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EVIDENCE BRIEF

The **Social Sciences and Humanities Research Council** in collaboration with the **Natural Sciences and Engineering Research Council** and the **Canadian Institutes of Health Research**

SSHRC's Imagining Canada's Future initiative mobilizes social sciences and humanities research to address emerging economic, societal and knowledge needs for Canada, and help guide decision-making across all sectors toward a better future. This evidence brief addresses the Future Challenge Area of: **Living Within Earth's Carrying Capacity**

Improving climate policy projections: A pan-Canadian review of energy-economy models

About the project

Canada has committed to reduce its greenhouse gas (GHG) emissions by 40% to 45% below 2005 levels by 2030 and to net zero by 2050. To achieve these targets, the federal and many provincial and territorial governments implemented a variety of climate policies, including carbon pricing, sector-specific regulations, incentives for clean technologies and low-carbon infrastructure investments. However, forecasted impacts of these policies vary dramatically across different energy-economy models in terms of GHG and economic outcomes. We conducted a mixed-method review of the key strengths, gaps and improvements in energy-economy models in the public, private and not-for-profit sectors in Canada over the past 10 years.

The main objectives were to:

1. develop a publicly accessible inventory of energy-economy models in Canada;
2. develop best practices for modelling climate policies; and
3. engage stakeholders to synthesize and disseminate research results, including model critiques and best practices.

To develop a publicly accessible inventory of models, we combined the use of a narrative literature review with a web-based "expert" survey of Canadian model developers and users (n=14). First, we studied academic peer-reviewed literature and open-access reports to identify the key characteristics for assessing the ability of energy-economy models to evaluate climate policy impacts, and to develop a list of energy-economy models in Canada. Second, we implemented a web-based "expert" survey that helps update literature review results, identifies missing energy-economy models and describes models that lack published information.

Key findings

The survey analysis, combined with the narrative literature review, results in a comprehensive modelling inventory that compares and contrasts 24 distinct energy-economy models used across public, private and not-for-profit sectors in Canada. The models are compared against seven assessment characteristics found important for projecting climate policy effects on GHG emissions and economic outcomes. These characteristics include technology representations, microeconomic and macroeconomic realism, policy representations, treatment of uncertainty, high-resolution spatial and temporal representations, and data transparency.

The assessed models fall under four methodological categories: top-down (17%), bottom-up (25%), hybrid (41%) and integrated assessment models (17%).

We find that models sharing similarities in overarching methodological approaches are also similar in the way they represent technologies, market heterogeneity, trade effects, different policy types and energy equilibrium. Conversely, there are quite diverse approaches used in the representation of technological change, non-financial decision factors, financial or monetary features and non-energy equilibrium. For the most part, models represent technology, micro- and macroeconomic characteristics according to the classic typology of bottom-up, top-down and hybrid models. However, several modelling evolutions have emerged. To varying extents, top-down models can explicitly represent technologies and some bottom-up models incorporate microeconomic characteristics.
We find that models differ in the types of policies they can simulate, sometimes underrepresenting politically popular

performance regulations, government procurement, and research and development programs. All models use at least one method to explore uncertainty, rarely incorporate spatial and temporal representations, and lack transparent methodological documentation.

Based on our results, we suggest six best practices that can help researchers and policy-makers improve energy-economy models and better assess impacts of climate policies. Specifically, models should:

1. explicitly represent energy-related technologies and technological change dynamics;
2. capture both market heterogeneity and non-financial costs of technologies;
3. include a representation of trade and finance;
4. link energy supply-demand using price-quantity adjustments;
5. accurately represent different types of policies and policy interactions; and
6. explore uncertainty in forecasted impacts.

These suggestions do not determine which model is “best” because model choice depends in part on the type of research and/or policy question posed. However, the inventory and the best practice suggestions can assist researchers, modellers and policy-makers in choosing the most suitable modelling tools for their specific questions and help identify methodological gaps to address in future research.

Policy implications

No model is ideal for every climate policy question, but certain models are better suited to answer certain questions. The comprehensive model assessment inventory helps policy-makers choose a suitable model for their policy questions.

- Almost all models can simulate carbon pricing; however, hybrid or top-down models are more suited to represent this policy type due to their incorporation of macroeconomic feedbacks and the ability to represent carbon revenue recycling.
- Most models seem to explicitly represent certain technologies, making them suitable to answer technology-specific policy questions.
- All hybrid models can simulate a variety of prescriptive regulations, performance standards and subsidies, due to their incorporation of the strengths of bottom-up and top-down methodologies.
- At the municipal level, using models that incorporate high-resolution spatial representations can help account for the non-spatial uniformity of land-use policies. Similarly, policy questions regarding renewable energy generation are better addressed in models with high-resolution temporal representations that account for the intermittency of renewable energy supply.
- The observed lack of transparency in model data and assumptions is a concern deserving policy-making attention. The movement toward more transparent and open-access data can advance the accuracy of modelling results and lead to more informed and trusted climate policy decisions.

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FURTHER INFORMATION

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