Realizing Canada's Decarbonization Commitments using an Integrated Assessment Model
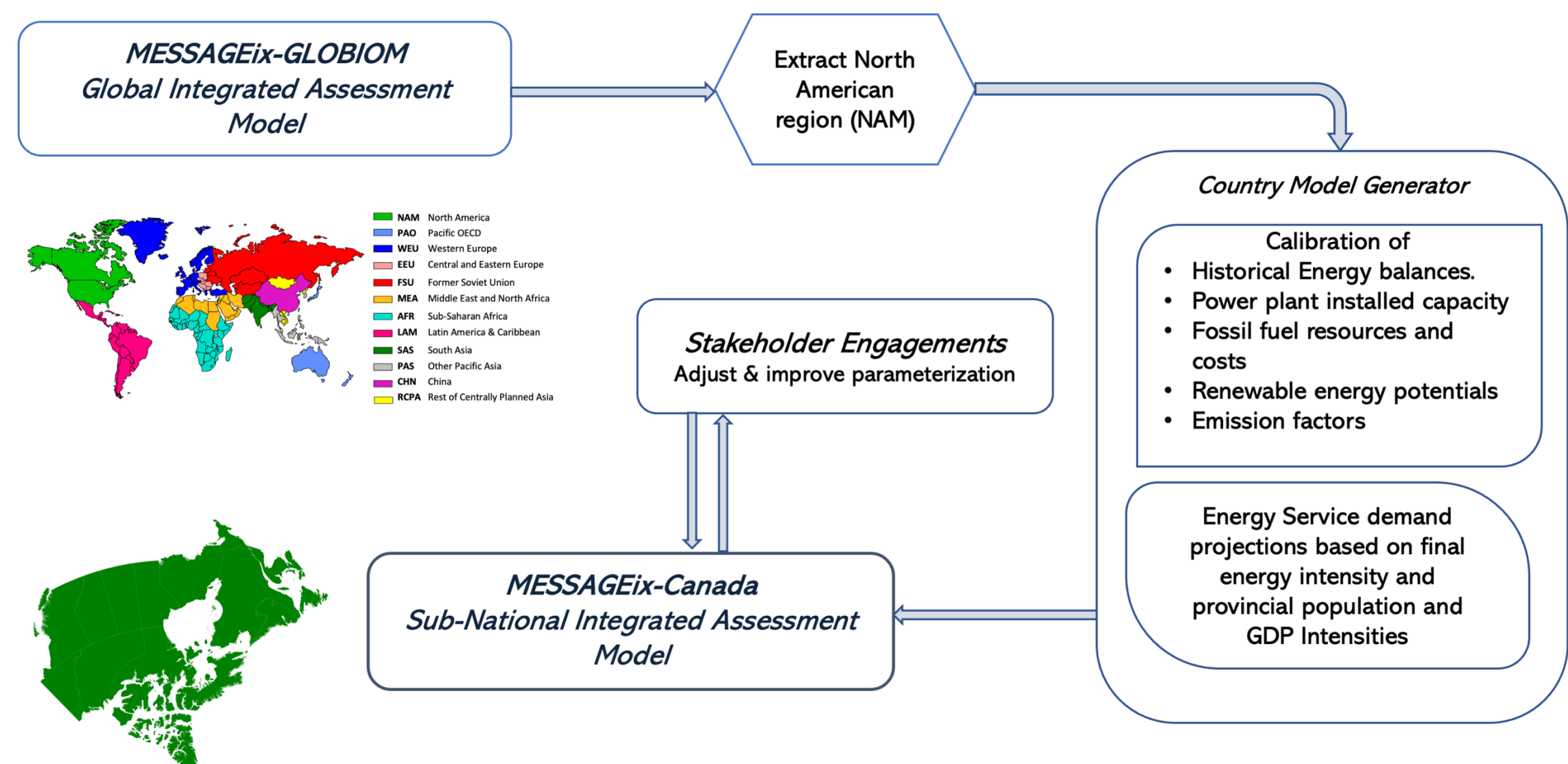
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MESSAGEix

Canada's energy system

Canada's role in global climate policy is of considerable importance, given its substantial energy resources and commitment to reducing greenhouse gas (GHG) emissions. Despite accounting for approximately 1.6% of global emissions, Canada's influence on climate policy is amplified by its extensive oil and gas sectors and its position as a leading energy producer. The country's energy landscape is marked by significant regional diversity, with provinces varying widely in their energy production profiles, policy frameworks, and economic dependencies on fossil fuels. This heterogeneity allows a nuanced approach to energy and climate policy analysis, one that can accommodate the complex interplay between federal and provincial objectives.

MESSAGEix-Canada
A sub-national Integrated Assessment Model

The MESSAGEix-Canada model is an engineering-economic optimization energy systems model that optimizes energy systems across Canada's provinces and territories. It uses a Linear Programming (LP) model and Python API packages for data management and analysis. The model comprises 13 subregions, each with distinct techno-economic parameterization, allowing for better understanding of regional disparities in energy systems. The model is calibrated using national databases, Statistics Canada's Energy Balance Reports, and the Canada Energy Regulator Future Energy Reports. The model also incorporates downscaling algorithms to assimilate localized energy, economic, and emissions data. This makes the MESSAGEix-Canada an invaluable tool for policymakers to formulate effective, region-specific climate solutions.

Combining bottom-up and top-down approaches

Key federal policies are covered in the model
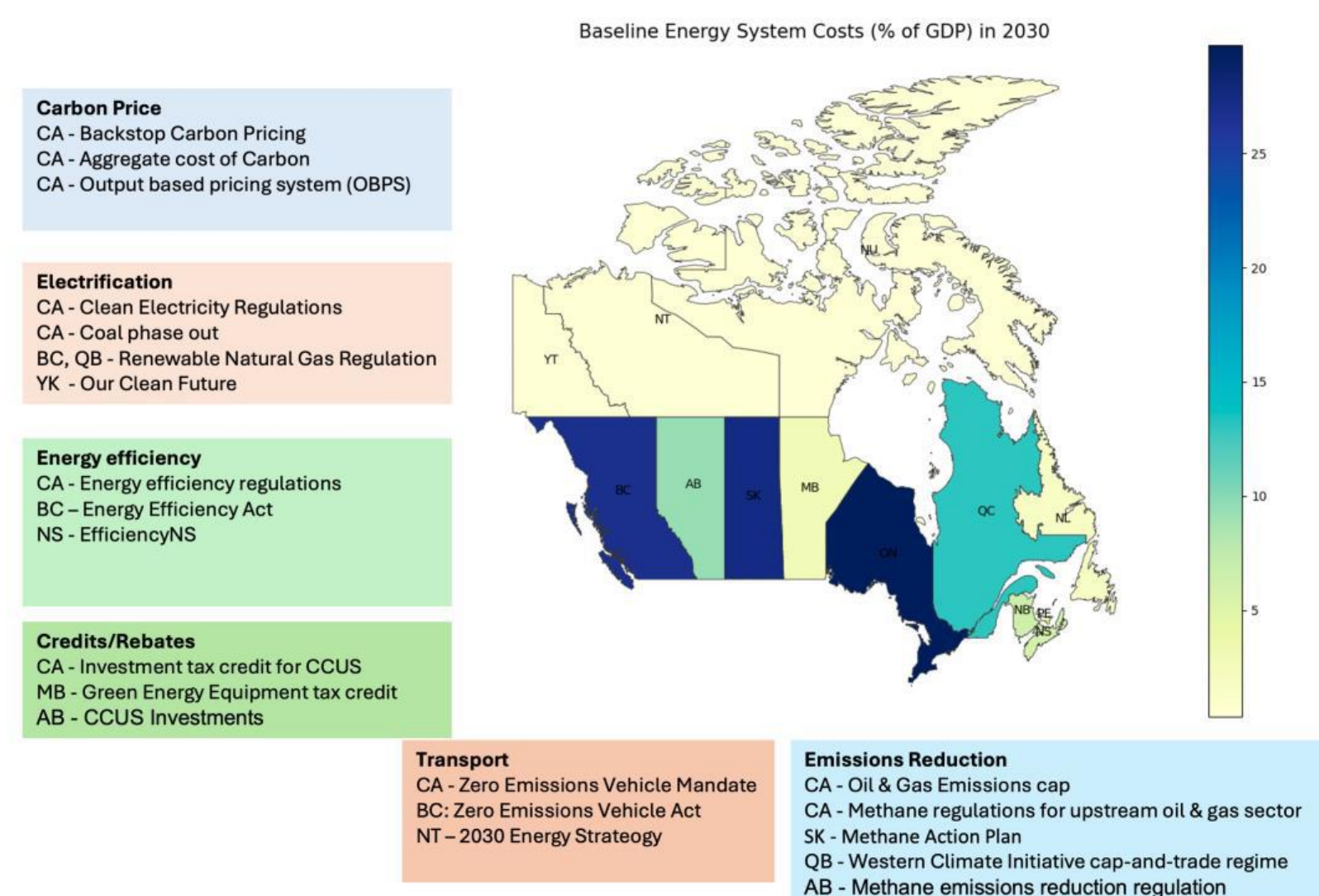
- The backstop carbon price and aggregate cost of carbon are applied to emissions above the policies' stipulated intensity limit for each technology/commodity

- Emissions Trajectory in Net Zero → **Provincial trajectories** calculated based on Reference scenario

- **Coal** Phaseout by 2030 in all scenarios except coal w/ CCS

- **Renewable electricity** share in Net Zero scenarios and some provinces where these are legislated.

Rapidly Prototyping Pathways

The model is designed to adapt to new policies through constraints, including activity-based, emissions, and complex policy frameworks.

The modular model architecture allows for the rapid addition of new technologies by defining key parameter using a pre-defined template.

All model versions are tracked on GitLab, enabling collaborative development and version control.

Comprehensive documentation for the usability and transparency is maintained for both academic and policy stakeholders.
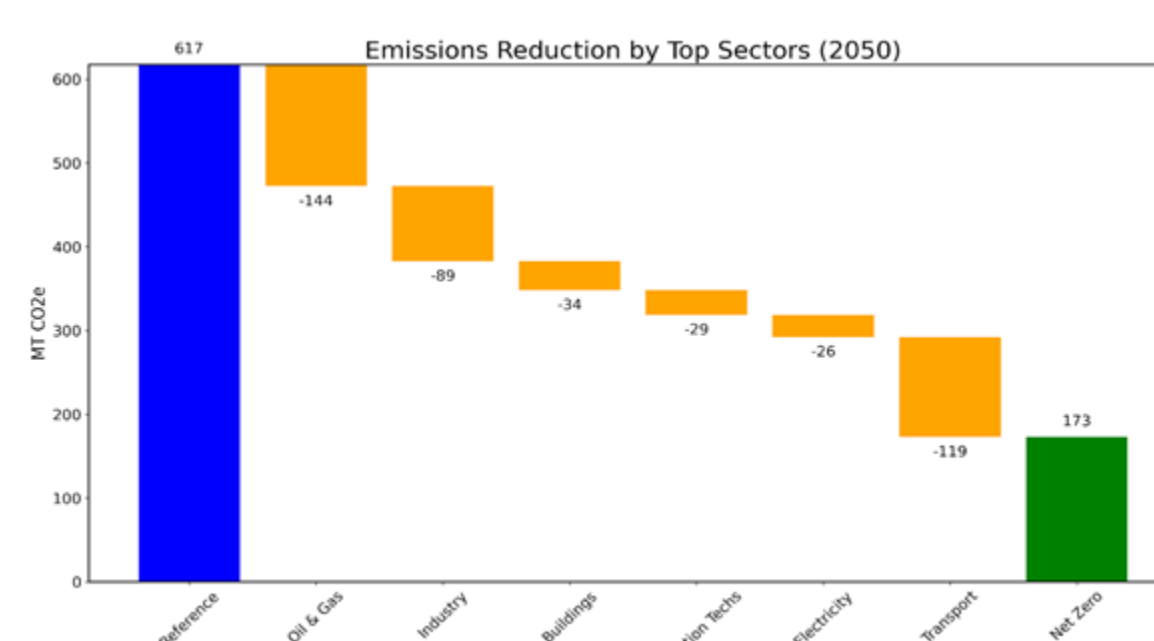
An interactive visualization dashboard enables stakeholders to explore model outputs and promoting stakeholder engagement.

Open Insights
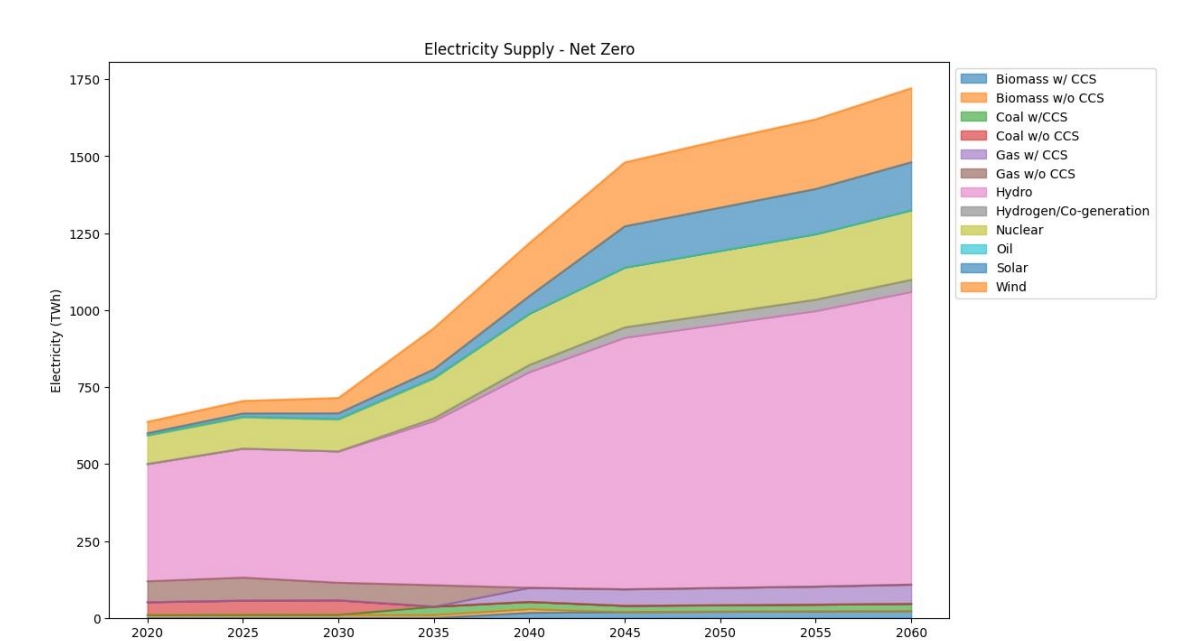**Advancing Accessible and Transparent Modeling for Canadians**

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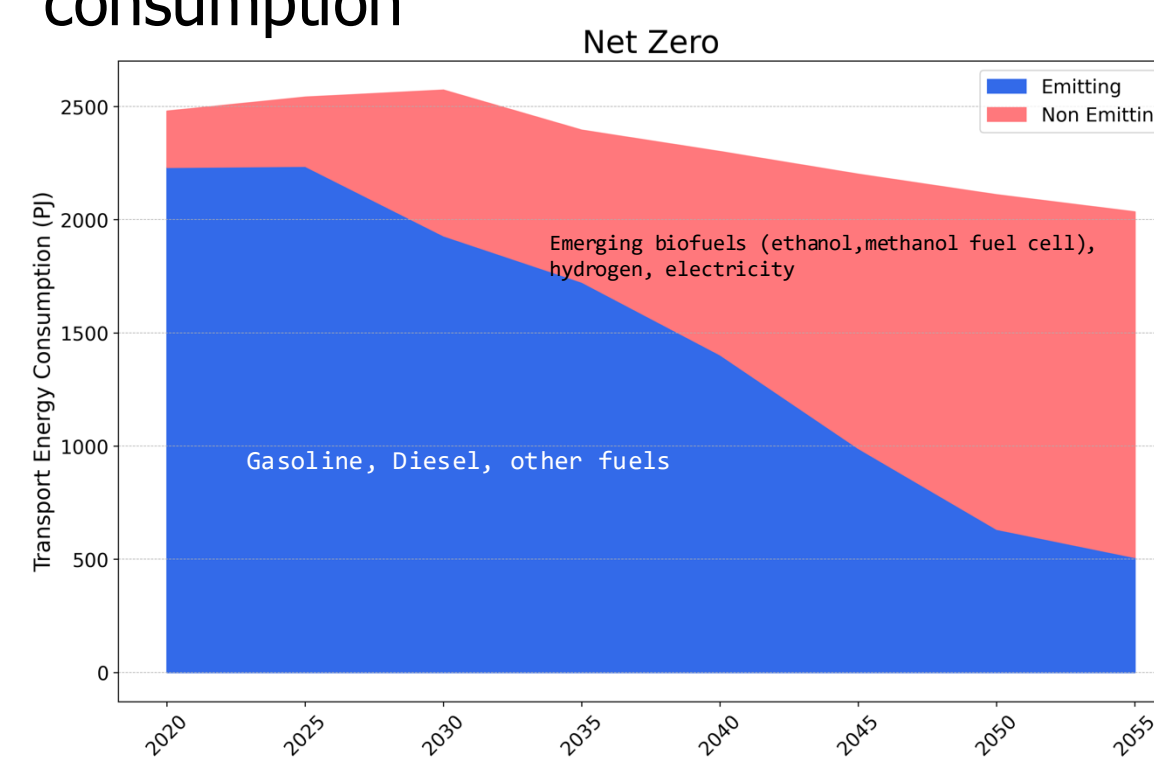## Preliminary Results

Oil and Gas sectors show high emission reductions

Electrification of sectors increase by 45% in 2050 in the Net Zero

Transport sector constitute about 20% fossil fuels of the Final Energy consumption

- Biomass and coal with carbon capture and storage (CCS) play prominent roles in Net Zero scenarios.
- Reference scenario shows about 76% fossil use on average over time horizon, showing the need for deep industrial de-carbonization.
- Oil & gas extraction and processes has the highest system costs.
- Mitigation Technologies with high learning rates leads to less shadow prices