TRANS-FORMING THE POWER GRID

BY
CURT
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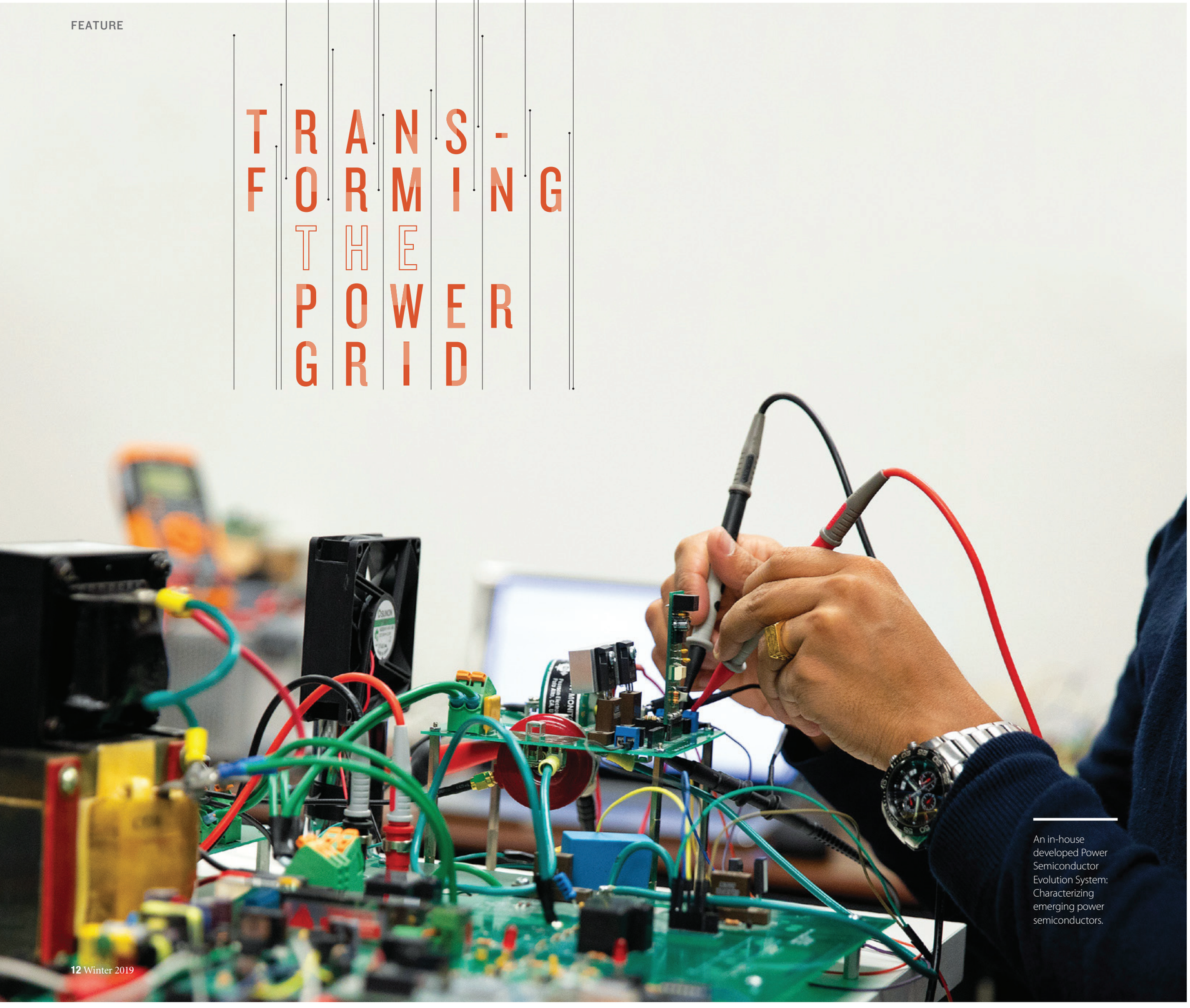
CARL HO'S RESEARCH IS HELPING POWER PRODUCERS TRANSITION TO THE ERA OF THE SMART GRID.



An in-house developed Power Semiconductor Evolution System: Characterizing emerging power semiconductors.

WITHIN THE OLD testament lies a metaphor for the modern-day power grid: the story of the Tower of Babel.

God smites the tower's workforce with multilingualism, preventing its labourers from communicating among themselves and as a result halting construction of the idolic structure.

As new energy sources are developed, and as traditional ones are modernized, the power grid is becoming ever-more populated with new energy communication devices, new unstable electricity and new entrance points for electricity.

As a result, power producers are having to overcome the same multilinguistic conundrum as Tower of Babel labourers.

Researchers such as the U of M's Carl Ho are ensuring that electricity isn't lost in translation before reaching the grid and, ultimately, consumers and industry.

Nearing the end of a five-year term as Canada Research Chair (CRC) in Efficient Utilization of Electric Power in the Faculty of Engineering, Ho is developing technologies that improve the efficiency, stability and costs of power grids and the power electronic systems that run them.

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On the heels of his CRC appointment in 2014, Ho formed the Renewable-energy Interface and Grid Automation (RIGA) Lab—his main vehicle for research.

In addition to the CRC program, the RIGA lab is funded through the Canada Foundation for Innovation (CFI) and Research Manitoba.

Ho and his research team tackle issues that often arise from multiple unstable power systems vying for space on the same grid at once.

These can include load loss, power surges, voltage fluctuations and inefficient power conversion.

"The power systems industry is changing from using only passive devices and conventional energy sources to using more high-frequency switch-mode power electronics devices and renewable energy sources," said Ho.

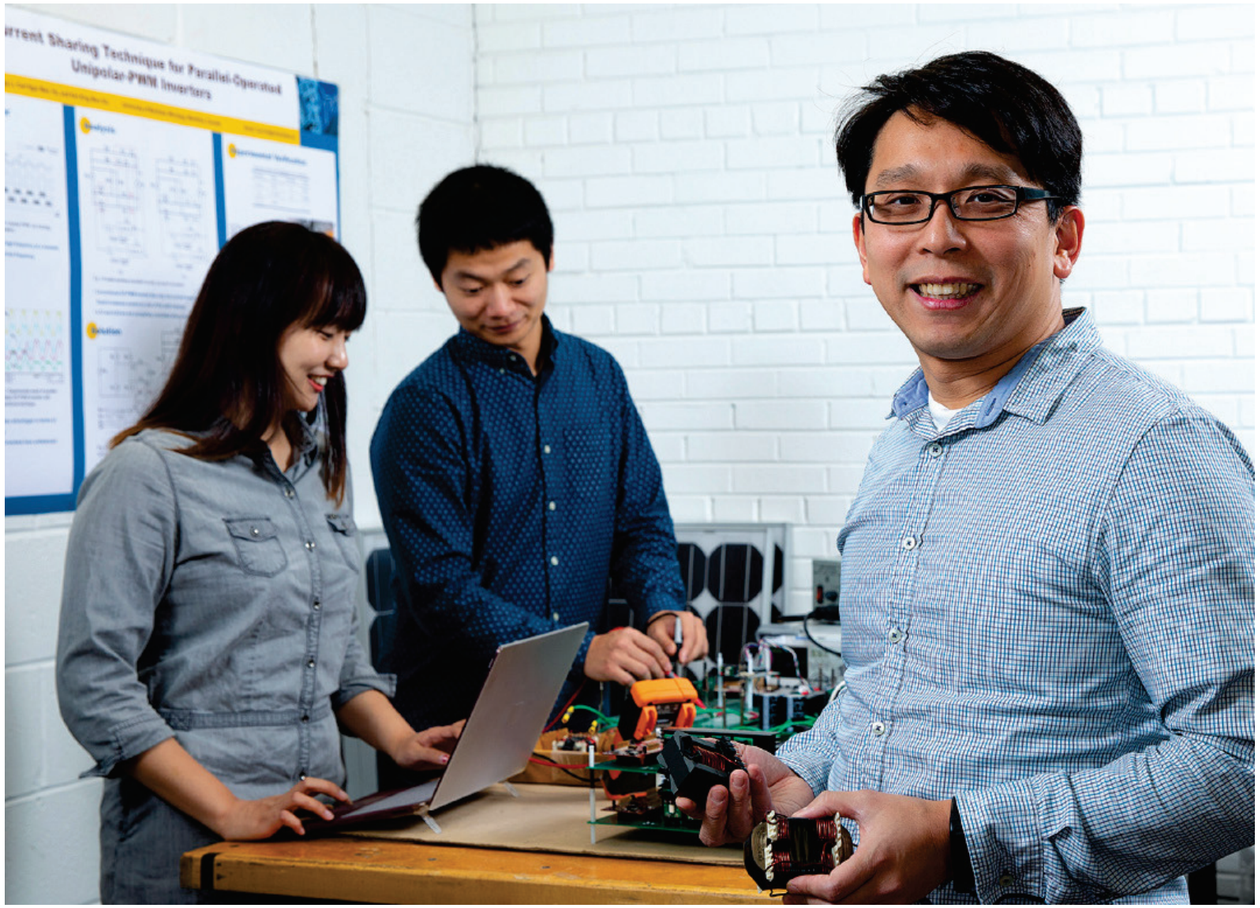
He noted that the once-conceptual "smart grid" is becoming a reality. He described the smart grid as the convergence of traditional and renewable energies, energy storage elements, power electronics, and new advanced communications and control devices for power systems.

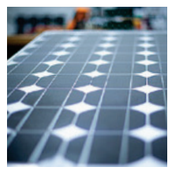
"The university and I would like to keep the advantage that Manitoba has and to be technological pioneers in the future smart grid era–that's why I created the RIGA lab," said Ho.

Each particular power source, whether traditional or renewable, has its own idiosyncratic problems.

Take solar for example, which is a focal point of Ho's research.

Sunlight's transformation from radiant energy to, say, electricity in a countertop plug, is arduous: When sunlight hits a solar panel, that panel converts radiating light into energy by essentially jostling electrons free from conductive plates. The electrons are collected as direct current (DC) power.





ABOVE: Ho (R) guiding research with PhD student Dong Li (L-R) and undergraduate student Qiyan Li to prepare an experimental setup.

BELOW: A solar panel, used to convert solar energy to electricity.

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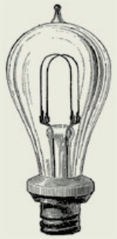
The panel's DC power output is unstable and changing all the time, depending on factors such as the panel's surface temperature, radiation levels (which are higher in the afternoon) and cloud cover.

The RIGA lab is developing energy conversion technologies that can better stabilize solar-generated DC power, and more efficiently convert DC power into alternating current (AC) power—the form that power needs to take to enter the grid.

For example, Ho's team is developing so-called "intelligent" communication devices, that can allow solar-power converters to speak to each other digitally.

These devices can improve and better control the flow of multiple power sources at once.

MOTHER OF INVENTION



CARL HO PLACES AN EMPHASIS on researching solutions for marketplace problems. The first application of his research came in the 1990s while he was still a technical college student. He invented a heart-rate monitor that could wirelessly transmit data and display heartbeat waveform in real-time, without any data-loss, to archaic 1990s computer technology.

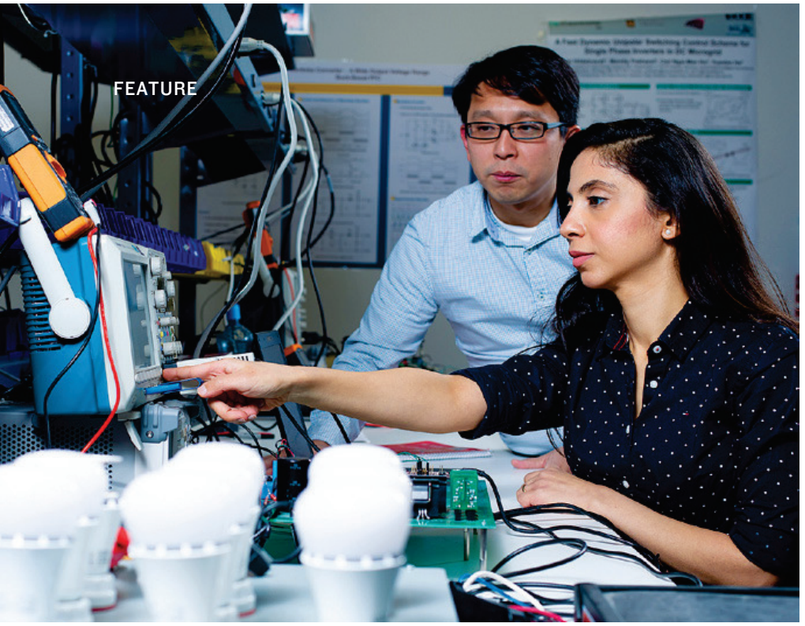
He developed his second important invention as a PhD student. A municipal government approached a professor of his regarding over-voltage and surges it was experiencing at night, after the city's factory shutdown for the evening. He found a way to control and ultimately stabilize this reactive power. A private firm eventually took ownership of his system and sells it worldwide.

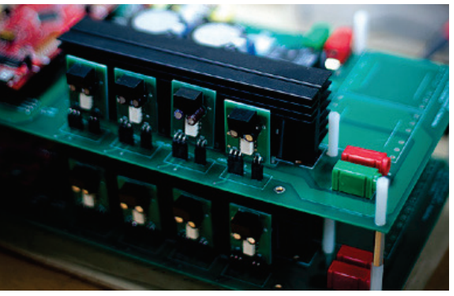
Ho's RIGA lab has filed two patent applications for technologies developed so far in his time at the U of M.

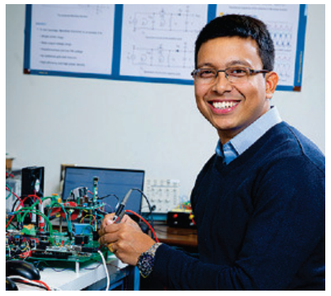
The Manitoba Inverter is a single-stage grid-connected conversion device. It uses the novel concept of "shaping" electrical waveforms to convert and connect energy from solar panels to the grid. As a single-stage converter (the market standard is two-stage converters), it can reduce material costs for solar power generation.

The second patent application is for a system called Transformerless Unified Power Quality Conditioner (UPQC). The system's development stemmed from an issue Manitoba Hydro customers were experiencing with dimmable LED light bulbs: flickering light.

The lab found a way to harmonize power flowing to LED lights to eliminate the flickering, ultimately reducing energy costs and extending the life of the bulbs.







"RIGA'S INTELLIGENT DEVICES CAN ALSO REDUCE ENERGY CONSUMPTION BY TURNING DEVICES OFF OR PLACING THEM IN STANDBY DURING PERIODS OF INACTIVITY."

RIGA's intelligent devices can also reduce energy consumption by turning devices off or placing them in standby during periods of inactivity.

Currently, Ho leads a team of seven PhD students, three Masters students and one visiting professor. He also typically has a handful of undergraduate students working in the lab during the summer.

Educated in Hong Kong, Ho completed his PhD there in 2007 and relocated to Switzerland to do applied research for power-electronics giant ABB Switzerland Ltd.

There, he led a research team on the development of the company's solar conversion technology.

With a career that has crossed from academia to industry and back again, Ho appreciates the need to balance fundamental research and applied research.

TOP: Ho with PhD student Radwa Abdalaal, conducting an experiment to evaluate their patented Power Quality Conditioning Technology.

BOTTOM LEFT: Smart inverter modules

BOTTOM RIGHT: MSc student Avishek Ghosh in the lab.

"You can do basic research in a corporate setting, but you really need to produce," said Ho.

Looking to the future, Ho wants to explore the idea of the "Energy Internet."

It's the idea that power systems will evolve from being uni-directional systems into ones in which electricity and information can flow two ways—in much the same way television has evolved in recent years.

"TV viewers passively received programs from central producers," explains Ho. "But now people can broadcast their own videos in, for example, YouTube—everyone can be a producer."

Similarly, the control of electricity remains largely at the moment with centralized producers.

"I foresee consumers generating power by themselves," said Ho, "but controlling the flow of that power will be challenging."

And while at the academic level, research tends to follow a linear path from theory to eventual application, research in a business setting occurs in reverse.

First, a potential application or need in the marketplace is identified (along with the potential profits stemming from it).

Secondly, researchers follow the breadcrumbs back to the theory needed for invention.

"In the field of engineering, you cannot decouple from industry. If you do, you're closing the door to having your research develop into an outdoor application or product."

CONTINUING THE LEGACY

DISCOVERING NEW INSIGHTS INTO THE ROLE OF GENES AND THE ENVIRONMENT IN TYPE 2 DIABETES IN OJI-CREE YOUTH

BY TAYLOR MORRISEAU

Taylor Morriseau is a member of the Peguis First Nation with mixed British and Cree ancestry. A recent graduate of a Faculty of Science (double honours) degree, she is now pursuing a PhD in Pharmacology to study early-onset Type 2 Diabetes among Oji-Cree youth. Taylor's personal and academic ambitions act in synergy, fueled by a desire to redress the staggering gaps in health and disease that continue to dominate the narrative of Indigenous peoples.

IN THE 1980'S, U OF M PROFESSORS Heather Dean, Ronald Mundy and Michael Moffatt shifted the medical landscape with twenty—highly-contested but carefully diagnosed—cases of type 2 diabetes (T2D) in school-age children. Surprisingly, these young Oji-Cree patients were united by their heritage to four First Nations communities in northeastern Manitoba. Given the localization and pervasiveness of this disease in coming years, a unique genetic variant (known as HNF-1 G319S) was soon identified.

"It is important to understand, however, that the diabetes epidemic coincided with a shift away from land-based food strategies towards Western-based diets."

Hailed as the strongest genetic predictor of T2D currently known, it remains unclear why Manitoban Indigenous youth have the highest rates of T2D in Canada, when incidences were incredibly low just two generations ago.

It is important to understand, however, that the diabetes epidemic coincided with a shift away from land-based food strategies towards Western-based diets; a consequence of colonization that cannot be accounted for by one's genetic status. Hence, it is unknown how the rapid dietary transformation has influenced diabetes development, particularly in those who carry the HNF-1 G319S variant.

To test this relationship, we used state-of-the-art gene-editing technology to generate the HNF-1 G319S mouse expressing the G319S variant. Under the direction of Max Rady College of Medicine professors Christine Doucette and Vernon Dolinsky who work at the university's affiliated research institute, the Children's Hospital Research Institute of Manitoba, my Vanier Scholarship-supported research investigates cellular mechanisms responsible for T2D development. By modifying experimental diets to mirror nutrient intakes of modern vs. historical Oji-Cree diets, we then assess markers of diabetes development to better understand the relationship between genetics, diet and diabetes in the Oji-Cree population.

Importantly, this project opens the dialogue on race, genetics and disease while contributing prerequisite information to facilitate this larger discussion. To refine our methodologies, we continually seek consultation with an established Indigenous stakeholder committee within the Diabetes Research Envisioned and Accomplished in Manitoba (DREAM) theme. By centering Indigenous voices, we not only provide a greater understanding on diabetes development in Indigenous youth, but locate our science within the greater social, cultural and historical context. It is our hope that this research contributes another strand in the long history woven by dedicated patients, community members, caregivers, and researchers—bound by the hope that these young people will leave their own legacies unburdened by disease.