Carrefour de modélisation énergétique | Energy Modelling Hub

ENERGY MODELLING HUB & ENVIRONMENT AND CLIMATE CHANGE CANADA

NET ZERO MODELLING WORKSHOP

SEPTEMBER 20-21, 2023

OTTAWA - ONLINE

ENERGY MODELLING HUB
INFO@CME-EMH.CA — WWW.CME-EMH.CA

ABOUT THE EMH:

The Energy Modelling Hub (EMH) is a national network of energy and electricity modellers, policymakers and other experts that was created to guide the transformation of our complex energy systems. Our mission is to support timely evidence-based policymaking toward a net-zero economy by bringing together public policy and energy modelling communities as well as facilitating access to energy modelling expertise and tooling.

The EMH follows on from the Energy Modelling Initiative. The EMH was initiated by Natural Resources Canada. On May 25, 2022, the government department announced an investment of nearly $5 million in the Institut de l'énergie Trottier at Polytechnique Montréal and the partner organizations, the Institute for Integrated Energy Systems at the University of Victoria and the School of Public Policy at the University of Calgary, to establish the Energy Modelling Hub to help realize a decarbonized energy system for Canada.

POLYTECHNIQUE MONTRÉAL | INSTITUT DE L'ÉNERGIE TROTTIER | School of Public Policy | UNIVERSITY OF CALGARY | University of Victoria | Institute for Integrated Energy Systems

Citation: Energy Modelling Hub. (November 2023). «Energy Modelling Hub & Environment and Climate Change Canada Net Zero Modelling Workshop".

EXECUTIVE TEAM

Edouard Clement
Executive director - Energy Modelling Hub
*Contact information : edouard.clement@cme-emh.ca

Louis Beaumier
Executive director - Institut de l'énergie Trottier

Madeleine McPherson
Assistant professor - University of Victoria

Normand Mousseau
Professor - University of Montréal

Blake Shaffer
Assistant professor - University of Calgary

STAFF

Jacob Monroe, Ph.D.
Research Analyst - Energy Modelling Hub

Josée Provençal, Ph.D.
Mobilisation & Liaison Coordinator - Energy Modelling Hub

ACKNOWLEDGEMENTS:

The Energy Modelling Hub (EMH) acknowledges the financial contribution of Environment and Climate Change Canada for their support in organizing this workshop.

Furthermore, the activities of the EMH are supported by funding from the Renewable and Electrical Energy Division of Natural Resources Canada.

Natural Resources Canada | Ressources naturelles Canada

Canada

EXECUTIVE SUMMARY

This report encapsulates the proceedings and insights from the ECCC-EMH Net Zero Modelling Workshop held on September 20-21 in Ottawa and Online. Aimed at advancing the goals of Environment and Climate Change Canada (ECCC) towards achieving net-zero emissions by 2050, the workshop brought together a diverse group of domestic and international experts. The focus was on evaluating ECCC's modelling tools, discussing strategies for net-zero scenarios, and enhancing overall model transparency and accuracy.

The primary objectives of the workshop were:

- To assess and critique the current modelling tools and approaches used by ECCC.
- To explore and discuss various strategies and methodologies for modelling net-zero emission scenarios.
- To foster collaboration among experts in the field, enhancing the effectiveness of greenhouse gas emissions modelling.

The workshop utilized an interactive format comprising presentations, panel discussions, and Q&A sessions to facilitate a thorough exploration of four key topics:

- Session 1: Long-term Modelling - Practice, Approach, and Reporting
  - This session provided insights into the practices, methodologies, and reporting mechanisms associated with long-term energy modelling.
- Session 2: Net-Zero Modelling Approaches - International and Canadian Practices
  - Participants explored various modelling approaches adopted both internationally and within Canada to achieve net-zero emissions targets.
- Session 3: Assessing ECCC's Modelling Tools - Improvement vs. New Development
  - A critical assessment of ECCC's existing modelling tools was undertaken, weighing the benefits of refining current tools against the potential of developing new ones.
- Session 4: Open-Source Net-Zero Modelling Tools
  - The focus shifted to the advantages and challenges of using open-source tools for net-zero emissions modelling, emphasizing the importance of transparency and collaboration in the modelling community.

After these sessions, a series of recommendations were identified and categorized **into three key areas**. These recommendations are intended for the broader modelling community, and are also proposed for consideration in Environment and Climate Change Canada's (ECCC) planning:

1. COMMUNITY ISSUES: Highlighting the need for stronger partnerships between government, academia, and stakeholders to enhance the quality and accessibility of modelling efforts. Main recommendations included:

a. Collaboration and Resource Availability:
- Seek collaborative opportunities with the other government-based modelling organizations (e.g., U.S. Energy Information Administration (EIA) and US Environmental Protection Agency (EPA)) and academic institutions.
- Ensure models are well-documented with robust user support.
- Propose creating a Canada-focused scenario modelling forum for energy and climate issues.
- Strengthen government-academia partnerships for model development and training.
- Promote knowledge exchange with other modelling communities.
- Establish structured training for modellers, possibly via a dedicated hub.

b. Guidance for Advancing Canadian Energy Modelling and Climate Policies:
- Focus on sector-specific aspects in energy-emissions-economy modelling practices.
- Recognize the interplay between climate and energy policies.
- Use energy modelling as a tool to guide climate policy-making.
- Balance local and global perspectives in models, considering affordability in climate and energy policies.
- Encourage collaborative workshops to enhance modelling skills.

c. Transparency and Open Sourcing:
- Increase transparency in energy modelling, while respecting data confidentiality issues.
- Consider open-sourcing models for greater scrutiny and transparency.

d. Model Integration and Comprehensive Approach:
- Link different models to enhance capabilities and address specific issues.
- Evaluate the potential for a comprehensive overarching model.

2. GENERAL MODEL ISSUES: Focusing on diversifying model usage, enhancing transparency, addressing model limitations, and suggesting improvements for process efficiency and real-world applicability. Main recommendations included:

a. Diverse Use of Models and Scenario Variability:
- Use a variety of models for different scenarios to avoid dependency on a single model.
- Expand scenario range for in-depth analysis.

b. **Probabilistic Analysis and Open Source Models:**
   - Include probabilistic elements in scenarios to reflect uncertainties.
   - Where possible, promote open-source models for credibility and transparency.

c. **Critical Strategies and Insights:**
   - Perform price sensitivity and other analyses in long-term strategies.
   - Address uncertainties and set realistic expectations.
   - For the CGE suite of models, consider machine learning for faster results and integrate engineering insights and validation in modelling.

d. **Model Alignment and Integration:**
   - Align short-term and long-term models for policy relevance.
   - Appreciate diverse economic philosophies in model selection.

e. **Addressing Limitations and Enhancements:**
   - Recognize and overcome model limitations.
   - Consider more complex models capturing behavioral changes and urban densification.
   - Update models for non-linear technology adoption and interaction effects.

f. **Integration of Alternative Models:**
   - Continue exploring alternatives and complements to CGE models and their interactions with other analytical tools.

3. APPLICATIONS: Providing practical advice for applying models in policy-relevant scenarios, improving accuracy, and managing the structural changes required to achieve net-zero emissions. Main recommendations included:

a. **Carbon Capture and Storage (CCS):**
   - Investigate CCS alternatives, including Land Use, Land Use Change, and Forestry (LULUCF).

b. **Practical Application:**
   - Apply models to practical inquiries and provide actionable advice.

c. **Sector-Specific Modelling:**
   - Use regional or provincial models for sector-specific precision.

d. **Elasticities and Structural Change:**
   - Tackle the modelling of structural changes essential for net-zero emissions, considering elasticity variations.

e. **Follow-Up Workshop on Long-Term Policy:**
   - Plan a follow-up workshop to review long-term net-zero policies and assess model accuracy in representing these policies.

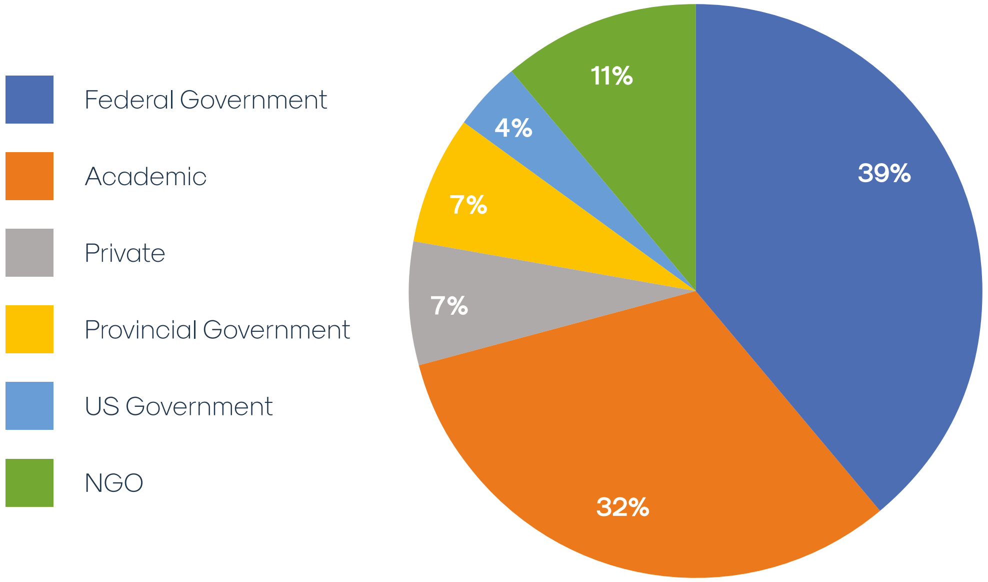
TABLE OF CONTENT

BACKGROUND

As part of the March 2022 Emissions Reduction Plan (ERP), Environment and Climate Change Canada' (ECCC) is committed to enhancing the transparency and accuracy of its greenhouse gas emissions modelling. This workshop was designed to assemble a group of esteemed domestic and international experts actively analyzing and delving into the challenges of attaining net-zero emissions by 2050. Together, we assessed and deliberated upon ECCC's existing suite of models within the context of modelling net-zero scenarios, evaluating whether enhancements or entirely new models are warranted. The workshop followed the recommendations outlined in the Boothe Report, Beale Report, and the Net-Zero Advisory Body's First Annual Report, emphasizing the importance of collaboration and the availability of necessary tools for net-zero modelling and analysis.

The conference report is organized into four distinct sessions, aimed at examining specific facets of ECCC's initiatives to improve greenhouse gas emissions modelling towards achieving net-zero emissions by 2050. The first section captures key insights from expert presentations, laying a groundwork for subsequent dialogues. After each presentation, there's a Q&A segment that, on a thematic basis, collates all questions posed to the speaker along with their responses. Following the presentations, each session distills critical points and themes into a key takeaway, aiding in succinctly understanding the main messages of the session. Each session also facilitates interactive discussions among experts, yielding valuable insights, challenges, and solutions. This section of the report encapsulates the outcomes of these discussions, underscoring the consensus and avenues for further exploration. To conclude each session, a set of recommendations is provided, offering a roadmap for tackling challenges, enhancing transparency, and refining modelling approaches.

About the attendees:



DAY ONE – SEPTEMBER 20, 2023

SESSION 1: LONG-TERM MODELLING – PRACTICE, APPROACH, AND REPORTING

In this first session we delve into the insightful presentations delivered by esteemed experts from various institutions, each providing insights into modelling approaches pivotal for the transition to net-zero emissions. Eric Stewart from Environment & Climate Change Canada (ECCC) commenced with an overview on Canada's Long-term low greenhouse gas emission development strategies submissions to the United Nations Framework Convention On Climate Change, focusing on the mid-century and approaches for Canada's transition to net-zero emissions. Following, Matthew Binsted of the U.S. Department of Energy (DOE) and Pacific Northwest National Laboratory explained the U.S. Long-Term Strategy and modelling approaches from the perspective of the US government and OP-NEMS modelling, alongside GCAM modelling. Prof. Mark Jaccard from Simon Fraser University rounded off the session by shedding light on the modelling endeavors undertaken by the Canadian academic and non-government modelers for pathway analysis. The presentations offered a rich tapestry of knowledge, underscoring the confluence of efforts and methodologies adopted across borders to navigate the transition towards a net-zero emission realm.

CONFERENCE 1.1

Eric Stewart, Environment and Climate Change Canada

Link to presentation

Eric Stewart shared Canada's pathways for transitioning to net-zero emissions, submitted to the United Nations Framework Convention on Climate Change. The presentation was structured into two primary sections:

Firstly, the Mid-Century Strategy (MCS), submitted in 2016, aimed to achieve an 80% reduction in emissions from 2005 levels by 2050. It used multiple international models to analyze decarbonization pathways and sectoral impacts. In contrast, the Long-Term Strategy (LTS), submitted in 2022, supported Canada's net-zero emissions commitment for 2050. It explored five scenarios (i.e., a current assumption scenario plus four sensitivities around alternative technology assumptions), employing three ECCC international models to assess sectoral emissions and energy use impacts.

The presentation highlighted Canada's extensive experience analyzing long-term emission pathways, which began in 2014 with model development. Key components of the MCS included electrification, energy efficiency, GHG abatement, sequestration, and innovation. Various models like GCAM Canada, EC-MSMR, and CIMS-GEEM were used to explore deep decarbonization pathways.

The 2022 Long-Term Strategy explored a "Current Assumption" plus four sensitivity scenarios focused on high electrification, increased use of renewable and alternative fuels, and engineered CO_2 removal technologies. The models emphasized electrification's significance across sectors, reducing fossil fuel usage and increasing electricity demand.

The presentation stressed the complementarity of the models, with consistent results across institutions. Some limitations were acknowledged, particularly in modelling novel industrial processes and non-energy goods trade. Future enhancements, including developing a provincial-territorial version of GCAM, were discussed. Overall, the presentation highlighted Canada's commitment to modelling diverse pathways for achieving net-zero emissions and its role in shaping climate policies for global sustainability.

QUESTIONS AND ANSWERS SESSION 1.1

During the Q&A session of the conference, several important questions and discussions arose regarding the modelling approaches presented:

- **Biomass Consideration:**
  - There was a question about whether biomass is considered a resource in the models. There are varying perspectives on biomass use, with GCAM considering competing uses and MSMR focusing on land use. Details of biomass vary among ECCC's models. GCAM incorporates biomass from agriculture and forest residuals and municipal waste and biomass grown for commercial purposes. EC-MSMR and EC-IAM do not have such details of biomass and activate biomass-related policies through exogenously defined MAC curves.
- **DAC in CGE vs. IAM Models:**
  - The question was raised about the differences in considering Direct Air Capture (DAC) in Computable General Equilibrium (CGE) versus Integrated Assessment Models (IAM). The speaker acknowledged that there has been no in-depth investigation into this aspect and a lack of information on the cost of DAC. In CGE/MSMR models, it quickly dominates once DAC becomes marginally profitable.
- **Uncertainty and Model Confidence:**
  - Participants expressed concerns about the uncertainty in the models and asked about the sources of the largest uncertainties. It was acknowledged that there is a significant amount of uncertainty when modelling future actions, and as a result, the outcomes should be interpreted with caution. The models need to account for uncertainty better due to their recursive dynamic approach, which follows classical economics.
- **Competition Between Bioenergy Supply:**
  - The competition between bioenergy supply and the reduction of bioenergy in the projections was discussed, raising questions about the model's assumptions.
- **Probabilistic Approach:**
  - There were inquiries about why the models do not use a probabilistic approach to account for uncertainty. It was explained that while probabilistic methods are standard for some models, they are not widely used for large-scale integrated assessment models due to their computational demands.
- **Behavioural Changes and Governance:**
  - Questions about whether the models incorporate societal and behavioural changes and uncertainties related to global governance were raised. It was recognized that considering these factors and the unpredictability of international events is crucial.

CONFERENCE 1.2

Colin Cunliff, U.S. Department of Energy

Matthew Binsted, Joint Global Change Research Institute

Link to presentation

Colin Cunliff and Matthew Binsted provided insights into modelling in the U.S. Long-Term Strategy (LTS) for energy efficiency and renewable energy. The U.S. LTS aligns with ambitious climate and clean energy objectives, including significant reductions in greenhouse gas emissions, achieving 100% clean electricity, and net-zero emissions by 2050.

The strategy was formulated by a collaborative team from the Department of Energy (DOE) and the Environmental Protection Agency (EPA), using various modelling tools. These tools, including the National Energy Modelling System (NEMS) and the Global Change Analysis Model (GCAM), do not represent specific policies but explore multiple scenarios and sensitivities.

NEMS, a detailed U.S. energy-economic modelling system, provides insights into energy production, consumption, and conversion, relying on various assumptions. Future enhancements are planned to incorporate emerging technologies and other factors.

On the other hand, GCAM is a global model that integrates energy, water, land, economics, and climate systems, operating in five-year time steps. It offers insights into energy prices, resource use, land utilization, and greenhouse gas emissions, focusing on global perspectives.

Key takeaways from the conference emphasize the necessity of robust, long-term analysis supported by multiple models and scenarios. Achieving net-zero emissions requires contributions from all sectors and consideration of various greenhouse gases, highlighting the importance of integrated, long-term models.

The LTS identified five pivotal transformations for the U.S., including decarbonizing electricity generation, electrifying end uses, reducing energy waste, addressing non-CO_2 emissions like methane, and scaling up carbon dioxide removal.

The conference highlighted the diversity of approaches needed to address long-term climate and energy challenges. It underscored the importance of embracing multiple pathways, considering all greenhouse gases, and recognizing the necessity for contributions from all sectors to achieve ambitious climate goals.

QUESTIONS AND ANSWERS SESSION 1.2

In the Q&A session following the conference, the discussion revolved around five main topics:

- **Emission Levels and Precision:**
  - A question was asked if the presentation accounted for forest fire emissions in the 750 million MT of LULUCF emissions. The speaker confirmed that the Environmental Protection Agency (EPA) holds the data and affirmed the land sink's consistency with their findings.
  - Concerns were raised regarding the precision of the results. It was clarified that the model possesses more accuracy than what was presented during the conference. The models allow for granular insights into sector-specific details beyond the high-level overview.

- **Detailed Data and Granular Findings:**
  - Attendees sought to understand the level of detail available in the models. The response highlighted that the LTS documentation contains sector-specific needs and more granular information. The conference presentation aimed to provide a high-level overview, but deeper insights are available in the LTS documentation.
- **Contributions from External Modelling:**
  - Discussions centred on whether focusing on specific regions or global regions is better. While the conference presentation offered a broad view, more granular modelling can provide valuable insights.
  - During the discussion, they discussed different ways external modelling can contribute. These ways include comparative modelling for concerned citizens, realistic technology and policy pathways, ideal vs. politically achievable policies, visualizing opportunities for regions, and assisting politicians in reducing greenhouse gas emissions to gain voter support.
- **Affordability of Policies:**
  - Questions were raised about the affordability of policies. Various factors, such as energy prices, rebates, and social systems, impact affordability. The concept of affordability can vary significantly between regions and contexts.
- **Data Sources and Conclusions:**
  - Attendees inquired about the data sources for land sinks, and the response referred to the U.S. Energy Information Administration (EIA) as the data source.
  - Regarding the conference's general conclusions, it was clarified that the LTS report contains more precise and detailed information. Specific details about the electricity sector, technology deployment rates, energy end-use sectors, and more are available.

CONFERENCE 1.3

Mark Jaccard, Simon Fraser University

Link to presentation

Mark Jaccard, offers an extensive overview of the evolution of non-governmental energy-economy modelling in Canada from the late 1980s to the period between 1990 and 2020. Initially, the landscape featured various categories of energy-economy modellers, including those specializing in short-run energy demand econometrics, scenario modelling centred around «soft energy paths,» bottom-up technico-economic modelling, and optimization of energy systems.

There has been a noticeable shift towards a heightened interest in long-term energy system transitions. This shift has led to a degree of convergence in modelling methods, resulting in the emergence of hybrid models. Nevertheless, essential distinctions persist, such as the differentiation between simulation and optimization, partial equilibrium versus general equilibrium, revealed versus stated (or assumed) preferences, regional versus global trade considerations, and the balance between energy-economy limitations and integrated economy-climate concerns.

The presentation delves into the specific characteristics and nuances of Canadian energy-economy models developed over this period, with a more comprehensive exploration provided in the article titled «Understanding climate policy projections: A scoping review of energy-economy models in Canada.»

Furthermore, the presentation underscores the potential for Canadian energy-economy models to become even more beneficial in addressing climate-related challenges. It presents four illustrative examples of how modelling can significantly contribute to this endeavour, ranging from comparative modelling to empower climate-concerned citizens in discerning climate-sincere politicians, modelling the juxtaposition of ideal and politically viable policies for politicians to assess implementation trade-offs, demonstrating how practical technology and policy pathways can address concerns of affordability, to aiding regions in visualizing opportunities within a net-zero future.

In conclusion, Mark Jaccard acknowledges the substantial advancements in modelling within and outside the Canadian government since the late 1980s. While acknowledging the progress made, the presentation emphasizes the ongoing potential for further enhancing these models' utility in driving the transition toward a net-zero future. It underscores the importance of workshops and collaborative opportunities in this continuous journey towards more effective modelling for climate and energy challenges.

QUESTIONS AND ANSWERS SESSION 1.3

In the Q&A session following the conference, the discussion revolved around key points and questions, emphasizing the role of modelling in government and policy contexts:

- **Suitable Modelling Examples for Government**
  - Considerations of climate sincerity and affordability.
  - Addressing distortions and debates within government contexts.
- **Regional vs. Global Modelling**
  - The importance of both regional and global perspectives in modelling.
- **Helpful Modelling Outside Government**
  - Comparative modelling for informed citizens.
  - Modelling ideal vs. politically achievable policies.
  - Demonstrating realistic technology and policy pathways.
  - Assisting regions in visualizing opportunities within a net-zero future.
  - Aiding politicians in reducing greenhouse gas emissions and gaining voter support.
- **Affordability Concerns**
  - Exploring the concept of affordability and its nuances in different contexts.
  - Considerations of energy affordability in countries like Denmark and Sweden.
- **Connecting Climate Modelling and Affordability Sectors**
  - Highlighting the interconnected nature of these aspects.
  - Emphasizing the need for greater alignment and collaboration.

TAKEAWAY MESSAGES

Long-term Modelling - Practice, Approach, and Reporting

In the «Key Takeaways» section of this report, we have distilled the insights garnered from the presentations into six themes:

1. **Modelling Practices and Sectoral Focus:**
    - Multiple international models, such as EC-MSMR and GCAM Canada, analyze decarbonization pathways.
    - Sector-specific considerations include electrification, energy efficiency, GHG abatement, and innovation.
    - Consistency in results across models enhances confidence in outcomes.
    - Electrification is a significant focus, especially in industry, buildings, and transportation.
    - Anticipation of a global shift in fossil fuel supply and demand.
    - Significance of carbon removal technologies in offsetting hard-to-abate sectoral areas.
2. **U.S. Long-Term Strategy (LTS):**
    - Aligns with ambitious climate and clean energy goals, including significant GHG emission reductions by 2030 and achieving net-zero emissions by 2050.
    - Achieving net-zero emissions involves multiple pathways and different scenarios.
    - Collaborative teams utilize models like NEMS and GCAM to explore various scenarios and sensitivities.
    - NEMS offers detailed insights into U.S. energy markets, while GCAM provides a broader perspective on a five-year time step.
    - Achieving net-zero emissions necessitates contributions from all sectors and consideration of various greenhouse gases.
    - The LTS identifies five critical transformations for the U.S., emphasizing the complexity of climate goals. (decarbonizing electricity generation, electrifying end uses, reducing energy waste, addressing non-CO_2 emissions like methane and scaling up carbon dioxide removal.)
3. **Evolution of Canadian Energy-Economy Modelling:**
    - Categories of modellers evolved, leading to increased interest in long-term energy system transitions.
    - Some convergence in modelling methods resulted in hybrid models.
    - Distinctions remain, including simulation vs. optimization and regional vs. global considerations.
    - Ongoing potential for enhancing the utility of Canadian models.
    - Three illustrative examples of modelling contributions: comparative modelling, demonstrating practical pathways, and helping regions visualize opportunities.

4. **Government Applications and Regional vs. Global Modelling:**
    - Discussion on the suitability of modelling examples for government applications.
    - Focus on addressing distortions and debates within government contexts.
    - Consideration of the advantages of regional vs. global modelling efforts.

5. **Helpful Modelling Outside Government:**
    - Examples include comparative modelling for informed citizens assisting politicians in reducing emissions and gaining voter support.

6. **Affordability of Policies:**
    - Discussion on the concept of affordability and government measures like rebates and social systems.
    - Acknowledgment of interconnectedness between climate modelling and government efforts focused on affordability.

INTERACTIVE SESSION

In the interactive session post-presentations, the EMH facilitated a discussion among attendees around three pivotal questions:

1–1 What can we learn from the international landscape to enhance Canada's LTS modelling and scenario analysis? Are there global best practices that can be adapted to improve Canada's approach?

Key Takeaways on Enhancing Canada's LTS Modelling and Scenario Analysis:

- **Diverse Use of Models**
  Avoid relying on a single model for all scenarios and consider the limitations of models in representing the real world.
- **Scenario Variability**
  Learn from the U.S. and incorporate broader scenarios, providing a more comprehensive analysis.
- **Carbon Capture and Storage (CCS)**
  Explore alternative sources of CCS, like Land Use, Land Use Change, and Forestry (LULUCF), especially in relation to biomass.
- **Practical Application**
  Directly apply models to answer practical questions, providing actionable recommendations for households and firms.
- **Open Source Models**
  Embrace transparency and open-source models, allowing independent use and scrutiny of assumptions. Proper documentation is crucial for model credibility.
- **Collaboration with EIA**
  Explore opportunities for collaboration with the U.S. Energy Information Administration (EIA) on open-source initiatives similar to their strategic review of NEMS.

- **Collaboration with Academia**
  Engage universities and fund projects to attract young talent and foster innovation.
- **LULUCF Approaches**
  Investigate different approaches for modelling Land Use, change, and Forestry emissions.
- **Detailed Open Source Databases:**
  Publish comprehensive open-source databases to support model transparency and scrutiny.
- **Review of European Practices**
  Examine European practices, which are often conceptually ahead, and consider knowledge transfer.
- **Data Sharing Challenges**
  Recognize that data sharing among modellers can be challenging due to funding constraints and government confidentiality.
- **International Collaboration**
  Foster communication and participation with international modelling groups to exchange knowledge and data.
- **Resource Availability**
  Ensure resources, such as comprehensive documentation and user support, are available to support model users and the broader community.

1-2 Could you highlight critical strategies from around the world that stand out and share insights on how they align or diverge from ECCC's approach?

Critical Strategies from Around the World and Insights for ECCC's Approach:

- **Training Students**
  Develop a structured pipeline for training energy modellers within academia, bridging the gap between academic and private sector modelling.
- **Energy Modelling Hub**
  Establish an energy modelling hub to train modellers for government and industry, fostering the development of modellers.
- **Explicit Representation of Non-CO_2**
  Include explicit representation of non-CO_2 emissions in modelling to analyze climate strategies comprehensively.
- **Price Sensitivity Analysis**
  Incorporate price sensitivity analysis, such as oil prices, in LTS to assess its impact on energy transitions.
- **Handling Expectations and Uncertainty**
  Address expectations and uncertainties in modelling, considering forward-looking versus recursive dynamic approaches.

- **Machine Learning Exploration**
  Explore using machine learning models for faster results and reduced computational costs.
- **Industrial Policies vs. GHG Policies**
  Distinguish between industrial policies and greenhouse gas (GHG) policies in modelling, recognizing that models may not be suitable for industrial strategy policy assessment.
- **Collaboration with Academia**
  Foster collaboration between government and academic institutions to train students, develop models, and bring creativity into energy modelling.
- **Involvement of Engineering**
  Include engineering perspectives in energy modelling to enhance its comprehensiveness.
- **Dimensions to Consider**
  Evaluate which institutes should be involved in academic-government partnerships for model development and training.
- **Non-Universality of Experience**
  Recognize that the unique characteristics of academia in Canada can facilitate successful collaboration between academia and government, but this experience may only be partially replicable.

1-3 In light of the current ECCC approach, what specific limitations or challenges have you identified? How can ECCC overcome the constraints in implementing these long-term modelling approaches?

Limitations and Challenges of ECCC's Long-Term Modelling Approach and Potential Solutions:

- **Restricted Data Access:**
  The StatsCan data, which is privileged, limits public access to critical data, hindering transparency and analysis. Potential solution: Address data access issues and consider making relevant data more accessible to the public.
- **Data Standardization:**
  The lack of standardized data across sources challenges ensuring consistency in modelling efforts. Solution: Collaborate with data providers and coordinate efforts to establish common data formats and practices.
  The lack of a standard data format among different sources, provinces, and internationally can complicate data integration. Solution: Promote a coordinated effort, possibly led by StatsCan, to establish standard data formats and ensure timely data release.
- **Sensitivity Analyses**
  The absence of sensitivity analyses, possibly due to time constraints, limits the comprehensive exploration of scenarios. Solution: Allocate resources and time for conducting sensitivity analyses to improve the robustness of modelling results.

- **Collaboration with Other Modelling Communities**
  Engaging with other modelling communities, such as optimization modelling, can offer valuable insights and approaches. Solution: To enhance practices and foster collaboration and knowledge exchange between different modelling communities.
- **Validation of Model Logic**
  Ensuring the accuracy and reliability of model logic is crucial for meaningful results. Solution: Implement rigorous validation processes to verify the logic and assumptions underlying the models.
- **Solving Time**
  Long solving times for complex models can be a constraint. Solution: Consider the time required to solve models and optimize computational efficiency.
- **Data Publication**
  The limited publication of distinct scenarios similar to other studies can impact transparency and knowledge sharing. Solution: Consider publishing and sharing modelling scenarios to facilitate broader understanding and discussions.
- **Collaboration with the Community**
  Greater collaboration with the modelling community can help address limitations. Solution: Foster collaboration and open-source initiatives to leverage collective expertise and resources.
- **Licensing Constraints**
  Rigidity in data licenses and restrictions on certain data types can hinder modelling efforts. Solution: Address licensing issues and explore flexible data usage agreements to facilitate modelling.

RECOMMENDATIONS

In this section of the report, we encapsulate the key recommendations garnered from the presentations, Q&A, and interactive discussions. These recommendations reflect the collective insights and suggestions aimed at advancing Canada's Long-Term Strategy (LTS) modelling and scenario analysis. They serve as a roadmap for addressing identified challenges and leveraging global best practices to foster a robust, informed approach towards achieving net-zero emissions.

Diverse Use of Models and Scenario Variability:

- Avoid reliance on a single model for all scenarios.
- Incorporate broader scenarios for a more comprehensive analysis.

Carbon Capture and Storage (CCS) and Practical Application:

- Explore alternative CCS sources, like Land Use, Land Use Change, and Forestry (LULUCF).
- Directly apply models to answer practical questions, providing actionable recommendations.

Probabilistic Analysis and Open Source Models:

- Consider, where feasible, using probabilities in scenario analysis to reflect realistic uncertainty.
- Embrace transparency and open-source models to enhance credibility.

Collaboration and Resource Availability:

- Explore opportunities for collaboration with the U.S. Energy Information Administration (EIA) and academia.
- Ensure comprehensive documentation and user support are available.

Canadian-based Energy Modelling Forum

- Consideration of forming a scenario modelling forum highlighting energy and climate-related issues with a particular focus on Canada.

Critical Strategies from Around the World and Insights:

- Develop a structured pipeline for training energy modellers.
- Establish an energy modelling hub for training.
- Include explicit representation of non-CO_2 emissions.
- Incorporate price sensitivity analysis in LTS.
- Address expectations and uncertainties in modelling.
- Explore machine learning models for faster results.
- Foster collaboration between government and academia.
- Include engineering perspectives in energy modelling.
- Evaluate academic-government partnerships for model development and training.

Limitations, Challenges and Potential Solutions:

- Address data access issues and make data more accessible.
- Collaborate to establish common data formats and practices.
- Allocate resources and time for sensitivity analyses.
- Enhance collaboration and knowledge exchange with other modelling communities.
- Implement rigorous validation processes.
- Optimize computational efficiency to reduce solving time.
- Publish and share modelling scenarios for transparency.
- Foster collaboration with the modelling community.
- Promote standard data formats and timely data release.
- Address licensing issues for flexible data usage agreements.

Guidance for Advancing Canadian Energy Modelling and Climate Policies:

- Continue emphasizing sector-specific considerations in energy modelling.
- Ensure results align with other institutions and validate against realistic data.
- Provide granular insights for sector-specific details.
- Integrate emerging technologies into energy models.
- Consider multiple pathways to achieve net-zero emissions.
- Recognize the interconnected nature of climate and energy policies.
- Extend energy modelling to inform climate policies.
- Balance regional and global modelling approaches.
- Address affordability concerns in climate and energy policies.
- Improve uncertainty handling in energy models.
- Engage in collaborative opportunities and workshops to enhance modelling capabilities.

SESSION 2: NET-ZERO MODELLING APPROACHES - INTERNATIONAL AND CANADIAN PRACTICES

In this second section of the summary report, we delve into the outcomes of Session 2 titled 'Net-Zero Modelling Approaches - International and Canadian Practices'. This session spotlighted the robust discussions and presentations from esteemed professionals in the field. Mike Beale, a former Assistant Deputy Minister at ECCC, initiated the session by elucidating the findings from the Independent Modelling Review on ECCC's long-term suite of models. Following this, a cadre of ECCC experts, Diego Vannucci Chiappori, Eric Stewart, and Alexandre Larivée, delineated the functionalities and frameworks of GCAM Canada, EC-MSMR, and EC-IAM models respectively, offering a deep dive into the long-term models utilized by ECCC. Post a brief interlude, Dave Sawyer from the Canadian Climate Institute illuminated the requisites for bolstering Canada's Net-Zero Act, emphasizing on the Canadian Net-Zero Modelling Approach.

CONFERENCE 2.1

Mike Beale, Former Environment and Climate Change Canada

Link to presentation

Mike Beale discussed the Independent Modelling Review Report on Consultations, which responded to the Government's commitment in the Environmental and Regulatory Programs (ERP) released in March 2022 to improve transparency in its modelling approach and to inform the modelling to be included in the 2023 Progress Report. The Boothe consultations and report were crucial, featuring interviews with various stakeholders. The report highlighted the strength of ECCC's current modelling but called for improvements in transparency, peer review, and external engagement. It also stressed the importance of analyzing 2050 net-zero trajectories and «what if» scenarios.

To address these findings, ECCC proposed an Action Plan based on the Boothe Report and NZAB's first annual report, focusing on transparency, external engagement, modelling refinement, and net-zero modelling. Phase 2 consultations involved a broader group of external modellers who admired ECCC's modelling team. Concerns were raised about the aging Energy2020 model and transparency issues. Recommendations included publishing detailed model documentation and code for Energy2020, offering more modelling detail and addressing uncertainties, considering net-zero model enhancements, creating a Canadian version of the Stanford Energy Modelling Forum (EMF), and establishing a peer review process for ECCC's modelling.

The remaining questions included differentiating net-zero modelling from short-term models, integrating net-zero modelling with policy, and incorporating user perspectives. The recurring themes of transparency and peer review were prominent, emphasizing the alignment of modelling efforts with policy for increased credibility and accountability of ECCC's climate policies.

QUESTIONS AND ANSWERS SESSION 2.1

- **Transparency in modelling, given the confidentiality of data:**
  - The discussion involved weighing the value of transparency against the confidentiality of data.
  - Striking a balance between these principles is essential. Frustration arising from the lack of understanding of results derived from confidential data is valid.
- **Energy2020 open source:**
  - The decision to make Energy2020 open source will be based on consultation with the model developer.
  - There is recognition that all models have the potential to benefit from open sourcing, which may be considered in the future.
- **Alignment of Short-Term and Long-Term Modelling:**
  - Aligning short-term and long-term modelling is essential to ensure long-term work has policy-relevant impacts and is connected to short-term efforts.
  - Short-term modelling primarily serves the purpose of validation, while long-term modelling focuses on optimization.

CONFERENCE 2.2

Diego Vannuci Chiappori, Environment and Climate Change Canada

Link to presentation

Diego Vannucci Chiappori provided an overview of the GCAM-CANADA model, a versatile and widely utilized environmental and energy modelling tool. This open-source and open-data community model is continuously developed and globally recognized, with governments, research organizations, and academic institutions employing it extensively. It was developed with the Pacific Northwest National Laboratory's Joint Global Change Research Institute.

Key attributes of the GCAM-CANADA model were highlighted, emphasizing its significance in environmental and energy modelling. Operating as a «recursive-dynamic» model within a partial equilibrium framework, it projects outcomes up to 2100 in 5-year intervals, covering various variables, including regions, energy sectors, agriculture, water resources, and climate-related emissions. This comprehensive model is integral to an integrated assessment model system, featuring data development components, component systems, dynamic integration, disaggregation methods, and climate model emulators.

The presentation underscored the model's strengths, such as its intricate representation of interconnected systems, including energy flows, water resources, agriculture, land use, and forestry. It allows for incorporating feedback mechanisms across these systems, making it a valuable decision-making tool for addressing complex environmental and energy challenges. However, it was acknowledged that the model operates as a partial equilibrium model with limited feedback mechanisms related to socio-economic impacts.

Future directions for GCAM include:

- Incorporating macroeconomic feedback.
- Enhancing industry and technology representation.
- Improving bilateral trade representation by commodity.

The presentation illustrated the integration of ECCC models, comparing GCAM with other models like EC-MSMR and EC-IAM, emphasizing the model's credibility and the ongoing enhancements to meet evolving requirements.

Overall, the presentation highlighted the extensive capabilities and applications of the GCAM-CANADA model in addressing climate and energy-related challenges, positioning it as a valuable open-source resource that supports decision-making processes and long-term strategies within Canada's environmental and regulatory programs.

QUESTIONS AND ANSWERS SESSION 2.2

During the Q&A session following the conference presentation, several questions and answers provided valuable insights into the GCAM-CANADA model and its applications:

- **Choice of GCAM Over Other IAM Models**
  - Mainly selected GCAM because it collaborated with the USA, which is beneficial for joint work.
- **Use of Provinces vs. National Model**
  - The model with provinces provides results that sum up to the same as the national version for Canada, ensuring consistency.
- **Model Capabilities**
  - GCAM-CANADA can simulate both pathways and policies.
  - The core GCAM model is available online, and efforts are underway to publish GCAM Canada, making everything accessible.
- **Provincial Disaggregation Benefits**
  - Disaggregating provinces allows for a finer representation, enabling the capture of policy impacts on individual provinces.
- **Land Needs for Biomass**
  - Land use is currently at the national level, but plans are to expand it to the provincial scale.
- **Maintaining Two Models**
  - Reasons for having both the national and provincial models were not explicitly mentioned, but they appear to be related to their specific use cases and research requirements.
- **Incidence of Policies on Provinces**
  - The benefit of provincial disaggregation is exemplified through its ability to capture how policies affect individual provinces.
- **Sharing Data and Model**
  - Efforts are being made to make all models open-source, intending to release GCAM Canada for public access.

CONFERENCE 2.3

Eric Stewart, Environment and Climate Change Canada

Link to presentation

Eric Stewart introduced the EC-MSMR model, which is short for Environment and Climate Change Canada's global multi-sector multi-region computable general equilibrium model. This model operates as a recursive-dynamic system, guided by three classic constraints: the zero profit condition, market clearing, and income balance. It relies on input-output tables for its structure and boasts extensive disaggregation, encompassing various sectors and technologies, including electricity, crude oil, bitumen, and heavy oil. Additionally, EC-MSMR incorporates the concept of backstop fuel substitution, allowing for different energy sources due to price fluctuations and technological advancements.

EC-MSMR's notable strength is its capacity to effectively capture both the direct and indirect impacts of energy and environmental policies, making it a versatile tool for analyzing various policy packages. However, it has certain limitations, such as the absence of regional granularity, as it predominantly operates at a national level and doesn't adopt a bottom-up approach.

In the context of Canada's efforts to reduce greenhouse gas emissions in the mid-century and long term, EC-MSMR plays a pivotal role in assessing how different sectors affect emissions and energy use. It is part of a suite of models, including GCAM Canada and EC-IAM, which collectively consider assumptions about GHG emissions reductions for the G20 countries.

Key insights from the modelling efforts include a shift towards electrification in industry, buildings, and transportation, a decrease in the use of fossil fuels, and an increased focus on electricity generation. The modelling also predicts changes in the supply and demand for oil and gas, with a projected decrease in the market share of Canadian oil supply. While global natural gas demand is anticipated to increase, the Canadian market share might decrease. Nevertheless, the model does have limitations, particularly in modelling novel industrial processes and the trade of non-energy goods.

In summary, EC-MSMR is a valuable tool for evaluating energy and environmental policies. It evolves to meet changing requirements and has detailed sectoral representations and region-specific features, making it a reliable research tool in climate and energy policies.

QUESTIONS AND ANSWERS SESSION 2.3

- **Provincial data**
  - EC-MSMR operates internationally, making it more suitable to use national data.
- **EC-MSMR compared to Energy2020 in terms of output**
  - Different models have different philosophies, so running the same scenario in Energy2020 and EC-MSMR would yield varying results.
- **Incorporating the total use of biomass**
  - The inclusion of biomass varies across models, and in EC-MSMR, it's present in the agricultural sector.
- **Behavioural changes**
  - Behavioural changes are not deeply examined, but the models rely on existing literature for cost assessment.

- **Uncertainties in the models and probabilistic approach**
  - Integrated assessment models like EC-MSMR work with assumptions based on the available literature, and a probabilistic approach is computationally demanding and less common at a large scale.
- **Hydrogen, substitution for fossil fuels, and its transport cost**
  - Hydrogen is considered a substitution, but transport costs for hydrogen are not accounted for yet.
- **Limitations**
  - Access to provincial-level trade data is a significant limitation, and the model struggles with large differences between regions.

CONFERENCE 2.4

Alexandre Larrivée, Environment and Climate Change Canada

Link to presentation

Alexandre Larrivée introduced the Environment Canada Integrated Assessment Model (EC-IAM). This international model is a forward-looking tool operating in 5-year intervals and projecting until 2100. Its primary objective is to optimize the utility of consumption over the long term, combining a «top-down» approach for macroeconomic activities with a «bottom-up» approach for energy technologies.

With coverage spanning 15 regions globally, EC-IAM provides extensive support for Canadian decision-making in energy and greenhouse gas (GHG) reduction policies. Its contributions to Canada's long-term strategy study offer a range of pathways to achieve Net Zero by 2050. EC-IAM also delves into assessing the social cost of GHGs, incorporating CO_2, CH_4, and N_2O into its analyses.

While EC-IAM is a valuable resource, it does face certain limitations, such as the absence of detailed economic sector information, non-representation of non-energy commodities, and a lack of technology details in fossil fuel sectors. To address these issues, strategies for enhancement include the introduction of more economics by sector, revisiting the hotelling module, and improving the representation of fossil fuel sectors.

The model's structure consists of an economy and energy modules encompassing primary energy production, transformation, final energy demand, and emissions projections. It calculates emissions for seven GHGs, focusing on energy-related emissions, abatement strategies, and direct air capture. EC-IAM incorporates the FAIR model to facilitate climate assessments, and its damage functions are based on the Meta-Analysis Approach.

Compared to other models like EC-MSMR and GCAM, EC-IAM offers unique features, especially in its sector and region-specific representations, focusing on CO_2 and non-CO_2 gases. However, its equilibrium approach, foresight, technology choice modelling, spatial aggregation, sectoral coverage, and base years differ. The electric sector representation includes 14 technologies, and the model covers buildings, commercial, residential, and industry representations, providing various carbon management options.

EC-IAM remains crucial for Canada's environmental and energy policy planning despite its strengths and limitations. It has played a significant role in policy studies and strategies, positioning itself as a valuable asset for policymakers and researchers working toward Canada's Net Zero goals.

QUESTIONS AND ANSWERS SESSION 2.4

The questions in the Q&A session can be categorized into several themes:

- **Concerns about Underestimating the Cost of Climate Change**
    - Some participants expressed concerns about whether EC-IAM underestimates the cost of climate change.
    - The response indicates that while there may be concerns, the Social Cost of Carbon (SCC) input in EC-IAM has increased the impact of climate change by 2-3 times compared to earlier versions.
- **Relevance of EC-IAM for Canada**
    - Participants question the relevance of using EC-IAM for Canada, given its unique perspective that includes a forward-looking approach and focuses on damages.
    - The response clarifies that EC-IAM is a research tool and offers a different perspective.
- **Modelling Consumer Preferences**
    - Questions are raised about how consumer preferences are modelled in EC-IAM.
    - The answer states that consumer preferences are modelled by implementing a factor to represent them.
- **General Underestimation of the Cost of Climate Change**
    - Participants ask if Integrated Assessment Models Consortium (IAMC) models generally underestimate the cost of climate change.
    - The response notes that the equation used in EC-IAM is 2-3 times higher than in previous versions.
- **Relevance of EC-IAM for Canada's GHG Emissions**
    - Questions are posed about the relevance of EC-IAM for Canada since the country is not a major contributor to greenhouse gas (GHG) emissions.
    - The response explains that EC-IAM differs from other models and adds feedback on damages resulting from climate change, making it valuable for Canada.
- **Social Cost of Greenhouse Gas Emissions**
    - Participants inquire about the social cost of greenhouse gas emissions.
    - The answer mentions that the damages are estimated using the Howard and Sterner equation, similar to the U.S. Environmental Protection Agency (EPA).
- **Reexamining the Social Discount Rate**
    - The discussion briefly touches on reexamining the social discount rate.
    - The response indicates that a 2% discount rate is currently used, and there is flexibility for a range of discount rates.
- **Evaluation of Consumer Preferences and Technology Sensitivity**
    - Participants refer to Navius research and how the model evaluates consumer preferences.
    - Additionally, there's a mention of input from Normand's study and its association with sensitivity to technologies.

CONFERENCE 2.5

Dave Sawyer, Principal economist at the Canadian Climate Institute, consultant at EnviroEconomics Inc and University Lecturer at the University of Ottawa

Link to presentation

Dave Sawyer delved into the complexities of greenhouse gas (GHG) policy modelling in Canada. He emphasized the pivotal role of models in shaping GHG policies and their high stakes. The growing demand for stocktaking in Canada regarding GHG policies is multifaceted, requiring impact analysis across regions, sub-sectors, technologies, and international reporting. It also calls for independent audits and third-party reviews to ensure accountability.

Sawyer highlighted the considerable influence of modelling on political decisions and policy development. While acknowledging strong support for GHG policies, he cautioned against unwavering reliance on models, humorously comparing them to «Harry Potter modelling» with whimsical incantations.

The presentation delved into the limitations and uncertainties associated with emission projections. Notably, only three out of nine projections for 2020 were accurate, indicating substantial modelling uncertainties, particularly in long-term projections. Sawyer also highlighted the challenges of forecasting emissions in the upstream oil and gas sector, which exhibit significant variability.

A central theme was the dynamic nature of emission drivers across sectors and regions. Sawyer emphasized the need for sensitivity and uncertainty analyses to provide bounds for GHG projections.

Key takeaways include the necessity for stress-testing scenarios to account for uncertainty and the importance of governance in addressing uncertainty and setting realistic targets. The presentation called for a sector-by-sector approach and establishing a formalized Canadian Emissions Modelling Forum to enhance modelling comparison, improvement, and external review.

In conclusion, Dave Sawyer's presentation underscored the intricate nature of GHG policy modelling and the need for comprehensive policy assessment, balancing modelling insights with practical considerations. This holistic approach calls for continuous evaluation and adaptation to ensure the effectiveness of GHG policies in Canada.

QUESTIONS AND ANSWERS SESSION 2.5

In this Q&A section, two key themes emerge.

- **Policy Implementation**
  - There is concern about the limited implementation of policies and the absence of detailed plans for achieving Net Zero objectives in some provinces.
  - Questions are raised about specific provincial policies, such as incentives for electric vehicles (EVs) in Ontario, which have yet to be introduced.
  - A participant points out the need for sector-specific plans to work toward policy goals and notes a comprehensive assessment of the risks associated with not meeting targets.
  - While there's optimism about policy effectiveness, some participants feel that more on-the-ground action is needed to reach 2030 targets.

- **Tracking Progress and Robustness of Policy**
  - Participants ask how it can be determined whether policies are responsible for GHG reductions and if we are indeed on track.
  - There's an acknowledgment of the risk involved, but the modelling suggests progress. The overall policy package is viewed as robust.
  - Despite progress, some participants expressed the need for a more comprehensive Emissions Reduction Plan (ERP) and assessment of its underlying assumptions. However, it's noted that there has been substantial federal-level activity, even though the provincial situation remains patchy.

TAKEAWAY MESSAGE

The key takeaway from Session 2 can be regrouped into 8 themes:

1- **Modelling and Transparency:**
  - Transparency in modelling is crucial, even when dealing with confidential data.
  - Open-sourcing models like Energy2020 can improve transparency and may be considered for other models in the future.
  - Striking a balance between transparency and data confidentiality is essential.

2- **Model Alignment and Integration:**
  - Aligning short-term and long-term modelling ensures that long-term work translates into policy-relevant impacts.
  - Short-term modelling primarily serves the purpose of validation, while long-term modelling focuses on optimization.

3- **GCAM-CANADA Model:**
  - GCAM-CANADA is a versatile open-source model used globally and offers sector-specific representations.
  - Provinces are a suitable level of disaggregation, and this level ensures consistency with the national version.
  - The model can simulate pathways and policies, making it a valuable tool.
  - Efforts are being made to make GCAM Canada open source.

4- **EC-MSMR Model:**
  - EC-MSMR's focus on an international scale makes it more suitable to use national data.
  - Different models have distinct philosophies, leading to varied results when running the exact scenarios.
  - The model must work on significant regional differences and lags in providing a provincial-level trade dataset.

5- EC-IAM Model:

- EC-IAM offers a unique perspective with its forward-looking approach and focus on damages.
- The Social Cost of Carbon (SCC) input in EC-IAM increases the impact of climate change by 2-3 times.
- EC-IAM differs from other models and provides valuable insights into Canada's climate policies.
- The model does not provide deep insights into consumer preferences but relies on existing literature for cost assessment.
- The model has flexibility in choosing a range of discount rates, and a 2% discount rate is currently used.

6- Comprehensive Policy Implementation:

- Concerns exist about the limited policy implementation and a need for detailed plans in some provinces.
- There are questions about specific provincial policies, like EV incentives in Ontario.
- Calls for sector-specific plans and a comprehensive risk assessment are made.
- While there is optimism about policy effectiveness, more on-the-ground actions are perceived as necessary to reach 2030 targets.

7- Policy Tracking and Robustness:

- Participants question how it can be determined whether policies are genuinely responsible for GHG reductions and if Canada is on track.
- Acknowledging the risk is coupled with modelling suggesting progress, and the overall policy package is considered robust.
- Concerns about the need for a comprehensive Emissions Reduction Plan (ERP) and overly optimistic assumptions are raised, but federal-level activity is noted.

8- Modelling's Role and Complexity:

- Modelling is pivotal in shaping GHG policies and necessitates comprehensive policy assessment.
- The complex and dynamic nature of emission drivers across sectors and regions requires sensitivity and uncertainty analyses.
- Establishing a formalized Canadian Emissions Modelling Forum is emphasized for modelling comparison, improvement, and external review.
- Balancing modelling insights with practical considerations is vital to ensure effective GHG policies in Canada.

INTERACTIVE SESSION

In the second interactive session, the EMH facilitated a discussion among attendees around three pivotal questions:

2-1 Could you provide specific comments or insights on the design and functionality of the presented ECCC models?

Inclusion of Canada in IAM Models:

- Participants discussed whether it's worthwhile to include Canada in Integrated Assessment Models (IAM), considering its relatively low emissions on a global scale.
- It was acknowledged that Canada can provide valuable insights through IAM models even as a smaller emitter.

Trade-Off Between Models:

- There was a debate about the trade-off between using numerous models versus finding a single, comprehensive model.
- Some participants believed a provincial model with multiple technologies could be viable.
- Finding a single model is challenging, and it's crucial to address decarbonizing electricity and transitioning services from fossil fuels to electricity.

Integration of Multiple Models:

- Integrating multiple models into a single, comprehensive model was discussed as a significant challenge.

Need for a Universal Model:

- There was a desire to have a universally accepted «everything model,» but it was recognized that reaching a consensus on what such a model should entail is difficult.

Limitations of Existing Models:

- Concerns were raised about what might be missing from the existing models, particularly related to technology-focused aspects.
- Participants expressed the need for more detailed models, focusing on potential behavioural changes and urban redesign, especially concerning densification.

Behavioural Changes:

- The topic of behavioural changes and their implementation in models, particularly GCAM, was mentioned.
- There was a consensus that models should not be solely technology-based and should also consider behavioural changes.

Comparing Models:

- Discuss why a particular model, such as GCAM, was chosen over other options. The importance of multiple models with different economic philosophies was emphasized.

Use of Models as Guides:

- It was highlighted that models are not definitive answers but guides for decision-making.

Adapting Models for Industries:

- In industries where perfect competition is not a realistic assumption, returns to capital can be adjusted to represent profit more accurately.

Continuity of Insights:

- The challenge of providing insights to the government while potentially building a new model for the next 1-3 years was raised. Participants explored how to ensure policy insights in the meantime.

Regional/Provincial Modelling:

- There was a suggestion that regional or provincial modelling would be a valuable addition to enhance precision.

Technological Aspects in Energy Models:

- Questions were posed regarding the depth of technological aspects in energy models. It was noted that the previous model was characterized as technology-rich, while EC-IAM is not.

Trade-Off Between the Number of Models and Staffing:

- Participants discussed the trade-off between the number of models and the available staffing resources. The idea of creating a model that can perform various tasks was considered.

Elasticities and Structural Change:

- Elasticities to model net zero were questioned, particularly regarding whether they are suitable for capturing the structural changes required for net-zero emissions.

Consideration of User Needs:

- Understanding users' needs and the intended use of model outputs was highlighted. Models should be used with other areas of expertise, such as economics and engineering studies, to maximize their value.

Limitations and Missing Technologies:

- It was mentioned that the models have limitations, primarily related to the technologies they include based on their mandates.
- There was a call to consider non-linear technological adoption, especially given that cost curves for various technologies have differed from expectations.
- The transition to an hourly framework was suggested for electrification-related modelling.

2-2 In the context of international comparisons, how do ECCC's models stack up against other global models used for net-zero scenarios?

Maintaining multiple models at ECCC with a small team

- Suggestion: Consider a «model to rule all models.»
- Resource constraints in ECCC favour a suite of models.
- All models have limitations, but some are useful for specific questions.
- Weigh the idea of having one comprehensive model.
- Focus on decarbonizing electricity for net zero modelling.

Models' ability to handle local behavioural aspects

- Models can't handle local behaviours.
- Consider developing additional models to address specific issues.
- Need more sector-specific details to understand pathways and impacts.

Elasticities in models

- Elasticities may vary across communities.
- High-level assumptions are necessary.
- Calibration based on historical data may not inform the future.

Considering alternative models besides CGE

- CGE models are useful for exploring unexpected interaction effects.
- Consider linking with other models like electricity dispatch models.

Need for a follow-up workshop on long-term policy for net zero

- Assess how well current models reflect policies.
- Response: «Stay tuned.»

2-3 Considering the complexity of net-zero modelling, what tools and resources do you believe are essential for successful modelling endeavors? Are there any critical requirements or best practices that should be emphasized?

Emphasis on Results Utilization

- The results from models should serve as inputs for policymaking and other areas of expertise.
- Consider the role of stakeholders when using models.

Consideration of End User Needs

- Determine the specific results end users require from the models.
- Collaborate with end users to understand their data needs.

Expanding Toolset Beyond General Equilibrium Models

- Explore ways to incorporate other tools into modelling efforts.
- Suggestion to link general equilibrium models with capacity expansion and planning models.

Variability in Economic Models

- Acknowledge that not all models are general equilibrium models.
- Some models have high-level economic assumptions.

Integration of Different Types of Models

- Models can be linked to enhance modelling capabilities.

RECOMMENDATIONS

The key recommendations from session 2 are listed below and underscore the necessity for transparency, model alignment, and addressing existing limitations in energy modelling.

Transparency and Open Sourcing

- Make efforts to enhance transparency in energy modelling, especially when dealing with confidential data.
- Consider open-sourcing models like Energy2020 to improve transparency and make them accessible for public scrutiny.

Model Alignment and Integration

- Emphasize the importance of aligning short-term and long-term modelling to ensure long-term efforts have real-world impacts.
- Recognize the value of having multiple models with different economic philosophies to address various aspects of energy modelling.

Addressing Limitations and Enhancements

- Acknowledge that all models have limitations but can be useful for specific questions. Consider the limitations of existing models and find ways to address them.
- Explore the need for more detailed models, particularly focusing on potential behavioural changes and urban redesign related to densification.
- Enhance models to consider non-linear technological adoption and unexpected interaction effects.

User Needs and Collaboration

- Understand end users' specific needs and collaborate with them to ensure that models provide the necessary data.
- Collaborate with experts from various fields, such as economics and engineering, to maximize the value of the models.

Model Integration and Comprehensive Approach

- Consider linking different models to enhance modelling capabilities and address specific issues.
- Evaluate the potential for creating a comprehensive «model to rule all models» that can handle various tasks.

Sector-Specific Modelling

- Explore the use of regional or provincial models to enhance precision, especially in areas with specific sectoral requirements.

Elasticities and Structural Change

- Address the challenge of modelling structural changes required for net-zero emissions, considering the variations in elasticities across communities.

Integration of Alternative Models

- Consider using models other than CGE models, exploring their interactions with electricity dispatch models and other tools.

Follow-Up Workshop on Long-Term Policy

- Plan for a follow-up workshop to examine long-term policies for achieving net-zero emissions and assess how well existing models reflect these policies.

DAY TWO – SEPTEMBER 21, 2023

SESSION 3: ASSESSING ECCC'S MODELLING TOOLS – IMPROVEMENT VS. NEW DEVELOPMENT

In this segment of our report, we delve into the discussions and insights shared during Session 3, titled «Assessing ECCC's Modelling Tools - Improvement vs. New Development.» The session kicked off with a recap from Day 1 by Nick Macaluso from ECCC, followed by presentations on various modelling tools and approaches. Samuel Forget Lord from ECCC introduced us to Environment Canada's Forward-Looking Provincial Model (EC-Pro). Subsequently, Allen A. Fawcett, Ph.D., from the U.S. Environmental Protection Agency, enlightened us with a multi-model analysis of the Inflation Reduction Act using 10 economy-wide models, including GCAM, and discussed net-zero modelling work done in the LTS context. Rounding off the session, Dr. Madeleine McPherson from the University of Victoria shared her perspectives on the tools and methodologies vital for successful net-zero modelling.

CONFERENCE 3.1

Samuel Forget Lord, Environment and Climate Change Canada

Link to presentation

Samuel Forget Lord introduced EC-PRO Version 2, a comprehensive model developed by the quantitative research division of Environment and Climate Change Canada. This model is designed for analyzing domestic climate policies in Canada and boasts a wide range of features. It covers up to 50 industries and three final demand categories across all 13 Canadian provinces and territories, drawing on the most recent data from Statistics Canada and the Energy, Emissions, and Economy Model for Canada (E3MC) for calibration.

EC-PRO uses flexible, functional forms to describe production and consumption, assuming competitive markets with profit-maximizing producers and utility-maximizing consumers. While primary factors remain immobile across regions, labour is flexible within them, and capital allocation is based on rates of return. The model employs myopic expectations and a recursive-dynamic approach to problem-solving.

A key feature of EC-PRO is its detailed approach to electric power supply, differentiating between various discrete generation technologies. The model links fossil fuel-related CO_2 and non-CO_2 emissions to fossil fuel use and offers mechanisms for emissions abatement, including fuel switching, efficiency improvements, and backstop technologies.

EC-PRO's strengths lie in its integrated approach to modelling the economy, energy, and emissions, making it suitable for assessing the impacts of various energy and environmental policies. It can evaluate the effects on industries and households across all Canadian provinces and territories and compare the cost-effectiveness of different policy proposals, from command-and-control regulations to market-based approaches like carbon taxes and emissions cap-and-trade systems.

However, there are limitations, such as baseline calibration to an exogenous reference scenario, potentially leading to economic inconsistencies. The model's recursive-dynamic structure based on myopic expectations is less suited for studying the long-term financial adjustments needed for achieving net-zero emissions by 2050.

The presentation also highlighted the extensions made in EC-PRO Version 2 to address these limitations and improve its capacity to analyze net-zero climate policies. These extensions include a flexible baseline projection routine, a fully dynamic model with rational expectations, and a putty-clay version for assessing economic adjustment costs. The model now offers an enhanced representation of negative emissions technologies and electricity-based technologies for various applications.

In summary, EC-PRO Version 2 is a sophisticated and versatile model tailored for climate policy analysis in Canada. Its extensive features and recent improvements make it a valuable tool for assessing the impact of various policy scenarios on the Canadian economy while addressing the challenges of moving toward net-zero emissions.

QUESTIONS AND ANSWERS SESSION 3.1

- **Model Capabilities and Policies:**
  - The audience inquired about the model's ability to handle multiple policies simultaneously, and the response indicated that different markets within the model could accommodate various policies by setting targets or using proxies. This enables the model to address several policies concurrently.
- **Recursive Dynamics and Exogenous Scenarios:**
  - Questions arose about the model's recursive dynamics. It was clarified that the model uses supply-use tables as the base year, aligns with E3MC data, and reallocates capital each year based on the previous year's rate of return. The potential for introducing exogenous events or perturbations in the model was also discussed.
- **Transition to EVs and Carbon Removal Technologies:**
  - The transition from internal combustion engine (ICE) cars to electric vehicles (EVs) was addressed. The model handles this transition by adjusting the final demand for transport and freight to include EVs. Regarding carbon removal technologies, the model incorporates technologies like Direct Air Capture (DAC) and Carbon Capture and Storage (CCS), considering policy uncertainties and cost curves.
- **Comparison of Electricity Sources:**
  - A question was raised regarding the comparison of electricity sources, particularly intermittent sources like wind, with dispatchable sources like nuclear power. The model did not fully capture intermittency but attempted to represent storage capacity and curtailment.
- **Multiple Models vs. Single Model Approach:**
  - There was a discussion about whether to use multiple or single models. A multi-model approach could be helpful for complementary analysis, especially for profound decarbonization transitions, as different models have varying strengths. This approach might be precious for addressing transition risks in the macroeconomic context.
- **Policy Rollback and Durable Provisions:**
  - Questions were asked about potential policy changes and rollbacks in response to an administrative shift. It was noted that, as of that time, no major policy rollback had occurred, and many provisions were considered durable, with substantial financial commitments by states and local governments reducing the likelihood of rollbacks.

CONFERENCE 3.2

Allen Fawcett, U.S. Environmental Protection Agency

Link to presentation

Allen Fawcett's presentation focused on developing a comprehensive strategy to enable the United States to reach net-zero greenhouse gas (GHG) emissions by 2050. This ambitious objective aligns with the Nationally Determined Contributions (NDC) for 2050. To achieve the 2050 NDC goal, this presentation takes an analytical approach that explores various pathways.

The analytical framework draws upon two fundamental models: the National Energy Modelling System (OP-NEMS) and the Global Change Analysis Model (GCAM), in conjunction with sectoral models. These models investigate potential technological trajectories for crucial sectors like electricity, transportation, buildings, industry, and land. The presentation emphasizes that the strategy's primary goal is to evaluate diverse technology scenarios and their impacts rather than specifying specific policies.

The long-term strategy is designed to deliver a substantial 50-52% reduction in GHG emissions compared to 2005 levels by 2030, culminating in net-zero GHG emissions by 2050. These scenarios are deliberately varied, encompassing options such as balanced advancements, scenarios with lower emissions, high removal strategies, and accounting for variables like fluctuations in oil and gas prices, population growth, and GDP projections.

Notably, all the presented scenarios are aligned to achieve net-zero emissions. To complete the NDC target, there must be aggressive reductions in energy-based CO_2 and non-CO_2 emissions. This reduction effort is augmented by enhancing the role of land use as a GHG sink.

The conference presentation and the accompanying notes highlight that the most substantial reductions in CO_2 emissions are expected from the electricity sector, followed closely by the transportation sector. Furthermore, the presentation underscores advancements in primary energy efficiency and electrification, with a corresponding decline in fossil fuel use and a surge in renewable energy sources. The pivotal role of renewable capacity expansion, particularly in wind and solar energy, is emphasized, along with a measured reliance on fossil fuels with Carbon Capture and Storage (CCS) technology.

The presentation also emphasizes the interconnection with the Low Emission Electricity Program and its focus on the power sector, energy-related CO_2 emissions, and the specific provisions of the Inflation Reduction Act (IRA). The analysis hinges on a multi-model framework, incorporating sensitivity analysis and various models to examine the subject matter comprehensively. The findings acknowledge substantial reductions in emissions driven by the IRA but underscore the sensitivity to technology costs and deployment constraints.

The presentation delves into the complexities and limitations involved in achieving these goals, including the challenge of modelling cost dynamics, the need for further guidance on specific IRA provisions, barriers related to investment, and the exclusion of proposed policy measures. A comprehensive approach to environmental policies is considered essential. Finally, the presentation underscores the importance of cross-cutting funds and grants to facilitate GHG reduction and the transition to a net-zero economy. In summary, this presentation and the accompanying notes detail the United States' comprehensive, multifaceted strategy for deep decarbonization, elucidating various scenarios, the analytical approach, and the critical role of IRA provisions in achieving ambitious GHG reduction and net-zero emission objectives by 2050.

QUESTIONS AND ANSWERS SESSION 3.2

- **Integration of Multiple Models:**
  - Given its calibration to the existing economic structure, a question was raised about how the model handles longer-term scenarios. The response emphasized using multiple models to examine longer-term scenarios, providing a more comprehensive analysis.
- **Probability of Future Rollbacks:**
  - Concerns were expressed about potential rollbacks by future governments. The speaker clarified that while no probability for rollbacks is currently implemented, the likelihood of rollbacks is considered low, especially for the provisions in the Inflation Reduction Act (IRA). Congress gave reassurance regarding the durability of most IRA provisions, although only time will tell.
- **Single Model vs. Multiple Models:**
  - The topic of using one model versus multiple models was explored. In evaluating regulations, it was mentioned that a single model, such as the IRM model, is used for legal purposes. However, utilizing multiple models was advantageous for displaying a broader context of the IRA's provisions and their implications.
- **Resistance to Rollbacks:**
  - When asked about the possibility of rolling back IRA provisions, it was explained that it would be challenging, given the complexity and multiple features of the legislation. The financial support provided to states and local governments makes it less likely for these provisions to be rolled back.
- **Short-Term vs. Long-Term Assessments:**
  - A question regarding the preference for short-term versus long-term assessments was addressed. The response underscored the complementarity of these assessments. Short-term assessments help visualize immediate system changes, while long-term assessments offer insights into the overall pathways.
- **Integration of Multiple Models (Continued):**
  - The debate on whether to use one comprehensive model or multiple models was discussed again. The consensus was that both approaches could complement each other effectively. A single model is valuable for assessing deep decarbonization, while various models are beneficial for validating individual sub-systems.

CONFERENCE 3.3

Madeleine McPherson, University of Victoria

Link to presentation

Madeleine McPherson's conference presentation emphasized the need for comprehensive strategies and tools to achieve net-zero modelling. Net-zero emissions require a holistic approach that spans the entire economy, using multi-sector, multi-vector, and multi-scale modelling techniques. The core objective is to identify robust and internally consistent pathways, minimizing the risk of getting locked into specific scenarios, all while considering policy actions and their implementation.

Various essential tools and models for net-zero modelling were discussed, covering grid integration, power systems, energy systems, resilience, life cycle assessment, renewable energy, transportation, and social and behavioural aspects. These tools play a vital role in understanding the path towards net-zero emissions.

One key challenge highlighted was the use of various models, each designed with specific scopes in mind. The choice of models should depend on the particular issue, and integration between models is crucial, requiring data harmonization and interoperability.

The importance of a holistic perspective was stressed, involving an integrated modelling approach that spans different systems, scales, and vectors. This approach should be adaptable and extensible, accommodating various model formulations.

To address the need for robust and consistent pathways, the conference tackled challenges like defining net zero, managing uncertainties, and dealing with non-linear socio-political aspects. Strategies for identifying practical solutions across different economic dimensions include stress-testing scenarios, comparing multiple models, and coordinating across various model types.

Taking action and implementing policies were also emphasized, involving stakeholder engagement, mediated modelling, and collaborative working groups. Learning from other institutions and using open-source tools were highlighted to expedite progress. Building capacity to address existing and future knowledge gaps was crucial.

In conclusion, McPherson's presentation outlined a holistic approach for moving towards net-zero emissions, involving the entire economy and demanding robust pathways, timely actions, and an integrated process that includes stakeholder engagement, collaboration, transparency, and resilience. The presentation provided a comprehensive perspective on the journey towards net-zero emissions.

QUESTIONS AND ANSWERS SESSION 3.3

- **Utility Engagement:**
  - A question arose about increasing engagement with power operators and utility regulators across Canada. The speaker confirmed that EMH has yet to look into this but expressed their willingness to explore it in the future.
- **Engaging Utilities and Regulators:**
  - The engagement of utility regulators was discussed, with comments indicating that there have been some discussions with utilities, but resource constraints have limited these interactions. However, it was acknowledged that greater engagement is essential and should be explored.
- **Model Robustness Efforts:**
  - A question was raised about where efforts should be made regarding model robustness. It was suggested that robustness be defined in various dimensions, including inputs, pathways, and models.
  - Addressing uncertainties and the modelling of robustness were also discussed. Stochastic modelling and multi-stage uncertainty were mentioned as tools to handle uncertainties. Demonstrating the validity of a model can be challenging but was encouraged through multi-model comparison workshops, where standard inputs are used to compare results and identify areas of inconsistency between models.

TAKEAWAY MESSAGES

The key takeaway from Session 3 are as followed:

1. **Model Development and Improvement:**
   - EC-PRO Version 2 is a comprehensive model designed for analyzing domestic climate policies in Canada.
   - The model's strengths lie in its integrated approach to modelling the economy, energy, and emissions, making it suitable for assessing the impacts of various energy and environmental policies.
   - The model can evaluate the effects on industries and households across all Canadian provinces and territories.
   - It has been extended to address limitations, including baseline calibration and challenges in studying long-term financial adjustments for net-zero emissions.
   - Improvements include flexible baseline projections, rational expectations, and enhanced representations of harmful emissions and electricity-based technologies.
2. **Deep Decarbonization Strategy:**
   - Various scenarios and pathways are explored, targeting a substantial 50-52% reduction in GHG emissions by 2030.
   - Key sectors targeted for reductions are electricity and transportation.
   - The strategy considers fluctuations in oil and gas prices, population growth, and GDP projections.

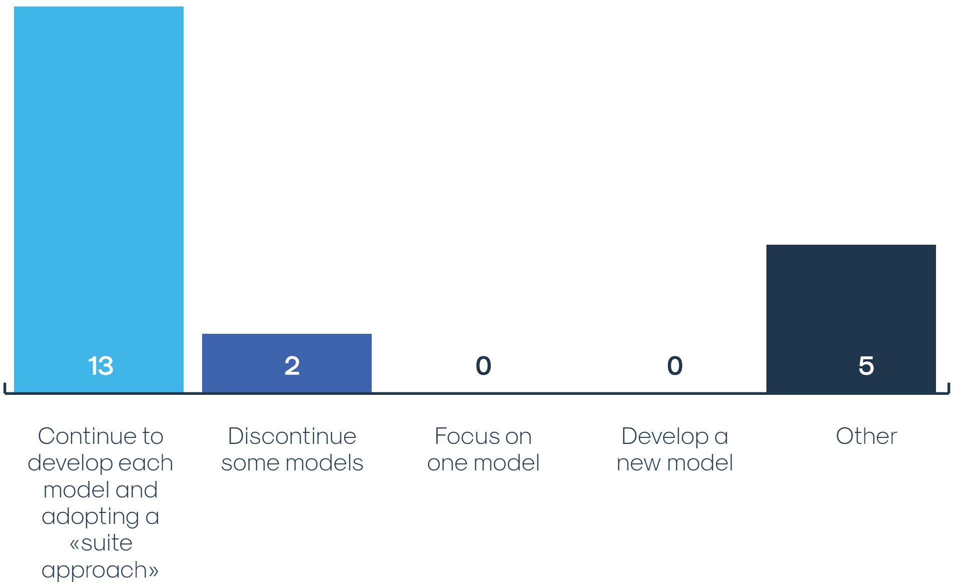
- A multi-model framework, sensitivity analysis, and IRA provisions are used to evaluate the strategy's impact.
- Achieving these goals involves complex modelling of cost dynamics, policy guidance, investment barriers, and comprehensive environmental policies.
- Cross-cutting funds and grants are essential to facilitate GHG reduction and the transition to a net-zero economy.

3. **Net-Zero Modelling Strategies:**
    - Achieving net-zero emissions demands a holistic, adaptable, and integrated modelling approach.
    - Various tools and models play crucial roles in understanding the path to net-zero emissions, covering grid integration, energy systems, resilience, and more.
    - Challenges include integrating models designed with specific scopes and managing uncertainties.
    - Stress-testing scenarios, comparing multiple models, and stakeholder engagement are essential to identify robust solutions across economic dimensions.
    - Open-source tools, learning from other institutions, and building capacity are valuable for accelerating progress.
    - Demonstrating model robustness can be achieved through multi-model assessment workshops.
    - Engaging power operators and utility regulators is essential and should be explored for greater involvement.
    - Enhancements to model robustness should be multi-dimensional, addressing inputs, pathways, and models.
    - The adoption of stochastic modelling and multi-stage uncertainty can help handle uncertainties effectively.

INTERACTIVE SESSION

In the first interactive session of Day 2, the EMH orchestrated a dialogue among attendees centered around five important questions. Some of the feedback captured via an online pooling tool is presented below, followed by a summary of the discussion.

3-1 In regard to ECCC modelling approach, please provide your opinion on the following options. Should ECCC ...



3-2 Please rank the following list of development priorities for our suite models

- **1st** Linking alternative/green technologies to themacroeconomic structure (e.g. supply and use tables for Canada or GATP Internationally.
- **2nd** A more discrete/detailed representation of technologies for specific processes in key sectors.
- **3rd** CGE provincial-territorial model that is linked to International trade and has Flexible baselise projection routine time treatment and capital malleab
- **4th** Enhancing the bilateral trade by commodities at resource and other level of supply chain (e.g. energy exports to all the world and not just the US)
- **5th** Electricity dispatch
- **6th** Introduce detailed household information in economic dynamics

During the workshop, participants engaged in thoughtful discussions, addressing a trio of pivotal questions that converged to shape the future trajectory of Environment and Climate Change Canada's (ECCC) modelling endeavours. Here are the three questions:

3-3 What other model enhancements or developments should be the ECCC focus?

3-4 What are your recommendations to ensure that the models provide information that is useful to users?

3-5 Moving forward, what are the top 3 things/strategies ECCC should do to enhance the effectiveness and value of their modelling efforts?

SUMMARY OF THE DISCUSSION

Collaboration and Information Sharing:

- Collaborating with diverse modellers and groups is essential to gain more information.
- The challenge is bridging gaps between models that work differently, mainly for economic sectors with varying levels of disaggregation.
- Models need to communicate and share information outside of their specialized domains.
- More attention should be given to integrating the information and intelligence from other models into a collaborative effort.
- Expanding communication beyond modellers in energy economics is vital.
- Transparency in model details is essential to understand what's inside the models.

Model Development and Enhancement:

- The focus should be on continuously developing and improving existing models.
- Efforts should be directed toward creating an energy system model within ECCC.
- There should be capabilities to represent and analyze policies and policy interactions.
- Detailed representation of potential mitigation options for non-CO_2 emissions is essential.
- Supply chain considerations need to be integrated into the models.
- Model developers should work collaboratively with other model developers instead of creating new models from scratch.
- Reports should not only present results but also outline model limitations.

Model Interactions and Time Frames:

- Interaction between models can be time-consuming and depends on the complexity of the scenarios.
- A «suite approach» with a collection of efficient and fast-solved models is preferred for collaboration.
- Integrating data between models, especially for emerging technologies and energy systems, is crucial.
- Computation time varies based on the models and questions explored.
- Integrating energy transport system costs into models is essential but requires accurate data.
- Understanding the relationship between renewable energy sources and transportation challenges is crucial for modelling.

- For CES (Clean Electricity Standard), modelling preference and technological change is a complex task that needs consideration.
- Compatibility between clean energy pathways and the long-term Net Zero pathway is a challenge that must be addressed.

Community Collaboration and Sector-Specific Modelling:

- Building a community and expanding communication is essential to connect with different groups conducting various types of modelling.
- Collaboration is not about the models but connecting and integrating insights from different fields.
- Collaboration between engineers and non-economists is essential, as models are exemplary, but the community and collaboration need improvement.
- Multi-disciplinary groups need to come together to focus on provisions and implementations in models.
- The modelling community should work on more provisions and implementations and have a larger community to address these aspects.
- There is a need to expand beyond silos and communicate with various groups and modellers to achieve a holistic approach.
- Collaboration should move from setting targets and policy tools to focusing on implementation and the practical aspects of achieving goals.
- Integrating data and knowledge from different models and groups is essential to understanding the challenges thoroughly.

RECOMMENDATIONS

Recommendations from session 3 emphasize the importance of collaboration, continuous model improvement, transparency, and the need to address the challenges and complexities associated with energy modelling for achieving net-zero emissions.

Model Development and Improvement

- Focus on continuously developing and improving existing models.
- Create an energy system model within ECCC.
- Represent and analyze policies and policy interactions.
- Provide a detailed representation of potential mitigation options for non-CO_2 emissions.
- Integrate supply chain considerations into the models.
- Collaborate with other model developers instead of creating new models from scratch.
- Ensure that reports not only present results but also outline model limitations.

Collaboration and Information Sharing

- Collaborate with diverse modellers and groups to gain more information.
- Bridge gaps between models that work differently, primarily for economic sectors with varying levels of disaggregation.
- Facilitate communication and information sharing between models from different domains.
- Integrate information and intelligence from other models into a collaborative effort.
- Expand communication beyond modellers in energy economics.
- Maintain transparency in model details to help users understand the models.

Model Interactions and Time Frames

- Understand that interaction between models can be time-consuming, depending on the complexity of the scenarios.
- Prefer a «suite approach» with a collection of efficient and fast-solved models for collaboration.
- Integrate data between models, especially for emerging technologies and energy systems.
- Address the challenge of varying computation times based on the models and questions explored.
- Integrate energy transport system costs into models with accurate data.
- Focus on understanding the relationship between renewable energy sources and transportation challenges in modelling.
- Address the complexity of modelling preferences and technological change for the Clean Electricity Standard (CES).
- Tackle the challenge of compatibility between clean energy pathways and the long-term Net Zero pathway.

Community Collaboration and Sector-Specific Modelling

- Build a community and expand communication to connect with different groups conducting various types of modelling.
- Foster collaboration between engineers and non-economists to integrate insights from different fields.
- Encourage multi-disciplinary groups to focus on provisions and implementations in models.
- Promote collaboration from setting targets and policy tools to focusing on implementation and practical aspects of achieving goals.
- Expand beyond silos and communicate with various groups and modellers to achieve a holistic approach.
- Integrate data and knowledge from different models and groups to understand challenges thoroughly.

SESSION 4: OPEN-SOURCE NET-ZERO MODELLING TOOLS

In this section, we delve into the insights garnered from Session 4, themed «Open-Source Net-Zero Modelling Tools.» This session illuminated the scope and potential of open-source tools in advancing net-zero objectives, enriched by international and Canadian perspectives. Dr. Daniel Huppmann from the Energy Climate Environment Program at IIASA shared valuable lessons from international model comparison projects, particularly highlighting the openEntrance project. Following this, Dr. Taco Niet from Simon Fraser University elucidated on the open-source approaches being pioneered in Canada. Together, these presentations offered a thorough understanding of how open-source tools are being leveraged globally and domestically to drive transparent and collaborative net-zero modelling endeavors.

CONFERENCE 4.1

Daniel Huppmann, Energy Climate Environment Program, The International Institute for Applied Systems Analysis (IIASA)

Link to presentation

In Daniel Huppmann's conference presentation, the focus was on «Tools for Scenario Analysis & Model Comparison» and the pivotal role of the IIASA Scenario Services infrastructure in facilitating scenario analysis, model comparison, and open science in the energy, climate, and environmental domain. The presentation highlighted the IIASA Energy, Climate, and Environment (ECE) program as a vital community scenario hub, which has supported the modelling community for over a decade. ECE plays a crucial role in hosting scenario databases for model comparison projects related to the IPCC and the Energy Modelling Forum (EMF) organized by Stanford University.

Data stewardship, adhering to the FAIR principles (Findable, Accessible, Interoperable, Reusable), and making research data openly accessible and reusable were significant themes. The involvement of data stewards across IIASA research programs is vital to ensure reproducibility, transparency, and reusability.

The presentation stressed the need for an ecosystem for model comparison, including open-source models, standardized data formats, validation tools, and a central scenario results database. The IIASA Scenario Explorer, an interactive web interface, was highlighted as a versatile tool used in various projects, including the IPCC's Sixth Assessment Report (AR6).

The IAMC template for time series data, adopted by around 50 global teams, was introduced, emphasizing its use in projects like IPCC reports and Horizon 2020 projects. The presentation also showcased multiple tools and packages, such as Pyam[1] for scenario processing and the IIASA database API for third-party tool development.

In summary, the presentation emphasized the infrastructure and tools enabling scenario analysis, model comparison, and open science in the energy, climate, and environmental fields. Key takeaways included the importance of data standards, documentation, early adoption of common formats, and the value of automation and validation in research and analysis efficiency. Lessons learned from past projects underlined these priorities for open science success.

1. "The open-source Python package pyam provides a suite of tools and functions for analyzing and visualizing input data (i.e., assumptions/parametrization) and results (model output) of integrated-assessment models, macro-energy scenarios, energy systems analysis, and sectoral studies".pyam: analysis and visualization of integrated-assessment & macro-energy scenarios — pyam 2.0.1.dev12+g6583339 documentation (pyam-iamc.readthedocs.io)

QUESTIONS AND ANSWERS SESSION 4.1

- **Funding and Future of Open Entrance Scenarios**
  - A question was raised regarding the future of Open Entrance now that funding has stopped. The response emphasized that while funding for Open Entrance has paused, the scenario explorer and tools will continue to be developed through other projects. The community projects and open-source models will still be maintained, and there's a website for contributions.
  - There was a question about the best practices for result standardization and whether there are common ways to display model structures. The answer suggested this is a good research question and referred to a new research article.
  - An attendee mentioned facing issues in EMH (Energy Model Comparison Hub) and asked if the same model was used. The response confirmed that the message model used in EMH faces similar challenges, especially with IEA data used for calibration, and recommended seeking data sources that avoid such issues in the first place.
- **Model Validation and Auditing**
  - A question arose about the best way to audit a model, to which the answer highlighted the need for extensive discussion with modellers to evaluate assumptions and identify whether they produce unusual or valuable insights.
  - There was a request for further explanation regarding the validation of model outcomes. The answer discussed the importance of data format readability, standardized processes, correct data structure, clear error messages, and consistency in logic. It emphasized the need to address issues like data units (e.g., MT vs. GT) and regional aggregation.
- **OpenEntrance Scenarios**
  - The discussion touched upon OpenEntrance scenarios' operations and efforts to support community projects. The objective was mentioned as building upon existing models to avoid starting from scratch, and case studies were proposed to learn how to link parts of different models together.
  - The question was raised about funding and maintaining services for EMH, to which it was clarified that the scenario explorer would continue to operate with the support of a pipeline of projects using the same infrastructure. PYAM[2] and other packages are actively developed.
  - An inquiry was made about whether there is a framework for comparing different model structures. The response noted that it's an exciting research question but requires extensive work and discussions to automate the process.
  - An attendee from EMH highlighted the importance of transparency but mentioned encountering confidentiality issues with ECCC. The response indicated similar issues, especially with using proprietary data for calibration in the MESSAGE[3] model. It was recommended to identify potentially problematic data sources early and seek alternatives.

2. A Python package for managing, analyzing, and visualizing data from integrated assessment models (IAMs) in climate and energy research.

3. MESSAGE (Model for Energy Supply Strategy Alternatives and their General Environmental Impact): An integrated assessment model developed by IIASA for simulating global energy systems and evaluating their environmental impacts, especially in relation to climate change.

- **General Model Validation**
  - A question was posed about how to validate the logic of a model, with the response emphasizing the importance of readable data, understanding the model's structure, defining allowable ranges, ensuring global and sub-regional data consistency, and flagging discrepancies.
  - There was also mention of standardizing output data, using open-source data inputs, and collaborating with the community for model comparison and scenario analysis.
  - The issue of confidentiality was raised again, and the response suggested avoiding the use of such data, but it was acknowledged that this may not be a good solution in some cases.
  - A final question revolved around funds and how the project continues. The response mentioned that the community will continue to support it, and funds will come from other projects.

CONFERENCE 4.2

Taco Niet, Simon Fraser University

Link to presentation

Dr. Taco Niet delivered a conference presentation on «Open Modelling Best Practices,» emphasizing the importance of open-source modelling and its implications. Dr. Niet introduced the ΔE+ Research Group, which specializes in sustainable energy engineering and modelling, tackling various issues from land and water to climate impact (GHGs), equity, and justice. The group's primary mission is to aid decision-makers in aligning energy investments with sustainable solutions across different energy sectors.

A central point in Dr. Niet's presentation was the significance of employing open-source and accessible modelling tools to ensure transparent analysis. He presented practical modelling examples, including using open-source models for Canada and creating an open-source global electricity system model generator.

The core concept explored was «open modelling,» encompassing open-source software, open data, processing scripts, and toolpaths. Available modelling aims to enhance policy development by promoting transparency, thereby increasing the credibility of model results, fostering community involvement, and enabling collaboration with academia without the need for non-disclosure agreements (NDAs).

The presentation delved into both the advantages and challenges of open modelling. While it offers improved collaboration, credibility, and policy development, it can face hurdles regarding sharing highly detailed and private data.

Dr. Niet emphasized open-source best practices, notably the 4RIA framework, which covers the retrievability of artifacts, repeatability of model runs, reusability of software artifacts, reconstructability of the entire analysis chain, interoperability with other analyses, and auditability of the whole process. These practices aim to provide value by ensuring proper metadata, licensing, and openness.

The importance of building a community around open modelling, referred to as «Ubuntu,» was underscored. Dr. Niet presented examples of open-source models and projects from various regions, illustrating how available modelling can create a global network for collaboration and capacity-building to address energy and sustainability challenges.

In summary, Dr. Taco Niet's presentation highlighted the value of open modelling practices in enhancing collaboration, credibility, and transparency for sustainable energy solutions. It encouraged data, script, and scenario sharing to establish a global community that addresses energy and sustainability challenges.

QUESTIONS AND ANSWERS SESSION 4.2

- **Why open modelling?**
  - Enhances policy development.
  - Allows different contributors to enhance models.
  - Promotes collaboration with academia.
  - Open models are accessible globally and can help other countries.
  - Open licenses for data should be the default.
- **Why not open modelling?**
  - Private information/data can pose challenges.
  - Training requires additional time and resources.
- **Theme: Upcoming Models and Projects**
  - Lenz model of the City of Toronto will be released soon.

TAKEAWAY MESSAGE

The key takeaway from Session 4 are as followed:

1. **Open Modelling Best Practices**
   - Dr. Taco Niet emphasized the value of open-source modelling tools for sustainable energy solutions.
   - The ΔE+ Research Group focuses on diverse energy sectors: land, water, climate impact, equity, and justice.
   - «Open modelling» encompasses open-source software, open data, scripts, and toolpaths.
   - Open modelling enhances policy development, credibility, community involvement, and academic collaboration.
   - Open-source best practices include the 4RIA framework for retrievability, repeatability, reusability, reconstructability, interoperability, and auditability.
   - Building a global community around open modelling, referred to as «Ubuntu,» is crucial for addressing energy and sustainability challenges.
2. **Tools for Scenario Analysis & Model Comparison**
   - Daniel Huppmann highlighted the role of IIASA Scenario Services in scenario analysis, model comparison, and open science.
   - The IIASA Energy, Climate, and Environment (ECE) program is a vital community scenario hub.
   - Data stewardship and adherence to FAIR principles (Findable, Accessible, Interoperable, Reusable) were emphasized.
   - The need for an ecosystem for model comparison includes open-source models, standardized data formats, and validation tools.
   - The IAMC template for time series data, used by around 50 global teams, was introduced.
   - Tools like Pyam for scenario processing and the IIASA database API were showcased.

3. **Funding and Future of Open Entrance Scenarios**
    - Although funding for Open Entrance has stopped, the scenario explorer and tools will continue development through other projects.
    - Community projects and open-source models will still be maintained, and a website for contributions will exist.
4. **Standard for Outputs of Models Results for and Model Structures**
    - Common ways to standardize results and display model structures are topics worth exploring.
5. **Model Validation and Auditing**
    - Model auditing involves extensive discussions with modellers to evaluate assumptions.
    - The validation of model outcomes requires ensuring data format readability, correct data structure, clear error messages, and logical consistency.
6. **Open Entrance Scenarios**
    - Open Entrance scenarios aim to build upon existing models and use case studies to learn how to link different models.
7. **Framework for Comparing Model Structures:**
    - Developing a framework for comparing different model structures is an interesting research question but requires extensive work and discussions.
8. **Confidentiality Issues**
    - Confidentiality issues, such as proprietary data, can pose challenges in model calibration and should be addressed by seeking alternative data sources.
9. **Future Funding**
    - The community will continue to support the project, and funds will come from other projects to ensure its continuation.

INTERACTIVE SESSION

In the final interactive session of our workshop, the conversation pivoted towards the evolving narrative of open-source modelling, a concept resonating with the ethos of transparency and collaborative endeavor. Participants delved into a structured dialogue on the implications and operational facets of transitioning to open-source models, particularly within the precincts of ECCC's net-zero modelling arsenal.

Adequate Definition of «Open-Source» in Net-Zero Modelling and Implementation

- A good definition of open-source includes well-documented code and the ability to run and compare it.
- Implementation should involve providing clear connections between the code and its theoretical underpinnings.

Challenges of Open Sourcing Models

- Open-sourcing models require a considerable amount of time and resources.
- Documentation is crucial but often a time-consuming aspect.
- Data confidentiality and whether synthetic datasets and training resources are sufficient were discussed.

Timely Open Source Release

- The timing of open-sourcing, a complex model with multiple versions, was raised as an important consideration.

Collaboration and Transparency

- They are collaborating more with other modelling teams through informal channels and discussions.
- A consensus emerged for retaining a suite of models instead of a single model approach.
- Transparency and the ability to compare models were emphasized as essential goals.
- Creating a simplified version of a model, a «toy model,» to display its basic structure was suggested as a potential step toward open-sourcing.

Data and Model Structure

- The challenge of making data available and how to use the code and select scenarios were discussed.
- Precise, understandable data and model structure are essential for successful open-source implementation.
- The process of understanding a complex model may take years rather than months.

Ongoing Collaboration and Validation

- Suggestions included collaborating with universities and students, who often have more time to learn complex models.
- A halfway version without confidential data that's well-documented was proposed to make models more accessible.
- Continuous collaboration, internal model validation, and cross-model comparisons were encouraged to improve and validate models.
- Concerns were raised about the ability to replicate confidential datasets and ways to improve it.

Cross-Model Comparison
- The concept of cross-model comparison and collaborative discussions to explain differences in model results was presented as a valuable approach to enhance transparency and understanding.

Role of Universities
- Universities can play a role in training and documenting models to address resource limitations in open sourcing.
- Collaboration with universities was suggested as a means to expand transparency and access.

Training and Learning
- The need for training resources to use open-source models, particularly for new users, was acknowledged.
- Different users may require varying amounts of time to understand and operate complex models.
- Adequate documentation and available training resources are essential for effective model sharing.

Balancing Transparency and Confidentiality
- The challenges of balancing transparency while protecting confidential data were discussed, especially in the context of government policy work.
- Creating a «happy medium» between full open sourcing and keeping models confidential was explored, focusing on well-documented and simplified versions.

Validation and Documentation
- Ensuring good software development practices was emphasized internally for model transparency.
- Internal model validation and documentation were seen as critical components of open-source practices.

Community Collaboration
- The need for the modelling community to collaborate and enhance transparency was highlighted.

Peer Review and Interdepartmental Engagement
- Leveraging peer review and interdepartmental engagement to increase transparency and harmonization of work within the government was suggested.

Synthetic Datasets
- The idea of providing synthetic datasets to overcome data confidentiality challenges in open sourcing-was discussed.

Transparency in Data Cleaning
- The importance of ensuring that data is already clean, following standard practices, before its release was mentioned.

Model Version Control
- Addressing the issue of central version control and model updates in an open-source context was discussed.

Collaborative Approval
- Assigning «modellers/super modellers» to approve updates in a collaborative model development process was proposed.

RECOMMENDATIONS

Session four recommendations revolve around the theme of open-source net-zero modelling tools and emphasize the importance of transparency, collaboration, and effective model sharing. They address challenges related to data, documentation, and the balance between transparency and confidentiality. They also stress the role of universities, community collaboration, and peer review in enhancing the quality and accessibility of open-source models.

Adequate Definition of «Open-Source» in Net-Zero Modelling and Implementation

- Define «open-source» to include well-documented code and the ability to run and compare it.
- Ensure clear connections between the code and its theoretical underpinnings.

Challenges of Open-Sourcing Models

- Acknowledge that open-sourcing models require significant time and resources.
- Prioritize documentation to facilitate open-source model development.
- Address concerns about data confidentiality and consider synthetic datasets and training resources.

Timely Open Source Release

- Consider the timing of open sourcing, especially for complex models with multiple versions.

Collaboration and Transparency

- Collaborate with other modelling teams through informal channels and discussions.
- Retain a suite of models rather than a single-model approach.
- Emphasize transparency and the ability to compare models.
- Explore creating simplified «toy models» to display the basic structure.

Data and Model Structure

- Ensure the availability of precise, understandable data and model structure for successful open-source implementation.
- Recognize that understanding a complex model may take years.

Ongoing Collaboration and Validation

- Collaborate with universities and students for learning and documentation.
- Consider releasing a halfway version of models without confidential data but with thorough documentation.
- Promote continuous collaboration, internal model validation, and cross-model comparisons for improvement and validation.
- Address concerns about replicating confidential datasets and ways to improve this process.

Cross-Model Comparison

- Encourage cross-model comparison and collaborative discussions to explain differences in model results.

Role of Universities

- Involve universities in training and documenting models to address resource limitations in open sourcing.
- Collaboration with universities can expand transparency and access to models.

Training and Learning

- Recognize the need for training resources to use open-source models, particularly for new users.
- Provide adequate documentation and training resources for effective model sharing.

Balancing Transparency and Confidentiality

- Address the challenge of balancing transparency while protecting confidential data.
- Explore creating a «happy medium» between full open sourcing and keeping models confidential, focusing on well-documented and simplified versions.

Validation and Documentation

- Ensure good software development practices internally for model transparency.
- Prioritize internal model validation and documentation as critical components of open-source practices.

Community Collaboration

- Emphasize the need for the modelling community to collaborate and enhance transparency.

Peer Review and Interdepartmental Engagement

- Leverage peer review and interdepartmental engagement to increase transparency and harmonization of work within the government.

Synthetic Datasets

- Consider providing synthetic datasets to overcome data confidentiality challenges in open sourcing.

Transparency in Data Cleaning

- Highlight the importance of ensuring that data is already clean, following standard practices, before its release.

Model Version Control

- Address the issue of central version control and model updates in an open-source context.

Collaborative Approval

- Explore assigning «modellers/super modellers» to approve updates in a collaborative model development process.

CONCLUSIONS & FINAL RECOMMENDATIONS

The identified recommendations fall into three categories: Community Issues, General Model Issues, and Applications. Within Community Issues, the emphasis lies on cultivating partnerships between government, academia, and stakeholders to amplify the quality and accessibility of modelling efforts. The General Model Issues category underscores the significance of diversifying model usage, promoting transparency, and mitigating existing model limitations while offering strategies for process improvement and policy relevance. Lastly, the Applications category furnishes practical guidance for deploying models in actual scenarios, refining precision, and managing the structural shifts necessary for achieving net-zero emissions.

Community Issues: Highlighting the need for stronger partnerships between government, academia, and stakeholders to enhance the quality and accessibility of modelling efforts. Main recommendations included:

a. **Collaboration and Resource Availability:**
   - Seek collaborative opportunities with the U.S. Energy Information Administration (EIA) and academic institutions.
   - Ensure models are well-documented with robust user support.
   - Propose creating a Canada-focused scenario modelling forum for energy and climate issues.
   - Strengthen government-academia partnerships for model development and training.
   - Promote knowledge exchange with other modelling communities.
   - Establish structured training for modellers, possibly via a dedicated hub.

b. **Guidance for Advancing Canadian Energy Modelling and Climate Policies:**
   - Focus on sector-specific aspects in energy modelling.
   - Recognize the interplay between climate and energy policies.
   - Use energy modelling as a tool to guide climate policy-making.
   - Balance local and global perspectives in models, considering affordability in climate and energy policies.
   - Encourage collaborative workshops to enhance modelling skills.

c. **Transparency and Open Sourcing:**
   - Increase transparency in energy modelling, while respecting data confidentiality issues.
   - Consider open-sourcing models for greater scrutiny and transparency.

d. **Model Integration and Comprehensive Approach:**
   - Link different models to enhance capabilities and address specific issues.
   - Evaluate the potential for a comprehensive overarching model.

General Model Issues: Focusing on diversifying model usage, enhancing transparency, addressing model limitations, and suggesting improvements for process efficiency and practical applicability. Main recommendations included:

a. **Diverse Use of Models and Scenario Variability:**
   - Use a variety of models for different scenarios to avoid dependency on a single model.
   - Expand scenario range for in-depth analysis.

b. **Probabilistic Analysis and Open Source Models:**
   - Include probabilistic elements in scenarios to reflect real-world uncertainties.
   - Promote open-source models for credibility and transparency.

c. **Critical Strategies and Insights:**
   - Represent non-CO_2 emissions explicitly in models.
   - Perform price sensitivity and other analyses in long-term strategies.
   - Address uncertainties and set realistic expectations.
   - Consider machine learning for faster results and integrate engineering insights and validation in modelling.

d. **Model Alignment and Integration:**
   - Align short-term and long-term models for policy relevance.
   - Appreciate diverse economic philosophies in model selection.

e. **Addressing Limitations and Enhancements:**
   - Recognize and overcome model limitations.
   - Consider more complex models capturing behavioral changes and urban densification.
   - Update models for non-linear technology adoption and interaction effects.

f. **Integration of Alternative Models:**
   - Continue exploring alternatives and complements to CGE models and their interactions with other analytical tools.

Applications: Providing practical advice for applying models in actual scenarios, improving accuracy, and managing the structural changes required to achieve net-zero emissions.
Main recommendations included:

a. **Carbon Capture and Storage (CCS):**
   - Investigate CCS alternatives, including Land Use, Land Use Change, and Forestry (LULUCF).

b. **Practical Application:**
   - Apply models to practical inquiries and provide actionable advice.

c. **Sector-Specific Modelling:**
   - Use regional or provincial models for sector-specific precision.

d. **Elasticities and Structural Change:**
   - Tackle the modelling of structural changes essential for net-zero emissions, considering elasticity variations.

e. **Follow-Up Workshop on Long-Term Policy:**
   - Plan a follow-up workshop to review long-term net-zero policies and assess model accuracy in representing these policies.

DAY 1 - SEPTEMBER 20, 2023

Registration: 9:30-10:00 am

SESSION 1: LONG-TERM MODELLING - PRACTICE, APPROACH, AND REPORTING

Speaker(s)	Organization	Description
Derek Hermanutz, Nick Macaluso, Edouard Clement	EMH & ECCC	Introduction
Eric Stewart	Environment & Climate Change Canada (ECCC)	Modelling Approaches for Canada's Transition to Net-Zero Emissions: Canada's Mid-Century and Long-Term Strategy Submissions to the United Nations Framework Convention On Climate Change Supporting document (in English) Supporting document (in French) Presentation is available here
Dr. Colin Cunliff **Matthew Binsted**	U.S. Department of Energy (DOE) Pacific Northwest National Laboratory	U.S. Long-Term Strategy and modelling approaches i) US government and OP-NEMS modelling perspective ii) GCAM modelling Presentation is available here
Prof. Mark Jaccard	Simon Fraser University	Modelling activities done by the Canadian academic and non-government modellers for pathway analysis Presentation is available here

Interactive discussions & wrap-up

- Considering the diverse array of strategies employed worldwide for long-term emission reduction, what can we glean from the international landscape to enhance Canada's LTS modelling and scenario analysis? Are there noteworthy global best practices that could be applied or adapted to further improve our approach?
- As we delve into the intricacies of Canada's LTS, it's crucial to compare and contrast our strategies with those of other nations. Could you highlight key strategies from around the world that stand out and share insights on how they align or diverge from ECCC's approach? What valuable lessons can we draw from these comparisons?
- In the pursuit of effective long-term modelling for emission reduction, we acknowledge the need for continuous improvement. In light of the current ECCC approach, what specific limitations or challenges have you identified, and what innovative suggestions do you propose for refining our modelling methodologies to better navigate these hurdles? How can ECCC overcome the constraints it may encounter in implementing these long-term modelling approaches?

Lunch

SESSION 2: NET-ZERO MODELLING APPROACHES - INTERNATIONAL AND CANADIAN PRACTICES

Speaker(s)	Organization	Description
Mike Beale	Former Assistant Deputy Minister, ECCC	25 minutes presentation: summary of the findings of the Independent Modelling Review on ECCC long-term suite of models Presentation is available here
Diego Vannucci Chiappori	ECCC	GCAM Canada PDF: Overview of ECCC Long-term models PDF: Annex_Model Description_eng (9 Aug 2022) p.1-9 ENG PDF: Annex_Model Description_fr (9 Aug 2022) p.1-9 FR Presentation is available here
Eric Stewart	ECCC	Environment Canada' Multi-Sector Multi-Regional Model (EC-MSMR) PDF: Overview of ECCC Long-term models PDF: Annex_Model Description_eng (9 Aug 2022) p.1-9 ENG PDF: Annex_Model Description_fr (9 Aug 2022) p.1-9 FR Presentation is available here
Alexandre Larrivée	ECCC	Environment Canada integrated Assessment model (EC-IAM) PDF: Overview of ECCC Long-term models PDF: Annex_Model Description_eng (9 Aug 2022) p.1-9 ENG PDF: Annex_Model Description_fr (9 Aug 2022) p.1-9 FR Presentation is available here
Break		
Dave Sawyer	Canadian Climate Institute	Canadian Net-Zero Modelling Approach: what is needed for supporting Canada's Net-Zero Act? Presentation is available here
Interactive discussions & wrap-up ○ Given the presentation on ECCC's net-zero modelling suite, could you provide specific comments or insights on the design and functionality of the presented models (GCAM Canada, EC-MSMR, EC-IAM)? What sets them apart and how do they contribute to our net-zero aspirations? ○ In the context of international comparisons, how do ECCC's models stack up against other global models used for net-zero scenarios? What distinguishes them, and where might there be opportunities for collaboration or improvement? ○ Considering the complexity of net-zero modelling, what tools and resources do you believe are essential for successful modelling endeavors? Are there any critical requirements or best practices that should be emphasized? ○ As we strive for net-zero emissions, the accuracy and reliability of modelling become paramount. In your opinion, how should models like GCAM Canada, EC-MSMR, and EC-IAM be assessed to ensure their effectiveness in guiding policy decisions? Are they fit for purpose, and if not, what adaptations are needed? ○ Drawing from your expertise, are there any specific recommendations or best practices you can offer to help ECCC enhance the utility of its long-term models in support of our net-zero policy agenda?		
Networking event		

DAY 2 - SEPTEMBER 21, 2023

SESSION 3: ASSESSING ECCC'S MODELLING TOOLS - IMPROVEMENT VS. NEW DEVELOPMENT

Speaker(s)	Organization	Description
Nick Macaluso	ECCC	Recap from Day 1
Samuel Forget Lord	ECCC	Environment Canada's Forward-Looking Provincial Model (EC-Pro) PDF: Overview of ECCC Long-term models Presentation is available here
Allen A. Fawcett, Ph.D.	U.S. Environmental Protection Agency	Multi-model analysis of the Inflation Reduction Act using 10 economy-wide models including GCAM & Net-zero modelling work done on LTS context Presentation is available here
Dr. Madeleine McPherson	University of Victoria	Perspectives on the tools and approaches for successful net-zero modelling Presentation is available here
Break		

Interactive discussions & wrap-up

- Given the thorough review of ECCC's modelling suite, do you believe that these models are suitable for our current net-zero aspirations, or are there notable areas that require enhancement or improvement? Please elaborate on your insights.
- ECCC has traditionally followed a suite approach, leveraging the strengths of individual models. Do you recommend continuing this approach, and if so, what recommendations do you have for effectively integrating the outputs of different models, such as EC-IAM, GCAM Canada, and EC-MSMR?
- Alternatively, if you believe that ECCC should consider a different modelling approach, could you specify the type of model that might be more appropriate for our net-zero goals? What advantages do you see in adopting a new approach?
- To foster greater collaboration and synergy in analyzing the net-zero agenda, what steps do you propose ECCC should take? Are there specific mechanisms, partnerships, or strategies that can be implemented to enhance the effectiveness of our modelling efforts?
- In the pursuit of refining our modelling tools for net-zero scenarios, are there any critical considerations or challenges that stakeholders should be aware of, based on your experience and expertise? What valuable lessons can we draw from your insights in this regard?

Lunch

SESSION 4: OPEN-SOURCE NET-ZERO MODELLING TOOLS

Speaker(s)	Organization	Description
Dr. Daniel Huppmann	Energy Climate Environment Program, IIASA	Lessons learned from international model comparison projects and the openEntrance projet Presentation is available here
Taco Niet, Ph.D.	Simon Fraser University	Open-source approaches in Canada Presentation is available here
Interactive discussions & wrap-up ○ The concept of open-source models has gained prominence for enhancing transparency. What is your stance on whether ECCC should make its models open-source, and what advantages or potential challenges do you foresee in doing so? ○ Defining a model as 'open source' can take various forms, from sharing model documentation to releasing core versions of the model. In your view, what constitutes an effective definition of 'open source' in the context of net-zero modelling, and how should it be implemented? ○ Among ECCC's net-zero modelling tools, which model do you believe should be the primary candidate for open-sourcing? What factors or criteria should guide this decision, and what benefits might arise from this choice?» ○ In the process of making models open source, what key considerations and challenges should ECCC address to ensure a smooth transition? Are there specific mechanisms or safeguards that should be in place to maintain model integrity and accuracy? ○ While open-source models offer transparency, are there alternative approaches or strategies that ECCC could explore to achieve greater transparency if making models entirely open source is not feasible? What alternative paths forward do you recommend for ensuring the public and stakeholders have access to critical modelling information?		
Concluding remarks		

Name	Organization
Michail Bachras	University of Toronto
Mike Beale	Former Assistant Deputy Minister, ECCC
Louis Beaumier	Institut de l'énergie Trottier
Umberto Berardi	Toronto Metropolitain University
Michael Bernstein	Net-Zero Advisory Body
Dale Beugin	Canadian Climate Institute
Alexandre Bilodeau	Ministère des finances du Québec
Matthew Binsted	Pacific Northwest National Laboratory
Dallas Burtraw	Resources for the Future
Diego Chiappori	Environment and Climate Change Canada
Edouard Clement	Energy Modelling Hub
Darcy Cornu	Energy and Environment Policy Division, NRCan
Edgar Cudmore	Finance Canada
Colin Cunliff	U.S. Department of Energy
Evan Davies	University of Alberta
Sébastien Debia	NRCan
Philippe Descheneau	Environment and Climate Change Canada
Brett Dolter	University of Regina
Simon Donner	University of British Columbia / Net-Zero Advisory Body
Allen Fawcett	U.S. Environmental Protection Agency
Melissa Felder	Clean Prosperity
Franziska Forg	Navius Research
Rachel Freeman	UKERC
Catherine Gibson	NZAB Secretariat
Brad Griffin	Simon Fraser University
Ahmed Hanafy	Dunsky Energy + Climate Advisors
Matthew Hansen	Canada Energy Regulator
Sam Harrisson	Navius Research
Derek Hermanutz	Environment and Climate Change Canada
Sydney Hoffman	Environment and Climate Change Canada
Mark Jaccard	Simon Fraser University
Adoumou Hugues Kouassi	Ministère de l'Économie, de l'Innovation et de l'Énergie
Alexandre Larrivee	Environment and Climate Change Canada
Kristin Lutes	Office of the Auditor General of Canada
Nathan Lemphers	Net-Zero Advisory Body Secretariat - ECCC
Nick Macaluso	Environment and Climate Change Canada

Sylvie Marchand	Office of the Auditor General of Canada
Tyler Markowsky	NRCan
Peter Massie	NRCan
Sean McCoy	University of Calgary
Madeleine McPherson	University of Victoria, Energy Modelling Hub
james Meadowcroft	Carleton University
Eric Miller	University of Toronto
Florian Mitjana	HEC Montréal - Chaire de gestion du secteur de l'énergie
Jake Monroe	Energy Modelling Hub
Normand Mousseau	Institut de l'énergie Trottier, Energy Modelling Hub
Taco Niet	Simon Fraser University
Will Noel	Pembina Institute
Glasha Obrekht	Environment and Climate Change Canada
Kowan Okeefe	University of Maryland / Center for Global Sustainability
Olivier Ouellette	NRCan
Nelson Paterson	Department of Finance Canada
Nathan Platte	NRCan
Daniel Posen	University of Toronto
Josée Provençal	Energy Modelling Hub
Luis Ricardez-Sandoval	University of Waterloo
Nick Rivers	University of Ottawa
Dominic Rivest	Energy Modelling Hub
Nidhi Santen	EPRI
Dave Sawyer	Canadian Climate Institute - EnviroEconomics
Charles-Antoine Seguin	Ministère des finances du Québec
Muhammad Siddiqui	Environment and Climate Change Canada
Alpha Sow	Office of the Auditor General of Canada
Eric Stewart	Environment and Climate Change Canada
Conrard Giresse Tetsassi Feugmo	University Of Waterloo
Kathleen Vaillancourt	ESMIA Consultants Inc.
Andrea Vallejos	Ministère de l'Économie, de l'Innovation et de l'Énergie
Sarah Van Wyngaarden	NRCAN
Cameron Wade	Sutubra Research
Jason Wang	Pembina Institute
Marcus Williams	Sustainability Solutions Group
John Wright	Net-Zero Advisory Body (NZAB)
Xiao Yu	Environment and Climate Change Canada