Written Submission for the Pre-Budget Consultations in Advance of the 2023 Budget

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Recommendation 1: That the government provide funding in the amount of $12.5 million CAD for the Canadian Battery Innovation Center (CBIC) program.

Executive summary:

Batteries are the only readily deployable and scalable technology for both electric vehicles and large-scale grid energy storage of renewable electricity. While the battery industry is rapidly scaling up cell production in new Gigafactories, intensive research and development is needed to lower the cost of modern battery cells, increase their lifetime and energy density, and improve their safety. In particular, a shift to more sustainable, cost-effective and abundant elements like iron and manganese, and eco-friendly manufacturing technologies are needed to allow for continued growth in an environmentally friendly way. Canada has existing research expertise, knowledge, and strategic partnerships and is considered a global leader in battery research. A long-lasting commitment to a center for research excellence - the Canadian Battery Innovation Center (CBIC) - is now required to scale up innovations from Canada's world-class battery laboratories to transfer to our domestic industry and ultimately the Canadian consumer. CBIC provides an ultra-low humidity dry room with a high-end pilot line for battery manufacturing and characterization to the Canadian academic and industrial research community on a self-sustaining user fee model. It represents a unique opportunity for Canada to stay at the forefront of a rapidly changing global energy system, train personnel for the domestic energy industry and create battery technology that benefits all Canadians.

Project summary:

The fight against anthropogenic climate change requires a global shift to electrified mobility and a large-scale adoption of renewable electricity generation. Electrochemical energy storage in rechargeable batteries is the only readily deployable and scalable technology for both on-board energy storage in electric vehicles (EVs) and large-scale grid energy storage of renewable electricity. However, the predicted scale-up of battery production necessary to store sufficient renewable energy to power our global society is massive. Approximately 300-400 terawatt-hours of battery capacity will be needed for mobility, industrial and residential purposes. While the battery industry is rapidly scaling up cell production, intensive research and development is needed to lower the cost of modern battery cells, increase their lifetime and energy density, and improve their safety. In particular, a shift to more sustainable, cost-effective and abundant elements like iron and manganese, and eco-friendly manufacturing technologies are needed to allow for continued growth in an environmentally friendly way.

Internationally competitive research and technology development through the equitable participation of expert team members – The Canadian Battery Innovation Centre (CBIC) will be a first-of-its-kind battery prototyping facility that will give researchers the ability to construct and demonstrate the feasibility of next generation battery technologies. Dalhousie University has allocated space for CBIC in its Dunn Building, but in order to outfit this space with equipment needed for high-end battery research and development (e.g., dry room components, high-precision electrode coaters, battery cyclers and advanced analytic tools) a budget of $12.5 million CAD will be needed. The CBIC will serve as a research hub for collaboration with critical infrastructure needed to elevate Canada's position across three globally relevant themes aimed at improving energy density, cost, lifetime, sustainability, and safety of batteries:

Theme 1: Novel processing methods for materials scale up and prototyping. The "dry battery electrode fabrication" is a new ecofriendly roller pressing method that is free of toxic solvents that are typically used in electrode fabrication. This method will be used to make battery electrodes consisting of active material for lithium or sodium storage, carbon additives for improved conductivity, and polymeric binders for electrode cohesion. The "zero-liquid discharge process" will be used to make active material precursors, e.g., nickel hydroxide, needed for sustainable cathode production. This method starts from raw metals instead of metal sulfates and recirculates all process water to avoid sodium sulfate and waste water, which are typical by-products associated with battery materials production. The "all-dry cathode active material synthesis" represents a sophisticated way of making battery active materials, e.g., lithium nickel manganese oxide, directly from raw starting materials by appropriate mixing, high temperature calcination and particle size control. These three cutting-edge materials scale-up and processing methods will be developed at CBIC with industry partners including Tesla and Novonix, to yield battery prototypes with improved sustainability, reduced cost and multi-decade lifetime.

Theme 2: Affordable, sustainable and energy dense battery cells. Novel prototype battery cells to be developed in theme 2 include cells with a new class of active material, the lithium-chloride lithium-bromide graphite cathode chemistry discovered by CBIC Co-Team Lead Yang, which meets the cost, sustainability and energy density demands of future battery technology. This chemistry eliminates transition metals, e.g., nickel and cobalt, from the battery cells, can be made in a simple room temperature synthesis, and operates at relatively high voltage. Its use in CBIC prototype cells will yield low-cost, high-energy density batteries for EV and stationary storage applications. Other CBIC prototypes will rely on lithium manganese iron phosphate or cobalt-free nickel and manganese oxide, two other important materials classes for high energy, sustainable battery prototypes.

Theme 3. Sustainable sodium-ion batteries for grid energy storage. Mature sodium-ion batteries are required as an alternative to lithium-ion batteries since sodium is high in abundance and low in cost. CBIC researchers will develop prototype sodium-ion cells based on sustainable iron- and manganese-based Prussian White and oxide cathodes. The sodium-ion prototypes will be tailored towards grid energy storage, with an emphasis on scalability and lifetime, to enable long-lasting battery technology with a 25-year lifetime target for storing renewable energy from intermittent sources like wind and solar photovoltaics.

The above battery solutions currently do not exist, but an expert team of global leaders, including early career researchers, in the battery field has been formed with expertise that spans the full range of interdisciplinary research needed for future battery breakthroughs. The competencies include materials science, electrochemistry, solid-state chemistry, microscopy and spectroscopy, as well as mechanical and materials engineering. Combined, the team members have been awarded over $70M in research funding in the last 5 years and have established strong partnerships with major companies in the energy and automotive sectors. Among the 10 team members are 4 Tier 1 Canada Research Chairs (Botton, Chen, Dahn, Sun), two Industrial Research Chairs (Goward, Obrovac), two early career researchers with named Research Chairs (Herzberg-Dahn Chair Metzger and Tesla Canada Chair Yang), and an Officer of the Order of Canada (Dahn), reflecting the team's global leadership in the battery field. Numerous industrial partners have been confirmed as users of the CBIC research infrastructure and end-users of the research deliverables, including battery industry leaders Tesla ($200,000 cash contribution) and Novonix, energy provider Emera Technologies ($350,000 cash contribution), and start-ups Salient Energy, Li Metal and Zen E-bikes.

In addition to a commitment to scientific excellence, the CBIC team will implement specific actions to promote best practices in equity, diversity, inclusion and accessibility (EDIA). This will be accomplished by recognizing and addressing systemic barriers in the battery field, establishing outreach and support programs to Indigenous peoples, racialized minorities, women, persons with disabilities and the 2SLGBTQ+ community. The team members are committed to establishing a healthy, diverse, safe, and inclusive research environment at CBIC. An independent EDIA committee will be formed, which will oversee an inclusive and unbiased hiring process for new CBIC personnel, review the research team's composition on a yearly basis and help to develop strategies for recruiting and retaining more HQP from equity deserving groups.

Novel infrastructure for the Canadian research community with an accessible and sustainable operations and maintenance plan – Currently, Canadian researchers do not have access to a domestic user facility to scale up the innovative materials developed in their laboratories. This capability is urgently needed to assess whether battery breakthroughs on the lab-scale can feasibly translate to successful commercial products. CBIC will unify competences needed for materials synthesis, electrode processing, cell assembly and advanced analytics. By co-locating world-class battery researchers and critical manufacturing and characterization equipment, CBIC will promote collaboration and enhance training opportunities. To support internationally competitive and inclusive battery research in Canada, the new CBIC facility will consist of an ultra-low humidity dry room with a high-end battery manufacturing pilot line for fabrication of novel prototype cells (e.g., high temperature furnace, high speed mixing and precision coating equipment, and flexible semi-automatic battery cell assembly machines), and a suite of characterization equipment to study the new cell prototypes in operation (e.g., ultra-high precision battery chargers and cell impedance testers for lifetime testing and quality control). Moisture in the air reacts with battery materials and needs to be kept at a minimum level in order to ensure battery prototype fabrication at CBIC to highest quality standards. The dry room will be a highly unique and innovative aspect of the facility and is essential for enabling novel manufacturing technologies described in theme 1 and handling next-generation battery materials described in themes 2 and 3. The research team is highly experienced in using the proposed infrastructure through past industry experience at Bosch, 3M, and Moli Energy.

The CBIC has an organizational structure that will promote long-term strategic development through a scientific advisory committee that will provide input on core research themes and future expansion of CBIC's capabilities. Guided by the EDIA Committee, the CBIC will establish inclusive and accessible operations protocols to support researcher access to the facility. CBIC's ambitious operations plan sets the milestone goal of building a first batch of 100 prototype cells after one year of operation. This will also mark the start of revenue generation through a self-sustaining user-fee model supported by engaged research and industry partners, which is projected to establish a sustainable model for long-term operations and maintenance.

Benefits for Canadians – The proposed research will yield battery technologies that will address five key characteristics that are necessary to improve and enhance electrochemical energy storage: high energy density, affordable cost, ultra-long lifetime, improved sustainability, and advanced safety. The ability to fabricate custom, high-quality cells for battery R&D at CBIC will advance Canada's strategic battery initiative for domestic supply chain and manufacturing. The proposed prototype cells will be essential to demonstrate the achievement of these deliverables in relevant form factors, i.e., flat and cylindrical pouch cells. Solutions demonstrated in these high-end prototypes will be directly transferrable to production cells and accelerate the product development of confirmed and potential industry partners. The breakthroughs anticipated in high energy density cells will enable longer driving range electric vehicles and will be transferred out of academia to industry through the existing research partnership with Tesla and future partners like Emera Technologies. CBIC's focus on lower cost, sustainable battery materials, such as manganese and iron-based phosphate cathodes, will accelerate the adoption of EVs and e-bikes in collaboration with Tesla and Zen E-bikes. The research on low-cost, long-life sodium-ion batteries has the potential to lead to a substantial increase in wind and solar energy for Canada, as it will make the associated energy storage systems much more affordable.

CBIC will also provide a unique training experience for highly qualified personnel (HQP). CEOs from Tesla and Novonix have reported a shortage of HQP and a high need for training in battery process technology – in particular for high-quality electrode coating and cell assembly. CBIC is forecasted to provide thorough training for ~250 HQP over the first five years of operation. It is anticipated that these individuals will be in high demand by the domestic Canadian battery industry and contribute essential skills to future high-tech battery production. Ultimately, the innovative materials and processes supported by the CBIC will offer ample possibility for the creation of new start-up companies, especially in the new emergent green economy.

The CBIC will support world-leading research in the development of next generation battery cells with novel processing methods, to the highest industrial standards. The CBIC researchers have the expertise, knowledge, and strategic industry partnerships needed to maintain Canada’s position as a global leader in battery research, with the capacity to support the scale-up needed to bring novel battery technologies to benefit all Canadians.