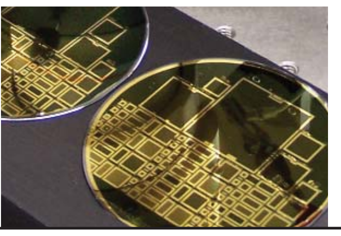
Quantum leap

Page 3

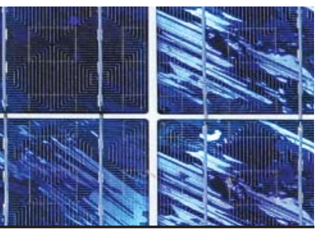


Canadians benefit

Page 7

What's this?

Find out on page 8



NRC NewsLink

ISSN 1913-1607 NATIONAL RESEARCH COUNCIL CANADA SPRING 2008

A gas hydrate is a crystalline solid consisting of water "cages" in which gaseous compounds, such as methane, are trapped one molecule at a time. At sufficiently high pressures, methane hydrates can remain "frozen" at temperatures above the melting point of ice, as shown in this "burning snowball".

Energy from fiery ice

Around the world, many countries with limited fossil fuel reserves are exploring ways to harvest natural gas hydrates — or "methane ice" — that are found in permafrost regions and on the ocean floor. "Natural gas hydrates are a huge potential hydrocarbon resource if the methane can be extracted cheaply enough," says Dr. Chris Ratcliffe of the NRC Steacie Institute for Molecular Sciences (NRC-SIMS). "Some people have estimated that global supplies of natural gas hydrates could store more energy than all the known resources we have from oil, natural gas and coal."

Whatever the future of this untapped resource in Canada, NRC will likely play an important role. "We're experts in the basic physical characterization of gas hydrate structures," says Dr. Ratcliffe. "We look at natural gas hydrate samples from all over the world, which get sent here for structural and compositional analysis."

> *"Natural gas hydrates are a huge potential hydrocarbon resource if the methane can be extracted cheaply enough."*
>
> Dr. Chris Ratcliffe, NRC

NRC researchers — including Dr. Ratcliffe and Dr. John Ripmeester — are currently studying gas hydrates from several angles. For example, the team has analyzed samples from an experimental gas hydrate well in Canada's Mackenzie Delta, a project led by Natural Resources Canada. "We've also been doing research with the Japan Oil, Gas and Metals National Corporation, which is interested in trying to harvest natural gas hydrates off the shores of Japan," says Dr. Ratcliffe.

Another research focus concerns the possibility of creating hydrates that store hydrogen for use in fuel cells. "It's possible to make pure hydrogen hydrates, but only at very high pressures and low temperatures," says Dr. Ratcliffe.

Continued on page 2

Energy code to get facelift

NRC and Natural Resources Canada (NRCan) have joined forces to update the Model National Energy Code for Buildings, which was last published in 1997 by NRC. The new energy code will establish minimum energy efficiency requirements for new construction, bringing technological innovation and energy-related concerns to the fore.

NRCan is providing technical expertise and up to $5 million to support this initiative. As home to Canada's model national construction codes, NRC is managing the updating process, which will ultimately help buildings save energy while reducing air pollution and greenhouse gas emissions as added benefits.

"The development of a single national energy code will encourage Canadian companies to create new energy-efficient technologies — thus promoting sustainability across the country," explains NRC President Dr. Pierre Coulombe.

The new code will be developed following the same broad consensus process that is used for the National Building Code of Canada and other model codes. Under the direction of the Canadian Commission on Building and Fire Codes (CCBFC), a standing committee will review and develop proposed technical changes to the current code.

"Interested stakeholders will have opportunities to provide feedback during our annual two-month review process that takes place every fall," says Cathleen Taraschuk, an officer with the Canadian Codes Centre at NRC. "And if anyone feels that we need to add or change something in the existing code, they can submit a code change request through our website. Every single comment we receive will be reviewed and assessed by the standing committee."

With support and input from the provinces and territories, the updated model energy code will be published in 2011. The new code will complement the next version of the model national construction codes, which are scheduled for publication in 2010.

Once enacted into legislation by the provinces and territories, the model energy code will apply to new buildings and provide Canada's construction sector with a single source of minimum requirements for energy efficiency in buildings. Today, provincial and territorial governments and industry rely on other regulatory and non-regulatory standards to design energy-efficient buildings. But with an updated national energy code, builders, designers, product manufacturers and the enforcement community will have access to a single made-in-Canada approach to energy efficiency, enabling them to conduct their business in more than one region. ■

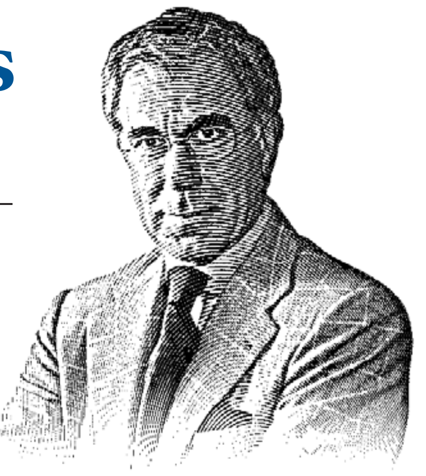
Dr. Richard Normandin, Vice-President NRC Physical Sciences, announces the update to the Model National Energy Code for Buildings.

For more information, visit: **www.nationalcodes.ca**

In this issue

40062591

President's outlook



Dr. Pierre Coulombe
National Research Council Canada

Discovering new ways to power our lives

Living in a modern society, we take energy for granted. Not only do we need oil, gas and electricity to run our homes and cars, but our manufacturing and transport industries use vast amounts of energy to deliver the products we depend on. The world's demand for energy is growing, and the environmental cost of traditional energy has become too great.

Energy research today is all about developing safe, affordable and reliable technologies that will not harm our environment or deplete our natural resources. NRC has been working for several years with industry and university partners to develop clean, renewable energy solutions.

At our Vancouver facility, NRC showcases groundbreaking fuel cell and hydrogen technologies through demonstration projects that include a hydrogen refueling station and storage tower for hybrid vehicles. Our objective is to help make fuel cell and hydrogen technologies a mainstream solution for Canada.

NRC is also leading a multi-partner research initiative on plug-in hybrid vehicles. Our expertise in new battery technologies will make a valuable contribution toward the development and commercial success of such vehicles.

NRC researchers are also studying the potential of extracting energy from ocean waves, offshore winds, tidal currents and fast-flowing rivers. NRC recently participated in the technical evaluation of proposals for Nova Scotia's Tidal Energy Demonstration Project, which aims to generate electricity from the tidal forces in the Bay of Fundy. NRC is also helping Canadian firms develop more efficient solar cells, wind turbines and small-scale, low-impact hydropower.

This research is already yielding results. I have every reason to believe that tomorrow's buildings will feature green energy technologies and that, gradually, our cars and industries will rely less and less on fossil fuels. It's just a question of time. ■

SUPPORTING INNOVATIVE COMPANIES

Harnessing the power of wind, earth and sun

Solar and wind power may offer hope for the future, but they're also dependent on one of life's great uncertainties — the weather. A Newfoundland company has invented a sophisticated system that lets Canadians take advantage of renewable energy when it's there, and revert to conventional sources when it's not.

The ARCS1000 is a control system that integrates a homeowner's wind, solar and conventional grid power systems. It was developed by WES Power Technology Inc. of St. John's, with support from the NRC Industrial Research Assistance Program (NRC-IRAP). "WES Power recognized that there was no one out there trying to integrate these different systems," says Carl King, an industrial technology advisor with NRC-IRAP.

The ARCS1000 manages all three power sources and decides which should be active at any given time. When the sun shines or the wind blows, the system takes advantage of the available energy rather than drawing on the conventional power grid. It determines the optimal mix of solar and wind power, and automatically takes power from the grid when renewable energy isn't available.

WES Power's technology is so promising that the company was recently acquired by ICP Solar Technologies in Montréal. The company is housed in the industry incubator at the NRC Institute for Ocean Technology in St. John's, and has received financial support and advice on market trends from NRC-IRAP. "We recognize the movement of the world towards greener power," says King. "We saw that WES Power had designed a product for tomorrow's markets." ■

WES Power founders Michael Snow and Philip Crowley saw a gap in the renewable energy market for a technology that could link together a homeowner's wind, solar and conventional power systems.

Energy from fiery ice

Continued from page 1

"We've been trying to find ways to create mixed hydrates that include hydrogen plus a second gas that can form a hydrate at higher temperatures and lower pressures. You then try to remove the second gas." So far, the NRC team has made gas hydrates that contain up to four percent hydrogen by weight.

In collaboration with Dr. Virginia Walker, a Queen's University biologist, and Peter Englezos, a chemical engineer at the University of British Columbia, the NRC team is also testing the effects of natural microbial materials for inhibiting the formation of gas hydrates.

According to Dr. Ratcliffe, gas hydrates can plug up pipelines, causing a huge problem for the oil and gas industry, which spends billions of dollars every year trying to prevent such blockages. Frozen hydrate plugs can not only stop the flow of natural gas, they can also damage a pipeline during thawing. "There can be a huge pressure difference on either side of the plug," he says. "When the plug begins to melt, it can shoot down the pipeline until it meets a restriction or bend in the pipeline and basically knock it apart."

In addition, NRC has started investigating the possibility of using hydrates to capture and store carbon dioxide, thereby reducing the build-up of this greenhouse gas in our atmosphere. "Carbon dioxide is one of the gases that can form a hydrate structure quite readily, and scientists have proposed storing a huge bed of CO_2 hydrates under the ocean floor, where it would be stable," says Dr. Ratcliffe. "How feasible this would be is another question." ■

Publications Mail Agreement No. 40062591
Return undeliverable Canadian addresses to:
National Research Council Canada
1200 Montreal Rd.,
Ottawa ON K1A 0R6

SUPPORTING INNOVATIVE COMPANIES

Quantum leap in solar cell technology

Despite significant progress, solar power still does not compete with fossil fuels or large electric grids in meeting a significant portion of a nation's energy demands. That's because today's conventional silicon-based photovoltaic cells are still too inefficient and expensive to manufacture for large-scale electricity generation. But recent advances in nanotechnology and photonics could change all that, according to Dr. Simon Fafard, the former NRC scientist who founded Cyrium Technologies. Thanks to support from NRC and the Canadian Photonics Fabrication Centre, this young Canadian firm has developed an innovation that will significantly improve the efficiency of solar power generation while reducing its cost.

After working for NRC and the optoelectronics industry, Dr. Fafard founded Cyrium Technologies in late 2002 to design and produce photovoltaic solar cells. The company is riding on the exceptional expertise of Fafard and his team in fabricating custom-tailored quantum dot materials — the heart of the advance his company will soon bring to market.

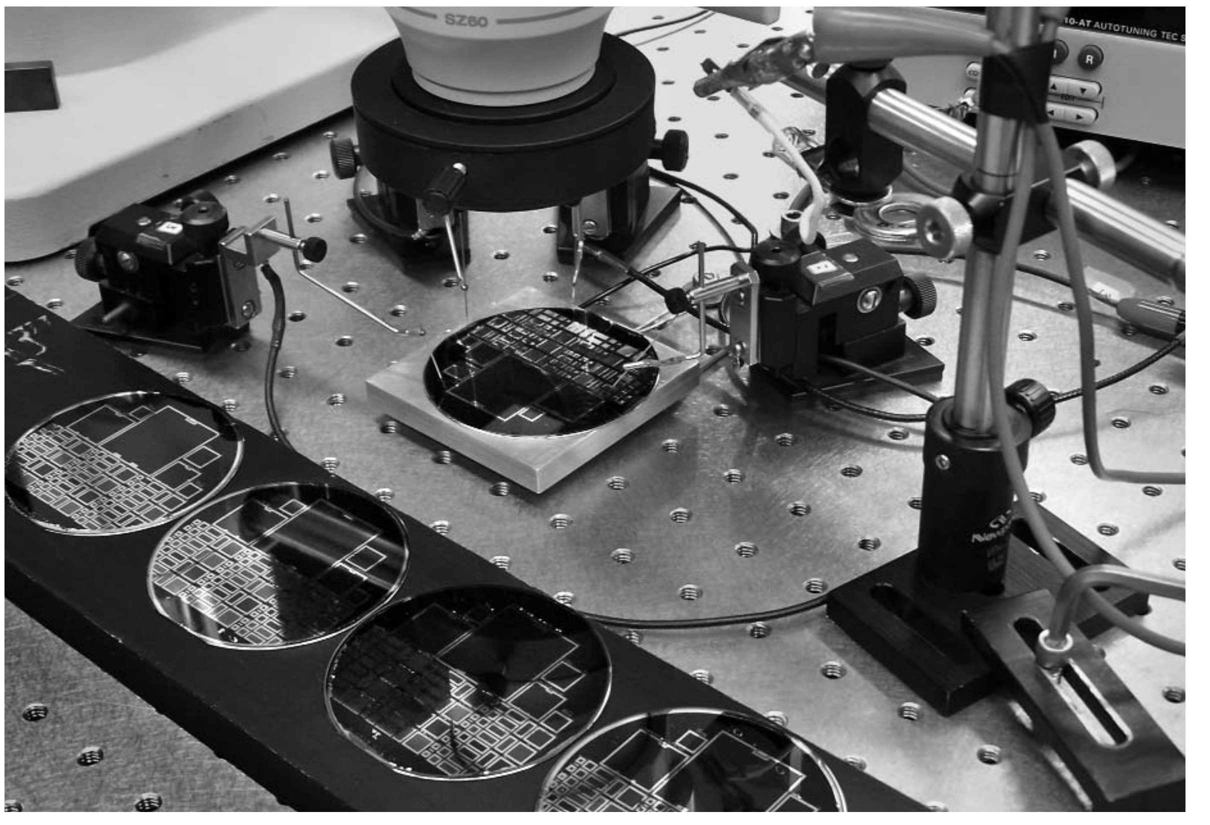
"Quantum dots are tiny nano-engineered crystals with specific optical properties dictated by their size and shape," explains Dr. Fafard. "By controlling their growth conditions, we can produce crystals that will absorb a particular segment of the solar spectrum." Smaller dots absorb more of the blue part of the spectrum, while bigger ones absorb more of the red part. Crystals of the right composition, size and shape can capture the near-infrared part of the spectrum, of particular interest to solar cell development.

Today's most efficient technology for generating electricity from solar radiation is triple-junction solar cells based primarily on gallium-arsenide semiconductors. Triple-junction technology converts a much higher proportion of light energy into electricity than conventional silicon solar cells, which deliver about 15 to 18 percent. Although today's best triple-junction solar cells are about twice as efficient as silicon solar cells, they still need to be more efficient to improve the economics of solar power.

According to Dr. Fafard, the drawback of today's triple-junction solar cells is that the middle junction absorbs too little of the solar spectrum, which limits the overall efficiency of the device. With custom-tailored quantum dots added to the middle junction, the Cyrium device is much more efficient. "By adding the quantum material we produce in controlled growth conditions, we can currently deliver more than 10 percent greater efficiency than today's best triple-junction devices. And, once optimized for photovoltaic concentrators (CPVs), our enhancement will bring our solar cells up to about 44 percent efficiency," he says.

Cyrium's unique contribution and expertise is its capacity to manipulate the production of quantum dots — man-made semiconductors — to capture a very precise range of light wavelength. Dr. Fafard filed for a patent in 2003, and today, Cyrium is the only company in Canada pursuing this application of quantum dots.

"Within the year, we will be selling our high-performance solar cells to CPV manufacturers throughout North America," says Dr. Fafard. These manufacturers will incorporate Cyrium solar cell chips into their product and sell it to big box stores, municipal power stations or remote, off-grid communities. "With our enhancement of today's CPV technology and enough volume, I believe we will be able to reach grid parity — the cost of coal-generated electricity."



Cyrium solar cell samples are inspected and tested to verify and optimize their photovoltaic performance after final processing at the Canadian Photonics Fabrication Centre.

The Canadian Photonics Fabrication Centre (CPFC) offers the expertise and equipment to prototype and produce small batches of photonic-based technologies for researchers and entrepreneurs. NRC, the Province of Ontario and Carleton University jointly founded the Centre, on the Montreal Road campus of NRC in Ottawa.

Cyrium has won the backing of three major venture capital firms. The Business Development Bank, Chrysalix Energy and Pangaea Ventures have invested about $6 million to help Cyrium create and share its prototypes with potential customers.

Dr. Fafard calls it a strategic decision to open the first Cyrium office within NRC's industry partnership facility in Ottawa. Cyrium has agreements to use NRC's labs and equipment, and has also received support from the NRC Industrial Research Assistance Program. "One of the best advantages of being at NRC is the access we have to the Canadian Photonics Fabrication Centre in the same building," he says. Because the CPFC is helping Cyrium fabricate its prototype solar cells, the young firm doesn't have to invest large amounts in its own labs and equipment while trying to break into the market.

With the quantum enhancement Cyrium is offering, solar power may soon become one of the world's most viable alternatives to fossil fuels. "We probably won't see large-scale adoption in Canada in the near future," he says. "But markets in the sunniest parts of Australia, Asia, the United States and Europe are ripe for the taking."■

LEADING-EDGE R&D

Plug-ins: where hybrids hit the road

Could electricity become a feasible, affordable fuel for vehicles? To find out, NRC is guiding a $7 million federal R&D program on plug-in hybrid electric vehicles (PHEVs), such as the concept car shown here, to further develop and reduce the cost of this technology. The interdepartmental program's focus is on energy storage, electrical drive components, power train optimization, and regulations for emissions and fuel efficiency.

Hybrid electric vehicles combine an electric motor and an internal combustion engine. Plug-in hybrids have larger batteries than hybrid electric vehicles and can be recharged by the vehicle engine, by regenerative braking, or by plugging them into an electrical outlet.

Improving battery safety is the top concern. "Lithium ion batteries were originally designed for portable electronics and power tools — not for large moving objects that can crash into each other."

Dr. Davidson, NRC

NRC researchers are working primarily on energy storage issues. "Lithium ion batteries are the strongest contender for a PHEV propulsion system," says Dr. Isobel Davidson, program manager of the PHEV initiative and a researcher at the NRC Institute for Chemical Process and Environmental Technology. "We're trying to make the batteries cheaper, safer and more compact."

Improving battery safety is the top concern. "Lithium ion batteries were originally designed for portable electronics and power tools — not for large moving objects that can crash into each other," Dr. Davidson explains. "Standard lithium batteries can catch fire if ruptured. Our idea is to develop components that make the battery more oxygen-tolerant so it won't burn if accidentally exposed to air."

This five-year NRC-led initiative is funded by Natural Resources Canada's Program on Energy R&D. Launched in 2007, the PHEV R&D program also involves Environment Canada, National Defence, Transport Canada, and various university and industry partners. ■

PARTNERSHIPS AND COLLABORATIONS

Personal controls save energy

Office buildings equipped with both automatic and personal lighting controls can achieve major energy savings compared with conventional lighting systems — while improving the environmental and job satisfaction of office workers, according to a recent NRC study.

The study — conducted in partnership with the federal government's Program on Energy Research and Development, Public Works and Government Services Canada, BC Hydro Power Smart, and Ledalite Architectural Products — looked at the performance of a commercial lighting system that features three types of controls. These included occupancy sensors that gradually switch off lights when people leave a work area, light sensors that slowly dim lights when there is enough daylight to maintain illumination levels, and personal lighting controls that workers operate from their computer screens.

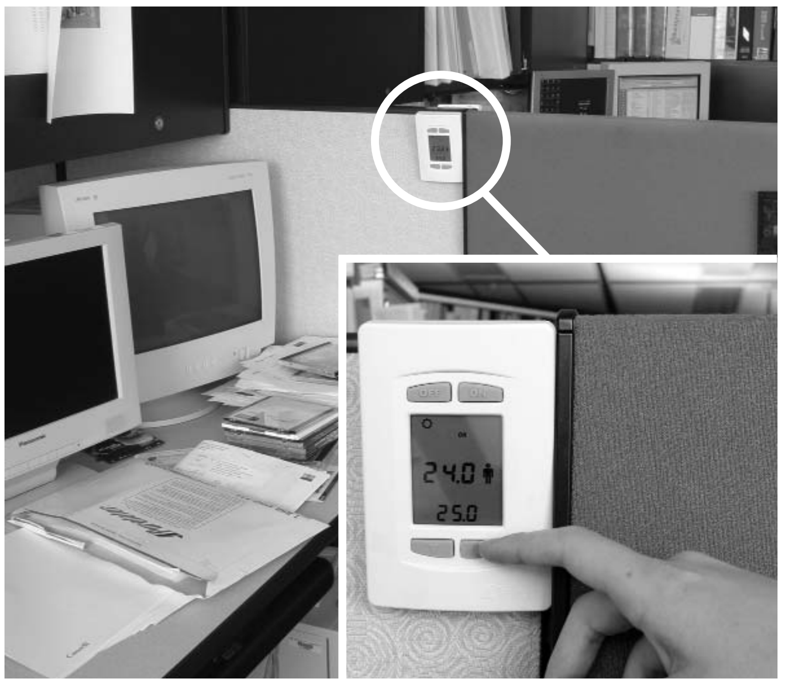
"A truly sustainable building can only be sustainable if it provides conditions that are pleasant and satisfactory to occupants as well as being environmentally friendly," says Dr. Guy Newsham, who leads the lighting research group at the NRC Institute for Research in Construction (NRC-IRC). "Our main interest is how to improve the satisfaction, comfort, mood and performance of people in buildings, using lighting systems."

Today, some green-minded workplaces have occupant and light sensors, but few have invested in personal lighting controls. "In a typical North American office environment, everyone gets the same light level regardless of personal preferences," says Dr. Newsham. "Personal lighting controls would allow people to choose their own workstation lighting level, largely independent of what their neighbours might want."

"Some workers use those controls to choose higher light levels than are recommended by prevailing standards," he adds. "But we've found that workplaces, on average, will save energy because more people tend to choose lower levels. And since they have personal controls, office workers can turn their lights off when they leave and turn them on when they arrive in the morning."

The NRC research team found that the combination of automatic and personal lighting controls reduced energy use by about 70 percent over a year-long period. "Most of these savings came from the automatic sensors, while the personal controls accounted for about 10 percent of the total energy savings," says Dr. Newsham.

"However, we also found that personal lighting controls improved both the personal and job satisfaction of office workers. So if you look at the intangible benefits they provide to occupants, we believe that over the long term an investment in this technology will pay off," he concludes. "We hope these findings will give building owners, managers, and practitioners more confidence to adopt such controls, to the benefit of the occupants and the environment." ■



Personal lighting controls, as shown in the inset, allow cubicle dwellers to choose their own lighting levels.

The NRC research team found that automatic and personal lighting controls reduced energy use by about 70 percent over a year-long period.

Reducing peak demand

When demand for electricity rises rapidly — especially on hot summer afternoons when air conditioners are on full blast and office lighting is still being used — brownouts or blackouts may occur. To prevent grid stress, many utilities are interested in load shedding, which involves signalling large power users such as commercial buildings to reduce electricity use.

With federal government and industry partners, Dr. Newsham's group is studying how far and how fast office buildings can lower their lighting and cooling requirements before workers start to notice. "The goal is to do this so that, at least initially, it will not affect people. Of course, in a greater emergency more extreme measures might be required," he says.

In lab studies, the group found that in work settings where no daylight is available, "you can only dim the electric lights by about 20 percent over a 10 second period without most people noticing. But if you dim them more slowly, over half an hour and in a daylit setting, you can dim the lights by about 50 percent for a few hours and the majority won't notice," says Dr. Newsham. "And we've raised office temperatures by 1.5 degrees (from 22 to 23.5 degrees) over a three hour period, without most people noticing the increase." This summer, his team plans to verify these findings in a real office or college building.

UPCOMING EVENTS

NanoForum Canada: Canada Nanoscience & Nanotechnology Forum, May 28–30, 2008 in Edmonton, Alberta

This forum will take place immediately after the 91st Canadian Chemistry Conference and will include four themed presentation sessions, each one featuring an opening address by an invited speaker and presentations selected from submitted abstracts. There will also be extensive poster sessions. The presentation themes include: material science; nano-scale applications of the Canadian Light Source (including biomedical); nano implications for drug delivery; and energy applications of nanotechnology. For more information, visit: **www.nanoforum.ca**

Emerging and New Approaches to R&D Management, June 18–20, 2008 in Ottawa, Ontario

This conference will look at practices, models, theories, frameworks and case studies to provide insight and better equip R&D-based organizations to deal with today's environment — allowing for better decisions with greater impact. Potential topics include: R&D for emerging technologies; managing R&D in China, India and other emerging economies; setting R&D direction and investments in the face of uncertainty; partnerships and collaborative approaches; and models to maximize the impact and value of R&D. For details, contact Flavia Leung by email: **Flavia.Leung@nrc-cnrc.gc.ca**

6th International Conference on Gas Hydrates, July 6–10, 2008 in Vancouver, British Columbia

This conference will highlight gas hydrates research from NRC and around the world. The conference themes include: energy and resources, environmental considerations, geohazards, oil and gas operations, novel technologies, and fundamental science and engineering. For details, visit: **icgh.org**

Laser-induced Incandescence: Quantitative Interpretation, Modeling, Application, July 30–August 1, 2008, in Ottawa, Ontario

Laser-induced incandescence (LII) is a powerful tool for particle concentration and particle size measurements in combustion and particle synthesis, as well as in environmental applications. The objective of this meeting is to identify and address the hurdles facing LII for its acceptance as an industry standard for particulate measurement. The unique capabilities of LII over other diagnostics will be identified and strategies developed to overcome inertia from industry. For more information, consult: **www.liiscience.org**

SUPPORTING INNOVATION

Environmentally friendly hydropower

Thanks to its EnCurrent product line, Calgary-based New Energy Corporation is taking the environmental sting out of small-scale hydropower. It's also making hydropower a viable alternative in locations not previously considered suitable.

The EnCurrent in-stream hydro turbine technology allows the company to harness the energy of water currents without dams. And, the slow movement of the EnCurrent turbine eliminates fish kill, a major disadvantage of other turbine technologies.

This technology emerged from work NRC conducted during the 1980s on a vertical-axis hydro turbine. After proving the technical validity of this type of turbine, NRC looked for a firm to take it to market. New Energy Corporation benefited from NRC-IRAP grants and technical advice to improve the design and performance of the technology, especially in low or restricted flow conditions.

The EnCurrent turbine can extract 35 to 40 percent of the energy in the water moving through it. Unlike other turbines, EnCurrent can capture the energy regardless of which way the current flows.

New Energy Corporation aims to provide sustainable hydropower to homeowners or businesses located beside a stream, river or tidal flow. It also intends to sell its technology to independent power producers and utilities above 1 MW of generating capacity. ■

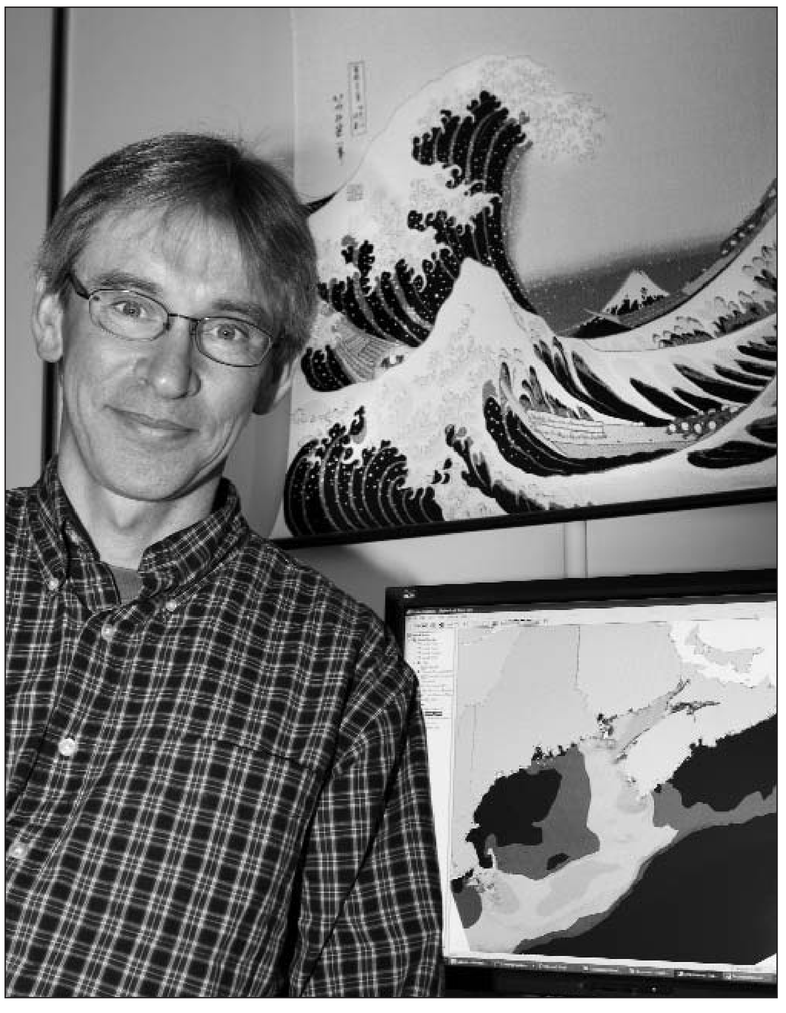
For more information, visit: **www.newenergycorp.ca**.

PARTNERSHIPS AND COLLABORATIONS

Oceans of energy

"On a global scale, Canada has one of the richest renewable marine energy resources of almost any country."

Dr. Andrew Cornett, NRC



Dr. Andrew Cornett, NRC Canadian Hydraulics Centre

What's the largest untapped source of renewable energy in Canada? Hint: it's not the usual suspects: wind, solar and biomass. According to the first comprehensive, Canada-wide inventory of marine renewable energy resources, the combined might of waves and tides off Canada's coasts has the potential to meet a large proportion of our electricity needs.

The NRC-led study, which grew out of a 2005 industry-government roundtable on ocean renewable energy in Vancouver, found that the total wave energy potential at depths of 1 kilometre off Canada's Pacific coast averages about 37,000 megawatts (MW), or over 55 percent of Canada's electricity consumption, while the total wave energy potential off the Atlantic coast is almost 150,000 MW — more than double our current electricity demand.

"On a global scale, Canada has one of the richest renewable marine energy resources of almost any country," comments Dr. Andrew Cornett, who leads the coastal engineering group at the NRC Canadian Hydraulics Centre (NRC-CHC) in Ottawa.

According to the inventory report, which Dr. Cornett prepared, "only a fraction of the available wave energy resource can be extracted and converted into useful power. Even so, the Canadian resources are considered sufficient to justify further research into their development as an important source of renewable green energy for the future."

The original aim of this study was to develop an interactive atlas — modeled after the Canadian Wind Energy Atlas — for use by power utilities, regulators, project developers, environmental scientists and other interested parties. Although the atlas development has not been funded yet, "private industry has used the inventory results to help attract more investment in marine energy R&D," says Dr. Cornett.

"So far, our work has mainly opened people's eyes to Canada's vast marine energy resources," he says. "Our inventory answers some key questions about tidal and wave energy: how large are the potential resources, where are they located and what are their characteristics?"

To conduct the study, Dr. Cornett's group collaborated with Triton Consultants, the Department of Fisheries and Oceans (DFO), Environment Canada, Powertech Labs and the industry association Ocean Renewable Energy Group.

The study included a site-by-site inventory of places where tidal currents were high. "We found about 190 sites whose potential power collectively exceeds an annual average of 42,000 MW, or roughly two-thirds of Canada's current electricity demand — although only a fraction of this amount could be extracted using available technology," he says.

Dr. Cornett's team is now conducting detailed resource assessments for three geographic areas where marine energy developments will likely take place first: the Bay of Fundy, the west coast of Vancouver Island, and the St. Lawrence River. "In these assessments, we're doing numerical modeling to better understand the tidal currents, river flows and wave resources closer to the coast." This work should be completed by the summer of 2008. ■

SCIENCE OUTREACH

Student site makes facts more fun

"This popular resource gives students a better understanding of the relevance of science in their daily lives and its significance in the world around them."

Margaret Kennedy, NRC

Since going online, NRC's Student Science & Tech website has created an expanding menu of interactive tools designed to stimulate elementary and high school students to explore concepts in the physical and life sciences — and find out about related research underway at NRC.

The site's interactive Periodic Table of the Elements was formally launched at the annual conference of the International Union of Pure and Applied Chemists in 2003. "Rather than creating a table of numbers and symbols — which is how the Periodic Table has traditionally been taught — we present real-life applications and research links along with the basic physical and chemical properties of each element," says Margaret Kennedy, senior science outreach advisor at NRC. The entry for hydrogen, for example, explains how the chemical energy generated when hydrogen combines with oxygen to produce water is converted to electrical energy in a fuel cell.

"Our primary audience is the grade nine and ten levels, when the Periodic Table is first introduced in science classes," says Kennedy. "Because this resource comes from NRC, this tool is regarded by educators as a reputable source of information, in both English and French."

The biology section features a microscope that allows visitors to explore the structures of a plant cell, animal cell, bacterium and virus — displayed in a virtual Petri dish. "The aim is to show students the differences in complexity of these building blocks and to highlight cellular structures in a fun and interesting way," says Kennedy.

If you click on the plant cell graphic, for example, the microscope zooms in to display its typical components. By moving your mouse around, you can highlight 15 different structures ranging from the cell wall and cytoplasm to the nucleus and ribosomes. Clicking on a specific structure reveals a magnified version and a definition. The biology section also provides links to Canadian research underway at NRC.

"We've received positive feedback from teachers who use our interactive tools to help students who might otherwise have trouble grasping scientific concepts," notes Kennedy. ■

To explore these web pages, visit: **www.nrc-cnrc.gc.ca/student-science-tech**

INNOVATION IN ACTION

Goal: net zero energy consumption

In one of its newest research facilities, NRC is walking the talk when it comes to clean, energy-efficient technologies. The new $20 million building that houses the NRC Institute for Fuel Cell Innovation (NRC-IFCI) in Vancouver is not just an ultramodern workplace for scientists and engineers to develop and test hydrogen and fuel cell systems. It's also a living lab in which technologies that rely on fuel cell and hydrogen advances are incorporated into the building's design and construction. These technologies provide valuable insights about how well they would work in real building conditions, and what needs to be considered to regulate such technologies for wider use.

According to David Semczyszyn, Director of Operations and Technology Demonstration at NRC-IFCI, the building is a showcase for hydrogen and fuel cell technologies. "We're using a 5-kilowatt solid-oxide fuel cell inside the building to provide heat and electricity. It's one of our demo projects." He explains that this fuel cell is working in tandem with ground source heat pumps that transfer the heat to floor heating coils. "It's a great opportunity to see exactly how effective a fuel-cell heating system could be in various energy-demand scenarios."

Another alternative energy technology is the building-wide system of photovoltaic cells (solar panels) installed in skylights, roofs and walls. These cells power a hydrogen electrolyzer that separates water into hydrogen and oxygen. NRC researchers are looking at using stored hydrogen in photovoltaic applications as a potential alternative to batteries for stored electricity. "We're testing the hydrogen produced by this system to see if we can use it for lab experiments," says Semczyszyn. "We're also looking into using this hydrogen in fuel cells that would back up our power supply for the building's computer network and cell phone booster station."

Pointing to the advantages of using the hydrogen produced on site, Semczyszyn comments: "Most commercially available hydrogen is produced by processing natural gas which is then compressed and transported by truck or rail — a process that emits greenhouse gases. We're way ahead by using photovoltaic cells for our heat and power because they produce hydrogen without emitting greenhouse gases."

Lining the top of the facility's atrium skylights are 93 photovoltaic panels that turn solar energy into electrical power.

With hydrogen and fuel cell systems running in their own workplace, NRC researchers have an exceptional opportunity not just to determine their effectiveness and safety, but also to test the best ways to install and integrate them. Because fuel cells and hydrogen delivery systems are not yet widely used, Canada is still in the early stages of developing and applying the codes and standards for their installation and use. NRC engineers have laid the groundwork for future regulations by using sound engineering principles to install the indoor fuel cell and ensure it operates safely. They have also developed extensive safety procedures and fire-detection systems for the building, given that hydrogen is highly flammable. Their objective is to share what they've learned about such alternative energy systems in buildings, and work with officials toward removing regulatory barriers to their widespread use.

The NRC-IFCI facility is yielding valuable information about hydrogen and fuel cell systems for buildings. Information like this could help pave the way to net zero energy consumption for tomorrow's built environment.

Despite the experiments going on at every turn, people walking around this research facility don't get the impression they're cloistered in a windowless lab. During the planning stage, NRC-IFCI called on a consortium of researchers in the fields of engineering, acoustics, indoor air quality, architecture and lighting to create the most comfortable conditions possible. Not only are there double-glazed energy-efficient windows everywhere, but daylight reaches deep into the most central office spaces. Employees can open windows, adjust thermostats and vary their own lighting.

By all accounts, the NRC-IFCI facility is a well-run experiment that's yielding valuable information about hydrogen and fuel cell systems for buildings. Information like this could help pave the way to net zero energy consumption for tomorrow's built environment. ■

LEADING-EDGE R&D

Biohydrogen — clean green energy

"Producing hydrogen from organic matter is better for the environment and requires considerably less energy than other methods. But we have to cross several hurdles to make it feasible on a large scale."

Dr. Serge Guiot, NRC

NRC researchers are busy engineering the production of hydrogen from organic wastes and crop residues. Their goal: turn low-grade waste into affordable, clean energy without producing greenhouse gases.

Today, most hydrogen is produced from natural gas, with the balance produced primarily from heavy oils, naphtha, and coal. Not only do these methods consume a lot of energy, they also produce greenhouse gases.

"Producing hydrogen from organic matter is better for the environment and requires considerably less energy than other methods," says Dr. Serge Guiot, who leads the environmental bioengineering group at the NRC Biotechnology Research Institute. "But we have to cross several hurdles to make it feasible on a large scale."

Dr. Guiot's team is trying to find the best mix of microorganisms and growth conditions to capture hydrogen from organic matter. Given that the hydrogen yield of conventional fermentation is quite limited, the team is looking at developing and optimizing microbial fuel cells assisted by a small electrical current. This approach, called biocatalyzed electrolysis, boosts the hydrogen yield after fermentation. The team is also examining a high-temperature fermentation approach to increase the hydrogen content of the synthetic gas produced by gasification, should this thermochemical technique work better for processing solid wastes, straw, wood residues, or coal.

"Our objective is to come up with biosystems that could be grouped into a multiple-stage process to capture almost all the hydrogen from the primary feedstock," notes Dr. Guiot.

Given time, this research may well lead to innovative solutions. Stay tuned. ■

Did you know?

For many years, Canada's pulp and paper industry wrestled with a huge problem: traditional pulp bleaching methods — which use chlorine — generate vast amounts of toxic liquid waste. But in the 1990s, NRC developed a new industrial enzyme that greatly reduces the pollution discharged by pulp mills.

The NRC-designed enzyme has helped Canadian pulp mills decrease chlorinated waste products by 4,000 tonnes per year, while saving each mill about $500,000 annually.

This enzyme, called xylanase, was long seen as a non-toxic and biodegradable tool that could facilitate pulp bleaching. Since natural xylanase falls apart under harsh industrial conditions, NRC researchers tailored a xylanase molecule to work at the higher acidity and temperature levels typical of pulp processing. ■

PARTNERSHIPS AND COLLABORATIONS

High-tech houses benefit Canadians

NRC, CMHC and NRCan are helping Canada's housing industry to develop, assess and increase consumer acceptance of new energy-saving technologies.

A solar concentrator system being evaluated at the CCHT test house.

When today's homeowners opt for a high-performance heating and cooling system or the best in energy-efficient windows, they might be buying a product assessed at the Canadian Centre for Housing Technology (CCHT). Since 1998, the CCHT has conducted research on a wide range of innovative technologies designed to significantly reduce home energy consumption.

CCHT is a partnership among NRC, Natural Resources Canada (NRCan) and Canada Mortgage and Housing Corporation (CMHC). It operates on the Montreal Road campus of NRC in Ottawa. "Since we opened ten years ago, we've assessed more than 30 housing-related technologies," says Mike Swinton, CCHT's research manager. "Many of these technologies are making their way into the marketplace or increasing their market share."

The Centre has assessed various heating and cooling systems, including systems that combine heat and power generation and technologies that use alternative energy. The Centre has also assessed various energy-efficient window technologies and devices. It conducts research in twin R-2000 houses, each endowed with more than 300 sensors and 23 utility and water meters. These houses are set up to simulate the conditions of a family of four taking showers, cooking, washing dishes, and generating body heat. Simulated occupancy helps provide a detailed assessment of how various technologies would perform in an inhabited R-2000 home.

CCHT provides the authoritative findings that manufacturers need to back up their products on the market. "We've been able to provide top-quality technology assessments partly because we have access to world-class research labs and computer modeling specialists," says Swinton. CCHT results have contributed to model benchmarking, which is used to predict residential energy performance for different locations across Canada.

Combined heat and power generation

CCHT researchers have examined residential technologies — called micro Combined Heat and Power technologies, or microCHP units — that generate both heat and energy. One unit, assessed in 2005, was the first-ever fuel cell installed for home heat and power. Fuel cell core technology could become a viable alternative to grid electricity for homes through small, distributed micro CHP plants.

CCHT researchers have also assessed two generations of a Stirling engine that produces electricity for home use, and an internal combustion engine coupled to ground storage. These experiments examined not only performance but also connectivity issues that arise between microCHP technologies and the house.

Alternative energy

The CCHT InfoCentre and FlexHouse — a showcase for flexible house design — both have rooftop solar panels, which generate electricity during daylight hours. A solar concentrator system connected to a storage tank in the basement of the FlexHouse provides heat for water and space heating.

Heating systems

The first systems assessed in the CCHT twin houses were gas-fired combined space and water heating systems. CCHT researchers have also examined a two-stage natural gas furnace, a high-efficiency condensing gas furnace, and electric furnaces with innovative controls and fan motors. In a novel heating project, a hydrogen electrolyzer produced hydrogen from water and electricity, which was added to the natural gas stream of a high-efficiency condensing gas furnace.

High-performance windows

In 2007, the CCHT compared the performance of high and low solar gain windows in both the heating and cooling seasons. Based on the results, models were created for different locations across Canada, which showed that higher energy savings were achieved with high solar gain windows for all the cities considered.

Energy-efficient devices

To assess products such as compact fluorescent lights and furnace motors, the staff at CCHT has measured both the electrical savings and their impact on space heating and cooling loads. CCHT researchers have also evaluated shower water heat recovery systems, which resulted in an online calculator to determine savings and payback periods.

"Saving energy in our homes is one of the best ways to contribute to a sustainable future," says Swinton. "With every passing year, we'll see more and more new housing built to run on the technologies we've assessed." ■

For more information, visit:
www.ccht-cctr.gc.ca/projects_e.html

WORKING WITH INDUSTRY

Testing the winds

Decades after developing one of the world's first vertical-axis wind turbines, NRC now helps manufacturers optimize their turbine designs. In December 2006, researchers at the NRC Institute for Aerospace Research (NRC-IAR) tested the performance of a wind turbine for the U.K. firm Quiet Revolution, using NRC's 9m by 9m wind tunnel. Earlier in 2006, the same crew evaluated an experimental turbine developed by Cleanfield Energy of Ancaster, Ontario, in collaboration with McMaster University engineers. Cleanfield has installed five of its 3.5-kilowatt wind turbines at an Ontario Ministry of Natural Resources facility in Kenora, and plans to install 150 more turbines on dozens of municipal buildings in Hamilton to reduce electricity costs and greenhouse gas emissions.

Besides testing wind turbines, NRC researchers are investigating whether their wind tunnels can be used to evaluate potential sites for turbines. "In Canada, the best places to put turbines tend to be higher elevation sites with hilly or mountainous terrain," says Dr. Guy Larose, a senior research officer at NRC-IAR. However, wind conditions can vary significantly over complex terrain, so wind farm developers must be sure the winds are reliable before they install turbines. "Since wind direction and wind speed are a function of the seasons, developers need to measure these variables for at least two or three years so they know how much wind energy they can depend on annually."

Dr. Larose and his colleagues believe that by measuring the air flow over scale models of terrain found at potential wind farms, they can slash the time it takes to assess the local wind energy resource from a few years to a few months. "So far, we've examined how to build scale models as efficiently as possible from topographic maps, and tested their characteristics," says NRC-IAR research officer Dr. Brian McAuliffe. "Next, we plan to test a scale model of a large wind farm on the Gaspé Peninsula, which will be operational by 2011. We hope to demonstrate that our wind tunnel data is comparable to the actual wind data from the wind farm site." ■

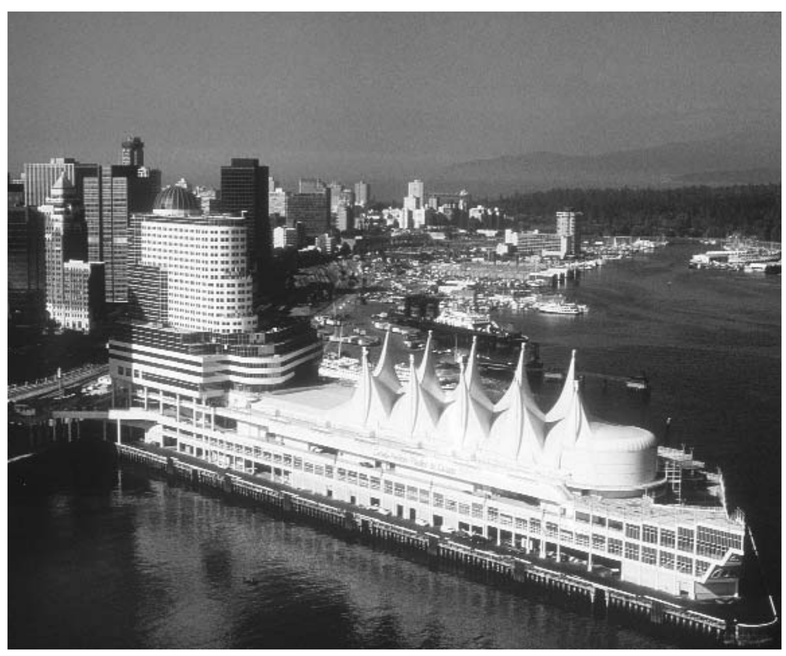
NRC research officer Paul Penna tests a vertical-axis wind turbine with Dr. Tamás Bertényi of Quiet Revolution.

SUPPORTING INNOVATIVE COMPANIES

Clean stacks: green power for homes

"It was critically important to have access to NRC's capability. They fully understood the scientific challenges of designing such an efficient fuel stack."

Jean-Guy Chouinard, Executive Vice President, Hyteon Inc.



Vancouver is home to the world's largest cluster of fuel cell expertise, with NRC-IFCI at its centre.

When Jean-Guy Chouinard was director of Quebec's Natural Gas Technology Centre, he was on the lookout for green solutions that would reduce the environmental impact of natural gas heating. That was when fuel cells caught his attention, and he has never looked back.

Today, the company that Chouinard co-founded, Hyteon Inc., has designed a complete fuel cell system that can power a home while reducing its carbon dioxide emissions by up to 40 percent. The proton exchange membrane (PEM) fuel cell was perfected with help from the modeling group at NRC's Institute for Fuel Cell Innovation (NRC-IFCI) in Vancouver, and the design is now being tested by major utilities in Europe and Japan.

Energy costs in Japan and some parts of Europe are among the highest in the world, and fuel cells are gaining great interest as a possible energy source for homes. But in order to offer a practical alternative to coal-fired and natural gas central power plants, fuel cells must reach extremely high levels of efficiency. "The name of the game is to have a system that is highly efficient at producing electricity while always recovering heat at the same time," says Chouinard.

Hyteon's unit, called a combined heat and power system (CHP), works in tandem with the electrical grid to meet all of a home's electricity needs. As an added bonus, the CHP recovers heat in the form of hot water that can be used for the home. "Homeowners see a savings on their annual energy bills, which provides a payback on the investment," says Chouinard.

The fuel cell stack runs on a gas mixture called "syngas," which contains mostly hydrogen. In order for the stack to reach peak efficiency, the gas must flow uniformly throughout the stack so that each cell carries an equal share of the load. "If some parts of the stack work harder than others, then the overall lifetime of the unit is shortened," says Dr. Simon Liu, leader of the modelling group at NRC-IFCI. The design of the unit must be finely tuned to reach this high level of performance. "It's very difficult for designers to figure this out without detailed modeling and simulation," says Dr. Liu.

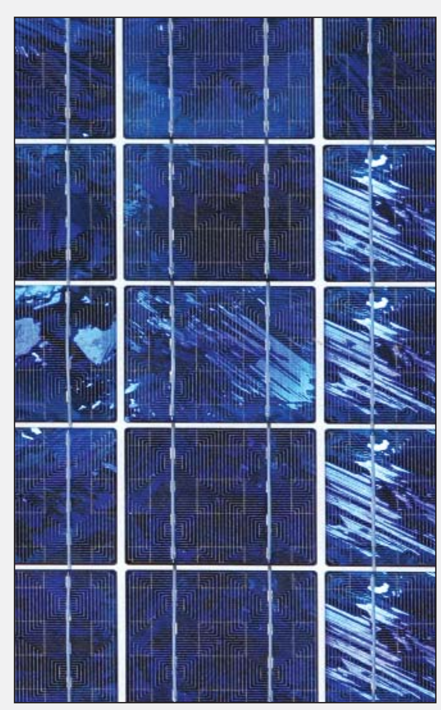
NRC created a 3D model of Hyteon's design and simulated the flow of gas through the stack. "We gave them the whole picture — where the gas concentration was high, where it was low, and where it was moving too quickly or slowly," says Dr. Liu.

The results helped Hyteon to perfect the design and surpass their goal of 90 percent system efficiency — more than enough to interest their European and Japanese clients. Without access to a 3D model, Hyteon would have been forced to build expensive prototypes to see their design in action. "This was the most important benefit for us," says Chouinard. "Through proper simulation, we avoided prototype costs."

Hyteon's CHP units are also attracting interest from Canadian utilities — in particular for use in remote areas where electricity cost is very high. "Our product offers potential for change in a practical way," says Chouinard. "It's a very viable technology that allows people to do something for the environment."■

What's this?

This is a close-up of a photovoltaic (solar) cell, a semiconductor device that generates electricity by capturing energy from the sun. Conventional solar cells are made from silicon crystals. What appears like snow is actually light reflecting off these crystals. ■



NRC NEWSLINK

NRC NewsLink is published four times a year by the National Research Council of Canada. It informs readers about the many NRC research and innovation programs, services and initiatives that serve the needs of industry, the economy and all Canadians.

Material in *NRC NewsLink* may be reprinted with permission, provided the source is fully acknowledged.

Publisher:
NRC Communications and Corporate Relations

Enquiries, subscription changes and requests for the electronic version of *NRC NewsLink* should be addressed to:

NRC NewsLink
National Research Council Canada
1200 Montreal Road
Ottawa, Ontario K1A 0R6
Canada

Fax: 613-998-8080
E-mail: info@nrc-cnrc.gc.ca
www.nrc-cnrc.gc.ca

ISSN 1913-1607

Recognized globally for research and innovation, NRC is a leader in the development of an innovative, knowledge-based economy for Canada through science and technology. NRC operates world-class research facilities as well as information, technology and innovation support networks coast to coast. Its outstanding people help turn ideas and knowledge into new products, processes and services, creating value for Canada. NRC works hand-in-hand with partners from industry, government and universities to help ignite the spark of innovation in communities across the land and to give Canadian companies a competitive edge in today's marketplace.