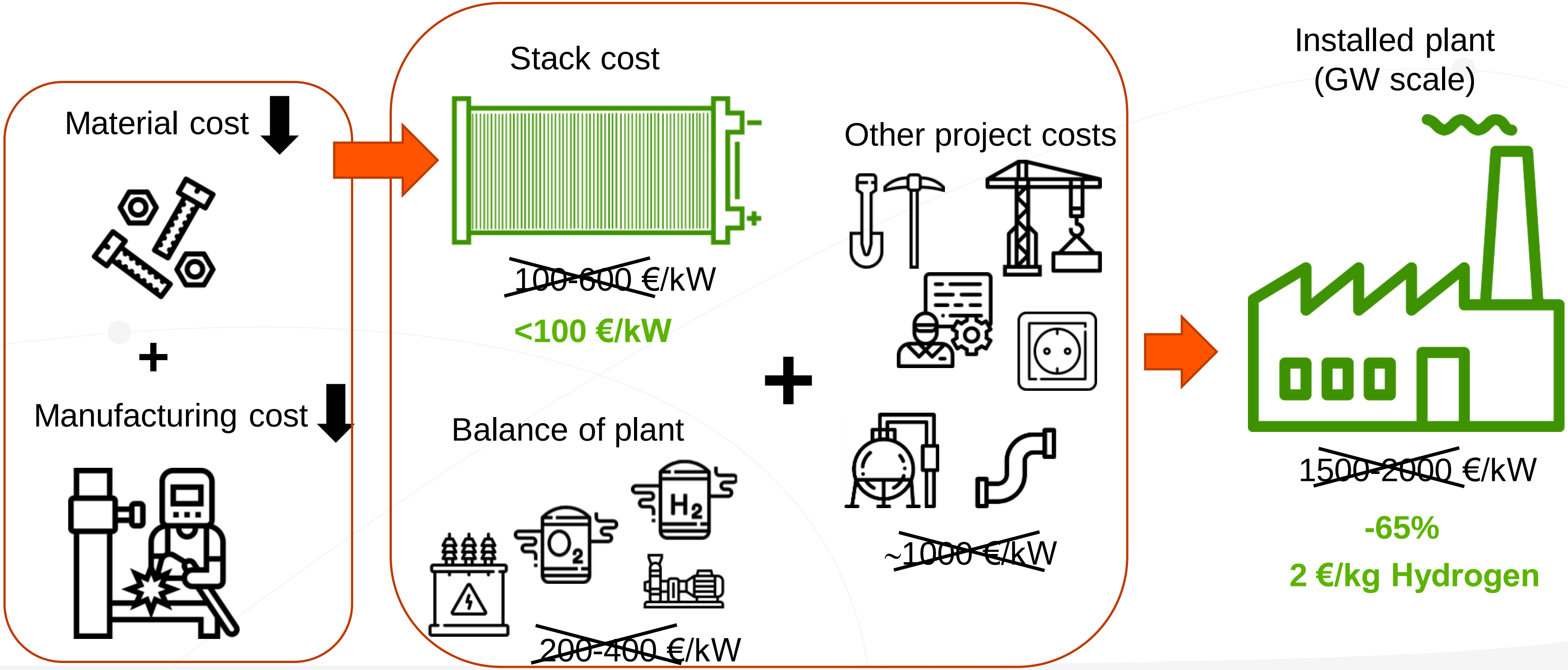
- 20 MW project in Delfzijl with Gasunie and BioMCN
- 100 MW project with Tata Steel and Port of Amsterdam
- 250 MW project with BP and Port of Rotterdam

Nouryon

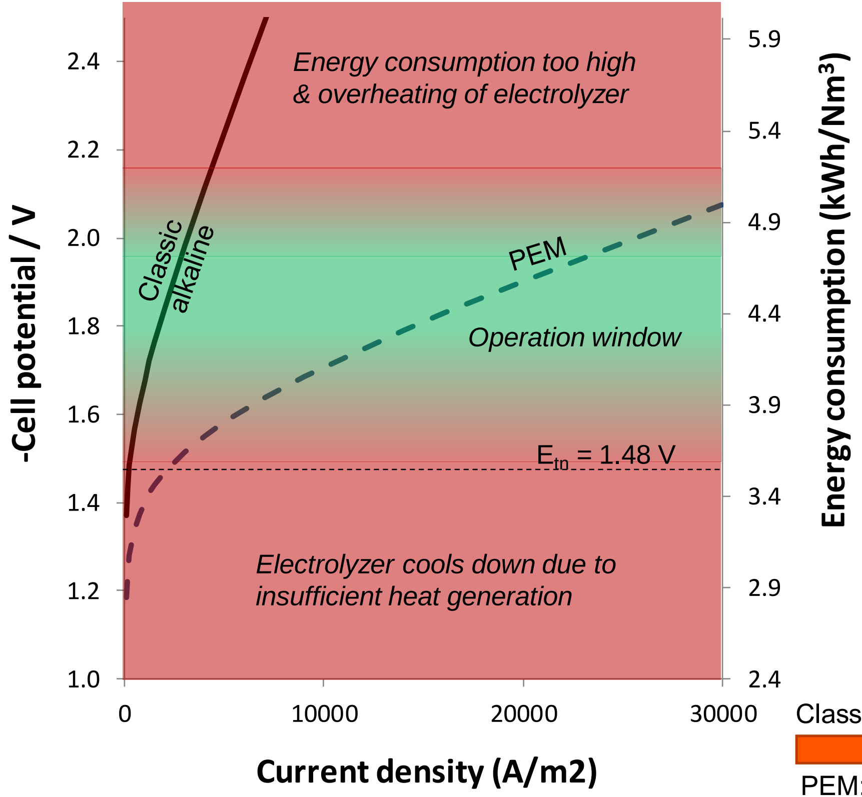
Plant costs



To make green hydrogen competitive we need to reduce cost

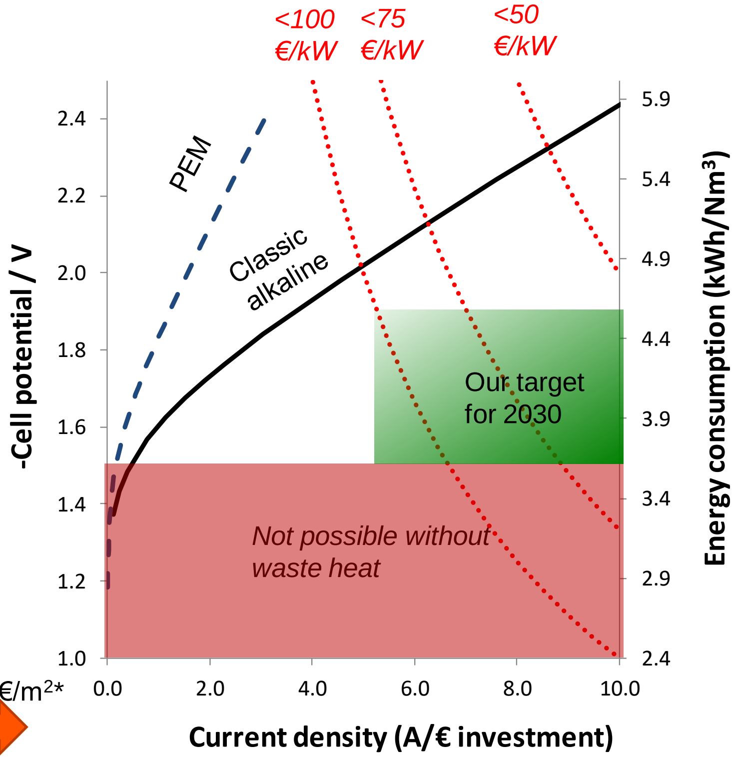


Alkaline and PEM comparison



Classic alkaline: ~660 €/m²*

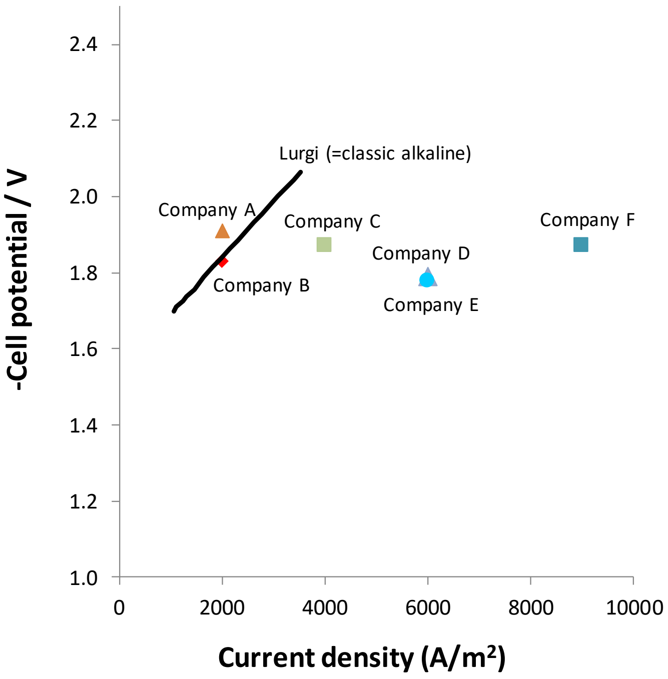
PEM: ~16400 €/m²*



Note: current efficiency is 98% for alkaline and PEM (due to leak currents and gas crossover)

* Nouryon stack price analysis based on public information

Developments in alkaline



- We see increased current densities while retaining the same efficiency, made possible by cathodes that have been developed for the chlor-alkali industry and improved membranes

	Classic Alkaline	Intensified alkaline
Separator	Asbestos (2-4 mm)	polysulfone-ZrO_2 (0.5 mm)
Ohmic resistance separator at 80°C	1.0-1.3 Ωcm^2 [2]	0.13 Ωcm^2 [1]
Cathode	Nickel (with iron contamination)	Nickel with noble metals
Cathode overpotential electrode at 90°V (V)	0.28 V[3]	0.08 V[4]

Graph: Recent company presentations and brochures & Vandenborre et al., Int. J. Hydrogen Energy 1984 (for Lurgi data)

[1] Vermeiren et al., Int. J. Hydrogen Energy 1998

[2] Tilak et al., Comprehensive treatise of electrochemistry 1981

[3] O'Brien, Handbook of chlor-alkali 2005, page 263

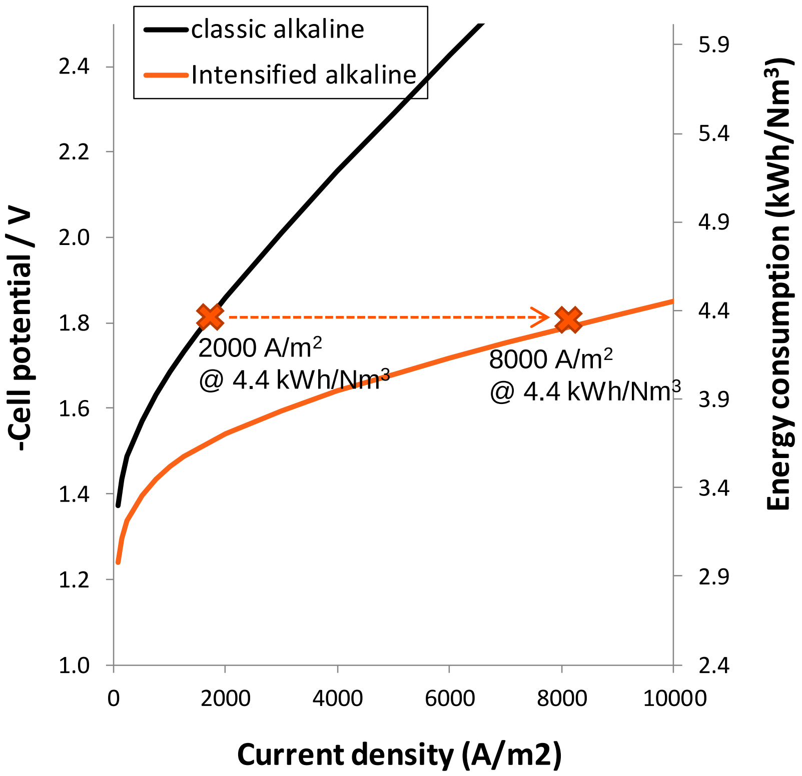
[4] Recent developments in of AKC' IM technology, 2009

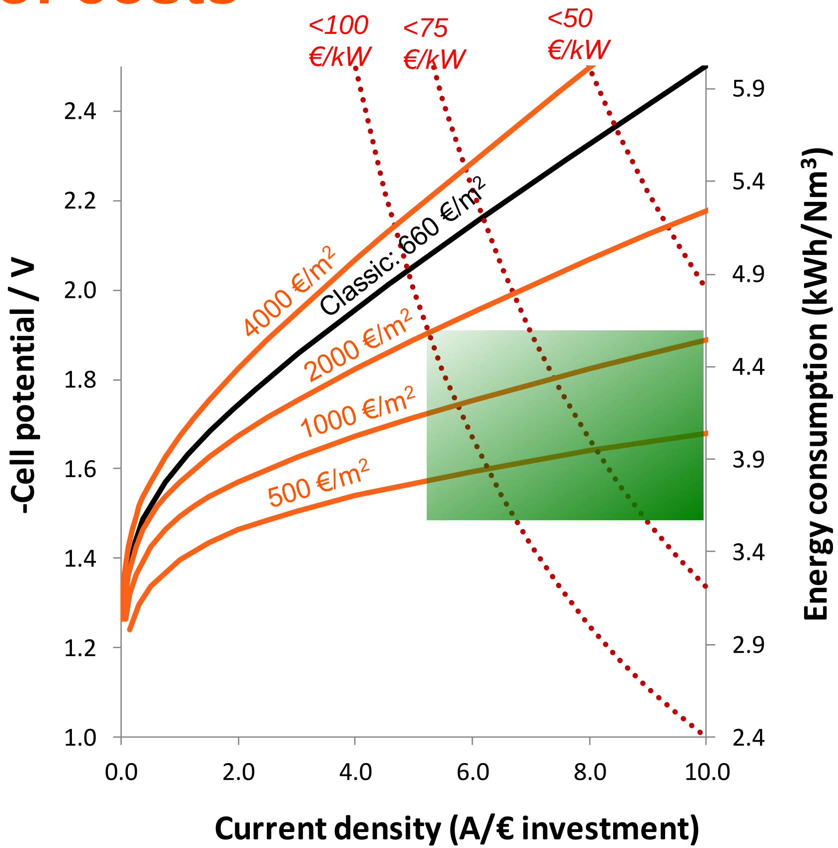
State-of-the-art and development potential

	State-of-the-art (in commercial products)	State-of-the-art performance	Further development potential
Separator	polysulfone-ZrO_2	$0.13\ \Omega\ cm^2$	Better conducting membranes, anion-exchange membranes
Cathode	Ni with noble metal loading	η_C = 0.08 V @ 0.6 A cm^{-2}, 90°C	Stable cathodes with reduced or no noble metals use
Anode	Ni (with iron contamination)	η_A = 0.35V @ 1.0 A cm^{-2}, 100°C[1]	Stable anodes with lower overpotential without noble metals
Electrode structure	"Zero" gap: meshes/expanded metal pushed against membrane	~$0.1\ \Omega\ cm^2$	Membrane-electrode assemblies with lower resistance
Cell materials	Nickel, Nickel plated steel, EPDM, PPS, Teflon		Reduced use of pure nickel and other materials (eg. thinner bipolar plates, plated steel)
Operating conditions	90 ºC, 30 bara		Operation at higher temperatures to reduce cell potentials
Total performance		**~1.8 V @ 0.6 A cm^{-2}, 90°C**	

[1] Baley et al., Int. J. Hydrogen Energy 1985, data for etched nickel plate

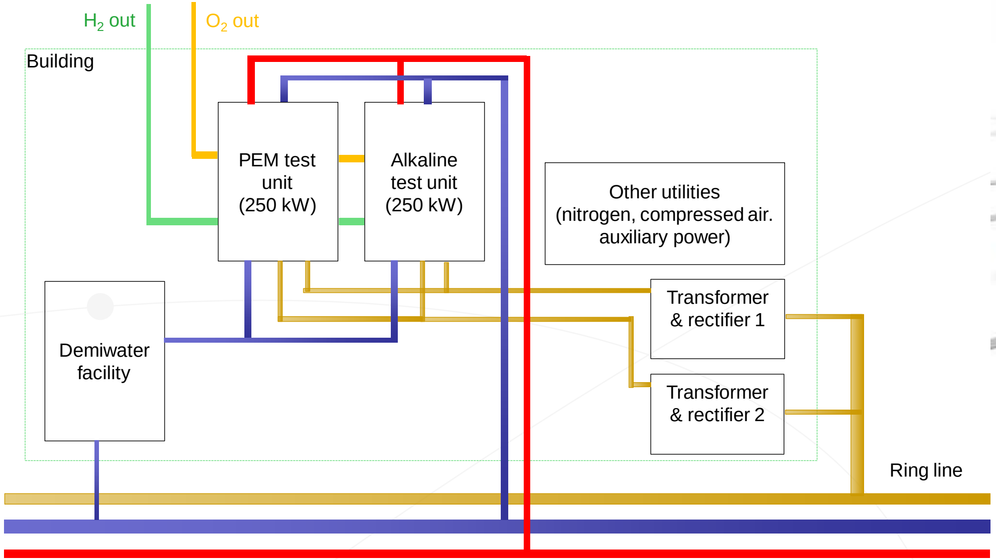
Intensified alkaline: importance of costs





MW test center in Groningen

- The MW test center aims to support technology development of water electrolysis at higher TRL levels (4-7).
- The technology development at the MW test center should lead to a cost prize for the electrolyzer stack of 50-100 €/kW at an efficiency of >80% (for first 5 years of operation) and a pressure of 30 bara by 2030.



- Partners: Shell, Gasunie, Yara, Frames, GSP, TNO/ECN, Hanze, RUG, ISPT, Yokogawa
- Planned to be operational in summer 2020

Conclusions

- We need to bring down the costs of water electrolysis plants by 65% for a completely installed plant and to <100 €/kW for the stack, while retaining the efficiency of <4.5 kWh/Nm^3

- There is ample room for innovation in alkaline electrolysis to achieve these targets

Thank you!

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