INSTITUT DE L'ÉNERGIE TROTTIER

Natural Resources Canada | Ressources naturelles Canada

Workshop on the Development of an Open Modelling Platform for Electrification and Deep Decarbonisation Studies

Synthesis Report

Prepared by
Institut de l'énergie Trottier

Presented to
CanmetENERGY, Varennes Research Centre

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Authors

Louis Beaumier
Vivanne Aubin
Elizaveta Kuznetsova

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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 discussions of 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.

Institut de l'énergie Trottier
Polytechnique Montréal
2900, Boul. Édouard-Montpetit
2500, chemin de Polytechnique
Montréal (Québec) H3T 1J4
iet.polymtl.ca
@EnergieTrottier

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Context

In an effort to better identify and define pathways to deep decarbonisation in Canada, Natural Resources Canada (NRCan) organized a 2-day workshop, on February 21-22 to explore the possibility of creating an Open Modelling Platform for Electrification and Deep Decarbonisation Studies to facilitate the adoption of federal and provincial policies fostering electrification and deep decarbonisation of Canadian energy systems at various levels.

The role of an Open Modelling Platform would be to ease the coordination of efforts at the national level of the various ongoing R&D modelling projects conducted in Canada. Additionally, it has been motivated by a desire to leverage and contribute to common American and Mexican initiatives.

The main objectives of this workshop were to

- Discuss the needs that could be fulfilled for both the modelling community and policy makers with the creation of an open modelling platform;
- List the key components of that said platform to make it a useful tool for electrification and deep decarbonisation initiatives;
- Identify current gaps in existing models and in data; and
- Propose a common development approach.

The present report provides a summary of the main outcomes from presentations, discussion panels and breakout sessions held during this two-day workshop.

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Workshop activities summary

The workshop was divided in three main activity types: presentations, discussion panels and breakout sessions. This section will present the main outcomes for each of these.

Presentations

Following are the key takeaways from the presentations grouped under three themes.

The use of modelling by governments and policy makers

- In Sweden, policy making and modelling for energy system is coordinated by the Swedish Energy Agency (SEA) and the Swedish Environmental Protection Agency (SEPA). Modelling is used for long-term strategies for decarbonisation and development of the energy system.
- The California Energy Commission (CEC) and the California Air Resources Board (CARB) produce frequent updated reports and climate change strategic plans. CARB uses various models to evaluate policy options for reducing emissions across all sectors of California's economy.
- Environment and Climate Change Canada's (ECCC) Economic Analysis Directorate offers economic support to environmental strategic plans and policy. They have started a conversation with stakeholders across Canada. The Pan-Canadian Framework on Clean Growth and Climate Change suggests actual measures for horizon 2030, while Canada's mid-century long-term low-GHG development strategy, a non-prescriptive document, looks at horizon 2050.

Modelling activities from outside Canada

- In the USA, the Electric Power Research Institute (EPRI) produced the US National Electrification Assessment. It evaluates the impacts of various scenarios that cover the spectrum between a conservative approach and a full transformation, regarding technologies improvement and cost, demand evolution and implemented policies.
- Also in the USA, the National Renewable Energy Laboratory (NREL) leads various global studies for energy transition, regarding technology cost and performance, demand-side and supply-side scenarios, impacts of electrification, amongst others. NREL has also developed a capacity expansion interactive tool that is no-modelers-friendly, and a common framework, including a suite of software components and data structures, that enables flexible and integrated infrastructure system representations. It incorporates a variety of solution methods, infrastructure data and data analytics.

- In Mexico, the Instituto Nacional de Electricidad y Energías Limpias (INEEL) has developed Modelo de Planificación de Expansión de Sistemas de Generación y Transmisión (PEGYT). It is a regional system expansion planning and interregional transmission planning, used by various organizations and researchers.
- In Europe, an open source toolbox for managing energy data and modelling integrated energy systems, named Spine, has been developed. It is a generic energy system modelling framework that facilitates faster model creation and subsequent extension and development. It contains an innovative problem independent data management infrastructure for easier integration. Multiple collaborations across the world are being built, notably with NREL.

Canadian modelling activities

- National Resources Canada has conducted the Regional Electric Corporation and Strategic Infrastructure Initiative (RECSI), which is based on simulations over Western region and Atlantic region. Both studies were commissioned to private companies; no such initiative was conducted for Ontario or Québec.
- The Institut de l'énergie Trottier (IET) in collaboration e3Hub at HEC Montréal produced a Canadian Energy Outlook, looking at various decarbonisation scenarios of the energy sector, based on national and provincial GHG reduction targets. It used NATEM from ESMIA, a techno-economic optimization model of the TIMES family.
- At University of Windsor, the Environmental Energy Institute, under the Climate Led Energy Evolution Network 2040 initiative (CLEEN2040) has worked on demand modelling. It created a model for current demand over which can be applied various expected new demand patterns, generating different demand scenarios, all that done through a user-friendly graphical interface.
- At University of Victoria, studies attempt at characterizing and predicting impacts of DR, EVs, system flexibility, variable renewable energy characterization, remuneration mechanism and market participation. Power system integration of BC and Alberta has also been studied for horizon 2060.
- In Montréal, a collaboration between the Energy Sector Management Chair at HEC Montréal and the IET studied gains from greater power system integration, assessing various power system decarbonisation strategies. They aimed at getting a better understanding of the potential regional role of hydropower reservoirs such as the ones in Quebec for the northeastern region of North America.
- EPRI has started the Canadian Clean Energy and Electrification Assessment initiative, of which the first stage was internally funded. When completed, it shall model the entire electric sector, from energy generation investment and dispatch to energy use, through building consumption characteristics and industrial demand. The outputs would provide insights on needed generation capacity and demand profiles but also on environmental impacts and expected electricity costs.

Discussion panels

Three discussion panels were organized covering three themes :

- Motivations and Goals
- Struggles, Barriers and Challenges
- Continuing the Momentum

Key takeaways from those panels can be organized under three categories, as presented below.

Contextual elements

- Canada presents a diversity of regional energy realities. That, combined with the size of the country, explains in part why not everyone is aware of all modelling activities taking place in various universities or research centres, making global perspectives hard to get.
- Since it is of provincial competency, there seems to be a general lack of interest for energy modelling at the national level. This is unfortunate as meeting the Paris agreement targets could benefit from nationally coordinated efforts.
- Electrification being a key to decarbonisation, electricity sector modelling becomes even more important to help forecast production costs and capacity expansion with emerging generation technologies (intermittent renewables, DG) and other disruptive technologies (EVs, smart devices, storage).
- There are modelling works already done that can be of help to policy makers, but they must be made aware of those and have results presented to them in a clear and understandable way.

Interactions between modellers and policy makers

- There are modelling works already done that can be of help to policy makers, but there is no easy way to find the pertinent model for a specific question or to identify and locate specific expertise across the country.
- There are some misunderstandings between modellers and policy makers on what can be expected from models, on how and when to use them in the policy elaboration process and on how to interpret their results.
- Policy makers often expect from models direct answers to their policy questions, which is rarely possible. Modellers could, in some instances, be able to have their models answer those questions if only enough time was given to them to do so. Most of the time though, models are not designed to answer specific policy questions but to be used in the elaboration of those policies by providing insights on the policy definitions; thus, they should be used earlier in the policy definition process.
- Comprehensive dialog must be established between policy makers and researchers. All stakeholders must share the same understanding of project

vocabulary, needs and goals. Models must be goal oriented and their results must be representative and easily consumable.

Observed challenges and issues with modelling

- The access to quality data in a timely manner is a challenge. In some cases there are privacy concerns that may slow down access to data, let alone the creation of a common open data source.
- Having a common data source that could be validated and commonly agreed as the reference source would help alleviate some of the credibility issues that models suffer from the policy makers and the utilities. Models credibility is also at risk when results are not reproducible, hard to interpret or not easily applicable to real context.
- Getting results in a timely fashion is another challenge. If not caused by the data-gathering process, delays can come from the integration of existing models to provide more complete results.
- Communicating modelling results in a clear and consumable way is rarely done. Not explaining the limits of the model used may lead to result misinterpretation, further affecting the model's credibility.
- Modelling the level of flexibility in Canada in its entirety is difficult, but a global consistent national perspective would be helpful for policy makers. A Canadian focus is also missing in some models. In addition, some of the identified missing (or incomplete) models preventing comprehensive results are production cost models; customer/social behaviour models; and demand and DR models.
- Funding model operation and maintenance is almost nonexistent, as is funding for a multidisciplinary initiative. Both are needed, however, as there is a need to involve (at minimum) engineers, economists and policy makers to work iteratively over existing models to define proper policies, identify decarbonisation pathways and keep the public informed and on board with the decarbonisation objectives.

Breakout Sessions

The two breakout sessions were organized as a thought experiment. Five groups were formed, each tasked with writing a report on a given subject. The first breakout was to identify components of the platform, including models and data, required to produce relevant results for the tasked report, and the second breakout was to identify what could be done over a 2-year period to produce those results.

The 2-year generic project scenario

- An initial review of existing technologies, models, policies should be done.
- Within 1 year: A data structure should be established and populated with data from governmental agencies and industries. There should be a certification authority in charge of populating the database. The needs for future models

should be identified. The platform architecture should be defined. Relationships between stakeholders should be fostered.

- Within 2 years: Existing models should be gathered, possibly improved. Some should be made available via the platform. A clear cartography of models and modellers should be developed, as well as a decision-support tool for policy makers to select relevant models and for other stakeholders to build collaborations. The platform should allow receiving feedback from users and stakeholders.

General observations

- Facilitating the readiness of energy system analyses to inform policy is a challenge.
- Model efficiency and accuracy are hard to evaluate.
- Current energy generation cost models are not always adapted for fast-evolving markets.
- Better estimates for future demand profile, impacts of climate change on the grid and costs of energy transition would be very useful.
- Accurate modelling of individual behaviour and societal benefits is missing in many models.
- A global electrification strategy must be defined. Which sectors should be electrified first and to which extent? Which technologies should be used or need to be developed?

Platform related comments

- Motivation in participating in the platform development and maintenance could be a challenge.
- Open access could avoid duplication of work.
- Intellectual property must be considered.
- Coupling models would generate more realistic results.

Workshop synthesis

Recommendations on the platform

- In its simplest form, the platform should be an inventory of available models, the people behind them and the interested model users, so to easily match decision-maker problems with the right tools and models. It could also be used as a loose structure for communication, collaboration, experience sharing.

  - Policy makers and researchers should provide mutual insight and feedback on what they need, what is relevant.
  - It should help enabling more structured conversations between federal, provincial, territorial and municipal governments.
  - The human dimension must not be forgotten. Communication is a key element.
- A more elaborated platform should serve as a centralized data sharing repository, with controlled access mechanism to some stakeholders data, validation processes for the submission of new data and certification of data set to ease model results comparison.
- Finally, in its more accomplished form, the platform could also serve as a model repository, to make them available to the modelling community. The platform could also store various sets of interface modules for interoperability between models if need be.

Recommendations on platform operation

- Data collection and management should be assigned to a dedicated entity, under the authority of the federal government to ease data collection and transfer. This entity should also oversee data validation and model calibration.
- Access could be limited (through different levels of accessibility) to obtain more data from the industry.
- There should be an oversight group that protects consistency and refers request to the right models or to the right people.
- There should be a common standard interface. Academic outputs should also be standardized.
- Platform functionalities should be regularly revisited and updated based on the major concerns.
- Collaboration with other similar projects or initiatives from around the world should be established.

Recommendations on models and their use

- Guidance on how to use models should be provided, including a clear description of their limits.
- Experts from other fields – like social science, economics, life-cycle assessment – should be involved.
- A comprehensive benchmark of available models should be established.
- A review of different models should be made. They should be evaluated through an analysis of model efficiency in terms of data usage (data requirement vs. value of generated results for the decision maker) and through identification of redundancies, complementarities and gaps (missing models).
- An annual forum/event on energy modelling should be organized.

On the role of Federal government

- Significant funding is required as a whole infrastructure needs to be built and maintained. The federal government should plan for a long-term funding mechanism.
  - Private investment could be considered, as long as independence is maintained. Industrial stakeholders would contribute if a clear value proposition is perceived.
- The platform should be hosted by the federal government. The federal government can play a great role by making the data available. It should offer the platform to aggregate data and models and be a founding member.
- Actual government issues should be the starting point of research.

Appendix A - Breakout sessions summary per table

Table / Topic	Day 1: Identifying the needs	Day 2: Defining the solutions
Table 1 Evolving Canada's electric grid to accommodate 80% electrification by 2060	**Challenges:** - modelling all energy sources - modelling individual behaviour - motivate participation in data (by access to tools?) - make the best out of current tools - demand forecast (multi-level: grid, sources, demand, time) **Questions:** - How can the grid support the transition to renewables and electrification? (stability) - Should we convert one sector entirely to electricity or every sector a little to reach the global target of 80%? **Solutions:** - high level scenarios with different cost levels for each technology - understanding of current situation in terms of energy demand/mix/ capacity by sector - forecast energy demand by sector in 2060 - study potential electrification with current technology (per sector) - define what sectors to electrify, what technologies to use - define what improvements should be done on the current grid for stability (generation, lines, equipment) - develop economic model (impact of electricity prices on customers behaviour)	**Challenges:** - considering policy landscape - transparency and trust, no black boxes, open access to avoid duplication of work **Questions:** - Is it better to diversify technologies or to focus on some with more potential? - Should we consider demand evolution (demand reduction)? **Solutions:** - list of priorities for sectors on which to perform electrification - Steps: 1. determine theoretical potential (technologically feasible) 2. techno-economic potential (technologies cost and their evolution) 3. social acceptance, customers behaviour (based on cost) *heating, transportation - study different ways to achieve the 80% with different evolution scenarios with solid references - models: NATEM, TIMES, PLEXOS, OSEMOSYS - production cost model - long-term planning model - power transportation model - timeframe for studies: few years, then 5, 10. Revision on an annual basis. - provincial/regional and federal representation, considering links with US - year 0: review/survey or existing technologies, policies, models - year 1: Spine database with "certified" data (peer review process for validation). Defining platform architecture. Build a relationship with facilities. year 2: sector-wise electrification solution
Table 2 Keeping the lights on: maintaining	**Challenges:** - capacity reliability and energy reliability	**Challenges:** - Resiliency and reliability are long-term issues

reliability and resiliency of next-generation grids	- visibility of DG, DR and storage devices, real time - modelling intermittency, reserves - modelling mechanical inertia - modelling operability between system operators and utilities - adaptation to extreme weather events related to climate change - modelling EV charging behaviour and charging stations, forecasting of their location - aggregation visibility for charge, demand, incentives or regulation - electrification leads to higher impacts of outages and different consumers behaviours that will have to be characterized - cybersecurity - outages: prevention and recovering, evaluate outages cost - vulnerability of gas supply if energy mix with renewables **Questions:** - Will there be a higher rate of outages in the context of climate change? **Solutions:** - data on climate (sun, wind, water inflows) - data transfer from sensors of the wire system - agent-based models for charging and consuming - data on registration for EVs, for their location especially (V2G) - regional specific data (depends on regulatory framework) - data aggregation for confidentiality - regulation on location of charging stations based on models - system monitoring and controlling down to the distribution to achieve resilience, self-healing	- Facilitate readiness for energy system analyses to inform policy **Questions:** - Should the platform be open source? - What should be the timeframe for the studies? - What should be the framework to study resiliency? **Solutions:** - Within 1 year: Defining a data framework (e.g. Spine). Organizing a central repository of data and models. - Within 2 years: Defining the scope of the models, from local to global, interconnecting, short/long-term. Common API. Gather data from all governmental agencies. Academics outputs standardization (based on Stanford U). Virtual network of models, grouped by category with links or contact information (based on OpenMod). - Steps: get funding, define an organization that would get funding for the portal, create the portal, contact the persons, gather the data, and gather questions that policy makers want to be answered. - Annual forum/event on energy modelling
Table 3 Rolling out 100% clean and renewable energy solutions in the face of technological, economic, and climate uncertainty	**Challenges:** - modelling cost performance and evolution, new technologies, people behaviour, load forecasting, storage, social welfare - modelling interactions between planning, operation, land use impact, power flow, check point, resource adequation **Questions:**	**Challenges:** - Diversity of energy mix, challenge in QC: EVs - Variability of the market - Considering risk management in scenarios - Climate forecasts **Questions:** - Main question: demand profile in 2050

	- When will we reach that 100% clean energy? How does this target affect the models and the platform? (see NREL studies) - Where is the potential location for future renewable generation? **Solutions:** - optimization with objectives such as reliability and cost - put costs as constraints - guidance explaining models - R&D investments for cost evolution of technology and electricity - output of the platform: key assumptions that have impact on the results	- Is it possible to cut the energy connection between the US and Canada? - Evaluate the costs of 100% clean energy - How can we make the best of our interconnected grid? - How do we integrate our current interconnections in 100% clean energy grid? - What are the strategies to decarbonise Canada? - Hourly loads or general view? - Data for transportation? **Solutions (within 2 years):** - Gather and improve existing tools - Gather existing data, identify the gaps and prioritize the problems - Characterize energy demand by sectors - Determine potential scenarios - Policies based on scenarios - Study electrification of loads - Study impact of aluminum industry - Collect data on climate change and its impact
Table 4 Taking on load: the role of users (e.g., prosumers, buildings, industry) in the new grid paradigm	**Challenges:** - models interoperability, ability of models to “speak” to each other (from different topics) - models and results dependence based on - data availability and input qualification, IP **Questions:** - Should we include the cost structure? - What is the grid going to look like? - How electricity market will evolve? - How to model impact of different factors on load? - How to evaluate models efficiency? - How to involve people in policy-making, convince consumers to change habits, ensure transparent decision-making process? **Solutions:** - Establish and share vision on “New grid paradigm” based on Smart energy grids concept, DER, electrification, flexible loads, AI,	**Challenges / questions:** - Data availability, structure, possibility to share or make data public - Protection of smart meter data - Open source: IP and other issues related to academic models usage/share - What is the effect/value of prosumers? Contradictory information regarding this issue - Funding aspects for the project - Involvement of industrial stakeholders, create value for businesses, encourage private investment. **Actions / solutions:** - Classify and organize available and potential available data. explore SPINE and NREL data sources, Environment Canada - Inventory of data on the electricity market, unlabelled (no personal) data - Build a community with specialized clusters/groups (build a human network), share same obligations

	blockchain, grid parity, utility roles - Work with connex experts/models to identify possible scenarios for market evolution. - Exhaustive model accounting for various factors (price, regulation, behaviour, etc.) - Data availability challenge may be partly handled by parametrisation - Establish a comprehensive benchmark of available models - Make available platform (its partly features) to everyone (beyond the current community). Collect stakeholders, users and energy customers feedback and update platform functionalities based on the major concerns.	(e.g., share developed codes) - Build an operational group who will work on the project - Work with academics to figure out IP issues related to available models, possibility to take only mathematical models (not code) and use a basis for development of commercial model, closer look on students' work and collaboration - Involvement of social science experts to conduct works to understand prosumers behaviour - Need involve experts from different fields: economic, social, life-cycle assessment, environment, reliability - Work on financial aspects, support academics and experts working on this project. Create a NSERC Strategic Network. - Integrate other projects/discussions working on the similar projects (the US, the EU) - Define the purpose of the platform and roles of different stakeholders.
Table 5 Money matters: Designing a market, economic, and policy framework to aid adoption of 100% clean and renewable energy	**Challenges:** - operating in the old market designed not for the system with various emerging technologies and behaviours (RES, prosumers). - current energy generation cost models are not adapted to test scenarios of different markets. - to be realistic the coupling between models is required (e.g., electricity market model and transportation) - data availability and format: common data "format" for data flowing between models, data distribution (geographically, by stakeholder). - legal issues related to data usage. **Questions:** - What is the type of market optimal to aid adoption (e.g., completely deregulated market)? - What is the time scale (time horizon) to account for? It could influence type of model to choose as well as its requirements. - What are market players, their objectives and interactions with other players (including new	**Questions:** - How different models could be compared to each other (criteria)? Different models are based on different assumptions and data sets, could give different results. - What is the understanding of word "integrated" and how it can be achieved between models of different purposes? - How to guarantee a real world modelling and ensure realistic results? Transforming policy problems into decision-making mathematical problem. - How to use analytical models to simulate people's reactions to regulations? How to show that this is the optimal policy (incentives) path? **Actions / solutions:** - engaging more people (industries, researchers) working on models in Canada - review of different models: evaluation (analysis of models efficiency in terms of data usage: data requirement vs. value of generated results for the decision maker), identification of

	possible players - prosumers)? - How to manage data challenges? - How to integrate different markets designs in different provinces? **Actions / solutions:** - Involvement modelling and policy experts working on different markets and different policies - Use of models/approaches adapted for market context, e.g., bidding behaviour to account with game theory approach. - Seeking for experience and best practices in other fields (e.g., gasoline market)? - Create entity (or assign a stakeholder) to facilitate data collection and management.	redundancies, complementarities and gaps (missing models). - models “test-drive”: comparison of models of different purposes by solving same (similar) scenarios, analysis of different results and perspectives. - work on the integration issues for models interconnection, e.g., application of integration framework used in system design field (interconnectivity between models of different purposes done with tools, such as Modelica). - work on communication, visualization, graphical aspects to simplify results adoption (e.g., communication with projects stakeholders and population). **Short-term deliverables:** - clear cartography of the existing models (focus, objectives, decision variables, limitations, data requirements, etc.) including comparison results from different models - decision-support tool (easy to use, possible in Excel) for the policy-maker (federal and provincial government) to select the optimal models (interlocutor) and for other stakeholders to find synergies and build collaborations **Long-term deliverables:** - numerical software backbone to plug in existing or new models (toolboxes) **Identified value:** - No one model winner: the added-value lies in models diversity and complementarity allowing emergence of optimal policies.