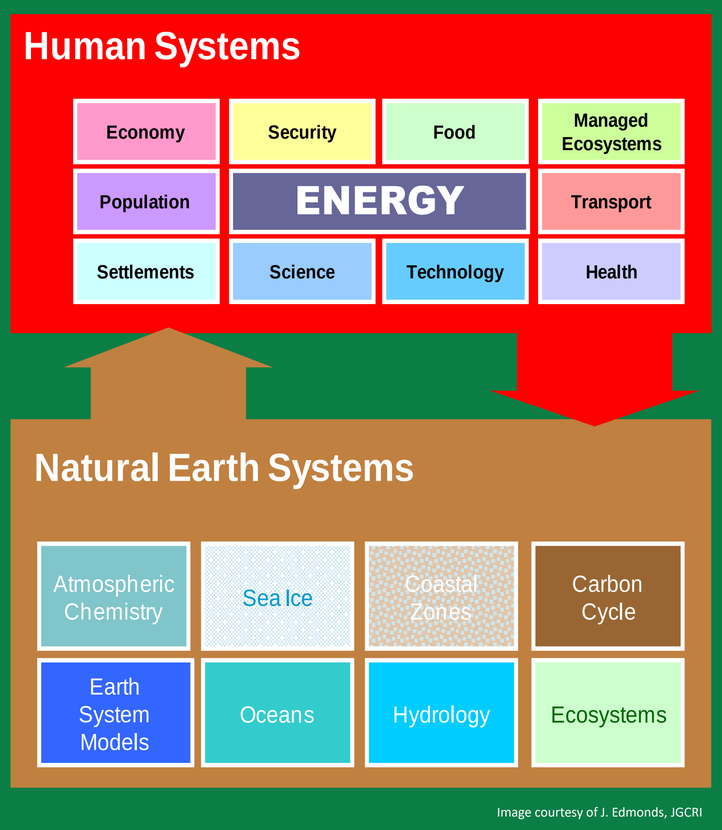
DEVELOPMENT AND APPLICATION OF GCAM-CANADA MODEL FOR FUTURE ENERGY SCENARIO ANALYSIS

Diego V. Chiappori[1], Evan G. R. Davies[1], Amit Kumar[1]

BACKGROUND



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Integrated assessment models (IAM) support sustainable resource development and infrastructure planning, which requires reliable long-term projections of both resource supply and demand variables. IAMs provide these projections. They also help to identify problems and potential trade-offs, and the "big picture" effects of alternative solutions.

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 Canada (ECCC) and the Joint Global Change Research Institute (JGCRI) to develop a 10-province **IAM** 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?

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 and others – Advisors for GCAM energy scenario implementation; researchers, collaborators and GCAM developers.

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EXPECTED OUTCOMES

Expected outcomes of this theme include:

- ✓ Incorporation of oil sands energy pathways in **GCAM;**
- ✓ 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.

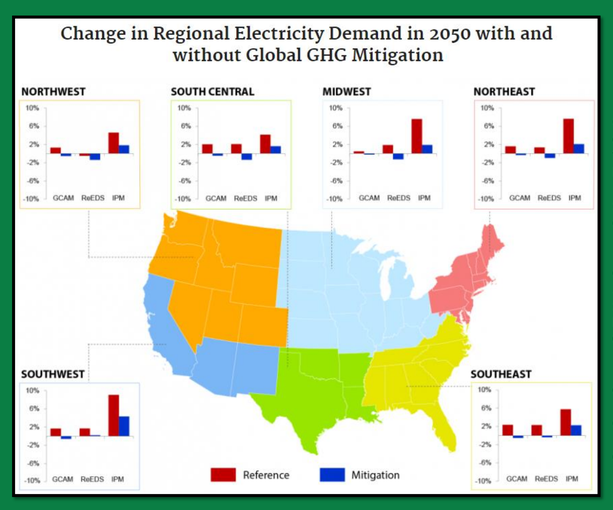
The resulting GCAM-Canada model can be applied widely. Sample applications include:

- ✓ Use by ECCC to assess effects of accelerated energy technology deployments and climate change policies – e.g. Canada's Mid-century Strategy for the Paris Agreement – on energy systems;
- ✓ Assessment of the broader feedbacks with climate, agriculture, land use and water systems.

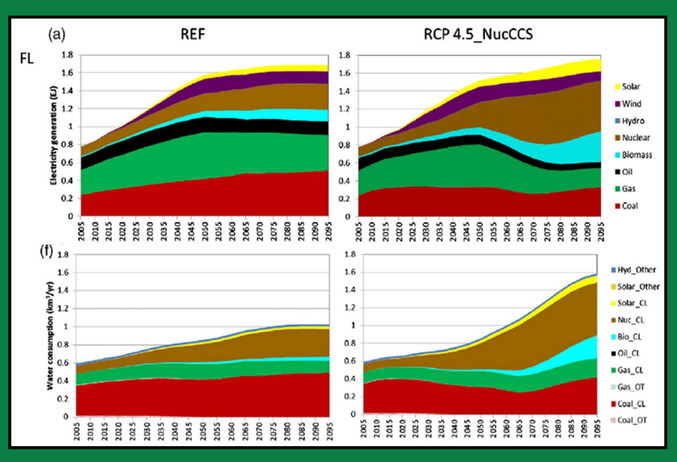
The model may also be of interest to Provincial governments for energy and climate change policy development and analysis, and the energy industry may benefit from a comprehensive national model for analysis of development plans and future projects.

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. It has been used to explore potential roles of emerging energy supply technologies and the greenhouse gas (GHG) consequences of specific policies or energy technology adoption. Examples include CO_2 capture and storage, bioenergy, hydrogen systems, nuclear energy, renewable energy technology, and energy use technology in buildings, industry and the transportation sectors. GCAM has been used by the IPCC, The US Government and its agencies, and a variety of multi-national corporations.



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.



(a) Electricity generation in Texas under the reference and RCP 4.5_NucCCCS scenarios. (f) Electric-sector water consumption in Florida (respectively) under the reference and RCP 4.5_NucCCS. Adaptation from Liuet al. (2015). **Water demands for electricity generation in the U.S.: Modeling different scenarios for the water–energy nexus**. Technological Forecasting and Social Change.

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.

FES PROJECT OVERVIEW

This research project will focus on improving 1) GCAM's representation of Canadian energy supply and demand, and 2) an 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 should benefit from long-term projections of energy supply and demand, and may help to refine model coefficients and long-term research questions. Work on the project will begin in May 2018.

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;
- MSc_1 will help Diego with data collection and input, model calibration and validation;
- PhD_2 will be involved in the longer-term objectives, focusing on model applications to policy and industrial priorities, and broader systems views of trade-offs.

[1]Donadeo Innovation Centre for Engineering, University of Alberta, 9211 116 St NW, Edmonton, AB - Canada T6G 1H9

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