



# Modeling the Value of Integrated Canadian and U.S. Power Sector Expansion

Wesley Cole, Philipp Beiter, Daniel Steinberg

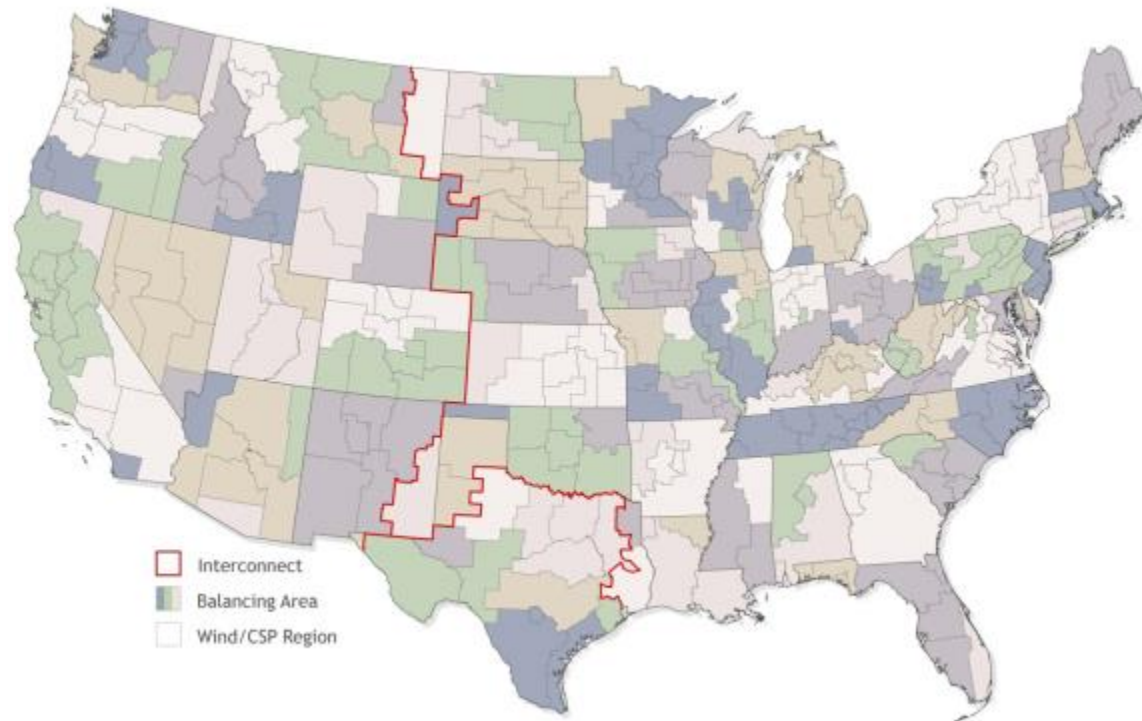
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# Outline

- ReEDS Model Description
- Background: U.S.-Canada Electricity System
- Scenario Descriptions
- Scenario Results

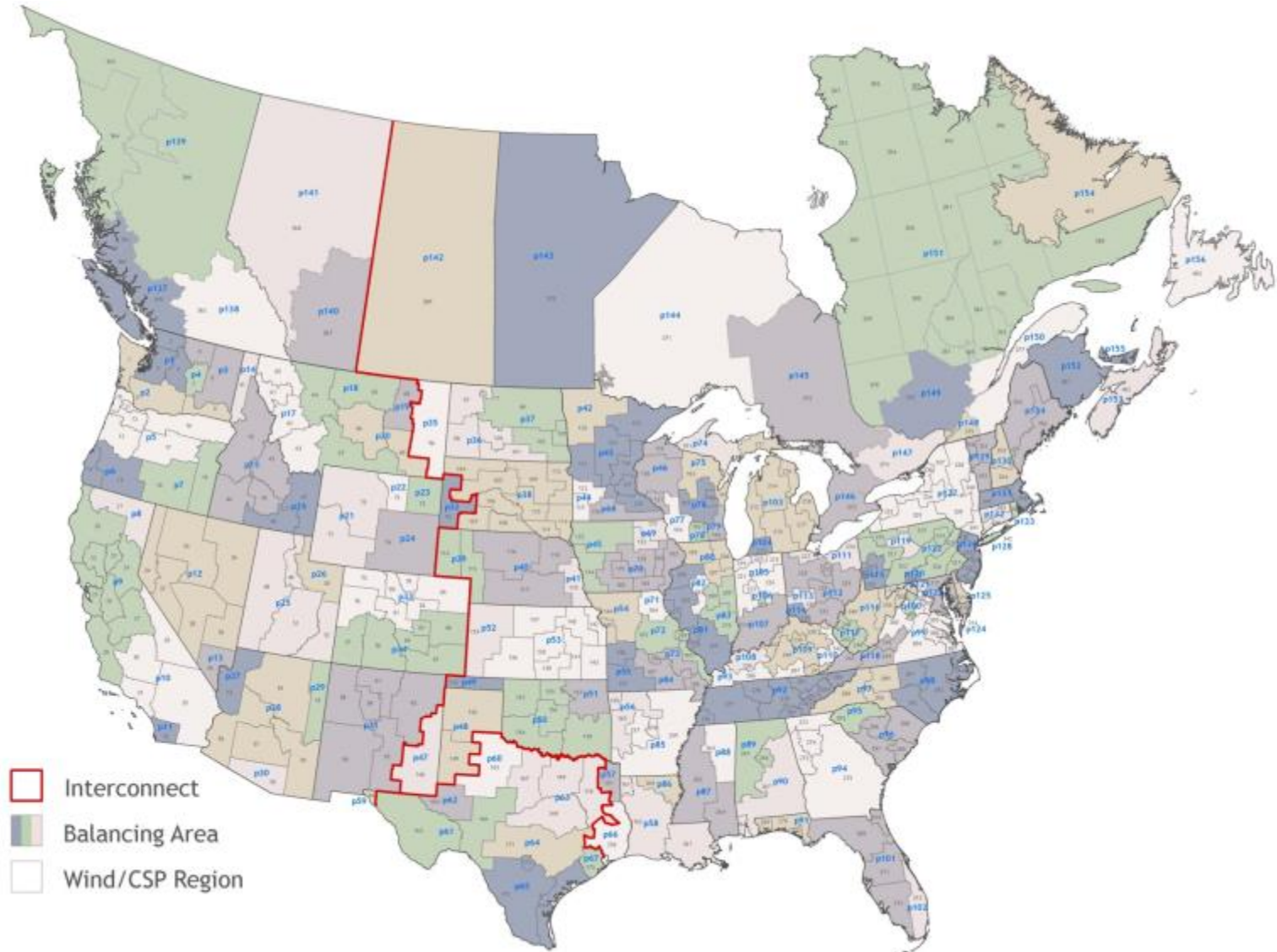
# Regional Energy Deployment System (ReEDS) Model



- Central-planning optimization model of U.S. Electricity Sector
- 134 Balancing Areas
- 356 Wind/CSP regions
- Explicit consideration of RE integration issues
- Solves combined capacity expansion and dispatch out to 2050 under different assumptions
  - Economic
  - Technology
  - Policy

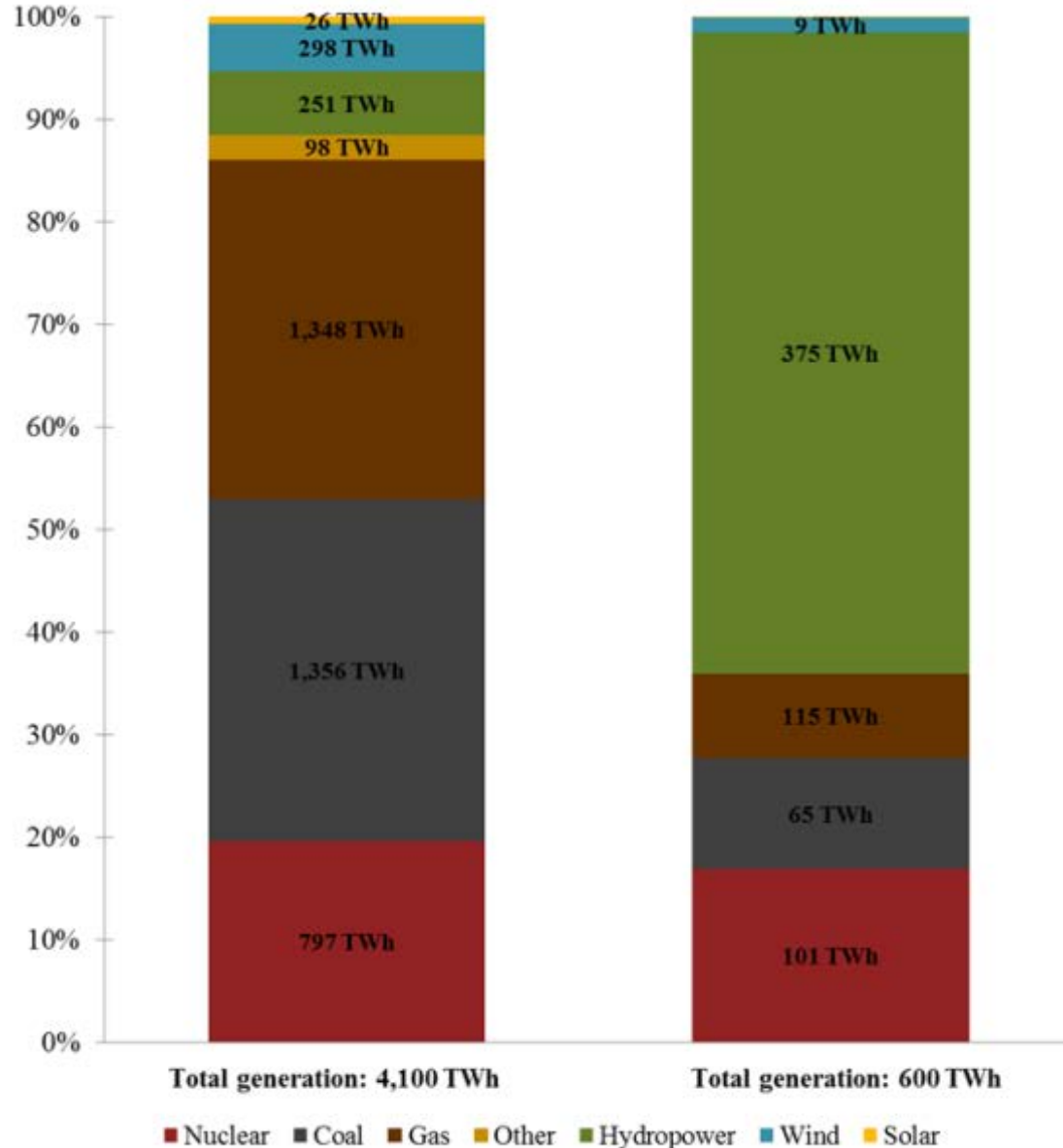
# ReEDS-Canada Model

- Extension of U.S. model; contains 156 regions



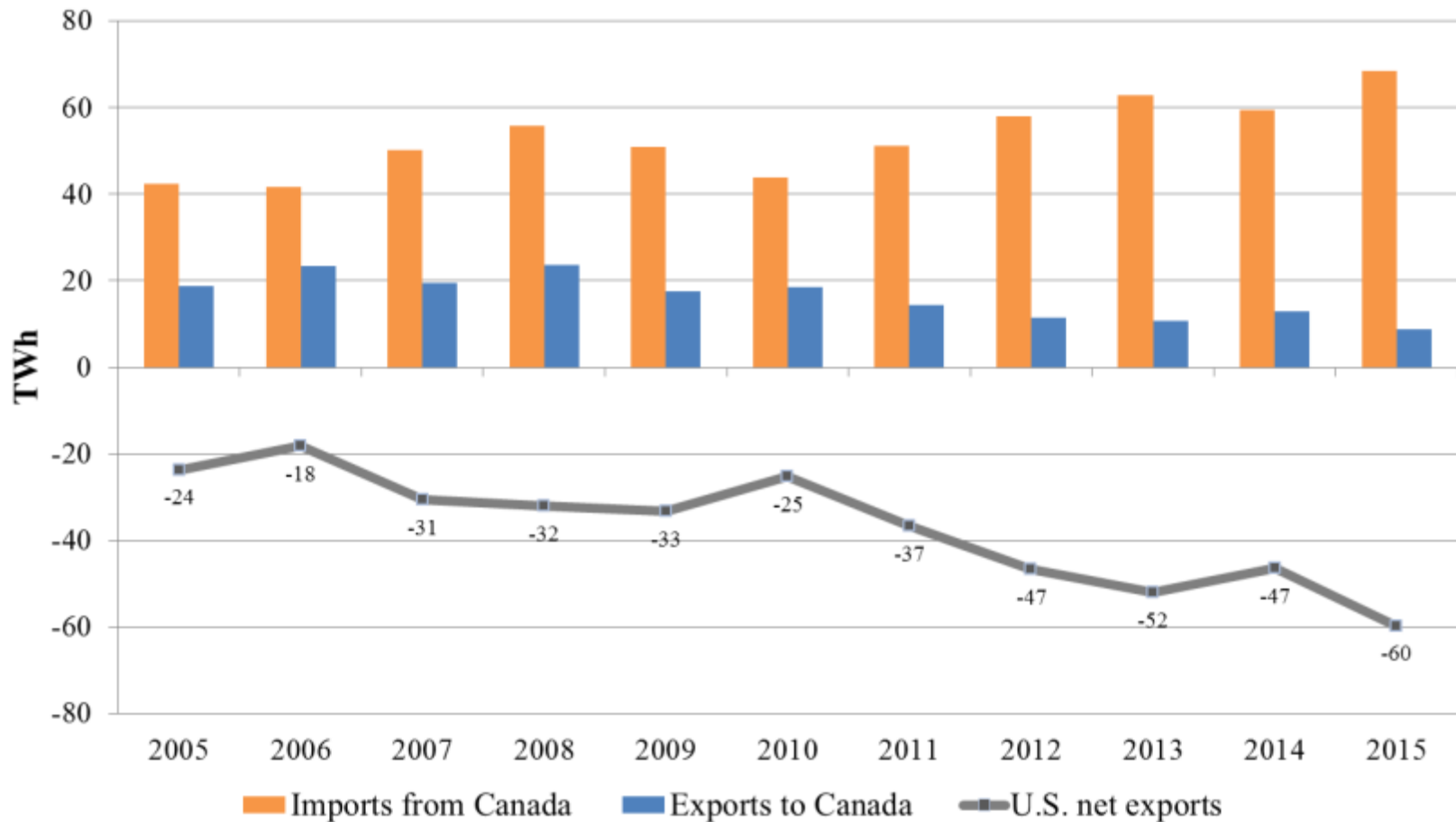
# U.S.-Canada System Configurations

- The U.S. system is ~6x larger than the Canadian system
- Canadian grid is largely decarbonized (80% of generation from carbon-free sources)
- Approximately 18 GW of existing transmission capacity between the two systems



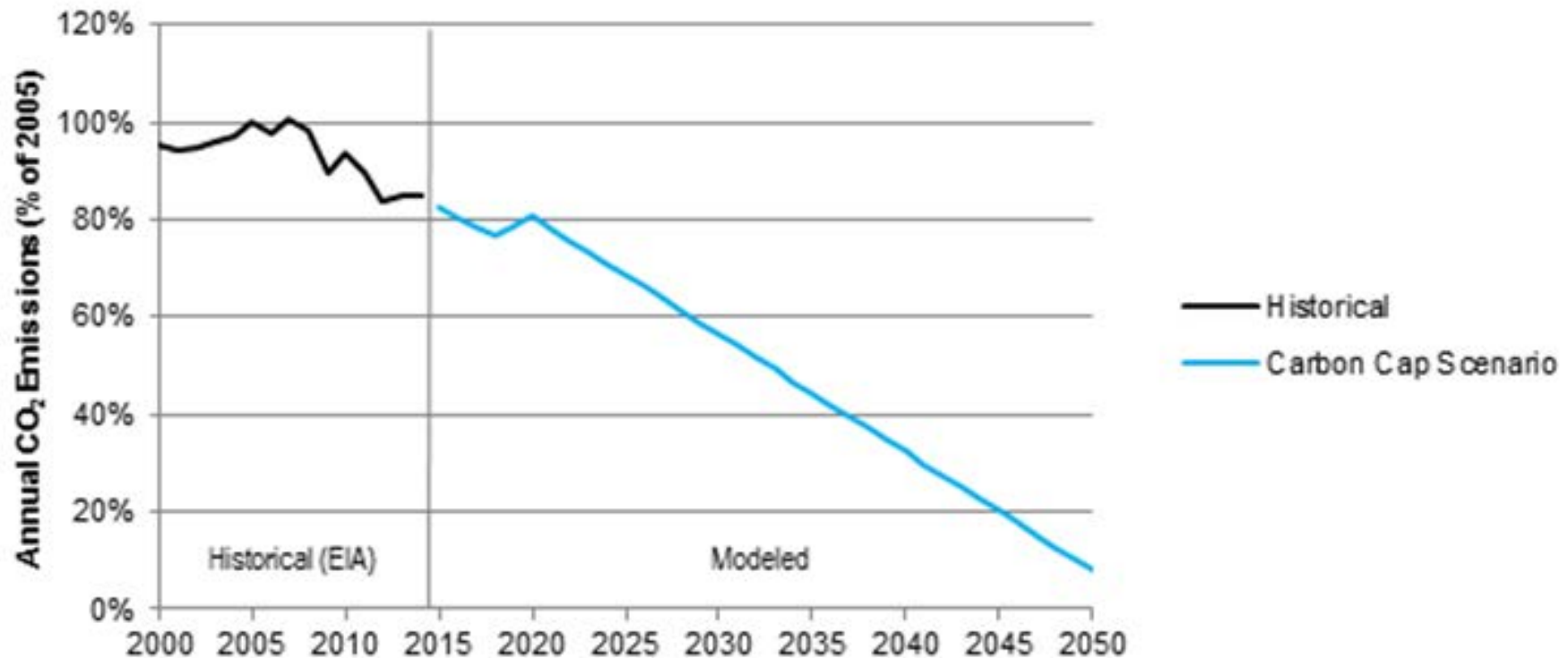
# U.S.-Canada Electricity Interchange

- Net power flow from Canada to U.S. has been increasing over the past decade



# Scenario Descriptions

- Reference: U.S. + Canada with “Business as Usual” assumptions – includes the Clean Power Plan
- Carbon Cap: 92% reduction in power sector CO<sub>2</sub> emissions from 2005 levels, beginning in 2020



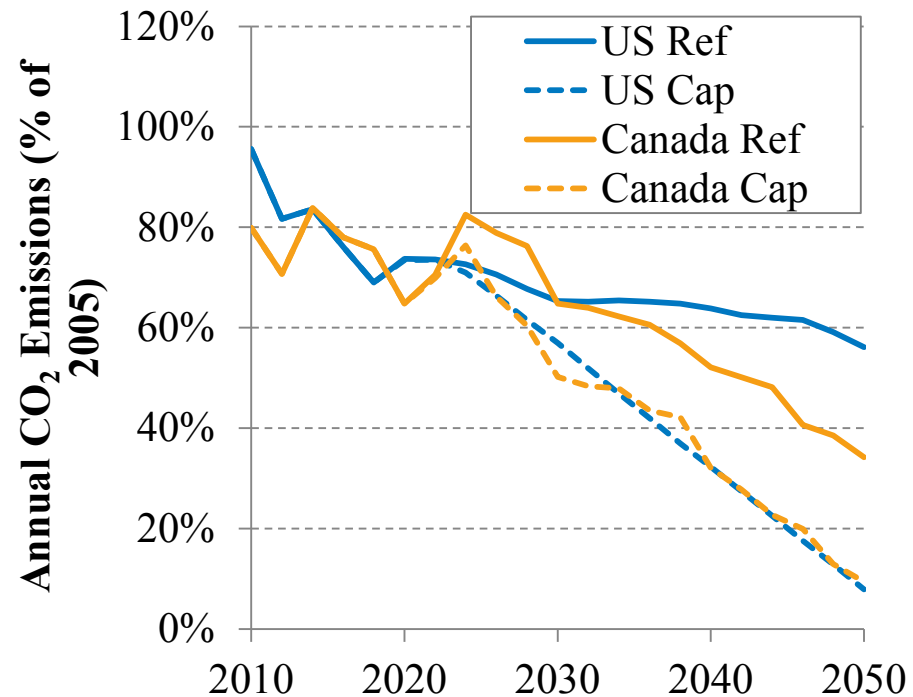
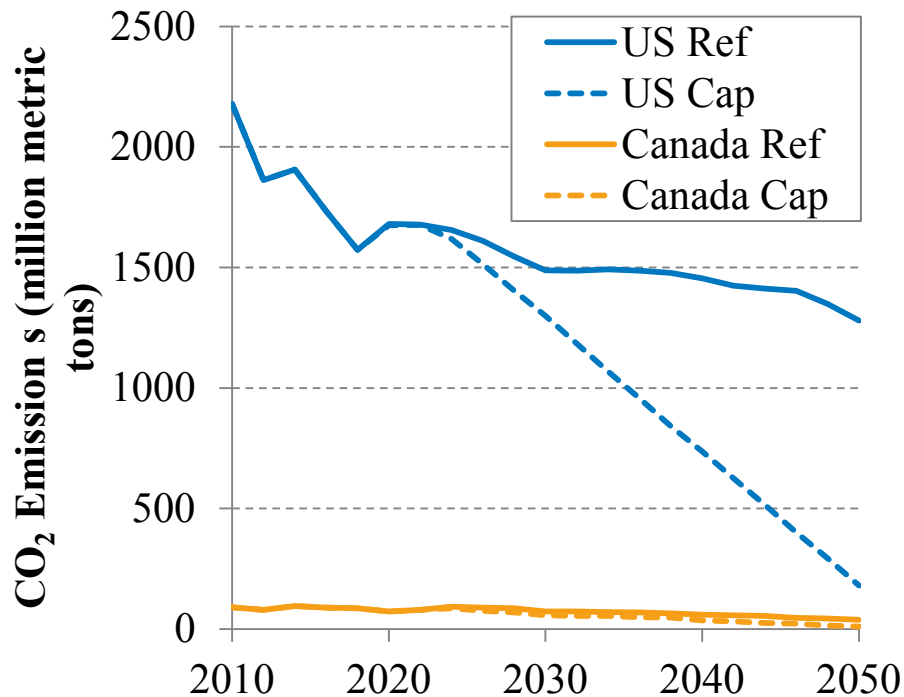
## Four Scenarios (abbreviated name in parenthesis):

1. Reference (Ref)
2. Reference + No New Cross-border Transmission (Ref – NoTrans)
3. Carbon Cap (Cap)
4. Carbon Cap + No New Cross-border Transmission (Cap – NoTrans)



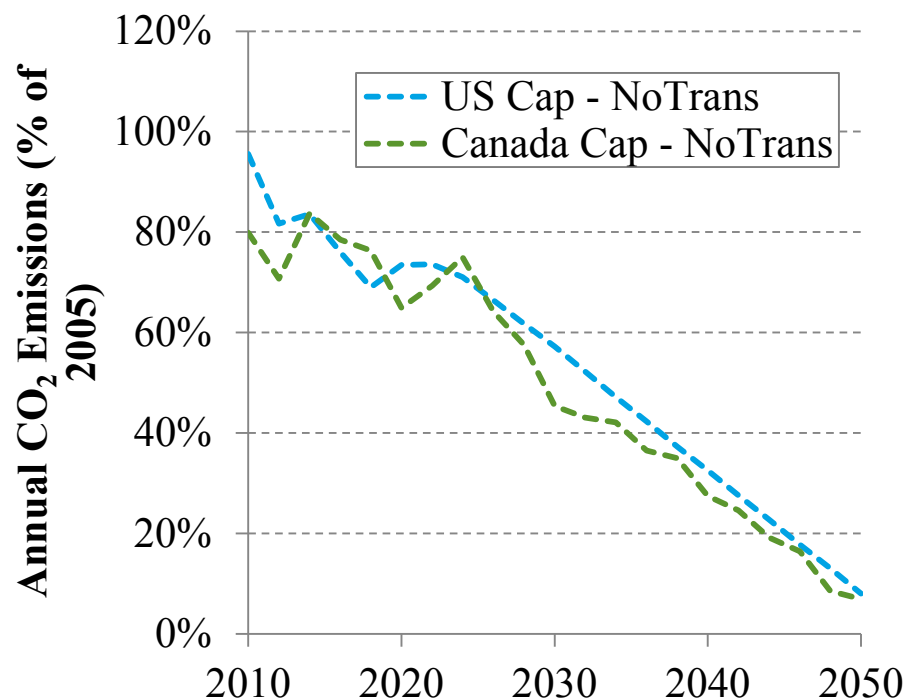
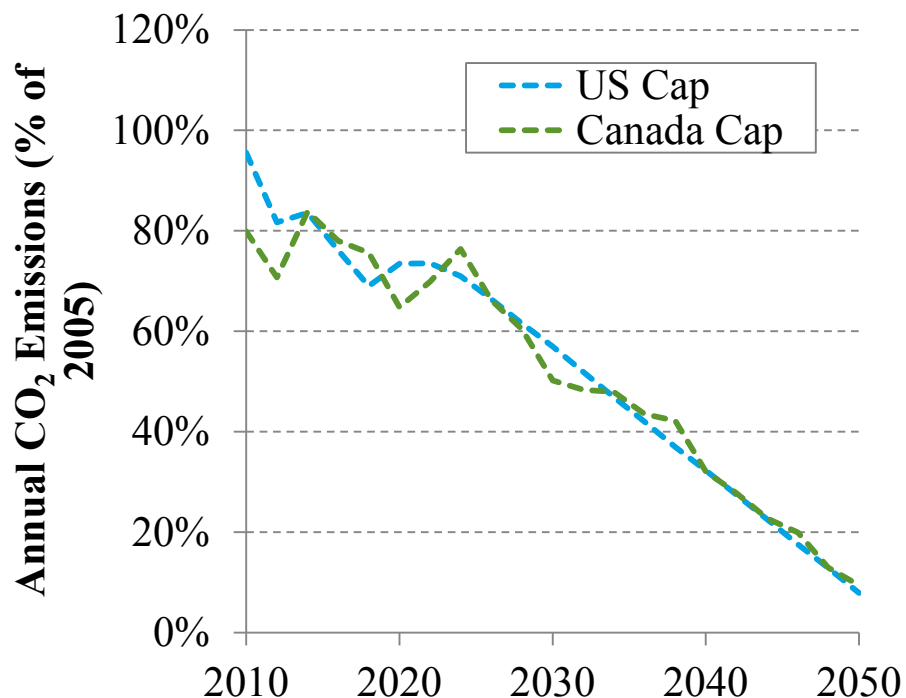
# CO<sub>2</sub> Emission Results: w/ New Transmission

- U.S. CO<sub>2</sub> emissions are 20x higher than Canadian emissions
- Without carbon cap, Canada has greater relative declines in long-term CO<sub>2</sub> emissions
- Relative long-term carbon reductions in each country are quite similar in carbon cap scenario



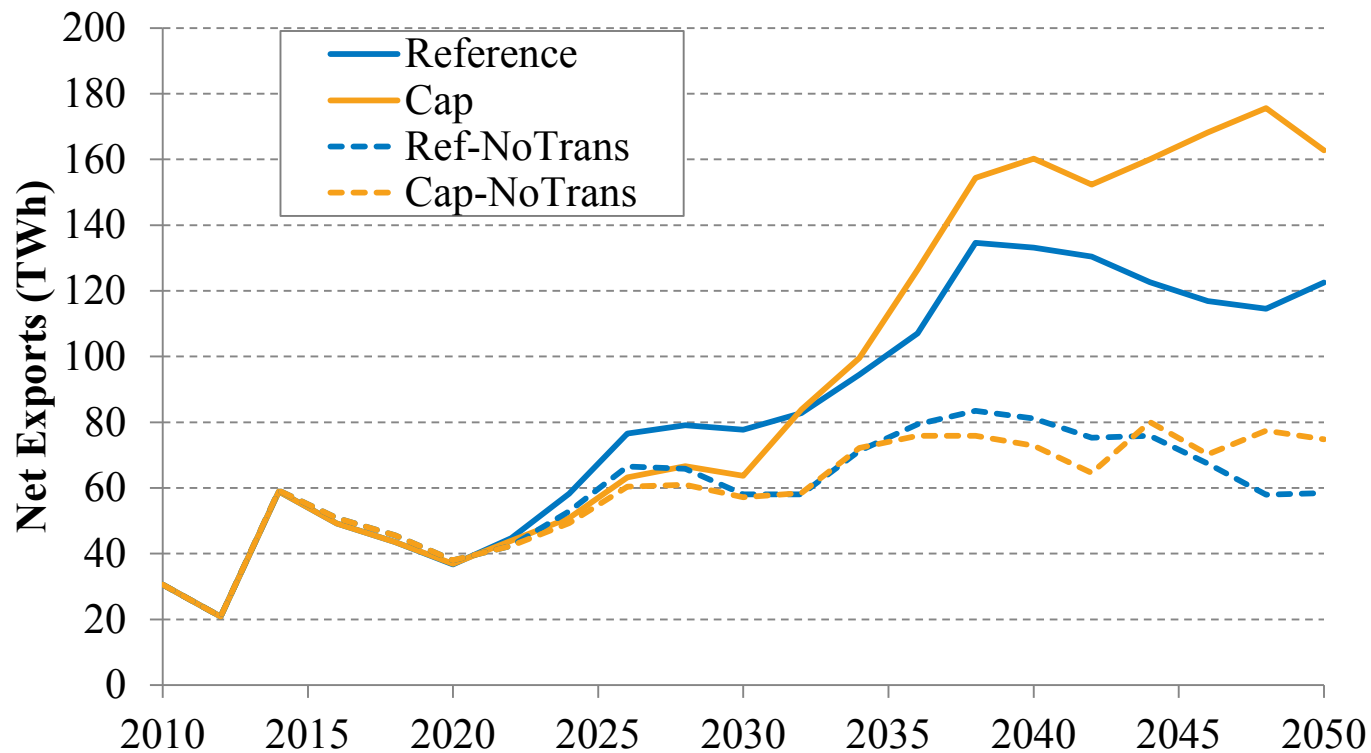
# Emission Impacts of No New Transmission

- Restricting transmission builds has little to no impact on country level emissions
- Canada's emissions are slightly lower in the noTrans scenario due to less combined cycle generation being exported to the U.S.



# Imports and Exports

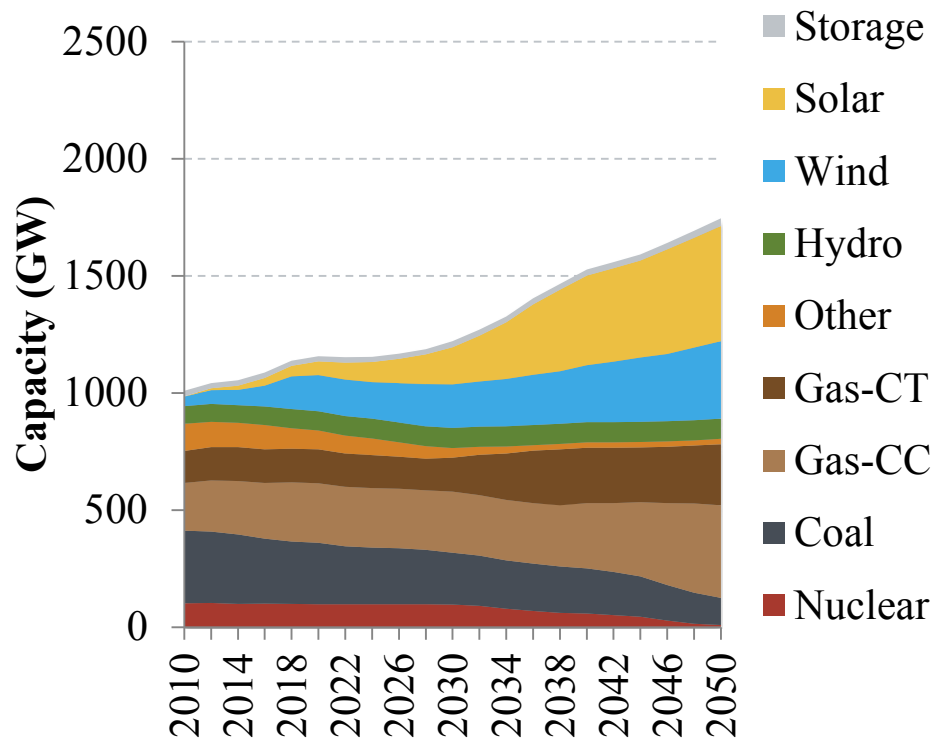
- Exports = Transfers from Canada to U.S.
- Long-term Canadian exports reduced by half with no new cross-border transmission



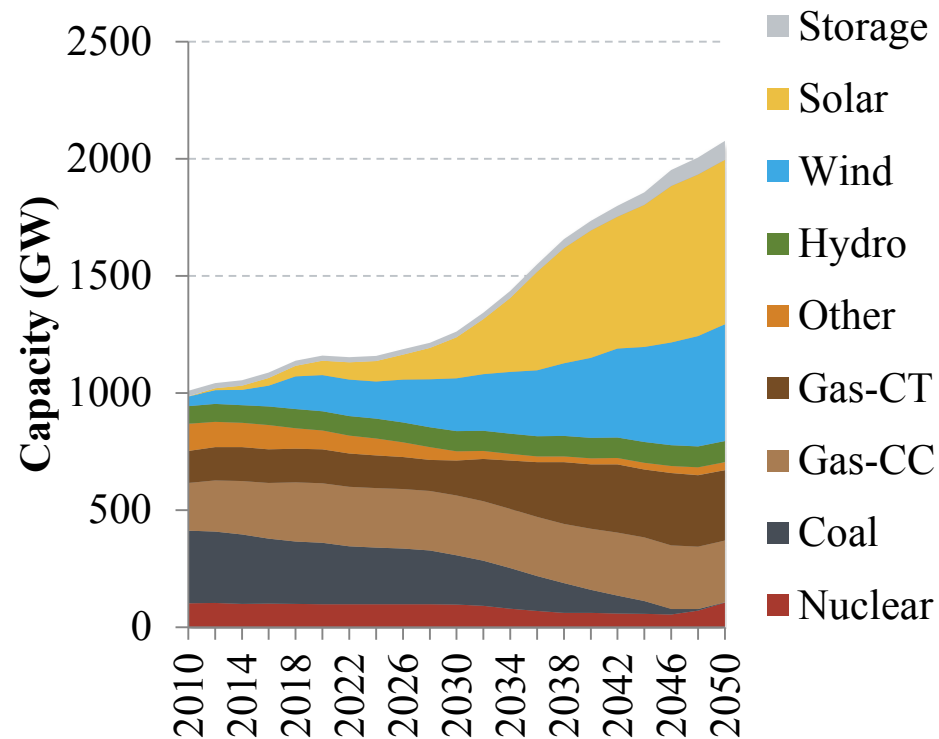
# U.S. Capacity Mix

- Carbon Cap leads to significant increases in RE capacity and reductions in coal
- 9 GW of Gas-CC-CCS is deployed

## Reference



## Carbon Cap

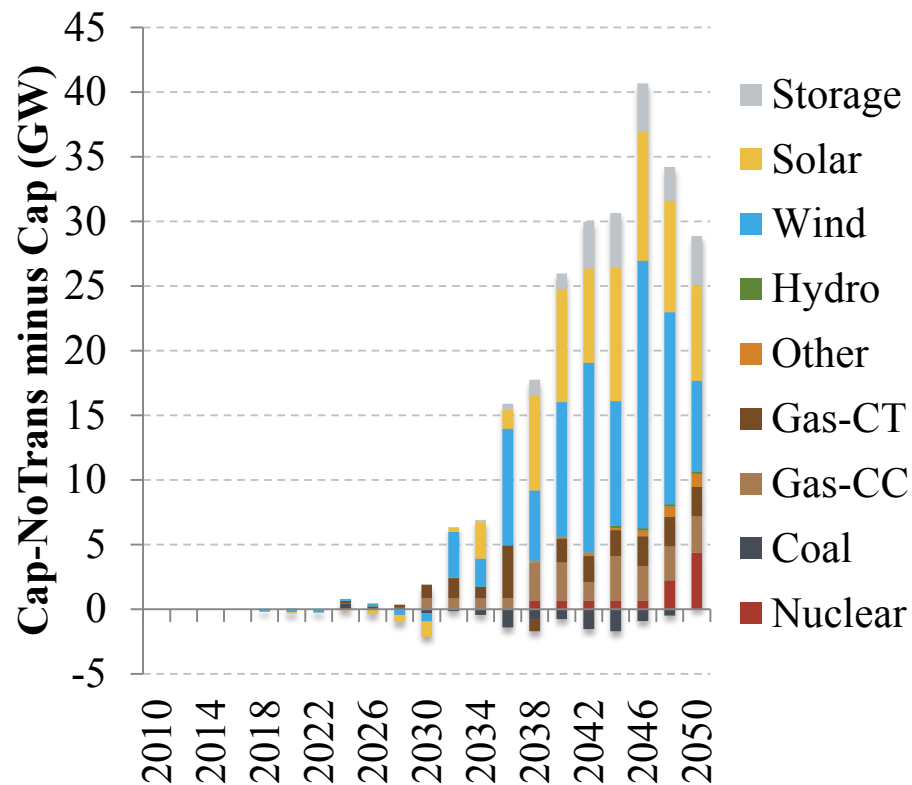
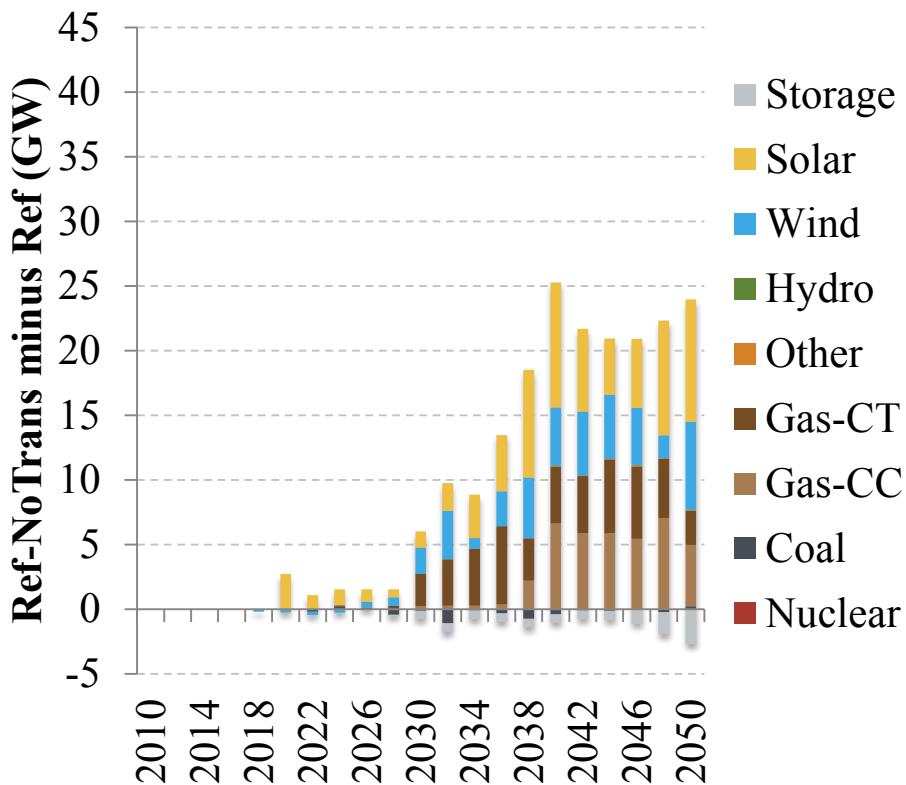


# U.S. Capacity Change with NoTrans

- Additional U.S. capacity is needed to make up for lost imports
- Additional capacity is primarily gas and RE, with some nuclear in the cap scenario

## Reference

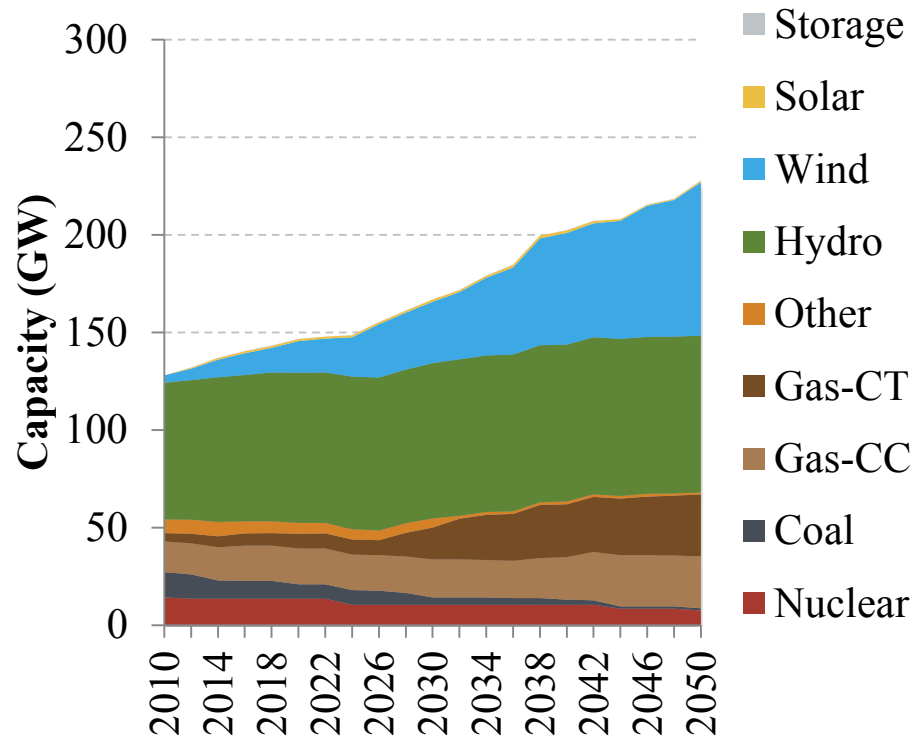
## Carbon Cap



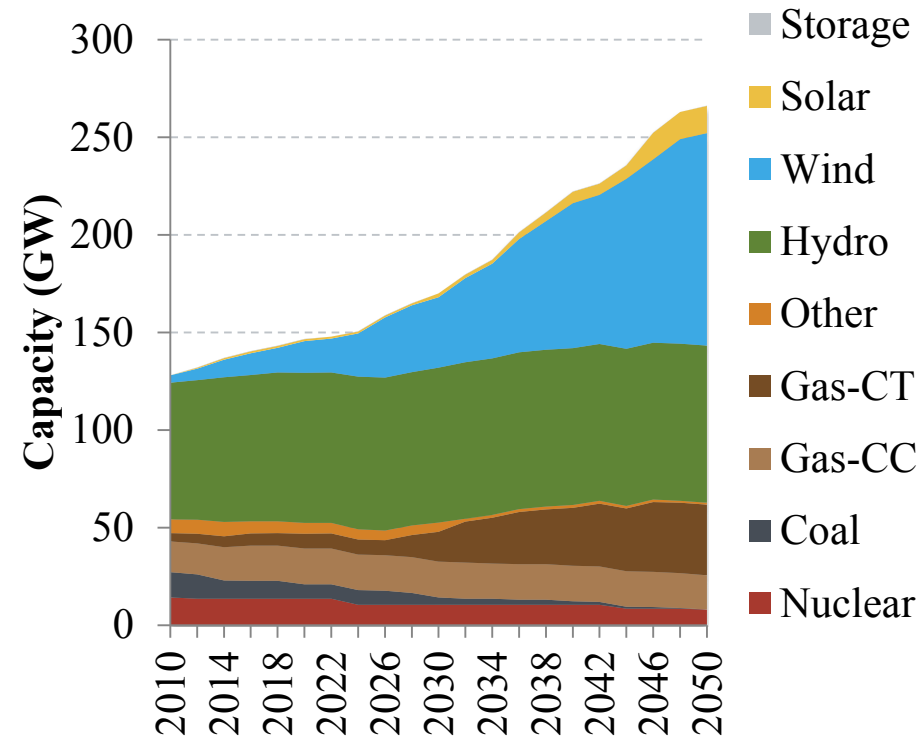
# Canada Capacity Mix

- Coal already phasing out, so carbon cap leads to increased renewables, including solar
- 0.2 GW of Gas-CC-CCS is deployed

## Reference



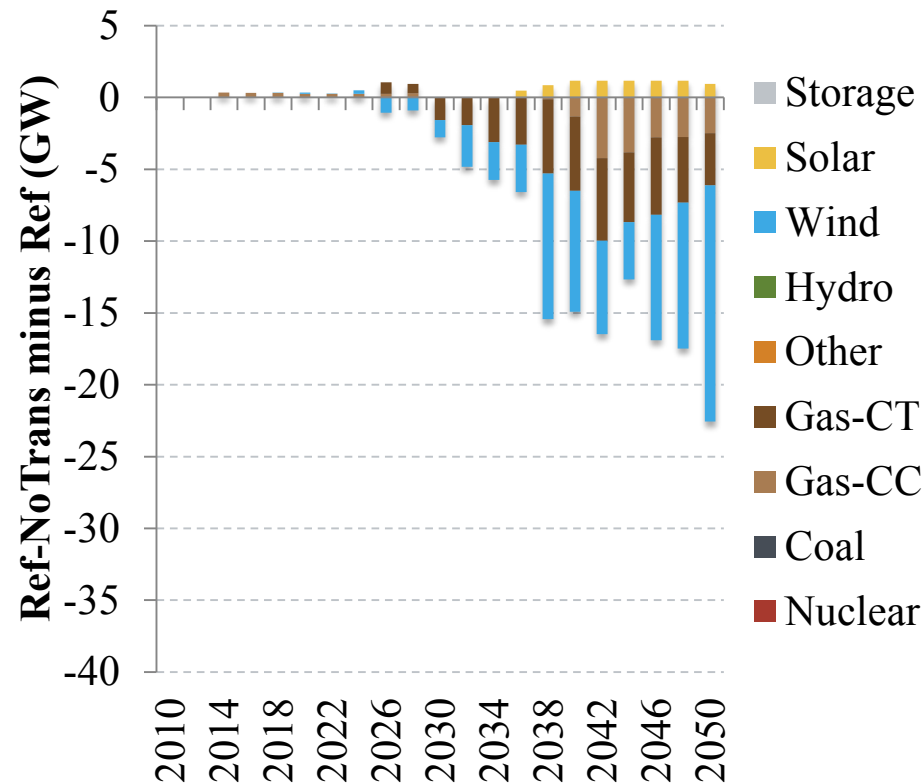
## Carbon Cap



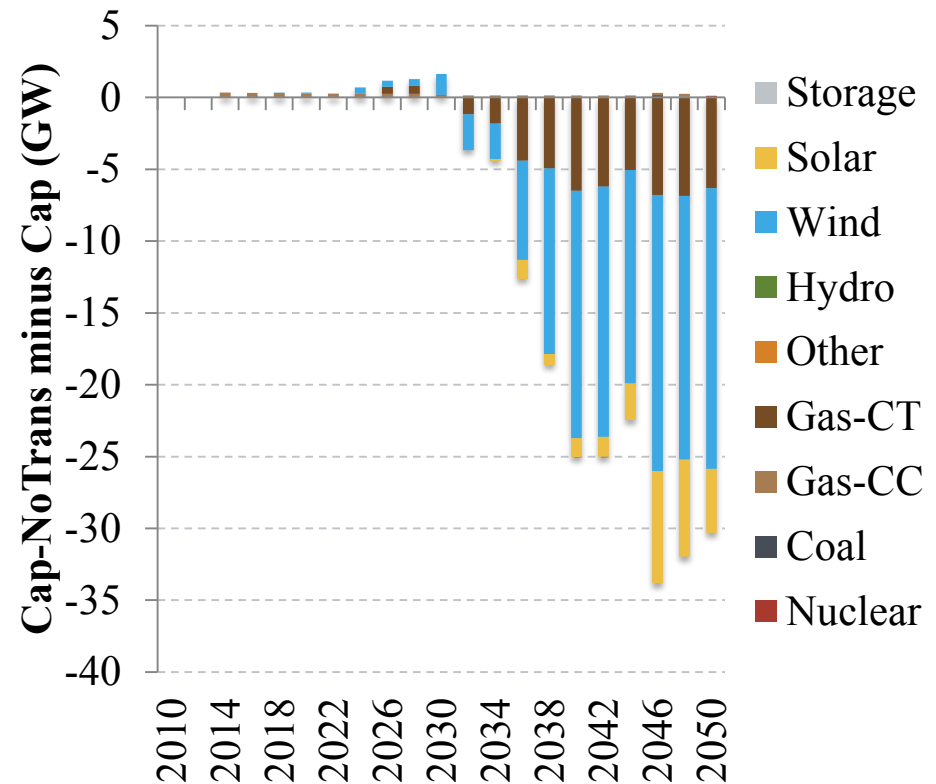
# Canada Capacity Change with NoTrans

- Less capacity is needed because of fewer exports
- Reductions exclusively in gas and RE

## Reference



## Carbon Cap



# Summary

- U.S. power system is much larger than the Canadian power system
- The U.S. and Canada are both rich in renewable energy resource – deep carbon reduction rely heavily on those resources
- U.S. and Canadian electricity trade has the potential to increase over time
  - The potential is increases with as carbon reduction targets become more stringent
- Cross-border transmission adds value to the U.S.-Canada power system, but the value is small relative to the system size

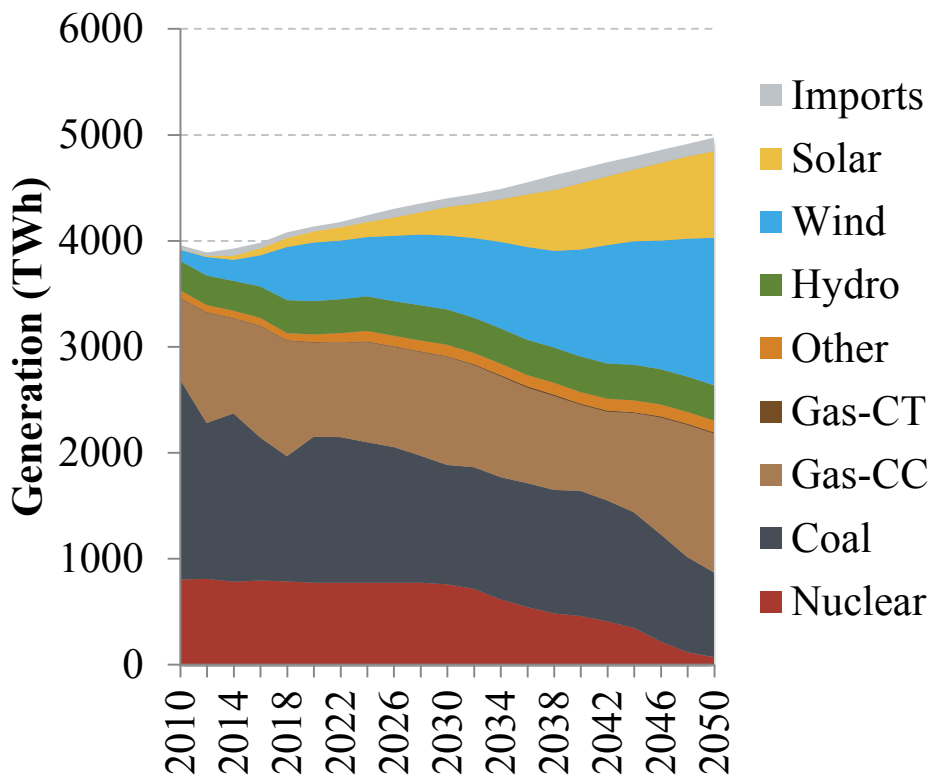


# Additional Slides

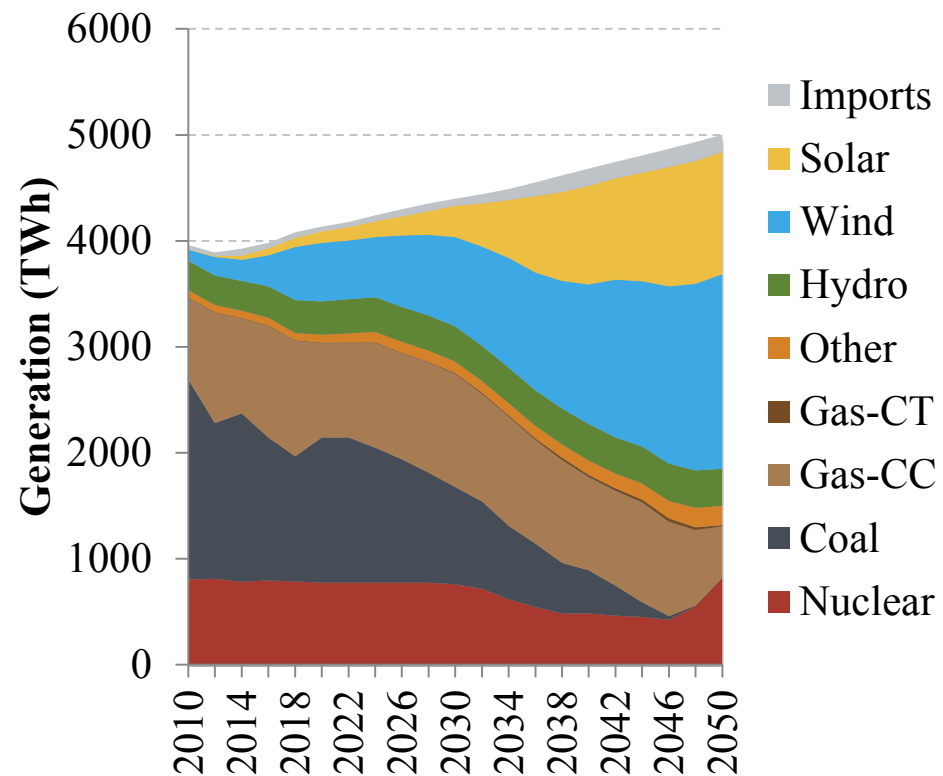
# U.S. Generation Mix

- Carbon cap has 55% variable renewable energy with 16% curtailment rate
- Nuclear plays a significant role in later years

## Reference



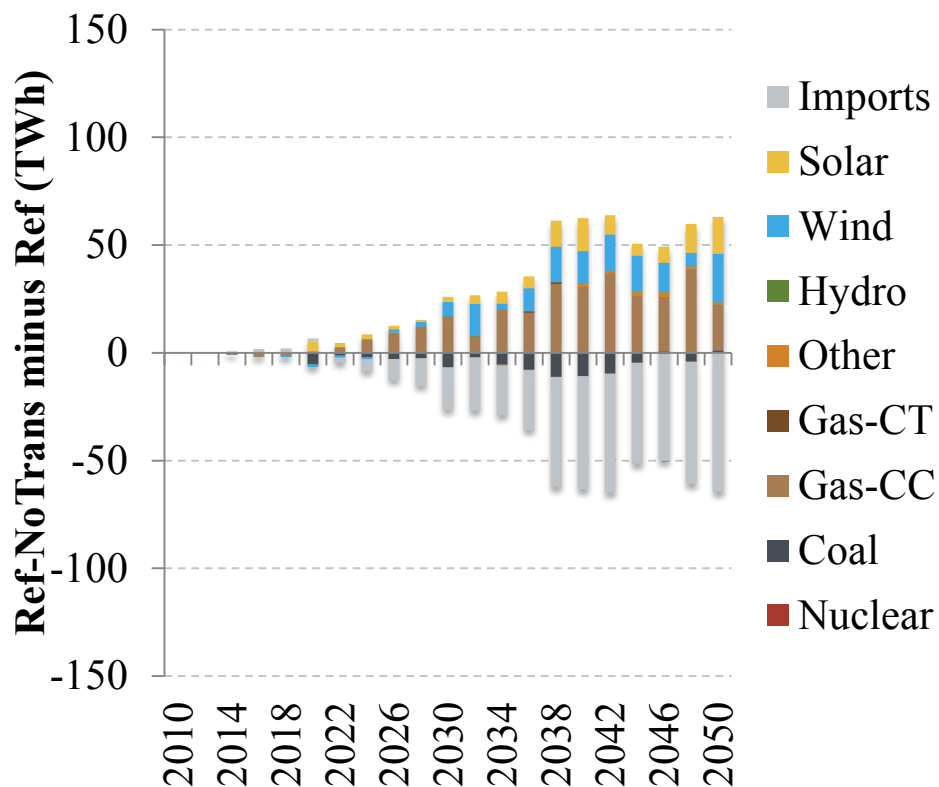
## Carbon Cap



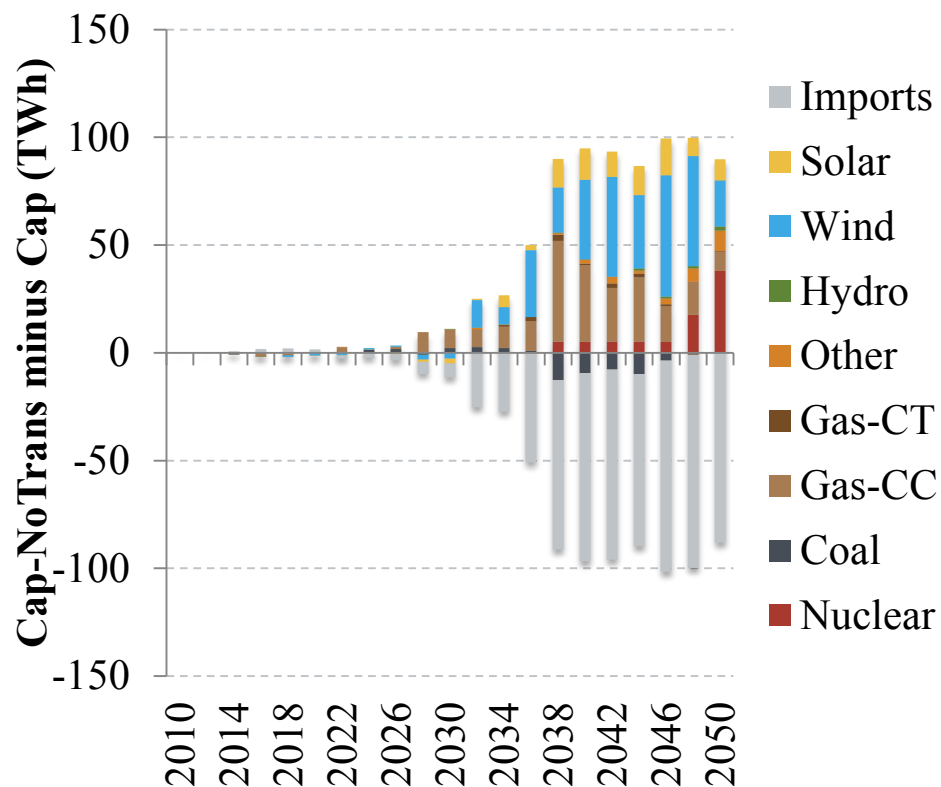
# U.S. Generation Change with NoTrans

- In Ref scenario, imports are replaced by a mix of gas, wind and solar
- In Cap scenario by 2050, imports are replaced with nearly 100% carbon free generation, including nuclear

## Reference



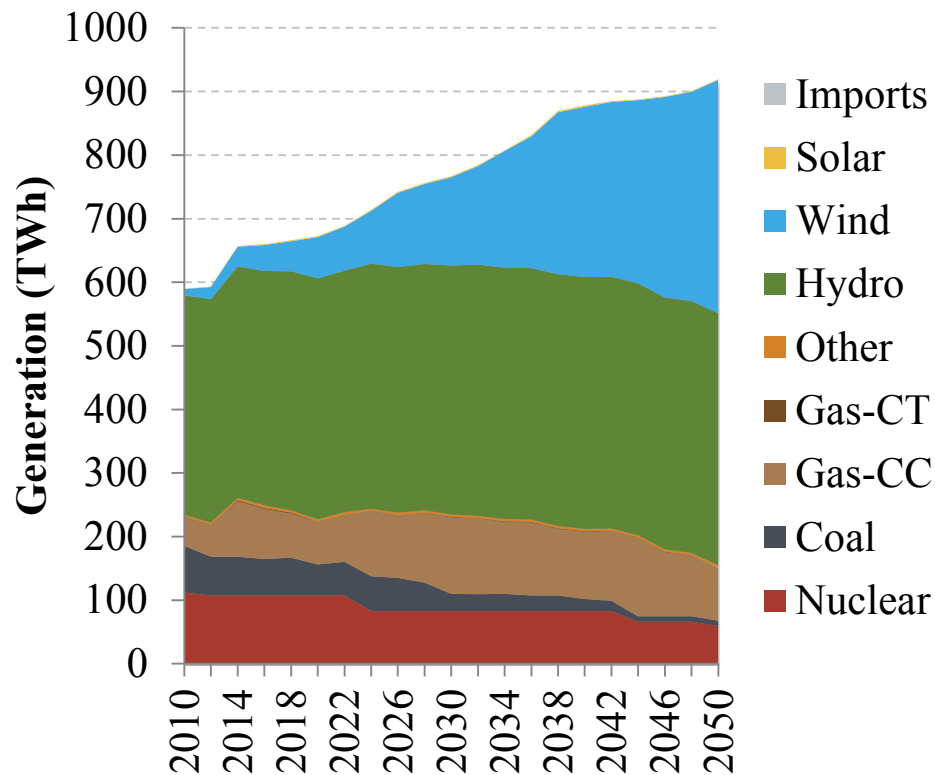
## Carbon Cap



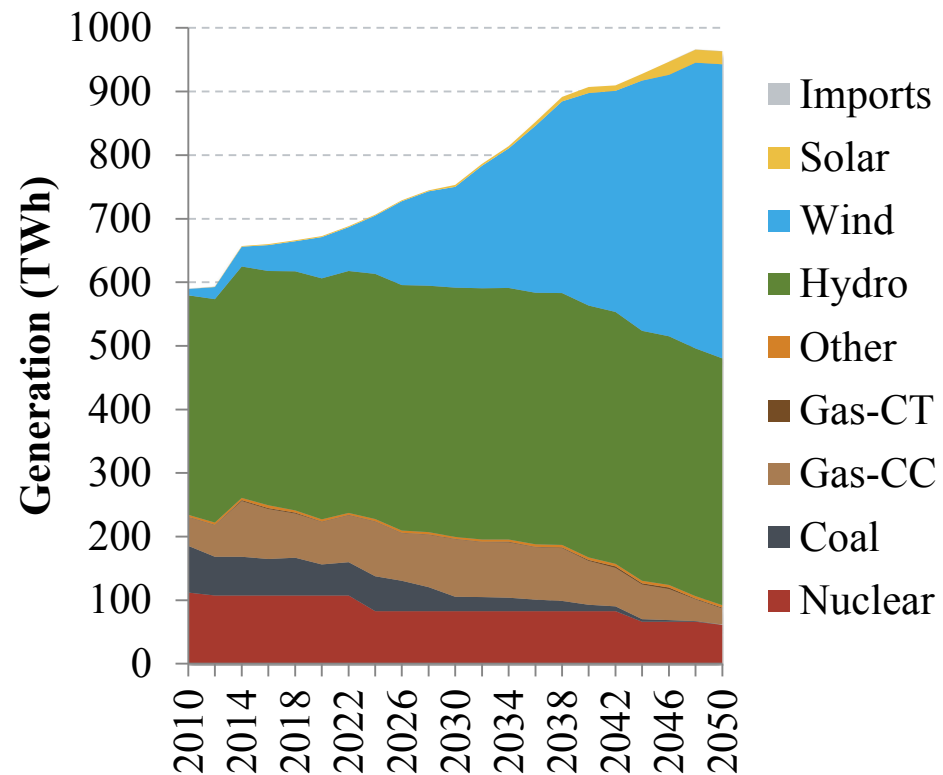
# Canada Generation Mix

- Carbon cap reduces Gas-CC generation and increases renewable energy generation
- Wind expansion is possible due to increased transmission into Northern Canada

## Reference



## Carbon Cap



# Canada Generation Change with NoTrans

- Fewer Canadian exports to U.S. means less generation, primarily for wind

