Collaboration Centre in Green Energy Materials (CC-GEM)

Call for Expressions of Interest

Deadline for Expression of Interest: May 30, 2022
Workshop for proposal development: July 18, 2022
Selection of proposals and notification: September 2, 2022
Completion of collaborative agreements & contracts: Fall/Winter 2022

CC-GEM Background

The Collaboration Centre in Green Energy Materials (CC-GEM) is a joint initiative of the National Research Council of Canada (NRC) and the University of Toronto, formally launched in June 2019 with an initial 7-year term. The aim of CC-GEM is to "*integrate and exploit synergies between UofT and NRC to develop and demonstrate emerging materials, processes, and platform technologies with potential for disruptive impact in reducing environmental impact in transformation, transmission and storage of energy*". At the core of CC-GEM are collaborative research projects led by Principal Investigators (PIs) from NRC and UofT, funded by a combination of dedicated NRC funding and grant (or other) funding contributed by the UofT PIs engaged in these projects. Under the CC-GEM Master Agreement, NRC and UofT have agreed that each organization will contribute 50% of the cost of graduate students and post-doctoral fellows (PDFs) involved in joint projects. These students and PDFs are expected to spend a substantial amount of time working on-site at NRC's new research facility in Sheridan Park, Mississauga, which serves as CC-GEM headquarters.

Scope of eligible projects

Projects funded under CC-GEM must fall within the defined technical scope for this initiative, which comprises the following Research Pillars and Platform Technologies:

Research Pillars:

- Next generation photovoltaics
- Renewable carbon-based feedstocks
- Renewable fuels and fuel cells
- Next generation, consumer-scale, energy solutions
- AI and robotics-enabled materials discovery

Platform technologies

- Accelerated materials discovery and process development
- Production scale-up, demonstration and standardization
- Materials and process sustainability and safety

More detailed definitions of each of these Pillars and Platform Technologies are provided in **Annex A**.

Available funding

It is planned that up to 4 new projects will be funded as part of the current call.

Funding to UofT PI: For each project, NRC will provide to the UofT PI (and any co-PIs) *up to a maximum* of $70k (CAD) over 2 years[1] for funding of UofT graduate students and PDFs, including any overhead costs. Funding for students and PDFs must be *at least* matched by funding by the UofT PI (and any co-PIs), who must also cover any other UofT project expenditures.

Funding to NRC PI: The CC-GEM initiative will provide to the NRC PI (and any co-PIs) necessary labour and equipment usage codes, and fund all *reasonable and justified* project operating costs. Note that it is expected that, other than in exceptional circumstances, operating costs should be much less than $30k/year

Relative NRC and UofT project expenditures: Each project will be different, but the total magnitude of contributions ($) to each project by NRC and UofT, including staff salary costs, student & PDF costs, etc) should ideally not differ by more than a factor of 2:1. For example, if one of NRC or UofT contributes $200k, the other should not contribute less than $100k.

Eligibility

Expressions of Interest (EOIs) may be submitted by researchers from either NRC or UofT. While all CC-GEM projects must be co-led by PIs from both NRC and UofT, at the EOI stage PIs from both institutions need not be identified (although this is preferable). All submitted projects must align with an on-going programs at NRC. The EOI application should specify which program, in addition to CC-GEM, is supporting the project. The table below shows the alignment between the CC-GEM pillars, detailed in the annex, and selected NRC programs. For other NRC programs please refer to: https://nrc.canada.ca/en/research-development/research-collaboration/programs/nrc-capabilities-clean-energy-resources

CC-GEM Pillars	Examples of NRC Programs
1,2,3,4,5	Advanced Clean Energy program
3,4,5	Clean and Energy-efficient Transportation program
1,2,3,4,5	Artificial Intelligence for Design Challenge program
2,3,5	Materials for Clean Fuels Challenge program

NRC PIs (OR a co-PI) must be full-time, continuing, researchers, and may be employees of *any* NRC Research Centre. UofT PIs must be full-time UofT faculty and may work within *any* UofT campus, faculty or department. NRC term PIs may also apply but would need to involve an NRC Co-PI that is full time & continuing to ensure project continuity. It is the responsibility of PIs to ensure that they comply with any relevant home institution policies and to obtain any approvals that may be required.

Please note that for the current round of proposals, co-PIs of CC-GEM projects that received funding in the previous rounds of projects ARE eligible to receive new funding.

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[1] Projects may have a duration of between 12 months to 36 months, with maximum total funding (per project) of $70k (combined NRC & UofT funding). Projects of less than 24 months will have funding prorated at a rate of duration / 24 months.

Employment equity, diversity, inclusion (EDI)

Explain the processes for ensuring gender and other diversity considerations throughout project planning and execution processes including, as applicable, research design and analysis.

EOI and proposal evaluation criteria:

Both EOIs and final project proposals will be evaluated by the CC-GEM Scientific Co-ordination Committee (SCC) according to the criteria outlined in **Annex B**.

Process and timelines

- Step 1: Completion of Expression of Interest (EOI). Deadline for EOI submission: **May 30, 2022**
    - Use the CC-GEM EOI template shown in **Annex C**.
    - EOIs must include both an NRC PI and a UofT PI and, as possible, an identified 3rd party contributor
    - Completed EOIs are to be sent to the CC-GEM Program Manager, Punita Mehta (Punita.Mehta@nrc-cnrc.gc.ca) by the identified submission deadline
- Step 2: Selection of screened-in EOIs: **June 24, 2022**
    - The primary purpose of EOI screening will be to ensure alignment with CC-GEM scope and objectives; the level of scrutiny vs other criteria will depend on the number of EOIs received.
    - The EOIs will be screened and evaluated by the CC-GEM SCC.
    - EOI leads will be notified by the date above whether their submissions are selected for development into full proposals, beginning with a workshop to be held via MS Teams.
- Step 3: Proposal development workshop: **July 18, 2022**
    - Invitees will include leads of (screened-in) EOIs, CC-GEM SCC members and selected U of T and NRC research leaders. Representatives of proposed 3rd parties may choose to join the presentations & discussions relating to the EOIs of which they are part.
    - EOI leads will be given a template to be used for a presentation of proposed projects, followed by Q&A, feedback and input to further develop their ideas, to be incorporated into full proposals
- Step 4: Proposal review, selection and notification by **September 2, 2022**
    - Proposals will be reviewed by the CC-GEM Scientific Co-ordination Committee (SCC) and those recommended for funding approved by the Management Board
- Step 5: Completion of collaborative agreements & contracts: **Fall/Winter 2022** (some 3rd party project agreements may take longer to negotiate)
    - Successful PIs from UofT and NRC and the external party will be required to complete contractual documents to define the detailed project statement of work (SOW), deliverables, invoicing schedule, etc., according to standard templates agreed as part of the CC-GEM Master Agreement, with which all PIs must agree to comply (copies available upon request).
    - Completion of documentation will be co-ordinated by the CC-GEM Program Manager (Punita Mehta)

Further Information

For further information about this call, about the CC-GEM initiative, or other related information, please contact the CC-GEM Program Manager, Punita Mehta (Punita.Mehta@nrc-cnrc.gc.ca). Technical questions or questions about the CC-GEM scope and objectives may also be directed to members of the CC-GEM Scientific Co-ordination Committee (SCC), listed below:

- **Alán Aspuru-Guzik**, Chemistry / Computer Science (UofT)
- **Aimy Bazylak**, Mechanical and Industrial Engineering (UofT)
- **Timothy Bender**, Chemical Engineering and Applied Chemistry (UofT)
- **Farid Bensebaa**, Energy, Mining and Environment Research Centre (NRC)
- **Robert Black**, Energy, Mining and Environment Research Centre (NRC)
- **Diana Facchini**, Energy, Mining and Environment Research Centre (NRC)
- **Parisa Karimi,** Energy, Mining and Environment Research Centre (NRC)
- **Patrick Malenfant,** Security and Disruptive Technologies Research Centre (NRC)
- **Jonathan Martin,** Energy, Mining and Environment Research Centre (NRC)
- **Alana Ogata,** Chemical & Physical Sciences (UTM)
- **Ted Sargent,** Electrical and Computer Engineering & VP International (UofT)
- **David Sinton**, Mechanical and Industrial Engineering (UofT)
- **Dwight Seferos**, Chemistry (UofT)
- **Martin Tyrawskyj,** Energy, Mining and Environment Research Centre (NRC)

Annex A: CC-GEM Scope: Pillar and Platform Descriptions

Pillar 1: Next generation photovoltaics

VISION

To push emerging photovoltaic/solar cell technologies to the Canadian market.

BACKGROUND

There is a pressing need to generate electrical power with a minimized GHG footprint across all Canadian communities including concentrated urban areas, rural areas and indigenous communities. Each community has different types of existing infrastructure such as grid connected solar farms, and different energy needs. To enable the adoption of solar power generation across this broad spectrum, we need to consider both the evolution of silicon-based solar cells and panels as well as newly emerging photovoltaic/solar cell materials such as sustainable organic materials, inorganic nano-scaled materials called quantum dots and organic ligated heavy metal materials called perovskites. Each of these classes of photovoltaics/solar cell technologies has the potential for community-focused niche applications in solar power generation.

OBJECTIVES

This pillar will focus on identifying emerging and revised photovoltaic technologies. Once identified the pillar will undertake research and development to move the technologies from laboratories to the Canadian market utilizing NRC resources and collaborative insight. The focus will include silicon-based solar cells and panels, which are currently in the market yet are under revision, and emerging alternative photovoltaic/solar cell technologies such as organic, quantum dot and perovskite solar cells.

SCOPE

Theme 1: Emerging Photovoltaic/Solar Cell Technologies.

There are three main emerging classes or solar cells: organic, perovskite and quantum dot. Organic photovoltaics are based on carbon materials utilizing the versatility of organic and polymeric chemistry to tailor properties including efficiency and ambient stability. Organic solar cells have manufacturing versatility including printing/solvent coating and thermal vacuum deposition. Perovskite photovoltaics are based on ligated lead (Pb) and are also printable. Similarly, quantum dots are also lead (Pb) based, also printable but are nano-scaled materials with specific versatility when it comes to nano-engineering and tailoring their properties. Within the FASE we have reached record power conversion efficiency or ambient stability for these emerging photovoltaics.

Within this theme, we will explore:

- Device engineering including anti-reflective coatings, photonic management, photon concentration, encapsulation methodology, and sizing and device configurations.
- Controlled and environment testing and the development of a protocol/standard to enable accelerated testing and points of comparison.
- Industry relevant fabrication methodologies such as printing, blade coating etc.

- Fundamental materials development and characterization to enhance power conversion efficiency and ambient environmental stability, including hole- and electron-transport, light absorption, hole- and electron-injection materials, etc.
- Consideration of production scale of materials.
- The complete life cycle consideration including embedded energy and associated GHG footprint.

Theme 2: Further development of silicon based solar cells.
Even as silicon based solar cells/panels are in the market, there are still research points to be addressed that will enhance their ultimate power conversion or provide alternative applications for the technology. Within this theme we will explore:

- The integration of emerging solar cell technologies with silicon based cells/panels.
- The nanoscale structure of silicon semiconductors and the influence on power conversion efficiency.

Pillar 2: Renewable carbon-based feedstocks

VISION

To develop and demonstrate technologies for the efficient conversion of CO_2 into carbon-based feedstocks with large existing markets.

BACKGROUND

Globally significant carbon utilization and conversion will require technology advancements that target the conversion of CO_2 into carbon-based fluids and materials that are both valuable and demanded at the ~ 1Gton/yr scale. High product value is critical to ensure the process is feasible on the scales required. High product volume demand is critical to ensure that if economic conversion is achieved, an existing market is available to be served. Carbon-based feedstocks, including the vast array of products currently provided by the petrochemical sector, provides carbon conversion target products that can offer both the required product value and scale.

OBJECTIVES

To develop and demonstrate novel and emerging materials and material engineering processes to leverage renewable energy to convert carbon dioxide into high-value feedstock that have an existing market demand on the order of ~ 1Gton/yr.

SCOPE

This pillar encourages a broad array of approaches to the carbon-based feedstock generation challenge, and will support materials discovery and development from early stages through to demonstration. The applicability of a given project will be assessed with respect to the potential to achieve the metrics outlined in the pillar objective. There are otherwise, however, no further restrictions on approach. All approaches will be considered provided the project has materials, and material engineering processes at the core, and renewable conversion of CO_2 into a high value large market feedstock. Examples of high-value large-market carbon feedstocks include ethylene, methanol and propanol, among others.

Breakthroughs in materials could advance, for instance, thermochemical conversion, photochemical conversion, and electrocatalytic conversion among others. Applicants are encouraged to assess and emphasize the aspects of their approach that provide competitive advantage over others, especially in terms of application at scale. For instance, applicants are encouraged to target materials discovery and engineering that *address* the realities of (i) the impurities in industrial CO_2 streams, (ii) the discount associated with impure product streams, and (iii) the embedded nature of the incumbent fossil-fuel based production technology. These later-TRL challenges will guide the program.

This Pillar includes all three platform technology areas: Accelerated materials discovery and process development; Production scale-up, demonstration and standardization; and Materials and process sustainability and safety.

Pillar 3: Renewable fuels and fuel cells

VISION

To develop technologies for the economical synthesis of renewable, carbon-free chemical fuels.

BACKGROUND

This pillar will focus on the development of carbon-free fuels, including hydrogen and ammonia, using renewable energy as inputs. Hydrogen can be produced by splitting water, while ammonia has the potential to be synthesized by direct reduction of nitrogen. These processes are accomplished using electrochemical reactions taking advantage of the increasing supply of clean electricity. Hydrogen and ammonia are chemical energy carriers that can be stored and used efficiently for heating of buildings and transportation.

While electrochemical hydrogen generation has been well established, it relies on expensive precious metal catalysts and newer high-current density configurations have not been scaled. Ammonia synthesis is very compelling, but only very low selectivities and yields have been demonstrated so far.

OBJECTIVES

This project will generate a fundamental understanding of electrocatalytic processes and their application to renewable fuel generation, taking advantage of Canada’s clean electricity grid. The technology developed in this pillar will enable the decarbonization of a broad range of industries that cannot directly and easily electrify, including agriculture, transportation, and chemical industries.

DESCRIPTION

Hydrogen economy: Hydrogen is an important energy carrier and chemical intermediate; however, it is currently produced primarily from natural gas. Breakthroughs are needed in renewable hydrogen generation, storage, and transportation in order for the hydrogen economy to become viable.

In this theme, we will explore:

- Precious-metal free catalysts for efficient water splitting
- Electrolyzer design and optimization, including alkaline, PEM, and solid-oxide configurations
- Membrane design for improved electrolyzer efficiency
- Liquid and solid vectors for hydrogen storage
- Reliability of electrolyzers/catalysts with intermittent electrical input
- Identifying pathways to synthetic fuels using CO_2/CO and H_2 as inputs

Renewable ammonia: Ammonia is an important fertilizer for the agriculture industry. It is currently produced by the energy-intensive Haber-Bosch process and is responsible for about 2% of global GHG emissions. Furthermore, only extremely large ammonia plants are economically viable, and therefore indirect emissions from transport is greatly increased. Ammonia is also emerging as an attractive liquid fuel that produces zero carbon emissions.

In this theme, we will develop new technologies for the synthesis of ammonia from water and electricity.

- Develop a fundamental understanding of pathways to activate the N_2 molecule
- Design and synthesis new catalysts for the selective synthesis of ammonia

- Development of electrochemical systems for ammonia synthesis, including non-aqueous electrochemical systems and solid-state electrolyzers.

Pillar 4: Next generation and consumer-scale energy solutions

VISION

To develop the next generation of energy solutions with flexible form factors that can be seamlessly integrated into consumer products, including textiles.

BACKGROUND

Polymer-based redox agents (redoximers) are poised to dramatically change energy storage devices, such as lithium-ion batteries, and enable emerging new technologies including redox-flow batteries. Redoxmers differ from inorganic electrode materials, not only due to their soft nature, but also that they do not require ions to intercalate into a rigid solid-state lattice, suggesting that it should possible to design polymers in new ways with functional groups tailored for a specific device's needs for both ionic and electronic conductivity.

Emerging battery-ion technologies such as Mg-ion batteries offer greater capacity, greater safety, and utilize more Earth abundant atoms. Magnesium-ion batteries are promising rechargeable batteries that could achieve widespread commercial success. Magnesium anodes exhibit nearly twice the volumetric capacity of lithium anodes (due to the two-electron oxidation of magnesium). A large natural abundance of magnesium also lowers the projected cost of magnesium-ion batteries.

Waste heat provides a means of capturing consumer-scale energy directly at the consumer. Polymer-based thermoelectric devices provide a means to not only personalize energy generation, but also to personalize heating and cooling, which is of paramount importance in the cold areas of Northern Canada and hot developing countries. Critical challenges in this emerging area such as the development of stable p/n-doped conductive polymers to realize safe and stable personal energy generation and heating and cooling.

OBJECTIVES

Under this pillar we aim to develop new forms of energy storage components. A significant focus will be on polymer-based active materials (redoxmers) which undergo redox chemistry and therefore carry the burden of managing the transfer and transport of both ions and electrons. A prototypical class of redoxmer that will be developed is one that combines high specific capacity with ionic and electronic conductivity thereby reducing the need for carbon additives in the electrode. They are expected to maintain their state-of-charge without incurring deleterious side reactions or undergoing significant changes in solvation and, ultimately, solubility. The redoxmers should be applied to both Li-ion battery and supercapacitors.

We will concurrently develop organic cathodes for Mg-based organic batteries. Organic cathodes have many inherent advantages over inorganic cathodes that should be harnessed to improve magnesium-ion battery performance. For example, organic materials are expected to operate at higher rates than inorganic materials due to more flexible migration pathways for magnesium ions and reduced intermolecular forces. The combination of resonance stabilization, leading to charge delocalization, and the presence of rotatable bonds, leading to rotational flexibility, results in facile charge redistribution and achievement of local electroneutrality. This should result in a high rate capability, similar to the Chevrel phases. Enhanced rate capabilities allow for rapid charging and discharging, which is a requirement for most energy storage devices.

Safety concerns surrounding advanced battery technologies will be addressed by the aforementioned aims and by the design of new electrolytes preventing dendrites from shorting. This requires high shear-modulus (*G*) polymer electrolytes, which are often out of reach with typical ion-conducting polymers, such as poly(ethylene oxide) or poly(oligo-oxyethylene methacrylate), due to their low *G* relative to lithium metal. To increase *G* of a soft ion-conducting polymer, nanostructuring with a hard, glassy matrix, such as polystyrene, or by tethering the polymer chain ends to access a variety of multi-block co-polymer architectures should be studied. A key part of all device and safety testing will be through the use of *in operando* analysis by advanced X-ray and electron microscopy techniques.

Hybrid materials that combine the advantages of polymers with other high carbon content materials like graphene or CNTs will be developed. Not only will these materials be useful for energy storage technologies, they should also provide the ideal combination of conductivity and power factor for use in personal power generation by the thermoelectric (Seebeck) effect, and as such be useful for personalized temperature management.

SCOPE

The work plan includes the development of new polymers and polymer composites, redox active small molecules and polymer electrolytes. The samples will be characterized to understand structure-property relationships. Prototype devices including coin cells, pouch cells, solid-state batteries, and thermoelectric generators will be produced. Scale up manufacturing methods (i.e. printing at a range of scales on a range of substrates) will be developed. Another key part of this thrust is device integration particularly into stretchable and wearable form factors.

Pillar 5: AI and robotics-enabled materials discovery

VISION

Design, develop and deploy self-driving laboratories, which integrate automated experimentation hardware with artificial intelligence (AI) into a single platform, to accelerate the discovery of functional materials.

BACKGROUND

Self-driving laboratories have the potential to significantly increase the rate of scientific discovery by leveraging the strengths and opportunities provided by automated experimentation platforms and AI. The potential of AI, notably machine learning (ML), to perform tasks without explicit instructions and learn from patterns and inference enables the self-driving laboratories to operate in full autonomy. While the robotic platforms execute experiments, such as synthesizing or fabricating a new material or characterizing its properties, the ML components of a self-driving laboratory speculates about the properties of uninvestigated materials using information from past experiments. By probing only the most promising material candidates suggested from the ML component, self-driving laboratories are expected to aid scientists in the discovery of new functional materials and thus decrease their time to market significantly.

OBJECTIVES

To design and develop a self-driving laboratory, which fully integrates AI-powered experiment planning strategies with automated experimentation platforms for accelerated scientific innovation and discovery of functional materials.

DESCRIPTION

This pillar will focus on the development of transferable and modular designs for both software and hardware components of a self-driving laboratory to leverage the strengths of automated platforms and AI to full capacity. To this end, this pillar will explore opportunities to rethink established experimentation protocols with the goal to maximize the experimentation throughout for accelerated discovery.

At the heart of the self-driving laboratory is the ML component for experiment planning. This pillar will explore and develop ML-based strategies for both identifying promising material candidates and determining the experimental parameters to synthesize/fabricate and characterize them. Methods such as Bayesian optimization for parameter identification have already been integrated into proof-of-concept implementations of self-driving laboratories. However, the ML-based in-silico design of new material candidates by means of, for example, generative models, has yet to be demonstrated in the context of self-driving laboratories.

Further key technologies to be developed include (i) the seamless integration of computational materials discovery approaches into the experimentation process, (ii) frameworks to exploit general relations between experimental parameters and measured properties from past experiments to serve as a prior for accelerated discovery across different applications, and (iii) the augmentation of laboratory environments with computer vision technologies to detect undocumented actions and correct for hardware irregularities in full autonomy.

While specific areas of materials discovery arguably pose particular requirements to an autonomous experimentation platform, all aforementioned technologies will be developed to be most transferable across multiple applications.

Platform 1: Enabling Platform Technologies

VISION

Accelerate the discovery, development, demonstration and integration of disruptive green energy materials through the application of cross-cutting platform technologies.

BACKGROUND

Bringing a new material to market is risky, time-consuming and costly, with some estimating 10-20 years and $2-20M USD in R&D alone to get from the lab to mainstream use. Notwithstanding market uncertainties, technological risk plagues each step of the materials development process. Further compounded by disconnects between stages of developing new materials and the products based on them leads to imprecise materials requirements definition, testing of materials under irrelevant conditions and a need to modify materials for manufacturability, resulting in a lengthy, risky and high-cost materials commercialization process. Transitioning new materials discoveries to commercial products can be accelerated by directly addressing key commercialization bottlenecks. For instance, transitioning laboratory-scale material synthesis to industrial scale production can be enhanced by research in computational materials design, automated material characterization and machine learning (AI) to optimize experimental design and accelerate interpretation of results. Moreover, these tools drive materials-by-design approaches that can radically accelerate the discovery of materials optimized to market-driven needs and generated by scalable processes. Transitioning materials discoveries to commercially relevant products can also be de-risked by offering metrology support and evaluation of materials and process health and safety and environmental sustainability. Closely coordinating material discovery efforts with later stages of material processing and integration, appropriate materials validation and certification can be performed in parallel, both reducing risk and accelerating the processes of scale-up, demonstration and prototyping.

OBJECTIVES

Develop, demonstrate and apply cross-cutting platform technologies that support the development and demonstration of one or more of the novel and emerging materials described in the five Pillars and/or processes associated with the creation or application of these materials.

DESCRIPTION

Working across all Pillars, platform technologies will be developed that contribute to the accelerated development and improved understanding of the proposed materials, processes and applications. Platform technologies to be developed and applied include:

- Accelerated materials discovery and process development including:
    - Computational materials discovery, design and process simulation
    - High-throughput materials characterization and processing experiments
    - Materials and processes databases, with the intent to make these open and available to the Canadian materials science community
- Production scale-up, demonstration and standardization including:
    - Materials and process standards development
    - Scaled-up materials synthesis and production
    - Design and demonstration of multi-functional materials and devices
- Materials and process sustainability and safety including:
    - Cradle-to-grave materials and product life cycle assessment (LCA), ideally coupled with technoeconomic analyses (TEA)
    - Health and environmental impacts and mitigation methods
    - Accelerated ageing of materials and devices, in particular those that combine physical testing with predictive modeling

It is expected that each platform technology will be developed and applied to a specific Pillar sub-topic (i.e., stage of material and/or process development or application) where it has the potential to yield the greatest benefits to the advancement of the Pillar objectives. To this end, the scope and timing of the platform technologies projects will be dependent on the Pillar scopes and roadmaps. While not all platform technologies will be applied to each Pillar, the intent will be to develop all platform technologies across multiple Pillars and throughout the term of CC-GEM. Preference will be given to approaches that show promise for future transferability to other materials, processes and/or applications.

As an in initial step, an integrated roadmap for platform technology development and application aligned to the Pillars will be developed. This will require active involvement of the Pillar leads to identify the anticipated near- (1-2 year), mid- (2-4 year) and long- (5-7 year) term state of development of their material(s), process(es) and application(s), challenges or opportunities that could be addressed by one or more platform technologies, and pathways to integrate or align platform technology development and/or application projects with Pillar projects. Joint annual review of platform technology and Pillar progress and plans will aid in further refinement of plans and priority areas, and help identify opportunities to apply developed platform technologies to other Pillars.

It is expected that platform development will occur in two or more waves, with an initial cluster of platforms focused on domains that are less dependent on Pillar progress and direction, for example, material and process database development, accelerated aging of materials and devices, and LCA/TEA, to be followed by a subsequent wave of platforms related to scale-up. Platform areas such as health and environmental effects and standards development will only be pursued as needed.

Annex B: Evaluation Criteria

The following criteria will be used in evaluation of Expressions of Interest (EOIs) and the later full proposals. As they contain limited information EOIs will primarily be screened on the basis of alignment with CC-GEM scope and objectives, with other criteria being considered, as possible, depending on the number of EOIs received.

1. *Alignment with NRC Strategic Mandate*
   a) Does the project align with a program already on-going at NRC?
   b) How does the project objective support program needs / objectives?
2. *Alignment with CC-GEM Strategic Mandate*
   a) Does the project address identified CC-GEM scientific, technological and economic priorities?
   b) Does the project align with NRC and UofT established strategic mandates?
   c) Does the project demonstrate relevance to industry? Does it have private support?
   d) Is the impact of the project clearly described? Does the project show potential for technology transfer or translational applications, commercial applications, or other benefits to Canada?
   e) Does the project build on existing collaborative relationships with other organizations or establish new ones?
3. *Scientific Excellence of the Proposal*
   a) Is the project idea original or creative? Does the project address an important question?
   b) Is the rationale/motivation for the project sound?
   c) Are the objectives of the project well-defined and worth pursuing?
   d) Are the proposed methods feasible and appropriate to achieve the project objectives?
   e) Are the anticipated outcomes of the project likely to have a significant impact on scientific / engineering knowledge or technology development?
4. *Scientific Excellence of the Project Team*
   a) Does the project team include substantial contributions from researchers from both UofT and NRC?
   b) Do the researchers bring a demonstrated track record of expertise and excellence appropriate to the project?
   c) Is there an appropriate level of commitment from the researchers?
   d) Does the project team as a whole include all of the expertise required to complete the project, with a track record of accomplishment? [Note: this includes excellence of students / postdocs / technicians and any external collaborators]
   e) Does the project team offer unique competencies?
   f) If appropriate, does the project team encompass cross-disciplinary experience?
   g) If appropriate, does the project bring in expert collaborators from outside the current NRC-UofT network to complement existing expertise?
   h) Are the appropriate resources (matching funds, equipment, etc.) needed to complete the project available to the project team members?
   i) Were there EDI considerations?
5. *Project Management*
   a) Are the timelines and deliverables of the project realistic?

b) Is the proposed budget well-justified and realistic?
c) Does the project take full advantage of potential leverage from other funding sources, or is there a well-developed plan to access any external resources needed to complete the project?
d) Does the proposal identify possible challenges and mitigation strategies?

6. *Highly Qualified Personnel (HQP) training*
   a) Does the project provide opportunities for HQP training/professional development, and do the applicants have a well-developed training plan?
   b) Does the project involve HQP from both UofT and NRC, and will training opportunities be available to team members from both partners?
   c) Does the project involve only current HQP or develop new HQP?

7. *If third party engagement is planned then:*
   a) Is the specific contribution of the *third* party clearly defined?
   b) Is the contribution of the *third* party important to achieving project outcomes?
   c) Will *third* party involvement contribute to overall CC-GEM goals
   d) Has commitment from the *third* party been obtained?

Annex C: Expression of Interest (EOI) Template

Project Information	
Project Title:	***DESCRIPTIVE TITLE***

Project Co-Leads

For NRC:		For U of T:	
Name		Name	
Title		Title	
Research Centre		Depart.	
Phone		Phone	
Email		Email	

Proposed project start:	20XX-MM	*Date of Submission:* 2021-MM-DD
Proposed project end:	20XX-MM	

Alignment to CC-GEM Strategic Mandate (check all that apply)			
	Next-gen photovoltaics		Computational materials discovery & process simulation
	Renewable carbon-based feedstocks		High-throughput experiments
	Renewable fuels and fuel cells		Materials and processes databases
	Next-gen. consumer-scale energy solutions		Materials and process standards
	AI and robotics-enabled materials discovery		Scaled-up materials synthesis & production
			Multi-functional materials and devices
			Materials and product life cycle assessment
			Health/environmental impacts & mitigation
			Accelerated ageing of materials and devices

Background and scope (200 words **maximum**)
EOIs exceeding word limits will not be accepted
Project objectives (200 words **maximum**)
EOIs exceeding word limits will not be accepted
Project third party (if any) and Approximate contribution (5%, 10%, 25% ….):
Organization:
Contact Name:
Phone number:
Email:
EDI consideration strategies (75 words maximum)