Development and Application of GCAM-Canada Model for Future Energy Scenario Analysis

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BACKGROUND

Integrated assessment models (IAM) support sustainable resource development and infrastructure planning, which requires reliable long-term projections of both resource supply and demand variables. These projections rest in turn on an understanding both of the problem and potential trade-offs, and the "big picture" effects of alternative solutions.

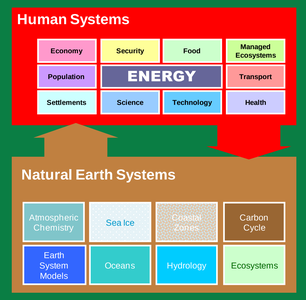


Image courtesy of J. Edmonds, JGCRI

Canada lacks a comprehensive IAM that integrates our country with global systems, and that can simulate broader effects of policy decisions. Therefore, we are working with Environment and Climate Change (ECCC) and the Joint Global Research Institute (JGCRI) to develop a 10-province **Global Change Assessment Model (GCAM)** for Federal and Provincial ministries and for Canada's energy industry.

This project aims to answer the following questions:

- How much primary and secondary energy sources do we use, and where? How does their production change into the future?
- What are their environmental footprints over the life cycle? GHG emissions, water use, land footprint?
- How do we decide which energy pathways to choose; how do they affect other sectors?
- What are the implications of decisions made elsewhere on the planet on our own situation?

SHORT-TERM OBJECTIVES

The goals for the first three years are to:

- ✓ Revise GCAM to incorporate detailed energy pathways for oil sands production, which is currently represented in the model as a single energy pathway
- ✓ Begin GCAM-Canada model development in cooperation with ECCC and JGCRI
- ✓ Collect, analyze and incorporate energy and other data into GCAM

PROJECT OVERVIEW

This research project will focus on improving GCAM's representation of Canadian energy supply and demand, and understanding of energy and environmental policy options and trade-offs. The aim is to identify environmentally sustainable, economically viable and socially acceptable energy pathways through a clearer understanding of risks and trade-offs for available policies and technologies. Other Future Energy Systems projects may benefit from long-term projections of energy supply and demand, and may help to refine model coefficients and long-term research questions.

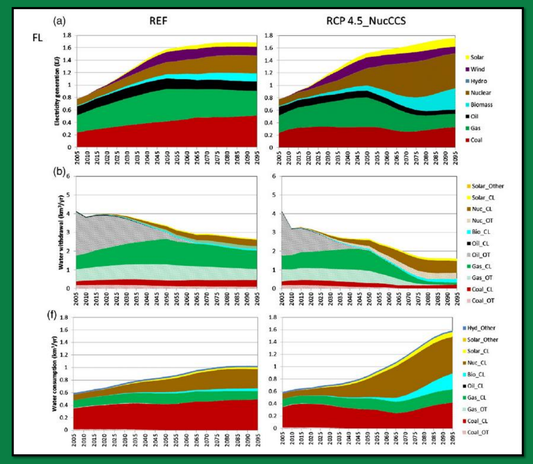
Students associated with the project will apply lessons-learned from two other regionalized versions of GCAM, GCAM-USA and GCAM-China.

- Rui Xing, a Post-doctoral Fellow, will implement and evaluate oil sands production pathways, and will begin developing GCAM-Canada;
- Diego V. Chiappori, PhD_1, will complete GCAM-Canada development and apply it to policy assessment;
- An MSc, (TBD), will help Diego with data collection and input, model calibration and validation;
- A PhD_2, (TBD), will be involved in the longer-term objectives, focusing on model applications to policy and industrial priorities, and broader systems views of trade-offs.

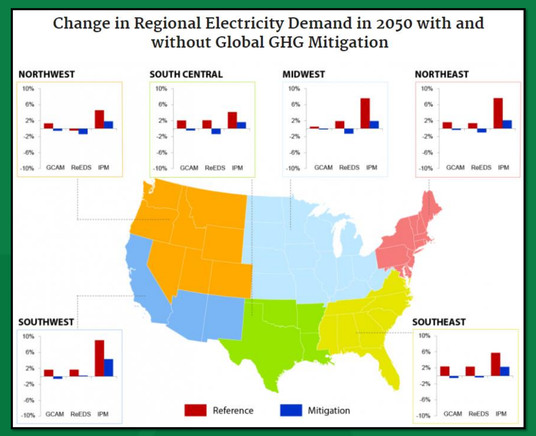
THE GLOBAL CHANGE ASSESSMENT MODEL (GCAM)

GCAM is a dynamic-recursive model with technology-rich representations of the economy, energy sector, land use and water linked to a climate model that can be used to explore climate change mitigation policies.

GCAM has been used to explore the potential role of emerging energy supply technologies and the greenhouse gas (GHG) consequences of specific policies or energy technology adoption including CO_2 capture and storage, bioenergy, hydrogen systems, nuclear energy, renewable energy technology, and energy use technology in buildings, industry and the transportation sectors. It can be used to simulate scenarios, policies, and emission targets from various sources, and has been used by the IPCC, The US Government and its agencies, and a variety of multi-national corporations.



(a) Electricity generation in Texas under the reference and RCP 4.5_NucCCCS scenarios. (b and f) Electric-sector water withdraw in Texas and water consumption in Florida (respectively) under the reference and RCP 4.5_NucCCS scenarios ("CL" is closed loop, including recirculating and cooling pond; "OT" is once-through; "Other" is none cooling related water use, usually associated with solar and hydro power). Adaptation from Liu, Lu & Hejazi, Mohamad & Patel, Pralit & Kyle, Page & Davies, Evan & Zhou, Yuyu & Clarke, Leon & Edmonds, James. (2015). **Water demands for electricity generation in the U.S.: Modeling different scenarios for the water–energy nexus**. Technological Forecasting and Social Change.



Change in regional electricity demand for the Reference and Mitigation scenarios relative to a Control (no temperature change). Results are presented for six regions and for each of the three models used in the analysis (GCAM, ReEDS, and IPM). EPA, 2015. **Climate Action Benefits: Electricity Demand.** Available on https://www.epa.gov/cira/climate-action-benefits-electricity-demand.

GCAM output includes projections of future energy supply and demand and the resulting greenhouse gas emissions, radiative forcing and climate effects of 16 greenhouse gases, aerosols and short-lived species at 0.5 × 0.5 degree resolution, contingent on assumptions about future population, economy, technology, water use and climate mitigation policy.

For more information about the GCAM, visit: http://www.globalchange.umd.edu/gcam/

EXPECTED OUTCOMES

Expected outcomes of this theme include:

- ✓ A ten-province, three-territory **GCAM-Canada** model;
- ✓ A clearer understanding of risks and trade-offs associated with available policies and technologies;
- ✓ An indication of where technology-specific details fit into the bigger picture and how they affect other alternative solutions developed under various future energy scenarios.

The resulting GCAM-Canada model can be applied widely. Sample applications include:

- ✓ Use of GCAM-Canada model by ECCC to assess effects of accelerated energy technology deployments and climate change policies – such as those associated with Canada's Mid-century Strategy for the Paris Agreement – on energy supply technologies;
- ✓ Assessment of broader feedbacks with climate, agriculture, land use and water systems;

The model may also be of interest to Provincial governments for energy and climate change policy development and analysis, and the energy industry may benefit from a comprehensive national model for analysis of development plans and future projects.

EXTERNAL PARTNERS

ECCC, Ottawa – Nick Macaluso – Access to Canadian data and E2020 model; advisor for GCAM development;

Government of Canada / Gouvernement du Canada

JGCRI, College Park, MD, USA – Haewon McJeon, Page Kyle, Mohamad Hejazi – Advisors for GCAM energy scenario implementation; researchers, collaborators and GCAM developers.

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