Storage: the next generation

Why build a new power plant when the technology exists to store excess megawatts until needed?

ADRIANA MUGNATTO-HAMU
SPECIAL TO THE STAR

Ontario is moving ahead with a natural-gas-fired generator on the Portlands, with plans to start building this summer. Local opposition is growing louder. Meanwhile, engineer Greg Allen of Sustainable EDGE Ltd., a Toronto engineering and design firm, has been quietly promoting an alternative he believes is cheaper, cleaner and faster to build.

One reason natural gas is attractive to the McGuinty government is that it is a natural complement to nuclear energy, which maintains a steady flow 24 hours a day. Natural-gas generators can accommodate fluctuations in electrical demand, filling in the daily peaks that nuclear reactors don't address.

The government's urgency in building the new generator is the result of warnings that the city could face rolling blackouts in the summer of 2008 without an increase in capacity during peak hours.

But there is another, cleaner way to handle peak demands. In the same way that natural-gas generators dovetail with nuclear reactors, the natural complements to wind and solar power are storage systems, or batteries, that collect the power of the sun and wind and deliver it to us even on calm, still evenings.

Storage systems can store power from the existing grid as easily as they can store power from renewable sources. This feature, Allen says, can conveniently solve Toronto's looming energy crisis today while simultaneously preparing us for a sustainable future tomorrow.

There is actually no shortage of electricity available to Toronto, on average. The problem is that for parts of the day electricity is abundant and inexpensive, while at others, particularly summer afternoons when everyone turns on their air conditioner, the transmission lines are inadequate and available energy is very expensive.

A battery could purchase the power at the lowest price available, store it, and release it to the city when transmission lines reach capacity at a much higher price. The battery that will one day save solar energy for night-time delivery can also be used now to store night-time generation for daytime delivery.

A variety of storage options are available or in development today. The one Allen proposes is a flow battery. Flow batteries are liquid electrolyte fuel cells that have been cost-effectively employed in power grids in Japan, Australia and the United States. The National Research Council of Canada is currently testing a small flow battery in its labs in Ottawa for applications involving renewable energy sources, such as wind and solar power, and remote-area power supply.

What distinguishes flow batteries from other storage options is that the energy is stored separately from the power cell in two separate tanks, each filled with electrolyte solution. The electrolyte is rotated with pumps through power cells, where the solutions from the two tanks are separated by a membrane that permits ionic interchange. Electrodes force a charge from one side of the membrane to the other. As the battery gets charged, the charge moves from one electrolyte tank to the other. As the battery is discharged, the charge moves back. The power is determined by the size, number and configuration of the power cells.

As a result, flow batteries can be reconfigured to provide high power or high capacity. A 15 kilowatt-hour (kWh) system can power 10 homes for one hour, or one home for 10 hours.

While flow batteries are not new, the first dating back to the 19th century, interest has grown since the 1970s, and especially recently as they have become commercially viable for large-scale applications. They currently sell for approximately $500 per kWh of storage capacity, with incremental storage costs in large-scale systems of only $150 per kWh. In comparison, the cost of the 550 MW Portlands Energy Centre is projected to be $700 million.

Installation costs are difficult to compare, as generator size is measured in megawatts (MW) while batteries are measured in megawatt-hours (MWh). The installation cost of a generator, to be compared to a battery, would have to take into account the number of hours it is expected to operate. If the Portlands Energy Centre served a daily peak of five hours duration, installation would cost $255 for each daily kWh it produced. Installation of a five-hour flow battery would cost $220 per kWh. Working lifetimes of the systems are comparable.

Operating and maintenance costs of flow batteries are dramatically lower than those of gas-fired generation, at a tenth of a penny per kWh. The system operates automatically. The "fuel" for flow batteries is inexpensive energy purchased off-peak at about 3 cents per kWh. With energy losses of 25 to 30 per cent, total costs for delivery are about 4 cents per kWh.

Gas-fired generation, by contrast, fluctuates around 7 cents per kWh just for the fuel to produce it, with much higher operating and maintenance costs that can bring the total cost to 10 cents per kWh produced.

Flow batteries offer other advantages over generation. They can be installed quickly — eight months for large multi-megawatt systems that require environmental assessments, and three months or less for small systems. They have no emissions and are very quiet. The only moving parts are the pumps, which need replacement every five to seven years. One drawback of flow batteries, at least compared to other batteries, is their size. While the power cells are not unusually large, the storage tanks of electrolyte solution can be enormous.

For vanadium redox flow batteries, for example, a 600 MWh system would require 30 million litres of electrolyte. If stored in six-metre-high tanks, its footprint would be the size of a football field.

On the other hand, Allen says, the Hearn building that will house the planned gas generator in the Portlands is four football fields in size.

Another concern is the toxicity of the electrolyte. The electrolyte for the vanadium redox battery, for example, is dissolved in dilute sulphuric acid. Under normal conditions, there is no human exposure to the electrolyte, which is stored in lined and double-walled tanks. However, leaks are possible.

One solution to the risk of a major leak is the distribution of many small batteries as backup power sources for buildings throughout the city. This has the advantage of distributing the enormous volume of electrolyte required over a vast network of small installations. Small, distributed applications are very well understood and marketed. The disadvantage is that the total cost would be higher.

Alternatively, Toronto could opt to install a single large battery. The largest flow batteries built to date are 12 MWh in size. Any single battery that would make a significant impact for a city the size of Toronto would be the largest battery ever built.

VRB Power Systems, a Canadian company that installs primarily vanadium redox flow batteries, also offers a new technology developed for very large applications for a project of this size. The RGN system has a much more concentrated energy density level, meaning that it would be substantially smaller than a vanadium redox system. The electrolytes it uses are also less toxic saline solutions of sodium bromide and sodium polysulphide. The drawback: It is somewhat less efficient, with five per cent more energy loss than vanadium redox batteries.

The RGN flow battery has no existing practical application. Developed as the Regenesys Project with the Tennessee Valley Authority and partly funded by the U.S. Department of Energy, the project generated tremendous interest through 2003. A 120 MWh peak system was to provide the power for 7,500 homes for 10 hours each day.

The project reached the point where electrolyte was being brought in. But when the energy company developing the process was purchased by a German firm, the project was suddenly halted. RGN has only been marketed again since VRB Power Systems acquired the rights to the technology late last year. An RGN battery would be a world first.

Allen's company has promoted several innovative sustainable technologies, from deep lake-water cooling to wetland bioregeneration to creating buildings that make soft footprints on the landscape. Preparing Toronto for a future powered by renewables would continue in this tradition. A flow battery to offset Toronto's energy needs would support a robust solar and wind program in the coming decades, and allow this city to set a new standard in urban energy planning.

Adriana Mugnatto-Hamu is the chief executive officer of the Toronto-Danforth riding association of the Green Party of Canada. Greg Allen will be speaking about flow batteries at the St. Lawrence Centre Forum, 27 Front St. East, Wednesday at 7:30 p.m.

The energy of flow

Flow batteries are a potential alternative to nuclear and gas-powered plants due to their energy storage capacity and their ability to provide power instantaneously to meet high demands. Energy is stored in electrolyte tanks rather than in a power cell, so capacity of a flow battery is only limited by the size of the tanks.

HOW FLOW BATTERIES WORK

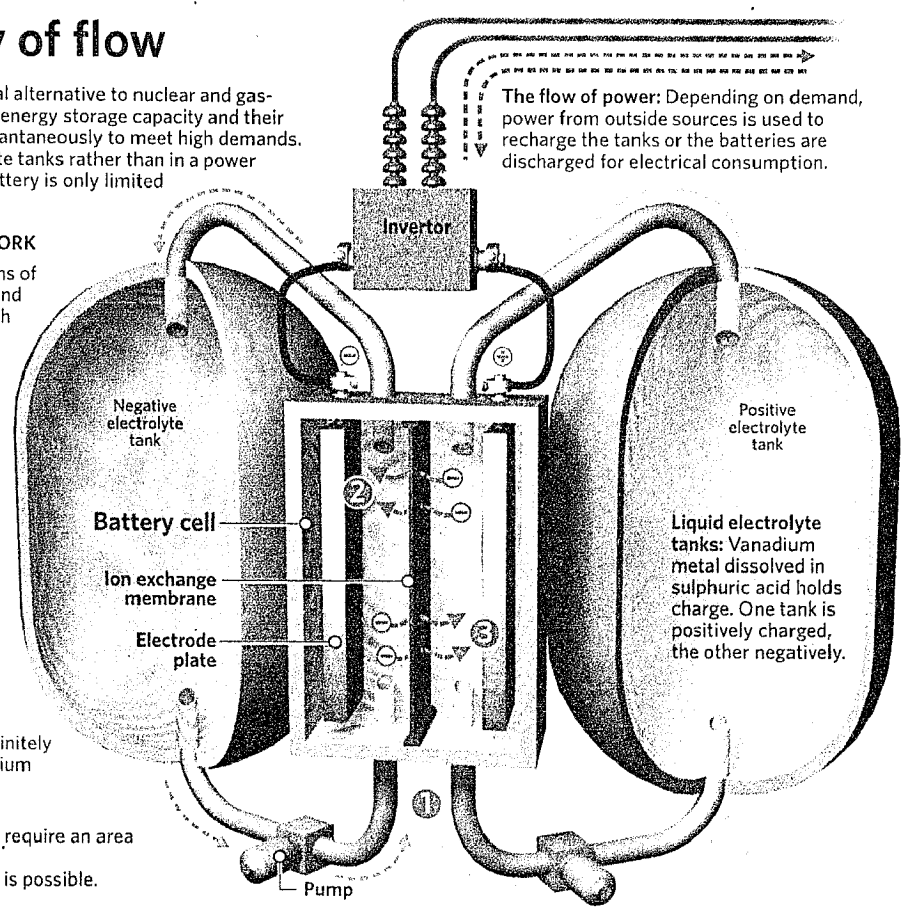
1. Activating a cell: Two forms of liquid electrolyte, negative and positive, are pumped through the battery cell.

2. Power out: Electrical energy is created when electrons stored in the electrolyte pass through the ion exchange membrane and are collected by electrode plates.

3. Recharge: Power from another source, such as solar or wind, recharges the tanks by running a current through the electrolyte, adding electrons.

Pros:
- No emissions
- Low maintenance
- Can remain charged indefinitely
- No waste disposal. Vanadium electrolyte is reusable.

Cons:
- A 200 MW system would require an area the size of a football field.
- Leakage of the electrolyte is possible.



SOURCE: University of New South Wales, VRB Power Systems, Pinnacle VRB Ltd. RESEARCH BY STACEY KOVIOS

BRIAN HUGHES/ TORONTO STAR

MICROSCOPE | A week's worth of science news, by Peter Calamai

GREAT BALLS OF WATER!
Five years ago, Josef Schmutz spotted something very odd along the shore of a small salt lake in south-central Saskatchewan: dozens of oval balls, some as many as 10 centimetres across.

Most of us would tell our friends, or maybe even take a photograph. But Schmutz is a conservation biologist, and he began asking questions, which is another description of doing research. Here's what he discovered from the scientific literature:

- Similar lake balls have been reported in Europe, New Zealand and the United States.
- A half-dozen languages have names for the lake balls, some dating back to Classical times.
- The balls from other North American locales (like those from his lake) were composed mostly of strands of widgeon grass or *Ruppia*, which grows submerged in brackish water.
- No one had observed the actual formation of the balls, but another researcher had produced something similar by putting turtle grass into a washing machine and checking the lint trap.

By cutting apart two balls (the experimental part), Schmutz determined they had nothing else inside. So now it was time for the hypothesis.

The fibrous stalks of the widgeon grass break easily and stick together, forming floating mats on the lake, which the wind drives to the shore. In the shallow shore waters, wave action rolls the mat back and forth, eventually forming round balls.

On windy days the balls get tossed so far up on the shore that they are stranded. There they dry out and settle into the final oval shape.

This fascinating example of scientific research will appear in a forthcoming issue of *The Canadian Field-Naturalist*.

DENNIS DYCK / UNIVERSITY OF SASKATCHEWAN

Dozens of balls of widgeon grass thrown up on the shore of Sandoff Lake in Saskatchewan.

HIGH-FLYING LOBSTER
Without moving its head, the lobster has an ultra-wide field of vision. After decades of study, a space telescope modelled on the lobster's all-seeing eye is being developed to alert astronomers to sudden and violent upheavals in the cosmos.

As described this past week at Britain's national astronomy meeting, the orbiting telescope would continually sweep the sky for X-ray wavelengths. Astronomers are interested in X-rays because they are spewed out by high-energy events, like black holes swallowing stars or supernova.

Existing X-ray space telescopes, like NASA's Chandra, can detect such rare happenings only if they happen to be pointed at the right place at the right time. The Lobster All-Sky X-ray Monitor, by contrast, will build up a complete sky picture during each 90-minute orbit. Alerts about cosmic turmoil would then be flashed to Earth, so other telescopes operating at different wavelengths could track the event.

The secret of the lobster's (and telescope's) prowess is reflection. Most animal eyes, including ours, focus light rays by bending or refraction. But the lobster's eye consists of millions of long square channels. Light entering these microscopic pores strikes the side of the channel at a very shallow angle and is reflected to different points on an inner spherical focal surface, providing the lobster with its ultra-angle view.

An American astronomer first suggested the lobster telescope a quarter-century ago, but it has taken until now to make reflecting tubes that work as well as a crustacean's eye. The telescope was initially intended for the International Space Station, but that is shaping up as a scientific dud. So instead the builders at the University of Leicester are talking to the Russian space agency about a custom-made orbiting platform.

Call it the Lobster Pot.

SHIRKING EVOLUTION
The Social Sciences and Humanities Research Council is the federal granting agency that can't get no respect.

SSHRC, pronounced "shirk," gets half the money given to two sister agencies that finance research in health and the natural sciences.

Yet the majority of the professors on Canadian campuses work in the humanities and social sciences.

A continuing image problem is that social science research, whether funded by SSHRC or not, often presents juicy targets for taxpayer ire, such as studies of lesbianism in *Anne of Green Gables* or French court ballet.

This past week, however, SSHRC shot itself in the foot. A council-grants committee rejected a proposal by a McGill University professor to study the detrimental impact of religious-based "intelligent design" on students, teachers, parents and policy makers. Check out the reasoning for rejecting the proposal.

"Nor did the committee consider that there was adequate justification for the assumption in the proposal that the theory of Evolution, and not Intelligent Design, was correct."

This scientific verdict from sociologists came in the same week that palaeontologists identified the fish that began the transition of animals from the ocean to land 380 million years ago — yet more evidence buttressing evolution.

A council spokeswoman said the letter had been "misinterpreted" and the grants committee wasn't actually expressing doubts about the theory of evolution.

Perhaps SSHRC could call upon humanities professors for help with the English language.

Haven't you always wanted to look down his throat?

CLICK HERE
http://tinyurl.com/ncpyf
At this time of the year, you'll have no trouble hearing the distinctive, piercing call of the northern cardinal.

This website features an X-ray movie showing how the cardinal continually changes the shape of its upper vocal tract to produce such pure tones, much as a soprano projecting high notes does to be heard above the orchestra

Caution: Requires a fast computer processor, QuickTime software, and a high-speed Internet connection.