Utility-Scale Energy Storage: Low temperature electrolysis

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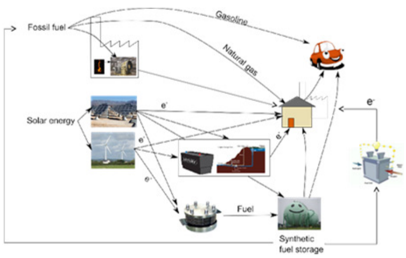
BACKGROUND

Alberta is committed to produce 30% of their electricity with renewable energy by 2030. Renewable energy technologies, such as wind and solar, however are intermittent making it difficult to meet supply and demand.

Also, only 40% of the secondary energy consumed in the US is in the form electrical power. Transportation sector is still dependant on fossil fuels (over 90%) [1].

Energy storage is necessary to increase grid reliability. The storage media should also be able to displace fossil fuels from the transportation sector and for heating.

Hydrogen energy storage would allow Alberta to store GWh of energy while allowing the energy to be used for electricity, heating and transportation.



SHORT-TERM OBJECTIVES

To develop proof-of-concept energy storage solutions suitable for storing energy in the MWh range and provide MWs of power to the grid at competitive costs

Reduce the cost of hydrogen electrolyzers by reducing the use of precious metal loadings from 4 mg/cm^2 to 0.5 mg/cm^2 of Ir and 0.1 mg/cm^2 Pt while achieving the same performance by studying the use of

- Novel, highly active, catalysts such as: a) **Iridium-Copper hydrous oxides** (from Dr. Bergen's laboratory) and b) **Ir-Ni alloys** (from Semagina's group),
- Novel **electrode fabrication methods** such as inkjet printing, and
- Polymer electrolyte **alkaline membrane** for electrolysis in order to eliminate the use of expensive titanium plates.

PROJECT OVERVIEW

HOW DOES IT WORK?

Hydrogen can be produced by splitting water into oxygen and hydrogen using devices called electrolyzers following the reaction: $2\,H_2O \rightarrow 2\,H_2 + O_2$. The heart of these devices is the catalyst layer, a layer made of precious metals that allows the reaction to occur.

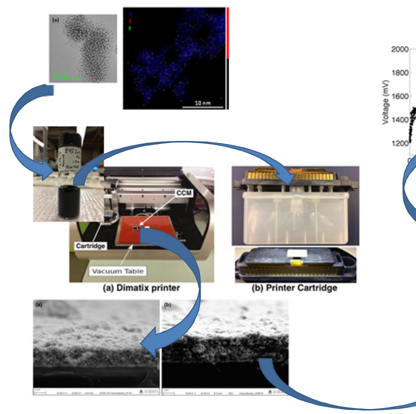
Large quantities of hydrogen can be store at 10 to 70 bar in depleted oil and gas fields, aquifers, and either salt or rock caverns. Imperial Chemical Industries and Gaz France have already operated large scale hydrogen storage facilities.

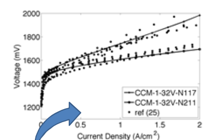
WHAT IS REQUIRED TO MAKE THE TECHNOLOGY SUCCESSFUL?

The development of abundant and cost-effective materials for electrolyzers, new electrode and electrolyzer fabrication technologies, and new electrolyzer designs are required to reduce the cost of the devices while increasing its efficiency and durability.

WHAT ARE WE DOING AT UALBERTA?

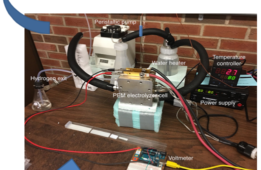
Facilities for the fabrication, characterization and testing of hydrogen electrolysis catalysts and single cell electrolyzers have been developed at the University of Alberta. These facilities have already been used to demonstrate that inkjet printer can be used to fabricate electrodes with less iridium and similar performance to conventional electrodes [2].





Ref	Fabrication method	Anode	Cathode	Membrane	E [V] @ 1 A/cm^2	E_{iR} [V] @ 1 A/cm^2
(26)	S-Decal	IrO_2 (0.5)	Pt black (0.5)	N115	1.78	1.695
(27)	S-Mem	IrO_2 (2)	20%Pt/C_{Etek} (0.4)	N115	1.65	1.565
(28)	S-Mem	IrO_2 (1.5)	30%Pt/C_{TKK} (0.5)	N1035	1.67	1.619
(29)	Decal	IrO_2 (1)	40%Pt/C_{JM} (0.2)	N212	1.64	1.606
(30)	Decal	IrO_2 (0.5)	46%Pt/C_{TKK} (0.25)	N115	1.72	1.635
CCM-1-32V-N117	Inkjet	IrO_2 (1.17)	46%Pt/C_{TKK} (0.1)	N117	1.743	1.624
CCM-2-32V-N117	Inkjet	IrO_2 (1.17)	46%Pt/C_{TKK} (0.1)	N117	1.743	1.624
CCM-1-32V-N211	Inkjet	IrO_2 (1.17)	46%Pt/C_{TKK} (0.1)	N211	1.608	1.591

Abbreviations: *TKK* = Tanaka Corp; *JM* = Johnson & Matthey; *Etek* = BASF; S = sprayed catalyst; Mem = membrane.



THEME OVERVIEW

Grids and Storage

New technologies enable us to exploit renewable energy resources, but truly harnessing their energy requires the ability to control and adapt to the complex interaction between multiple sources and users. Smart grid technology will enable systems that can adapt to the variation in supply that is common from renewable sources, while new storage technologies will make it possible to retain energy generated at during peak times to be withheld for later use. Developing hybrid grids that can accommodate both AC and DC power, accommodating distributed generation and energy storage, and effectively interface with legacy grid systems will be essential to our energy future.

EXPECTED OUTCOMES

The development of a multi-disciplinary network of researchers in the area of hydrogen and electrochemical energy storage at the UAlberta

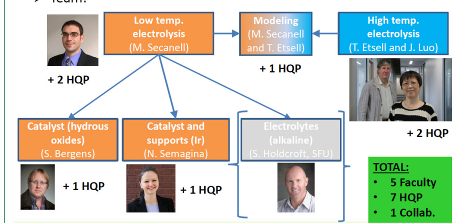
- 7 highly qualified personnel
- 5 Faculty involved from two engineering departments and from the Faculty of Science
- Monthly seminars, e.g., Peter Wagner (DLR) and Stefano Passerini (Helmholtz-Ulm)
- Annual conference

The development of novel Iridium hydrous oxides and Iridiun alloys for hydrogen electrolysis

The development of inkjet printer as a novel fabrication technique for electrolyzers and unitzed fuel cells

The development of numerical design and simulation tools to explore novel electrolyzer designs and for scale-up of designs developed at the University of Alberta to prototypes

➢ Team:



EXTERNAL PARTNERS

Dr. **Steven Holdcroft** at Simon Fraser University will provide polymer alkaline membranes for alkaline electrolysis

REFERENCES

[1] Annual Energy Review 2013, U.S. Energy Information Administration

[2] M. Mandal et al., ECS Transactions, 80 (8), 1085-1095, 2017

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