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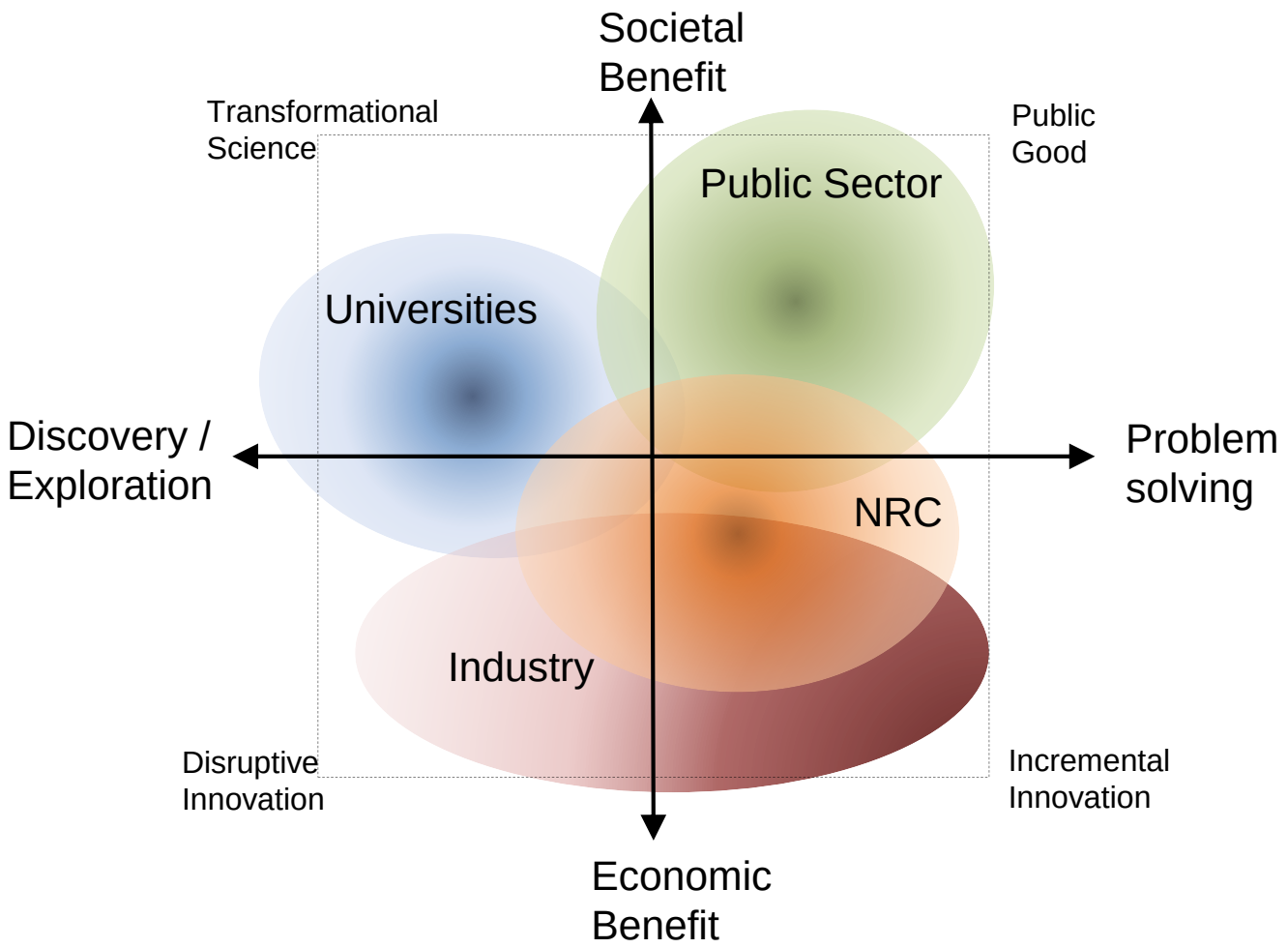
QC Research at NRC

François Girard, Technical Leader, Hydrogen and Fuel Cells
Energy, Mining & Environment Research Centre
National Research Council Canada

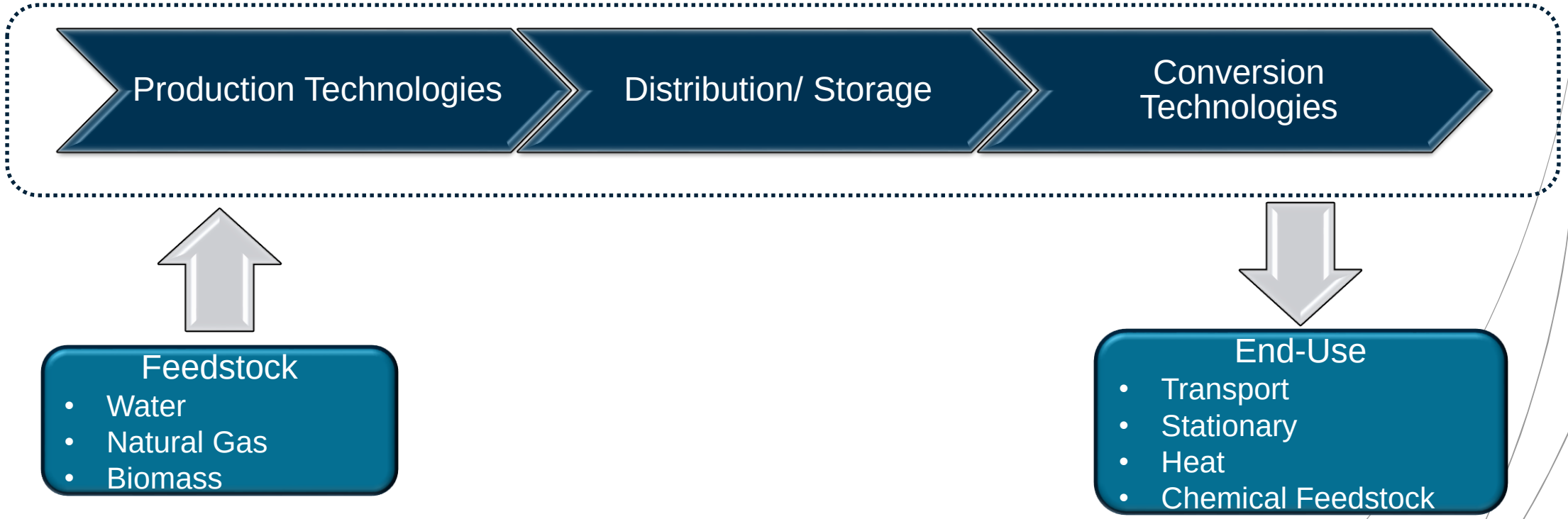
5th International QC Workshop
Hosted by the NREL (USA)
May 5-6 2021

NRC in Canada's Innovation Landscape



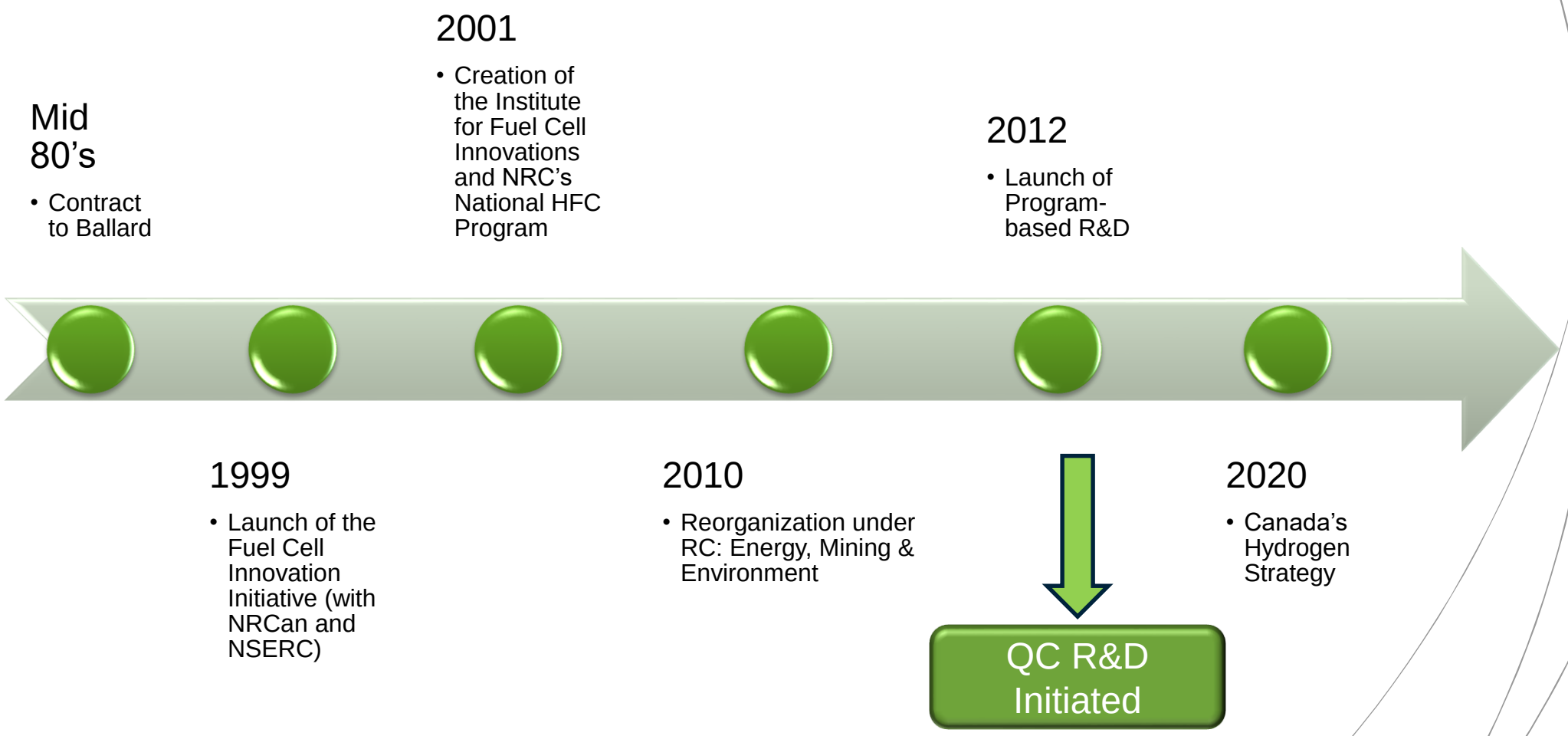
NRC Hydrogen Activities Scope

Enabling the use of zero-fossil GHG hydrogen in Canadian economic sectors, considering natural gas, water and biomass as the main feedstock

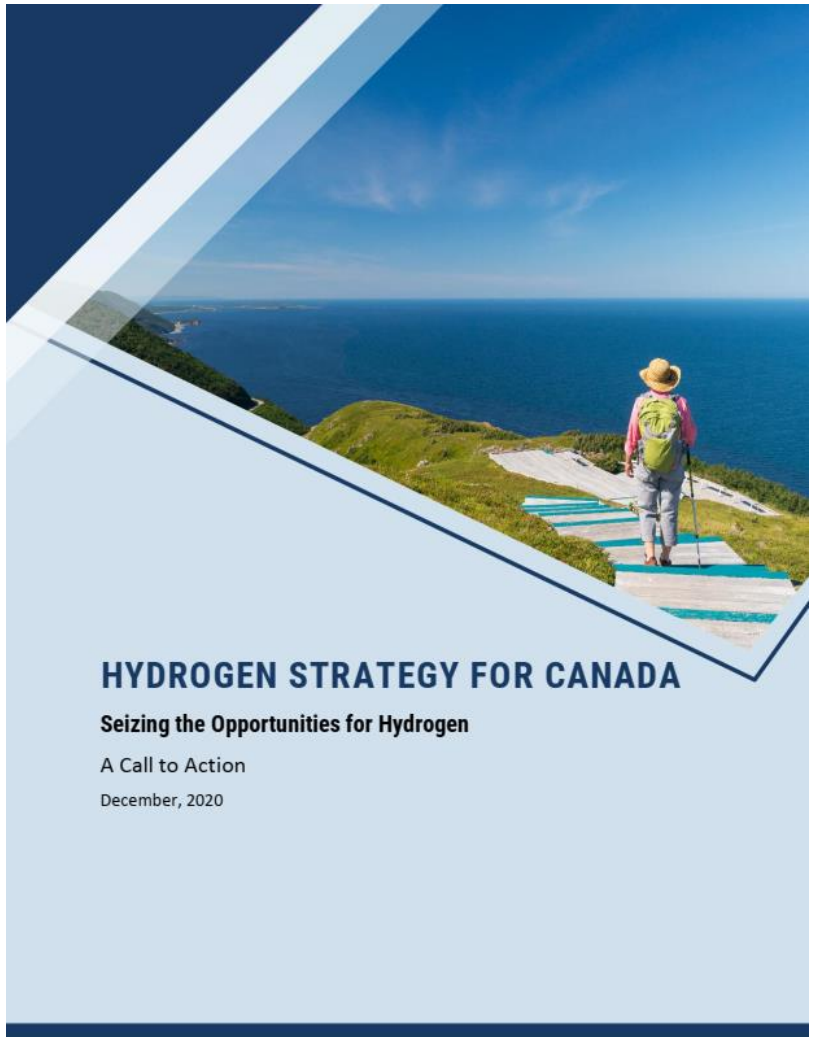


Working along the Technology Readiness Scale

Over 20 years of Hydrogen investment at NRC



Canada's Hydrogen Strategy



- Released December 16th 2020
- 3 years of intensive consultation
- Focus on both domestic adoption and export
- phases from Hydrogen Hubs to full deployment in 2050
- H2 seen to contribute to 26% of Canada's emission reduction and 30% of energy needs

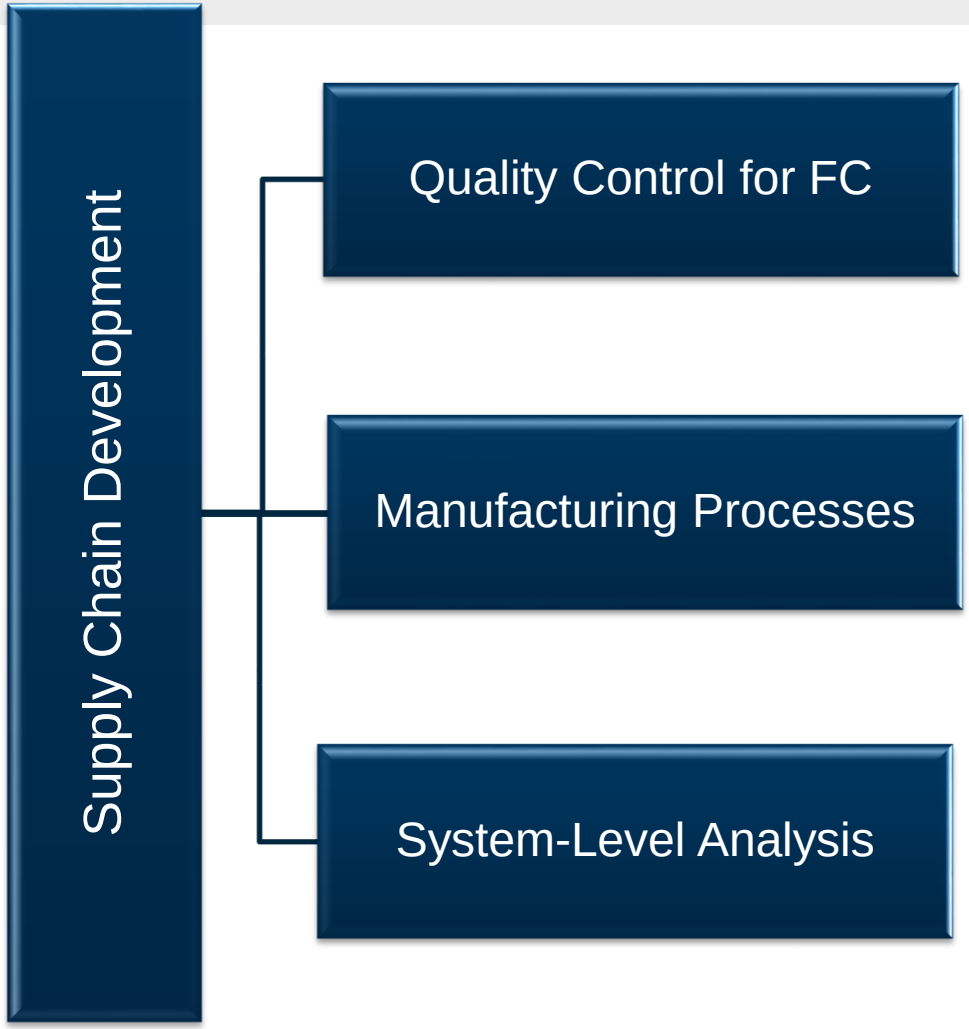
https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/environment/hydrogen/NRCan_Hydrogen-Strategy-Canada-na-en-v3.pdf

Why is QC important?

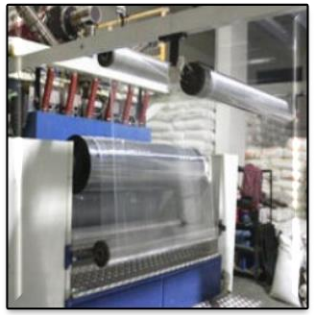
- **Reduces parts rejection**
- **Ensure reliability of product**
- **Provides clear expectations to suppliers**
  - Prioritize specifications of real importance
  - Reduces the number of specification testing
- **Stimulate the supply chain**

- **Manufacturing cost reduction**
- **Lowers the cost of ownership**
- **Harmonize specification measurement**
- **Increase healthy competition**

Industrialization of FC Technology



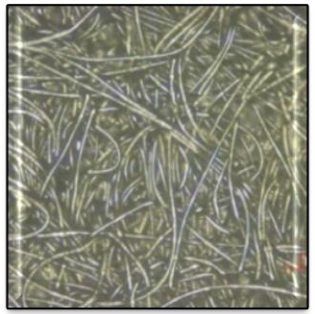
Manufacturing

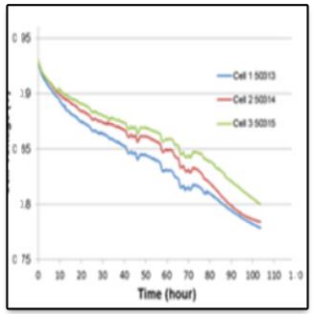


Membrane Manufacturing

Specifications Definition

Understanding MEA Process Impact on GDL Properties





MEA Conditioning

Diagnostic Tools

Quality Control Activities

International Collaboration

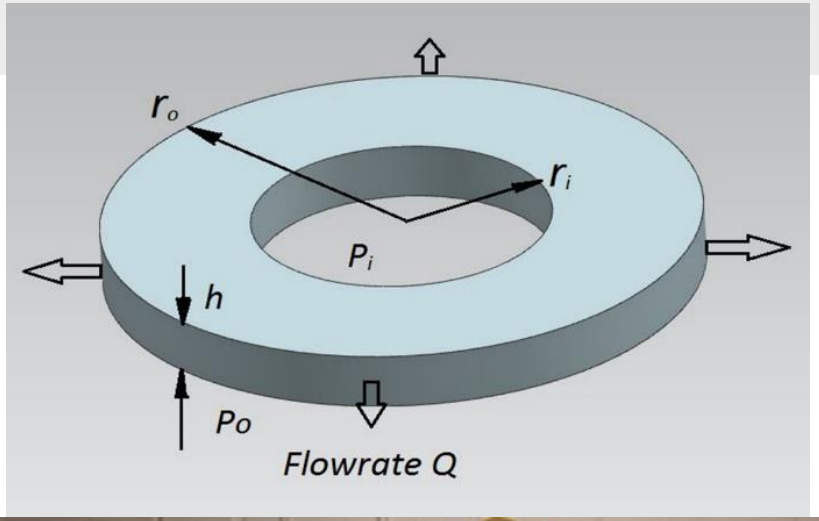
Understanding Defects Impact

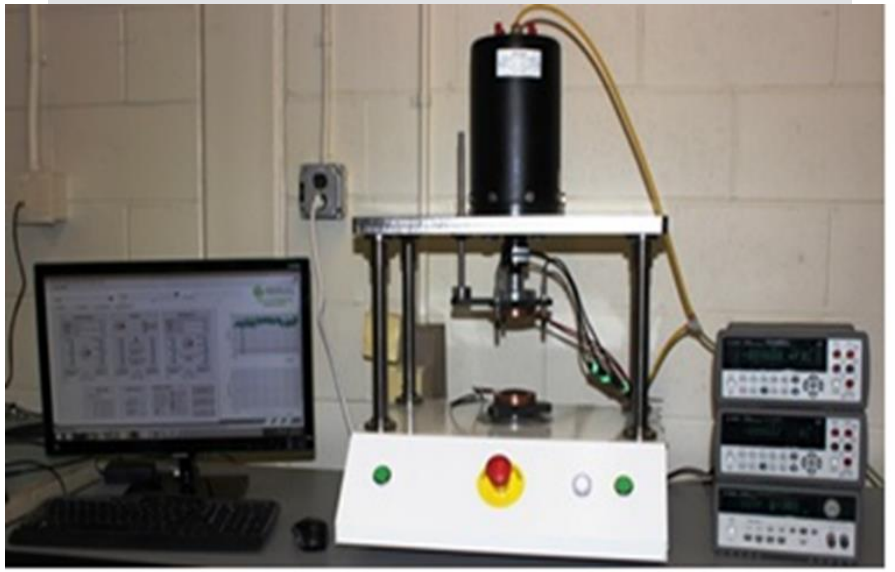
Develop QC Tools and Methods

- Workshops
- Book of Attributes
- Gap Analysis in Standards for Bipolar Plates QC
- Diagnostic Tools for MEA Conditioning
- Defects Impact Study
- TUC/RUC/IPP Measurement for GDL

Development of a 3-in-1 TUC/RUC/IPP Device for GDL QC

- To add IPP to TUC/RUC is challenging. It's realized by measuring the flow rate-pressure relationship in a radial-flow via an annulus of GDL samples.
- Simultaneous measurement of TUC/RUC/IPP with pneumatic compression under a varying load up to 5/10 MPa and a LabVIEW based interface with automated data collection.
- Through calibration, validation and benchmarking tests, main parameters of the machine met the design requirements.





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- 8 Peer Reviewed Articles
- 7 Communications
- 1 Book Chapter

Relevant Publications (1/4)

Peer-reviewed:

- Xiao-Zi Yuan, Nima Shaigan, Christine Nayoze, Nana Zhao, Monica Dutta, Carmen Chuy, Darija Susac, Nada Zamel, Taryn Biggs, David Fisher, Achim Bock, Pawel Gazdzicki, Ludwig Jörissen, Michael Ulsh, Ulf Groos, François Girard, "A review of functions, attributes, properties and measurements for the quality control of PEM fuel cell components", J. Power Sources, 491, 229540 (2021) https://doi.org/10.1016/j.jpowsour.2021.229540
- Nima Shaigan, Xiao-Zi Yuan, François Girard, Khalid Fatih and Mark Robertson, "Standardized testing framework for quality control of fuel cell bipolar plates", J. Power Sources, 482, 228 972 (2021) https://doi.org/10.1016/j.jpowsour.2020.228972
- Nana Zhao, Zhiqing Shi, Régis Chénitz, François Girard and Asmae Mokrini, "Effects of 1, 2, 4-Triazole Additive on PEM Fuel Cell Conditioning", Membranes, 10 (11), 301 (2020) https://doi.org/10.3390/membranes10110301
- X.-Z. Yuan, E. Gu, R. Bredin, M. Baker, S. Lee, T. Biggs, A. Bock, V. Banhardt, J. Russell, F. Girard, "Development of a 3-in-1 device to simultaneously measure properties of gas diffusion layers for the quality control of PEM fuel cell components", Journal of Power Sources, 477, 229009 (2020) https://doi.org/10.1016/j.jpowsour.2020.229009

Relevant Publications (2/4)

Peer-reviewed:

- N. Zhao, Y. Chu, Z. Xie, K. Eggen, F. Girard, Z. Shi, "Effects of Fuel Cell Operating Conditions on Proton Exchange Membrane", Fuel Cells, 20 (2), 176-184 (2020)
- Nana Zhao, Xiao-Zi Yuan, François Girard, Keping Wang, Jing Li, Zhiqing Shi, "Effects of Membrane Additives on PEMFC Conditioning", ChemistrySelect, 4 (43), 12649-12655 (2019)
- Xiao-Zi Yuan, Elton Gu, Ryan Bredin, Marek Baker, Stephen Lee, Taryn Biggs, François Girard, Jeffery Russell, "Methods and Devices for Measuring GDL Properties", 30th International Electric Vehicle Symposium 2017, (EVS30) Stuttgart, Germany, October 9-11 2017, pp. 4765-4771 (2017) The European Association for Electromobility (AVERE)
- Xiao-Zi Yuan, Hui Li, Elton Gu, Weimin Qian, François Girard, Qianpu Wang, Taryn Biggs, Matthew Jaeggle, "Measurements of GDL Properties for Quality Control in Fuel Cell Mass Production Line", 29th International Electric Vehicle Symposium 2016 (EVS29), Montreal, Canada, June 19-22 2016, pp 2133-2142 Electric Drive Transportation Association (EDTA) (2016)

Relevant Publications (3/4)

Communications:

- X.-Z. Yuan, F. Girard, “Progress on book of attributes for the QC of PEM fuel cell components”, F-cell + HFC2020, Vancouver, September 2020
- X.-Z. Yuan, F. Girard, “CCM book of attributes for the QC of PEM fuel cell components”, 4th International Workshop on Quality Control: Factory Acceptance Testing & Break-in of Fuel Cell Stacks, Vancouver & Freiburg, October 2020
- F. Girard, “Fuel Cell Manufacturing R&D at the National Research Council Canada”, Advanced Manufacturing & Characterization of Fuel Cells and Electrolyzers Workshop, Hartford (CT), September 2019 (invited)
- X.-Z. Yuan, F. Girard, “Development of CCM book of attributes for the QC of PEM fuel cell components”, 3rd International Workshop on Quality Control, Fraunhofer ISE, Freiburg, September 2019
- X.-Z. Yuan, E. Gu, R. Bredin, M. Baker, S. Lee, T. Biggs, F. Girard, J. Russel, “Development of Standard Methods and Devices for Measuring GDL Properties”, EVS 2017 - 30th International Electric Vehicle Symposium, Stuttgart, Germany, October 2017

Relevant Publications (4/4)

Communications:

- X.-Z. Yuan, H. Li, E. Gu, W. Qian, F. Girard, Q. Wang, T. Biggs & M. Jaeggle, "Measurements of GDL Properties for Quality Control in Fuel Cell Mass Production Line", EVS29 Conference, Montréal, Québec, June 2016
- F. Girard, Q. Wang & H. Li, "Modeling and Experimental Study of GDL Structure Change during the MEA Manufacturing Process", Fuel Cell Seminar, Los Angeles, California, November 2015

Book Chapter:

- X.-Z. Yuan, Chapter 0095: "MEA - Membrane Electrode Assembly for Fuel Cells" in Encyclopedia of Energy Storage (Ed. Luisa F. Cabeza), Elsevier, 2021

What’s next?

New project on understanding the impact of manufacturing defects on FC performance and durability

Expansion of QC R&D to PEM electrolyzers

Thank you / Merci

francois.girard@nrc-cnrc.gc.ca