ENERGY **MODELLING CENTRE**

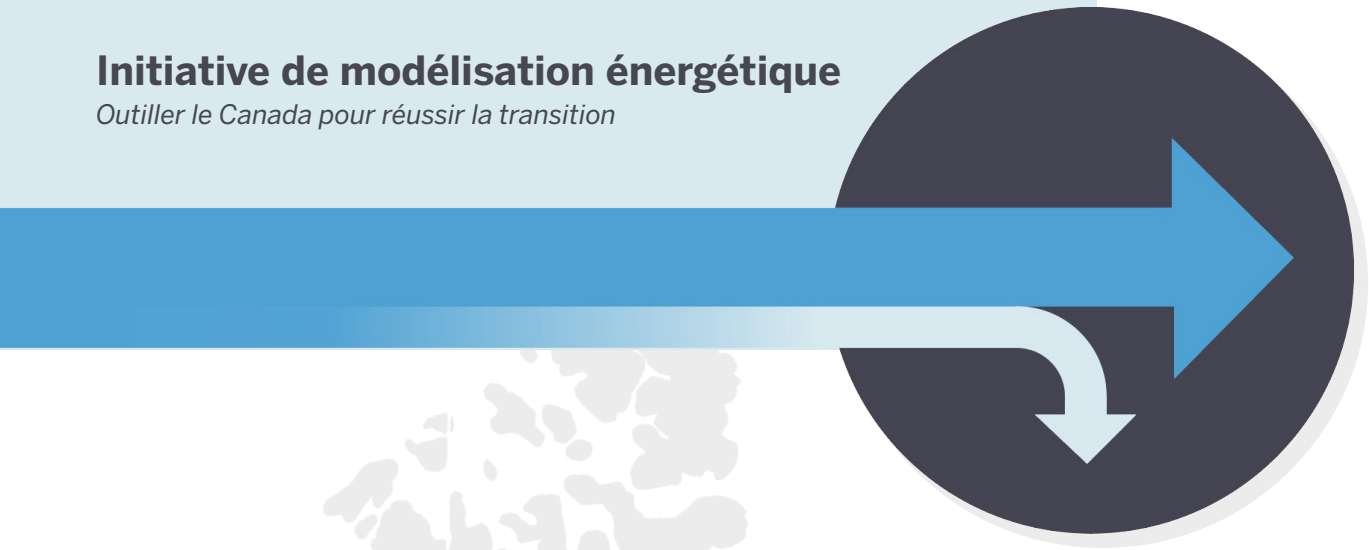
LONG-TERM PLAN PROPOSAL

Energy Modelling Initiative

Bringing the Tools to Support Canada's Energy Transition

Initiative de modélisation énergétique

Outiller le Canada pour réussir la transition



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INSTITUT DE L'ÉNERGIE TROTTIER

POLYTECHNIQUE MONTRÉAL

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Energy Modelling Centre – Long-term plan proposal

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About the Institut de l'énergie Trottier (IET)

The IET was created in 2013 thanks to a generous donation from the Trottier Family Foundation. Its mission is to train a new generation of engineers and scientists with a systemic and trans-disciplinary understanding of energy issues, to support the search for sustainable solutions to help achieve the necessary transition, to disseminate knowledge, and to contribute to societal dialogue on energy issues. Based at Polytechnique Montréal, the IET team includes professor-researchers from HEC, Polytechnique and Université de Montréal. This diversity of expertise allows IET to assemble work teams that are trans-disciplinary, an aspect that is vital to a systemic understanding of energy issues in the context of combating climate change.

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CONTEXT

The mandate for the Energy Modelling Initiative (EMI) was awarded by Natural Resources Canada (NRCan) to the Institut de l'énergie Trottier at Polytechnique Montréal (IET), under the leadership of Louis Beaumier (IET), Madeleine McPherson (Institute for Integrated Energy Systems, University of Victoria) and Normand Mousseau (IET/Université de Montréal). Following a workshop organized by NRCan on the "Development of an Open Modelling Platform for Electrification and Deep Decarbonisation Studies," in February 2019, NRCan sought to facilitate the adoption of federal and provincial policies that foster the electrification and deep decarbonisation of Canadian energy systems through a nationally coordinated program. A call for proposal was issued to initiate a dialogue with Canadian electricity system modellers and lay the foundation for establishing a modelling network to "support decision making by policy makers and other stakeholders for the transition towards a clean electric future."

The NRCan call for proposal identified the overarching challenge of the initiative; that is, to decarbonise the economy and transform Canada's complex energy systems. Given the lack of an independent institution and research coalition to advise stakeholders on various aspects of these challenges, NRCan called for a proposal to convene Canadian energy modelling expertise and develop a sustained "Canadian community of electricity system modellers."

In response NRCan's call, the proposal for the EMI has been built around four objectives, each associated with multiple activities:

1. To establish an **inventory** of Canadian energy modelling expertise across academia, governments and the private sector;

2. To **convene** the modelling community in order to foster collaboration;

3. To **demonstrate** the relevance and capacity of this community for realizing a clean electric future; and

4. To develop a **long-term work-plan** for a governance framework and a platform for models and tools to support a strong Canadian Community of Electricity System Modellers.

Since June 2019, EMI has brought the community of modellers together across Canada in three regional workshops with over 150 participants and in a national forum with over 100 participants from academia, governments, NGOs, public services and the private sector.

The resulting proposal for a long-term Energy Modelling Center has benefited from several rounds of consultations and on insights from a broad range of engaged stakeholders. After a year of network facilitation, consultations, surveys and conventions, we are confident that this proposal reflects the positions of a significant part of the Canadian modelling community and a broad range of stakeholders.

EXECUTIVE SUMMARY

Energy modelling is crucial to designing and implementing policy, prioritizing investment decisions and planning services. In many other countries, the community of energy modellers has been effectively structured and mobilized to contribute to critical national initiatives. Canada, however, lacks a coordinated, structured and effective ecosystem, leaving the community scattered and unable to fully support the needs of stakeholders and policy makers.

The energy modelling ecosystem in Canada consists of three major categories of actors: data providers (including federal government organizations, industries and utilities), modellers (housed in various levels of government, utilities, academic organizations and consulting enterprises) and model users (encompassing governments, utilities, industries, researchers and NGOs). While the federal government has put significant resources into structuring data providers through the newly founded Canadian Centre for Energy Information (CCEI) and model users through the Canadian Institute for Climate Choices (CICC), **there remains a significant gap at the core of this ecosystem – the country's energy modelling capacity.**

Supported by Natural Resources Canada, the Energy Modelling Initiative (EMI) is aimed at developing a long-term structuring proposal for modelling capacity through the convening of Canadian energy modelling expertise in order to bring together stakeholders in regional workshops across Canada to identify this community's needs and challenges, as well as through a national forum on developing a long-term work plan. The EMI's convening activities also facilitated surveying the community and its ecosystem, building a first national inventory of Canadian energy modellers and laying the groundwork for critical interactions and new collaborations among a broad range of stakeholders.

The conclusion of these several rounds of consultations with the advisory board, event participants and the broader community is clear: **although Canada can count on a rich and diverse energy modelling capacity, there is a need for a structure able to offer long-term support for specific energy models, to ensure a timely and relevant response to policy makers and, overall, to facilitate communications between Canadian energy modellers and governments, utilities and other stakeholders.** To respond to this need, the EMI has drafted a proposal for a governance framework for a long-term Energy Modelling Centre to foster the creation of a strong Canadian energy modelling response capacity, able to support the needs of policy makers, industry and analysts.

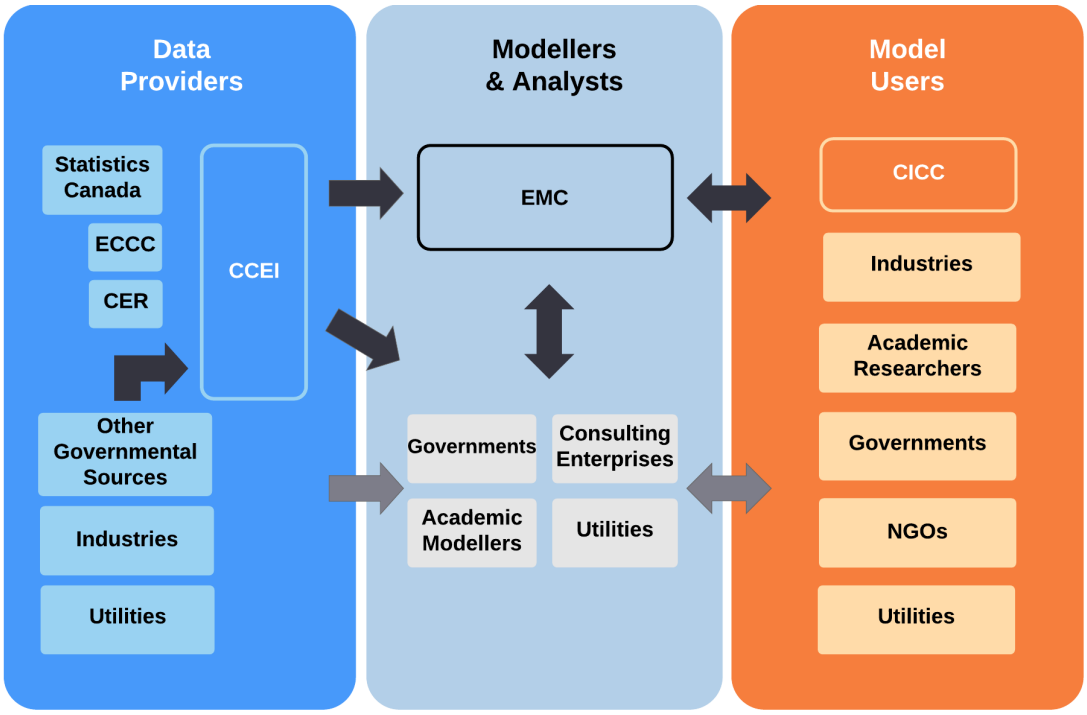

Figure S.1 – The place for EMC in the ecosystem

The proposed Energy Modelling Centre aims to play a central role in **evidence-based decision making on energy in the transition to a low-carbon global economy by producing independent, non-partisan and timely analysis.** As such, its mission will be to enable and streamline resources for efficient and timely modelling services, convene the network of energy modellers and stakeholders and create a platform to share modelling, training and inventory materials. To maximise its impact and avoid duplication of efforts, the EMC will work closely with the Canadian energy modelling ecosystem, complementing the work of CCEI and CICC and ensuring the achievement of desired outcomes while avoiding duplication of investments and efforts.

The following activities and deliverable will be at the core of EMC mission:

- For **supporting evidence-based decision making,** the EMC will facilitate access to modelling services across Canada, co-develop and implement a selection process for applied models, maintain documentation and training material and produce studies and reports.

- For **convening stakeholders,** the EMC will regularly organize regional and thematic workshop and an annual national forum to respond to timely and urgent challenges and emerging initiatives.

- For **creating a platform**, and online inventory of stakeholders, models and

projects along with a range of selected models will be maintained and updated. **Collaborations** with the CCEI will allow the platform to leverage their output while other collaborations such as with CER and CICC will lead to the establishment of reference scenarios to coordinate and focus modelling collaborations towards effective solutions.

After detailed analysis, the optimal organizational structure for the EMC is suggested to be a university based, multisite organization anchored across several provinces and a broad range of organizational stakeholders through its diverse range of leadership and staff appointments. The structure will consist of multiple regional centres led by regional scientific directors (a local faculty member), who assemble as the Scientific committee that guides the EMC. Each center will employ staff for coordination, operations, liaison and technical support. However, the EMC is led by the executive director who acts as the coordinator-in-chief, working with the regional centres, the Scientific committee, the advisory council and support staff. The executive director reports to the board of directors consisting of representatives from universities, policy makers and the private sector.

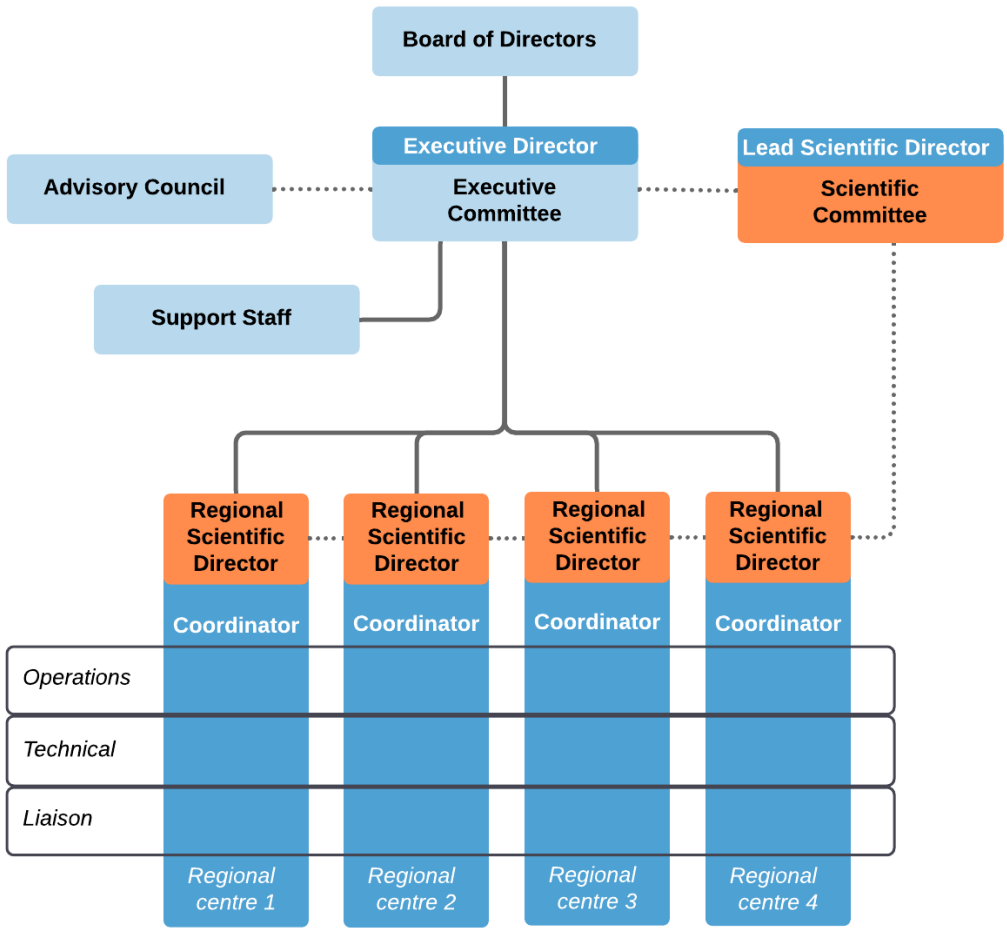

Figure S.2 – EMC Organizational chart

It is estimated that a staff of about 15 people will be required to meet minimum expectations, amounting to **an annual budget of about $2 M,** which is expected to be secured by a commitment from the federal government. Nonetheless, the EMC is expected to attract external funding and revenues to grow its operations further. With this structure, the EMC can be launched rapidly, producing results in its first year and reaching its full capacity in the third.

International examples such as in the UK, Sweden, Switzerland, California and New York, show that energy modelling is an essential instrument for testing policies, planning transformative changes, and finding and presenting the acceptable options to the public that would foster trust in the political leadership. As such and given the investment of the federal government in related efforts, we highly recommend that the EMC be added as the key connecting element to mobilize the existing ecosystem to deliver expertise and support for effective and efficient decision making, particularly to policy makers and investors.

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1. INTRODUCTION

Canada's energy sector is facing multiple disruptions that make transformative changes inevitable and pose major challenges. Political objectives for the climate and environment such as those articulated in the Pan Canadian Framework, disputes over resource extraction projects, the emergence of novel energy production and storage technologies, and energy insecurity in northern and Indigenous communities are just a few challenges that significantly affect Canada's economy and the everyday life of its citizens. Key actors in the Canadian energy sector, particularly **governments, utilities and the private sector need tools to anticipate such challenges, orient responses that overcome inherent tensions, and ensure the achievement of objectives while maximizing the benefits for all Canadians.**

With its ability to project possible situations, test various approaches and evaluate the impact of different decisions, the energy modelling community is essential to policy design and implementation, prioritizing investment decisions and planning services. The outstanding success of various countries like the UK, Sweden and Switzerland, and American states like California and New York that have invested in sophisticated energy modelling programs, testifies to the impact of a well-structured energy modelling program. **Canada's lack of a similar framework to support a structured modelling community leads to a significant deficit in our capacity to mitigate and adapt to climate change.**

> With climate change and the emergence of novel energy-related technologies, Canada's energy sector is facing profound disruptions. The energy modelling community can play a crucial role in maximizing the positive impact of these disruptions.

Over the past year, through its convening workshops and funding calls, the Energy Modelling Initiative has demonstrated that Canada's energy modelling community is rich and diverse. Canadian energy modellers embrace a wide array of approaches, as well as technical and geographical foci. Members of the community are based in governments, utilities, regulating bodies, the private sector and academia across

the country. **The Canadian energy modelling community is thus scattered, with members often working in isolation or exchanging views only with their close peers, remaining largely unaware of and disconnected from the broader range of Canadian energy modelling stakeholders.**

The costs associated with missing this opportunity to structure Canada's energy modelling capacity are enormous. The deficiency in leveraging energy modelling insights for decision making has severely limited our ability to establish a factual and scientific basis for a national dialogue on transition pathways and rendered any prospect of consensus impossible. It has also limited the reliable and robust development, assessment and optimization of urgently needed policies and investments. Above and beyond the considerable economic and political costs, the lack of objective tools undermines the democratic credibility of decisions since it leaves the general public in the dark about how options and solutions to address challenges that directly affect them are assessed and chosen.

In 2019, the federal government took several important steps to support energy transition and climate mitigation/adaptation more broadly, establishing the *Canadian Centre for Energy Information* (CCEI), which will improve access to quality energy data, and the *Canadian Institute for Climate Choices* (CICC), which supports evidence-based climate policy choices. **The present proposal aims at closing the gap between these major investments by establishing a Canadian Energy Modelling Centre (EMC), which will leverage data to provide quantitative evidence for energy and climate policies and support a successful Canadian energy transition.**

This proposal of an **Energy Modeling Centre** aims at completing the Federal government's efforts to strengthen its evidence-based energy and climate change data and policy capabilities.

2. THE ECOSYSTEM

2.1. A rich but disordered community

With funding that tends to support specific projects rather than long-term development or maintenance, Canada often lacks the energy modelling infrastructure — including the models themselves and appropriately trained staff— to address policy questions during their often-limited open policy window.

In Canada, models are usually the responsibility of small teams that lack the resources to maintain the dataset and implement the requested scenarios in a timely manner or to document or open-source the model to the rest of the community. The absence of mechanisms for funding model maintenance capabilities noted across academia, the private sector and government agencies/departments has meant that these models are either abandoned at the end of the funding period or shifted to consultants who lack the means to continue significant developments. This reduces Canada's access to state-of-the-art analysis, especially for integrated and complex questions.

2.2. Who is involved in modelling ?

Data providers are essential to energy modellers. Government agencies like Statistics Canada, the Canadian Energy Regulator, Natural Resources Canada, and Environment and Climate Change Canada provide key information on energy production, distribution and consumption and their effect on the economy. The recent creation of the Canadian Centre for Energy Information will strengthen the quality and availability of this data.

Utilities, the provinces, private partners and foreign entities also produce valuable information. However, its often-confidential nature means that it cannot be used for alternative explorations or shared with the broader modelling community.

Modellers are actors that develop and maintain energy models; some also analyze modelling results.

The field is dominated by academia, essentially professors, students and research associates. Consulting organizations, working either independently or in association with other modellers; modelling specialists in utilities, banking, insurance, etc.; and non-governmental organizations (mainly provincial and federal) also participate.

Model users are actors that either use the results of the modelling directly or consume the analysis of the results for a variety of purposes, which are often related

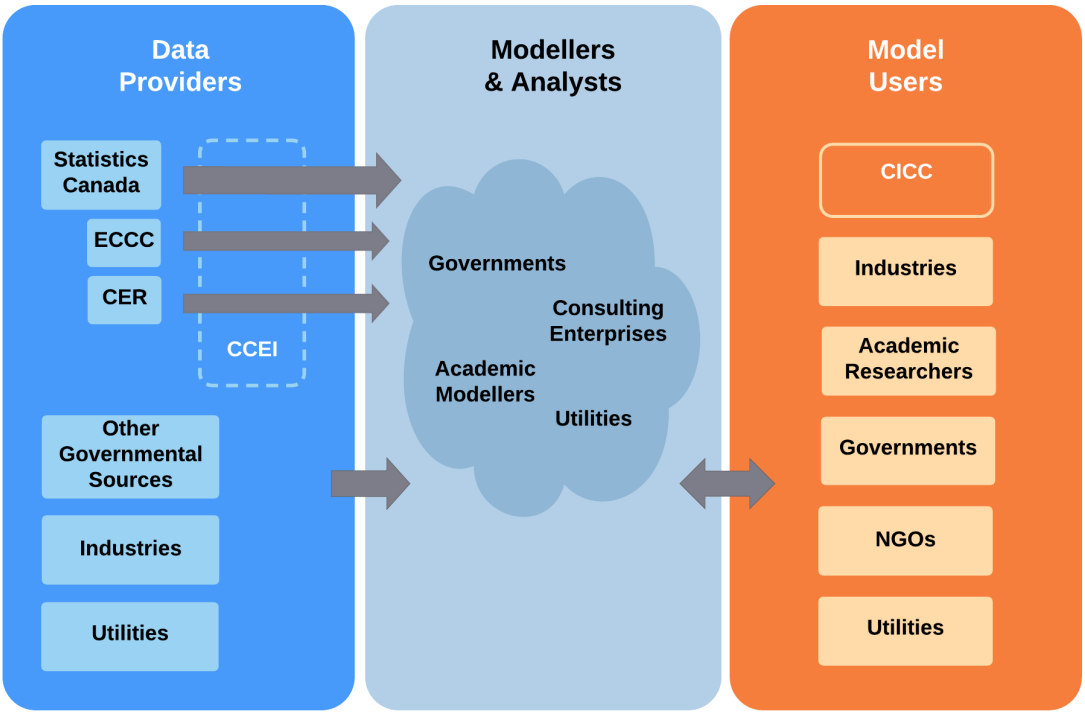

Figure 1 – Current Ecosystem

to anticipation and planning activities. Users are also governmental organizations (finance, economy, infrastructure planning, policy developments, environment, etc.); industrial organizations (such as the Canadian Association of Petroleum Producers and the Canadian Wind Energy Association); utilities, investors, etc.; non-governmental organizations (such as the IET, the David Suzuki Foundation, the Canadian Energy Systems Analysis Research initiative and the newly created CICC).

Sources of funding for modelling activities vary according to the organizational context. A large part of the academic modelling community is supported by various tri-council programs, which support innovative research but do not offer resources to maintain and update models.

Funding is also available for specific modeling projects from governments, utilities, industry associations and NGOs. This type of funding is generally in the form of limited term contracts that require a quick turnaround. As such, the sources of funding for the private sector are usually unpredictable and rarely reliable, making it difficult to invest in model development. Finally, a few stakeholders – mainly governments, utilities and regulators — maintain in-house expertise. They tend to commit to certain approaches and specific perspectives, thus limiting their ability to explore newer and potentially more useful approaches and models.

2.3. Adding the final piece of the puzzle to the structuring of energy and a rational understanding of climate change

This proposal for an **Energy Modelling Centre** is intended to complement the federal government's efforts to strengthen its evidence-based energy and climate change data and policy capabilities. The establishment of CCEI and CICC has significantly contributed to this goal.

CCEI, a joint project of NRCan, CER and Statistics Canada, is poised to become a one-stop shop for energy data, providing access to the general public. Created by ECCC, CICC is an independent not-for-profit organization mandated to support evidence-based climate change policy development.

While both CCEI and CICC aim at supporting and performing some energy modeling, there is no budget and only a limited mandate (focused on CER and ECCC models) to maintain and more broadly open models to support the more general need of energy-related projection and policy development.

The EMC proposed here will contribute a missing element to federal efforts by:

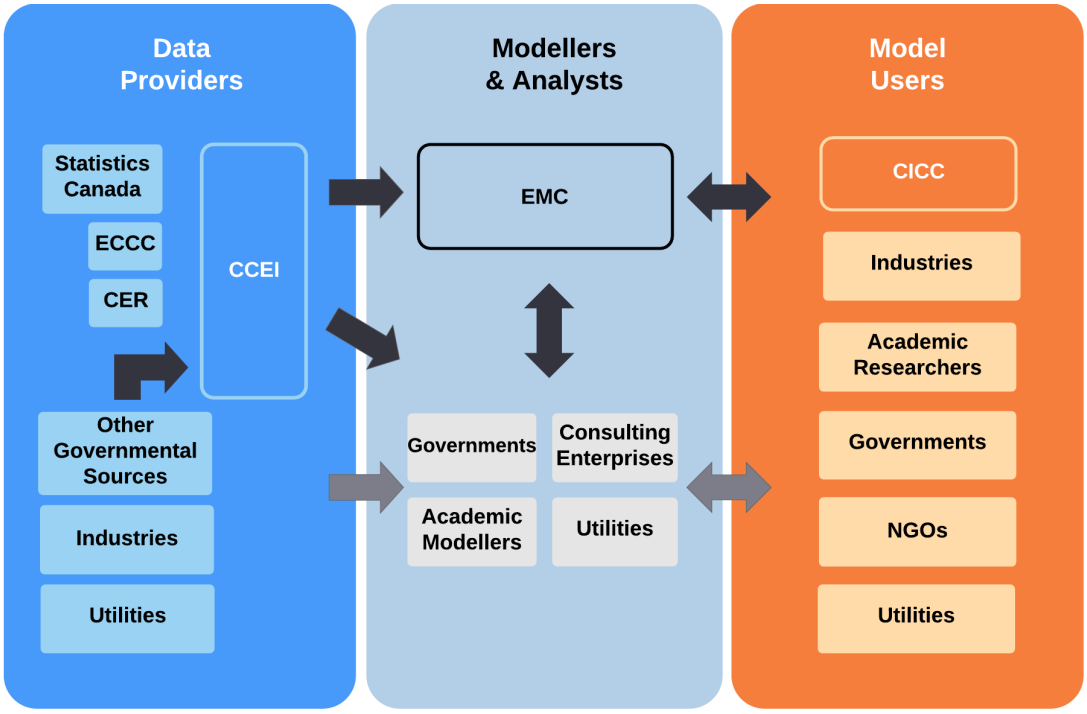

Figure 2 – Ecosystem with EMC

supporting evidence-based decision making on policy and economic questions through providing or connecting with the resources required to ensure the efficient and timely delivery of energy modelling services; **convening energy modellers and stakeholders; and implementing a platform to host modelling, training and inventory materials.** All these activities will be conducted in **collaboration with the other members of the ecosystem,** mainly data providers, model users and decision makers.

THE TRANSFORMATION OF THE CANADIAN ELECTRICITY SECTOR – AN EXAMPLE OF WHY CANADA NEEDS A STRUCTURED ENERGY MODELLING COMMUNITY

To demonstrate the added value of EMC, the following is an example of a policy question that requires a structured Canadian energy modelling capacity since no other country will look at this issue the way Canada needs to look at it:

"What is the value of the massive energy storage available behind Canada's hydroelectric dams? How can it facilitate Canada's decarbonisation of the grid while maximizing economic growth?"

A truly Canadian question

A structured Canadian energy modelling capacity is essential to answer a question like this for many reasons:

- Canada's energy storage capacity is unique. For example, Quebec's reservoirs alone can store 180 TWh, the battery equivalent of more than two billion Tesla cars, or more than an entire year of electricity consumption for the province of Quebec.

- Canada is also unique in terms of its geographical and political diversity. As a result, the technological infrastructure of its energy systems varies across the country, requiring solutions that are tailored to the local circumstances of different networks. Yet purely engineering oriented models are unlikely to provide universal scenarios that can reflect the reality or gain support across Canada. A deep understanding of political and economic intricacies is needed to achieve realistic, pragmatic and balanced solutions.
- In addition, introducing distributed energy resources like rooftop photovoltaic cells shifts the grid from being production centric to being distribution centric, a situation that becomes more complex with the penetration of electric vehicles because it makes demand patterns less and less predictable. This trend is creating issues that are yet to be fully understood and will be reflected in different ways across the country. Accordingly, targeted modelling must be carried out in close contact with local actors – at the provincial, territorial and even municipal level.
- Canadian modellers bring a different level of motivation and commitment to projects such as multi-year hydro-storage. They have the best knowledge, experience and resources to realize this value, particularly in the context of grid decarbonisation.

EMC's contributions

EMC's contributions will be many, ranging from problem and scenario definition to model selection and, when appropriate, the execution of models and analysis of results. But above all, EMC's key contribution will be to provide or organize timely and appropriate answers to policy makers.

More specifically, EMC will:

- Help potential users – such as policy makers and other decision makers – define their problems in a way that can be understood by energy modellers;
- Identify the best models for approaching this problem and the modellers to run them among academics, consultants, governmental agencies and EMC's own staff;
- If necessary, support the development of models adapted to specific Canadian-issues, such as massive hydro-storage;
- Support multiscale approaches, which go well beyond the few large-scale models currently used by the federal and some provincial governments, and the required interfacing of the various models adapted to the Canadian reality;
- Provide support to help understand modelling results by integrating information from multiple models and groups.

In addition, EMC will help to:

- Maintain communication with stakeholders and expand potential users;
- Identify gaps in modelling capacities linked to a specific project and seek ways to fill these gaps;
- Provide direction for further modelling or study.

At the moment, Canada lacks any structure to support a modelling study either of a key energy question such as the above-mentioned electricity system transformation or of many others.

3. THE PROPOSAL FOR AN ENERGY MODELLING CENTRE

Building on a year-long consultation process with energy modellers and stakeholders, this proposal presents a framework designed to significantly enhance Canada's energy modelling capabilities and relevance, as explained in the accompanying report ("Modelling Relevance and Value"). The following sections describe how this centre would be structured and a possible timeline for its setup.

This proposal for an Energy Modelling Center is the result of on a year-long consultation process with energy modellers and stakeholders supported by Natural Resources Canada.

3.1. Vision, mission and values

3.1.1. Vision statement

To contribute to evidence-based decision making on energy in the transition to a low-carbon global economy by producing independent, non-partisan and timely analysis.

3.1.2. Mission statements

To contribute to the government's commitment to build a stronger, more inclusive and more resilient country, the Energy Modelling Centre will coordinate the expertise available in the Canadian modelling community by:

1. Supporting evidence-based decision making on policy and economic questions, with timely, non-partisan analysis to help align resources with priorities, mitigate risks, validate the effectiveness of government actions and adapt them to unfolding events;

2. Convening energy modellers and other energy stakeholders to work together to make progress on priority energy issues;

3. Providing a platform to host modelling, training and inventory materials, which will facilitate effective and transparent interactions between energy stakeholders and improve the continuity, consistency and timeliness of responses by enabling the sharing of modelling-related resources.

All the above will be carried out in **collaboration with the other members of the ecosystem,** not only data providers and model users, but also decision makers from all jurisdictions – provincial, territorial

and municipal governments, Indigenous partners, communities and governments – to encompass the geographical, socio-economic and political diversity of Canadian energy issues.

3.1.3. Values

The following are the most prominent values identified during the regional workshops and the consultation process:

- Science and evidence-based
- Collaborative
- Transparent
- Open
- Timely

3.1.4. Stakeholder groups

- Energy Modellers from the academic community and the public and private sector
- Researchers interested in energy and environmental, economic and climate change policy
- Policy-makers and decision-makers from all levels of government – federal, provincial, territorial, municipal and Indigenous communities.
- Energy Regulators
- Utilities
- Industry
- Financial sector
- NGOs

3.2. Activities and deliverables

The EMC's proposed activities and deliverables – organized according to the mission statements – have all been designed from the perspective of **effective collaboration with other members** of the ecosystem to complement their work and ensure the achievement of desired outcomes, while preventing the duplication of investments and efforts. Given Canada's geographical and political diversity, the breadth of issues and the multiplicity of actors and investments, EMC will play a key role in coordinating collaborations and focusing efforts, resources and capabilities on effective solutions.

The following range of activities and deliverables emerged from several rounds of consultation with key actors and stakeholders in the energy modelling ecosystem, which werew obtained during EMI operations:

3.2.1. Mission Objective 1: Supporting evidence-based decision making

Facilitating access to modelling services

- Establish regional points of services for modelling-related requests from policy makers and other stakeholders and, if needed, direct requests to matching expertise;

- Leverage available expertise by providing a connection platform for stakeholders;
- Facilitate the interpretation of requests and communication of results;
- Offer project management and coordination services to help with the timely delivery of results.

Model selection process

- Co-develop and implement a selection process for models that will be supported by the EMC;
- Make the supported models available on the shared platform, along with the corresponding documentation, metadata, datasets and training materials.

Model maintenance

- Update supported models with the most recent data;
- Maintain their documentation and facilitate their use;
- Create and update corresponding reference datasets.

Training

- Develop training material on selected models in order to enable and streamline the user base.

Reports and studies

- Maintain a repository of modelling studies that can serve as a reference for inquires and requests;
- Produce short reports on specific models or their application to raise awareness, disseminate information and build knowledge on modelling.

3.2.2. Mission Objective 2: Convening energy modelling stakeholders

Annual forum

- Organize a meeting of stakeholders to assess progress, review work plans and adjust them accordingly;
- Highlight models and their applications to research and policy questions over the previous year, showcase capacity and discuss methodological and development progress.

Thematic workshops

- Organize workshops on specific activity sectors, regions or modelling issues on an as-needed basis;
- Use outcomes as inputs for the Annual Forum;
- Respond and contribute to emerging initiatives.

3.2.3. Mission Objective 3: Providing a Platform

Online modelling inventory

- Gather, organize and publish information on past, ongoing and upcoming energy-related modelling activities;

- Maintain a list of available trained modellers, including experts from the academic community, non-profit and private sectors, as well as the end-users of these experts' services;
- Update and maintain website and database.

Open access to supported models

- Provide access to supported models and their documentation.

Reference datasets

- Collaborate closely with the Canadian Centre for Energy Information and leverage its outputs;
- Gather missing data (excluded from the CCEI repository) from publicly available sources;
- Develop data adaptation tools to streamline data collection on a per source basis;
- Establish criteria and protocols for the selection and labelling of reference datasets.

Reference scenarios

- Establish criteria for national and regional reference scenarios and document hypotheses and projections based on consultations with stakeholders, including CER and CICC;
- Liaise and coordinate with stakeholders to update the criteria.

3.3. Proposed organizational structure

A university-based organization consistently emerged as the preferred structure during the consultations. It has the advantage of offering a flexible organizational set-up using university infrastructures and networks across Canada. Furthermore, it will not only allow the EMC to access research funding from the Tri-Councils and provincial resources, but will also be able to work with a broad range of organizations, including provincial and municipal governments, not-for profit organizations and the industrial and private sectors.

3.3.1. Structural Requirements

Based on the outcome of the EMI consultations, the structure of the EMC should meet the following key criteria:

- Be multisite and bilingual to facilitate interactions among a pan-Canadian group of stakeholders and modellers;
- Employ staff trained to: (1) manage and coordinate training and event organization, administration activities and public communication; (2) liaise and consult with stakeholders, including modellers and policymakers; and (3) lead technical operations tied to databases, data and code management;
- Collaborate with partners, including academics, consultants and various agencies;

- Converge the needs of policy makers and other stakeholders with the technical capability of Canadian energy modellers;
- Establish criteria of usefulness for energy models and select them accordingly.

3.3.2. Governance Structure

The EMC will be a university-based organization with a governance structure that is presented in the following organizational chart:

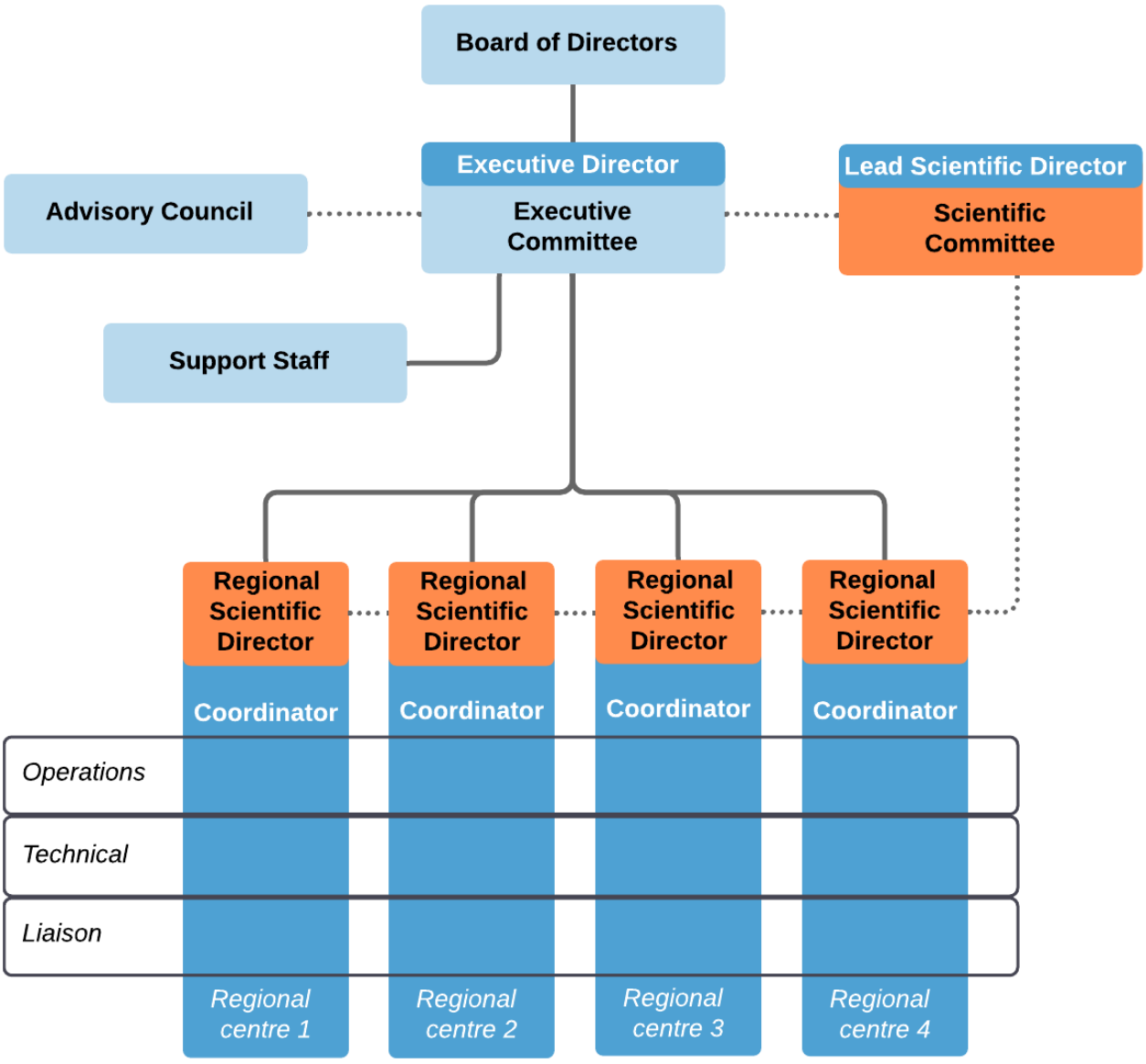

Figure 3 – EMC organizational chart

The Board of Directors will include representatives of universities and policy makers, industry stakeholders and other decision makers to ensure that a broad range of perspectives and interests are represented. Funding organizations will appoint the initial board, which can then be developed and modified based on recommendations from board members and new collaborations. The board will oversee the activities of the executive committee that guides the EMC's day-to-day activities.

The Scientific committee, which is composed of the four Regional Scientific Directors and the Executive Director, is chaired by the Leading Scientific Director, who is chosen by the board to oversee the activities and provide strategic guidance to the executive committee. **The Advisory Council consists of other key stakeholders** who have a significant connection to the modelling community and can provide valuable advice to the executive committee.

The EMC leadership is thus comprised of a diverse range of stakeholders, including academic appointees, government representatives and industry stakeholders involved in the energy sector. This lightweight management structure leverages existing capacities and entails limited expense (the budget for the Executive Director and the support staff). The daily activities would be overseen by a permanent Executive Director located at one of the regional centres that actively coordinates with the other centres. The executive director's chief responsibility is to oversee the coordination of staff activities in the regional centres. **Together, along with the Leading Scientific Director, the Regional Scientific Directors form the EMC executive committee,** which reports to the boards and is guided by the scientific and advisory committees.

Each regional centre is headed by a Regional Scientific Director who is a faculty member at a university within the respective region. **The board will choose one of these Regional Directors as EMC's Leading Scientific Director on a rotating basis (every three years).**

The responsibilities of the Regional Coordinators, who are paid EMC staff, include leading operational management, liaison and technical support staff (each of which is described below). As part of the executive committee, they will report to the executive and regional directors and coordinate the activities in their regional centre, based on decisions made in the executive committee.

3.3.3. Staffing and Budget

In accordance with the proposed operationalization plan (see next section), we estimate that it will requires a staff of about 15 people with developing responsibilities and cross-assignments to meeting minimum expectations, for an annual budget of around $2 M, which we expect to be secured by a commitment from the federal government. In later

years, we anticipate additional revenues from contracts and support from other levels of government. As the EMC attracts other sources of funding, its organizational structure will grow.

Four groups of staff will be located in each regional centre. Some technical staff may also be recruited/located outside the regional centres:

Management (3 people)

- Executive director (who acts as regional coordinator for one site)
- Two support staff for (1) clerical duties and finances; (2) human resources.

Technical (7 people)

- Maintain the modelling inventory (including models, modellers and users);
- Assemble and maintain datasets; establish reference datasets in collaboration with CCEI, CER and other key stakeholders;
- Maintain and operate models; develop documentation;
- Support researchers on an as-needed basis.

Operations (2 people)

- Organize workshops, forum, meetings;
- Organize training for both modellers and policy makers;
- Correspond with stakeholders and respond to demands/requests.

Liaison (3 people)

- Develop intellectual property (IP) rules to facilitate use of data and models;
- Coordinate with the ecosystem – CCEI, CICC, etc.;

Table 1 – Estimated budget for the first three years of operation

	Year 1			Year 2			Year 3 (full capacity)		
Salaries									
Executive Director	1	$ 120,000	$ 120,000	1	$ 123,600	$ 123,600	1	$ 127,308	$ 127,308
Support Staff	1	$ 65,000	$ 65,000	2	$ 66,950	$ 133,900	2	$ 68,959	$ 137,917
Operations	1	$ 80,000	$ 80,000	2	$ 82,400	$ 164,800	2	$ 84,872	$ 169,744
Liaison	1	$ 90,000	$ 90,000	3	$ 92,700	$ 278,100	3	$ 95,481	$ 286,443
Technical staff	1	$ 90,000	$ 90,000	3	$ 92,700	$ 278,100	7	$ 95,481	$ 668,367
Sub-total	**5**		**$ 445,000**	**11**		**$ 978,500**	**15**		**$ 1,389,779**
Other expenses									
Event Organization			$ 80,000			$ 150,000			$ 155,000
Modelling contracts			$ 150,000			$ 150,000			$ 100,000
Other external contracts			$ 150,000			$ 100,000			$ 75,000
Travel support			$ 60,000			$ 80,000			$ 100,000
Sub-total			**$ 440,000**			**$ 480,000**			**$ 430,000**
Overhead (20%)			$ 177,000			$ 291,700			$ 363,956
Total			**$ 1,062,000**			**$ 1,750,200**			**$ 2,183,735**

- Liaise with policy makers and other stakeholders, including provinces and territories, First Nations, municipalities, etc.;
- Lead strategic development, co-identify data, models to be supported, etc.;
- Leverage funding from other sources.

4. OPERATIONALIZATION

This section describes how the organization will be created, deployed and operate in the future. Since we propose a relatively light structure that will be integrated in an academic environment, building on the operation and outcomes of the EMI, we expect that EMC would be able to deliver results within the first year. At the end of the second year, the structure should be complete, delivering service at full capacity. Developing the model portfolio will be an ongoing endeavour.

4.1. Towards an institutional transition

Based on experience with other structures and insights gained from the EMI, we suggest the following timeline for structuring the EMC.

Various rationales and explanations for the timeline are presented below.

Centre start-up – Initial efforts to create the EMC will be devoted to implementing the multi-university agreement and hiring the right people. The first priority will be to hire the executive director, who, once hired, will be responsible for hiring the rest of the staff, in collaboration with the scientific directors as they are appointed. Achieving a full staff complement could take up to 18 months.

Facilitating access to modelling services – During the first year of operation, this task will mainly be limited to providing information on available expertise and directing requests to matching expertise. Once regional points of service have been set up and the Centre has become familiar with all stakeholders for about a year, project coordination services could be offered. Modelling services would be added only in the third year of operations, once the models have been supported by EMC.

Initial Modelling Project – To highlight the function and value of the EMC and to enhance its visibility, an initial modelling project will be launched in the first year. A consultation process will help identify a research question of interest, from which a case study will be produced and presented at the first national forum where required models could be identified. Modelling efforts, which would start in the months following the forum, should last for six months. The final report should be available four months later once the analysis has been completed.

Online platform – Since it is our intention to maintain the inventory produced during the EMI online, it will be available on Day 1 of the EMC. Its migration to a new platform will provide the opportunity to expand its content, thereby creating a second version

before the end of the first year. During the second year, reference scenarios and reference datasets will be added to the platform. Their format and content will have been defined in collaboration with other stakeholders and by considering the supported models selected. These will be made available in the third year.

Support model(s) – This phase will begin with the co-development of a selection process led by a specially formed committee. Many discussions and meetings with stakeholders are expected to be required over a six-month period. Another six months should be required to proceed to the first selection of model(s) to support. A few more months will be needed for the technical staff to adopt the model(s) and begin operations and maintenance.

Forum and workshops – No workshops will be held prior to the first forum since most efforts will be devoted to starting the EMC. The first forum will provide the opportunity to identify the theme of interest for a first series of workshops. A minimum of three workshops a year are planned.

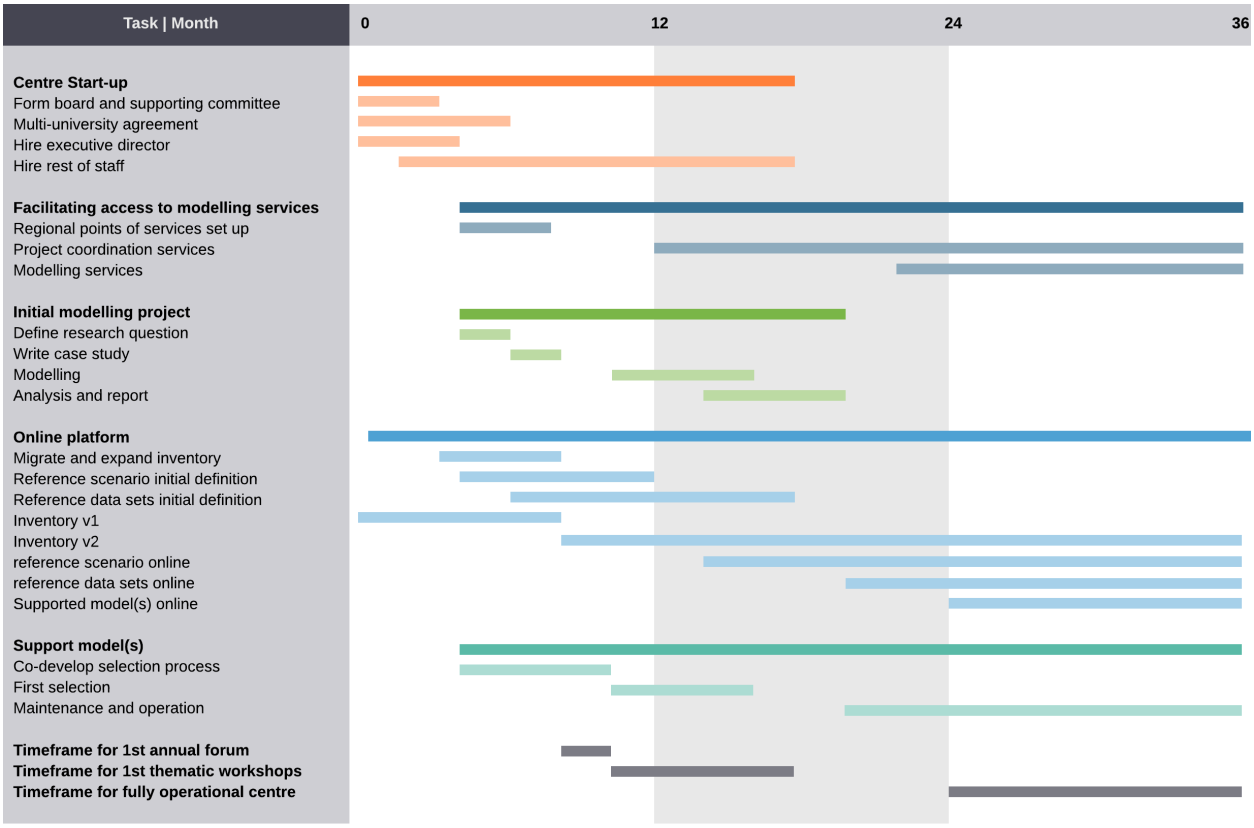

Figure 4 – Operationalization calendar

4.2. Strategic considerations

This section presents a number of strategic considerations explaining some of the choices and crucial aspects to ensure a successful EMC able to deliver on all aspects of its mission.

4.2.1. Structure

A geographically distributed organization. The proposed structure will be managed on four sites across Canada to ensure that the Centre's structure is relevant not only to federal concerns, but also to regional issues and challenges, thus creating incentives for long-term engagement by the provinces, municipalities, utilities and other more local stakeholders. By concentrating the staff on four sites, we will ensure critical masses, facilitating management and service delivery. As interest in the EMC grows, we will remain open to possibly creating additional sites or partnerships to facilitate work with local stakeholders.

An independent organization. As an academic-led organisation, the EMC will be independent as the Scientific committee does not benefit directly from its work. Being more closely akin to research networks, the Centre will also be more flexible and reactive to demands from stakeholders and changes in the modelling community. Led by academics, it will also be more able to benefit from a wider range of funding opportunities, linking fundamental research, development and applications.

A rotating leadership. Following the tradition in research networks, the organization's leadership will move from one institution to another every three years. This will provide a richer diversity in executive perspective, facilitate innovation and ensure that all regions and sectors are represented.

An inclusive consultation process for identifying models and tasks. The organization will adopt a systematic approach to consultation that includes the perspective of the relevant stakeholders and reflects the needs and preferences of the modelling community in developing its services. This will ensure that the Centre meets the demands of the users of modelling results, while including all modellers as much as possible and recognizing their needs in the model selection process.

4.2.2. Mandate

Long term commitment to specific models. This approach will set a global benchmark for openness by facilitating transparency and trust in the decision-making process and open dialogue as Canada embarks on its energy transition in pursuit of climate objectives. It will also provide policy makers and other stakeholders with common tools to discuss and analyze challenges, increasing accuracy and applicability by cultivating expertise, which in turn will lead to better decisions for all.

Development of a shared platform. Supported models and other products provided by the energy modelling community will be made available through a shared platform. To facilitate the use and integration of these models, training will be offered to both modellers and model users. The shared platform will also provide reference scenarios and related datasets. This platform will enhance innovation at all levels and help Canada develop competencies to address a broad range of local to national issues and thus contribute to international benchmarks.

Service to policy makers, model users. The EMC will also provide direct service to policy makers and model users, offering analysis and advice by connecting them to modellers across the private, public and academic sectors. In some cases, the Centre will also accept modelling contracts, especially to meet constrained timeframes.

Convening the community. The cornerstone mandate of the EMC will be to convene the energy modelling community to leverage its capacity, facilitate exchanges and ensure that it can provide the needed support to Canada's energy transition. This will be accomplished through the various advisory committees associated with the organization, constant informal exchanges with diverse members of the community, regional workshops and the annual national forum, which will also serve as the annual summit for energy modelling stakeholders and the community.

Maintaining a Canadian energy modelling inventory. In order to convene the Canadian energy modelling community, connect energy modelling stakeholders and match their interests, the EMC will maintain and expand the inventory that was developed as part of the EMI. This inventory will be made available to all interested parties to facilitate exchanges, communication and services.

4.3. Risk mitigation

This section identifies the main risks inherent in the proposed structure and provides an assessment and mitigation strategies.

Fixed regional offices exclude other potential collaborators. While it is essential for the EMC to have fixed regional offices to build critical-sized teams, the Centre will also create partnerships with interested academics across Canada, offering partial or full support for technical staff working on recognized models, as well as for the development of collaboration with the provinces, municipalities, First Nations and other stakeholders.

Rotation of both leading director and regional centre could destabilize strategic orientation and reduce efficiency. While the leading director will rotate every three years, the executive director will remain. Moreover, the members of the Scientific committee, formed from the regional and leading directors, will establish strategic stability.

Long term commitment to maintaining models precludes innovations and new potentials from being identified, developed and engaged with. Stable reference models are essential to establish a frame of reference for year-to-year comparison and monitor the impact of policy and the transformation of the sector. However, the model portfolio will also ensure a re-evaluation of models and revision procedures to roll-in and roll-out models as technology and algorithms evolve to ensure that Canadians have access to state-of-the-art energy modelling capabilities.

A consensus cannot be reached on which models to support. Various stakeholders may have diverging opinions on which models to support. The EMC will alleviate this problem by working with various funding agencies in parallel to support model development, while offering maintenance support to other models of interest for specific sectors periodically and on an ad-hoc basis.

A shared platform may turn out to be technically not feasible. The development of shared platforms for modellers is a relatively new concept and fairly uncharted territory. Several platforms are already available for open-source codes and models like GitHub. However, using data with various levels of confidentiality and IP issues requires the kind of expertise and infrastructure that CCEI has to offer. The EMC will thus rely on collaboration with CCEI as well as best practices in other fields (such as medical sciences) in dealing with data confidentiality issues. It will also pursue collaboration with other organizations such as Compute Canada and Canary, the leading Canadian organizations on supercomputing, to find feasible technological solutions.

Co-investment from the provinces, municipalities and other stakeholders could fail to materialize. Above and beyond the support from the federal government, the buy-in from these stakeholders is crucial to the relevance of this organization. The engagement of the Federation of Canadian Municipalities in the Energy Modelling Initiative, as well as preliminary negotiations with Transition Énergétique Québec in Quebec, indicates significant interest. Co-investment will require the organization to adapt models and results to regional realities and shape approaches that resonate with various stakeholders' orientations on various levels, particularly government organizations.

5. **ACTING NOW**

Every day, every month, every year that passes reduces the options that Canada can use to advance its energy transition and ensure its possible benefits through approaches that have been tried and tested around the world.

Building a reliable Canadian energy modelling capacity can be accomplished relatively quickly by structuring Canada's existing capabilities in energy modelling.

Examples abroad have shown that the most successful governments build their policies and orientations on solid and broad energy modelling that allows them to test policies, plan transformations, present options and build public acceptance and trust.

This proposal demonstrates that developing a reliable Canadian energy modelling capacity can be accomplished relatively quickly by building on Canada's existing energy modelling capabilities. By facilitating communication and exchange, the EMC will provide the tools to mobilize these potentials for delivering, particularly to policy makers and investors, the expertise and support needed for effective and efficient decision making in the Canadian energy sector.

APPENDIX A – **THE ENERGY MODELLING INITIATIVE**

The 10-month Energy Modelling Initiative (EMI), launched in response to a call issued by Natural Resources Canada (NRCan,) aimed at: creating an inventory of energy models, modellers and model users in Canada; convening the Canadian energy modelling community; demonstrating the necessity of structuring this community; and proposing an up to 10-year plan to achieve this goal.

This initiative was proposed by a multi-university team — Polytechnique Montréal, Université de Montréal and University of Victoria — and led by the Institut de l'énergie Trottier (IET). It involved a number of partner organizations, including universities from across Canada, consultants, the Federation of Canadian Municipalities, NRCan, and two newly created organizations: the Canadian Centre for Energy Information (CCEI), led by Statistics Canada in partnership with NRcan and the Canadian Energy Regulator; and the Canadian Institute for Climate Choices (CICC), funded by Environment and Climate Change Canada. To support this group, a full-time coordinator/analyst and a half-time communication staff were hired for the duration of the project and stationed at the IET head office in Montreal under direct supervision of the IET executive director.

Surveying the community

To convene and survey the energy modelling community in order to identify existing expertise and possible needs for further structure, we relied on a combination of regional workshops, online surveys, a national forum and direct discussions with several actors.

In collaboration with Transition énergétique Québec, the Chaire de gestion du secteur de l'énergie of HEC Montréal and the Institut de l'énergie Trottier, a first workshop with a similar goal, that is to bring together energy modellers and users from the Quebec government, utilities, consultants and academia, was organized in Montreal in February 2019. This meeting demonstrated not only the richness of the community, but also the lack of contact between the various individuals and organizations that are stakeholders in energy modelling.

As part of the EMI, similar workshops were organized across Canada – in Ottawa, Vancouver and Fredericton – by local partner organizations (respectively: the Environmental Energy Institute at the University of Windsor, the Institute for Integrated Energy Systems at the University of Victoria, and the Emera and

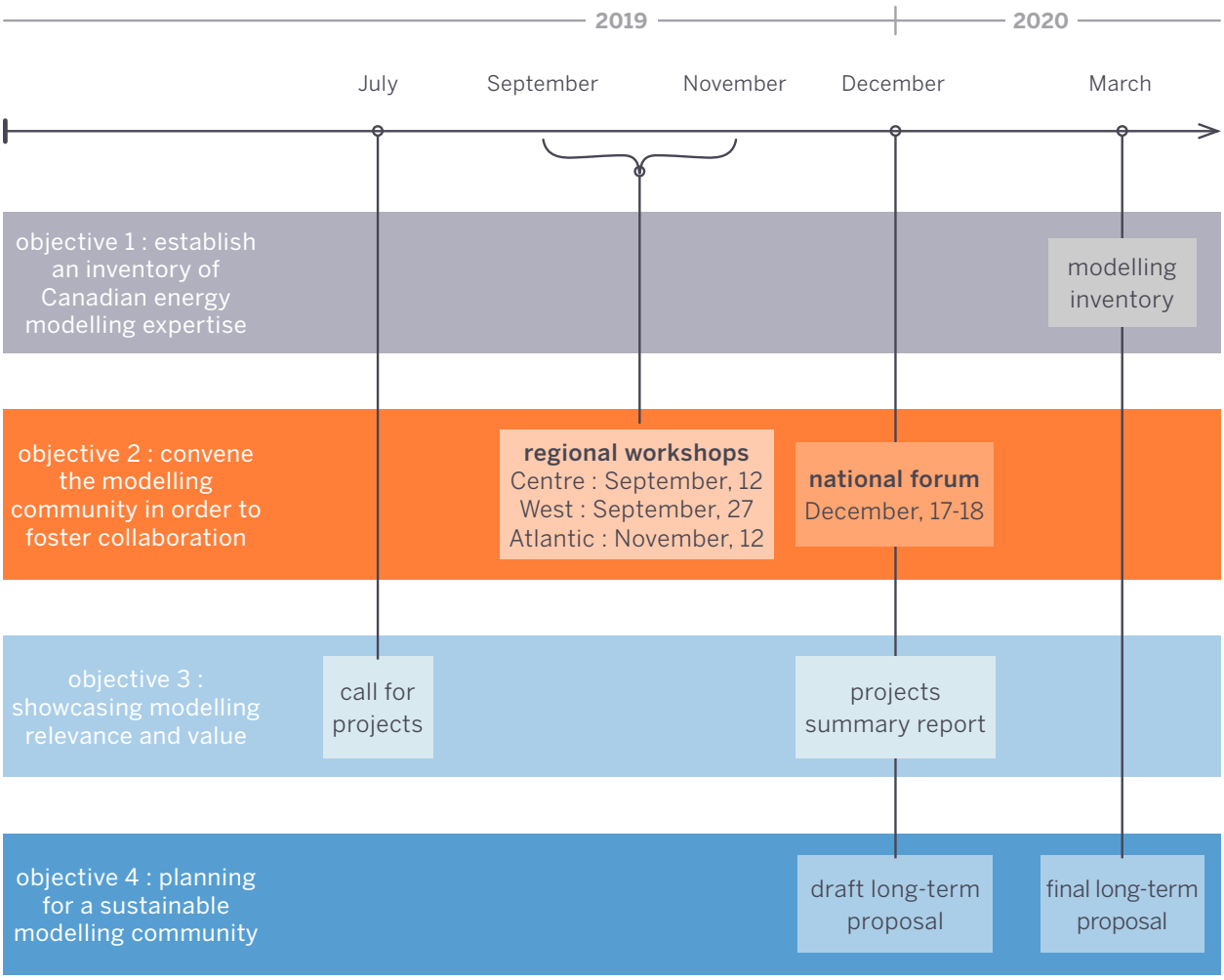

Figure A – EMI's objectives and activity calendar

NB Power Research Centre for Smart Grid Technologies at the University of New Brunswick). With an average attendance of 50 people, these workshops brought together regional players to discuss the state of energy modelling. These events attracted a broad range of stakeholders from academia to governments, utilities and the private sector, who were often meeting for the first time.

Following the regional workshops, an initial set of straw dog proposals for the long-term structuring of the community was developed, incorporating a number of demands, proposals and observations from the workshop discussions. These proposals were sent for comment to workshop participants and to several other individuals interested in energy modelling. The comments were then used to prepare a first version of the long-term plan, which included a discussion of the points that failed to achieve a consensus. This draft constituted the central document for the national forum held in Montreal on December 17 and 18, 2019.

This forum brought together 110 representatives of various stakeholders

from across Canada. To ensure a balanced participation, groups of tickets were reserved for academics, governments, NGOs, utilities, and the private sector. All but one of the 110 registered participants attended the forum, reflecting the stakeholders' deep level of engagement and interest.

The first day largely focused on energy model users and the ecosystem of organizations that would surround a national energy modelling structure. This discussion was intended to ensure that the proposed organization would not overlap with existing structures but would instead complement and leverage their mandates and meet the needs of energy model users. The second day focused more on energy modellers, with the presentation of the modelling projects funded by the Initiative and a discussion of this community's general needs.

The national forum served to determine the need for a national structure and develop a consensual proposal as represented in this document.

Demonstrating the strength of Canada's energy modelling community

An important facet of the EMI mandate is to demonstrate the strength and richness of Canada's energy modelling community and its capacity, if well structured, to support fruitful reflection on and action for Canada's energy transition.

This demonstration is built on a vast energy modelling inventory and the production of specific energy modelling projects led especially to achieve this goal and funded through the EMI.

A call for proposals was launched in mid-June 2019, which gave modellers only about three weeks to prepare their proposals. Despite this time constraint, 43 high quality proposals were received from a broad range of Canadian energy system modellers. From these proposals, a selection committee composed of independent stakeholders recommended 10 projects that were funded for $15,000 each. Three other proposals were submitted by government and utilities. Although the EMI could not financially support these proposals, the teams were encouraged to submit their report. The reports and abstracts of all these projects, which were presented at the national forum, are available through the EMI website.

At the same time, a survey based on preliminary consultations was distributed among participants in various EMI activities and other stakeholders to build an inventory of energy models, energy modellers and energy model users in Canada. Once again, the response from the community to this relatively comprehensive survey was surprisingly high – 175 valid responses – demonstrating the stakeholders' commitment to a better understanding and use of this community's capacity.

Early collaboration with linked initiative

In addition to the proposed EMI deliverables and in anticipation of a long-term program, another workshop was held on March 11, 2020 to specifically discuss the issue of energy data following the creation of the Canadian Centre for Energy Information (CCEI), an initiative recognized as being vitally linked to energy modelling. With more than 50 participants from StatCan, NRCan and the academic world, this workshop provided the opportunity to explore data-related challenges in energy modelling and initiate a discussion on how CCEI can contribute to and utilize energy modellers' work.

In addition to bringing together a diverse range of stakeholders, the outstanding result of this event was the determination of a set of actions and priorities to be expected from CCEI, as well as from a coordinated energy modelling program, which the proposed Energy Modelling Centre will embody, including themes and topics for future workshops. This workshop further confirmed the need for a sustained modelling program.

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