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US 100 27,015.4 -0.2 (0.00%) EUR to USD 1.16714 -0.00048 (-0.04%) Gold 4,543.715 -53.085 (-1.15%) Bitcoin 75,804 -519.00 (-0.68%) Ethereum 2,246.

How a Canadian Breakthrough in Thermoelectrics Could Turn Waste Heat Into the Next Clean-Energy Frontier

-Technology – Canada -

For decades, thermoelectric generators—solid-state devices that convert heat directly into electricity—have been heralded as a tantalizing clean-energy technology. They have no moving parts, require no maintenance, and can theoretically harvest power from any temperature difference. Yet despite their promise, thermoelectrics have remained stuck on the margins of industry, hampered by low efficiency, fragile materials, and manufacturing methods that couldn't withstand real-world conditions.

A Canadian company believes it has solved those problems.

PyroDelta Energy, a majority-owned subsidiary of Vancouver-based First Tellurium Corp., says its patented **Capillary Casting** manufacturing method has unlocked a new class of high-temperature thermoelectric modules capable of operating where previous systems failed: inside industrial furnaces and liquid cooling systems, in combustion engines for autos or unmanned aerial vehicles (UAVs), and even on the backs of solar panels at night.

If the technology scales as promised, it could reshape how industries—from AI data centres to heavy industry to transportation—think about waste heat, one of the world's largest untapped energy resources.

A decades-old problem: thermoelectrics that break before they pay for themselves

The physics behind thermoelectrics is well understood, but the engineering has always lagged. Traditional modules rely on brittle semiconductor legs bonded with solder and metal contacts. At high temperatures, these joints crack. Under thermal cycling, they delaminate. In corrosive environments, they degrade. And even when they survive, their efficiency is often too low to justify the cost.

“The challenge has never been the concept,” says Michael Abdelmaseh, PyroDelta's head engineer “It's been the materials and the way they're assembled. If a module can't survive the temperature swings of an industrial environment, it doesn't matter how good the physics are.”

Capillary Casting, developed over more than a decade, tackles these problems at the root. Instead of assembling thermoelectric legs piece by piece, the process forms them in place

inside a metal matrix using capillary action. The result is a monolithic, mechanically robust structure with no solder joints, no fragile interfaces, and far greater tolerance for heat and vibration.

“We essentially grow the thermoelectric material directly into the metal structure that supports it,” Abdelmaseh explains in a published interview. “That gives us thermal stability and mechanical strength that conventional modules simply can’t achieve.”

A manufacturing breakthrough with industrial consequences

The implications are significant. PyroDelta’s modules are designed to operate at temperatures above 600°C—far beyond the limits of most commercial thermoelectrics—and to survive thousands of heating and cooling cycles without degradation.

That durability opens the door to industrial deployments that were previously impossible.

“Industry doesn’t want a device that works in the lab—they want something that works for 10 years on a furnace wall,” Abdelmaseh says. “Capillary Casting is what finally gets us there.”

The company argues that the technology’s reliability, combined with improved efficiency at high temperatures, could shift the economics of waste-heat recovery. Instead of relying on bulky heat exchangers or complex organic Rankine cycle systems, facilities could install compact, solid-state generators that quietly produce electricity from heat that would otherwise be lost.

AI data centres: turning heat into power instead of a liability

One of the most promising early markets is the rapidly expanding world of AI data centres. These facilities generate enormous amounts of heat—so much that cooling has become one of the industry’s largest operational costs and environmental challenges.

Thermoelectrics offer a radically different approach: instead of removing heat as waste, convert part of it into electricity.

PyroDelta’s high-temperature modules can be integrated into heat-extraction surfaces, server racks, or liquid-cooling loops. While they won’t eliminate cooling needs, they can offset a portion of the energy load.

“Data centres are basically giant heat-producing systems that don’t do anything with the heat,” Abdelmaseh has said. “If you can recover even a small percentage of that energy, the impact is enormous at scale.”

With AI workloads projected to multiply global data-centre electricity demand several-fold over the next decade, even modest efficiency gains could translate into major emissions reductions.

Drones: extending range and payload with onboard power recovery

Another emerging application is in unmanned aerial vehicles. Drones are constrained by battery weight and flight time—limitations that thermoelectrics could help ease.

Combustion-powered drones, in particular, shed significant heat from their engines. By capturing that heat and converting it into supplemental electrical power, thermoelectric modules can extend flight duration or free up capacity for heavier payloads.

“Every watt matters in aerospace,” Abdelmaseh notes. “If you can reclaim power that would otherwise be lost, you can fly farther, carry more, or do both.”

The company is already in discussions with drone manufacturers exploring hybrid-power designs. In August of this year, PyroDelta will showcase its drone technology at The DARPA Lift Challenge, a U.S. Department of Defense competition to design drones with a payload-to-weight ratio of over 2:1. The aim is to revolutionize heavy vertical lift aviation, and PyroDelta believes it can achieve or exceed the 2:1 standard with its drone design.

Combustion engines: harvesting energy from exhaust systems

Internal combustion engines—whether in vehicles, generators, or industrial equipment—lose more than half their energy as heat. Thermoelectrics have long been proposed as a way to recapture some of that loss, but durability issues prevented real-world adoption.

PyroDelta believes Capillary Casting changes that equation.

Modules can be integrated directly into cooling systems, onto exhaust manifolds or integrated into heat shields, generating electricity that can power onboard electronics, reduce alternator load, or charge batteries in hybrid systems.

Automakers have experimented with thermoelectrics for years, but the technology has never been robust enough for mass deployment. PyroDelta’s high-temperature tolerance could revive those efforts.

Solar panels that work after sunset

Perhaps the most intriguing application is nighttime solar generation.

Solar panels radiate heat into the night sky, becoming cooler than the surrounding air. That temperature difference—small but steady—can drive a thermoelectric generator.

While the power output is modest, it provides a continuous trickle of electricity that can support sensors, micro-inverters, or grid-monitoring equipment without drawing from batteries.

“People think of solar as a daytime technology, but panels are actually thermodynamic devices 24 hours a day,” Abdelmaseh has said. “If you can harvest the temperature swing at night, you get a new layer of value from infrastructure that’s already installed.”

A Canadian foothold in the next clean-energy race

Canada has long been a leader in materials science, but rarely in thermoelectrics. PyroDelta’s work could change that, positioning the country at the forefront of a technology that many analysts believe is poised for a resurgence.

Global waste heat is estimated to exceed 100 exajoules per year—more than the total energy consumption of the entire United States. Even capturing a fraction of that could reshape industrial energy use.

“Waste heat is the world’s largest unused energy resource,” Abdelmaseh says. “We finally have the tools to do something about it.”

The road ahead

PyroDelta is now moving toward pilot deployments with industrial partners in North America and Europe. The company acknowledges that scaling manufacturing will be a challenge, but it believes Capillary Casting is inherently suited to mass production.

If successful, the technology could mark a turning point for thermoelectrics—transforming them from a scientific curiosity into a practical tool for decarbonization.

And for Canada, it could represent something rarer still: a homegrown breakthrough with global industrial impact.