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Winds of change

Producing cleaner, cheaper hydrogen

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It's a delight to be back as interim editor at the *Canadian Chemical News*. Replacing the inimitable Jodi Di Menna will be a challenge, and everyone here wishes her the very best as she explores new horizons within the scientific community.

This summer issue of *ACCN* is rich, varied and timely, with input from readers and columnists on topics as diverse (and divisive) as the shift in focus at the National Research Council to the need to formally license chemists.

ACCN news editor Tyler Irving's Chemical News section embraces the quirky to the practical, and everything in between. He writes about GreenCentre Canada's agreement to commercialize a new class of iron-based catalysts developed by Atlantic chemists that will lead to greener processes for pharmaceuticals and polymers. There is also a story of a remarkable advance by University of Toronto chemists and physicists who have captured — with femtosecond accuracy and atomic resolution — real-time images of molecules undergoing structural transitions.

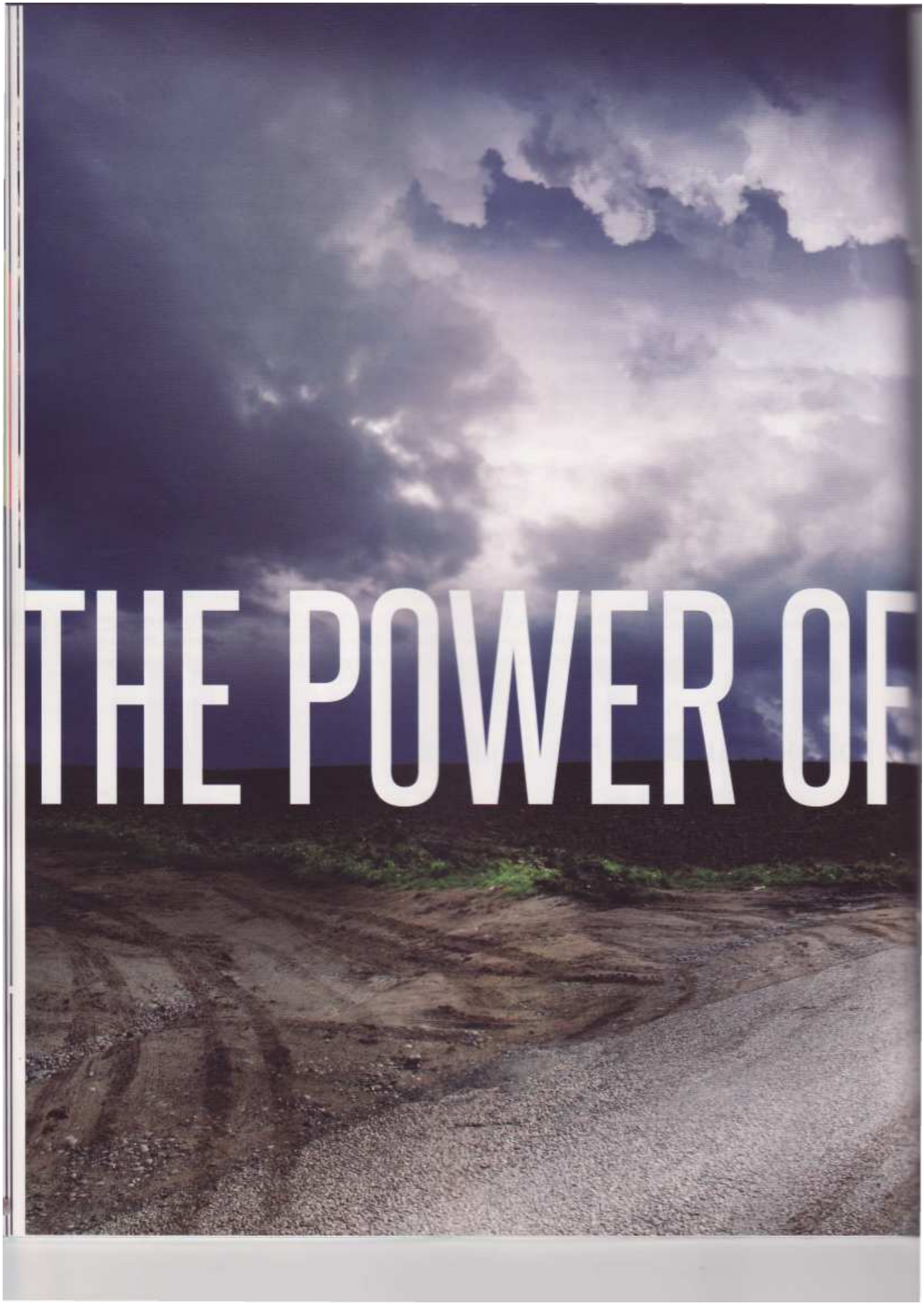
It is the quirky that is often the most interesting. *ACCN* has excerpted a chapter from Tyler Hamilton's book *Mad Like Tesla*, which profiles Louis Michaud of Ontario, who is pursuing a dream of turning waste energy into electricity-generating tornadoes. More than a story of an oddball inventor, the story highlights how lateral thinking and creativity spur scientific breakthrough.

This issue features yet another maverick — Alberta's Neil Camarta. After 35 years with Big Oil, Camarta has come out of early retirement and returned to his chemical engineering roots, commercializing a molten salt-based process to produce cleaner, cheaper hydrogen for the oil sands industry.

Innovation is at the forefront in the complex world of bottle recycling. Significant advances are being made in the area of polylactide (PLA) bioplastics made from biomass, which theoretically makes these plastic containers compostable. However, education is needed to ensure that the public learns to differentiate petroleum-based plastic from bioplastics, to prevent them getting mixed up at recycling plants. The creative solution? Create plant-derived plastics that are chemically indistinguishable from their oil-based cousins, allowing a seamless integration into existing recycling streams.

Finally, *ACCN* announces that Irving has brought home yet more silver to adorn his trophy shelf, being presented with the inaugural Award of Journalism Excellence in Engineering from the national Engineers Canada Awards Gala. Irving was recognized for the article "Nature's Industrialists," published last year in *ACCN*. We are incredibly proud of Irving's latest achievement.

Write to the editor at magazine@accn.ca


THE POWER OF

SPIN

In his book *Mad Like Tesla*, about underdog inventors and their relentless pursuit of clean energy, Tyler Hamilton profiles Louis Michaud, an Ontario engineer in hot pursuit of a dream to turn waste energy into electricity-generating tornadoes.

By Tyler Hamilton

There has been so much thought put into anticipating, avoiding, and destroying tornadoes that I became quite intrigued in early 2007 when I received the following email from a gentleman named Brian Monrad, a lawyer who was writing on behalf of a friend. "An engineer in Sarnia, Ontario, says he can create an artificial tornado and use it to produce electricity," he wrote. "Three top scientists from Oxford, Cambridge, and MIT agree that this is a real possibility and have joined the advisory board." Curiosity got the best of me, and a week later I found myself making the four-hour trek to Sarnia, where I was welcomed into the home of retired refinery engineer Louis Michaud, inventor of the patented atmospheric vortex engine concept.

Michaud, a grandfather of four, is a slight and soft-spoken man in his late 60s who lives in a 1950s-style bungalow in a quiet area. Michaud worked more than 25 years there as a process control engineer at Imperial Oil, which is majority owned by ExxonMobil and ranks as the largest petroleum company in Canada. A spare-time inventor for most of his career, it was only after Michaud retired in 2006 that he could throw himself into the idea of extracting energy from tornadoes. It was then that he formed a company called AVEtec Energy with an aim to commercializing his unique vortex engine.

Minutes after we met, he took me to his garage to demonstrate a small-scale version of what he'd like to build, one day, on a massive scale. In his garage, between hanging bicycles and a tool bench, sat a hollow plywood cylinder about two feet high and nearly four feet in diameter. It had a round opening at the top, just big

Refinery engineer Louis Michaud demonstrates a small-scale version of a miniature tornado, something he'd like to build on a massive scale in the near future to generate clean electricity.

CRAIG GLOVER

enough to stick your head into. At the bottom was a heating element connected to a small propane tank. Michaud fired up the propane heater and then lit a couple of pieces of saltpetre to get them smoking. As the heater began warming the bottom of the cylinder the air within it began to rise, carrying with it the smoke from the burning saltpetre. Within seconds, the rising saltpetre smoke started swirling and took on the shape of a vortex — a miniature tornado.

In a way, Michaud's vortex engines would operate like massive air conditioners for a warming planet but ones that produce, rather than consume, electricity.

The garage demonstration, Michaud said, was just to show how heated air can be made to spiral as it rises. His idea is to build a structure that would support the creation and control of a tornado-like vortex that stretches many kilometers into the sky and spins at more than 300 kilometers per hour, as powerful as an F4 tornado capable of serious destruction. Why on Earth would anyone want to do such a thing? To generate clean electricity. A tornado needs to sweep in warm air from ground level in order to survive, so any supporting base structure would need air-intake ducts, and those ducts could be equipped with turbines. The powerful suction of air through those ducts would spin the turbines and generate electricity, Michaud explained. "I'm talking about a 200-megawatt device here," he said. "It would be 200 meters across and the vortex would be one to 20 kilometers high. It would have 10 turbines installed around its base, each producing 20 megawatts." The key, he said, is to find a large source of low-grade heat that can get the tornado going, just like the propane heater he used in his garage prototype. One dependable source is waste heat from thermal power plants. Nuclear and coal power stations, as well as certain types of natural gas–fired plants, convert only one-third of their fuel into electricity. The rest of the energy in that fuel gets rejected as waste heat. That means a plant that produces 500 megawatts of electricity is throwing away the energy-equivalent of 1,000 megawatts of heat.

All of this might sound impossibly ambitious, but it's just the start. Longer term, Michaud sees the potential of building his vortex engines along tropical coastlines or on floating ocean platforms along the equator. Heat could be endlessly extracted from tropical waters as a way to sustain power-producing tornados. These same warm waters, which can reach as high as 32 degrees Celsius, are the source of energy for hurricanes and spontaneously appearing water spouts. "The passage of a hurricane can reduce surface temperature by up to 5 degrees Celsius," said Michaud. "They basically carry heat away from the surface."

Man-made tornadoes would achieve the same goal, drawing heat from the surface through the center of their vortex and dumping it into the upper atmosphere where it's more than 60 degrees Celsius cooler and the heat can more easily radiate into space, beyond the confines of the greenhouse effect. The only difference is that man-made tornadoes could generate electricity at the same time. In a way, Michaud's vortex engines would operate like massive air conditioners for a warming planet but ones that produce, rather than consume, electricity. "It's

the first energy source to contribute to global cooling, not global warming," touts Michaud's business plan. Two months after meeting Michaud, I wrote a story about his invention in the *Toronto Star*. It captured the attention of many readers, including Steven Levitt, professor of economics at the University of Chicago and co-author of the bestselling books *Freakonomics* and *SuperFreakonomics*. "This is probably too good to be true, but all you need is one big idea like this to work," he wrote in his *New York Times* blog. "Technology and human ingenuity have solved just about every problem we've faced so far: there is no obvious reason why global warming shouldn't succumb as well."

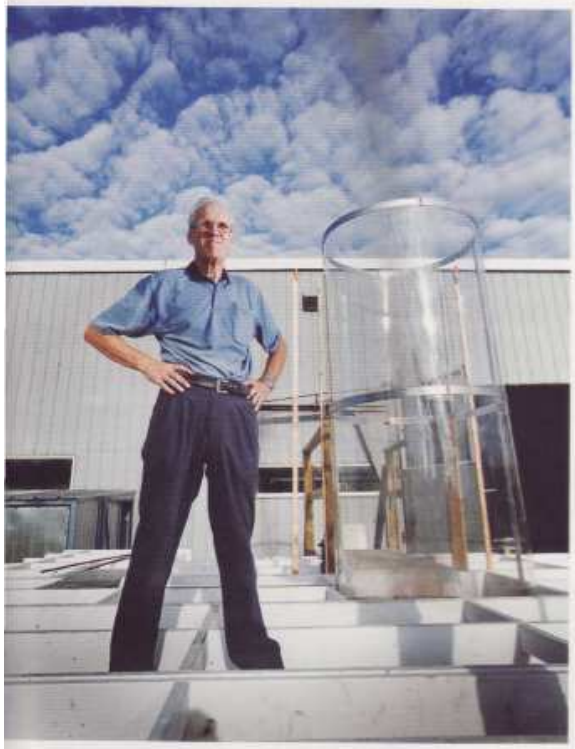
The idea of harnessing heat from warm ocean waters has been around for more than a century. Another idea that has been around for several decades is the manipulation of atmospheric convection to produce electricity, which is essentially what Michaud is attempting. Convection is one of three major ways that energy is transferred between the Earth's surface and the atmosphere. The other two are conduction and radiation. Conduction happens when heat moves from a higher temperature substance to a lower temperature substance, for example, from warm air into cold soil or warm soil into cold air. Radiation is a transfer of heat through electromagnetic waves, which you feel when the sunlight hits your face.

So the biggest question isn't whether we can create tornadoes, it's whether we can control them.

In the early 1980s the German government funded the construction of a "solar chimney" in Manzanares, a rural municipality about a one-hour drive from Spain's capital, Madrid. The $5-million pilot project didn't create tornadoes, but it did take advantage of convection as a way to generate electricity, in this case up to 60 kilowatts, or enough to power as much as 600 incandescent light bulbs. Some time in the mid-1970s, while working in a Quebec paper mill, Michaud turned to the idea of creating tornadoes to generate electricity. He knew that tremendous amounts of energy could be harnessed through atmospheric convection and saw the solar chimney as one way of doing it. At one point, he even considered the use of a chimney-like tube held high in the sky by a blimp, but it just wasn't practical or efficient enough. Then it struck him: tornadoes are their own chimneys. Not only that, these self-swirling columns of air can stretch several kilometers high.

It was only during the lead-up to his retirement in the first few years of this century that Michaud began to promote the commercial potential of tornado power. He drew up a detailed design for a utility-scale vortex engine in 2001 and filed for a patent the same year. In 2005, a year before his retirement, he created a website, VortexEngine.ca, and populated it with as much explanatory information as possible as part of a larger effort to raise awareness of the idea. He developed a business plan and started work on a small-scale prototype.

If you believe Michaud's calculations, his atmospheric vortex engine is an economic slam dunk. He figures it could generate electricity for less than 6 cents per kilowatt-hour, and possibly as low as 3 cents per kilowatt-hour, making it a better deal than nuclear and natural gas, far cheaper than renewables such as wind and solar, and competitive with the dirtiest of coal plants. The capital cost of building his vortex engine facility would be about $300,000 per megawatt, or about a quarter of what it would cost to build a new coal plant of the same power output. More than that, it eliminates the need for a conventional cooling tower that, at a new power plant, would cost just as much, if not more, to build. "From an engineering perspective, building this is not really a big deal," said Michaud. He firmly



RUSSELL MONK

Louis Michaud's vortex engines would operate like massive air conditioners that produce, rather than consume, electricity.

believes his power-generating vortex engine is one of the lowest-cost options for producing electricity, particularly zero-emission electricity.

The largest prototype Michaud has built to date is only four meters in diameter; it was tested in summer 2008 and created twisters more than 12 meters high. Decent enough, but like any new technology that requires an openness of mind and a willingness to take risk, finding the public granters or private investors who can take the project to the next level has proved to be a major hurdle, at least for now.

So the biggest question isn't whether we can create tornadoes, it's whether we can control them. And even if Michaud makes a convincing case that they can be controlled, and that the risks are extremely slim of a tornado hopping its concrete pen and terrorizing a town like Godzilla let loose on Tokyo, does it even matter? Can the fear factor be overcome?

Seeking advice on how to move his invention forward, Michaud traveled to Toronto in spring 2010 to meet with Tom Rand, who heads up the clean technology practice at the MaRS Discovery District, a kind of public-private incubator for technology ventures. Rand acts as an advisor at MaRS; in his private life, he's a big investor in and champion of clean energy and green technologies. When presented with Michaud's idea, he was intrigued but doubtful of its commercial viability.

"I'm sure in theory it works," he told me shortly after meeting with Michaud. "But seriously, we're going to control cyclones that reach into the sky? You have to imagine thousands of these man-made cyclones being controlled. But how do they affect the upper atmosphere, air routes, and weather systems, among other things?

Michaud understands the concerns, and while he finds them exaggerated, he also understands that perception is powerful. "At first they think my vortex engine is crazy. Then once they believe it's possible, they start saying it's dangerous," said Michaud. "But I don't think it's dangerous at all. It's actually relatively simple technology, and compared to nuclear power, it is peanuts." The reason Michaud believes his vortex engine is safe is because its lifeline — that is, the heat source that starts it up and keeps it alive — can be easily controlled or severed.

It's generally understood that much of the destructiveness of a tornado has to do with the dust and debris that whips around within its powerful vortex. Leaves, dirt, broken tree limbs, hail, fragments from destroyed buildings — even farm animals and vehicles — all of this material captured by a twister would explain its menacing look, as well as why it might sound like a freight train coming at you from a distance. The only thing visible in Michaud's vortex engine would be some water vapor, making it a bore by comparison. As for noise, he said much of it would be contained within the arena facility. "You could also find other ways to muffle it."

Is it just a matter of becoming comfortable with the technology? Michaud hopes that's the case. If he had $1 million (he doesn't), he figures he could build a sizeable vortex engine about 15 meters in diameter that could create a small tornado capable of reaching hundreds of meters into the sky. It might even produce a small amount of power, but its main purpose would be to show people what it would look like, how it would behave, and how it could be controlled. It might make the public more accepting of the technology, but that's just one of many big steps required to take tornado power mainstream.

Since the publication of Mad Like Tesla, *Louis Michaud has received funding for this initiative from PayPal founder Peter Thiel's Breakthrough Institute.*