From LFP to Flow Batteries: Canada's Strategic Role in the Future of Energy Storage

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The global energy transition depends not only on technological breakthroughs – such as lithium iron phosphate (LFP) and flow batteries, fuel cells, hydrogen, and CCUS, where Canada is at the forefront – but also on scale and commercial viability. Global markets and supply chains, particularly those in the U.S. and Europe, offer Canada a strategic opportunity to turn promise into profit. Focused on battery energy storage systems (BESS), this report examines that opportunity, outlining key considerations, market implications, and emerging avenues for growth.

I. Canada's Battery Innovation

Canada's battery sector is quietly carving out a niche on the world stage. With over 160 firms involved in batteries or battery-based energy storage, Canada punches well above its weight. Its clean electricity grid, over 80% powered by hydro, nuclear, and wind, provides a natural advantage for electrification. Backed by strong federal funding and a collaborative industrial ecosystem, Canada is turning innovation into export-ready solutions increasingly sought after by global markets.

The sector benefits from a pragmatic blend of policy support and private-sector initiative, fostering distinct regional strengths. Vancouver has long been a center for battery R&D, with institutions such as UBC's Battery Innovation Cluster and firms such as Invinity Energy and VRB Energy advancing vanadium flow battery technology. Toronto is a main hub for battery scale up, home to startups like e-Zinc, which is developing zinc-based long-duration storage solutions. In Montréal, Hydro-Québec's Center of Excellence in Transportation Electrification and Energy Storage is pushing the frontiers of LFP and solid-state batteries, while Lion Electric and Northvolt North America anchor a growing EV and battery manufacturing cluster.

Even Alberta, long tied to fossil fuels, is repositioning itself. With a rich mineral base and a deregulated electricity market, it is advancing battery storage through firms such as Summit Nanotech and E3 Lithium, which focus on sustainable lithium extraction, and TransAlta, which is deploying grid-scale energy storage systems.

Yet challenges remain. Canada's domestic market is limited, and its manufacturing base is still modest by global standards. To stay competitive, Canadian firms need to integrate deeply into global supply chains while keeping core intellectual property development at home. Collaboration with the U.S. and Europe, two key markets in batteries and BESS, offers a strategic path to scale Canadian technology globally.

Since 2010, Canada has co-led the Clean Energy Ministerial's (CEM) Electric Vehicles Initiative (EVI) alongside China, the Netherlands, and the United States. Under the EVI, the EV30@30 campaign was launched at CEM8 in 2017 and reaffirmed at CEM10 in Vancouver, setting a goal for EVs to reach a 30% market share by 2030 – a target that Québec and the Netherlands met well in advance, in 2024.

II. Canadian LFP Patents: Enabling the Global Battery Value Chain

A little-known Canadian invention has come to dominate the modern battery age. In the early 2000s, a consortium led by Hydro-Québec and the Université de Montréal made critical advances in lithium iron phosphate (LFP) cathode chemistry, a safer and more stable alternative to traditional lithium-ion variants. Rather than keeping the technology under lock and key, the consortium made a strategic decision: in 2011, it began freely licensing its patents to Chinese battery makers such as CATL and BYD.

The move proved prescient. Free from licensing costs, Chinese firms rapidly scaled up production and drove down costs, establishing LFP as a competitive rival to nickel-rich chemistries like NCA and NMC. Tesla, long a proponent of nickel-based batteries, adopted LFP cells for its Standard Range Model 3 and Model Y in 2021.

The Canadian consortium retained a global licensing window, collecting royalties on LFP products sold outside China until the patents expired in 2022. Afterward, the technology entered the public domain for global, royalty-free adoption. Today, LFP is the dominant battery chemistry: in 2024, it accounted for nearly 50% of EV batteries sold worldwide and 87% of newly installed stationary storage capacity.

The technology continues to advance. In June 2025, China's Envision Energy completed a large-scale fire test of its LFP-based storage systems, witnessed on-site by the CSA Group. Conducted in accordance with the CSA C800:25 standard for ESS reliability and fire safety, the test involved four fully charged 5 MWh units (totaling 20 MWh), placed in pairs just 5 cm apart. One unit was exposed to burn conditions; it took three hours to ignite and was then left to burn for 49.5 hours with no external intervention. The system passed with flying colors, further reinforcing LFP's credentials as not only cost-effective but also safe.

As batteries evolve, understanding each country's tech pathways and strengths is critical. The table below compares Canada's battery capabilities with those of China.

Batteries	Canada	China
R&D focus	Strong in early-stage innovation, especially in solid-state, zinc-air, and sodium-ion technologies	Massive investment in applied R&D with rapid commercialization cycles; leading in LFP and sodium-ion scaling
Key players	Hydro-Québec; Nano One, E3 Lithium, Corvus Energy, Electrovaya; Volt-Age	CATL, BYD, CALB, EVE Energy, SVOLT, Gotion, Farasis, REPT Battero, Sunwoda
Commercialization	Slow, more science-based and patent-focused	Extremely fast, with large-scale deployment and rapid product iteration
Manufacturing	Emerging; supported by major foreign investments (e.g., Stellantis-LGES, Northvolt North America)	China produces more than 75% of the world's batteries and leads all key stages of the battery value chain
Supply chain	Rich in critical minerals (Li, Ni, graphite); aims to build an integrated, ESG-compliant supply chain	Vertical integration across mining, refining, cell production, and pack assembly; global expansion in Europe
Technologies	Solid-state (Hydro-Québec/EVLO), zinc, Na-ion, cobalt-free cathodes	LFP and NMC at industrial scale; rapid moves into sodium-ion and solid-state
Government support	Green R&D, mineral processing; efforts to build domestic gigafactories	Strategic national priority with strong industrial plans and policies

III. Unlocking Canada's Potential in Flow Batteries & LDES

While LFP batteries dominate short-duration storage, their fire risk, limited lifespan, and fixed energy-to-power ratio constrain their use at grid scale. In contrast, flow batteries store energy in liquid electrolytes housed in external tanks, which are pumped through a central electrochemical stack.

This design enables independent scaling of energy capacity (by enlarging the tanks) and power output (by resizing the stacks). Such flexibility, combined with long cycle lives (over 10,000 cycles) and non-flammable electrolytes, makes flow batteries a promising fit for long-duration energy storage (LDES) applications requiring 10 to over 100 hours of discharge, far beyond the 4–6 hour limit of lithium-ion systems. To lower upfront costs, innovators are exploring business models such as electrolyte leasing, as electrolytes can account for 40–60% of total system costs.

With natural resources, research depth, and pilot-stage startups, Canada is developing a diversified portfolio of battery technologies, as shown in the table below.

Battery type	TRL	Electrolyte	Key players in Canada
Vanadium Redox Flow (VRFB)	7-8	Vanadium in sulfuric acid	Invinity Energy, VRB Energy (HQ in Vancouver, in-house membranes), VanadiumCorp (mining)
Zinc-Air Hybrid	6-7	Zinc + ambient O2	e-Zinc (Toronto); modular, pilot-ready system
Zinc-Air Flow Battery	~6	Zinc particles in circulating fluid	Zinc8 (Vancouver), public company; true flow system; New York utility-scale demo planned
Organic Flow Battery	3-4	Quinones or other organics	UBC, Universities of Toronto, Alberta & Calgary, Concordia University, NRC; early-stage research
Zinc-Ion Battery	6-7	Zinc sulfate, MnO_2 cathode	Salient Energy (NS); first UL-tested zinc-ion battery; pilot production for stationary storage
Sodium: SIBs, NaS, solid-state		SIBs: sodium salts, hard carbon anode	Dalhousie, McGill & Concordia Universities, UBC, UdeM, Universities of Calgary, Alberta & Waterloo

From Minerals to Megawatts

Canada's advantage begins underground. Its vast land holds some of the world's largest primary vanadium deposits, while in Alberta, vanadium can be recovered as a by-product from oil sands waste. Vanadium redox flow batteries (VRFBs) are the most mature flow technology, with major deployments in Asia, Canada, and the U.S. VRFBs are prized for durability (20+ years), zero fire risk, and zero degradation over thousands of cycles. Vancouver-based VRB Energy, which produces its own membranes in-house, has developed multiple scale-up projects in Asia since 2021.

Zinc-based energy storage is also gaining traction. Zinc is abundant, non-toxic, and chemically stable—and unlike lithium, it performs well in sub-zero temperatures, giving it a clear advantage during Canadian winters. Backed by Toyota Ventures and Eni Next, e-Zinc is piloting a zinc–air hybrid system that electroplates and dissolves zinc within compact, sealed modules. Though technically not a flow battery—since it lacks external tanks or pumps—it achieves comparable durations (up to 100 hours) with a simpler, modular design. Meanwhile, Zinc8 is developing a traditional zinc–air flow architecture using tanks of zinc particles suspended in electrolyte, aiming to compete with lithium-ion at half the cost per kWh for long-duration applications.

Batteries Built for the Cold: A Strategic Niche for Canada

For next-generation batteries, while China leads the commercial race through firms such as CATL and HiNa Battery, Canada is at the forefront of R&D and innovation. Salient Energy, founded in Nova Scotia and also operating in the U.S., is piloting a zinc–ion battery that is inherently fire-safe and low-cost. Academic research at Dalhousie University, known for its lithium-ion work with Tesla, is also pushing sodium-ion boundaries. McGill and Concordia Universities are likewise advancing the field, with recent breakthroughs in cathode materials and solid-state electrolytes.

One often overlooked advantage of zinc- and sodium-based battery systems is their performance in cold weather. Lithium-ion efficiency declines below freezing, often requiring costly thermal management systems, with round-trip efficiency dropping to 75–85% at −10°C. In contrast, zinc and sodium-ion chemistries perform better in cold conditions. Similarly, flow batteries, though less efficient than LFP overall, maintain a steadier 60–70% due to self-regulating electrolyte circulation, making them well-suited for deployment in Canada, the U.S. Midwest, and Nordic countries.

Data centres present another niche, where cooling systems can consume 30–40% of total energy. Canada's abundant renewable energy and cool climate offer a natural edge for efficient, sustainable data centre operations. TELUS, a Canadian IT giant, has unveiled a C$70 billion investment plan over five years in digital infrastructure and data centres, including C$13.5 billion for Alberta. The province itself aims to attract C$100 billion in AI data centre investment by 2029.

EU and U.S. Market Opportunities: BESS, Electrolysis & Fuel Cells

In May 2025, Brussels released a strengthened version of the Net-Zero Industry Act (NZIA) to boost support for solar, energy storage, hydrogen, and other climate technologies. On July 4, the U.S. federal government endorsed the revised Sections 45V and 48E, including updates to:

- Section 45V: extending eligibility for the Clean Hydrogen Production Tax Credit (up to $3/kg) to facilities that begin construction before January 1, 2028;
- Section 48E: providing a 30% Investment Tax Credit (ITC) for qualified battery storage, hydrogen storage, and fuel cell property that begins construction before January 1, 2034.

For Canada, this presents a timely opportunity: two large, subsidized markets for integrated "Solar + BESS + Electrolysis + Fuel Cells" systems and strategic partners just across the border and the Atlantic. In addition to BESS, Canada's strengths in electrolyzers and fuel cells align closely with global policy trends, positioning it as a key player in the net-zero energy transition.

OUTLOOK As the global market pivots from rapid solar and wind deployment to AI and grid-scale resilience, Canada is well positioned to lead in the technologies that matter next: long-duration, safer, and climate-resilient energy storage. What began with minerals may evolve into entire systems. With the right focus, Canada's leadership in batteries and LDES may be just beginning. Its role, though quiet, may prove decisive.