

Accelerating Green Hydrogen Production with Advanced Membrane Design

Dr. Simon Cleghorn

Senior Product Specialist
W. L. Gore & Associates

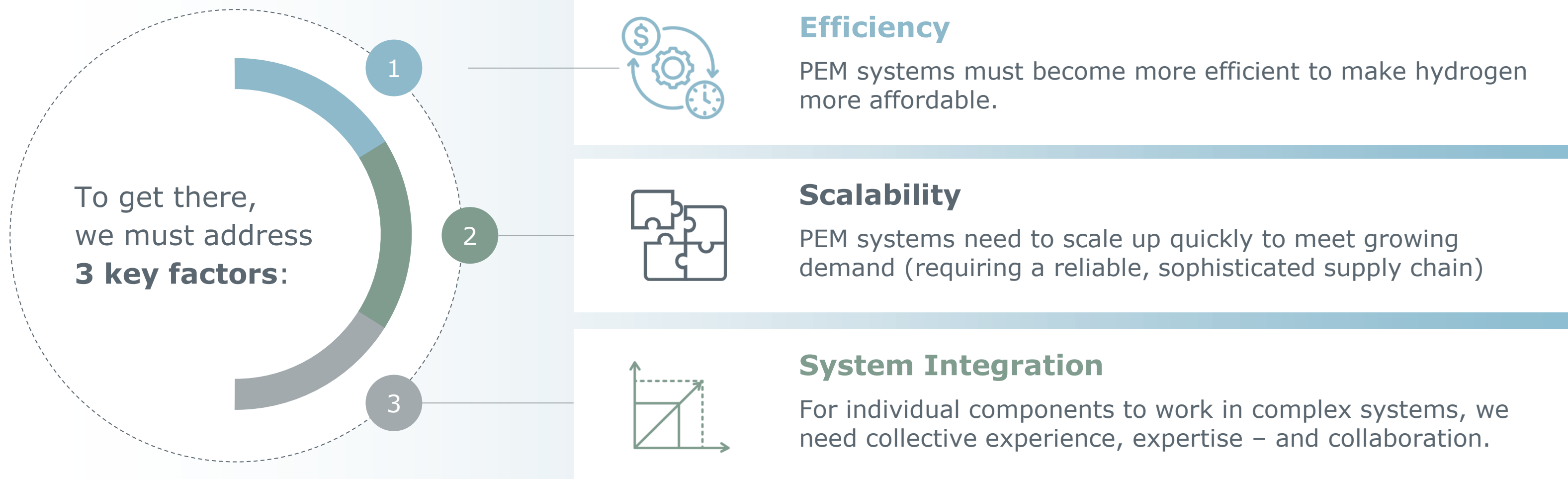
Together, improving life



Agenda: Three Pathways to Progress

Identifying — and overcoming — the challenges for green hydrogen production.

PEM Electrolysis is a viable production pathway to achieving decarbonization targets.

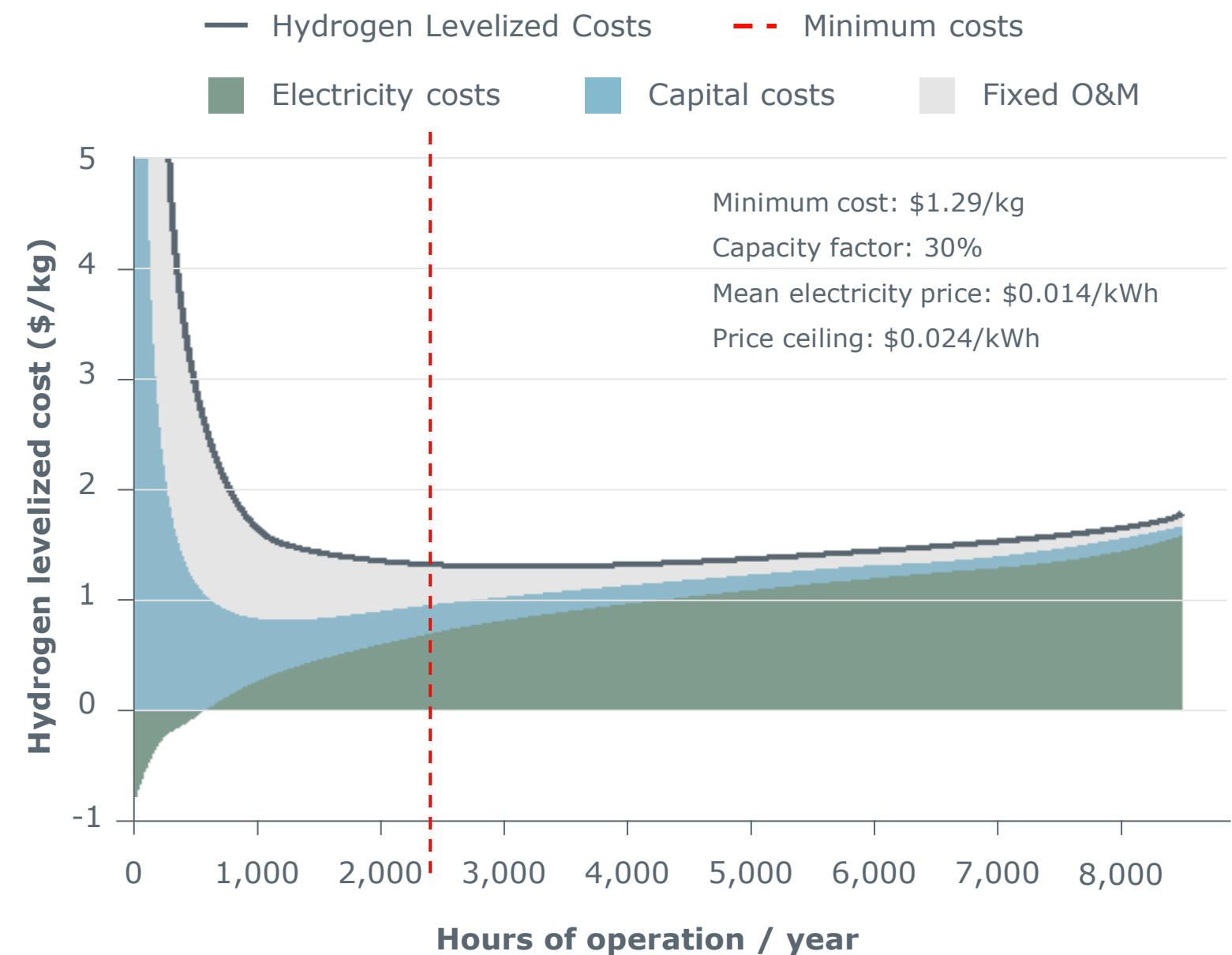


PEM SYSTEMS MUST
BECOME MORE **EFFICIENT**
TO MAKE HYDROGEN MORE
AFFORDABLE.



Reducing OPEX is key to delivering results

CAPEX is important. OPEX is **critical**.



NREL (2022), Operating strategies for dispatchable PEM electrolyzers that enable low-cost hydrogen production, Alex Badgett, Bryan Pivovar, Mark Ruth at the International Conference on Electrolysis 2021, Golden, Colorado, US

Massive industry scale-up will enable lower CAPEX via:

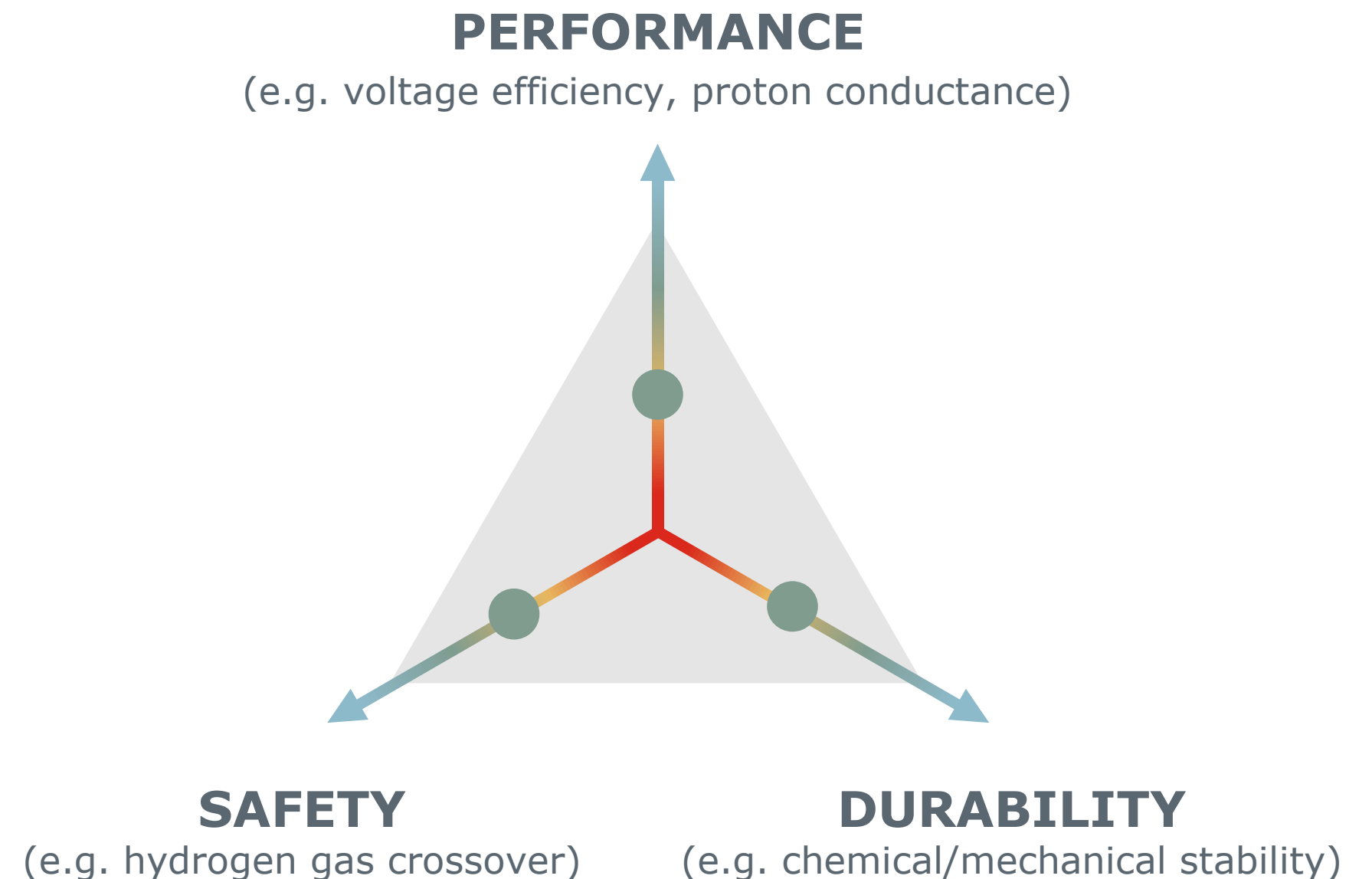
- Increased plant size & economies of scale.
- Optimized electrolyzer design & plant integration cost.

To scale up to meet net-zero demands,
OPEX is the deciding factor in delivering a lower levelized cost of hydrogen.

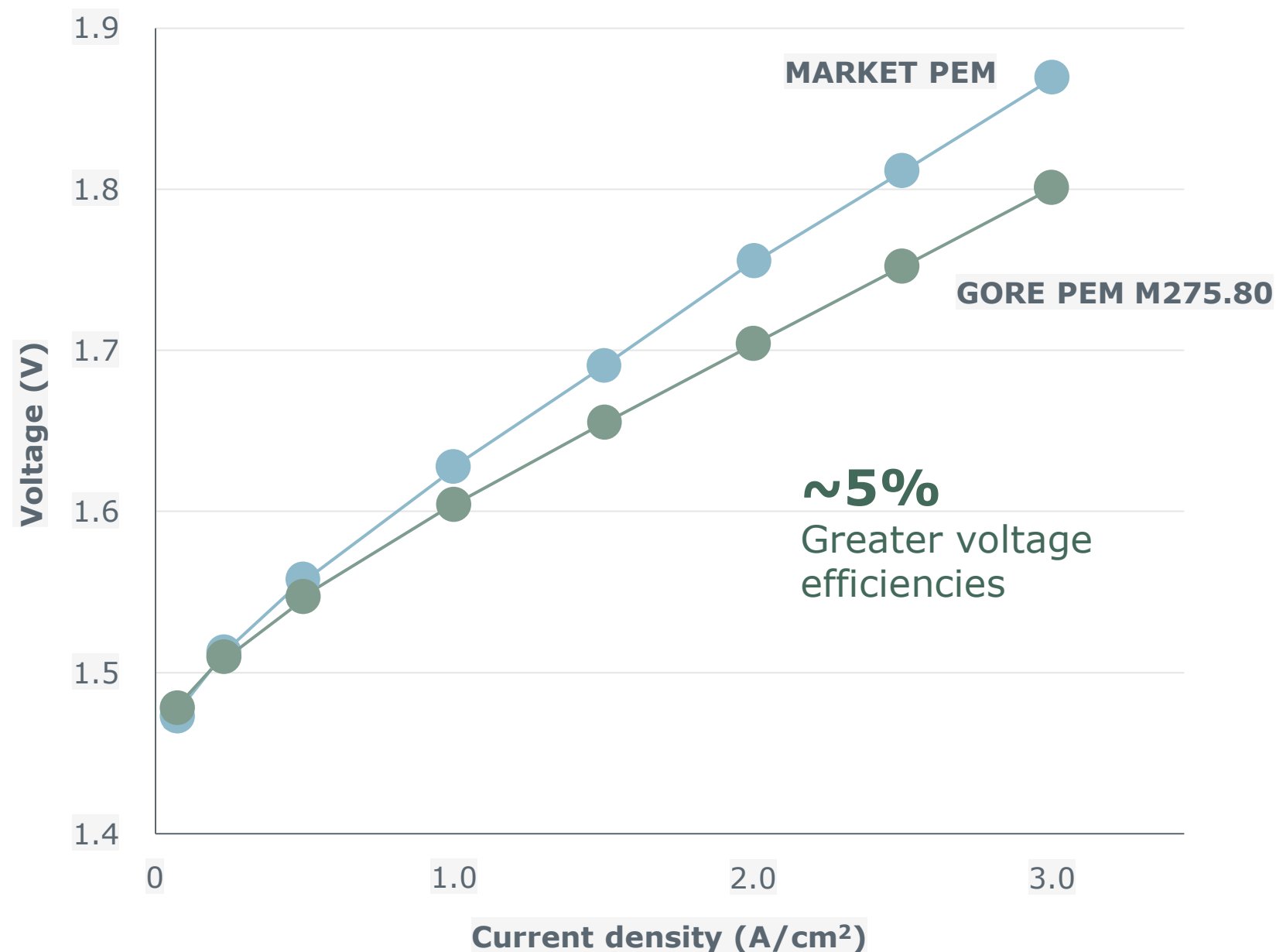
Tackling technology trade-offs to reduce OPEX

Why compromise – when you can optimize?

- Engineers typically face the 'system dilemma' of **optimizing performance, safety** and **durability**.
- Optimizing for 1 criteria has meant compromising on the others... until now.
- Gore has developed **an advanced PEM that can optimize them all – at the same time**.



Increased performance with Gore's PEM



- Gore's PEM M275.80 offers **~5% greater cell voltage efficiencies over other PEM** while meeting safety & durability requirements.
- This **reduces the amount of electricity required** to produce 1 kg of Hydrogen.
- A more efficient PEM enables a **smaller stack and a higher production of H₂**. Small stacks are important where space is premium/key.

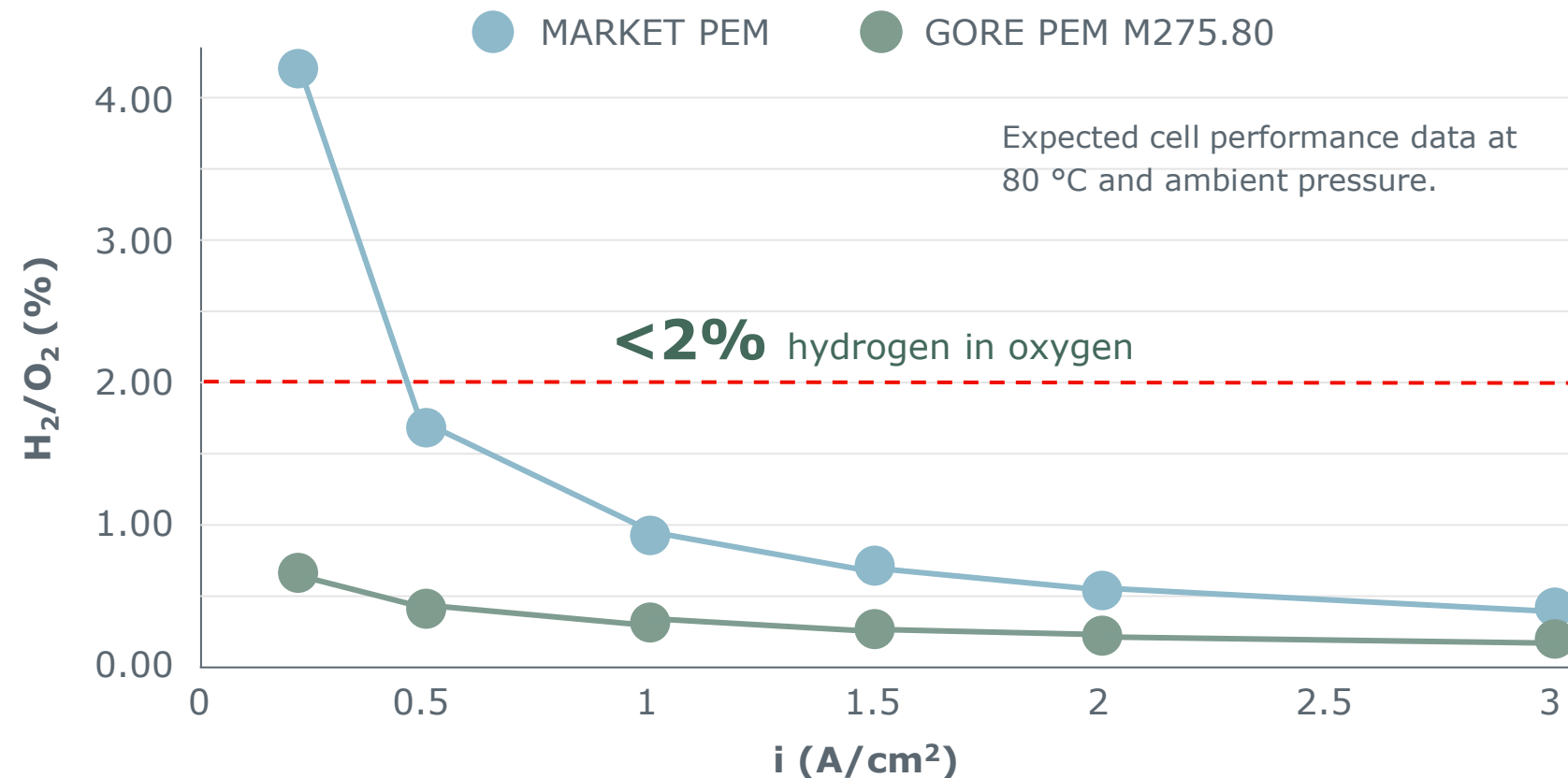
Increasing voltage efficiency enables **higher H₂ output for the same energy consumption** (or vice versa; less energy consumption for the same H₂ output)

How does Gore's PEM improve safety & durability?

Applying our materials science expertise to enable reliable and long-lasting WE systems.

SAFETY

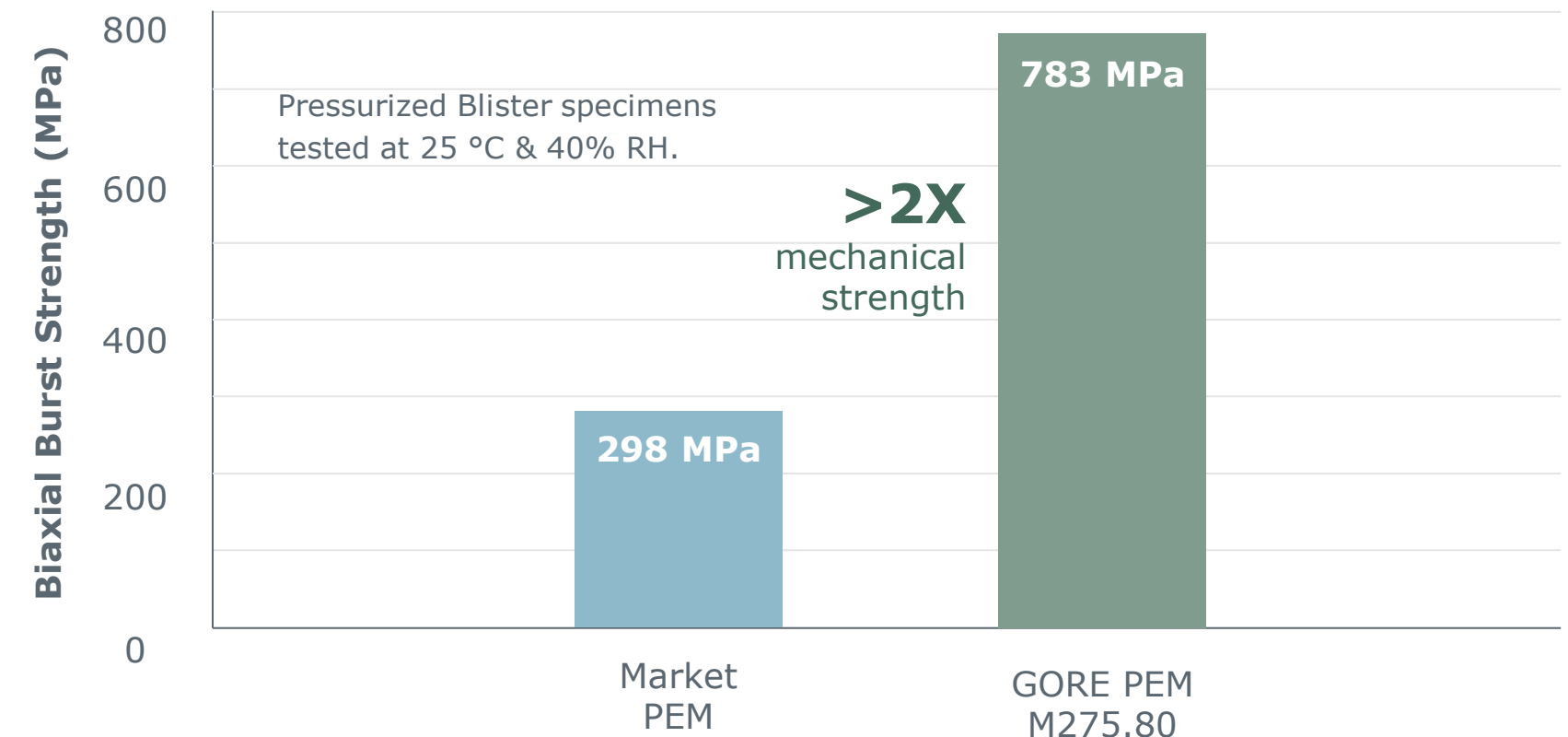
(e.g. hydrogen gas crossover)



- Gore's additive technology enables <2% hydrogen in oxygen concentrations over a wide operating range - even at low current densities.
- Wider Operation Range following load cycles results in longer uptime while staying below safety limits.

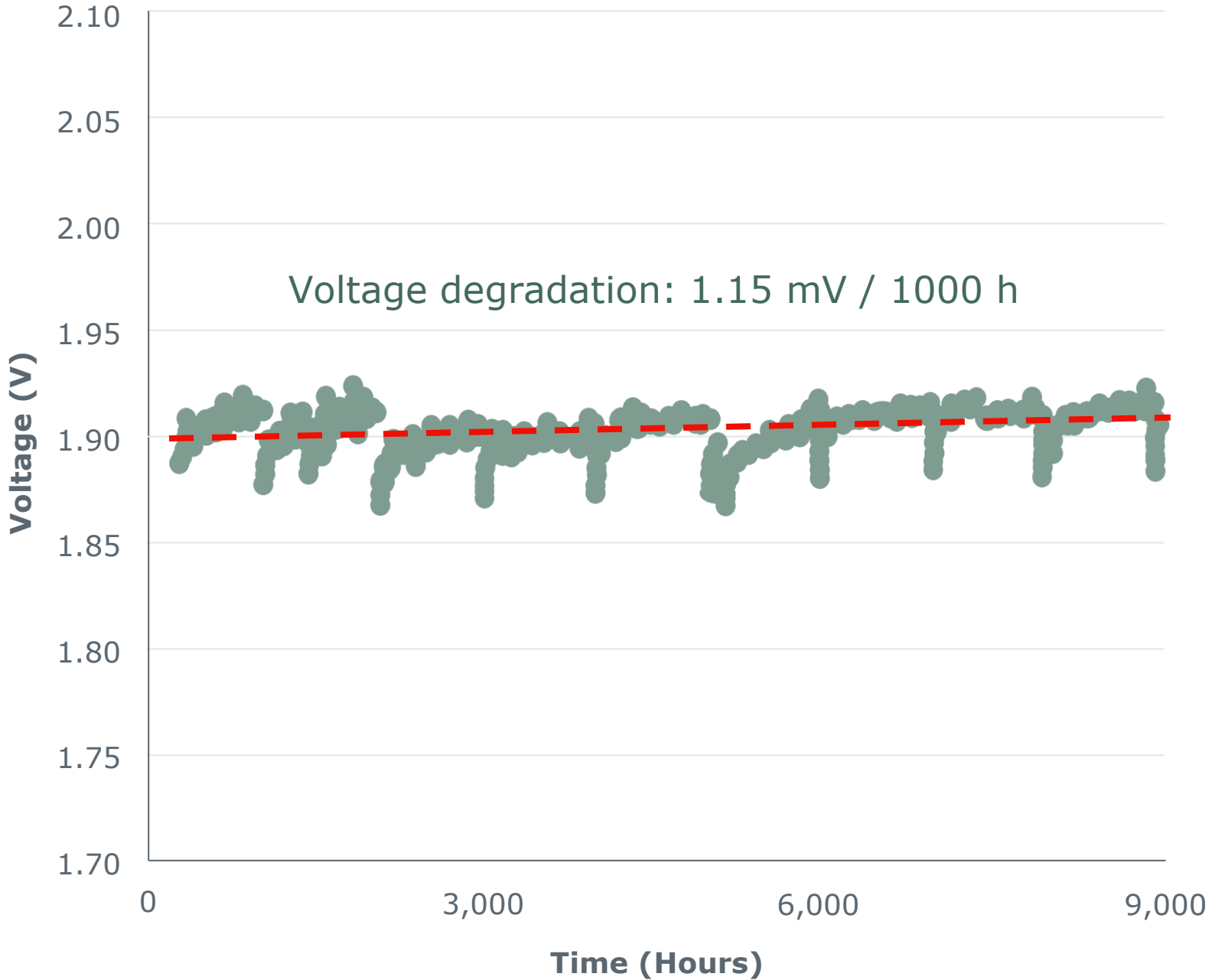
DURABILITY

(e.g. chemical/mechanical stability)



- This extends WE system durability and reduces service intervals for continuous operation.
- Higher mechanical durability enables long-life WE systems and reduces maintenance for longer system uptimes.

Demonstrating our PEM durability with ITM POWER



Data acquired & shared by ITM Power

- Durability testing of Gore’s PEM M275.80.
- Undertaken at ITM’s state-of-the-art test facility.
- Test performed under high current conditions (3.3 A/cm²) to maximize hydrogen production.
- Cell operation **>9,000 hours (and ongoing)**.

Test demonstrates **excellent membrane durability and <1% voltage degradation** (over the 9,000 hours test duration)

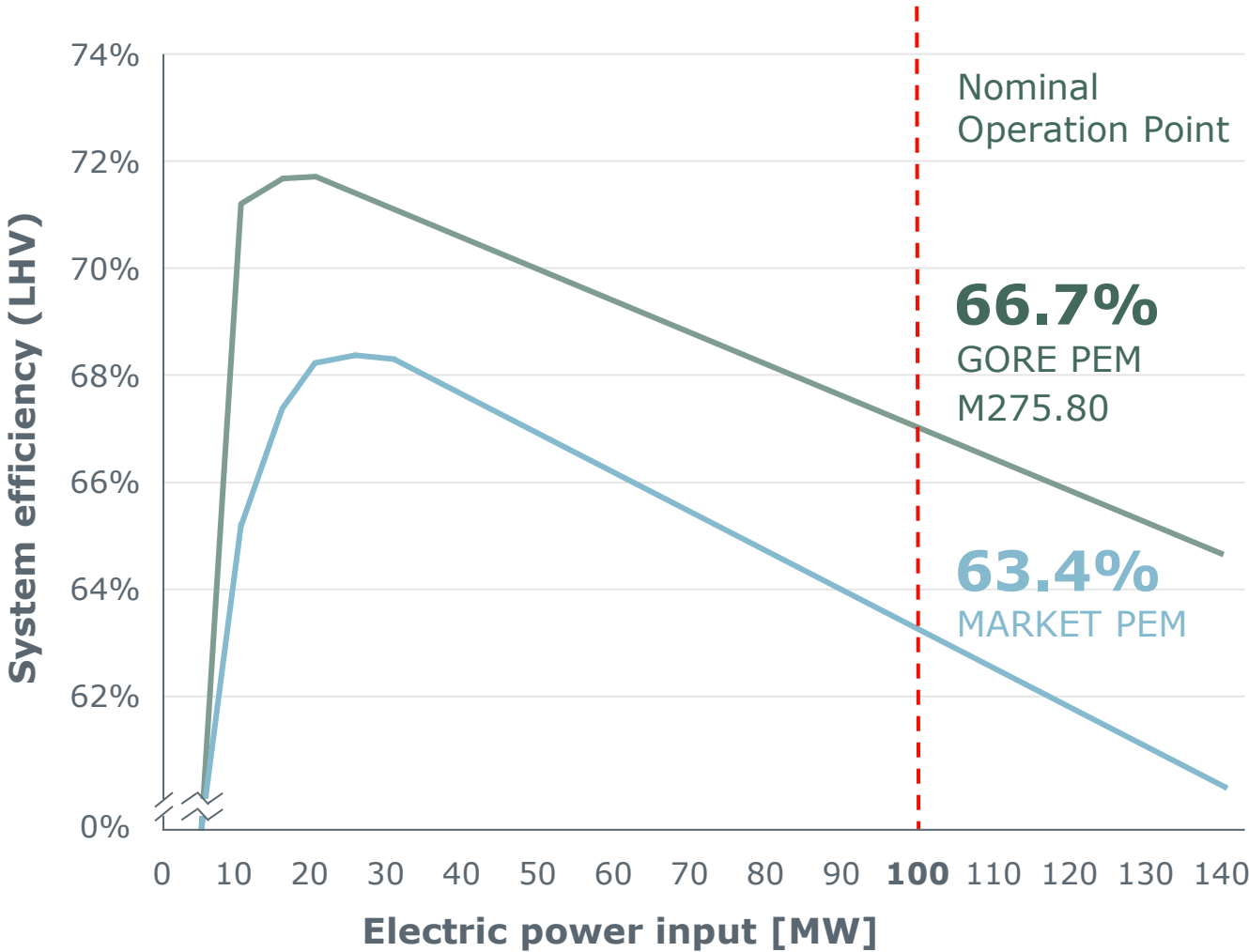
Achieving better efficiency and LCOH with Gore's PEM

Electrolyzer simulation for off-shore wind park

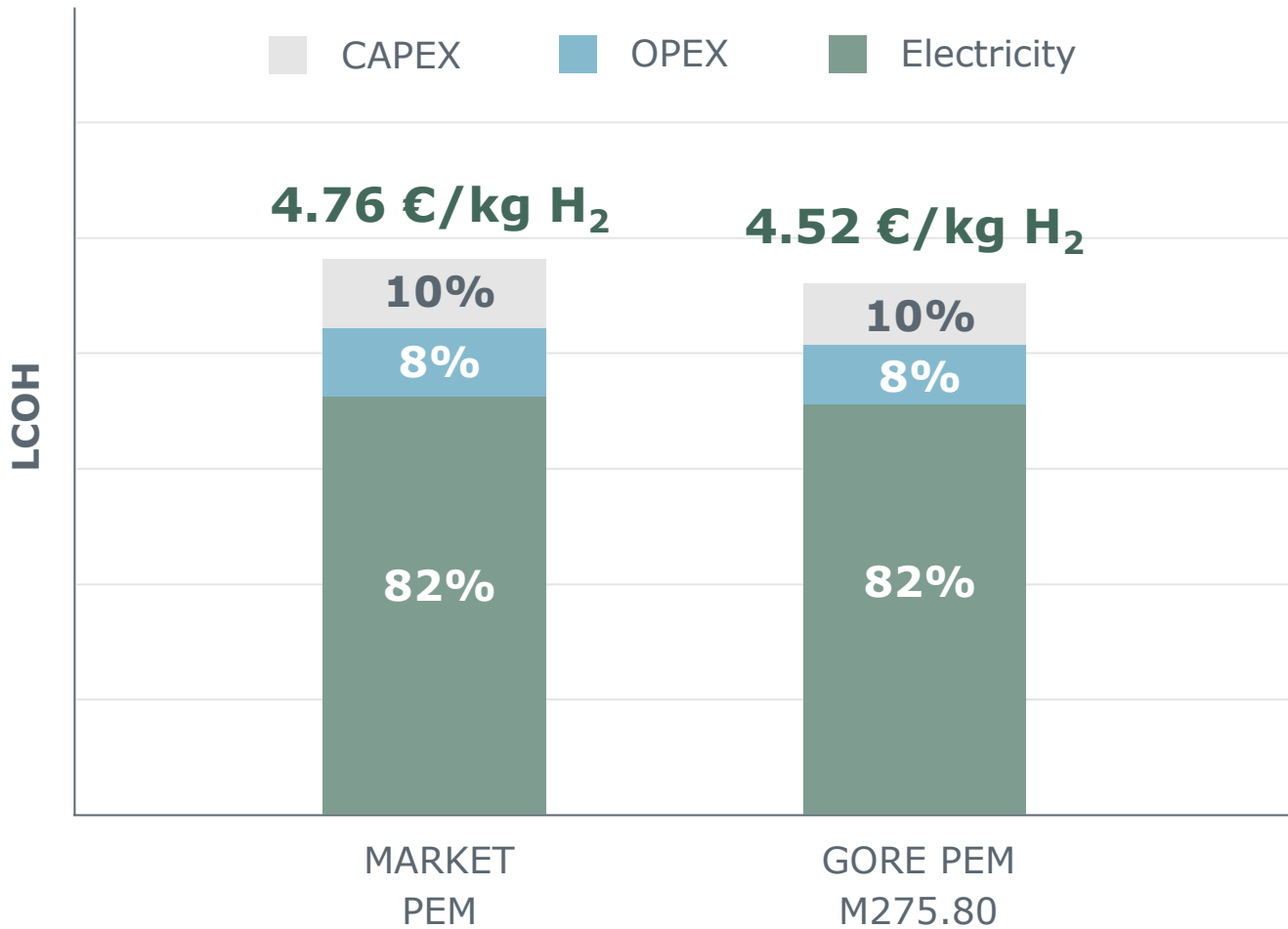


Off-Shore use case

- Wind Park: 200 MW
- Electrolyser: 100 MW
- H₂ output @ 30 bar
- Off-shore typical load profile
- FLH: ~5,600 hrs.



- Highest system efficiency is enabled with Gore PEM M275.80 – not only at nominal power but also in part load.



- System efficiency is crucial – electricity expenditures account for over 80% of the LCOH
- Gore membrane demonstrates **clear LCOH advantage** over Market PEM

Breaking performance barriers with Gore's high-performance PEM

Reducing system trade-offs with our advanced membrane technology.

Ionomer

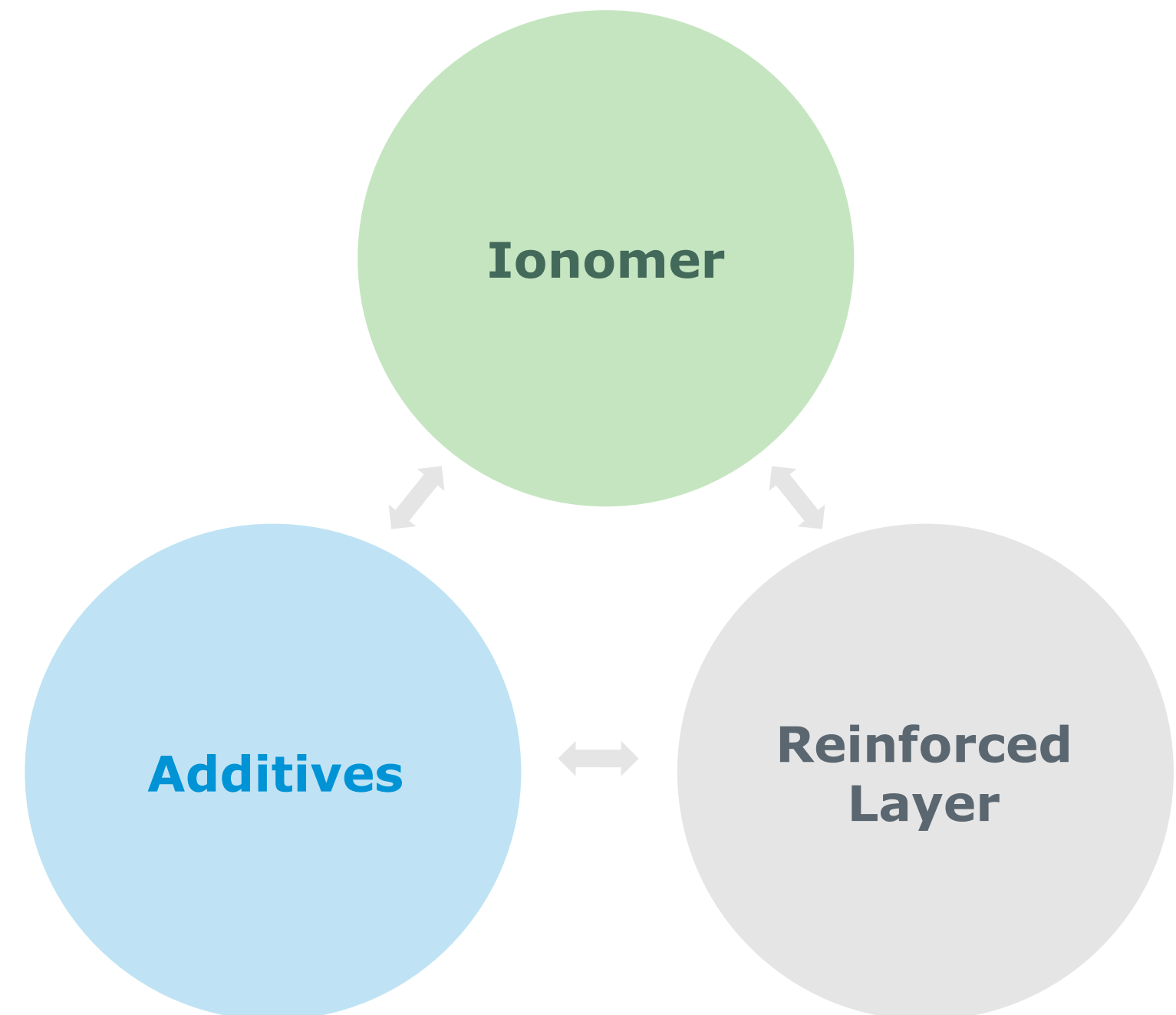
- High proton conductivity + high voltage efficiency for **increased performance**

Additives

- Greater chemical durability + reduced H₂ crossover for **increased durability and safety**

Reinforced Layer

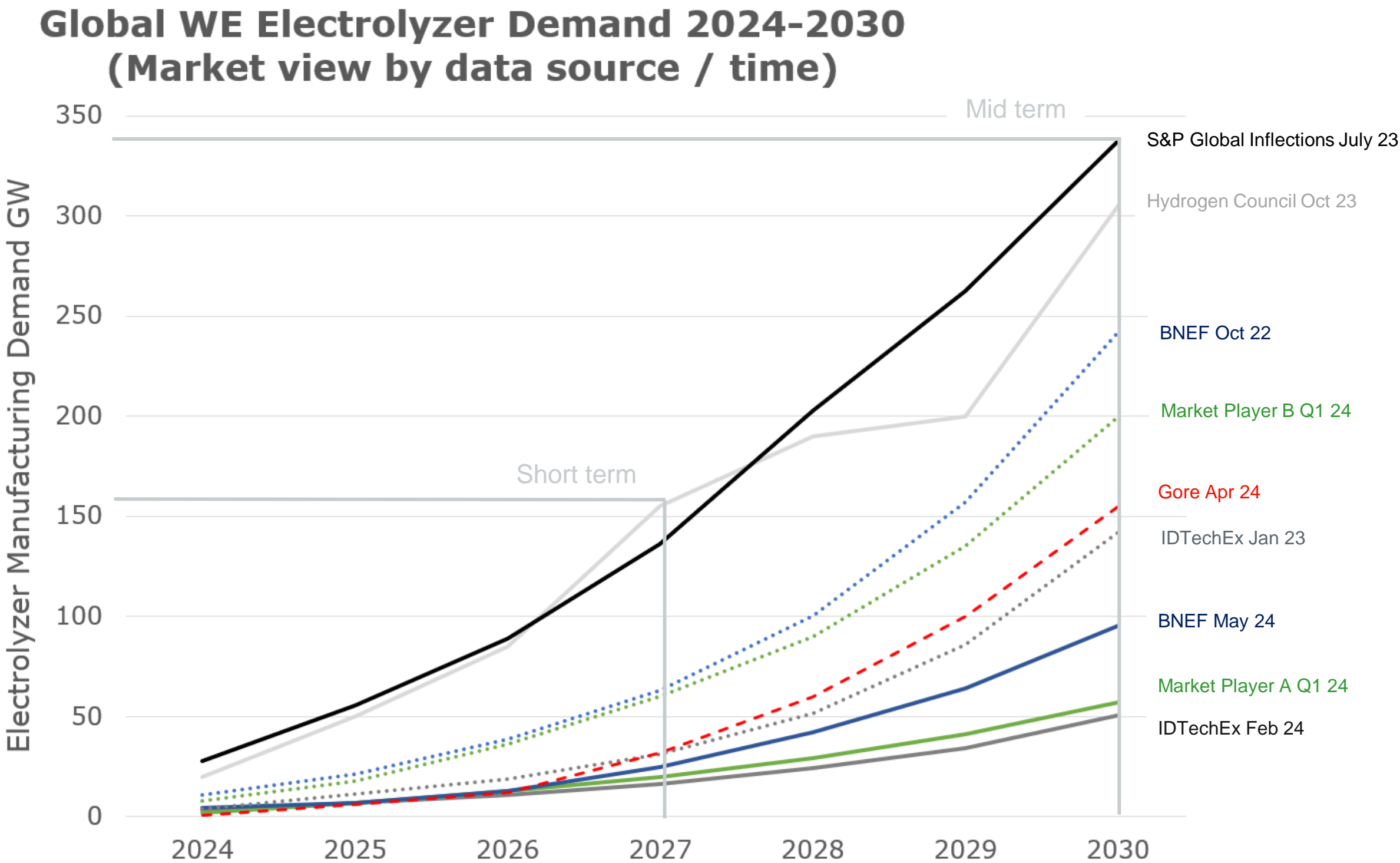
- Enabling thin, highly conductive, mechanically + chemically durable membranes for **increased durability and performance**



PEM SYSTEMS NEED TO
SCALE UP QUICKLY TO
MEET GROWING DEMAND,
REQUIRING A RELIABLE,
SOPHISTICATED
SUPPLY CHAIN.



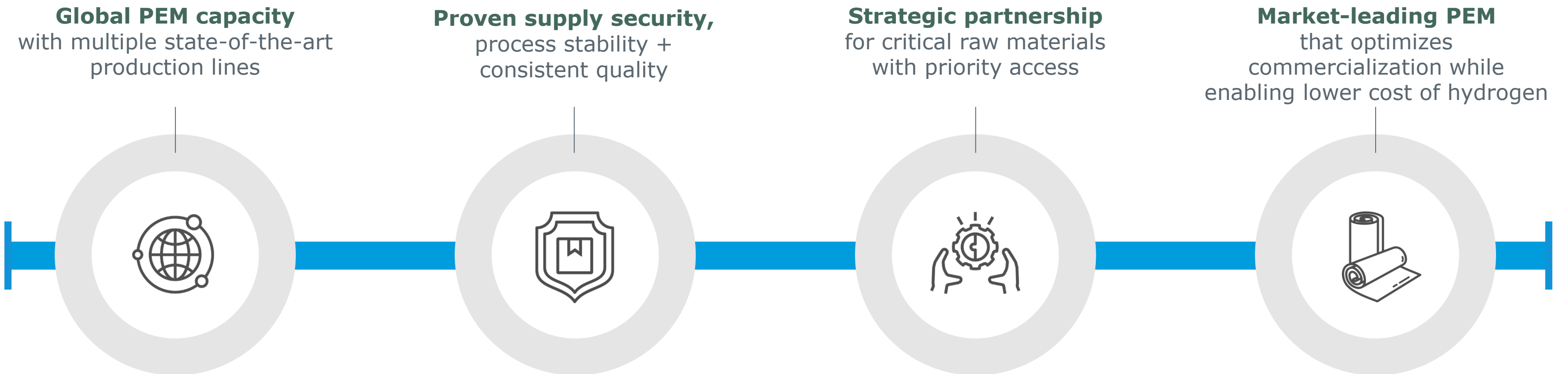
Next decade will see significant Green H₂ growth. Global water electrolyzer manufacturing has to scale to meet market demand



- Rate of market growth is uncertain
- As a critical component supplier Gore is uniquely positioned in the value chain
- Gore is investing to develop our own market perspective to ensure we are ready to meet future demand

Applying our fuel cell expertise to water electrolysis

Overcoming challenges and reducing risks in an uncertain environment.



Gore's established enterprise resources are set up to support **Multi-Gigawatt installations TODAY.**

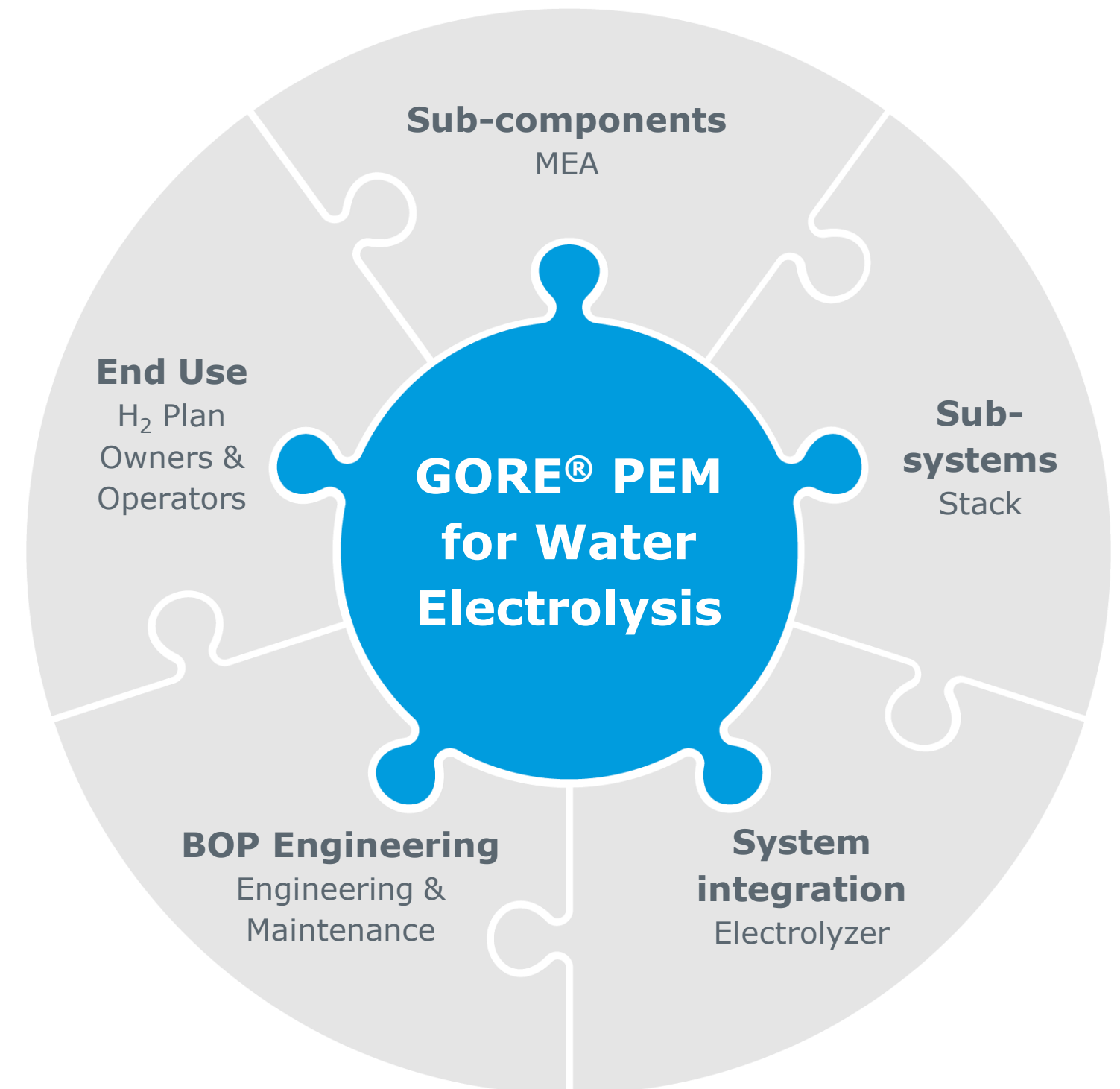
FOR INDIVIDUAL COMPONENTS
TO WORK IN COMPLEX SYSTEMS,
WE NEED COLLECTIVE
EXPERIENCE, EXPERTISE –
AND **COLLABORATION.**



Even an advanced membrane can't do it alone ...

- A new and complex technology presents new and complex challenges.
- Different stakeholders in the supply chain may have competing requirements.
- The solution? **Collaboration.**

Interdependent components require orchestration. Our collective expertise and experience can solve component integration challenges!



Creating the clean energy future – together.



- We have developed a "multi-use" membrane for broad application in Water Electrolysis ...
- ... and with the right partners, we can develop tailored WE membranes for different systems + requirements.



WE OFFER

1. 25 years' membrane technology & electrochemical expertise
2. Global analytical capabilities and prototyping facilities
3. Proven, reliable and secure supply

WE'RE LOOKING TO

1. Expand our fundamental understanding on PEM fitness-for-use in Water Electrolysis systems
2. Increase our technical insights on system performance and component interactions
3. Align on future development vectors and product roadmaps

In Summary - We can achieve our carbon targets
– if we collaborate

EFFICIENCY. SCALABILITY. SYSTEM INTEGRATION.

- ✓ WE systems must become more **efficient** to make hydrogen more affordable – enabled through Gore's **highly conductive and durable PEM**.
- ✓ For individual components to work in complex systems, we need **collective experience and expertise** – enabled by **effective collaboration**.
- ✓ WE PEM systems need to **scale up quickly** to meet growing demand – enabled through Gore's already established **high volume capacity and proven supply security**.

LET'S NOT WAIT TO CREATE A CLEAN ENERGY FUTURE.
PEM TECHNOLOGY IS **AVAILABLE AT SCALE TODAY**.



DOWNLOAD YOUR DIGITAL COPY.

Simply scan the QR code to access
this presentation online.

THANK YOU.

Contact our Clean Energy team to learn more about the new

GORE® PEM for Water Electrolysis.

gore.com/alt-energy

Together, improving life

