

Advanced Water-Splitting Technology Pathways Benchmarking & Protocols Workshop

Breakout Session Summaries *High Temperature Electrolysis (HTE)*

June 11 – 12, 2024

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HTE Breakout Sessions

Session ID	Topic	Lead	Note Taker
H1	HTE Priority Research Opportunities	Xingbo Liu (WVU)	Chris Coyle (PNNL)
H2	Comparing Durability and Performance	Long Le (PNNL)	Nicholas Kane (INL)
H3	Standardization Needs and Protocols to be Written	Hanping Ding (UO)	Zeyu Zhao (INL)
H5	HTE Protocol Validation	Neal Sullivan (CSM)	Jeremy Hartvigsen (INL)

Summary of discussion

- Revise HTE Roadmap to meet DOE's goal
- For O-SOEC, manufacturing/scale-up & reducing the degradation should be the focus, not new materials development
- P-SOEC needs separate roadmap since it is still in early-stage development
- R&D needs should be dictated by market

Consensus and/or dissenting opinions

- Both standardized and accelerated test protocols are needed, even though AST details need to be figured out
- AST must be prioritized
- Impurity (in steam, air) and chromium effect on SOEC long-term degradation need investigation

Key Take-Aways

- BOP accounts for >50% of system cost: need to simplify BoP
- In SOEC stack, cells account for <50% cost
- Interconnects, seals, coatings, contact materials need more attention
- Standardization is constricted by the lack of shelf products; OEM has unique design

Action Items

- Develop agreeable open-source standard for accelerated testing of single cell stack
- Determine what to use for standardized or representative interconnects and coating
- Sharing database
- Need standard protocol for testing impurities

Session Attendee List

Session ID: H1

Title: Priority Research Opportunities

Name	Affiliation
Olga Marina	Pacific Northwest National Laboratory
Long Le	Pacific Northwest National Laboratory
Jeremy Hartvigsen	Idaho National Laboratory
Elias Pomeroy	DOE
Chris Coyle	Pacific Northwest National Laboratory
Kiran Adepalli	Nexceris
Aadash Parashar	Colorado School of Mines
Nicholas Kane	Idaho National Laboratory
Samuel Koomson	Idaho National Laboratory
Hanping Ding	Oklahoma University
Zheyu Zhao	Idaho National Laboratory
Sarah Shulda	National Renewable National Laboratory
Xingbo Liu	West Virginia University
Tyler Hafen	OxEon Energy
Neal Sullivan	Colorado School of Mines
Seraphim Belko	Pacific Northwest National Laboratory

Session Summary

Session ID: H2

Title: Comparing Durability and Performance

Summary of discussion

- HTE is missing protocols and not reporting test details such as steam utilization, H₂ dilution, sensors used, etc
- Disagreements over SOP for testing and data reporting
- Need break in standardization and definition
- Some protocols need sections for PCEC and/or stacks
- Accurate measurements of Faradaic efficiency are critical and require a well written protocol

Key Take-Aways

- DOE can require adherence to protocols
- EPA has a model for this – does not define all specifics but outline critical requirements
- National labs are in a great position to write and validate protocols
- Universities can validate using DOE funded work

Consensus and/or dissenting opinions

- Protocols need improved, used, and adopted SOPs
- Many critical test specifics go unreported in literature

Action Items

- Protocols need shared with end users
- Write Faradaic efficiency protocol
- Protocols to be distributed to DOE projects and implemented on currently-funded work
- Identify ways to provide feedback to protocol authors

Session Attendee List

Session ID: H2

Title: Comparing Durability and Performance

Name	Affiliation
Olga Marina	Pacific Northwest National Laboratory
Long Le	Pacific Northwest National Laboratory
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Chris Coyle	Pacific Northwest National Laboratory
Kiran Adepalli	Nexceris
Aadash Parashar	Colorado School of Mines
Nicholas Kane	Idaho National Laboratory
Samuel Koomson	Idaho National Laboratory
Hanping Ding	Oklahoma University
Zheyu Zhao	Idaho National Laboratory
Sarah Shulda	National Renewable National Laboratory
Xingbo Liu	West Virginia University
Tyler Hafen	OxEon Energy
Neal Sullivan	Colorado School of Mines
Flavio Silva da Cruz	SoCalGas
Seraphim Belko	Pacific Northwest National Laboratory

Session Summary

Session ID: H-3

Title: Standardization needs and Protocols to written

Summary of discussion

- Focused on PCEC technologies
- Faradaic efficiency measurement protocol is needed
- Definition of conditions for FE measurement and degradation test
- Long-term degradation testing: standard conditions
- Strict temperature control

Consensus and/or dissenting opinions

- It is early to define standard materials system for PCEC
- Materials property measurements should be the same as for SOECs, including mechanical properties
- Faradaic efficiency could be more accurately measured by GC (up to 10 ppm H₂ produced)
- INL prefers to direct measurement of produced hydrogen with flow meter

Key Take-Aways

- PCEC shares some protocols with SOEC on basic characterizations
- Faradaic efficiency measurement procedures should be consistent to make correct comparisons and avoid misrepresentation
- Steam concentration can be 50%, cell area is >0.5 cm², and a 1000 h durability test is needed

Action Items

- INL/CSM will complete FE protocol writing using existing measurement procedures
- Revisit after one year operation and get feedback from users
- Need thermal cycling protocols, especially for PCEC

Session Attendee List

Session ID: H3

Title: Standardization needs and Protocols to written

Name	Affiliation
Olga Marina	Pacific Northwest National Laboratory
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Neal Sullivan	Colorado School of Mines
Seraphim Belko	Pacific Northwest National Laboratory

Summary of discussion

- Discussion of current protocols, their use and need for validation
- Barriers to adoption
- Difference between validating a protocol and validating an institution's capability to follow a protocol (validate equipment/samples/data quality, collect best practices)

Consensus and/or dissenting opinions

- Protocol validation through national lab consortium is progressing
- External protocol adoption is limited
- Publication in journal's does not result in an enduring or changeable protocol/standard

Key Take-Aways

- 8 out of 19 protocols have not been validated beyond protocol author
- 11 out of 19 have been validated
- Most important protocols for performance have been validated
- Work is progressing.
- Mechanisms for spreading the protocol usage are limited

Action Items

- Consider implementing protocol adoption through DOE FOAs
- Continue validating protocols developed in previous years through planned work
- Improve protocol accessibility

Session Attendee List

Session ID: H4

Title: Protocol Validation

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Olga Marina	Pacific Northwest National Laboratory
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