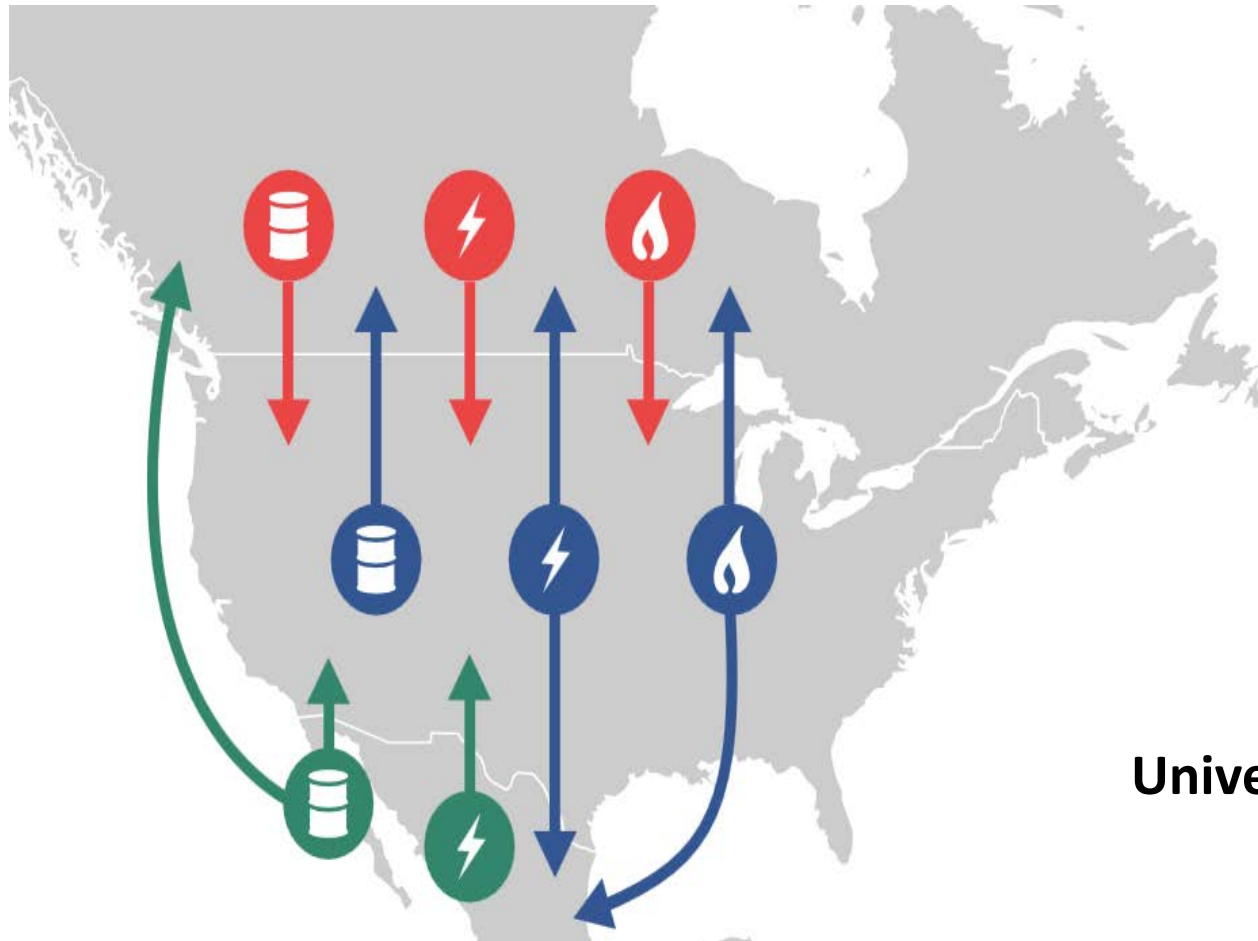


North American Energy Trade and Integration



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Stanford University

3rd Dundee Energy Forum

10-11 JUNE 2019

Centre for Energy, Petroleum and

Mineral Law and Policy

University of Dundee, Dundee, Scotland

Background



- Stanford EMF began holding a series of workshops on North American energy trade and integration in 2017 (<https://emf.stanford.edu/projects/emf-34-north-american-energy-trade-and-integration>).
- Closely coordinated with a framework for trilateral consultation and sharing of energy information initiated by the Energy Secretaries and Minister from Canada, Mexico, and the United States in December 2014. (<http://www.nacei.org/en/>).
- Remarks will describe EMF's effort and provide a few summary results as examples.

What does Stanford EMF do?



- Communication bridge between model developers and users
- Each study brings together leading experts and advisors from universities, research organizations, government and corporations
- Develop standardized scenarios with common input assumptions
- Compare results from different models
- Discuss portable insights for informing and making policies

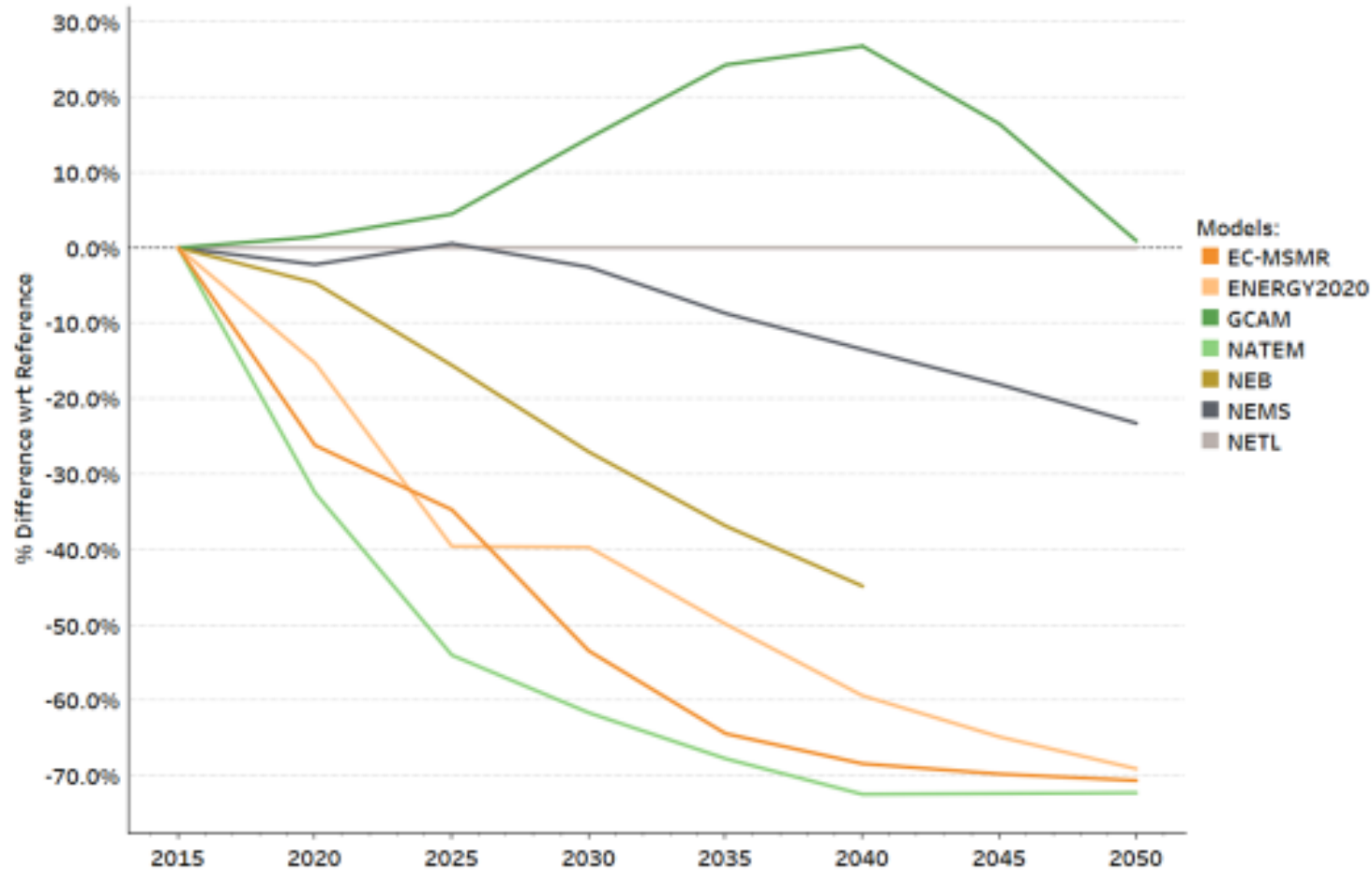
What are the goals of the current workshops?



- Promote collaboration between the three federal governments and other interested groups to better understand:
 - the availability of existing data,
 - the opportunities for developing new metrics meeting investors' and policymakers' needs, and
 - the sharing of market insights that flow from numerous analytical models and frameworks.

Canadian oil production response to lower price

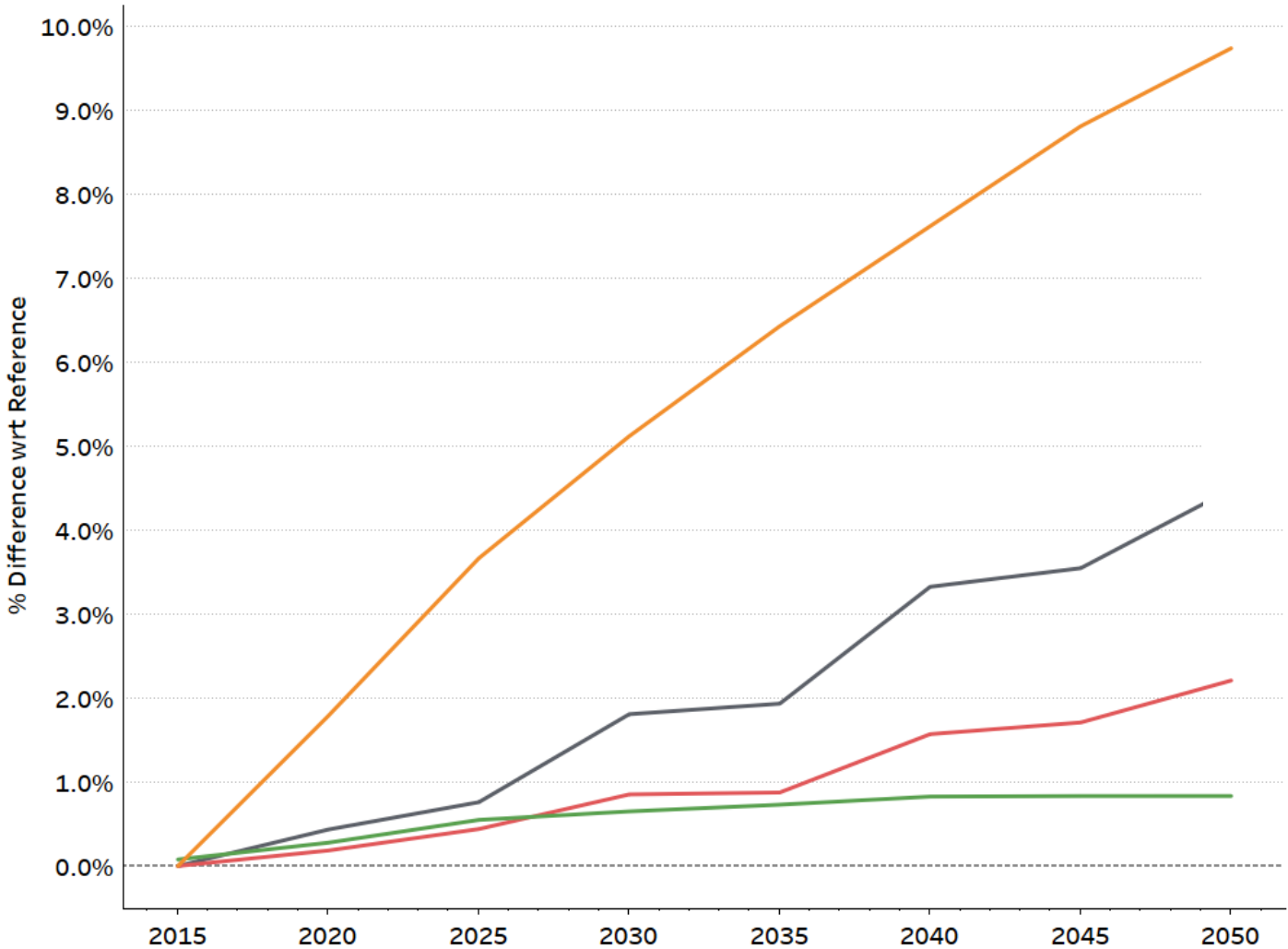
% Difference in Canada Crude Oil Production- Low Price Scenario wrt Reference Scenario



Production Response
(Elasticity) in 2040:
Canada 0.69
USA 0.30
Mexico 0.20

USA Natural Gas Production Response to Higher Prices

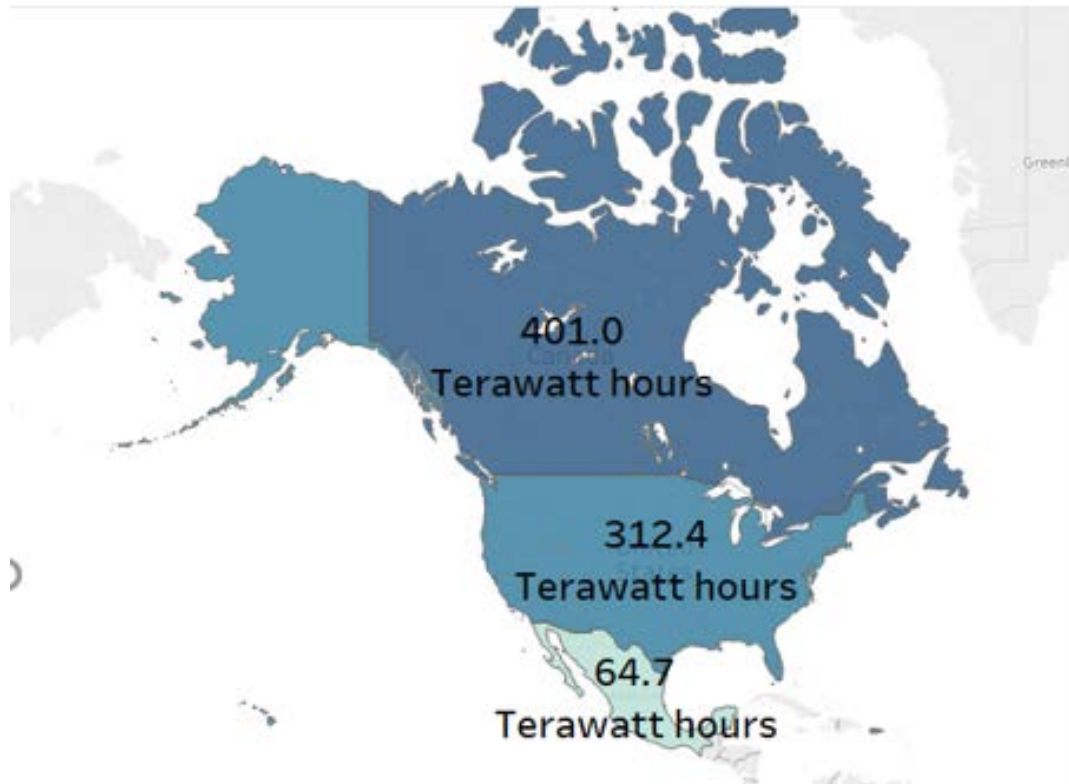
% Difference in USA Natural Gas Production- All HiMacro Scenario wrt Reference Scenario



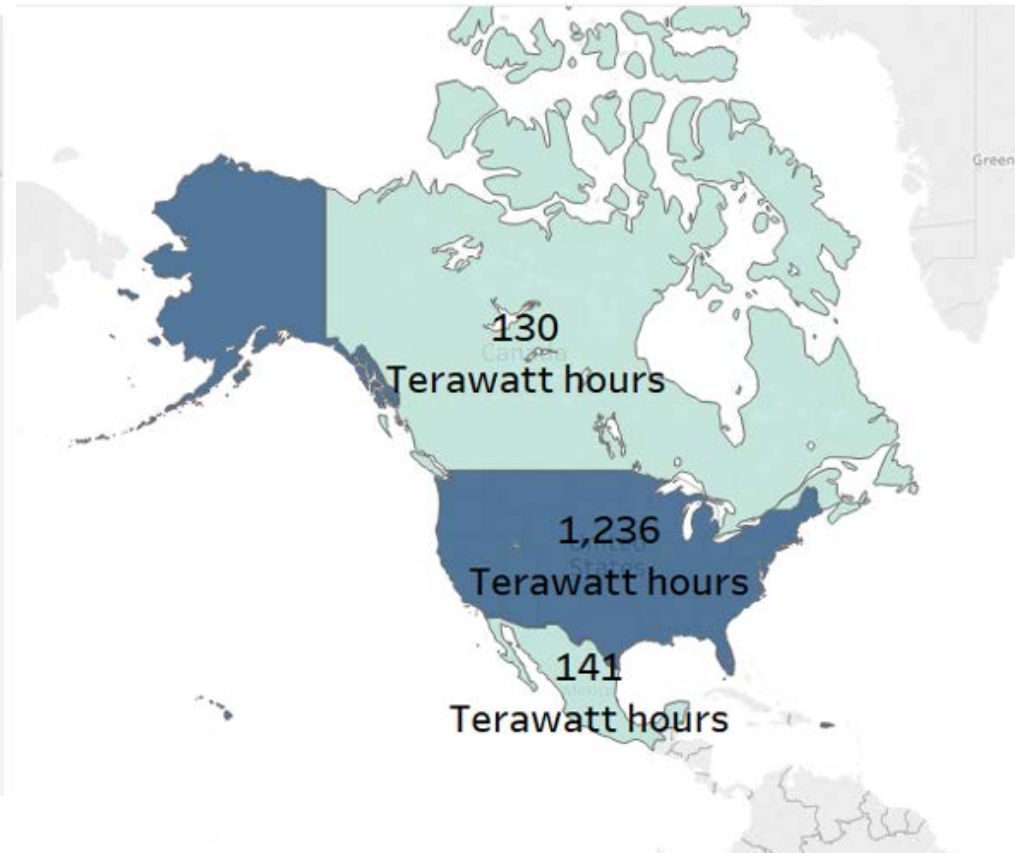
| Production Response (Elasticity) in 2040: | |
|---|------|
| USA | 1.15 |
| Canada | 1.21 |
| Mexico | 1.00 |

Power Generation in High Renewable Case

Hydroelectric Generation, 2040

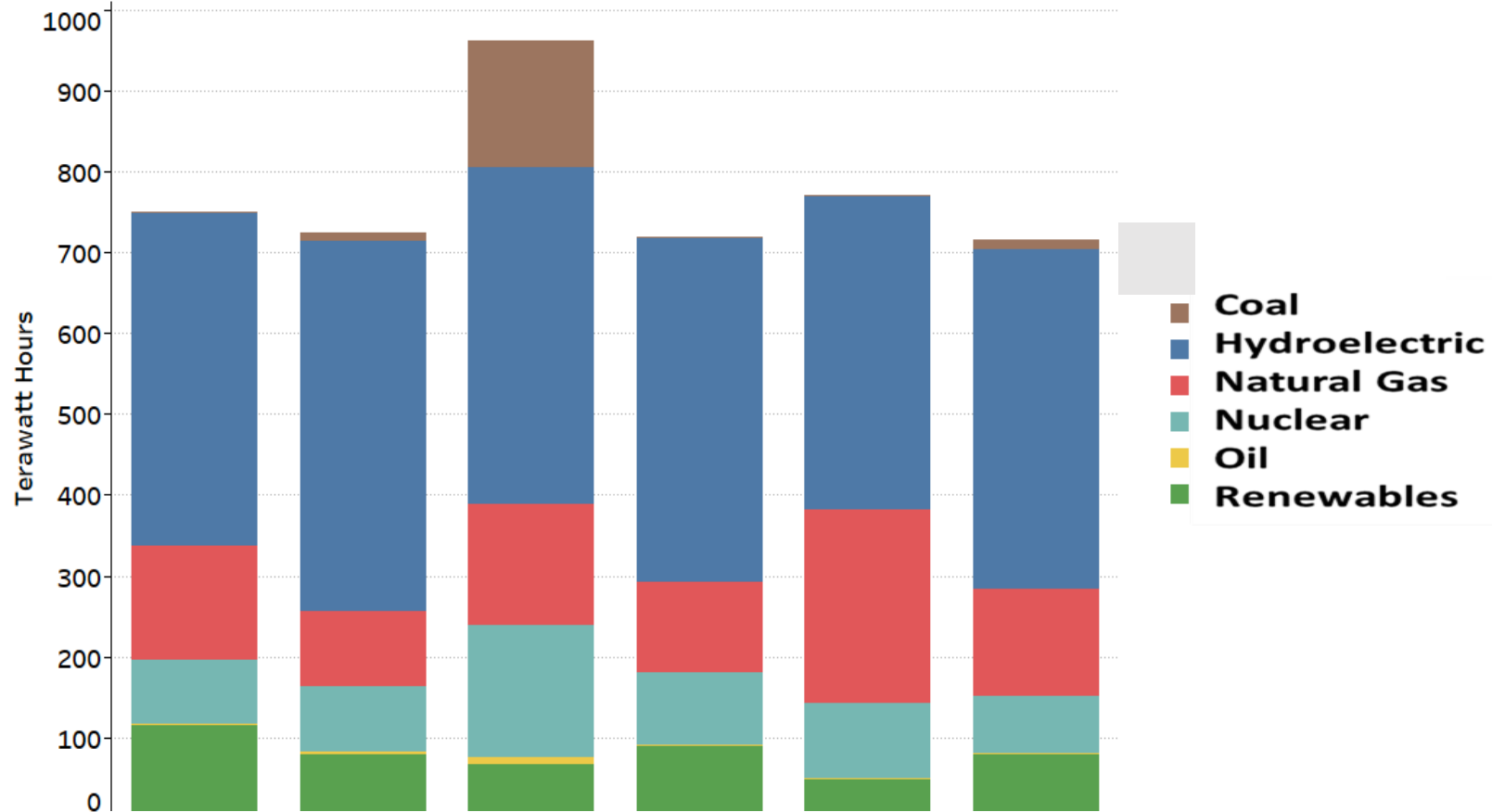


Renewable Generation, 2040



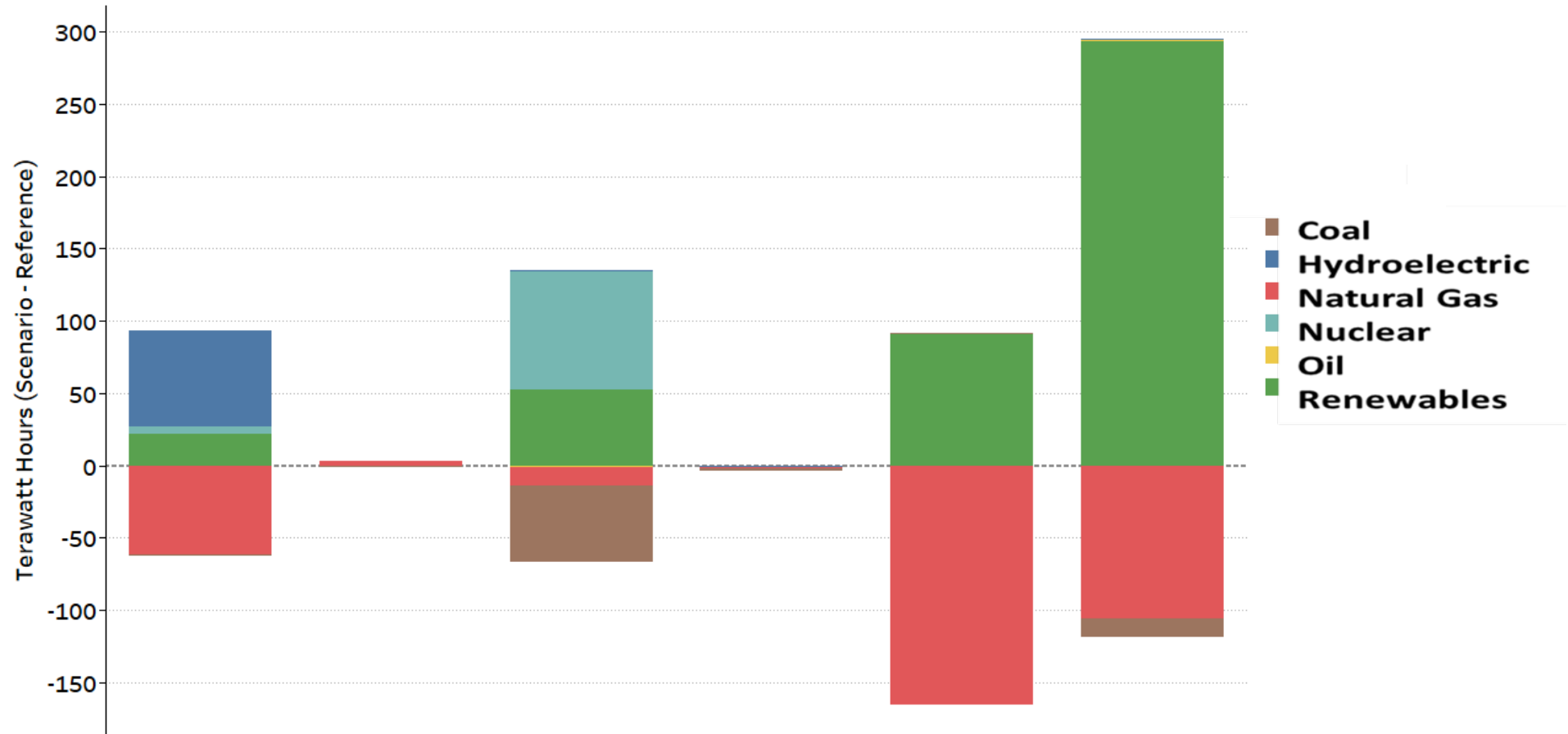
Hydro Dominates Canadian Power

Canada Electricity Production in 2040- Reference Scenario



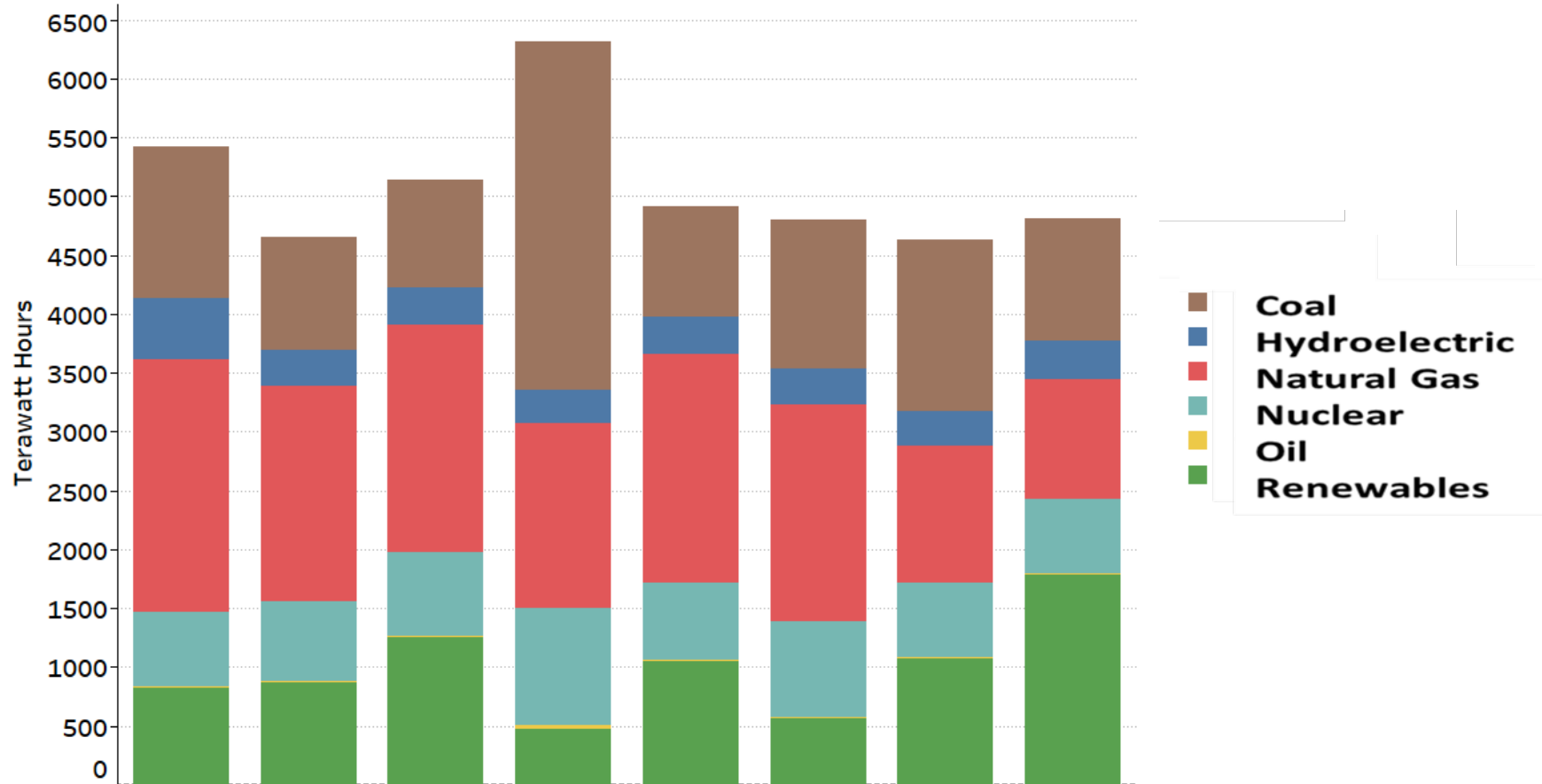
Carbon Price Displaces Gas & Coal

Difference in Canada Electricity Production in 2040- Carbon All vs. Reference Scenario



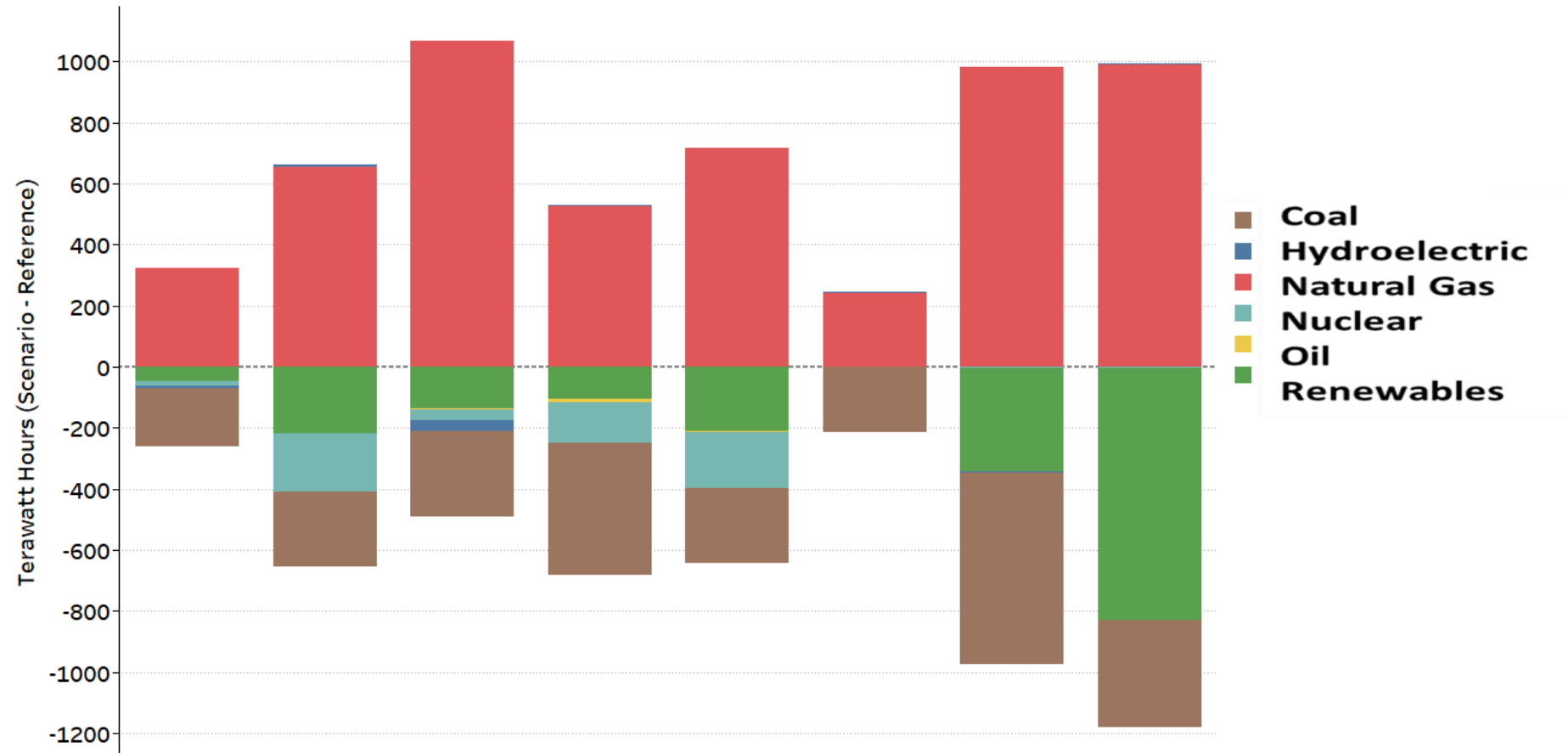
Coal & Gas Dominate USA Power

USA Electricity Production in 2040- Reference Scenario



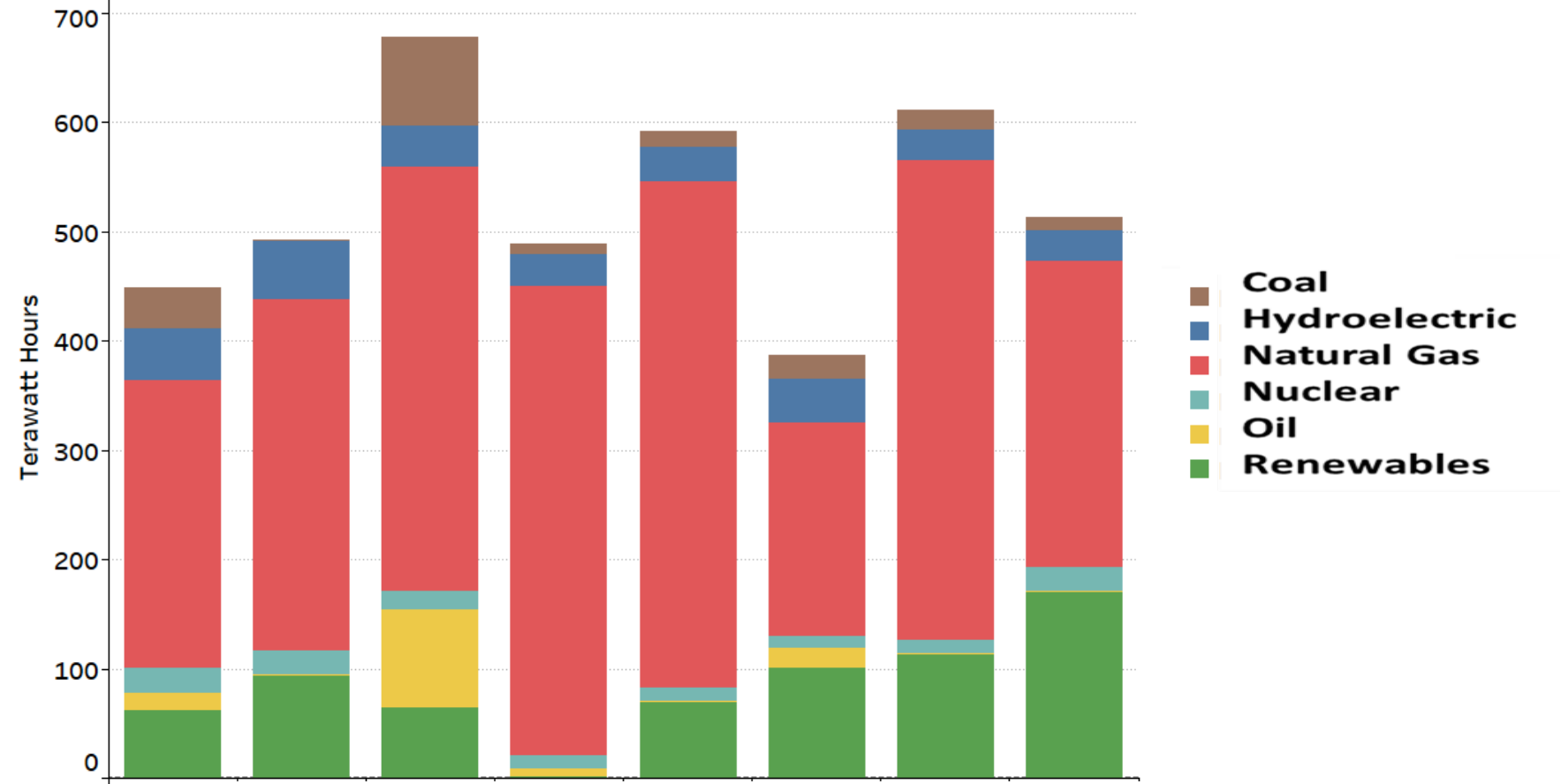
Abundant Gas Displaces RNs and Coal

Difference in USA Electricity Production in 2040- Hi Gas Supply vs. Reference Scenario



Gas Dominates in Mexican Power

Mexico Electricity Production in 2040- Reference Scenario



High RNs Displace Gas

Difference in Mexico Electricity Production in 2040- Hi Renewables vs. Reference Scenario



Regional Coordination Reshapes Power Mixes

- Group considered 3 types of renewable policy coordination:
 - No coordination within regions of any country (California does not coordinate with New England, etc.)
 - Regional coordination within one country (California coordinates with New England but not with Alberta or Baja Peninsula, etc.)
 - 3-Country coordination within North American (All USA regions coordinate with all Canadian and all Mexican regions)
- More coordination reduces policy costs (esp. for USA) and boosts Canadian hydro (sunk fixed costs versus lower-quality wind/solar)
- Less coordination primarily displaces gas, the most competitive resource in many areas. Also nuclear & coal in some areas.

A Few Highlights (so far)

- North American fuel supplies are modestly responsive to prices
- Varying dependence upon fossil, hydro, nuclear and renewables in the three country power sectors
- Gas replaces coal/renewables when gas prices are lower
- Renewables replace gas/coal when carbon is priced
- Size of the response varies by model
- Regional coordination reshapes country power mixes