

# Chapter Excerpt



## About the book

In a land dominated by oil and gas, this new *Cool Companies*® book has a surprise:

**Alberta has a clean technology industry.**

Designed for entrepreneurial-minded business leaders passionate about entrepreneurial opportunities and ideas, this *Cool Companies*® book delivers a collection of innovation-driven companies pioneering their own space in the clean technology and green products industry. It also features the latest technologies and opportunities, cutting-edge research and proven industry supporters.



**Fuel Cells**  
are exciting, again

By Claudia Sammer

**F**uel cells had a lot of hype in the 1990s and investors poured millions into the technology. But when the technology took longer than expected to get to market, many of them lost their money. In the past 20 years, many advances have been made to improve fuel cell technology and this has created renewed optimism. Current work is focused on improving durability and driving down costs.

Similar to a battery, a fuel cell releases electricity and has an anode, a cathode and a ion-conducting centre called an **electrolyte**. Unlike a battery, a fuel cell can generate electricity almost indefinitely, if it has fuel and air. In a fuel cell, the chemical energy of the fuel is released via an electrochemical reaction with oxygen from the air to directly produce electricity. Solid Oxide Fuel Cells (SOFC) achieve very high electrical efficiencies of greater than 50%; using the high-grade heat that is also generated, SOFCs can achieve total efficiency to 90% through cogeneration (p.40). By comparison, burning fossil fuels achieves total efficiencies of only 30% to 45%. In other words, for the same amount of fuel, SOFCs double the energy production with virtually no emissions associated with combustion.

Fuel cells are also quiet and vibration free. They have low maintenance, a long operating life and few moving parts which makes them very reliable. They are also scalable, which means many can be connected to operate as a larger system.

There are five main types of fuel cells. Canada is focused primarily on two. One of these is Proton Exchange Membrane Fuel Cells (PEMFC) that run on hydrogen or alcohol and are well-suited for mobile applications such as cars and laptops. Alberta's **Gen-X Energy** (profiled p.38) is pioneering small-sized PEMFCs as well as methanol-powered fuel cells, which is also a focus for **Evergreen Energy** (profiled p.37).

Canada also has a very strong research program in Solid Oxide Fuel Cells (SOFC), especially in Alberta. SOFCs are ideal for distributed power generation in homes, buildings and industry. SOFCs run on natural gas, diesel or hydrogen. In Alberta, **Versa Power Systems** (profiled p.38) and **DDI Energy** (profiled p.37) are SOFC leaders. With its high profile clients such as **Google** and **eBay**, SOFC producer **Bloom Energy** of Silicon Valley has already become a media darling.

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## Chapter Excerpt

### Fuel Cells

This chapter presents is the largest collection of Alberta-based fuel cells companies and researchers ever assembled. It includes companies delivering eco-friendly off-grid power using fuel cells as well as fuel cells to replace regular batteries in mobile applications such as laptop computers.



A polymer electrolyte (PEM) fuel cell assembled in a test block.

Photo Credit: Steve Bergens (p.37)

# Fuel Cells are exciting, again

By Claudia Sammer

**F**uel cells had a lot of hype in the 1990s and investors poured millions into the technology. But when the technology took longer than expected to get to market, many of them lost their money. In the past 20 years, many advances have been made to improve fuel cell technology and this has created renewed optimism. Current work is focused on improving durability and driving down costs.

Similar to a battery, a fuel cell releases electricity and has an anode, a cathode and a ion-conducting centre called an **electrolyte**. Unlike a battery, a fuel cell can generate electricity almost indefinitely, if it has fuel and air. In a fuel cell, the chemical energy of the fuel is released via an electrochemical reaction with oxygen from the air to directly produce electricity. Solid Oxide Fuel Cells (SOFC) achieve very high electrical efficiencies of greater than 50%; using the high-grade heat that is also generated, SOFCs can achieve total efficiency to 90% through cogeneration (p.40). By comparison, burning fossil fuels achieves total efficiencies of only 30% to 45%. In other words, for the same amount of fuel, SOFCs double the energy production with virtually no emissions associated with combustion.

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## DDI Energy

### Leader in off-grid power generation systems using Solid Oxide Fuel Cells

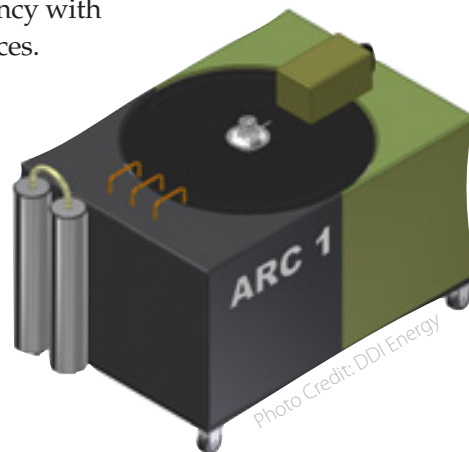
A village in Africa will soon be using DDI Energy's remote power generation system to power their hospitals, schools and orphanages and provide them with up to 100 litres of fresh water a day. DDI Energy specializes in integrating Solid Oxide Fuel Cells (SOFC) with hardware components and control software to create low-maintenance power generation systems for remote locations. DDI Energy makes several scalable systems from 3 to 40 kW that can be powered by natural gas, propane or methane, and can achieve 45% electrical efficiency with very low emissions and operating costs compared to other power sources.

**COMPANY:** DDI Energy Inc., [www.dionnedesign.ca](http://www.dionnedesign.ca), 20 employees, founded 2003, investor/revenue/grant funded, products sold in North America, Asia and Africa, larger manufacturing facility complete by Q1-2011 in Airdrie, 213 Railway Street East, Cochrane, Alberta T4C 2C3, 403.709.0047

**PRODUCTS:** Off-grid SOFC power generation systems (pictured)

**GROWTH STRATEGIES:** Seek investors and strategic distribution all over the world

**CONTACT:** Deborah Dionne, CFO and Co-Founder, [info@dionnedesign.ca](mailto:info@dionnedesign.ca), 403.709.0047



## Evergreen Energy

### New solar + fuel cell powered generator adds reliability, saves money and reduces environmental impact

A natural gas or oil well site needs a small amount of electricity to keep the well operational and to run monitoring equipment. Being in remote locations, these sites need an off-grid power source. While there are many different kinds of power sources available, many have drawbacks such as fuel inefficiently, the high cost of fuel and refueling, unreliability in harsh weather conditions and high greenhouse gas emissions. Evergreen has developed a new, robust, eco-friendly off-grid power generator (pictured) that runs on solar power when the sun shines. On cloudy days, the generator uses a fuel cell that consumes a small amount of methanol, resulting in very low greenhouse gas emissions.

**COMPANY:** Evergreen Energy Technologies Inc., [www.evergreen-eti.com](http://www.evergreen-eti.com), 1 employee, founded 2009, startup, grant/investor funded, cold weather field testing started 2010 with CCEMC funding (pp.23,74), sales in summer 2011, 10290 Tuscany Hills Way NW, Calgary, Alberta T3L 2G5, 403.370.5437

**PRODUCTS:** Reliable and green off-grid power for remote locations

**GROWTH STRATEGIES:** Seek distributors, joint venture manufacturers and licensees

**CONTACT:** Darryl West, President and Founder, [darryl.west@evergreen-eti.com](mailto:darryl.west@evergreen-eti.com), 403.370.5437



## Gen-X Power

### World's first compact user friendly fuel cells could be the next breakthrough

At the same size as a D size DC battery, Gen-X Power's light-weight and transportable fuel cells could be the world's next plug-and-play power source. Like the DC batteries we use today, Gen-X's fuel cells have a cylindrical design, which gives it many advantages: they are compact, have improved longevity and are available in modular units with different voltages. This unique design was chosen to keep maintenance low and improve safety. Gen-X's fuel cell design also uses a minimum amount of expensive noble metals as catalysts, meeting another key requirement of the Holy Grail of fuel cells: affordability. Gen-X's fuel cell uses a novel capillary membrane created by **Whitefox Technologies** (p.17) that works with both acidic or alkaline fuels. The company's manufacturing process is easily scaled up or down to a wide variety of fuel cell sizes and geometries.

Photo Credit: Whitefox Technologies



**COMPANY:** Gen-X Power Corp., sister company to **Whitefox Technologies** (p.17), [www.whitefox.com](http://www.whitefox.com), 11 employees, founded 2000, investor/grant funded, working prototype in development, several patents granted, 1101 - 19<sup>th</sup> Avenue NW, Calgary, Alberta T2M 1A1, 403.210.2999

**PRODUCTS:** Fuel cells that can be fuelled by liquid ethanol, methanol or hydrogen gas

**GROWTH STRATEGIES:** Continued R&D, seek investors and strategic partners for commercialization

**CONTACT:** Dr. Stephan Blum, CTO and Founder, [sblum@whitefox.com](mailto:sblum@whitefox.com), 403.210.2999

## Versa Power Systems

### North American leader in advanced solid oxide fuel cell (SOFC) stacks and modules

Versa Power Systems develops and builds SOFCs ranging from 5 to 50kW which commercial buildings use to generate their own environmentally-friendly and energy efficient electricity from natural gas. Versa's SOFCs are engineered to use waste heat and can achieve energy conversion efficiencies up to 85% through cogeneration. Through the **US Defense Advanced Research Projects Agency's** Vulture program, Versa is also working with **Boeing** to develop an unmanned aircraft that can remain in the air at 60,000 to 90,000 feet for at least 5 years and continuously deliver surveillance data to the earth. The aircraft's energy will be delivered by combining solar power with Versa's SOFC technology.

**COMPANY:** Versa Power Systems (also p.35), [www.versa-power.com](http://www.versa-power.com), 40 employees, founded 1996, investor/grant funded, early commercialization stage, 4852 - 52<sup>nd</sup> Street SE, Calgary, Alberta T2B 3R2, 403.204.6100

**PRODUCT:** SOFC stacks and modules

**GROWTH STRATEGIES:** Seek investors and strategic partnerships with energy companies

**CONTACT:** Dr. Robert Stokes, President, CEO and Founder, [information@versa-power.com](mailto:information@versa-power.com), 303.226.0763 (based in USA)



10 kW SOFC stack module integrated into a 10kW System

## Research

### SOFCs that run on fuel with impurities

Dr. Hill is exploring how SOFCs can be directly fuelled by hydrocarbons and hydrogen containing impurities. These fuel sources are often found as byproduct energy streams in the oil and gas industry, and energy efficiency would increase if the fuels did not need processing before being used. One challenge in creating robust SOFCs is the effect on the fuel cell components from the high temperatures in which they operate. Another challenge is preventing carbon contained in the fuel from depositing in the fuel cell, which causes the fuel cell to fail.

**CONTACT:** Dr. Josephine Hill, Chemical & Petroleum Engineering, University of Calgary, Zandmer/Canada Research Chair in Hydrogen and Catalysis, [jhill@ucalgary.ca](mailto:jhill@ucalgary.ca), 403.210.9488

### Ultra low platinum quality catalysts

The best electrodes for fuel cells contain platinum, which is a very expensive element. Dr. Bergens' nanoparticle engineering research successfully makes equivalent quality electrodes using only a tiny fraction of platinum.

**CONTACT:** Dr. Steven H. Bergens (also p.45), Chemistry, University of Alberta, [steve.bergens@ualberta.ca](mailto:steve.bergens@ualberta.ca), 780.492.9703

### Hydrogen fuel cells without water

Hydrogen fuel cells typically use water to carry a charge in the electrolyte. Drs. Shimizu and Thangadurai have found significant efficiencies and cost savings by using a non-water based electrolyte, a unique porous nano-crystalline material, and operating the fuel cell above 100°C. They are working on commercializing this technology with Canada's world leader in hydrogen fuel cells, **Ballard Power Systems**, and are looking for more partners.

**CONTACT:** Dr. George Shimizu (also p.62), Chemistry, University of Calgary, [gshimizu@ucalgary.ca](mailto:gshimizu@ucalgary.ca), 403.220.5347 and Dr. Venkataraman Thangadurai, Chemistry, University of Calgary, [vthangad@ucalgary.ca](mailto:vthangad@ucalgary.ca), 403.210.8649

### Cheaper and more durable fuel cells

Dr. Birss' team is developing new solid oxide fuel cell (SOFC) anode materials that are highly active, yet stable in sulphur-containing fuels found in Canada. This work, in collaboration with other teams in Canada, who are developing entirely new SOFC designs, will ultimately lower the cost of SOFCs. The team is also replacing expensive noble metals used in Proton Exchange Membrane (PEM) fuel cells and direct alcohol fuel cells with cheaper catalysts that will lower overall cost of

this technology. One component of the work is focused on developing novel nanostructured carbon support materials which keep the catalytic nanoparticles firmly attached, preventing carbon degradation and significantly increasing fuel cell lifetime.

**CONTACT:** Dr. Viola Birss, Chemistry, University of Calgary, Canada Research Chair in Electrochemistry of Fuel Cells and Related Systems, Lead investigator for the National SOFC Canada/NSERC Strategic Network (p.39 below), [birss@ucalgary.ca](mailto:birss@ucalgary.ca), 403.220.6432

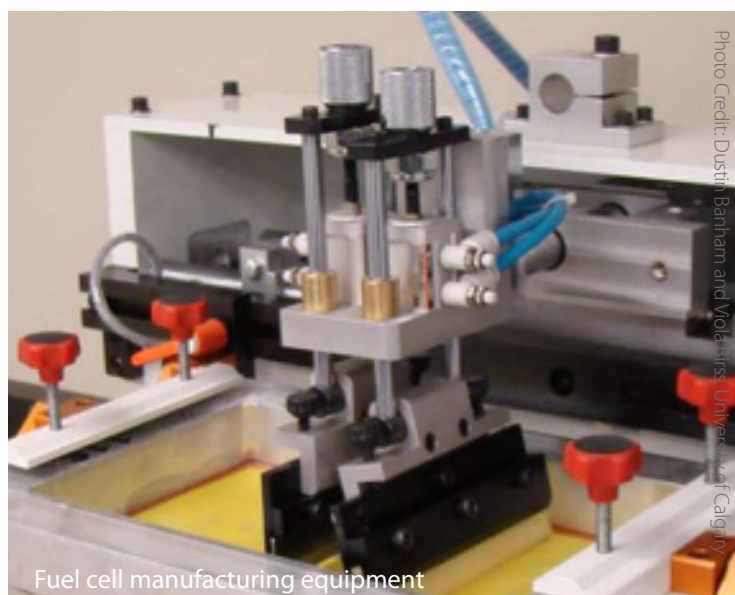


Photo Credit: Dustin Banham and Madeline Wainwright, University of Calgary

## Industry Support

### NSERC Solid Oxide Fuel Cells Canada (SOFC) Strategic Research Network

The SOFC Network is a network of researchers from across Canada focused on developing and improving the next generation of made-in-Canada SOFC technologies. These researchers from universities, companies and government are improving the lifetime, performance and fuel flexibility of SOFCs.

**CONTACT:** [www.sofccanada.com](http://www.sofccanada.com), Dr. Sharon Thomas, 403.210.6245

### Fuel Cells Research Lab at the University of Calgary

The University of Calgary is home to a state-of-the-art, \$5+ million fuel cell research facility where researchers and students are focused on accelerating the commercialization of next generation SOFC and PEM fuel cells and related materials. The lab also works with industry partners.

**CONTACT:** Dr. Viola Birss (p.39), University of Calgary, 403.220.6432