Enhance durability of electrolyser technologies

ELECTROLIFE

Degradation modelling and lifetime prediction in water electrolysis

Vincenzo Liso – Aalborg University AAU

Clean Hydrogen Partnership

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The Reality of Green Hydrogen Costs

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Cost of Hydrogen today

Low-emissions hydrogen is an emerging sector and, as such, there is uncertainty about costs. Today's electrolyser costs have been revised upwards for this report, based on newly available data from more advanced projects. The future cost evolution will depend on numerous factors, such as technology development, and particularly on the level and pace of deployment.

https://www.iea.org/reports/global-hydrogen-review-2024/executive-summary

Technical gap

Lack in understanding in degradation phenomena creates unpredictability in costs

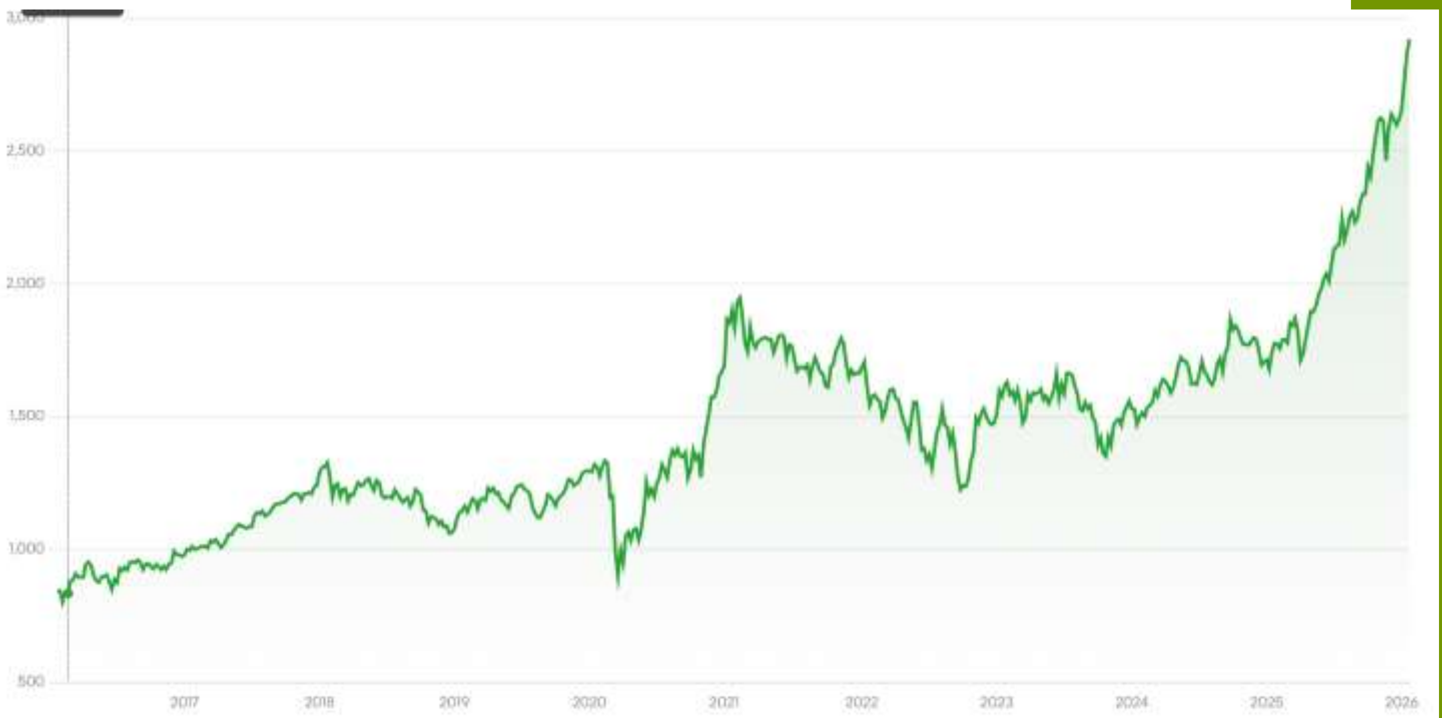
The long-term data gap

Degradation phenomena in electrolyzers are **not comprehensively understood** at scale.

- Significant lack of data in long-term operation.
- Disconnect between laboratory results and industrial stacks.
- Unexpected maintenance costs drive financial risk.

Overall the expectations on hydrogen are still high

- Bloomberg Hydrogen Screened Total Return Index is constructed to track the performance of companies that are expected to generate a meaningful portion of revenue from the manufacture of fuel cells and electrolyzers, as well as other activities related to hydrogen ecosystem. Industry research primer



Bloomberg Hydrogen Screened Total Return Index

Our approach to modelling degradation

Physical modelling of the degradation mechanisms

Cell modelling

Stack modelling

Model validation against real world data

Electrolyzer Lifetime prediction

Involved partners

Academia

- Aalborg University
- Politecnico di Torino
- Graz University of Technology
- University of Lille

Industry

- volytica diagnostics GmbH
- Enel Green Power SpA

Academic Partners contribution

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- **AAU (Aalborg University):** Focuses on **PEMEL** modeling, developing algorithms to simulate **catalyst agglomeration, dissolution** and **membrane thinning**.
- **POLITO (Politecnico di Torino):** Developed a model which include degradation for **AEL**, **AEMEL** and **PCCEL** which include main degradation mechanisms.
- **TUG (Graz University of Technology):** Looking in **SOEL** (Solid Oxide) systems using **Computational Fluid Dynamics (CFD)** to analyze high-temperature phenomena like **nickel (Ni) oxidation** and particle agglomeration.
- **ULille (University of Lille):** Concentrates on **PEM** systems through two lenses: a **Bond Graph** methodology for tracking power losses and a rigorous **Failure Mode and Effects Analysis (FMEA)** for the cell level.

Industrial integration

- **VDX (Volytica Diagnostics):** Developing a **stressor map methodology** and a diagnostic framework that integrates the universities' models into a unified health-monitoring tool.

- **EGP (Enel Green Power):** Acts as the bridge between model development and real-world deployment, coordinating the data flow from researchers to ensure these models are usable for **lifetime prediction of industrial electrolyzer system**

Mechanistic degradation models

Low-Temperature Electrolysis

- **Alkaline Electrolyzers (AEL):** cell model which include realistic aging mechanisms: bubble-induced ohmic losses, Fe^{2+} deposition, carbonate precipitation, reverse current effects

- **Proton Exchange Membrane (PEMEL):** Models for catalyst agglomeration, dissolution & membrane thinning.

- **Anion Exchange Membrane (AEMEL):** Microkinetic & dynamic models capturing catalyst dissolution and voltage degradation.

Mechanistic degradation models

High-Temperature Electrolysis

- **Solid Oxide Electrolyzers (SOEL):** Employs Computational Fluid Dynamics (CFD) models to analyze Nickel oxidation and particle agglomeration within the stack.

- **Protonic Ceramic Electrolyzers (PCCEL):** Utilizes advanced 2D and 3D cell models to investigate electrode-electrolyte interface stability.

The end goal

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Validated Modeling: physical models developed for **AEL, PEMEL, AEMEL, SOEL, and PCCEL**.

Operational Health: Direct transition from cell-level physics to real-world industrial stack diagnostics.

Economic Stability: Reduces investment risk by providing accurate lifetime predictions to lower the Levelized Cost of Hydrogen

Thank for your attention

Assoc. Prof. Vincenzo Liso

Research Group Leader

HYDROGEN and ELECTRO-FUELS

vli@energy.aau.dk

Aalborg University

AAU Energy

Denmark

1	**POLITO**	**Politecnico di Torino**
2	UNR	Uniresearch B.V.
3	EGP	Enel Green Power SpA
4	TUDA	Technische Universität Darmstadt
5	TUG	Graz University of Technology
6	KER	Kerionics s.l.
7	AAU	Aalborg University
8	FZJ	Forschungszentrum Jülich gmbh
9	ULille	University of Lille
10	STARGATE	Stargate Hydrogen Solutions OU
11	PF	Pietro Fiorentini s.p.a.
12	HYT	Hyter s.r.l. (Affiliated)
13	CNR	Consiglio Nazionale delle Ricerche
14	1s1	1s1 Energy Portugal Unipessoal Lda
15	AEA	AEA s.r.l.
16	VDX	volytica diagnostics GmbH
17	SE	SolydEra SpA

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