MODELLING ENERGY SYSTEMS HOW DOES CANADA COMPARE?

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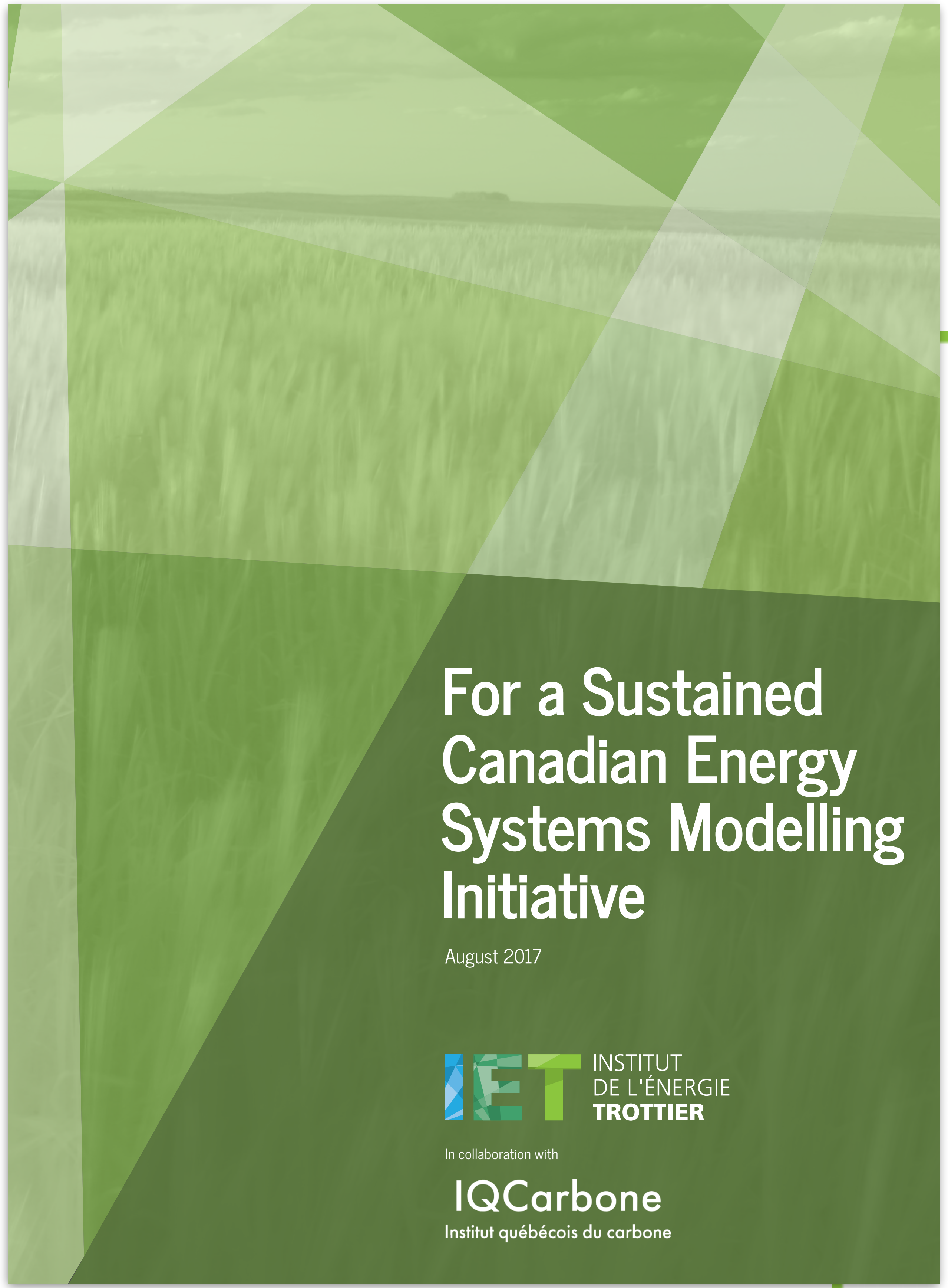
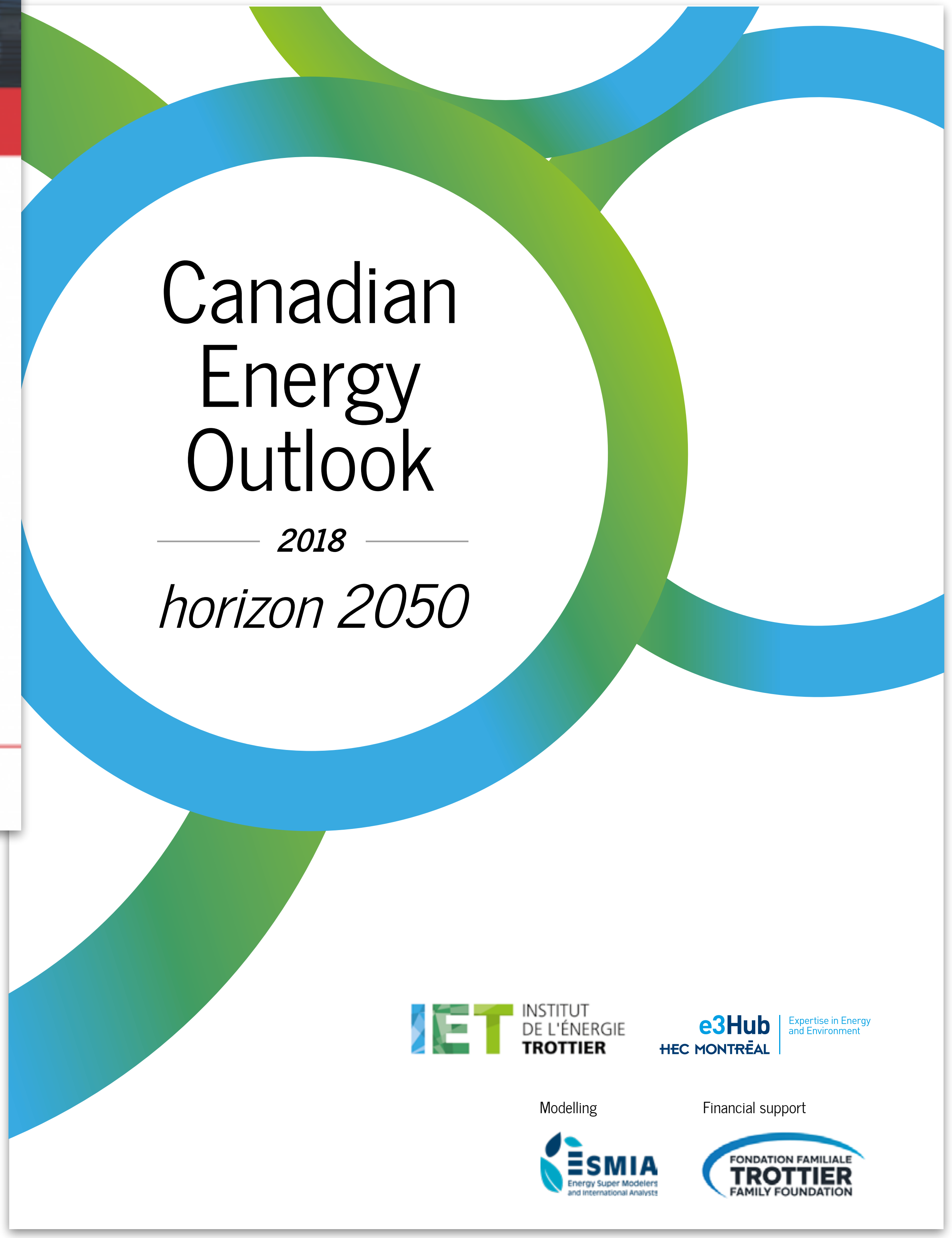
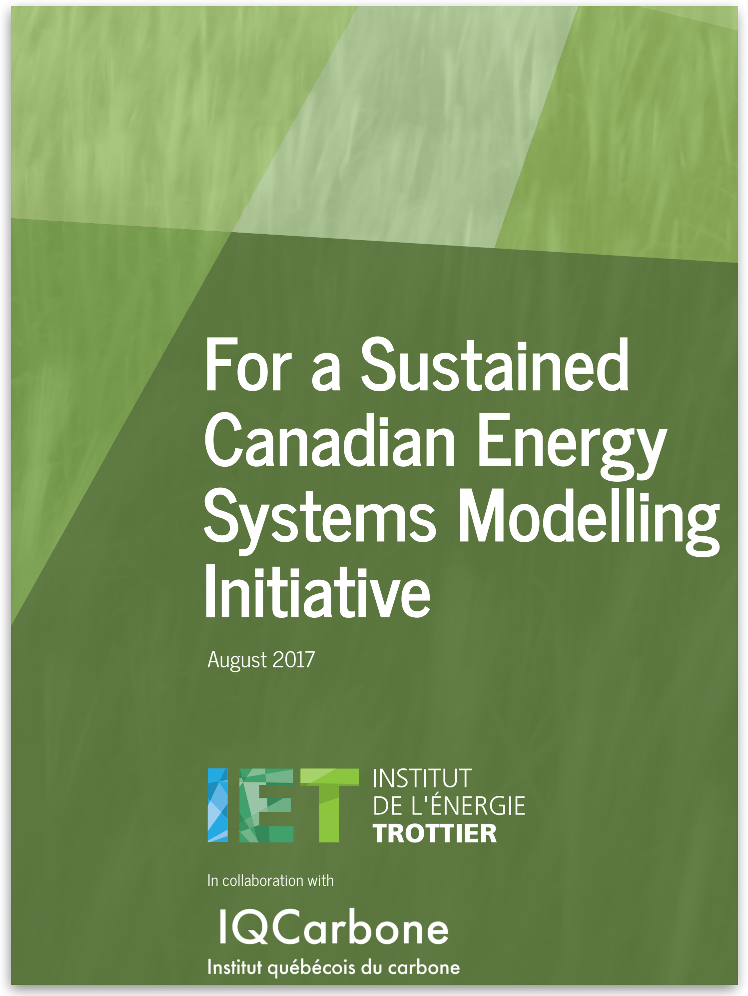
Institut de l'énergie Trottier: helping to move forward on the energy transition





WHAT IS SYSTEM MODELLING?

- *Resolution or integration of a mathematical equations used to describe the interaction between the system's components under the influence of different constraints*
- *In the context of an energy system : it helps obtain information on topics such as decarbonisation pathways, interactions between energy systems, impact of various mesures and policies and costs associates with selected scenarios*
- *Energy system modeling and simulation activities must be considered as prospective tools to help planners and decision makers and understand the transformations expected or taking place actually*



A FEW TYPES OF MODELS

Energy Systems

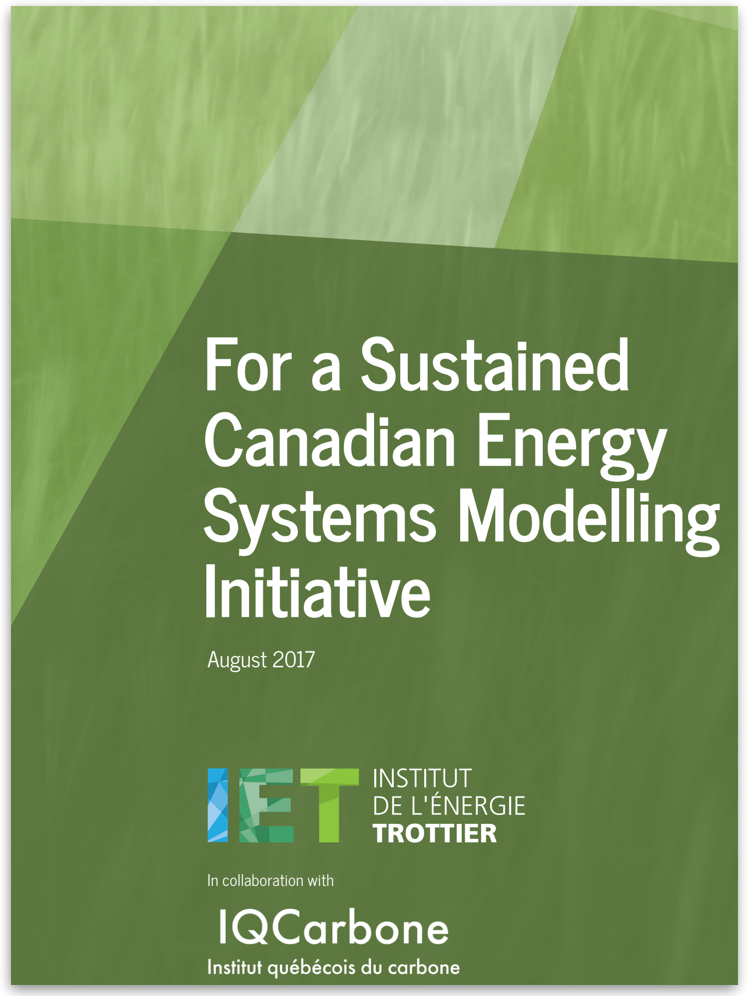
- ***Top-down*** *: Adhere to a macro-economic philosophy in order to simulate an energy system using aggregate economic relationships derived empirically from historical data. They capture relationships between the economic sector and other sectors of the economy, but they are not technologically explicit. Ex: computational equilibrium models like the R-GEEM (Regional General Equilibrium Energy Model) developed for Canada or the E-DRAM in California.*
- ***Bottom-up****: Adhere to a techno-economic engineering philosophy in order to either explore a wide range of energy futures driven by technology. Can be exploratory — Canadian Energy Systems Simulator (CanESS)) —or optimisation models such as TIMES ou Markal (NATEM) ,*
- ***Hybrids****: CIMS (Université Simon Fraser)*

Sectorial and technical

- *serve to model transportation and distribution networks, energy efficiency, buildings, etc.*

Emerging behavior

- ***Agent-based modeling****: based on the availability of large data sets and computational power that has opened the door to new energy system modelling approaches based on detailed information about linked consumption patterns.*



ENERGY MODELING IN CANADA

		Cdn Gov't		Consulting Companies / Universities			
	Type	NEB	ECCC	Navius/SFU	ESMIA/UM	WhatIf?/UC	SEI/UA
Top Down (defined in Macro-economic Space)	Macro-econometric	----- TIM[a] -----					
Top Down (defined in Macro-economic Space)	Computable Gen. Equil.		EC-pro	GEEM			
Bottom Up (defined in bio-physical Space)	Optimization				NATEM		
Bottom Up (defined in bio-physical Space)	Consumer Choice	Energy 2020[b]					
Bottom Up (defined in bio-physical Space)	Exploratory Simulation					CanESS	LEAP
	Hybrid		E3MC[c]	CIMS[d]			

[a] TIM is being redeveloped for ECCC by PolicyModels Corp
[b] Developed and supported for Canada by Systematic Solutions Inc. (USA)
[c] CIMS is a partial equilibrium model consisting of energy supply and demand, consumer choice and macro-economy components;
[d] E3MC (Energy, Emissions and Economy Model for Canada) computationally links Energy 2020 to TIM for work within ECCC.

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CHANGE AHEAD:
A CASE FOR INDEPENDENT EXPERT ANALYSIS AND ADVICE IN SUPPORT OF CLIMATE POLICY MAKING IN CANADA

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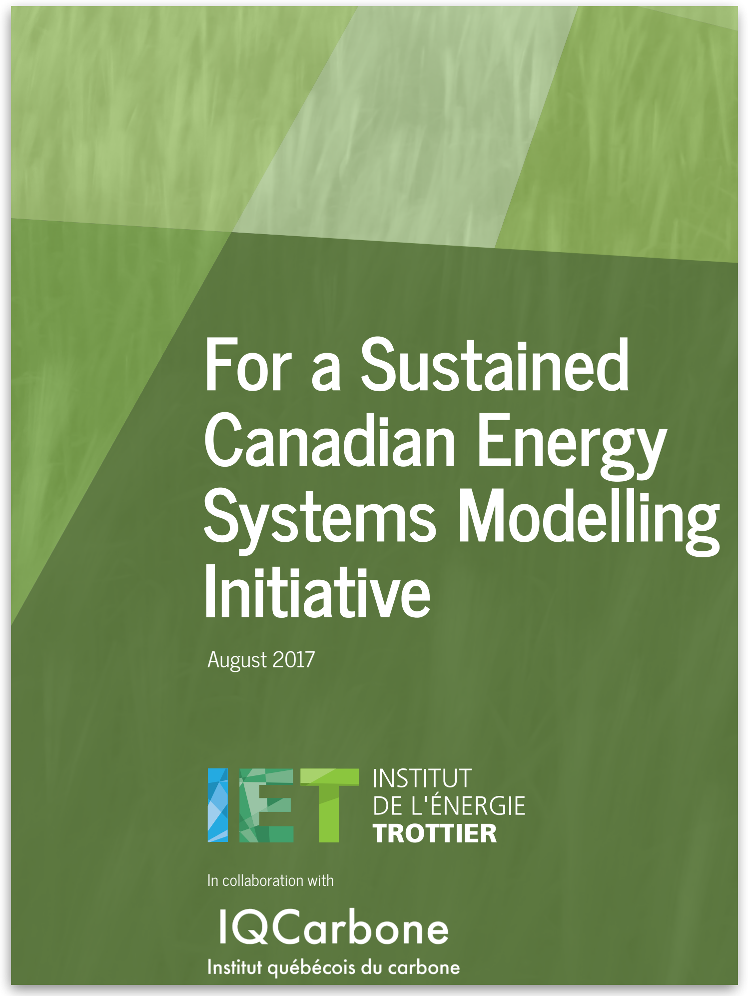
EXAMPLES OF INTEGRATION OF ENERGY MODELING : THE CASE OF SWEDEN

- *The Swedish Energy Agency (SEA) and the Swedish Environmental Protection Agency (SEPA) are together responsible for Swedish energy policy and modelling of the Swedish energy system.*
- *The SEPA has the **primary responsibility for developing environmental policy and its implementation** through drafting environmental scenario forecasts with the help of its sister agency, the SEA*
- *It is also responsible for the biannual **Report for Sweden on Assessment of Projected Progress** that is submitted every two years to the European Parliament*
- *The SEA has been supporting research in the field of energy systems since the 1970s, with two main objectives: "**to secure competence for future needs** as well as **to create direct benefits to decision-makers**"*

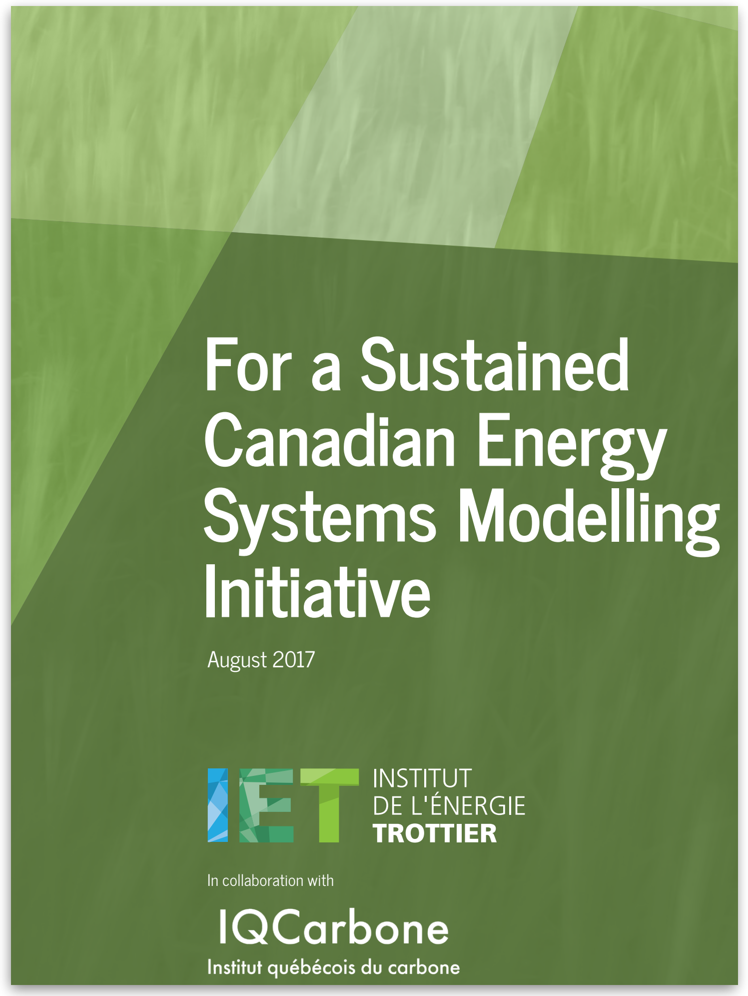


Use of Energy and Climate Models in Decision Making

- *In 2011, the Swedish Government tasked the SEPA to produce a roadmap for reaching a target of "zero net emissions" by 2050, considering various emission trajectories in different economic sectors*
- *MARKAL-Nordic was used to identify the most cost-effective strategy to develop Sweden's 2050 energy system for the electricity and district heating sectors*

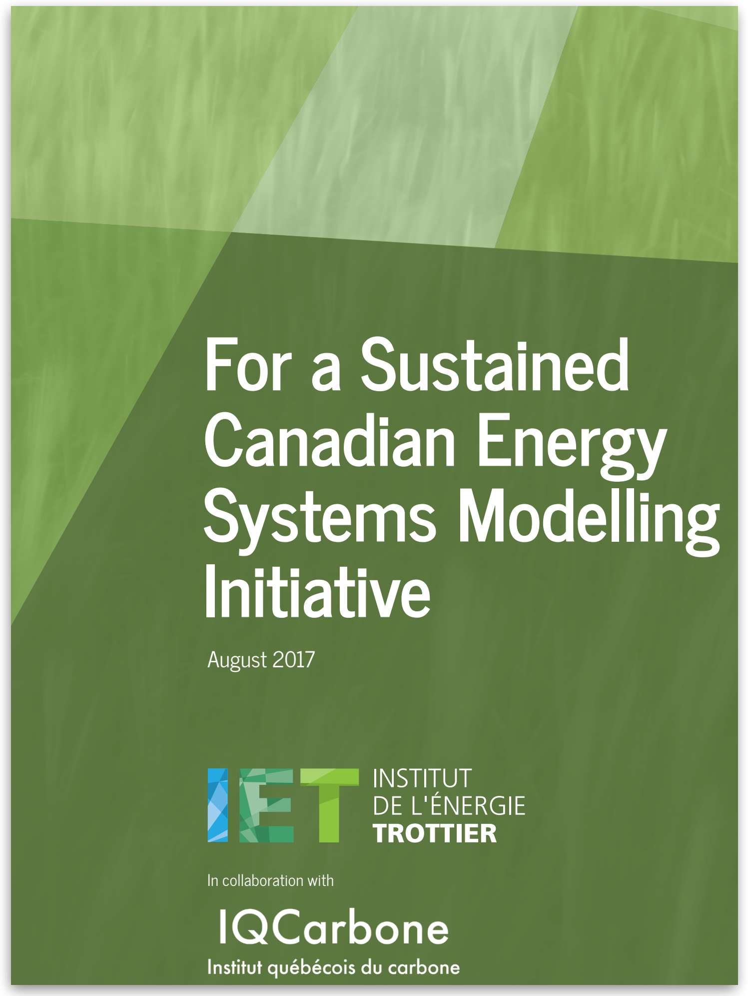
EXAMPLES OF INTEGRATION OF ENERGY MODELING : THE CASE OF CALIFORNIA

- *The California Energy Commission (CEC) is responsible for the biannual Integrated Energy Policy Report (IEPR), while the California Air Resources Board (CARB)updates a climate change Scoping Plan every five years*
- *The CARB uses **bottom-up** and **top-down models** to evaluate policy options for reducing emissions across all sectors of California's economy: Energy 2020 (bottom-up) and E-DRAM (top-down)*
- *The CEC have used the PATHWAYS model to develop several scenarios that varied the mix of low-carbon technologies and the timing of deployment*
- *Significantly, the CARB has also undertaken modelling exercises of its carbon market linkage with Quebec*
- *One of the most important applications of energy systems modelling policy is the production of a single forecast set in the context of the CEC's biannual IEPR*
- *Under the **Global Warming Solutions Act of 2006**, California is required to develop a comprehensive Scoping Plan to "identify and make recommendations on direct emission reduction measures, alternative compliance mechanisms, market-based compliance mechanisms, and potential monetary and nonmonetary incentives" in order to attain California's emission reduction goal, s well as to achieve "the maximum technologically feasible and cost effective GHG emission reductions"*



FOUR KEY PRINCIPLES TO RELEVANT ENERGY MODELLING

- **Transparency** – *Models and data must be open-source and publicly available*
- **Trust** – *In order for policy-makers, civil society and the private sector to trust and act upon modelling results*
- **Sustainability** – *Energy models and their associated data sets need not only to be developed, but also to be continually maintained, improved and updated through dedicated knowledge infrastructure*
- **Clear Policy Linkages** – *Mandating that energy systems modelling be considered in the policy process is one way of linking modelling to policy.*



CANADIAN ENERGY OUTLOOK – HORIZON 2050

- **NATEM** : *North American TIMES Energy Model*
  - **optimization** model: the model minimizes costs to meet energy service demands
  - follows a **techno-economic** approach: contains more than 4500 technologies characterized by technical and economic parameters

- **NATEM-Canada** :
  - projection to horizon **2050**
  - details the energy system of Canada's 13 provinces and territories
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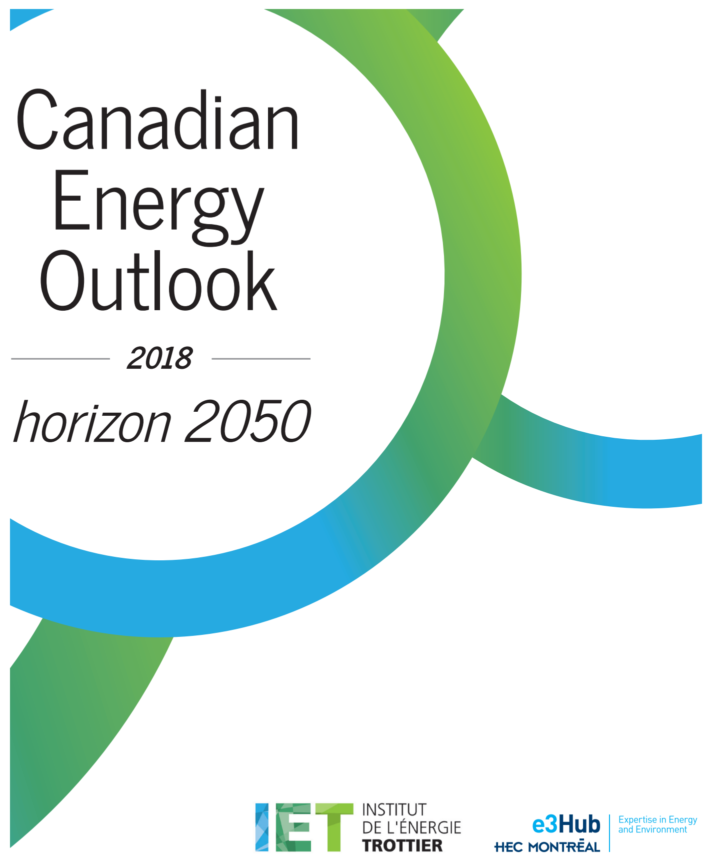
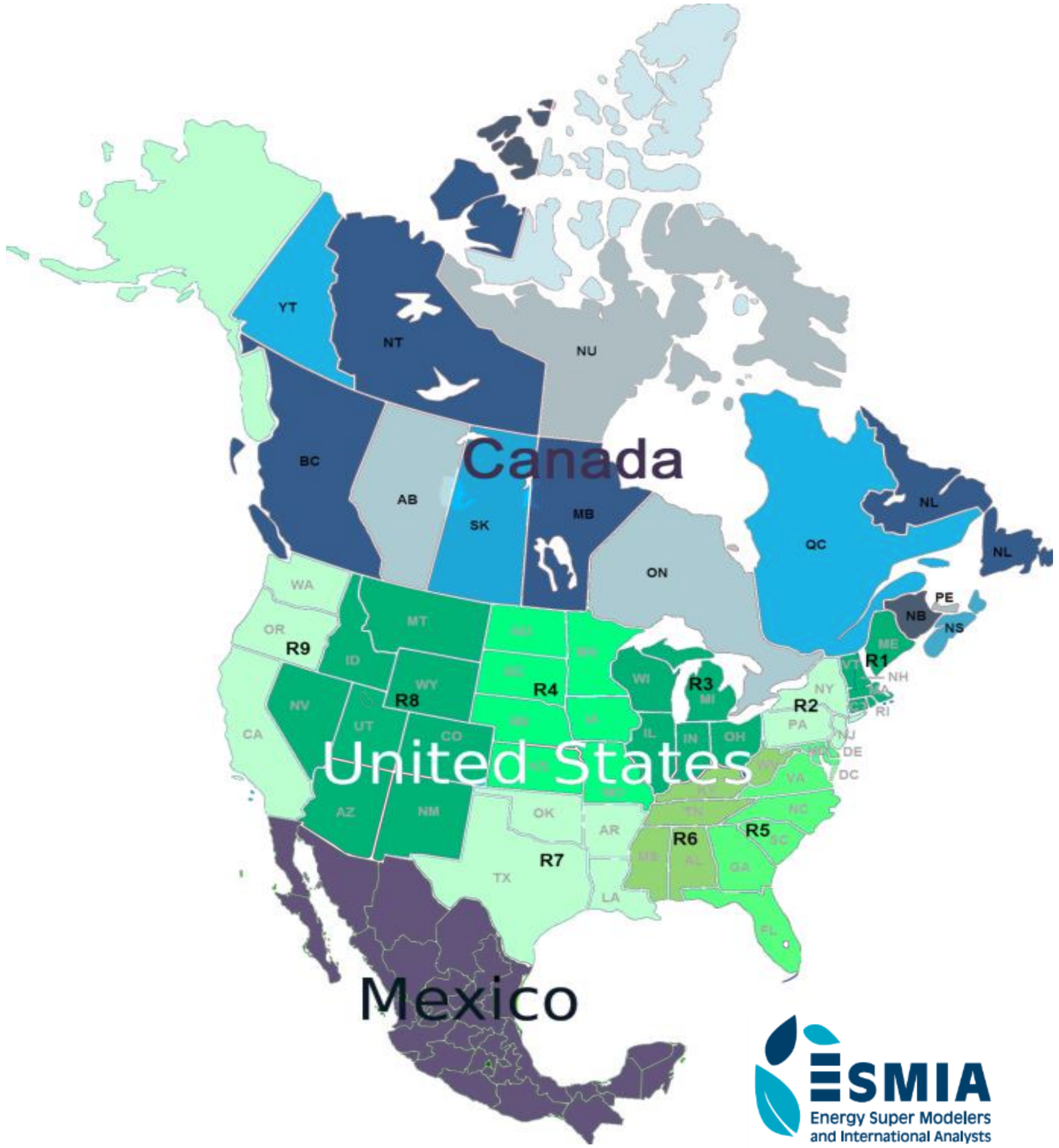
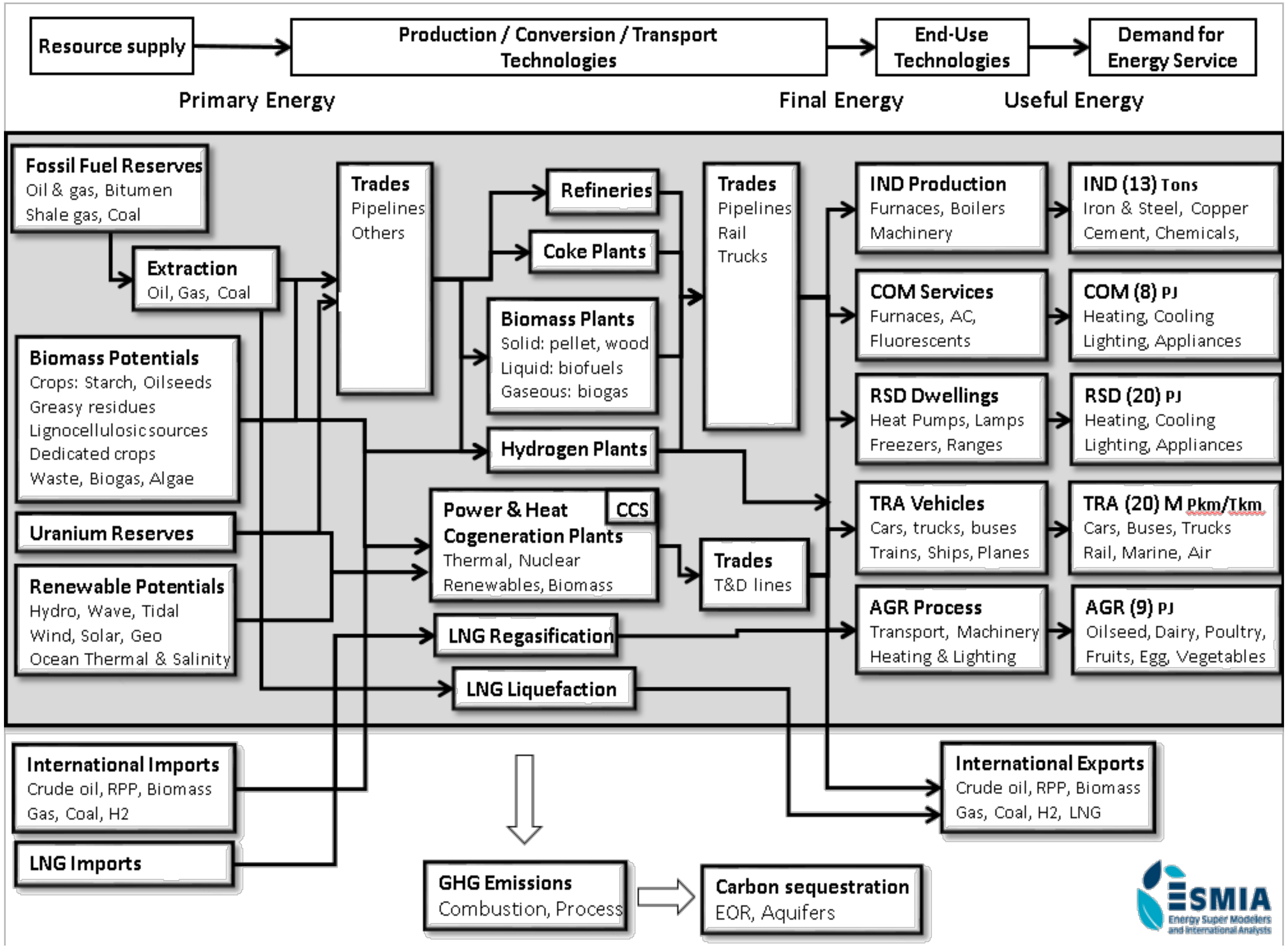




NATEM–CANADA



Canadian Energy Outlook
2018
horizon 2050

SCENARIOS

- **BAU** : Business-As-Usual or reference scenario
  Does not use GHG reduction targets and only incorporates current constraints
  Corresponds to the baseline scenario used in the NEB's "Canada's Energy Future 2017"

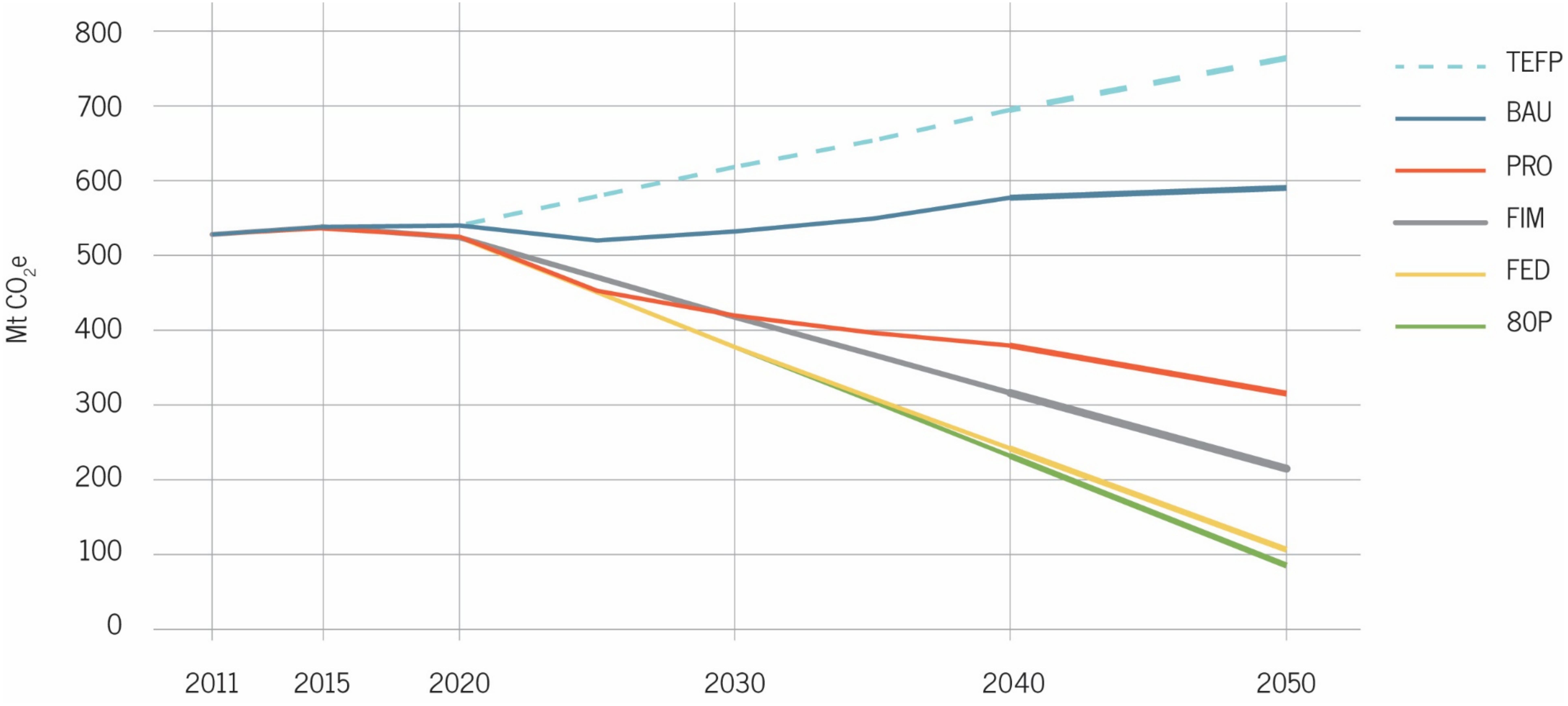
- **PRO** : Provincial scenario
  This reduction scenario imposes individual provincial targets for emissions – when they exist.

- **FED** : Federal scenario
  Uses federal government's stated 2030 and 2050 targets (30% and 80% reduction with respect to 2005)
  All reductions must be achieved domestically.

- **FIM** : Federal scenario with International carbon Market purchases
  Same as FED
  25 % of these reductions come from international carbon market purchases, in line with Canada's recent 7th National Communication and 3rd Biennial Report submitted to the United Nations Framework Convention on Climate Change.

- **80P** : 80 Percent scenario
  80% reduction by 2050, but this time from 1990 levels, (83% reduction with respect to 2005)

EVOLUTION OF GHG EMISSIONS



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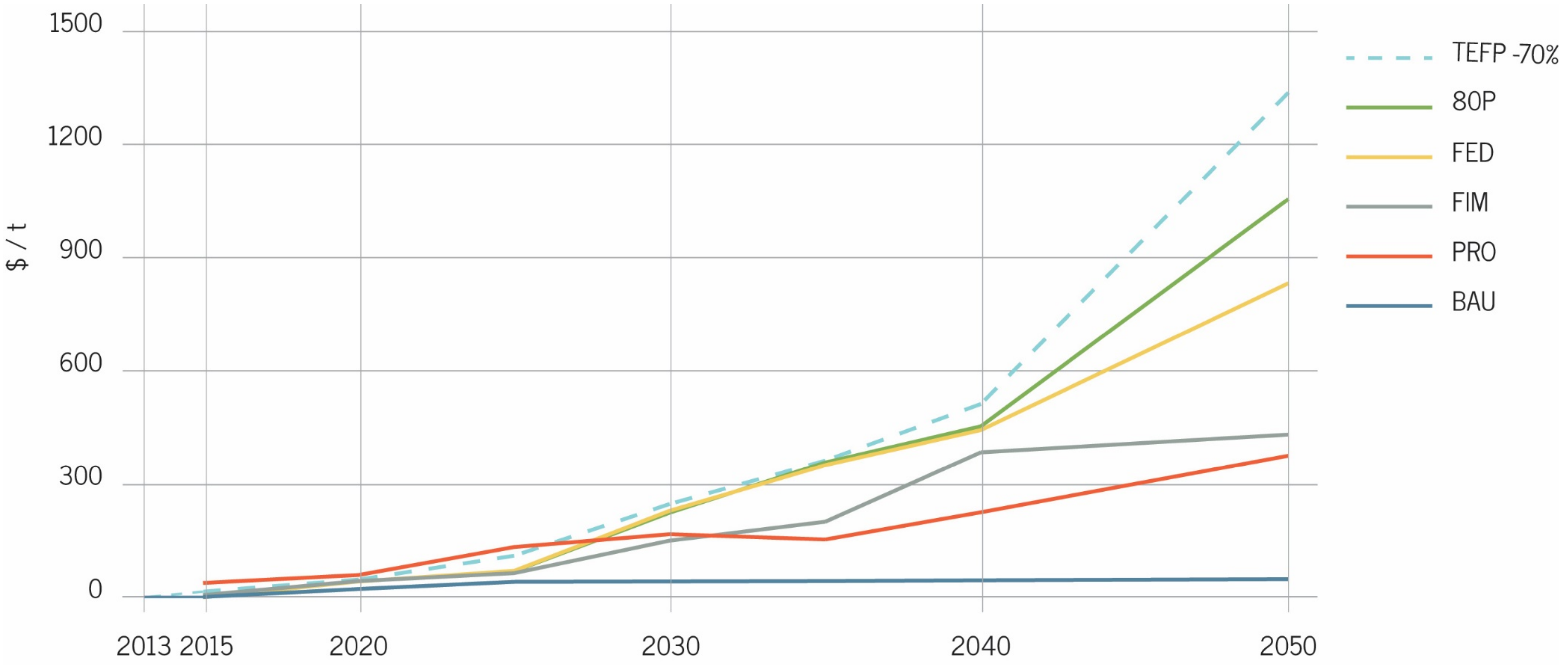
MARGINAL REDUCTION COSTS



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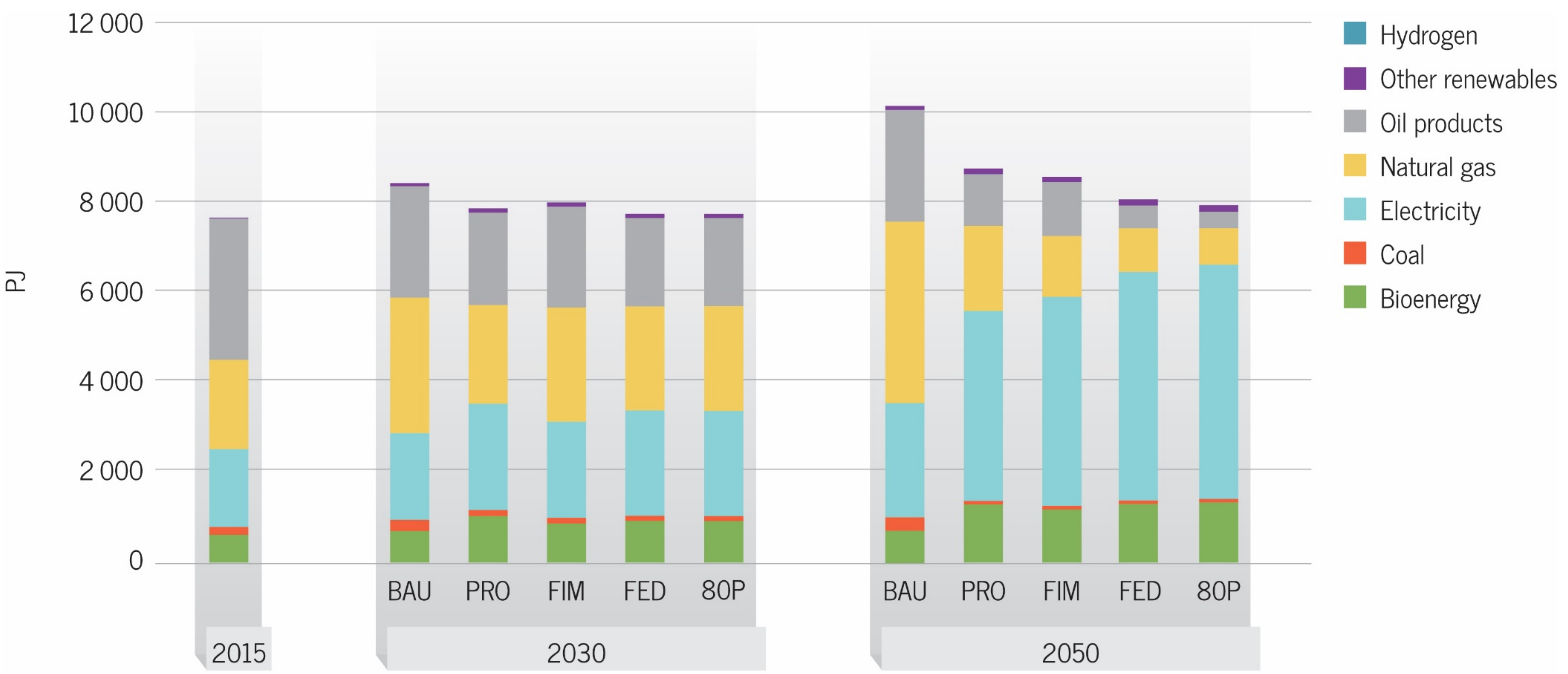
DEMAND EVOLUTION



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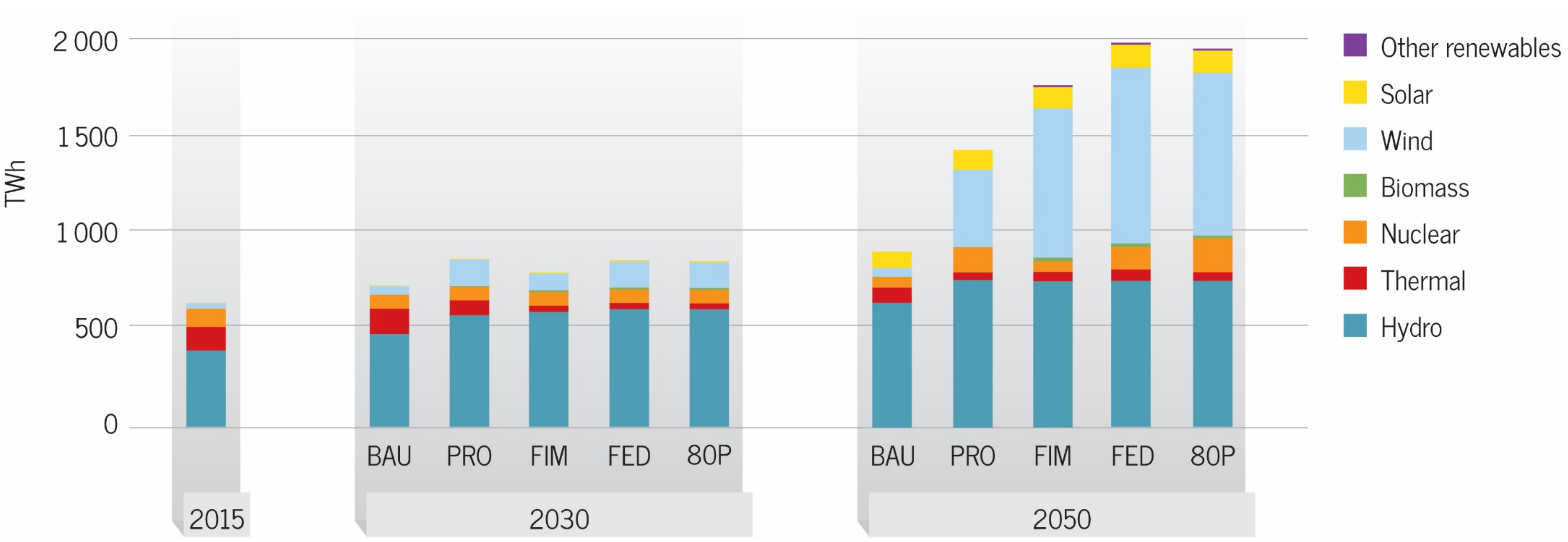
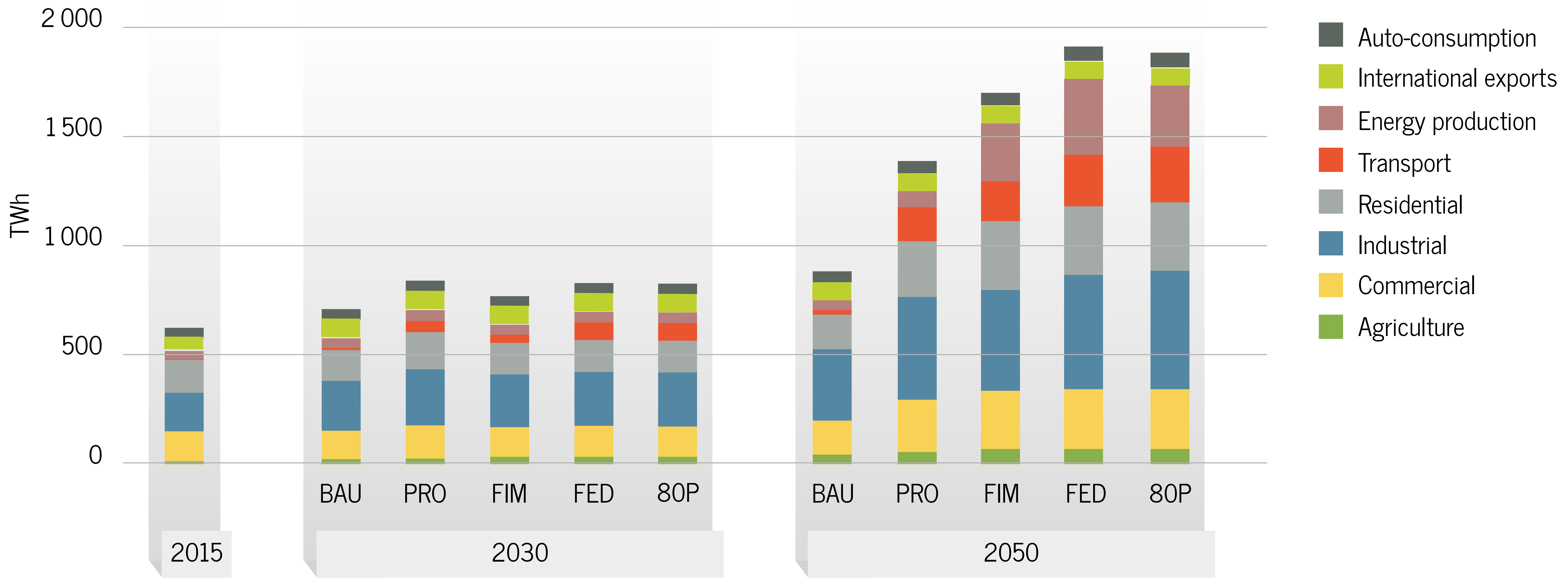
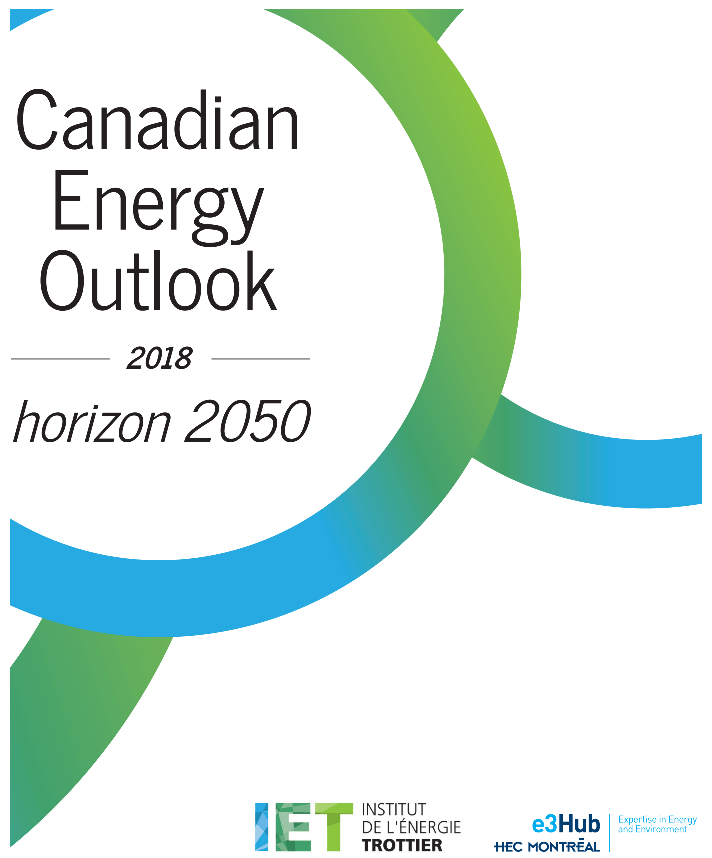
THE EVER GROWING ROLE FOR ELECTRICITY



THE EVER GROWING ROLE FOR ELECTRICITY





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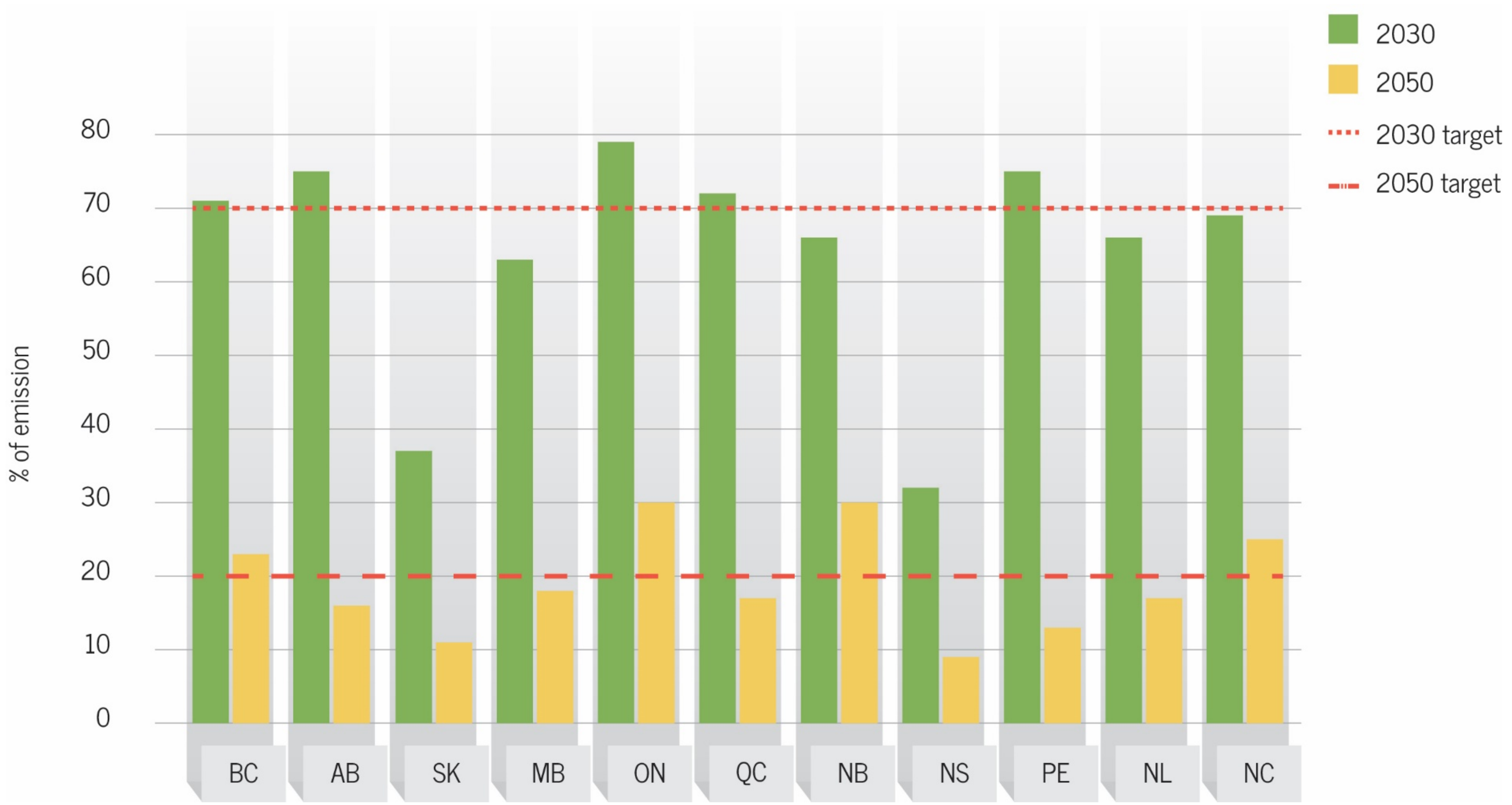
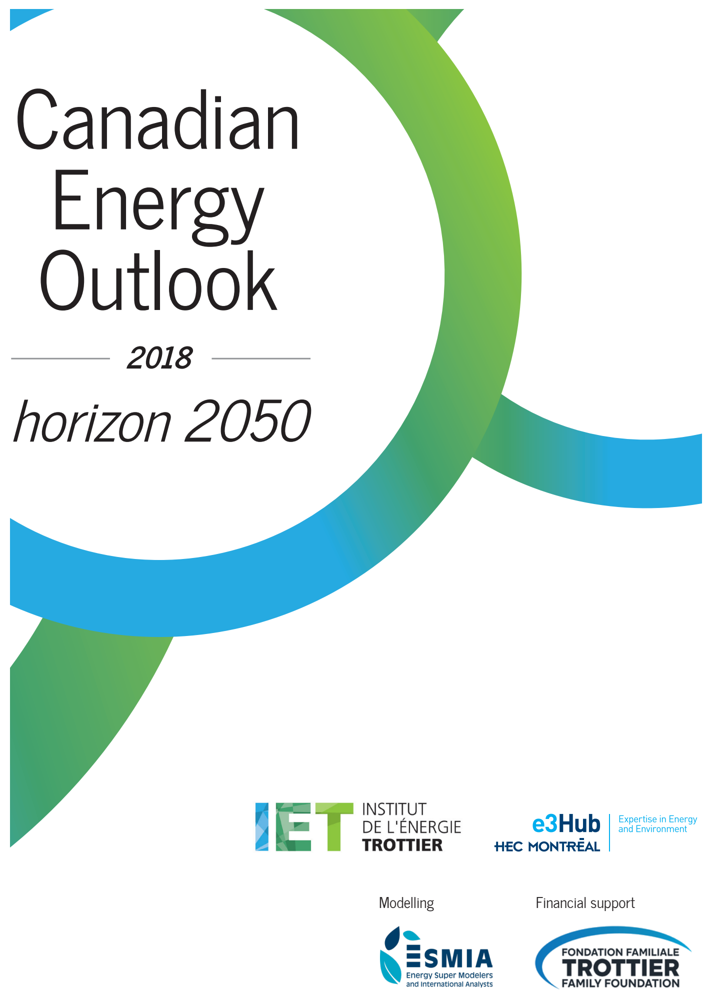
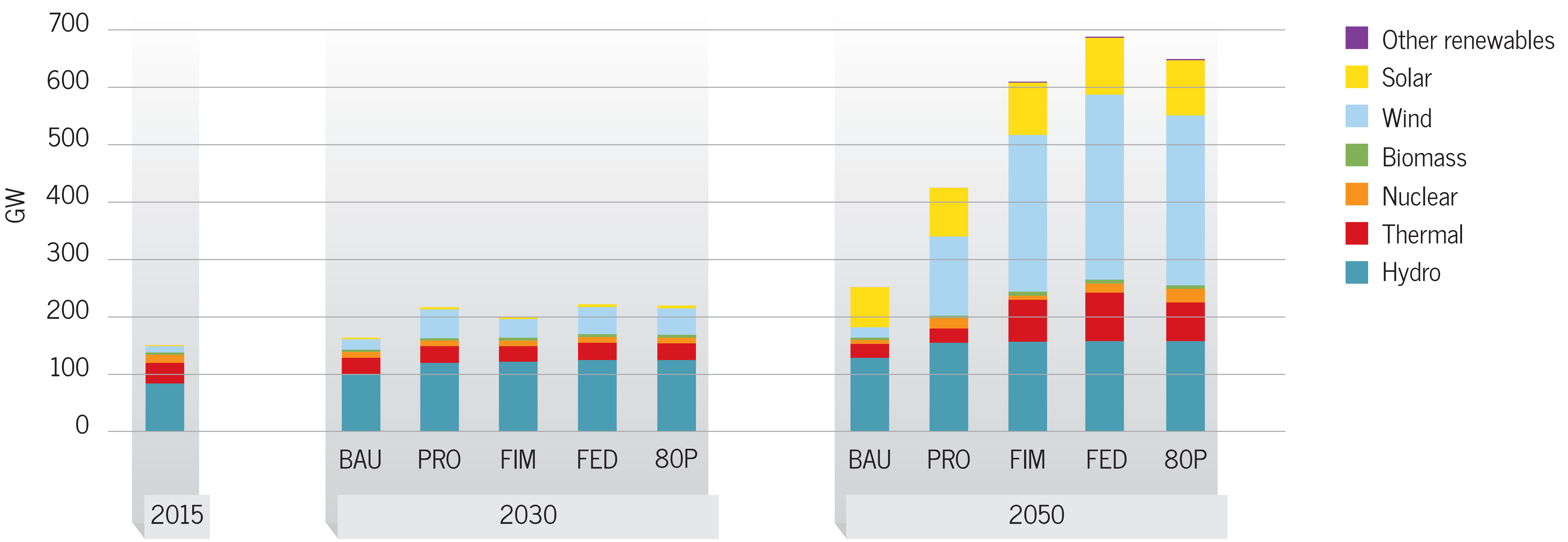
PROVINCIAL REDUCTION EFFORTS





ELECTRICITY INSTALLED CAPACITY BY ENERGY SOURCE



Canadian Energy Outlook

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KEY TRENDS (ELECTRICITY)

- ***The electrification of the Canadian energy system is almost unavoidable.*** *Its final shape, however, remains much more undefined due to a number of current hurdles and competing trends, including the capacity to for provinces to work together.*
- ***The role of self-generation in the electrification process is very much an open question at present****. Scenarios presented here lack the information to account for this aspect. However, as observed in other countries, the tipping point required for citizens and businesses to install rooftop PV is near*

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Some General Key Points

- General lack of detail on how to achieve the stated objectives.
- Even if current policies work as intended, Canada will still fall short of its 2030 GHG reduction target by 30%.
- As recent developments have shown, disagreements between the provinces and the federal government will add to the difficulty.
- This inconsistency creates a climate of uncertainty that prevents Canada from taking advantage of the economic opportunities of transition.
- Many promising avenues for the federal government to facilitate cooperation on challenges that cut across provinces.

Conclusions

Unless Canada's energy pathway becomes clearer, it will remain difficult for investors to accurately evaluate the costs of the various options and to make the most cost-effective decisions from both short- and long-term perspectives.

A long-term vision from a public dialogue is needed to fill the gaps in current political efforts and realize the enormous potential of this transformation.