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Fuel for thought

A UVic research team lays the groundwork for a new generation of fuel cells

by Shannon McCallum

Can you imagine a day when driving your car or heating your home does *not* contribute to air pollution or global warming?

UVic engineers Ned Djilali and Peter Oshkai can. They and others in the university's Institute for Integrated Energy Systems (IESVic) are investigating fuel cell technologies that may soon turn this scenario into reality.

A fuel cell is an electrochemical device that generates electricity by combining stored hydrogen with oxygen from the air. Water and heat are its only by-products. Fuel cells can also be portable, providing a clean, safe energy source that can power anything from a cell phone to a remote community.

Djilali, who is director of IESVic, is keen to share his vision of where fuel cell technology may take us. "A fuel cell about half the size of a microwave oven can power a small home," he says. "A fuel cell about five times bigger can power your car—with zero tailpipe emissions."

As one of Canada's leading fuel cell research centres, IESVic is committed to promoting and developing sustainable energy systems and clean energy alternatives for the next generation. Founded in 1989, IESVic works with industrial partners across Canada and globally on all aspects of sustainable energy systems.

Athough fuel cells hold much promise as one answer to our energy needs, critical research still needs to be done before they are efficient and inexpensive enough to be commercially viable. That's where the UVic research comes in.

"The way hydrogen and oxygen are distributed is crucial to the operation of a fuel cell," explains Oshkai. "If the flow of the gases is too smooth there won't be enough mixing for the fuel cell to function properly. If we can get the amount of mixing 'just right,' we can greatly improve performance."

Since no one has looked inside a fuel cell while it's working, not a lot was known about the flow of gases—until now. Graduate student Jonathan Martin is peeking into the micro-scale behaviour of fuel cells by working with a transparent model of a fuel cell channel. Using an experimental technique known as particle image velocimetry (PIV), he's capturing the first images of how gases flow in a fuel cell.

PIV works like this: fluid flowing through the transparent model is seeded with light-reflecting particles. A computer-controlled laser illuminates the particles and images of the flow are taken using high-speed digital photography. By measuring how far the particles have travelled between images, Martin can calculate how fast the flow is moving and how much mixing is occurring.

"Although there have been some computer simulations done to visualize the flow of gases, we really needed to verify what we've seen in computer models with observations in an actual fuel cell," says Martin. "Now that we have more accurate descriptions of the flow behaviour, we can input this information into sophisticated three-dimensional models that will optimize the design of fuel cells."

Adds Djilali: "Up until now, designing fuel cell systems has been more of an art than a science, and has relied on trial and error. Jonathan's research and the advanced computational modelling work at IESVic are helping us to systematically engineer the next generation of fuel cells—bringing us one step closer to transforming our global energy system into one that is clean, safe and sustainable."

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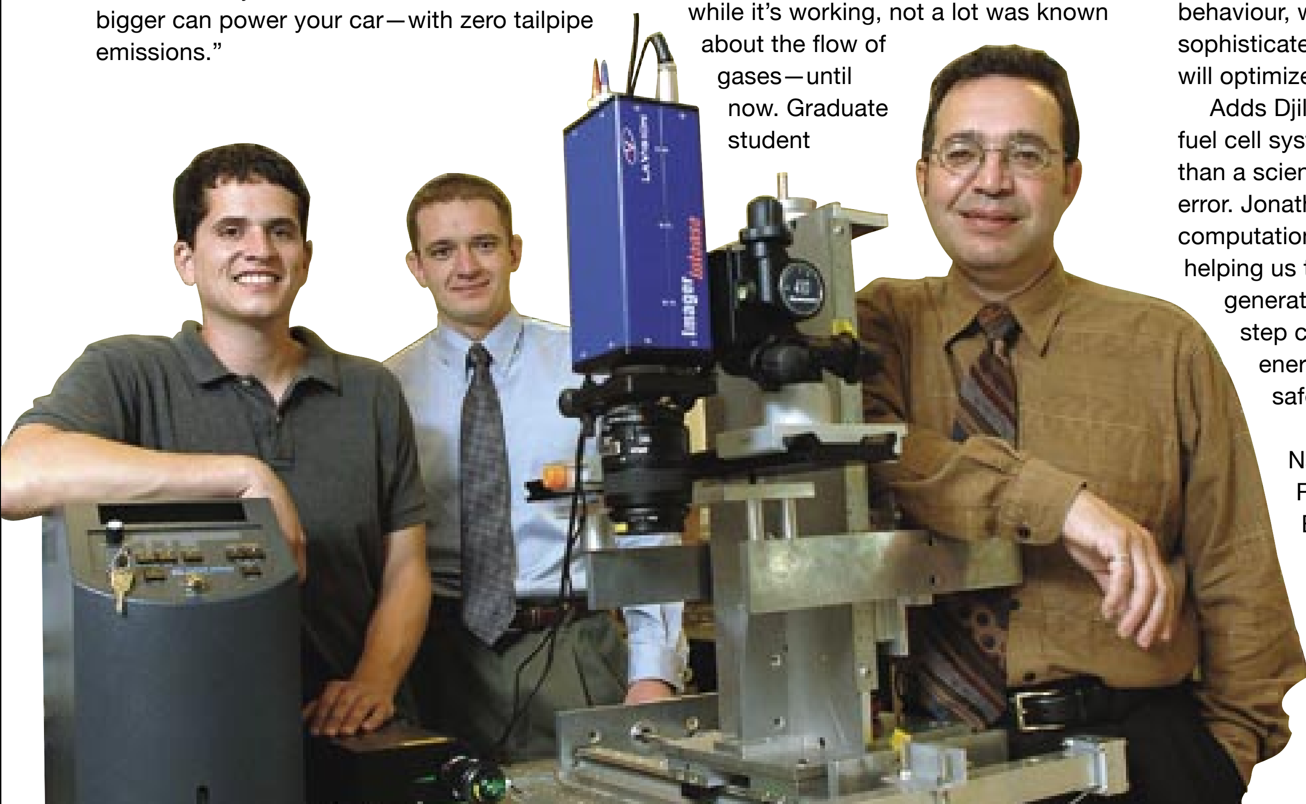

L-r: Martin, Oshkai and Djilali with an instrument that measures gas flow in fuel cells.

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Fuel cells are often compared to batteries, since both use chemical energy to generate electricity. But unlike a battery, a fuel cell doesn't store energy. It converts energy from one form (e.g. hydrogen) to another (electricity).

Unlike conventional heat engines, fuel cells convert chemical energy directly into electricity—in other words, without an intermediate conversion into mechanical power.

Hydrogen is a high-energy content, zero-emission, renewable fuel. It's also a highly flexible fuel that can be produced from a large variety of sources, and can be interchangeably converted to and from electricity.

A hydrogen-based economy would rely on an integrated approach to energy systems, combining renewable, hydrogen, hydro-electric and perhaps nuclear energy into a host of applications to meet the demands of a modern economy.

There's enough hydrogen currently produced in the world to power 250 million fuel cell vehicles. That's equivalent to the current fleet of road vehicles in North America.

Technologies exist to produce, store and distribute hydrogen and to convert energy. Some of them have even been commercialized. The main barrier is cost and lack of a hydrogen infrastructure.

To learn more about fuel cells and the range of other research at IESVic, visit www.iesvic.uvic.ca

This article was written by Shannon McCallum, a student in the faculty of graduate studies, as a participant in the UVic SPARK program (Students Promoting Awareness of Research Knowledge), supported by the vice president academic and provost and the vice president research.