

ACCELERATING GREEN HYDROGEN PRODUCTION WHILE MANAGING FINANCIAL RISKS

Why choosing the right supplier and PEM materials matters in WE system design.

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Global Head of PEM Water Electrolysis
W. L. Gore & Associates GmbH

Together, improving life



Agenda

1.0

Addressing operational challenges and investment risks for green hydrogen production

2.0

Making PEM systems more efficient

3.0

Scaling PEM systems demands a reliable supply chain

4.0

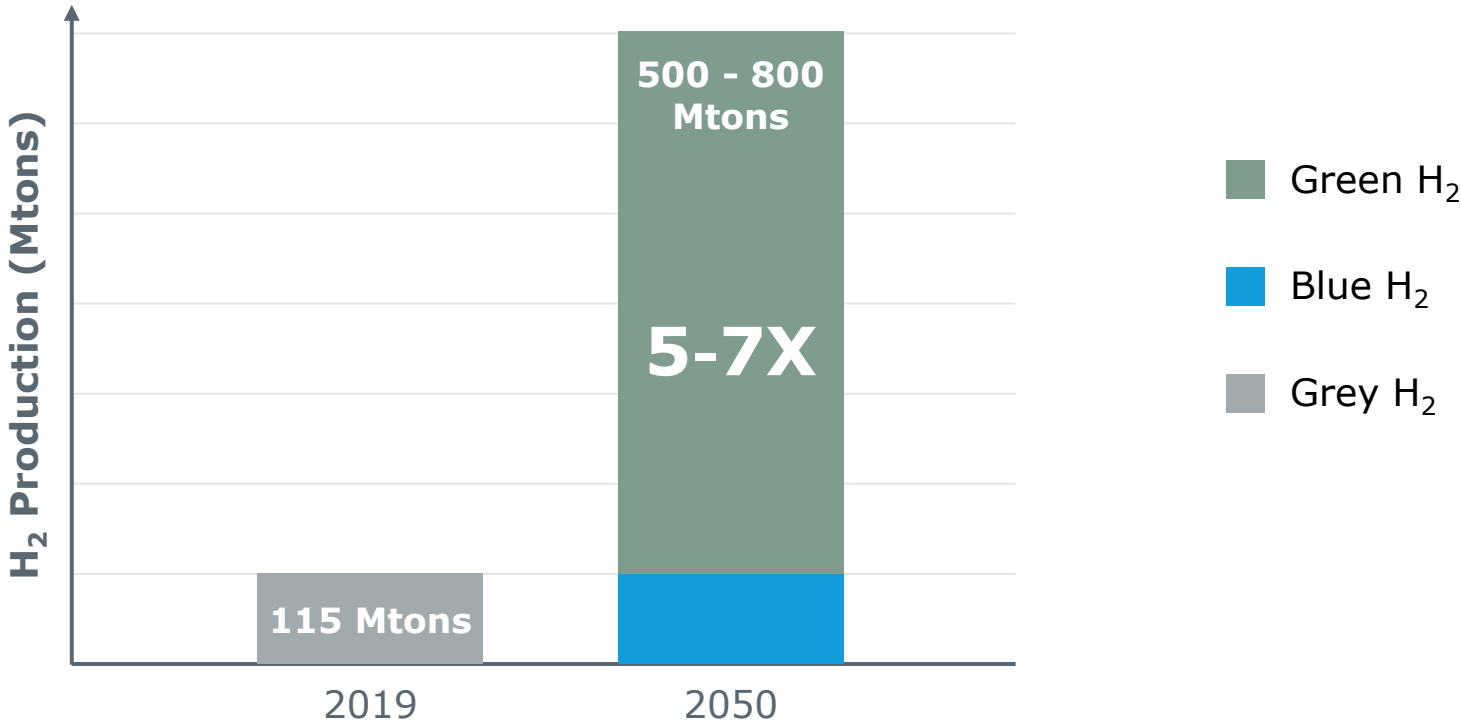
Collaboration is key for complex systems to work



The clean hydrogen industry has made great progress - and must go much further.

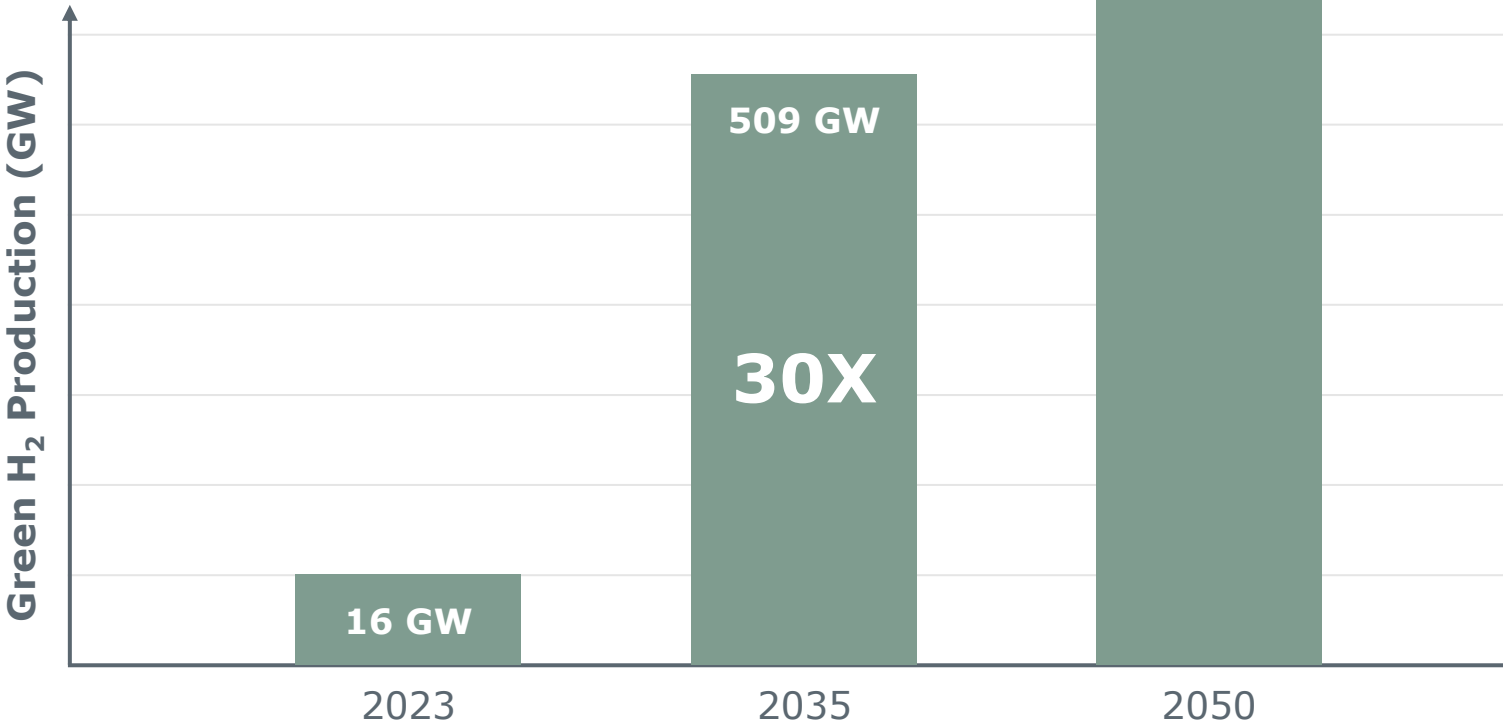
ULTIMATE GOAL

Total Hydrogen production scale-up required



Energy Transitions Commission (2021), Making the Hydrogen Economy Possible: Accelerating Clean Hydrogen in an Electrified Economy, Version 1.2

Green Hydrogen production scale-up required



IHS/S&P Global estimates from July 2023

We need to scale now, and we need to manage risk.

“Large infrastructure projects suffer from significant undermanagement of risk in practically all stages of the value chain ... destroying a significant share of their value.”

McKinsey Report

A risk-management approach to a successful infrastructure project



Entering new markets is expensive – and risky

Being a 'First Mover' in an emerging sector presents many financial and operational challenges.



What are the biggest risks of failures for investors in infrastructure projects like hydrogen plants?



1. **Technical Complexity:** Hydrogen plants are complex environments; inadequate engineering and design presents operational challenges
2. **Cost Overruns:** Initial cost estimates may underestimate construction and operational expenses, straining project finances
3. **Supply Chain Issues:** Delays in procuring necessary materials, equipment, or skilled labor can increase production costs
4. **Technological Challenges:** Developing and implementing new hydrogen production technologies can slow down progress and ramp up expenditure
5. **Financing Issues:** Securing sufficient funding can be a challenge for next-generation projects using new technologies with higher associated risks
6. **Lack of Expertise:** Insufficient experience or technical and commercial expertise within project teams can lead to delays and higher costs

Send a message

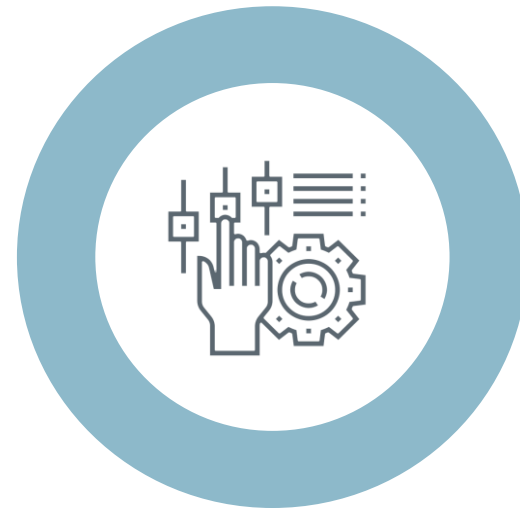


Managing risks with the right partner

Sustainable success takes more than a supplier – it needs a team.

Technical Complexity

A manufacturer and supplier with global industry experience and the capabilities to overcome challenges along the value chain



Technological Challenges + Lack of Expertise

A trusted technology partner who understands development dilemmas and system trade-offs

Cost Overruns + Supply Chain Issues

A stable and capable supply chain to deliver a reliable supply of quality material at high volume



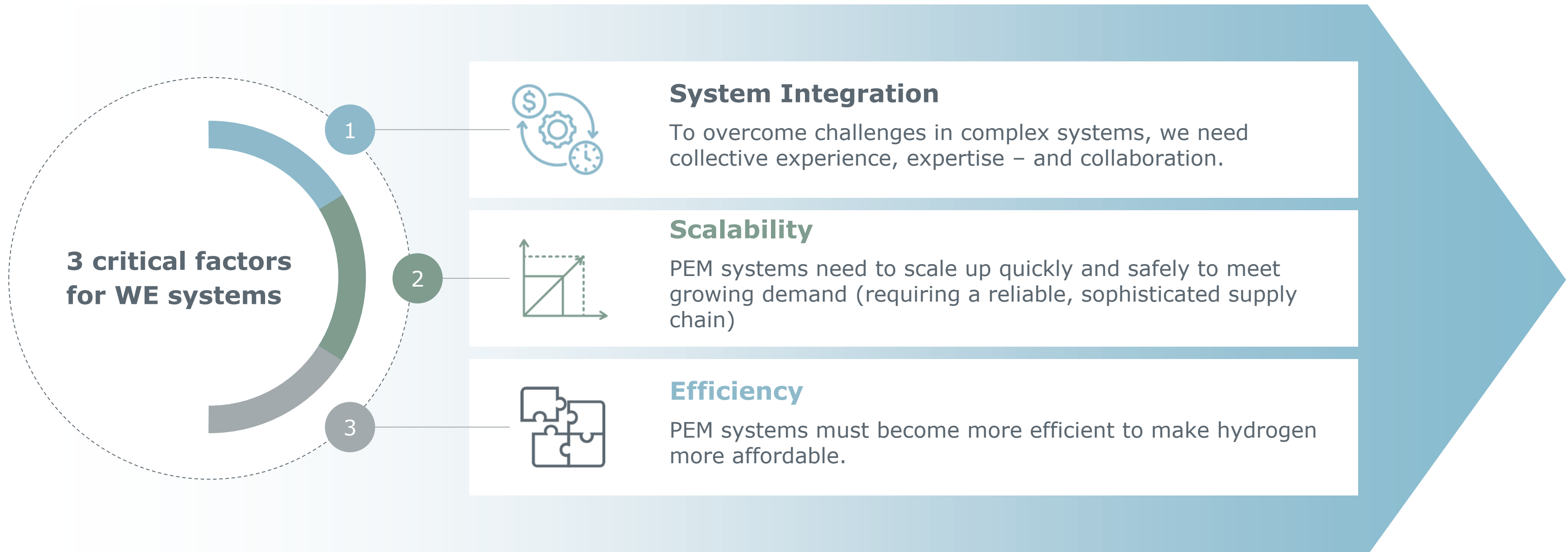
Financing Issues

A well-established and financially stable partner with a proven track record of commitment to clean energy technology

There are other factors like the regulatory environment and geopolitical landscape that we cannot control ...
but there are several ways to manage costs and risks.

PEM Electrolysis is a viable green hydrogen production pathway if we address development challenges

Gore has identified 3 key areas for commercializing this complex new technology.



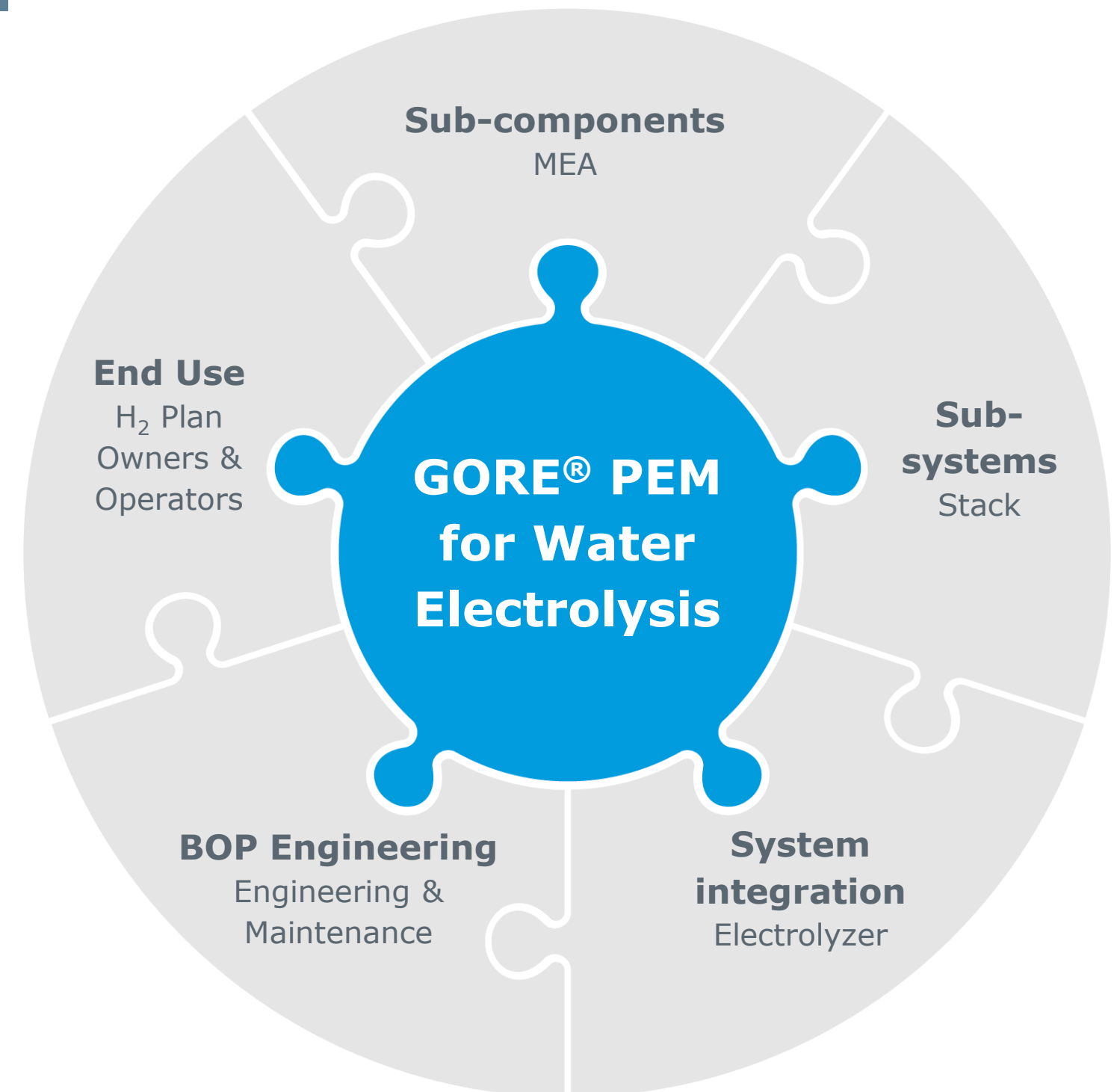
TO EFFECTIVELY MANAGE RISK IN
COMPLEX SYSTEMS,
WE NEED COLLECTIVE
EXPERIENCE, EXPERTISE –
AND **COLLABORATION.**



Many individual components. One collective goal: lowering risk.

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

When it comes to inherent risks in supporting new PEM technologies, **choosing the right partner is critical to ensuring short-term and long-term success.**

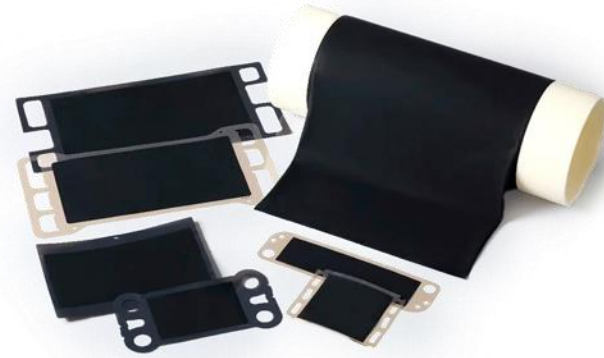


PEM SYSTEMS NEED TO
SCALE UP QUICKLY TO
MEET GROWING DEMAND,
REQUIRING A RELIABLE,
SOPHISTICATED
SUPPLY CHAIN.



Leveraging our world-leading fuel cell legacy

Offering an established platform as a trusted partner.



Millions

Of square metres
of PEM & MEA

Our established **process stability and supply security** produces a reliable and high volume of high-quality materials.



> 60,000

Fuel cell vehicles
powered

Our quality consistency delivers a uniform product that **reduces risk of failure & quality defects**, enabling higher process yields.



Toyota Project Award Technology Section

GORE-SELECT® Membrane is incorporated into the 1st & 2nd-generation Toyota MIRAI.

We are a **trusted long-term technology partner** to key global OEMs with our PEM supply **fully integrated into global commercial FCEV production.**



> 100

Different
models
developed

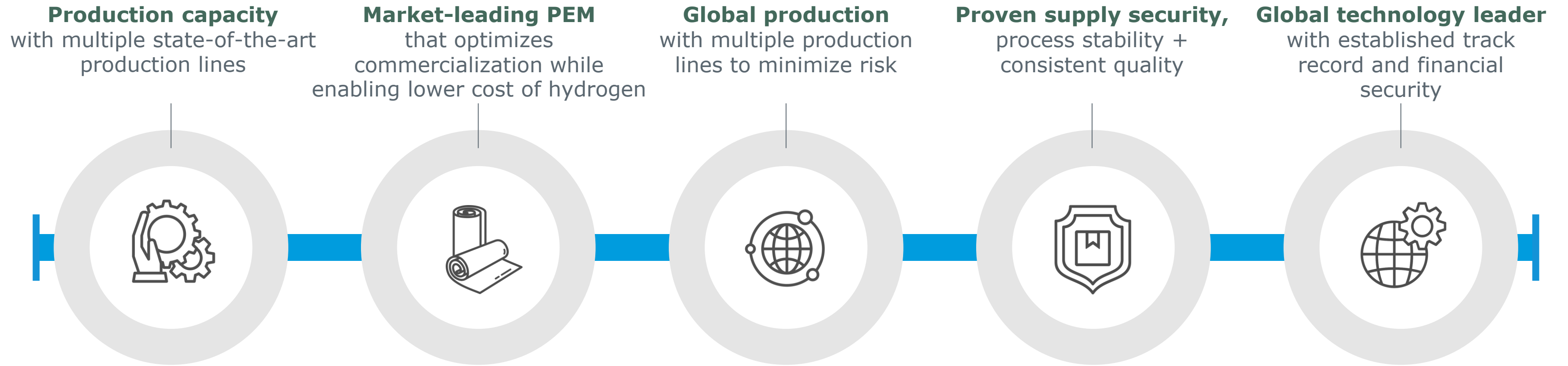


Powering
Hyundai's
NEXO Fuel Cell
EV SUV

Our R&D expertise and broad application & process knowledge helps **mitigate risks and provide operational stability.**

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.**

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



“More affordable” requires balancing various factors

Hydrogen production costs depend on **site-specific** and **technology-specific** drivers.

Achieving greater efficiency requires **improving both**:



Reducing OPEX is the key to delivering results

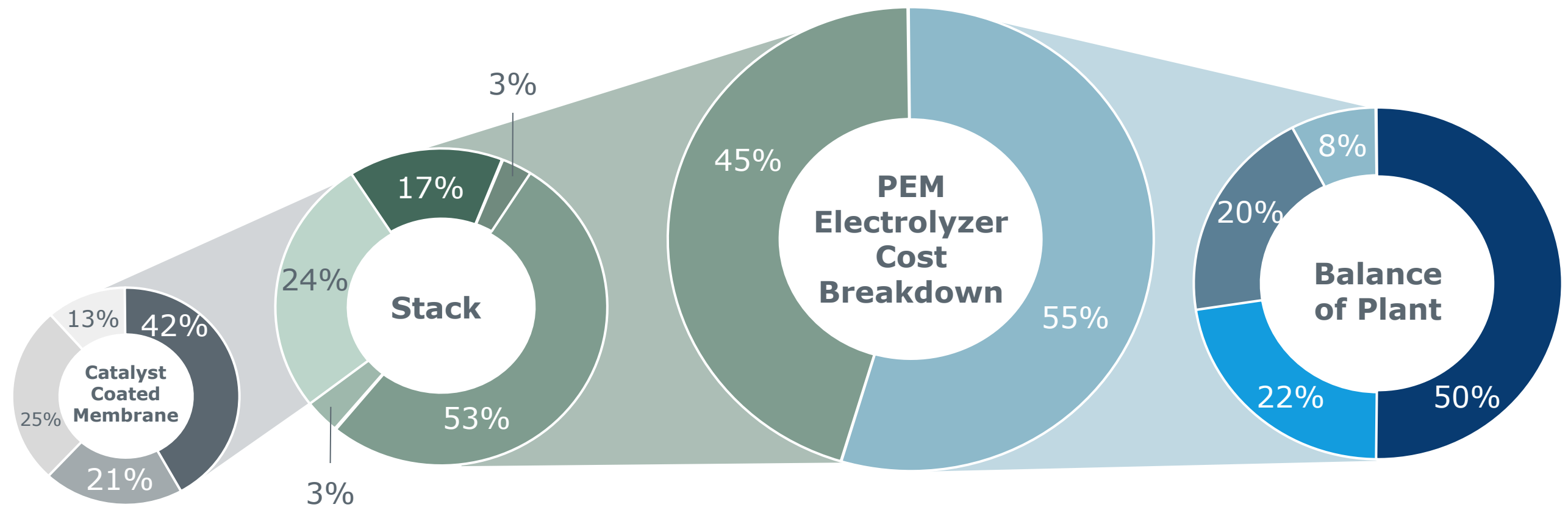
CAPEX is important. OPEX is critical.

TOTAL SYSTEM COST BREAKDOWN

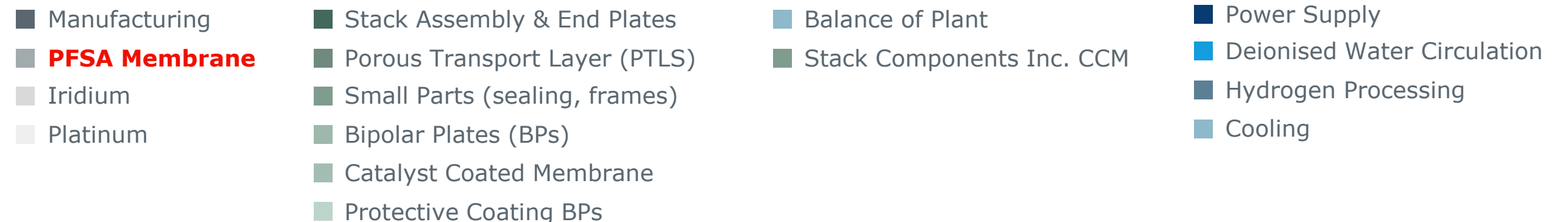
OPEX Costs

Massive industry scale-up will enable lower CAPEX via:

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



IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5 °C Climate Goal, International Renewable Energy Agency, Abu Dhabi.

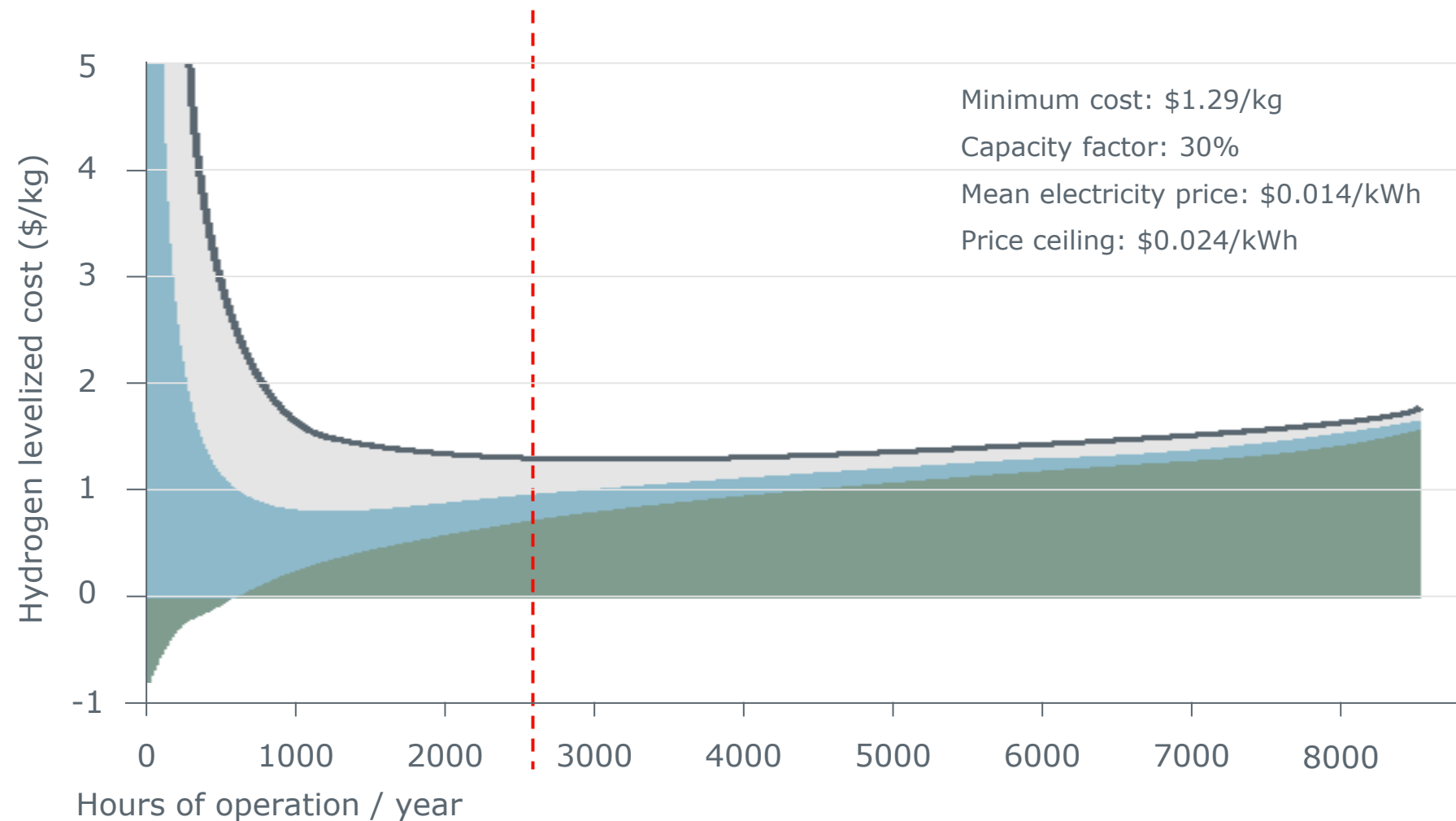


Reducing OPEX is the key to delivering results

CAPEX is important. OPEX is critical.

Total System Cost Breakdown

OPEX COSTS



- Hydrogen Levelized Costs
- Capital costs
- - - Minimum costs
- Fixed O&M
- Electricity costs

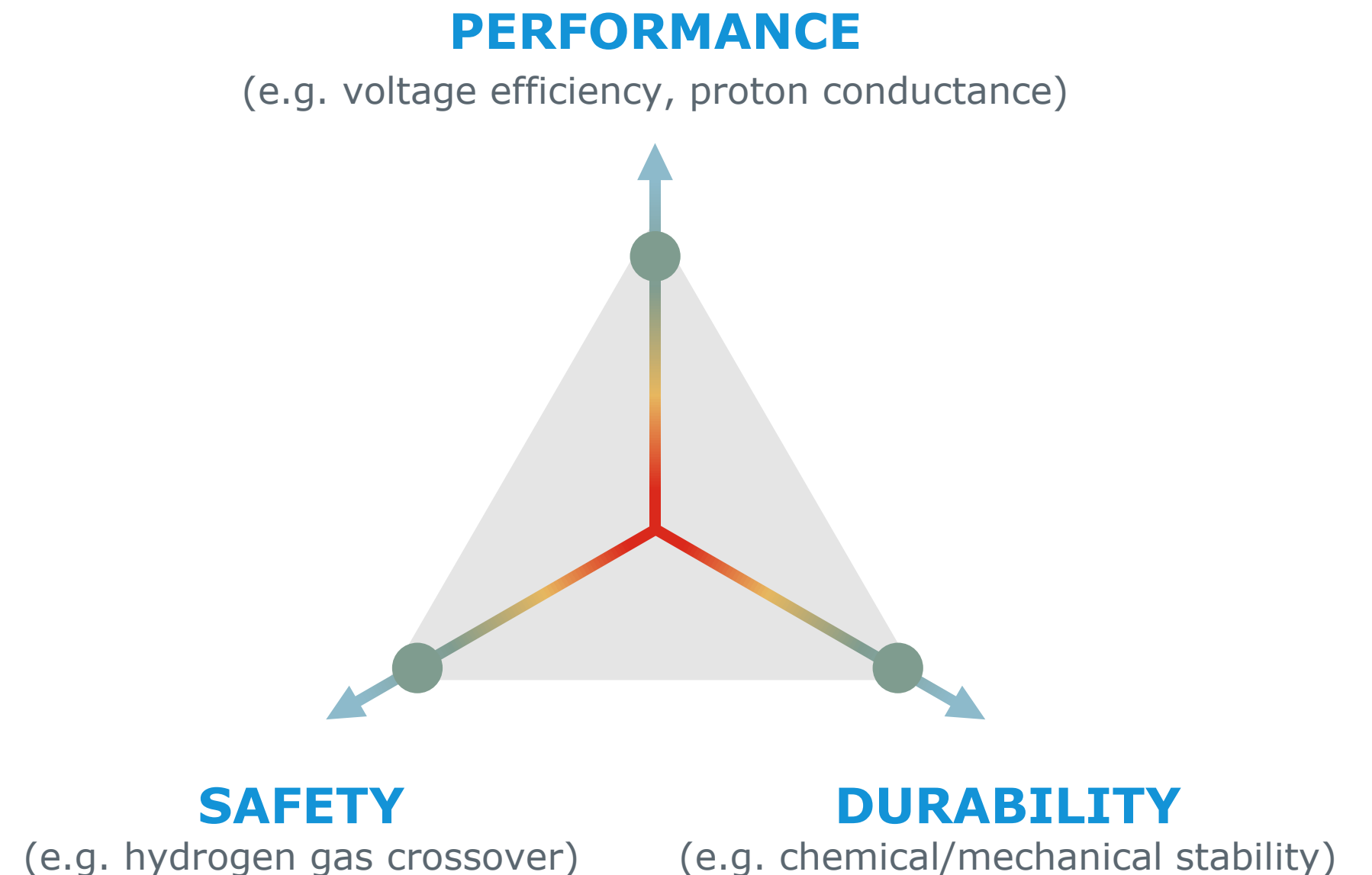
To scale up to meet net-zero demands,
OPEX is the deciding factor in delivering a lower levelized cost of hydrogen.

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

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**.



Selecting the right membrane = lower risk



Better performance increases **output**

- Gore's PEM offers **>5% greater cell voltage efficiencies** over other PEM while meeting safety & durability requirements.
- This dramatically **reduces the amount of energy required** to produce 1kg of Hydrogen.



Improved safety increases **uptime**

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



Greater durability reduces **maintenance** & enhances **lifetime**

- Gore's reinforced PEM offers **>2x higher mechanical stability** than non-reinforced membranes.
- This enables longer-life WE systems, **reduces servicing cost**, and increases **system uptime**

GORE® PEM for Water Electrolysis: Improving Output. Reducing LCOH.

Breaking performance barriers with Gore's high-performance PEM

Reducing system trade-offs with our advanced membrane technology.

Ionomer

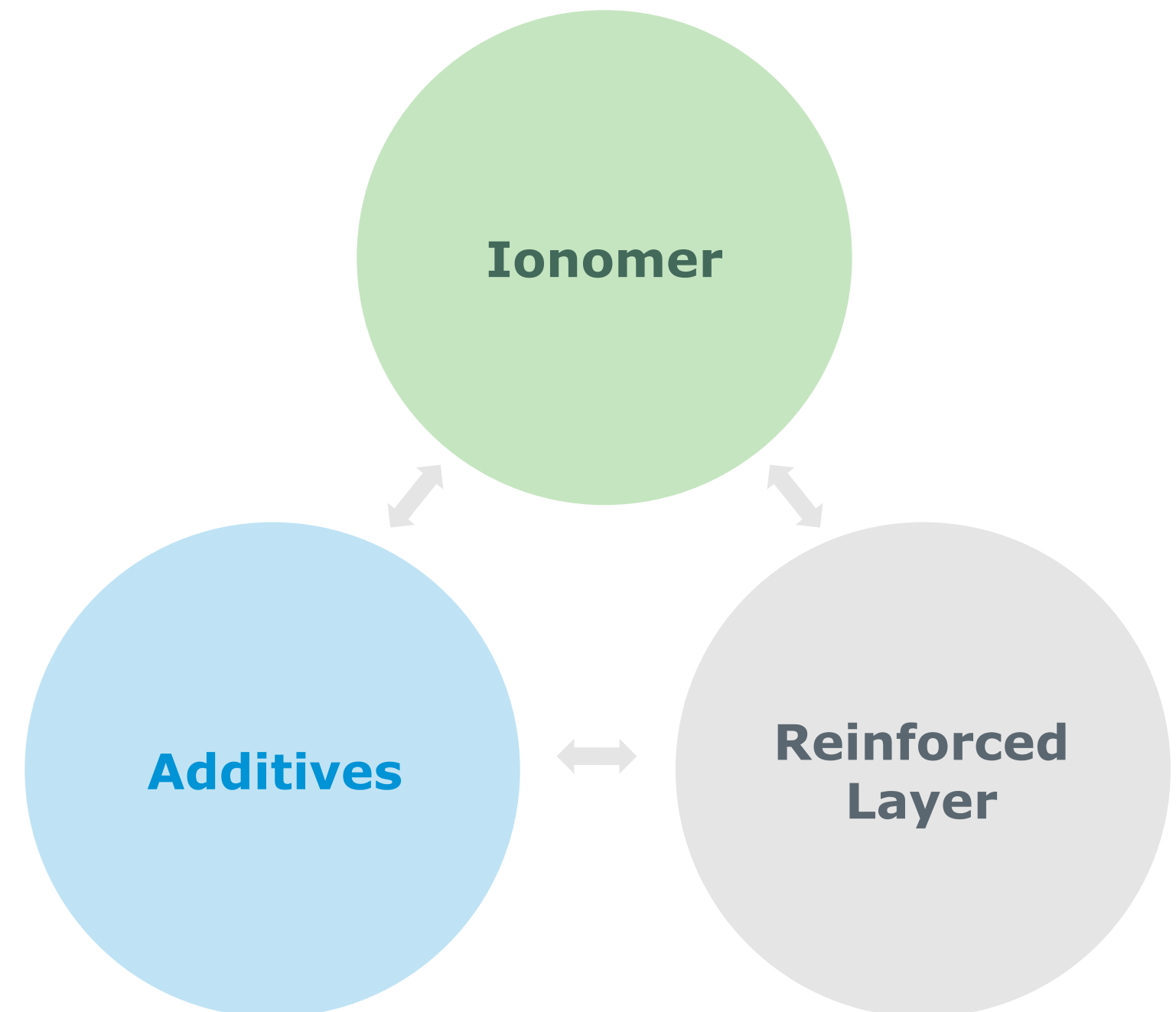
- High proton conductance + high voltage efficiency for **increased performance**

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**



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

- 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**

TO SUMMARIZE...



The right partner can help manage risk.

SCALABILITY. EFFICIENCY. SYSTEM INTEGRATION.



- High-quality, efficient PEM can **optimize OPEX and increase output.**
- A trusted technology partner with reliable product supply can **overcome technical and supply chain challenges.**
- Collaboration is key to driving the material innovation that will ultimately deliver **a lower cost of hydrogen.**

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



THANK YOU.

Together, improving life

