VOLTA CHEM

Shared Innovation Program VoltaChem: Electrification of the Chemical Industry

Impact of Dynamic Load from Renewable Energy Sources on PEM Electrolyzer Lifetime

Authors: Frans van Berkel[1], Arend de Groot[1], Sander ten Hoopen[2]

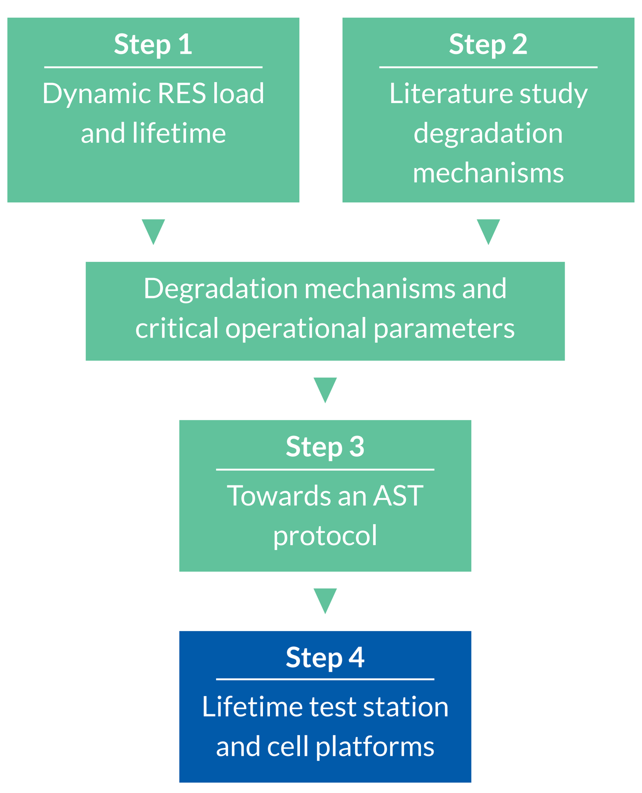
Corresponding author: vanberkel@ecn.nl

INTRODUCTION

Proposal for an Accelerated Stress Test (AST) protocol for PEM-based electrolyzers on single cell level:

- Hydrogen production by electrolysis is important for matching renewable energy supply (RES) and energy demand;
- Electrolyzer cost, efficiency, and lifetime needs further progress: Cost and efficiency improvement impact lifetime;
- Electrolyzer lifetime determination is time-consuming and expensive and therefore limits testing of large number of cell materials;
- Accelerated Stress Testing (AST) is cost efficient way for prediction of component lifetime.

APPROACH TOWARDS AST PROTOCOL PROPOSAL



STEP 1: DYNAMIC RES LOAD PATTERN AND LIFETIME

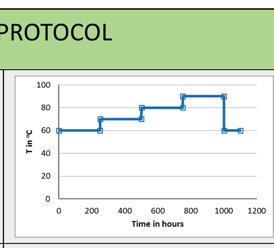
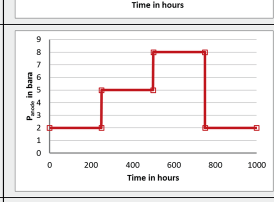
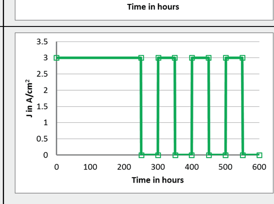
- PEM-based electrolyzers as demand response devices can respond sufficiently fast;
- Several main electrolyzer manufacturers show that dynamic load operation has no significant additional contribution to degradation behaviour;
- Reducing cost and improving efficiency for PEM-based electrolyzer puts more demands on lifetime issues due to introduction of new materials and more challenging operating conditions;
- AST protocols are needed to address in a cost and time efficient manner lifetime issues of the new materials and more challenging operating conditions.

STEP 2: DYNAMIC RES LOAD PATTERN AND LIFETIME

- Critical operating parameters: Temperature, anode oxygen pressure and variation in current density.

		Degradation mechanisms				
		Corrosion Loss of contact [10]	Catalyst contamination with Ti from PTL [10]	Ion impurities [11,12]	Radical attack and thinning [13]	Particle growth [14]
Operating parameter	P_{an}	X	X	X	X	
	P_{cat}					
	Temperature	X	X	X	X	X
	Current density (Voltage)	X	X		X	X
	Q-water			X	X	

STEP 3: TOWARDS ACCELERATED STRESS TEST PROTOCOL

AST PROTOCOL		In-situ analysis		Ex-situ analysis
Variation T: 60, 70, 80, 90 °C J = 1.5 A/cm² P_{an} = 2 bar P_{cat} = 10 bar Test time = 800-1200 hours		*V(t) vs T:* 60, 70, 80, 90 °C	*EIS, J-V:* Ohmic losses Polarisation losses	
Variation pO_2 (anode): 2, 5, 8 bara T = 80 °C P_{an} = 2 bar P_{cat} = 10 bar Test time = 800-1000 hours		*V(t) vs pO_2(anode):* 2, 5, 8 bara	*Gas analysis:* Increase in gas cross over	*Post test analysis:* Electrolyte thickness Catalyst particle growth Contact resistances
Variation J: J-high: 3 A/cm² J-cycle: 0-3 A/cm² T = 80 °C P_{an} = 8 bara P_{cat} = 10 bar Test time = 600 hours		*V(t) vs J:* J-high: 3 A/cm²; J-cycle: 0-3 A/cm²	*Water analysis:* Fluor release	

STEP 4: LIFETIME TEST STATION AND CELL PLATFORM

- Lifetime test station (ECN, Hydron Energy): Pcat < 100 bar; Pan < 10 bar; I < 300 A; Cell Area 25-100 cm²
- Cell platform for validation AST (Hydron Energy): Cell area: 25 cm²; Pcat < 100 bar; J < 6 A/cm², thermal management

CONCLUSION & OUTLOOK

- Development of cost and energy efficient PEM-based electrolyser cells and components requires Accelerated Stress Test Protocols (AST);
- AST-protocol proposed with potential to reduce test time 10-100x;
- Validation of proposed AST protocol by lifetime test station and Hydron Energy cell platform;
- Validated AST protocols will be lined up with EU harmonisation protocol and used for the quest to cost-efficient cell components.

REFERENCES

[1] Energy Research Centre of The Netherlands ECN, Petten, The Netherlands

[2] Hydron Energy, Noordwijkerhout, The Netherlands

hydron energy