Imperial College London

Future cost and performance of electrolysis: An expert elicitation study

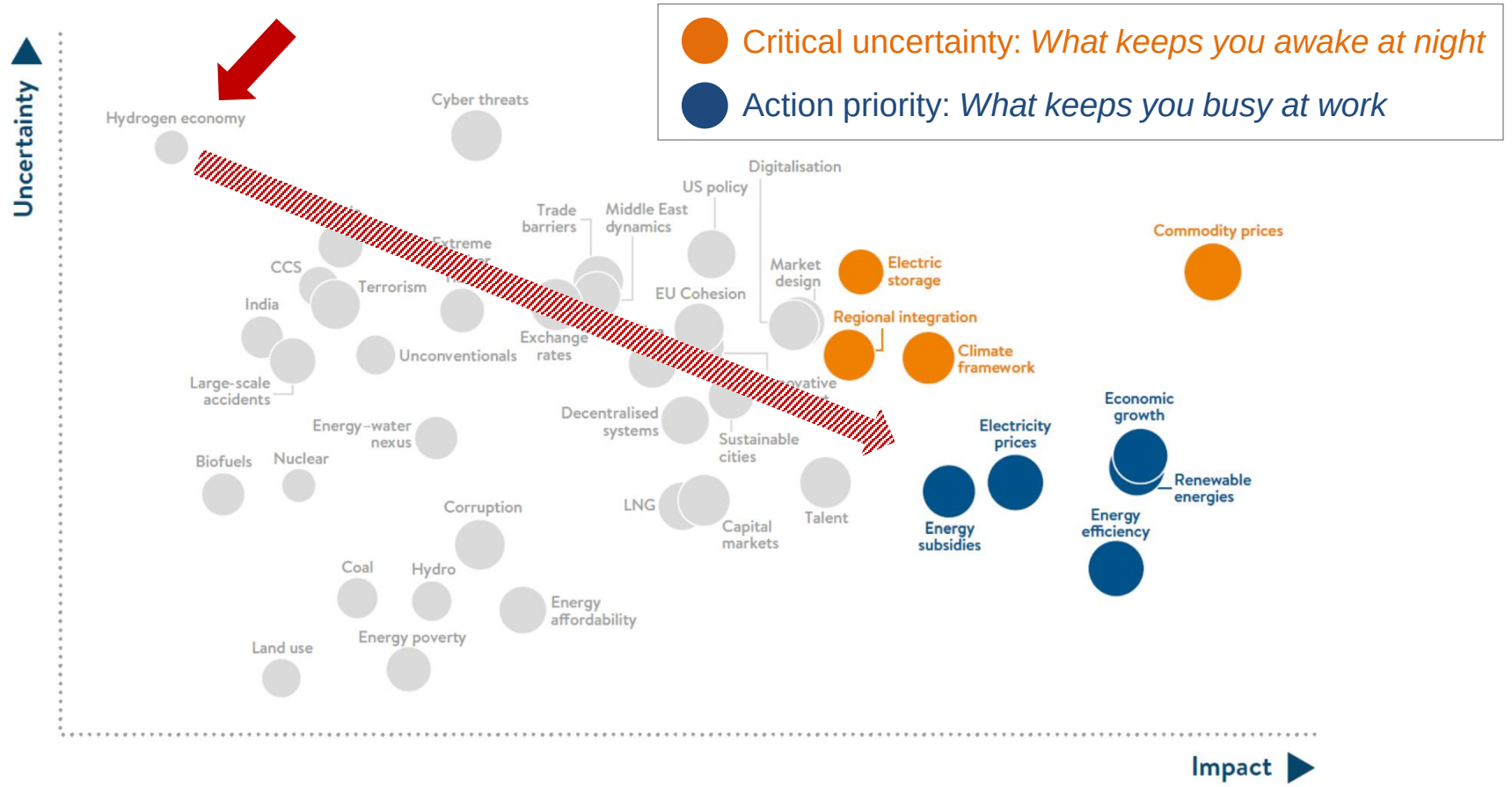
Oliver Schmidt

Hydrogen & Fuel Cells Energy Summit 2018
24-25 January 2018 | Brussels

Grantham Institute

Hydrogen economy is perceived as most uncertain and least impactful energy issue

World energy issues



Source: World Energy Issues Monitor 2017 | Exposing the new energy realities. World Energy Council; 2017.

Thus, more transparency on future cost and performance of electrolysis is needed

Forecasting methods

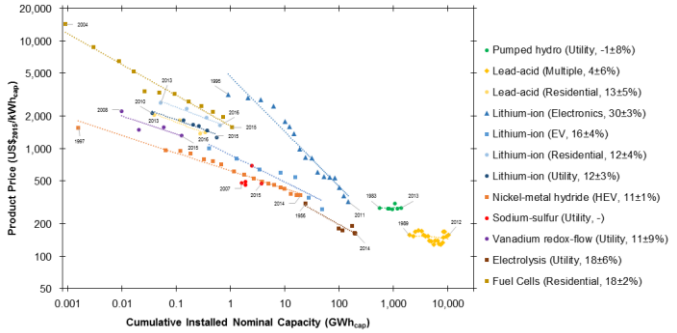
nature energy

ANALYSIS

PUBLISHED: 10 JULY 2017 | VOLUME: 2 | ARTICLE NUMBER: 17110

The future cost of electrical energy storage based on experience rates

O. Schmidt[1,2]*, A. Hawkes[3], A. Gambhir[1] and I. Staffell[2]



<u>Expert interviews</u>

- Elicitation of future parameter values in different scenarios
- Discussion of improvement drivers

10 experts project cost & performance for alkaline, PEM and solid-oxide electrolysis

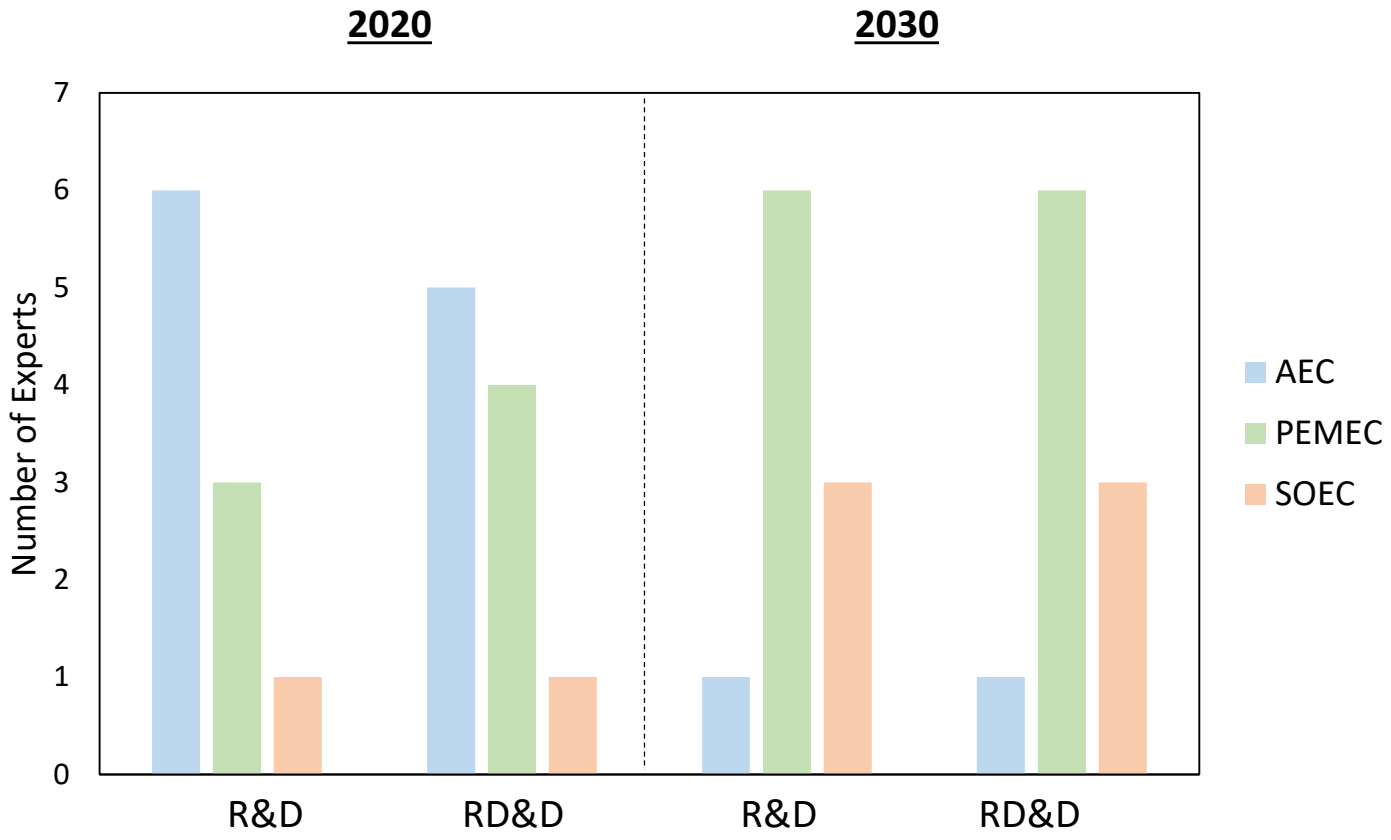
Case study parameters

Application	1	Power-to-Gas
Technologies	3	AEC: PEMEC: SOEC:
Experts	10	HYDROGENICS, Imperial College London, sunfire, DTU, UCL, E4tech, ITM POWER, elementenergy, Fraunhofer
Metrics	3	Capital cost: Lifetime: Efficiency:
Time	2	2020, 2030
Conditions	2	R&D – current market size: RD&D – scale-up:
Scenarios	3	1x, 2x, 10x current R&D funding

Power Source	Intermittent Renewables
System Size	10 MW_{el}
H_2 output pressure	20 – 30 bar
H_2 application	Injection to natural gas grid

6 of 10 experts believe PEMEC will be the dominant electrolysis technology by 2030

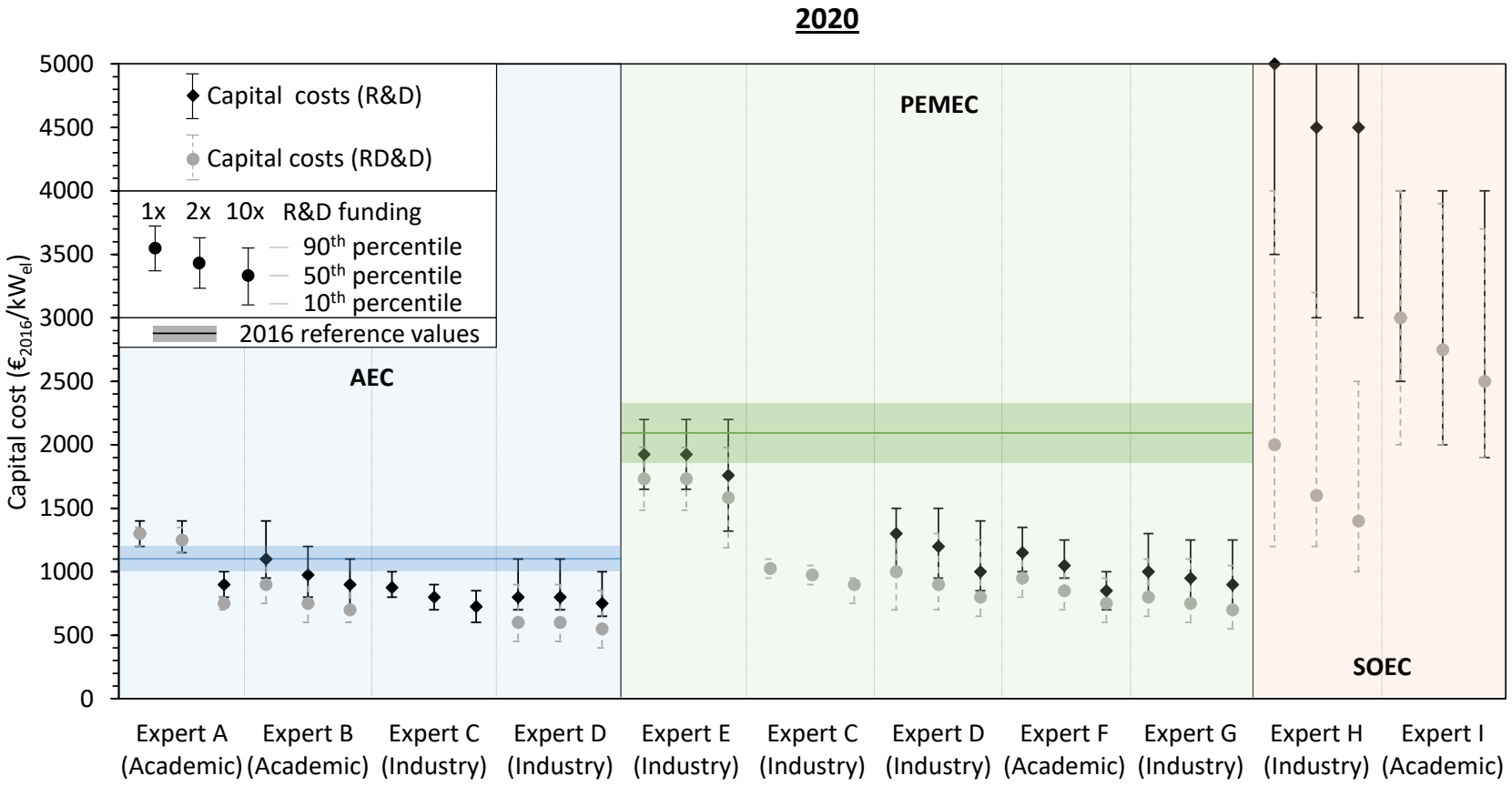
Technology dominance



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

Experts elicit cost values subject to time, deployment conditions and R&D scenario

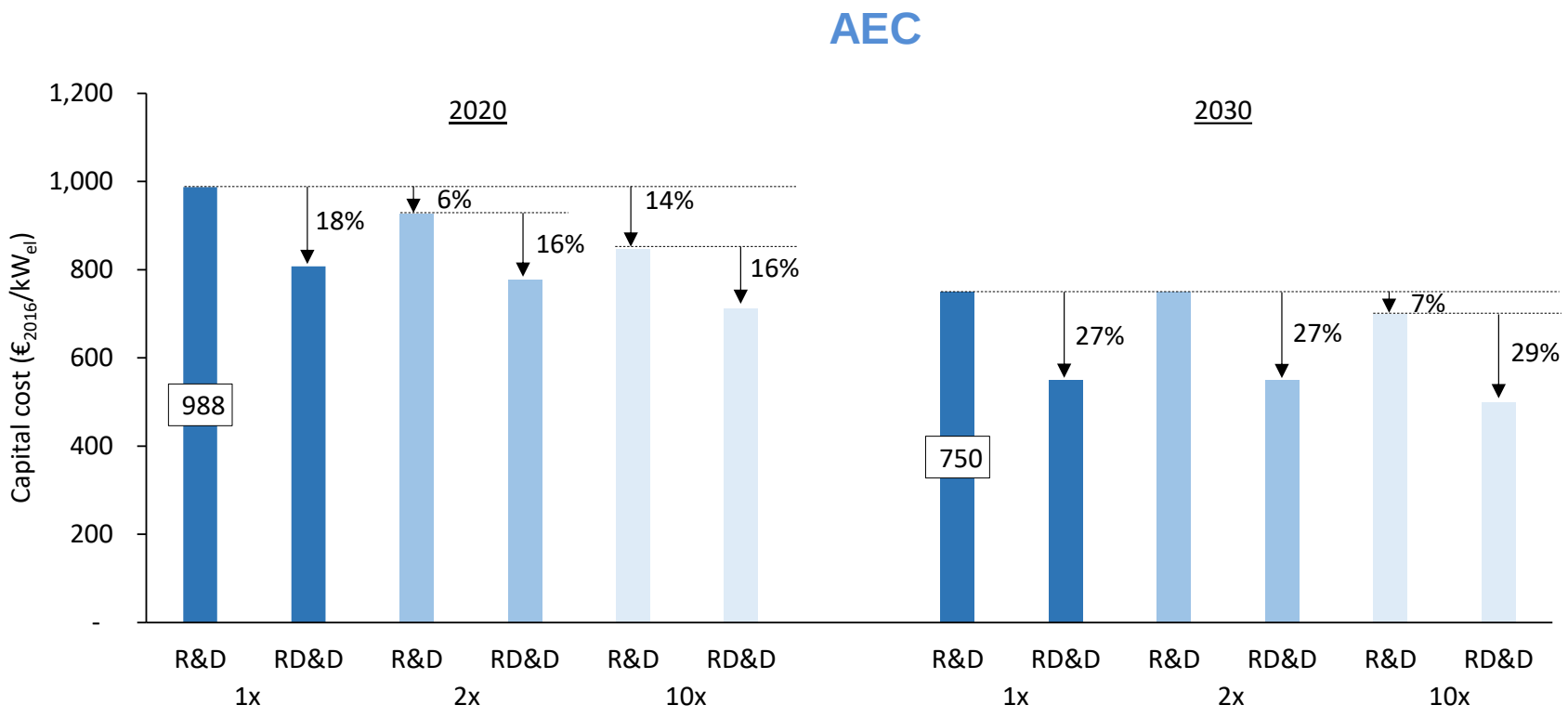
Elicited capital cost values



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

AEC cost reduce by 0-14% with more R&D and 16-29% via increased deployment

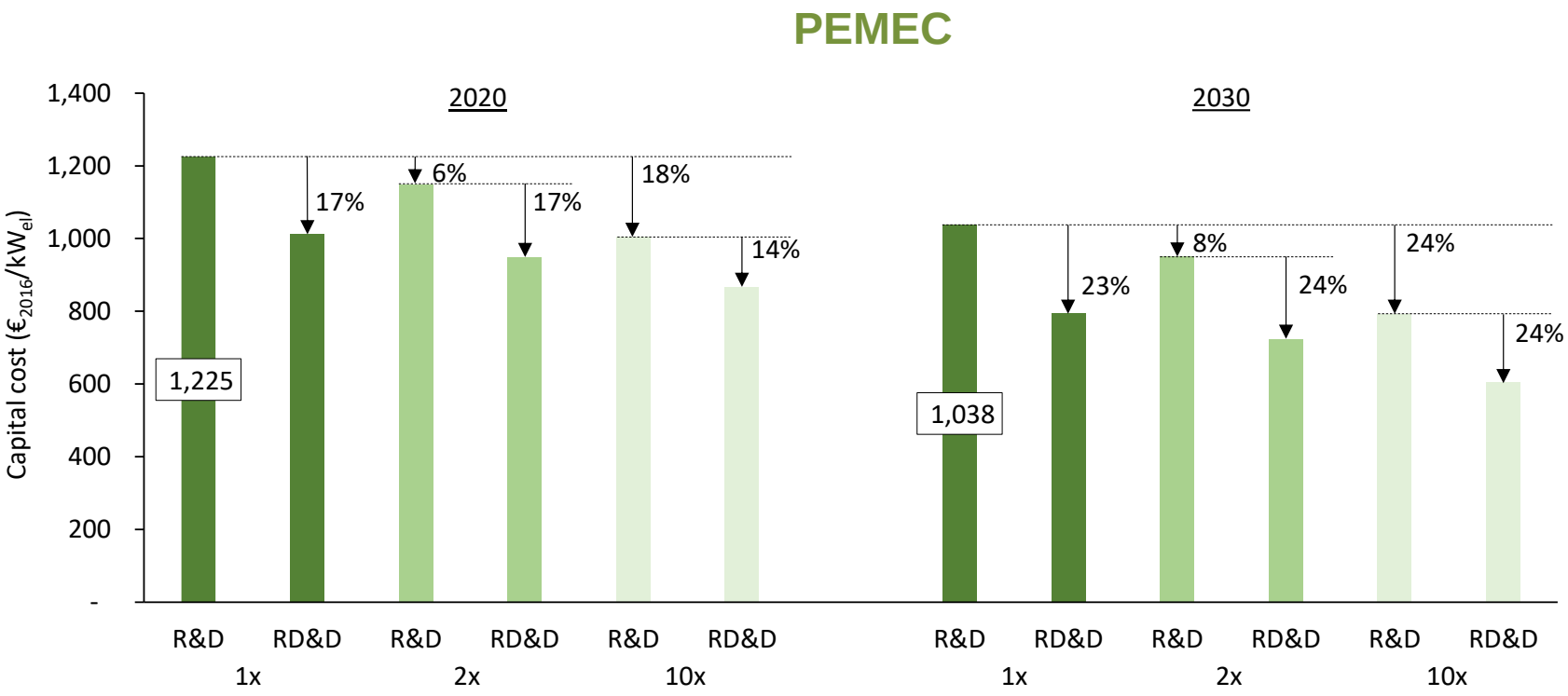
Median cost reduction values (1/3)



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

Similarly, manufacturing scale-up has a strong effect on cost than R&D for PEMEC

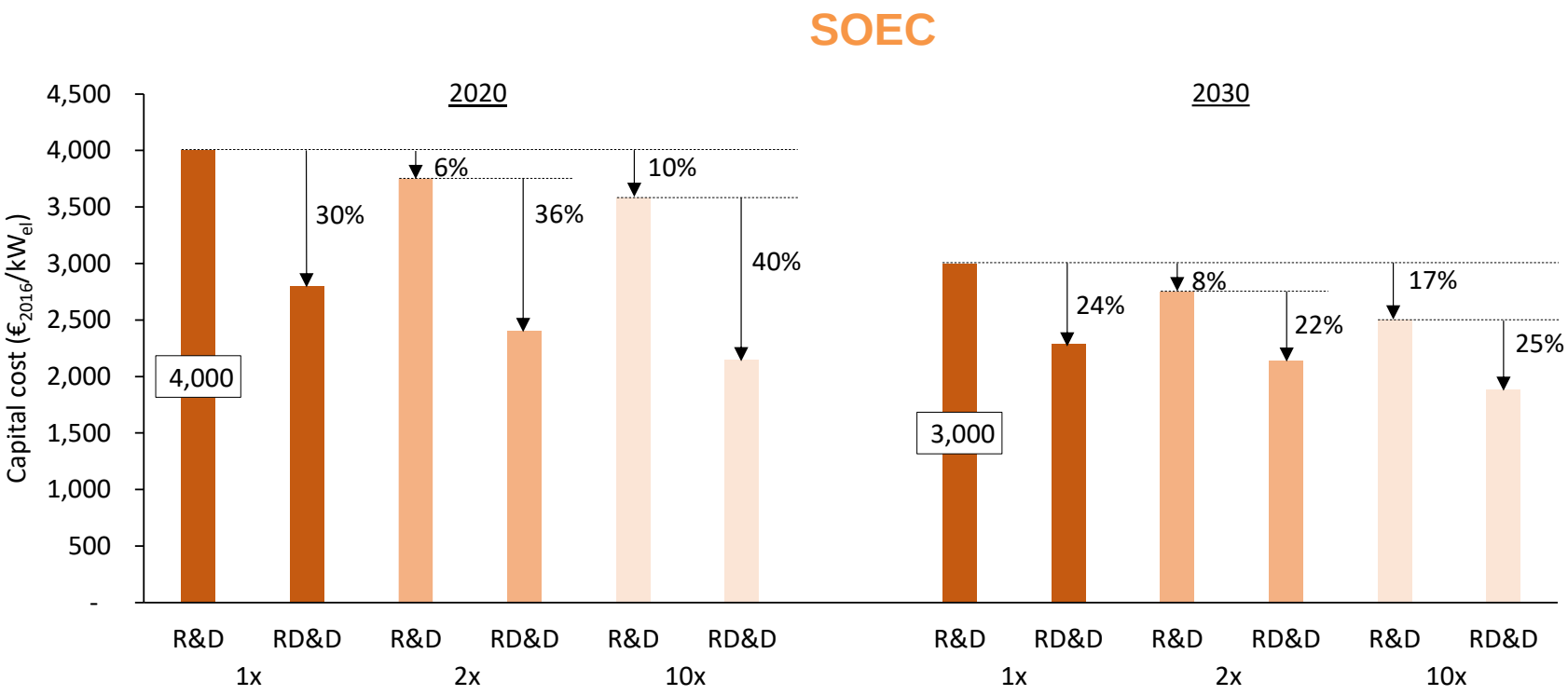
Median cost reduction values (2/3)



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

The strongest impact on cost through manufacturing scale-up is for SOECs

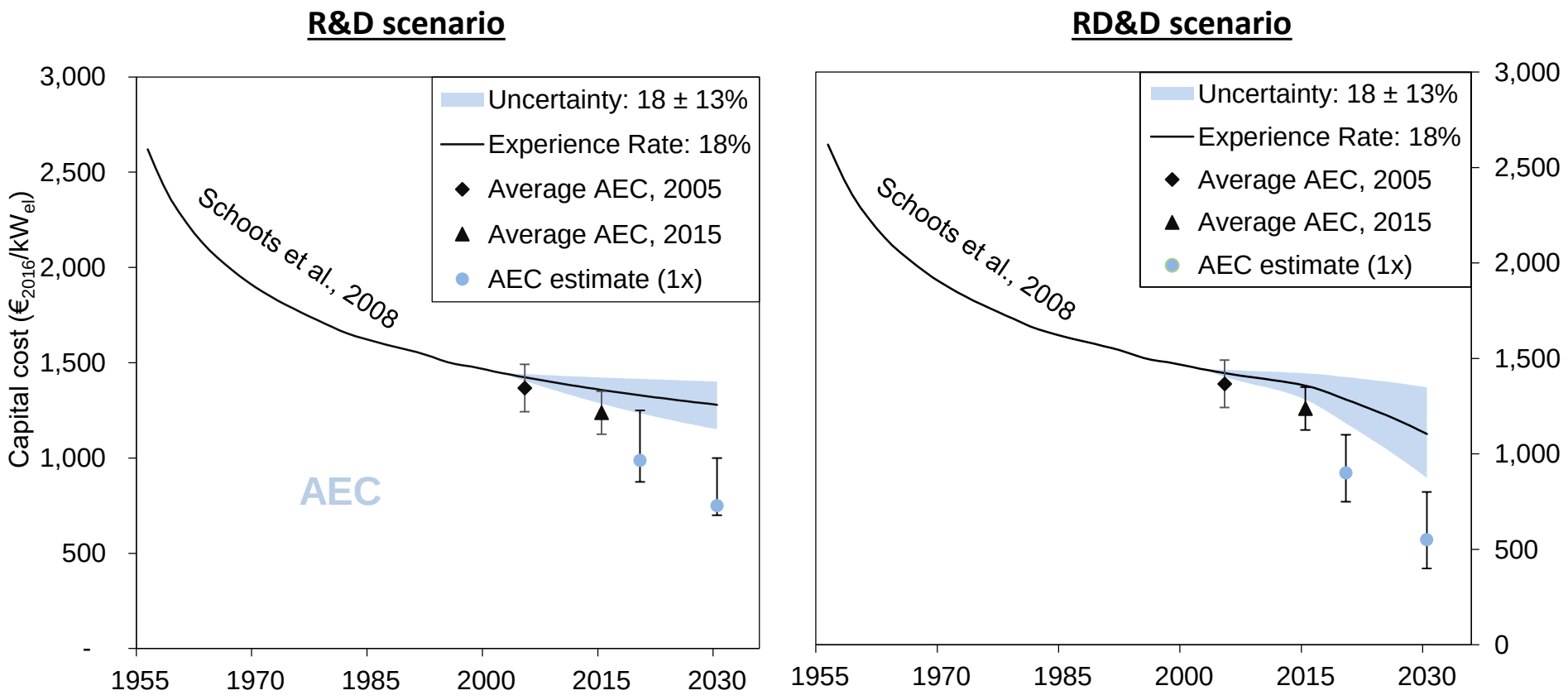
Median cost reduction values (3/3)



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

Experts project capital costs below the range given by experience rate forecasts

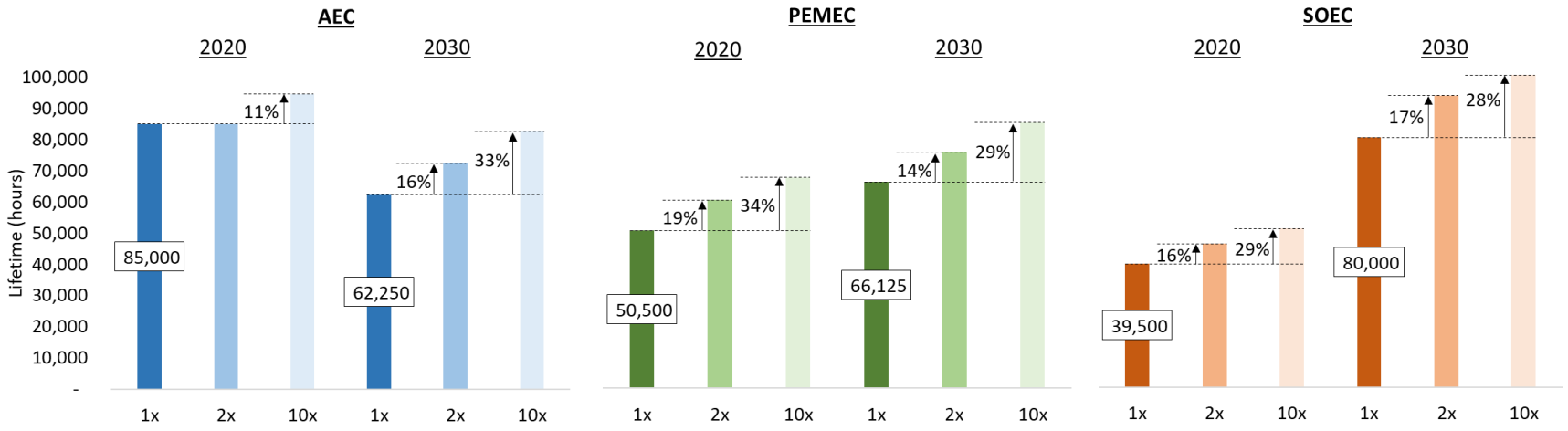
Experience curve comparison



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)
Schoots K, et al., Learning curves for hydrogen production technology, International Journal of Hydrogen Energy (2008)

System lifetimes may converge at around 60,000 - 90,000 hours (continuous operation)

Median lifetime improvement values

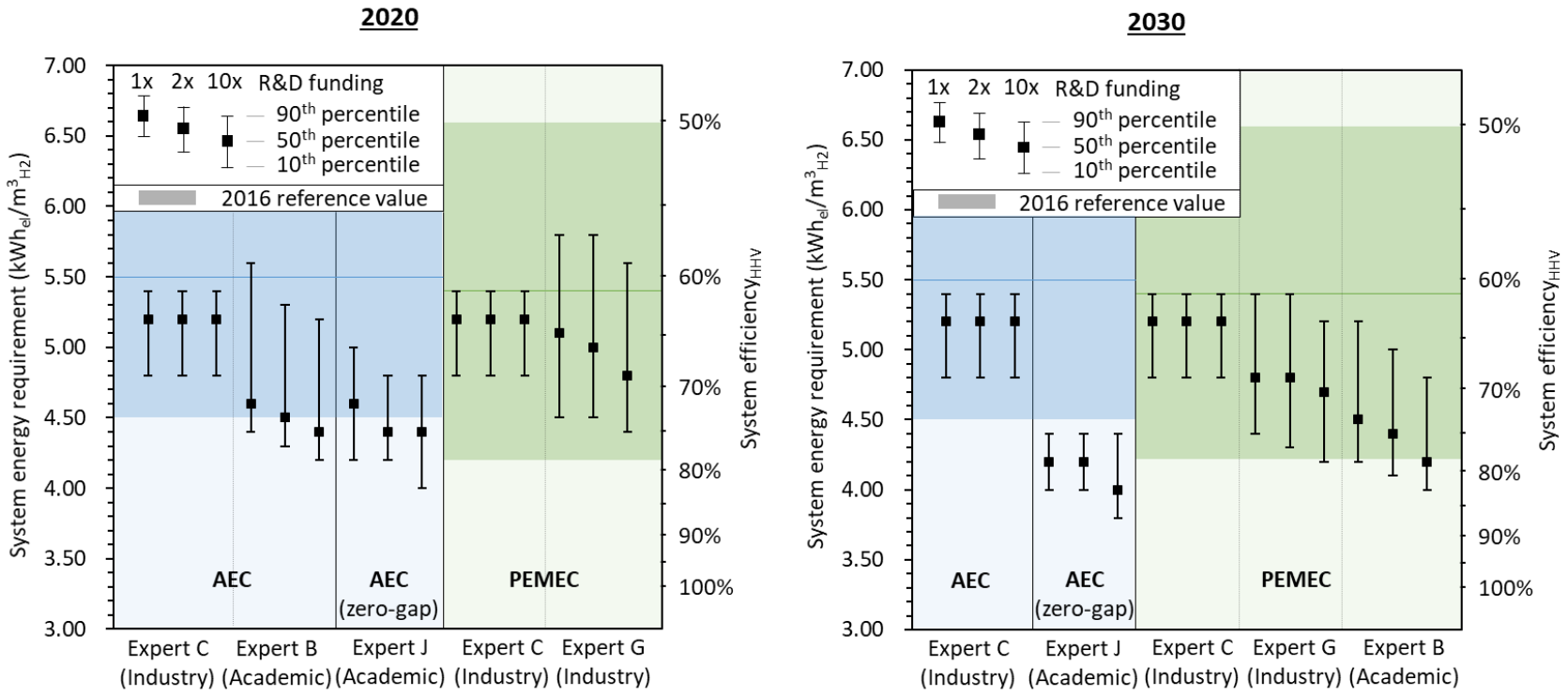


- AEC unlikely to see further lifetime improvement
- PEMEC to close gap to AEC latest by 2030
- SOEC potentially outperforming AEC & PEMEC by 2030

Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

Potential improvements in efficiency likely to be deprioritised in favour of cost reductions

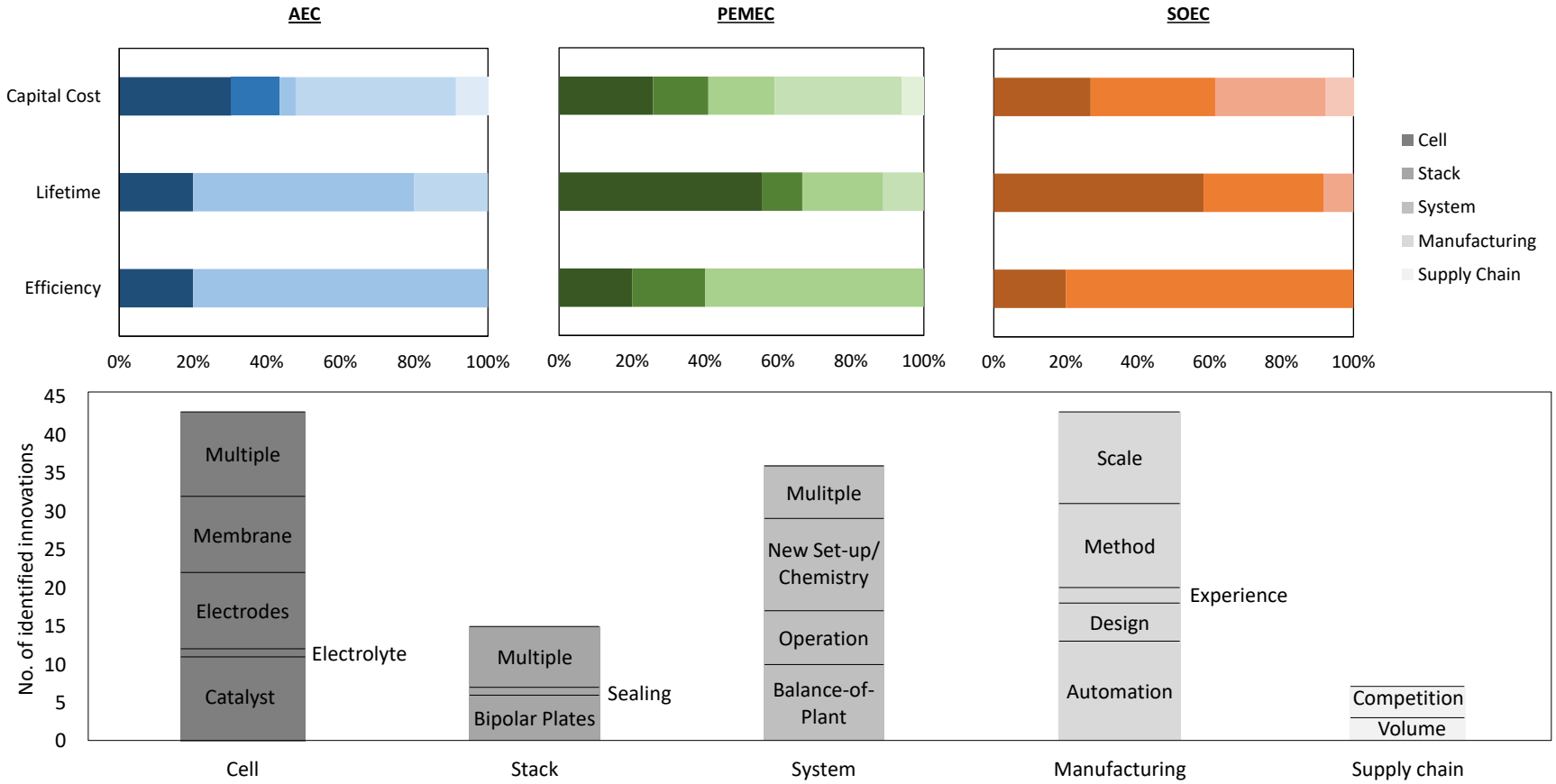
Efficiency estimates



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

Crucially, experts highlight the drivers for cost and performance improvements

Underlying innovations



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017)

Imperial College London

NERC SCIENCE OF THE ENVIRONMENT

Questions?

Oliver Schmidt | PhD Researcher in Energy Storage
Grantham Institute - Climate Change and the Environment
Imperial College London, Exhibition Road, London SW7 2AZ
Tel: +44 (0) 7934548736
Email: o.schmidt15@imperial.ac.uk

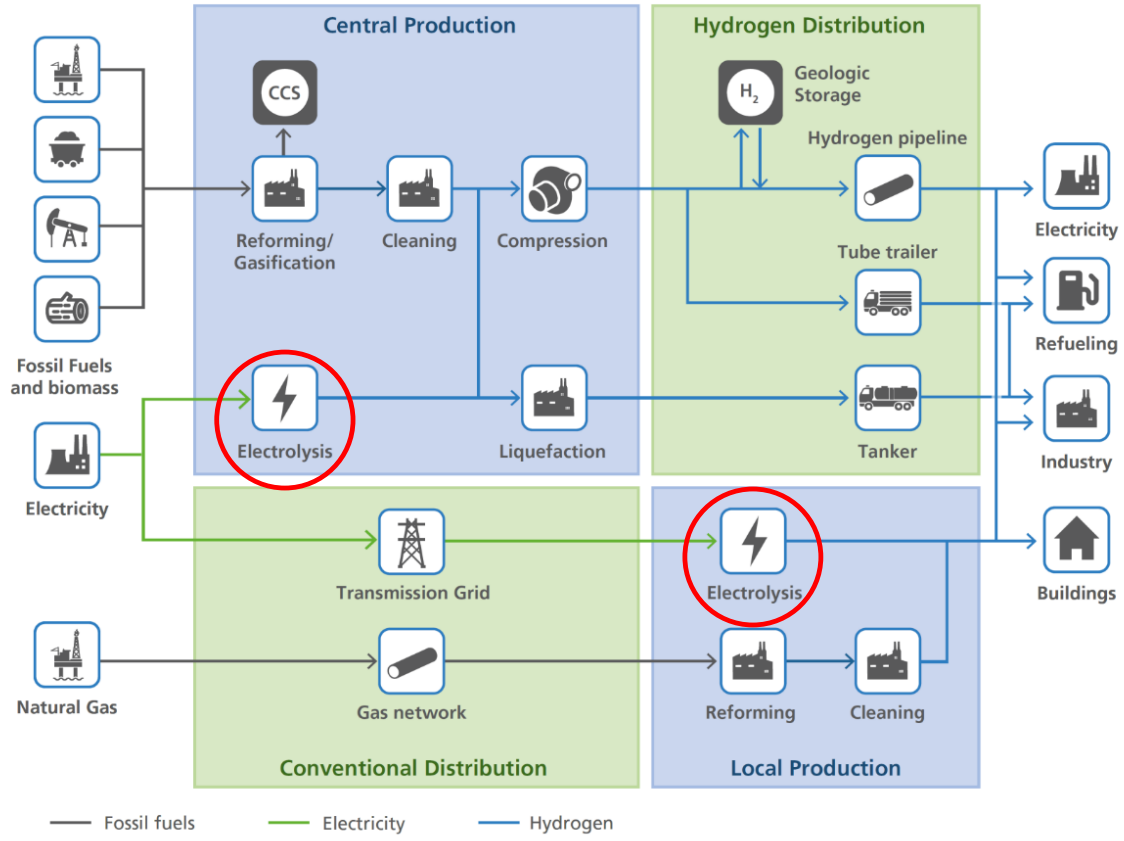
Storage Lab

Website: www.storage-lab.com

Grantham Institute

Electrolysis is key for hydrogen production given current technology trends

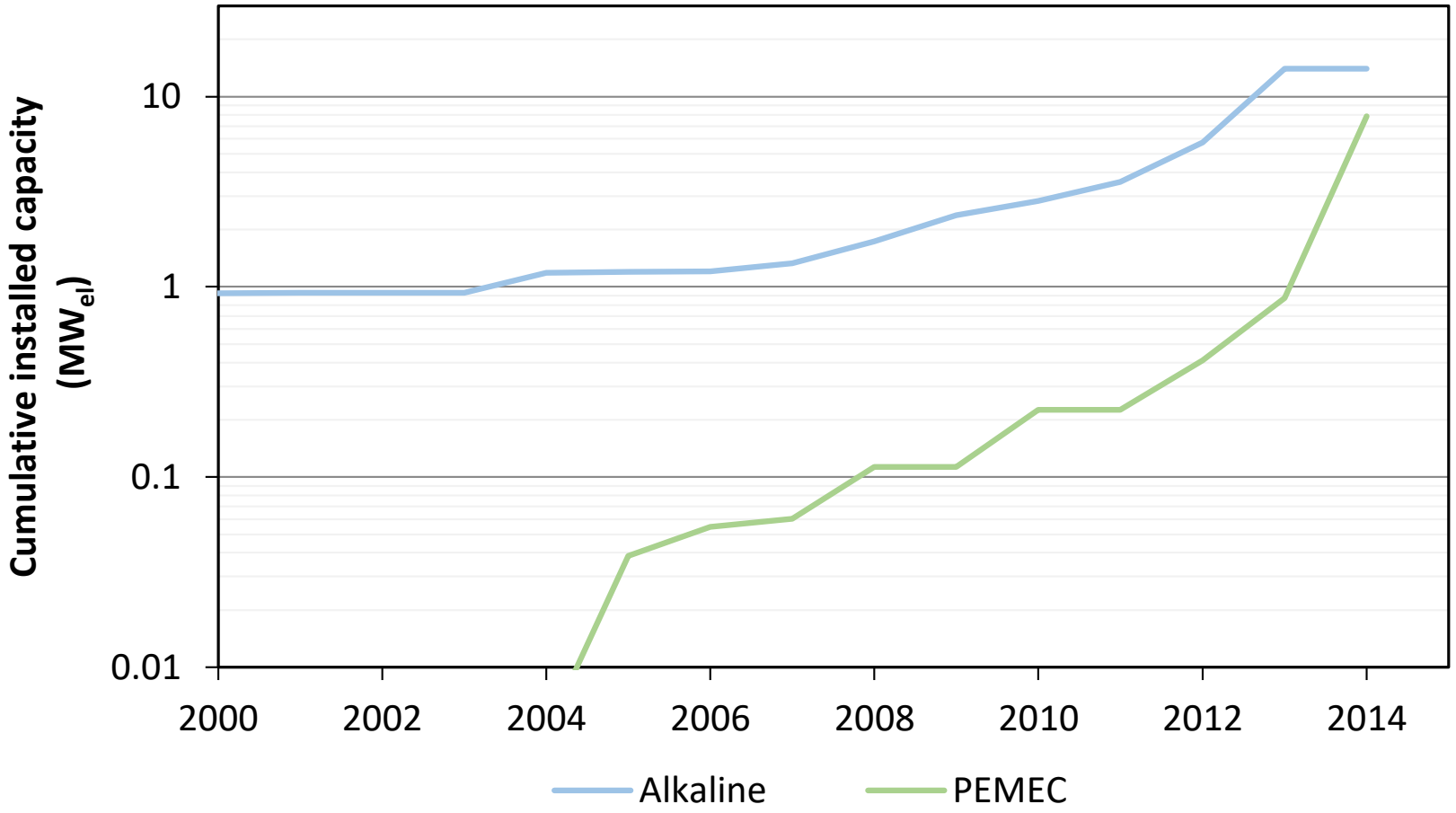
Hydrogen delivery pathways



Source: Staffell I, Dodds P, Daniel Scamman D, Velazquez Abad A, Mac Dowell N, Ward K, et al. The role of hydrogen and fuel cells in future energy systems. H2FC Supergen; 2017.

PEMEC systems used in power-to-gas applications are set to overtake AEC

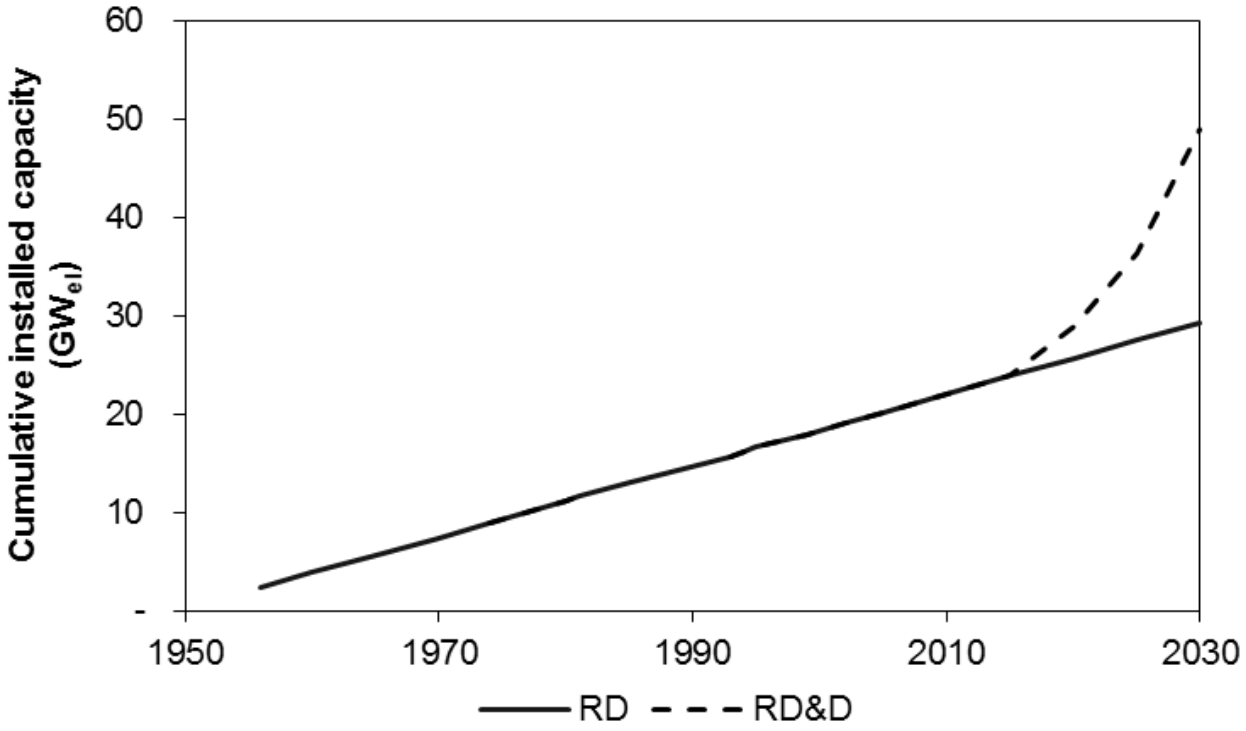
Electrolysis technology in power-to-gas pilots



Source: Gahleitner G. Hydrogen from renewable electricity: An international review of power-to-gas pilot plants for stationary applications. Int J Hydrogen Energy 2013;38:2039–61. doi:10.1016/j.ijhydene.2012.12.010.

Electrolysis market growth could translate into an additional 25 GW_{el} deployed by 2030

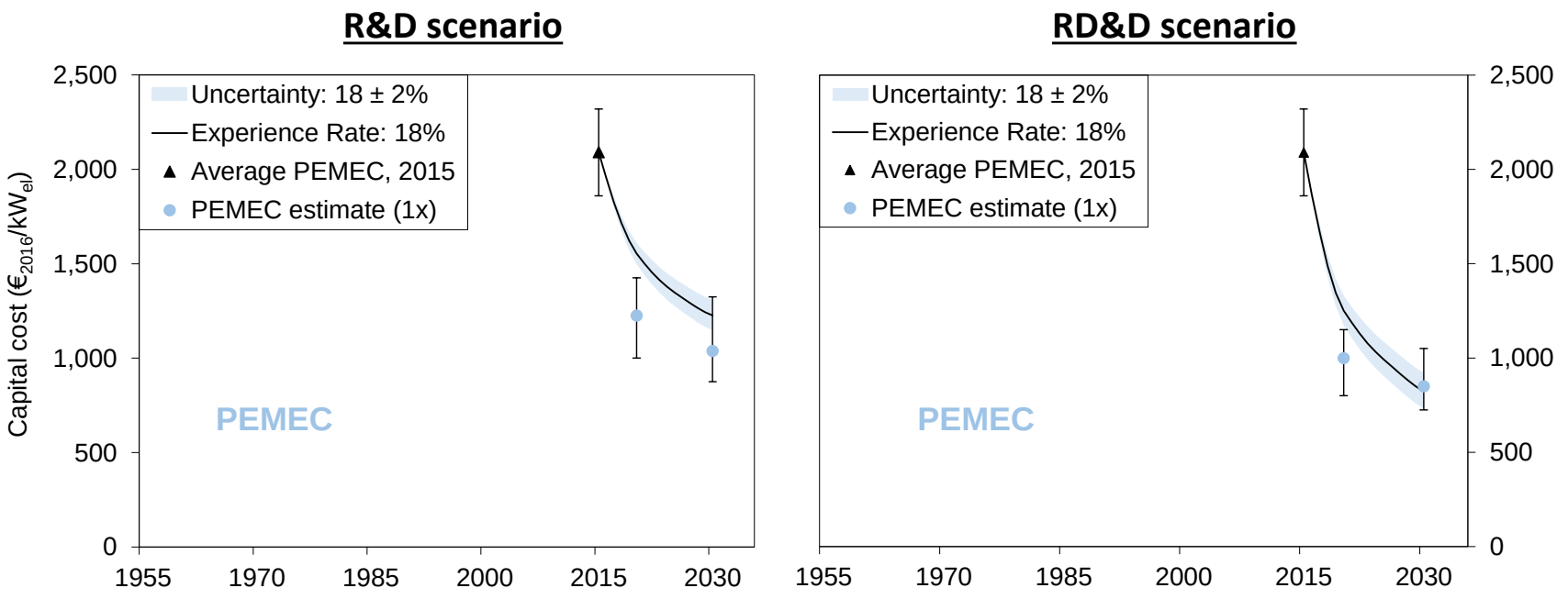
Global deployment projections



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045

Expert estimates relative to experience curve based cost forecasts for PEMEC

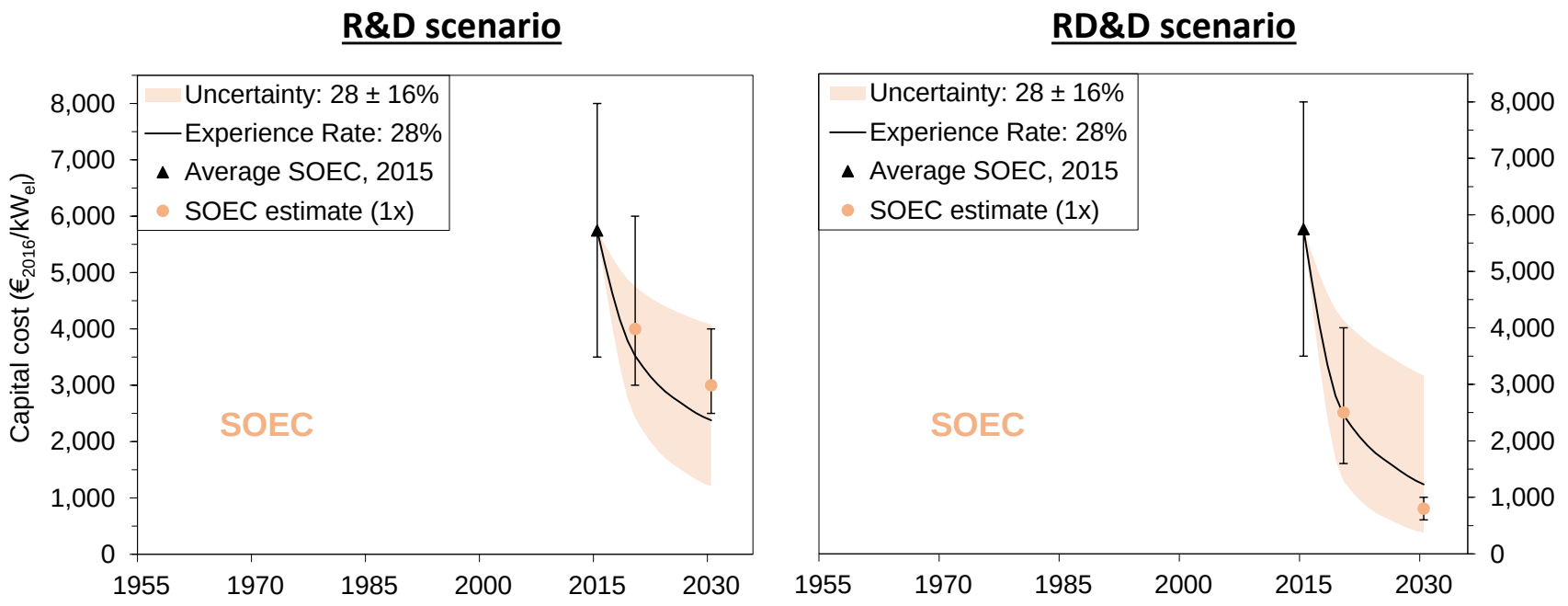
Experience curve comparison



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045

Expert estimates relative to experience curve based cost forecasts for SOEC

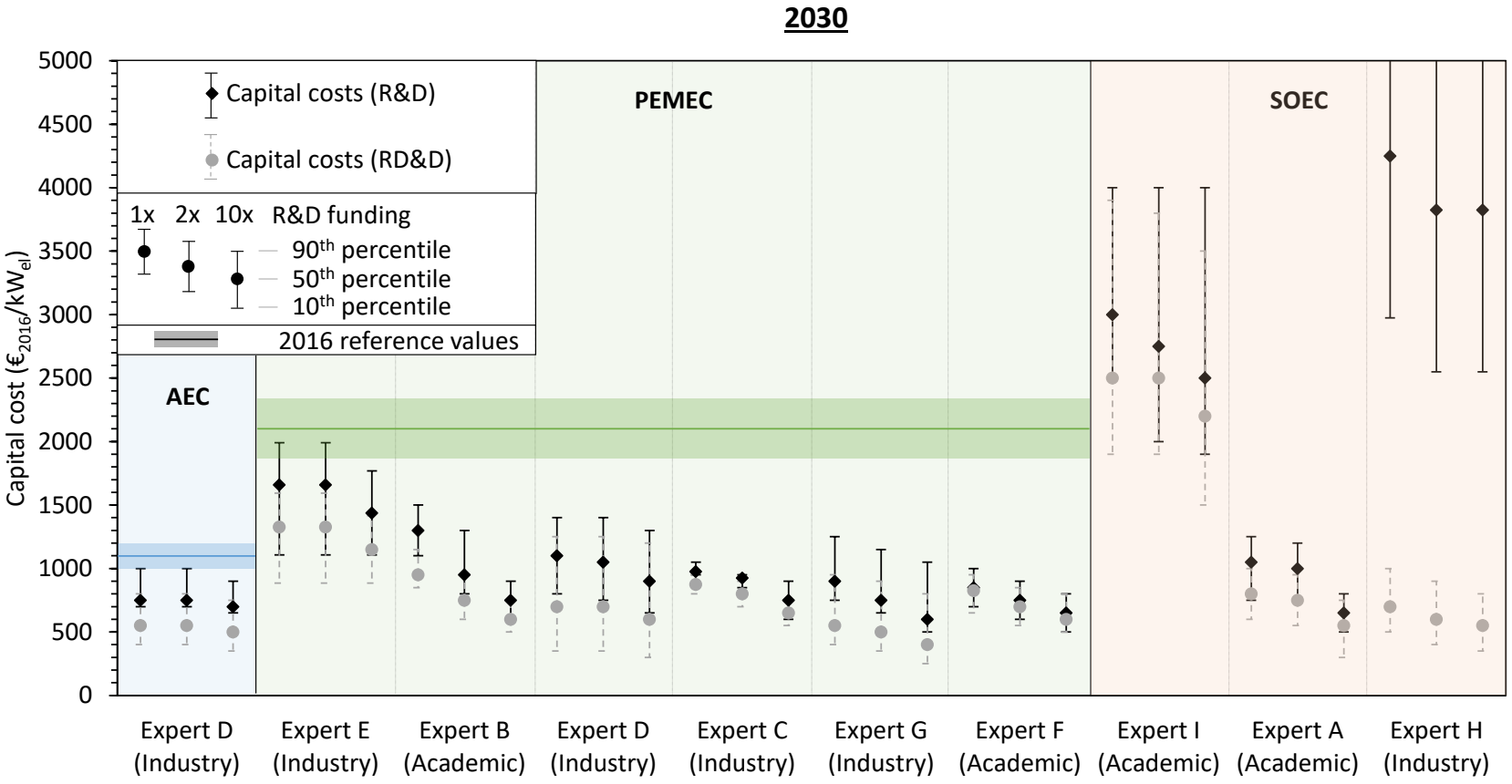
Experience curve comparison



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045

Capital cost - 2030

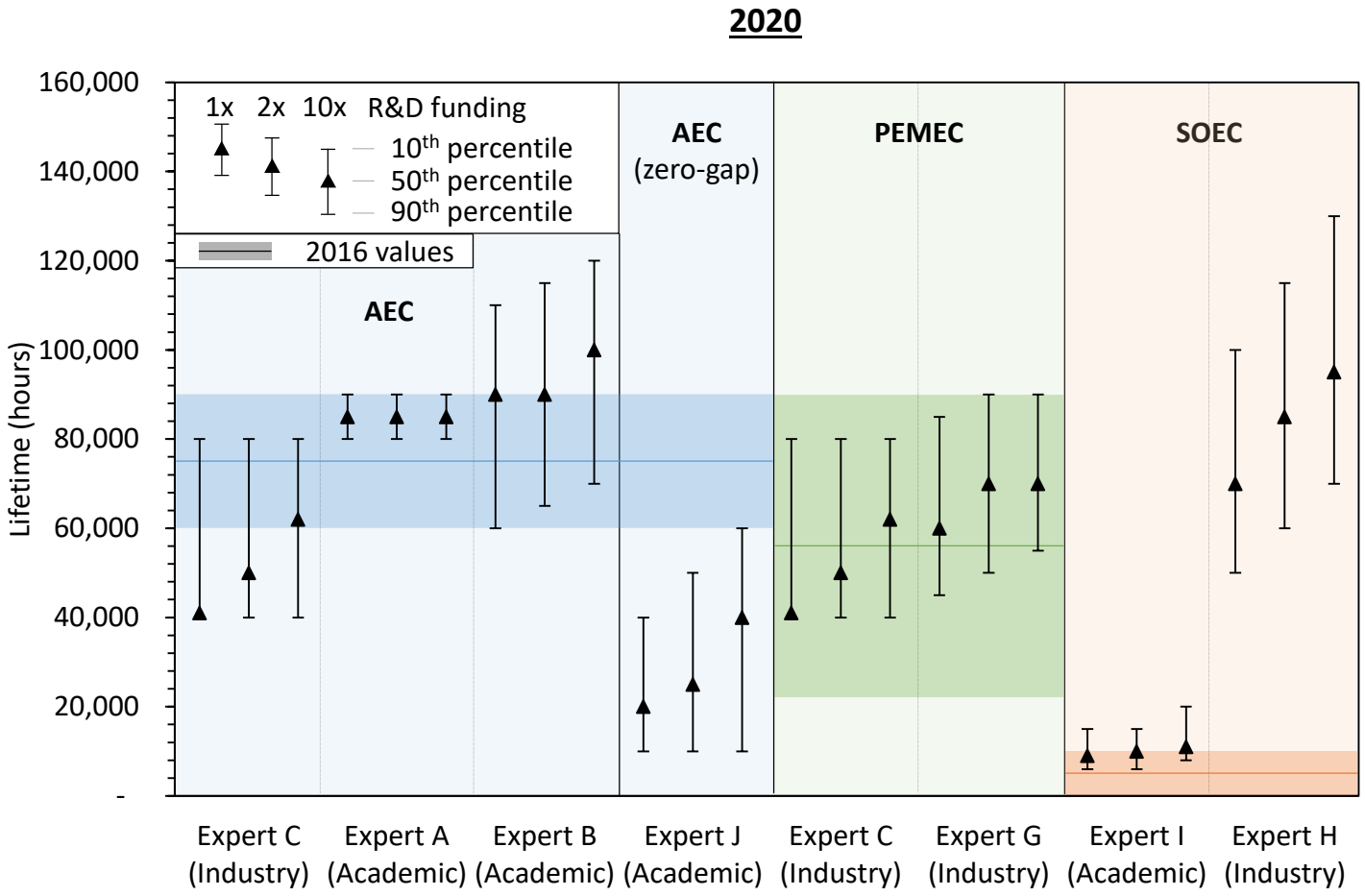
Elicited capital cost values



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045

Lifetime - 2020

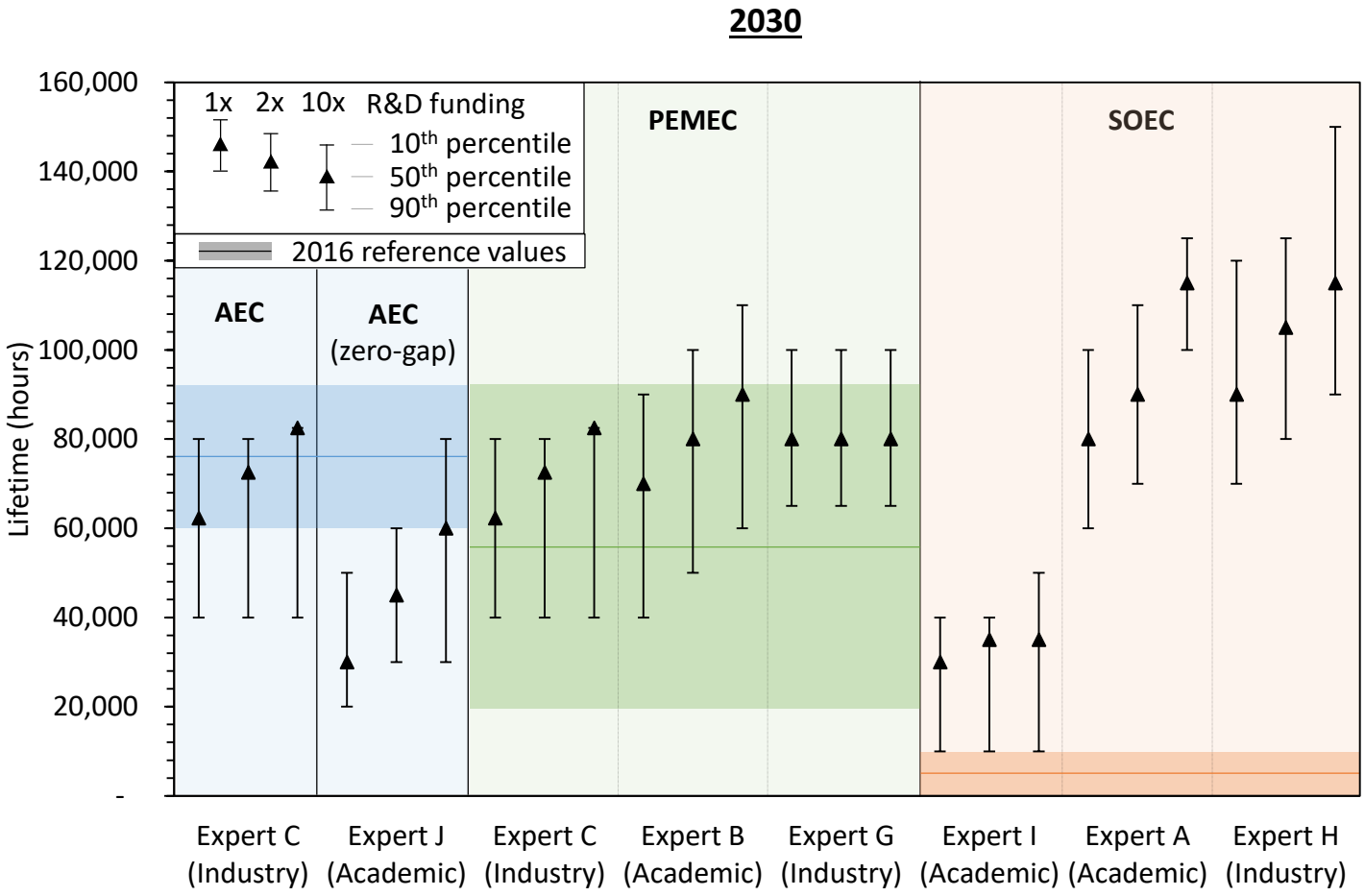
Lifetime



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045

Lifetime - 2030

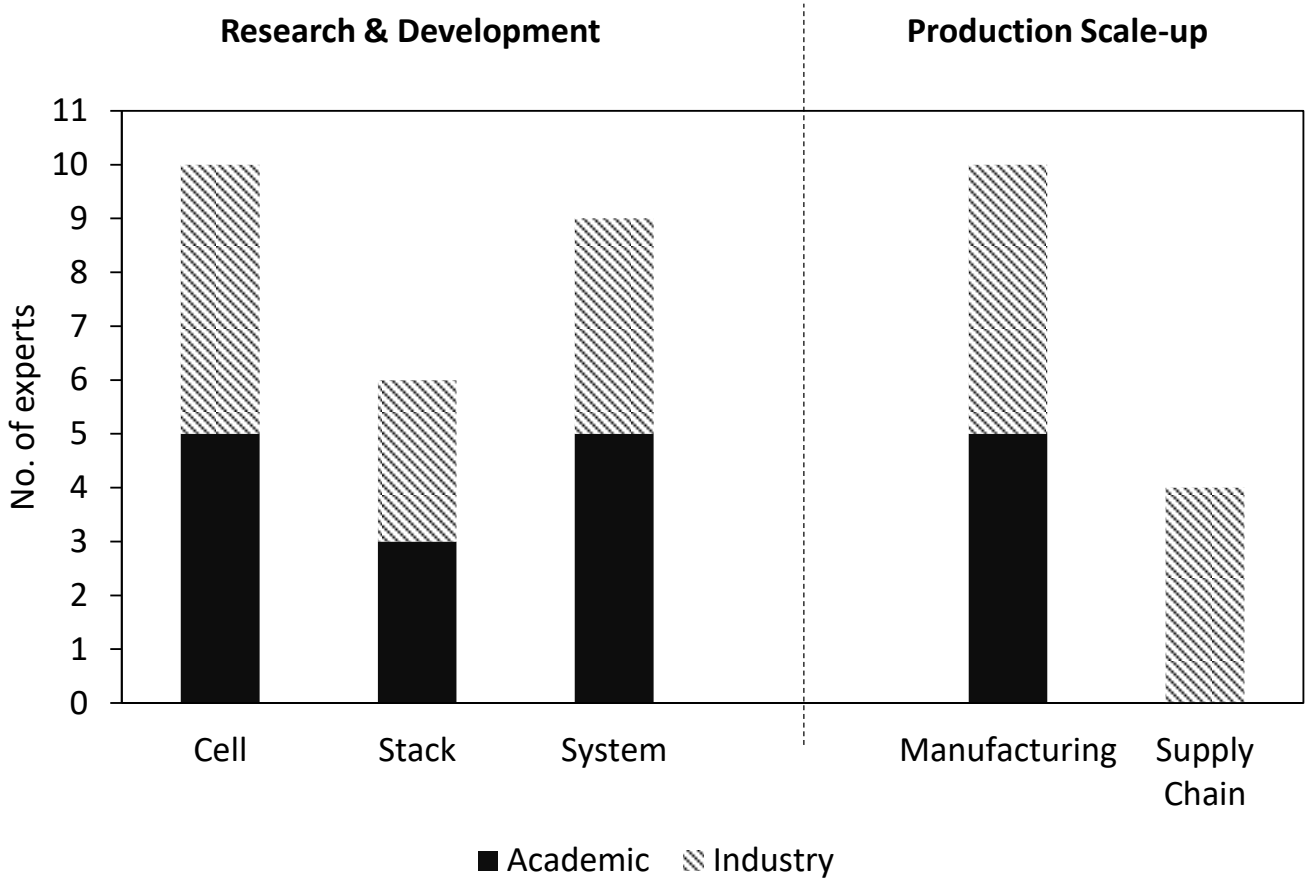
Lifetime



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045

Only industry experts considered innovations in the supply chain

Innovation categories mentioned



Source: Schmidt O, et al., Future cost and performance of water electrolysis: An expert elicitation study, International Journal of Hydrogen Energy (2017), https://doi.org/10.1016/j.ijhydene.2017.10.045