

An aerial view of a large industrial hydrogen production facility. The main building is white with 'HYDROGEN H₂' written in large blue letters on its side. The facility is surrounded by greenery and a road with streetlights. The sky is clear and blue.

Advances in Composite Membranes Design for Proton Exchange Membrane Water Electrolysis

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W. L. Gore & Associates

Hydrogen Technology Conference 2023

Together, improving life



Agenda

1.0

Introduction of
W. L. Gore & Associates

2.0

Clean energy ecosystem & challenges

3.0

Technology development for water
electrolysis application

- Trade-offs incorporating thin membranes
- Technology for breaking through the trade-off relationship





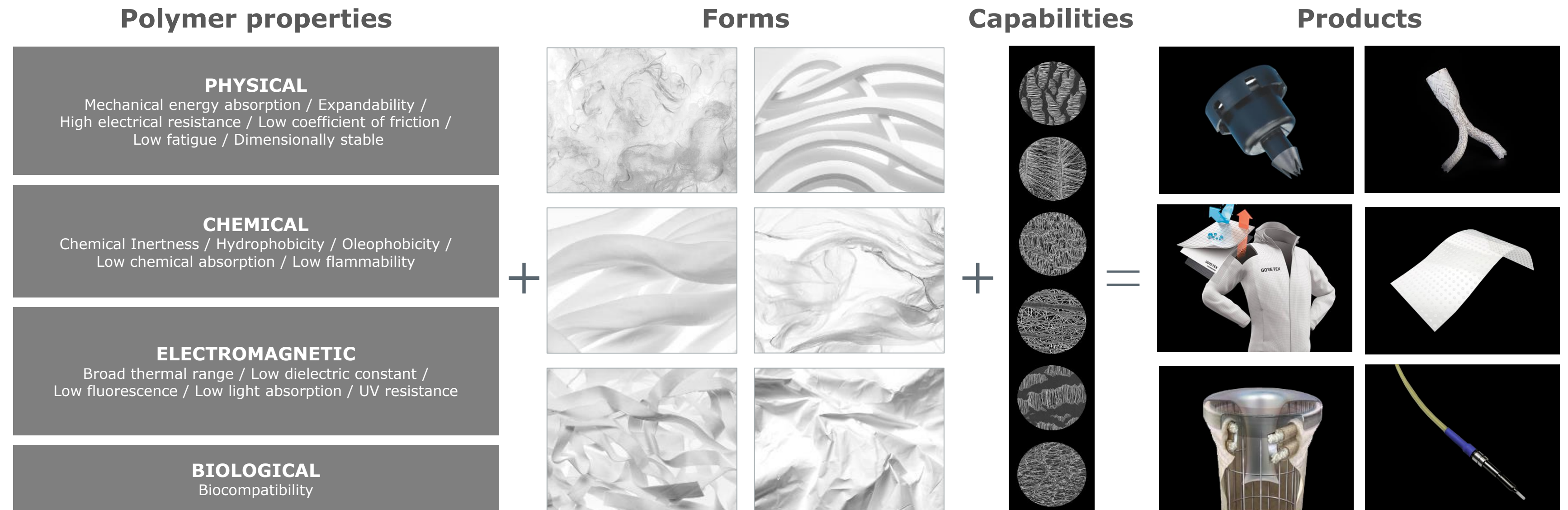
**The world needs energy.
Our planet needs clean emissions.**

**At W. L. Gore & Associates, we believe that
together, we have the power to harness both.**

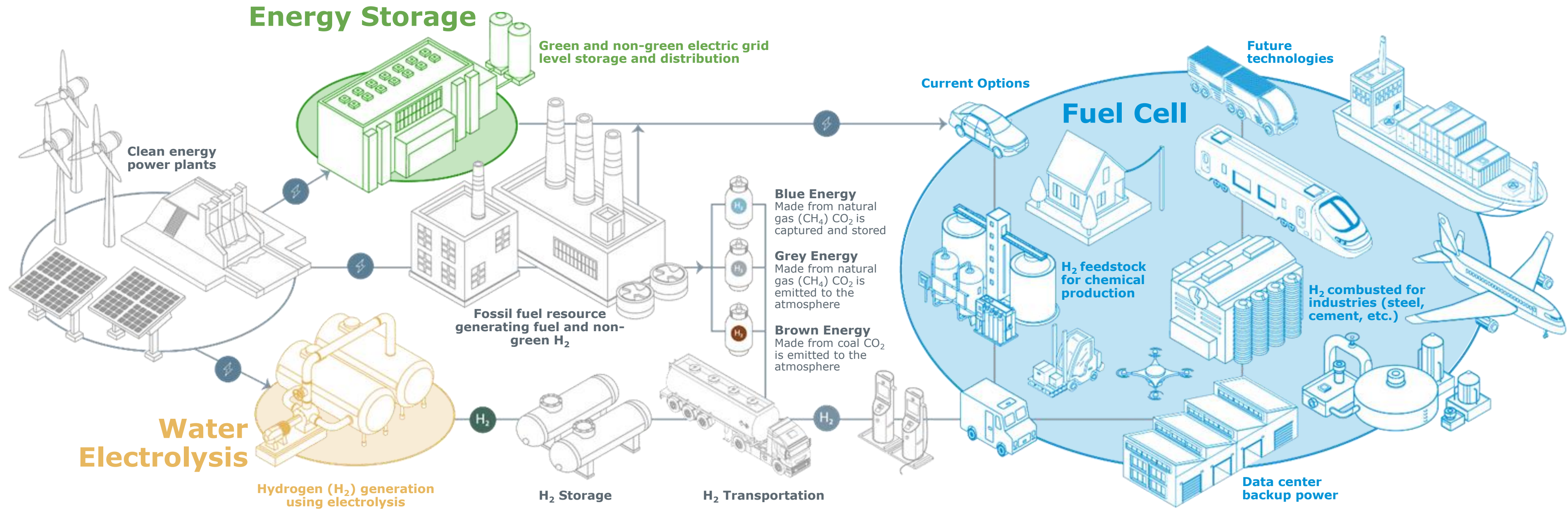
Gore: A global materials science company

Our advanced materials capabilities allow our customers to push boundaries — with confidence.

Our knowledge of diverse materials, including polymers, and our engineering capabilities, enable a wide range of remarkable products.



Clean energy ecosystem for Gore



Levelized cost of hydrogen production - Electrolyzer system

System Cost

Simpler system, less components, cheaper manufacturing

Operation / Maintenance

Reliable, relaxed inputs, longevity

Electricity

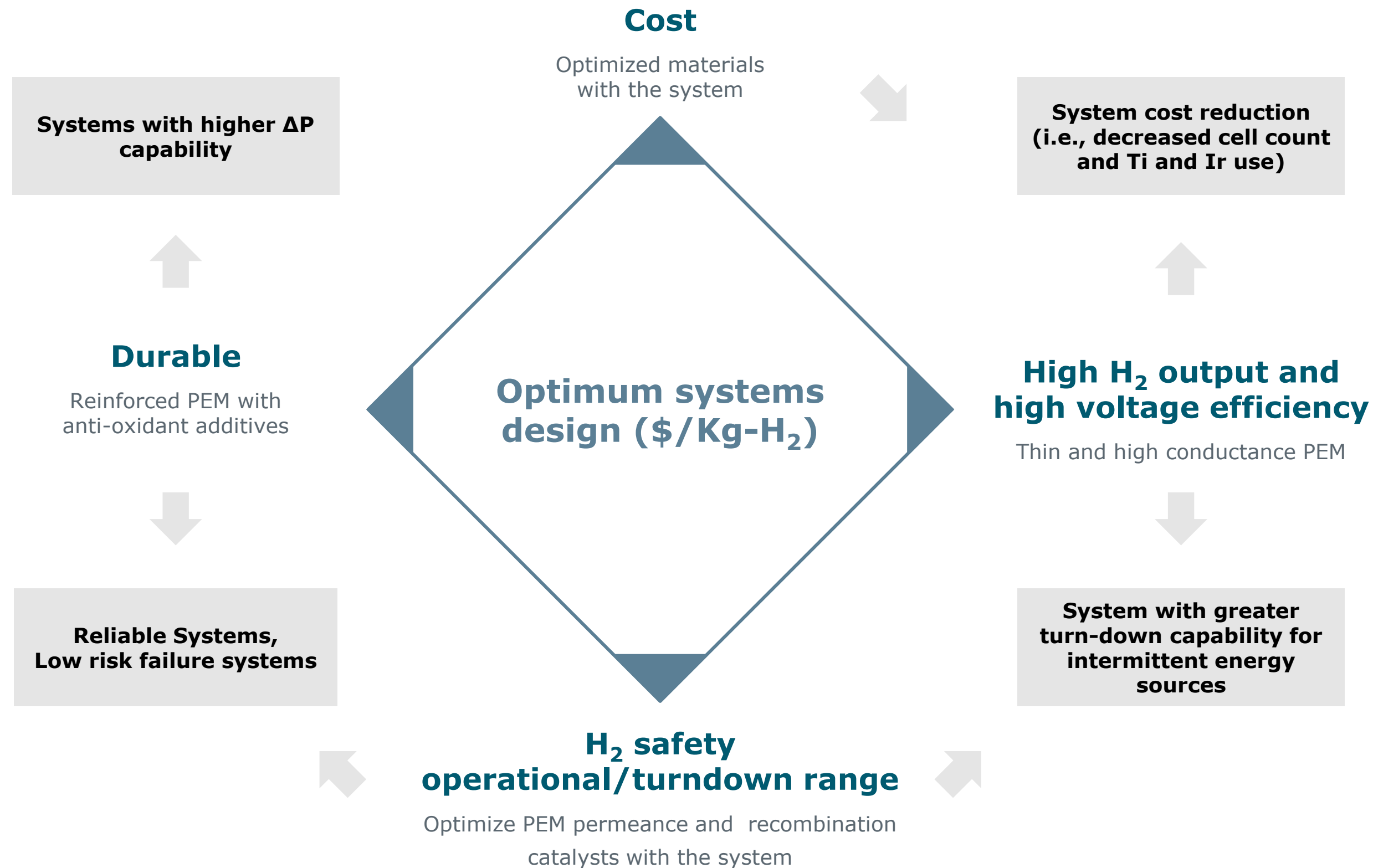
High H₂ output per electricity, less parasitic loss, high utilization, turndown ratio

Other considerations

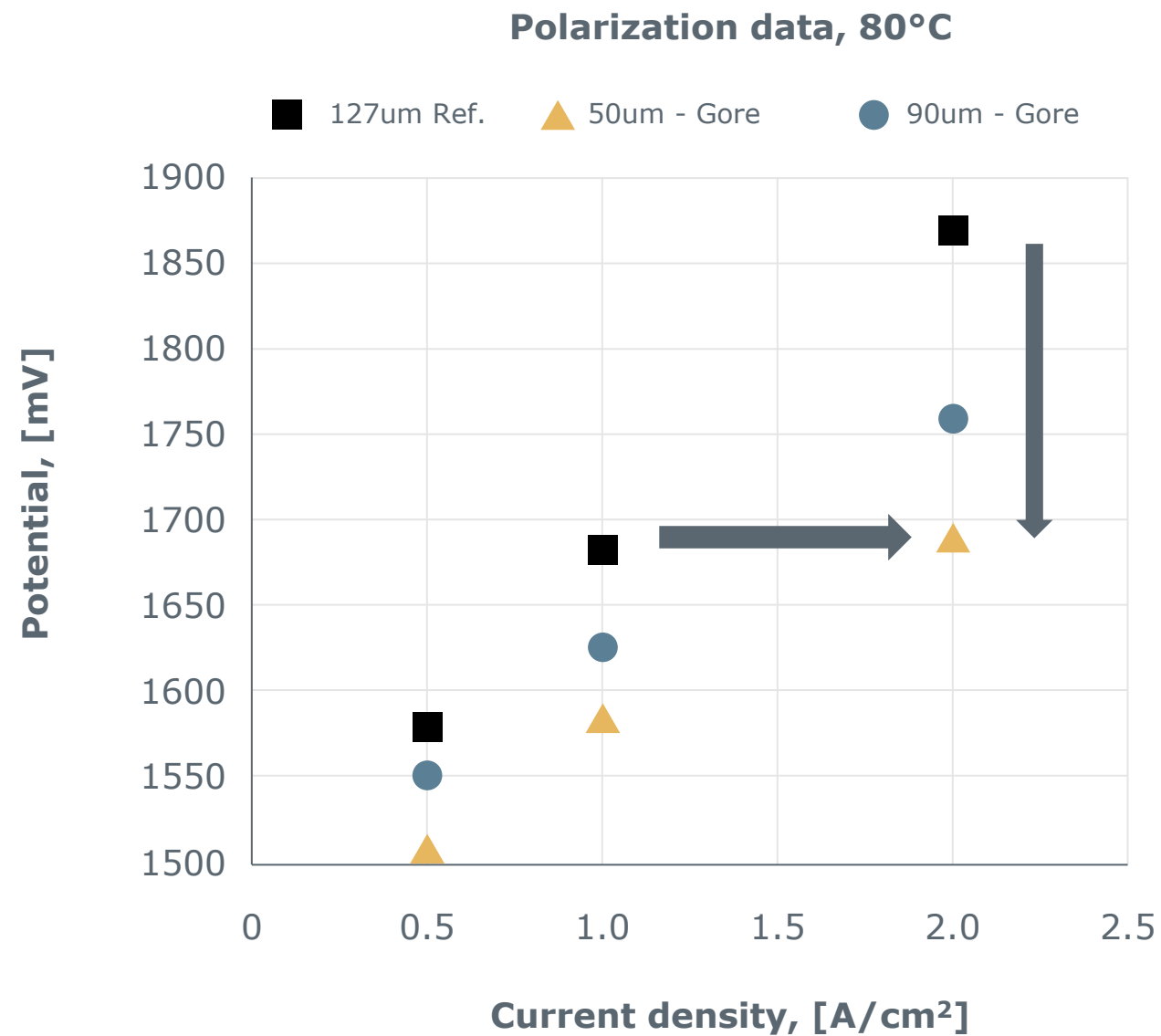
Grid fees, construction costs, land use and etc.

LCOH
(\$/kg-H₂)

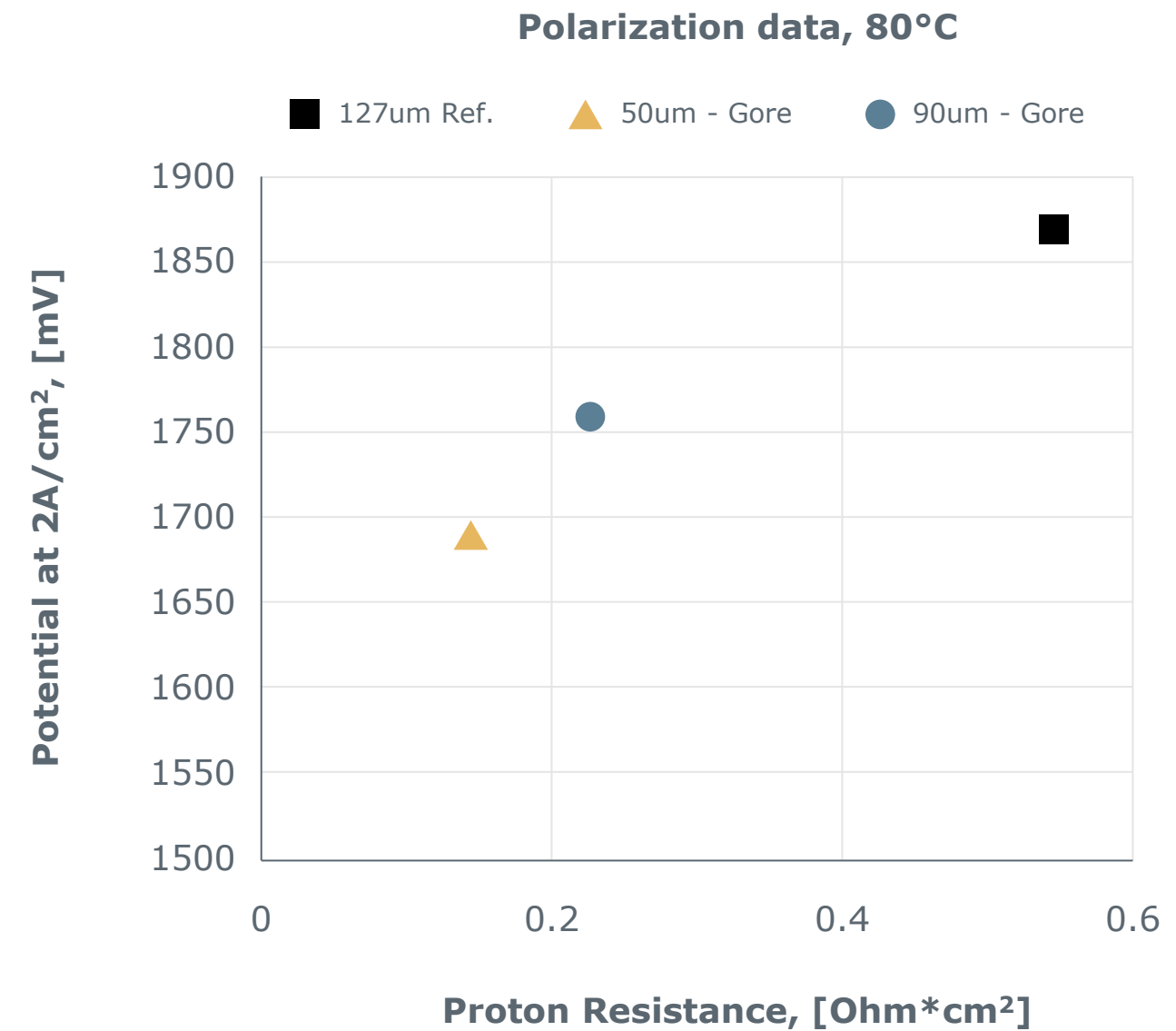
How can we manage trade-offs to optimize system design?



Advantage of thin membrane for high power output



CAPEX \$↓ from increased H₂ output
OPEX \$↓ from increased voltage efficiency

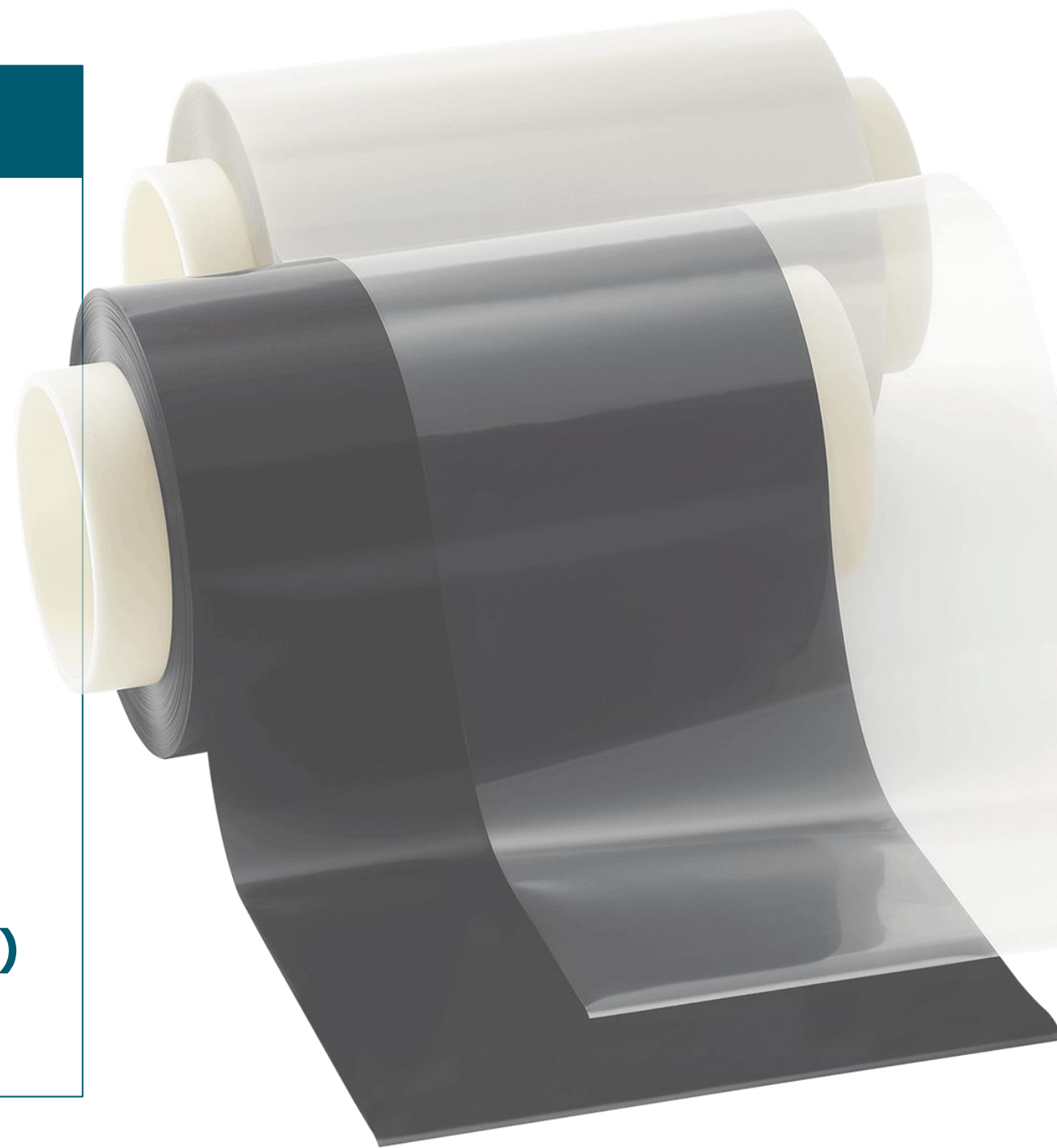


No surprise – membrane resistance is a large controlling factor

Trade-off between thin membrane and properties

Advantages

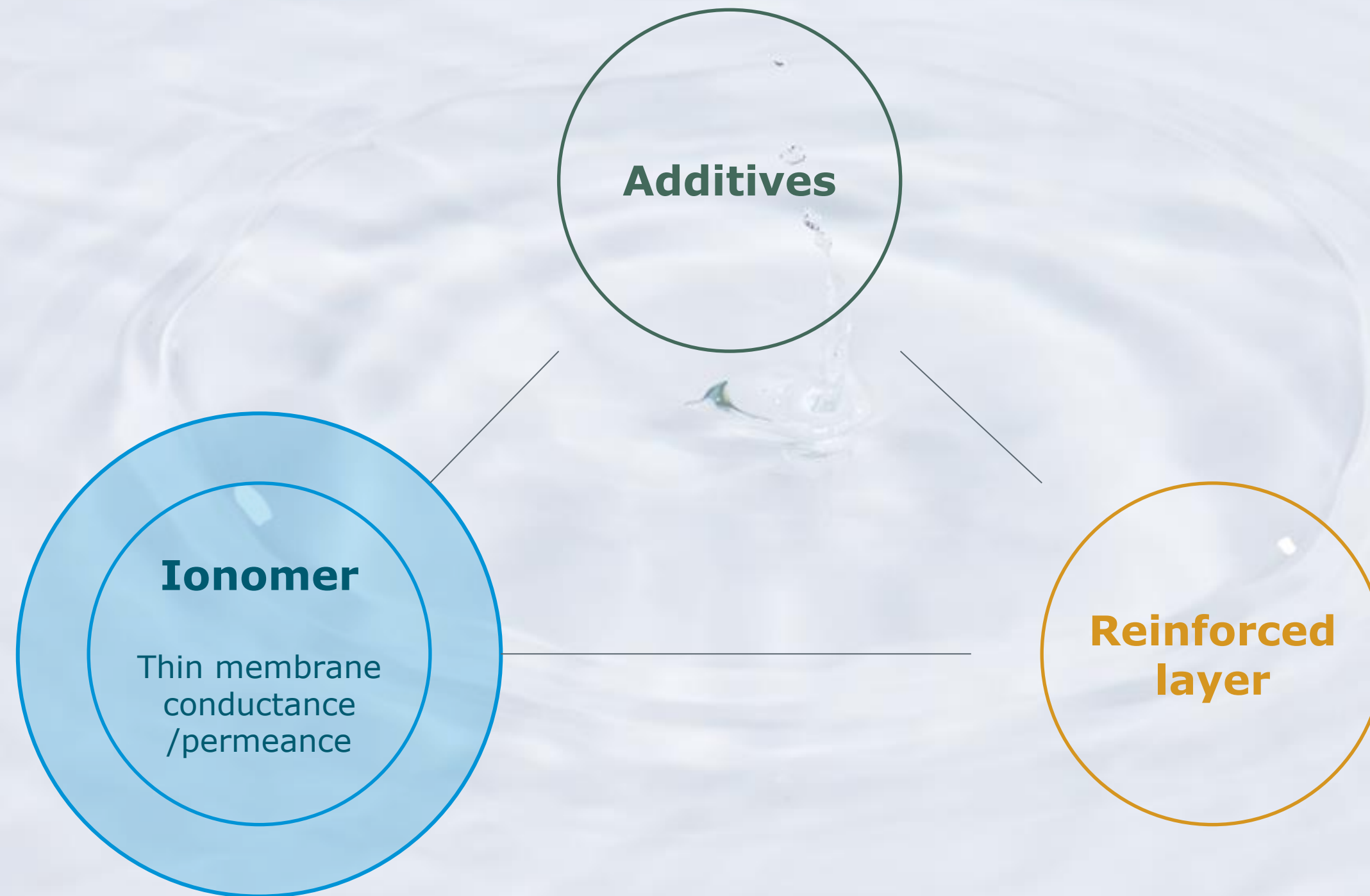
- High Voltage Efficiency**
- High H₂ Output**
- Reduction of Balance of Plant (BOP)**



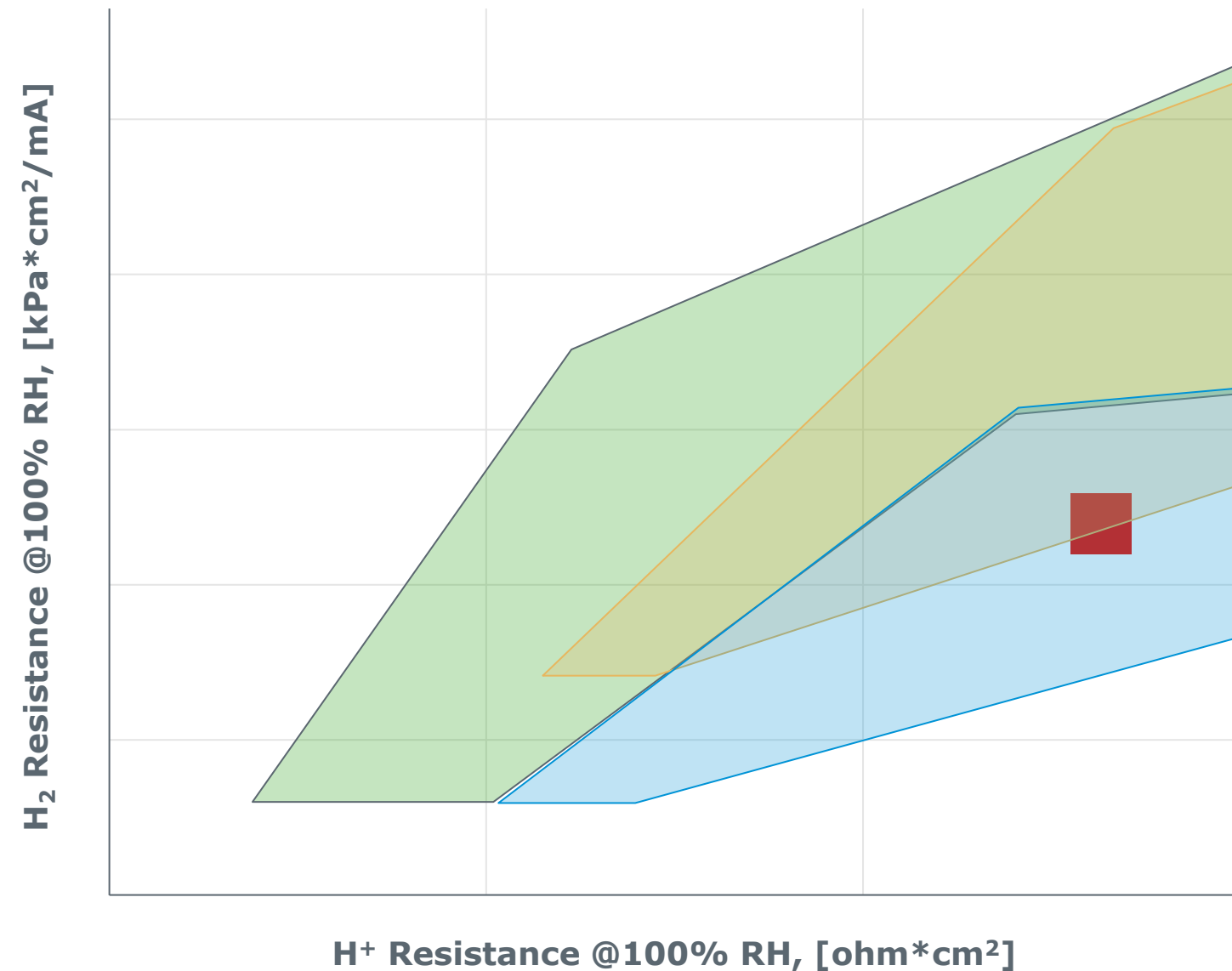
Challenges

- H₂ Efficiency**
- Durability**
- Safety / Operation range**

Technology for breaking through the trade-off



Gore proton exchange membrane (PEM) performance space



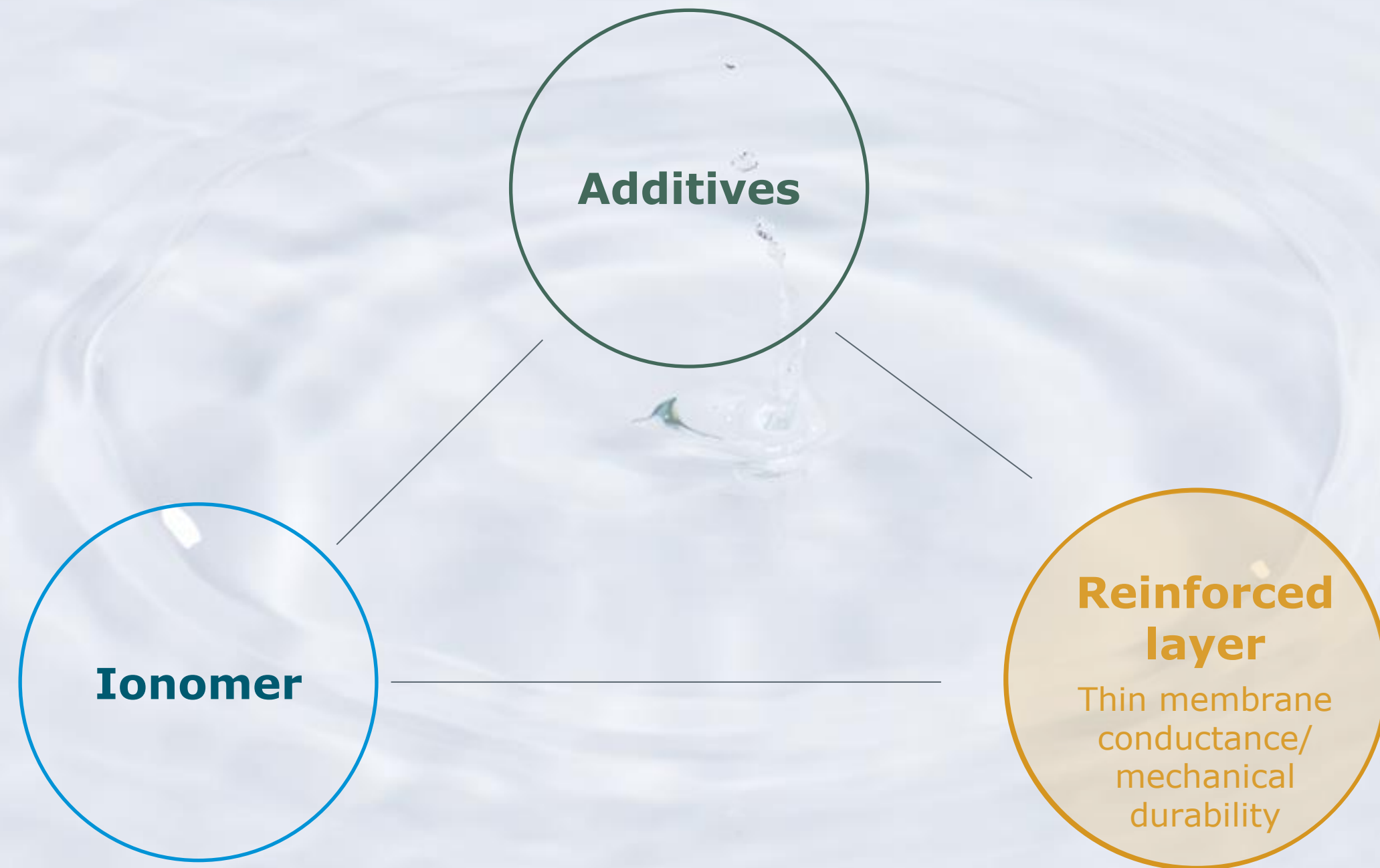
**Shaded space estimated by modeling*

Design target considerations:

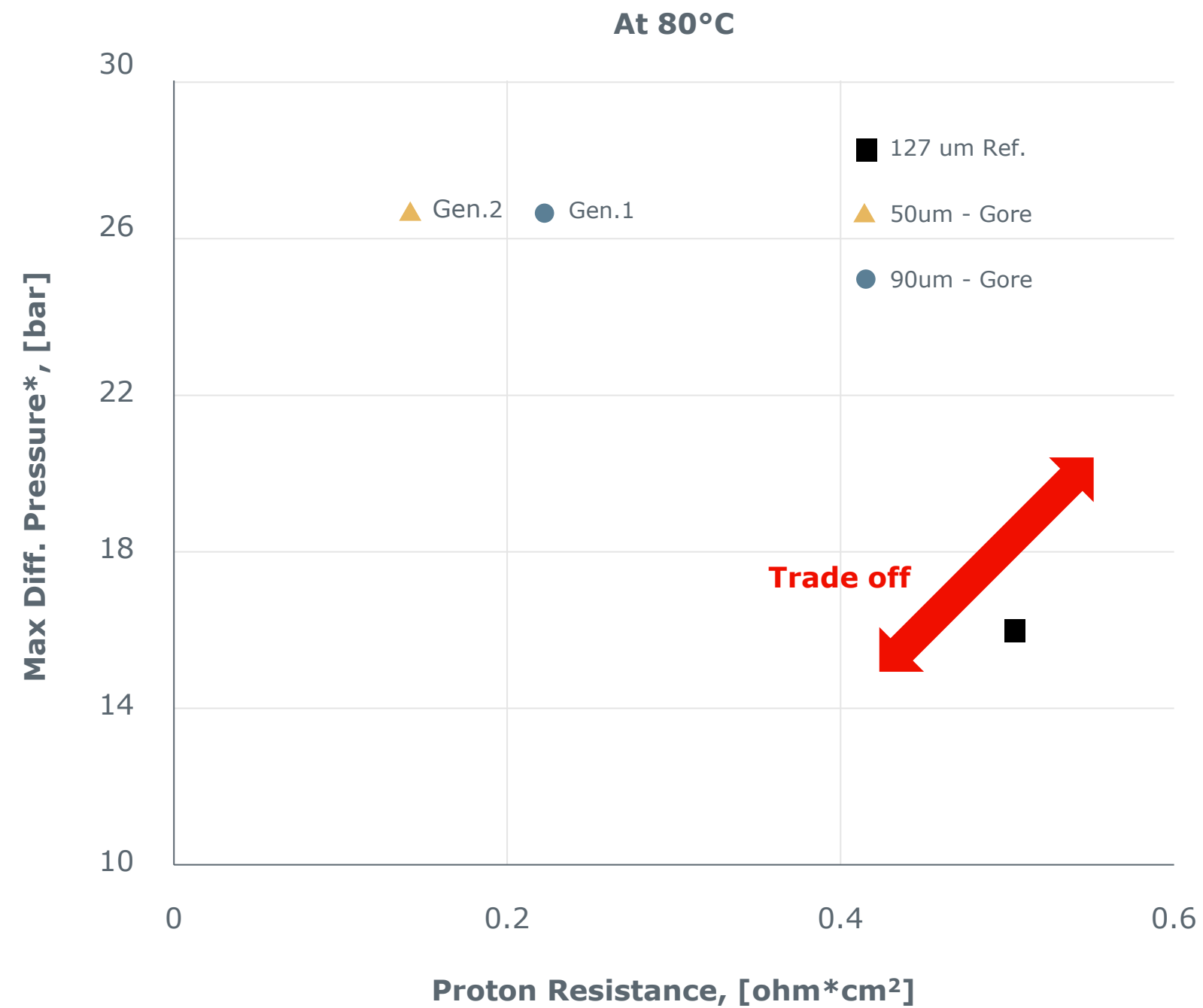
- H⁺ conductance → stack power / efficiency
- H₂ crossover → current efficiency
- Durability requirements
- Contamination
- Mechanical / chemical stressors
- CCM / MEA process requirements

Gore can reduce membrane resistance while maintaining same hydrogen crossover

Technology for breaking through the trade-off



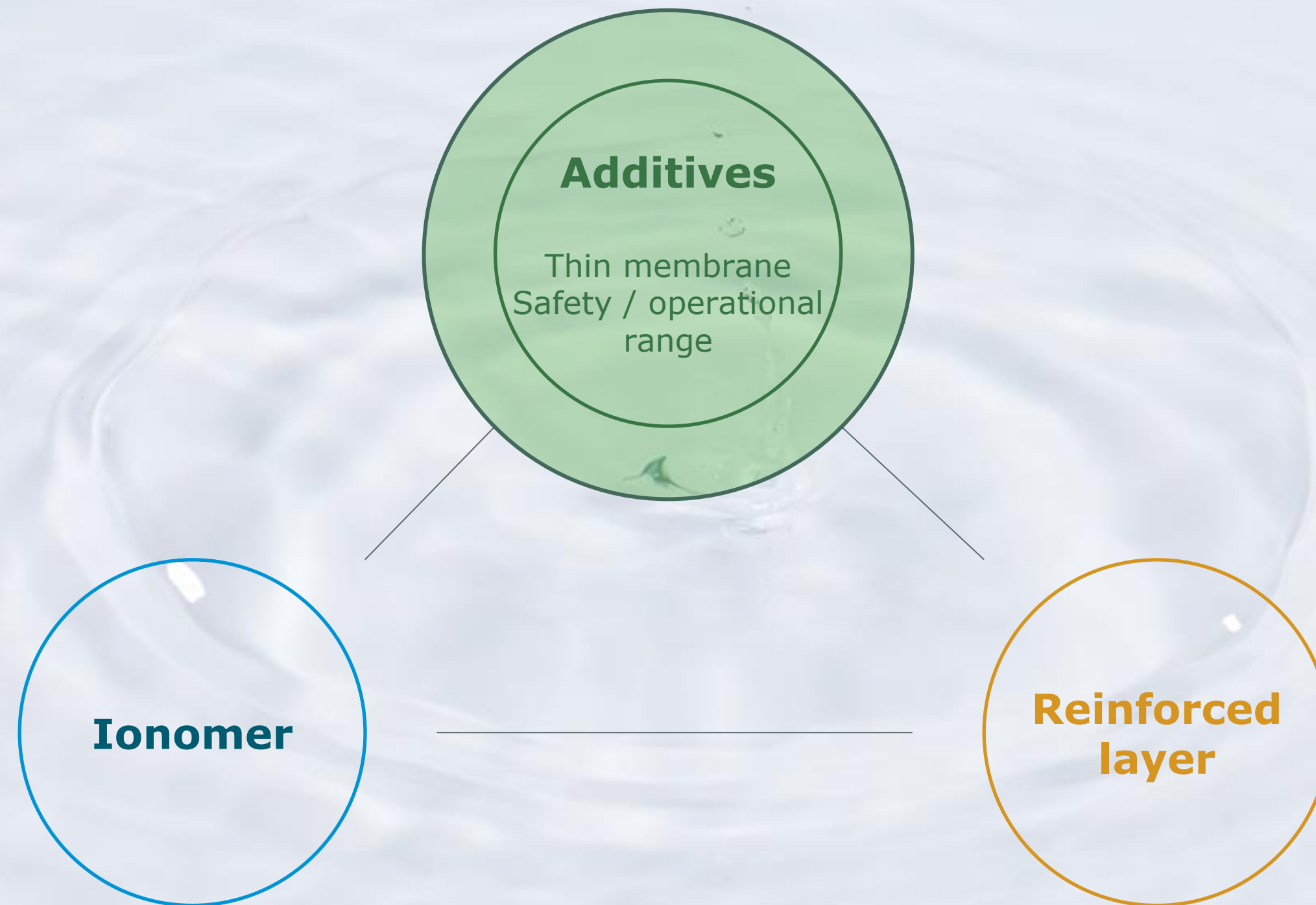
Development of reinforced layer



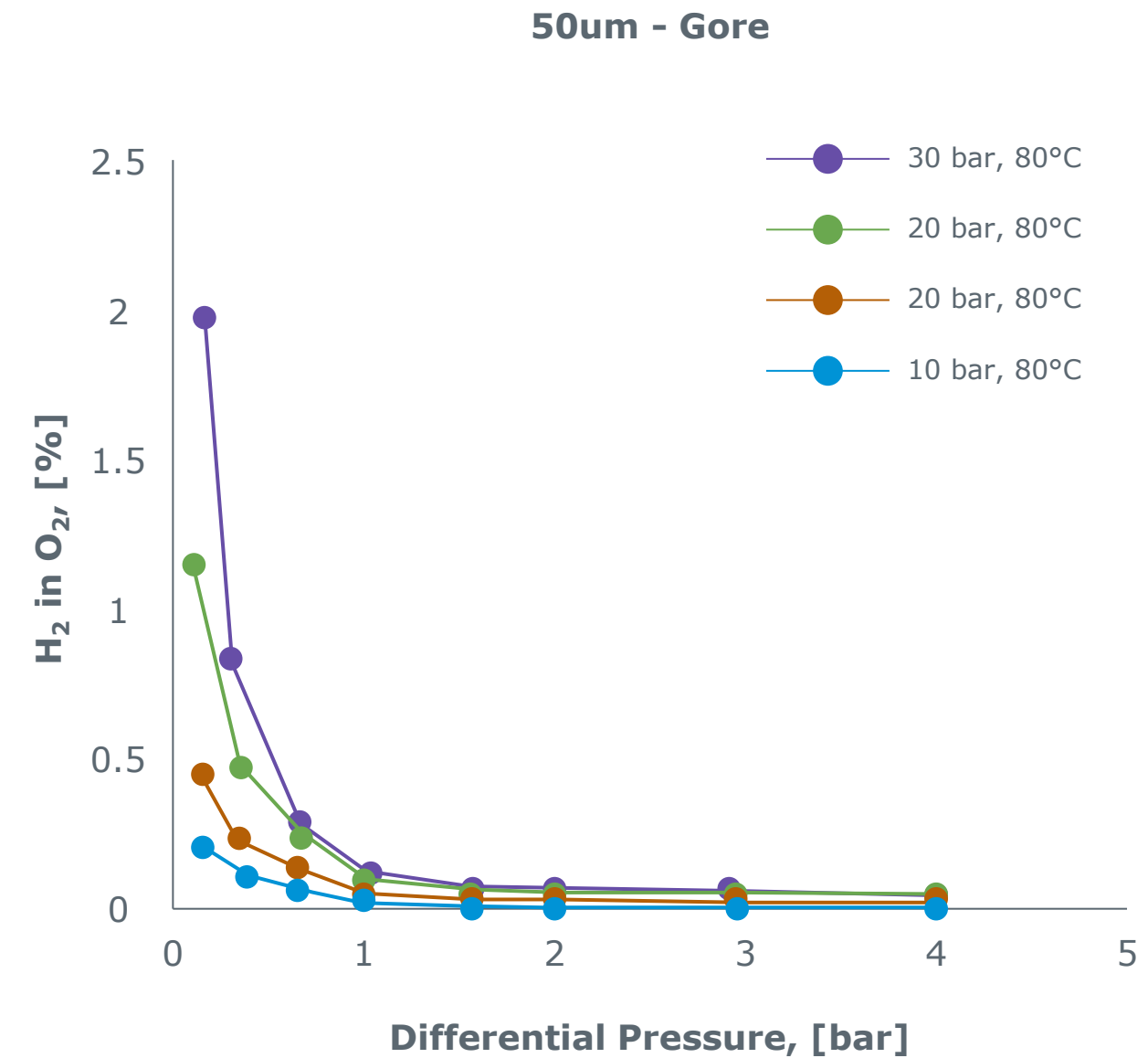
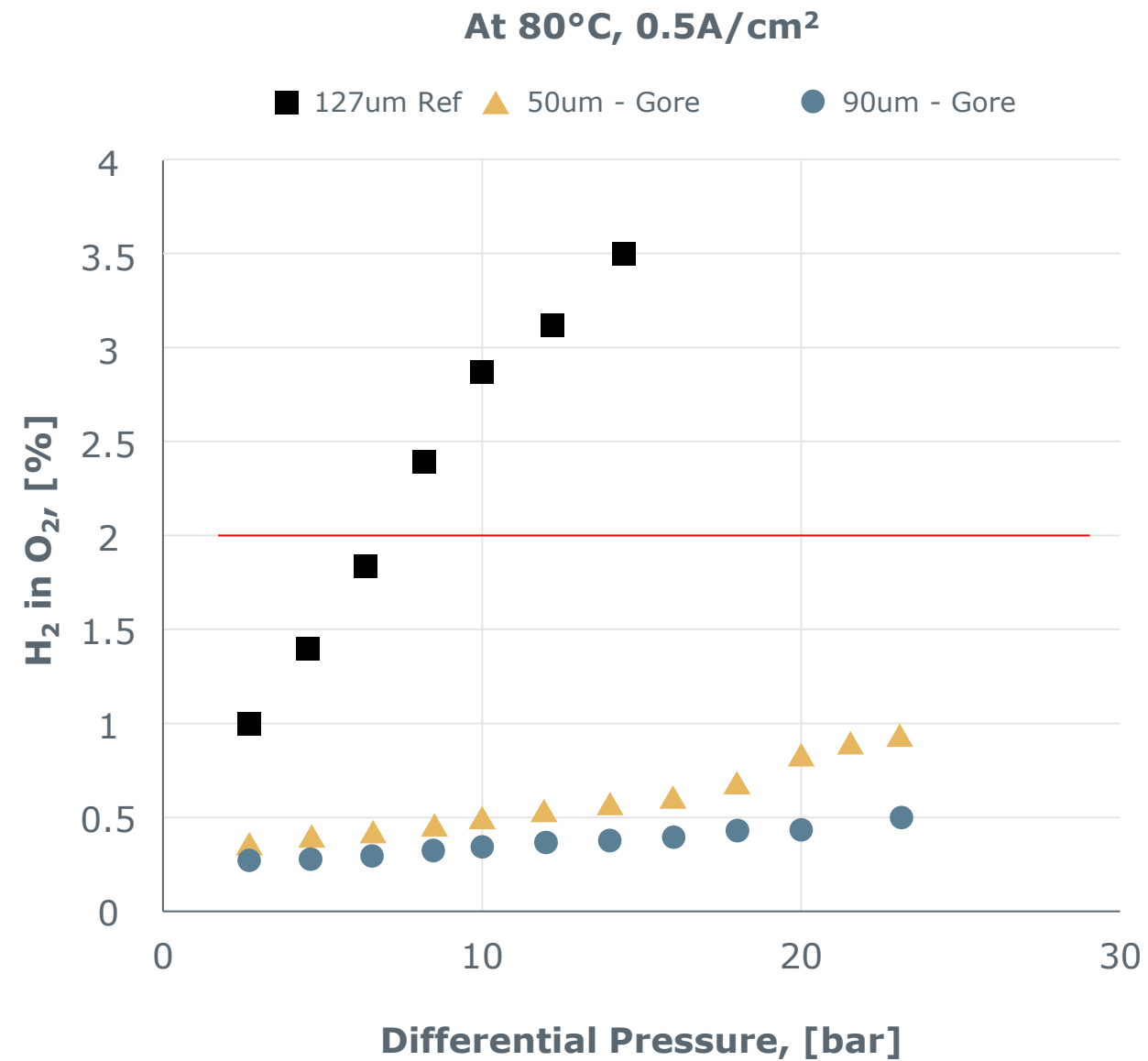
Improved trade-off between performance and mechanical durability by construction and reinforced layer

*Cell design dependent

Technology for breaking through the trade-off

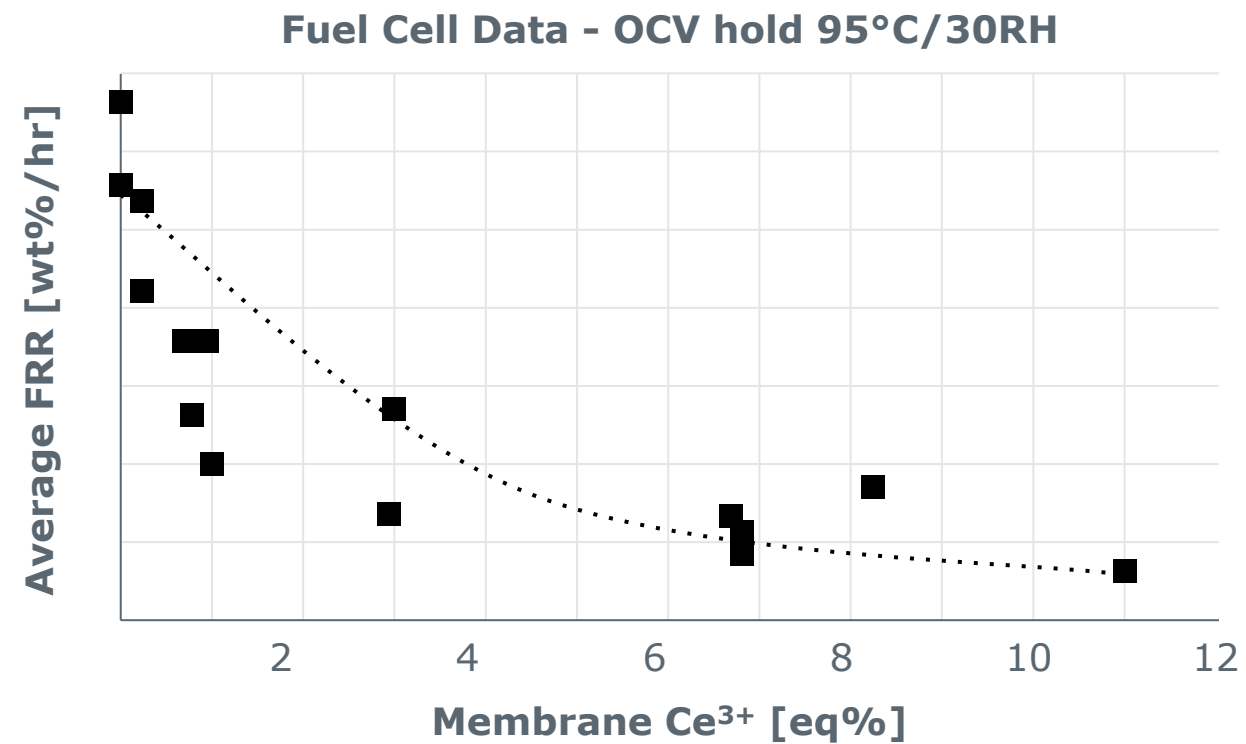


Recombination catalyst (RC) for wider operational range



Gore RC technology shows effectiveness at mitigating H₂ in O₂ safety concerns. Enables high system utilization and efficiency through a wide operating range.

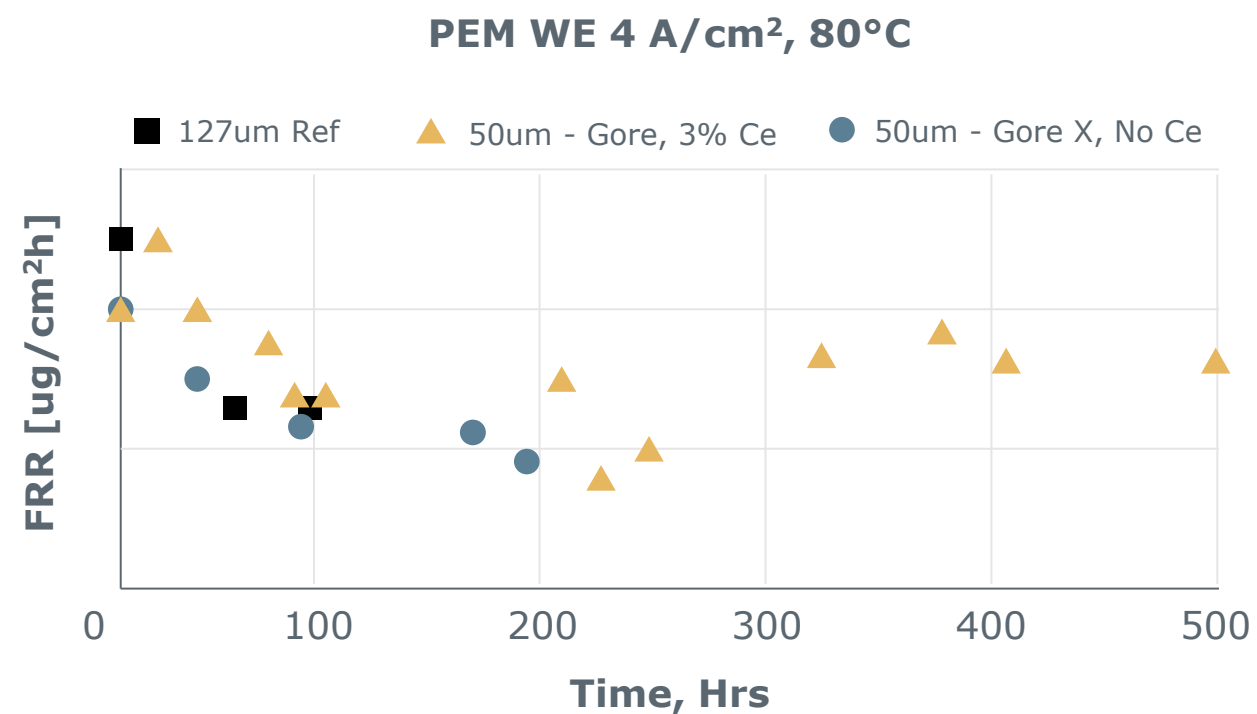
Leveraging additives for chemical durability



Cerium (Ce) is a known radical scavenger and an effective mitigation strategy to improve chemical durability in FC systems

Tradeoffs

- Mobile, moves under current and can reduce iV performance
- Ion exchange-able, can wash out with reconditioning acid flushes

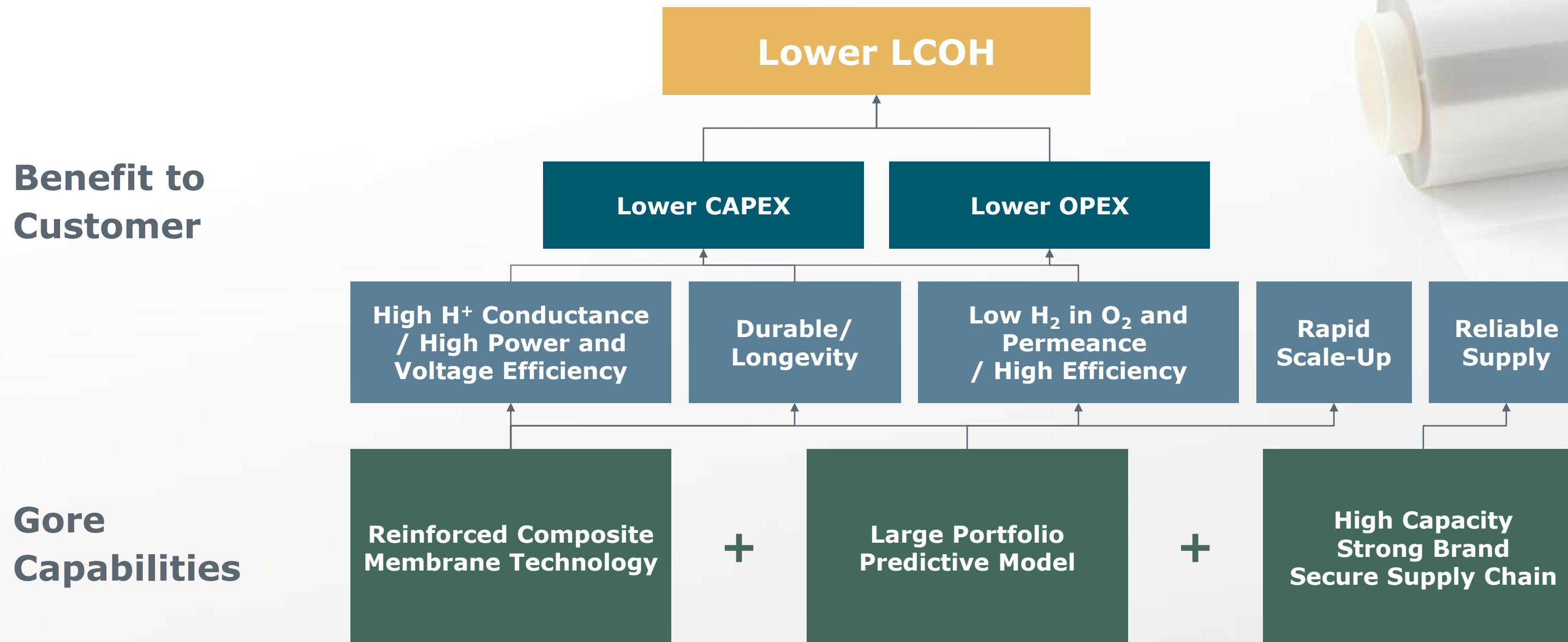


Electrode and PEM design interact

Optimal MEA design requires partnership

Creating value for a cleaner environment

Reinforced composite membranes enable higher-performing systems for OEMs and lower levelized cost of hydrogen for end-users.



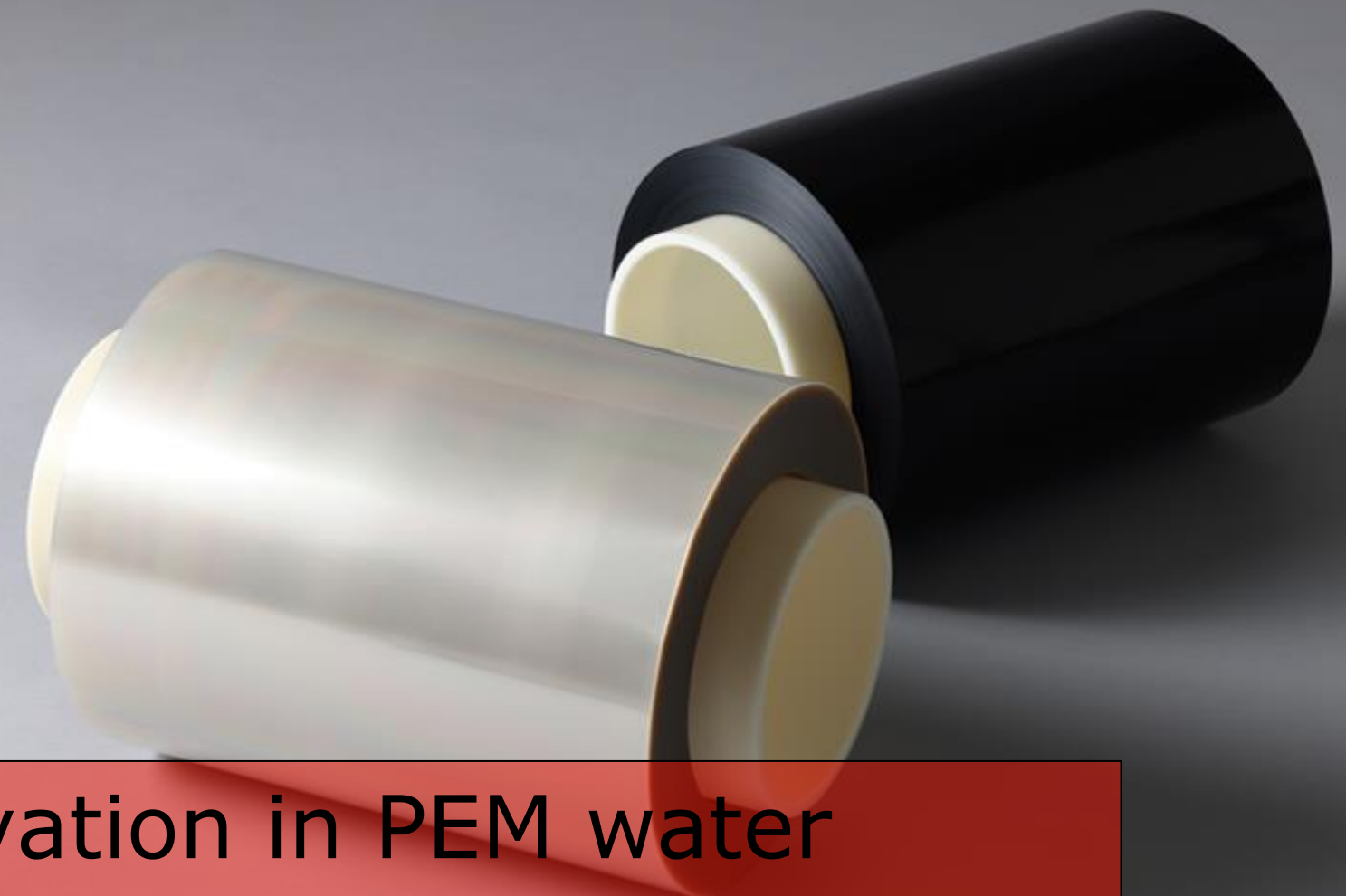
Summary

Gore's core technology is engineering polymers and polymer composites into unique structures.

LCOH is influenced by many factors and close collaboration is paramount.

Trade-offs in membrane design can be mitigated through advanced technology from Gore.

- Track record of delivering high performance materials
- Proven, high-quality, high-volume PEM manufacturing
- Ability to break the "performance/ durability" trade-offs to enable lower LCOH



Engage with us to further innovation in PEM water electrolysis!

Scan the QR Code on your handout for exclusive content.

Thank You!

Questions?

Together, improving life

