Deep Decarb in Northeast Canada and the US: Do We Have the Firm-Flexible Technology We Need?

MIT MANAGEMENT SLOAN SCHOOL

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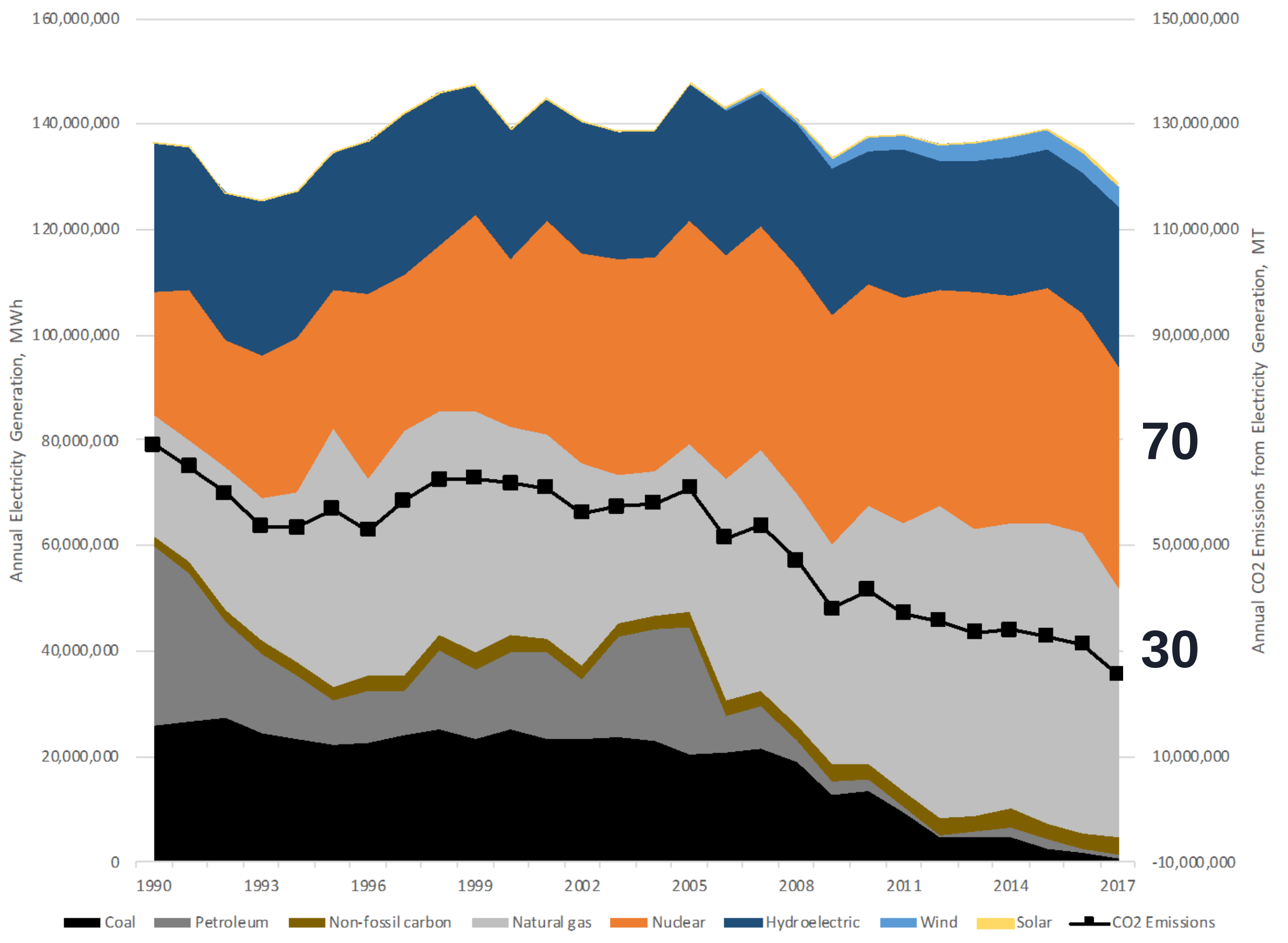
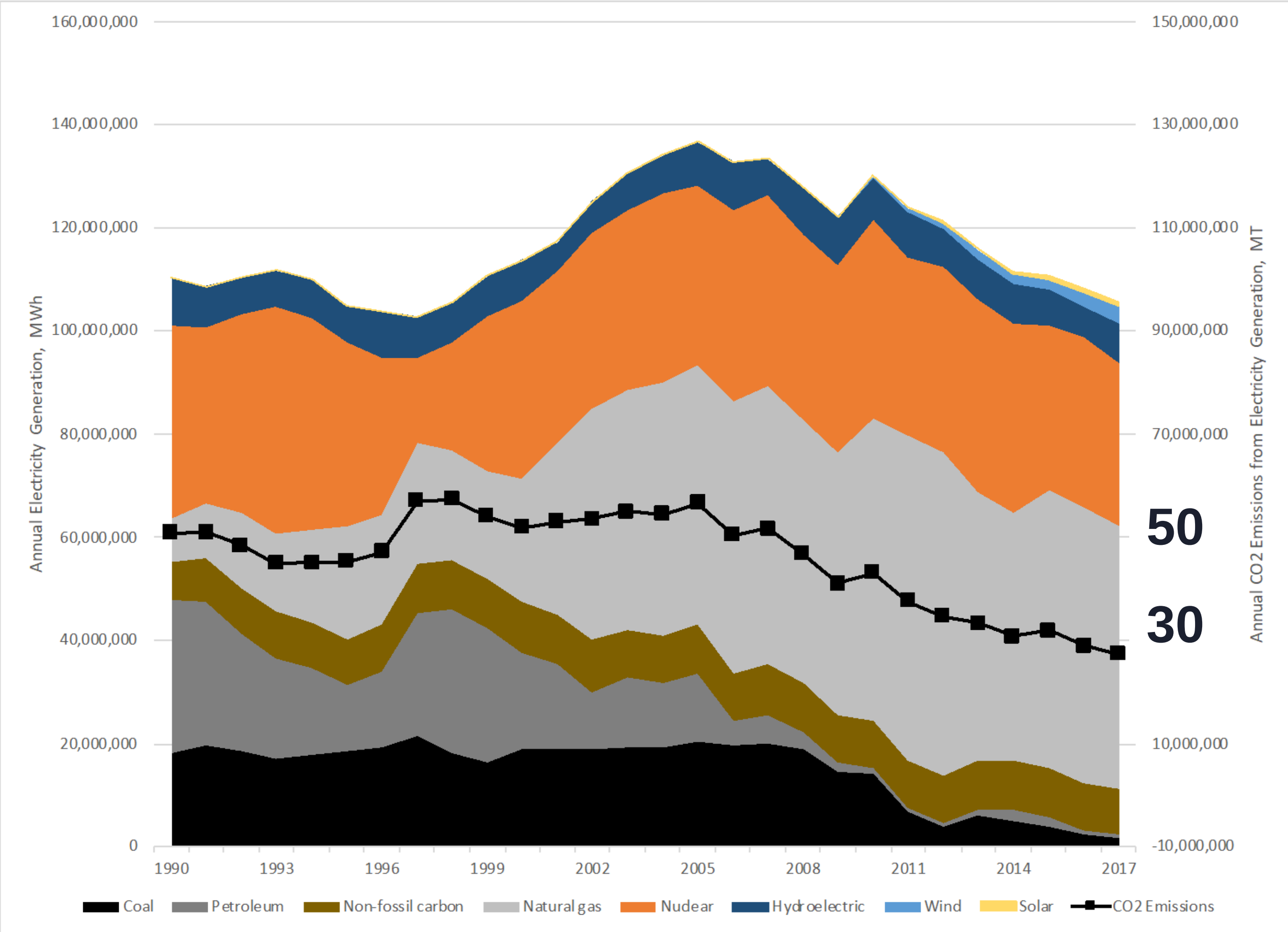
Deep Decarbonization

- **What do we mean by deep?**
  - Economy-wide 80% reduction from 1990 levels by 2050.
    - …or fully carbon neutral by 2050.
  - Electricity systems play a vanguard role: 100% renewable or clean energy by 2040-2050.
  - Substantive action on Transport / Buildings / Industry / Agriculture

Current Status: New York



Current Status: New England



Regional State Commitments (1)

- **New York in June 2019 passed the Climate Leadership and Community Protection Act.**
  - Economy-wide net-zero by 2050. (40% from 1990 by 2030)
    - 85% of reductions from energy and industrial emissions;
    - 15% from offsets, e.g., from forestry or agriculture;
  - Electricity 100% carbon-free by 2040. (70% renewably by 2030)
    - No offsets for stationary electric sources.
  - Climate Action Council to identify mechanisms.
  - Addresses issues of economic justice.

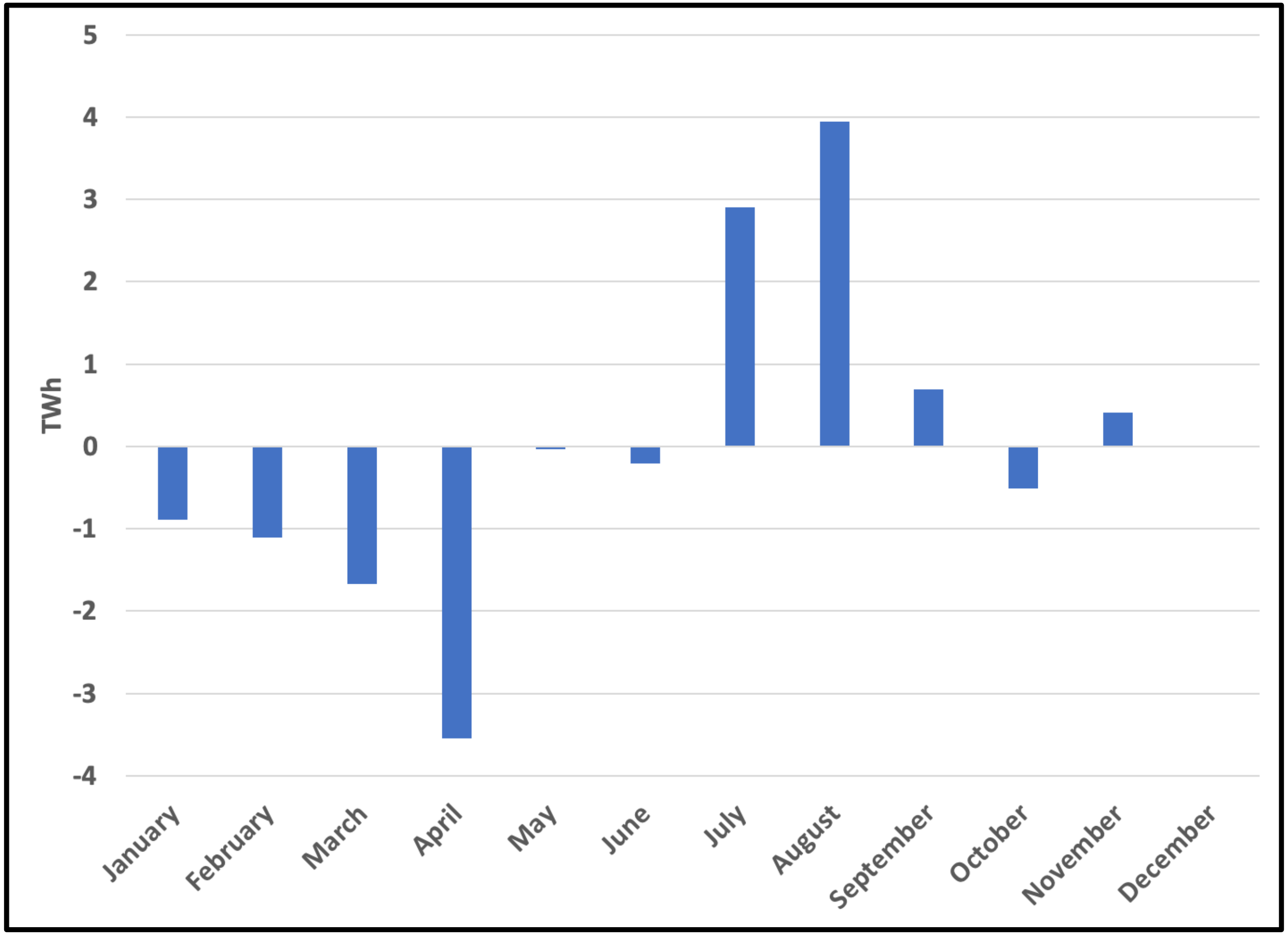
Regional State Commitments (2)

- **Maine in June 2019 passed a package of climate and energy bills.**
  - Targeting 80% reduction economy-wide by 2050.
  - 100% renewable electricity by 2050. (80% by 2030)
  - Supporting electrification of heating and transport.
- **Massachusetts**
  - Targeting 80% reduction economy-wide by 2050.
  - 2008 legislation, with a recent court decision requiring explicit steps and interim targets.
    - Electricity 90% reduction by 2050. (74% by 2030, 83% by 2040)
  - Tenders for 1.6 GW offshore wind, 1.2 GW other clean energy including imported hydropower.
  - Electrification of heating and transport only tentatively/tepidly addressed.

Some Challenges of Deep Decarbonization

- **The politics of siting.**
  - Offshore wind.
  - Onshore wind and solar PV.
  - Transmission.
- **Intermittancy at short time scales.**
  - E.g., the duck curve and low carbon fast ramping resources.
  - Inertia and frequency response.
- **Variability longer time scales.**
  - Daily.
  - Weeks.
  - Seasonal.

Seasonal Storage Task in New England for 100% Renew. System



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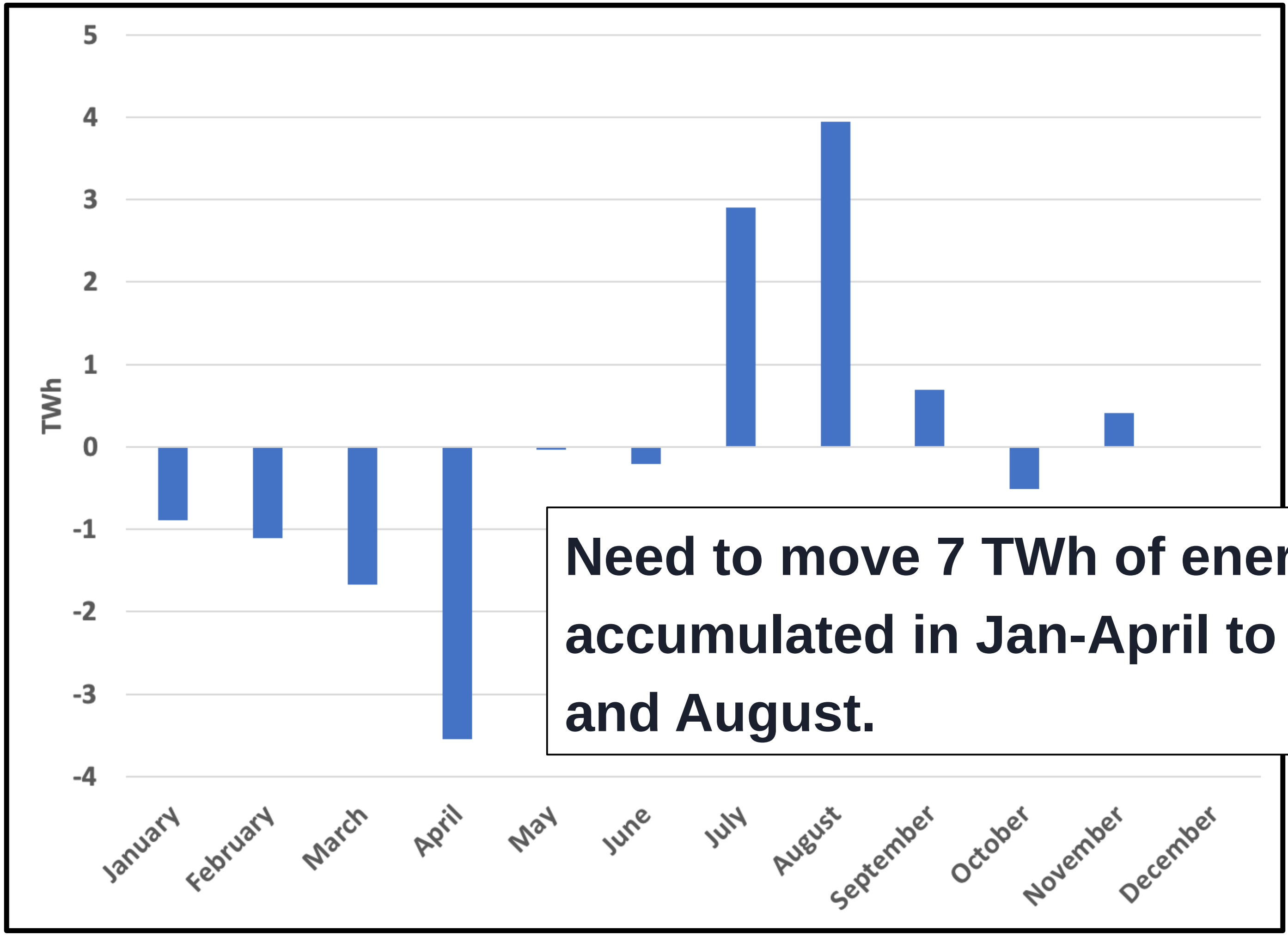


Need to move 7 TWh of energy accumulated in Jan-April to July and August.

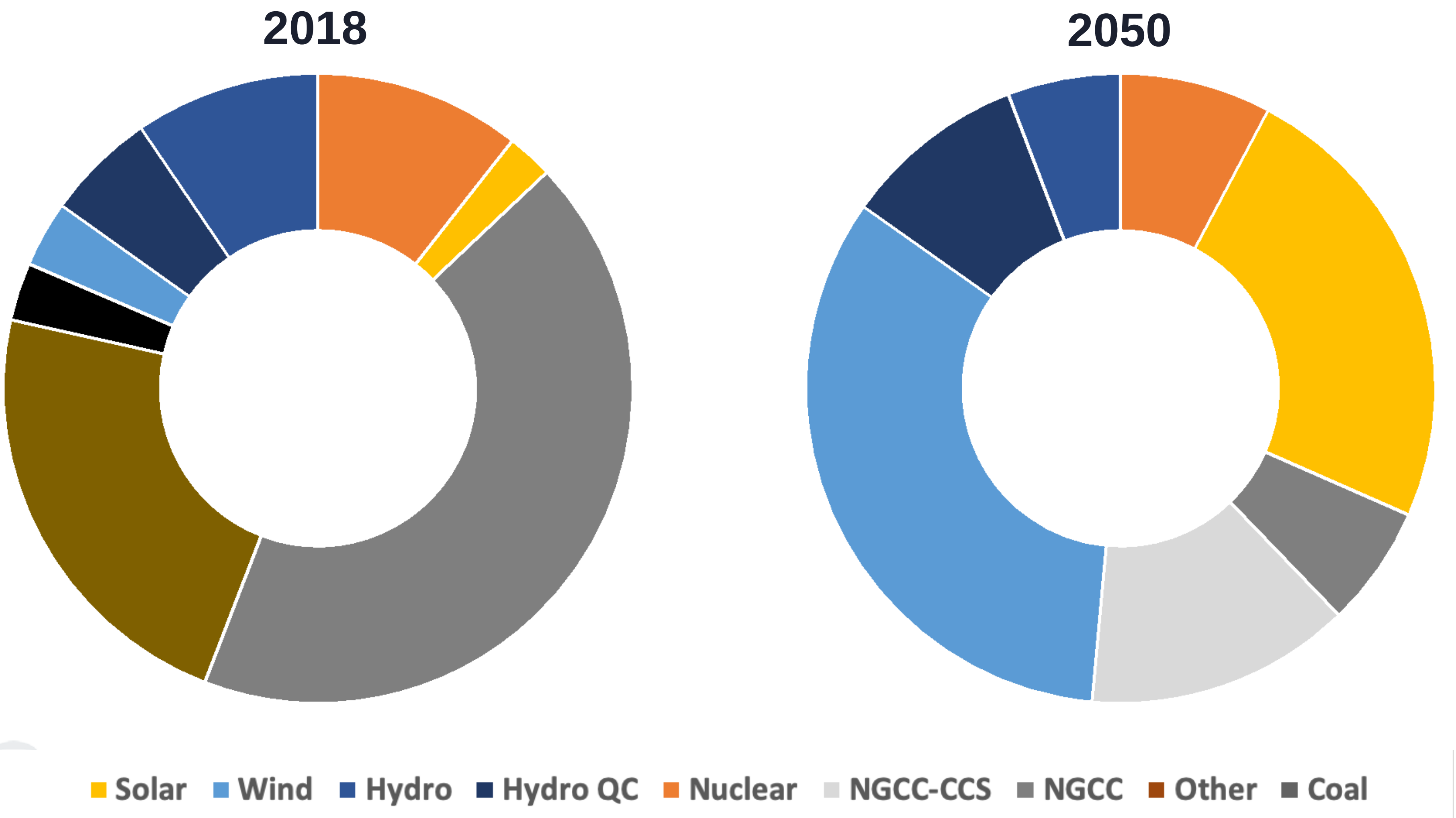
Alternatively, Adjust the Portfolio to include other Low C Generation

- **Nuclear**
  - Some existing plants could have life extensions to 80 years.
  - New nuclear.
- **CCS for NGCC plants**
- **Quebec Hydro + Transmission**
  - New York's Hudson Express line
  - New England's
    - faltered New Hampshire "*Northern Pass*"
    - live Maine "*Clean Energy Connect*"
- **others…**

Capacity Expansion Model

- **To meet 2050 load.**
  - Endowments of hydro, nuclear, CCGTs, wind & solar PV.
- **Initial results just NE & QC.**
- **Granularity to the level of hourly dispatch.**
- **Examine different levels of decarbonization.**
- **Examine different levels of transmission.**

Optimization of Capacity for 90% Reduction in 2050



The Value of Complementary Low C Generation

90% Decarbonization					
				System Cost	
	CCS	Transm	Nuke	Total	Average
Optimal	6.2 GW	4.2 GW	3.5 GW	$5.1 B	$39.37 /MWh
No CCS		4.2 GW	3.5 GW	$5.6 B	$43.38 /MWh
No New T	6.2 GW	2.2 GW	3.5 GW	$6.0 B	$46.48 /MWh
No Nukes	6.2 GW	4.2 GW		$6.0 B	$46.31 /MWh
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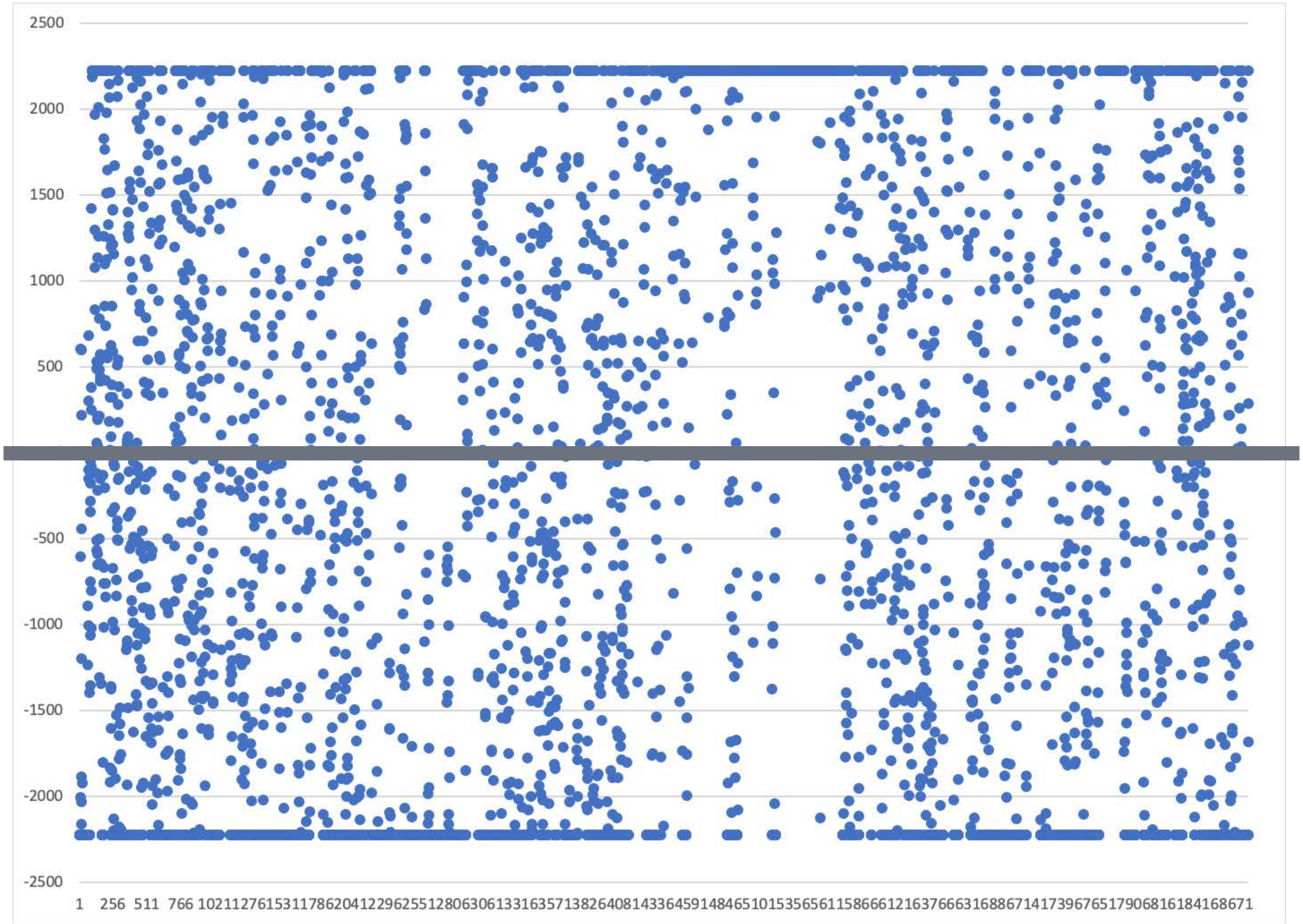
Hydro Operations Change Dramatically.



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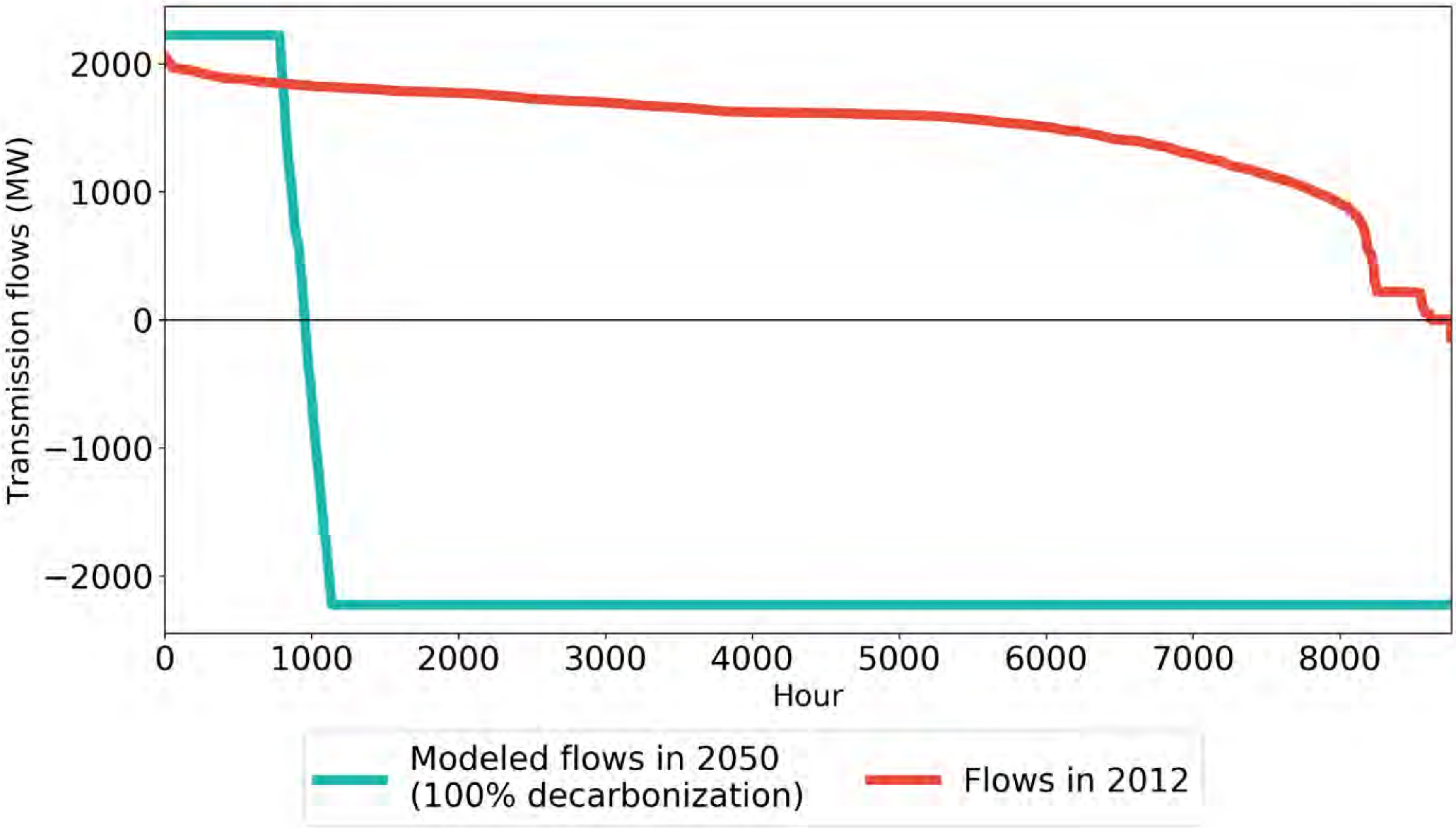
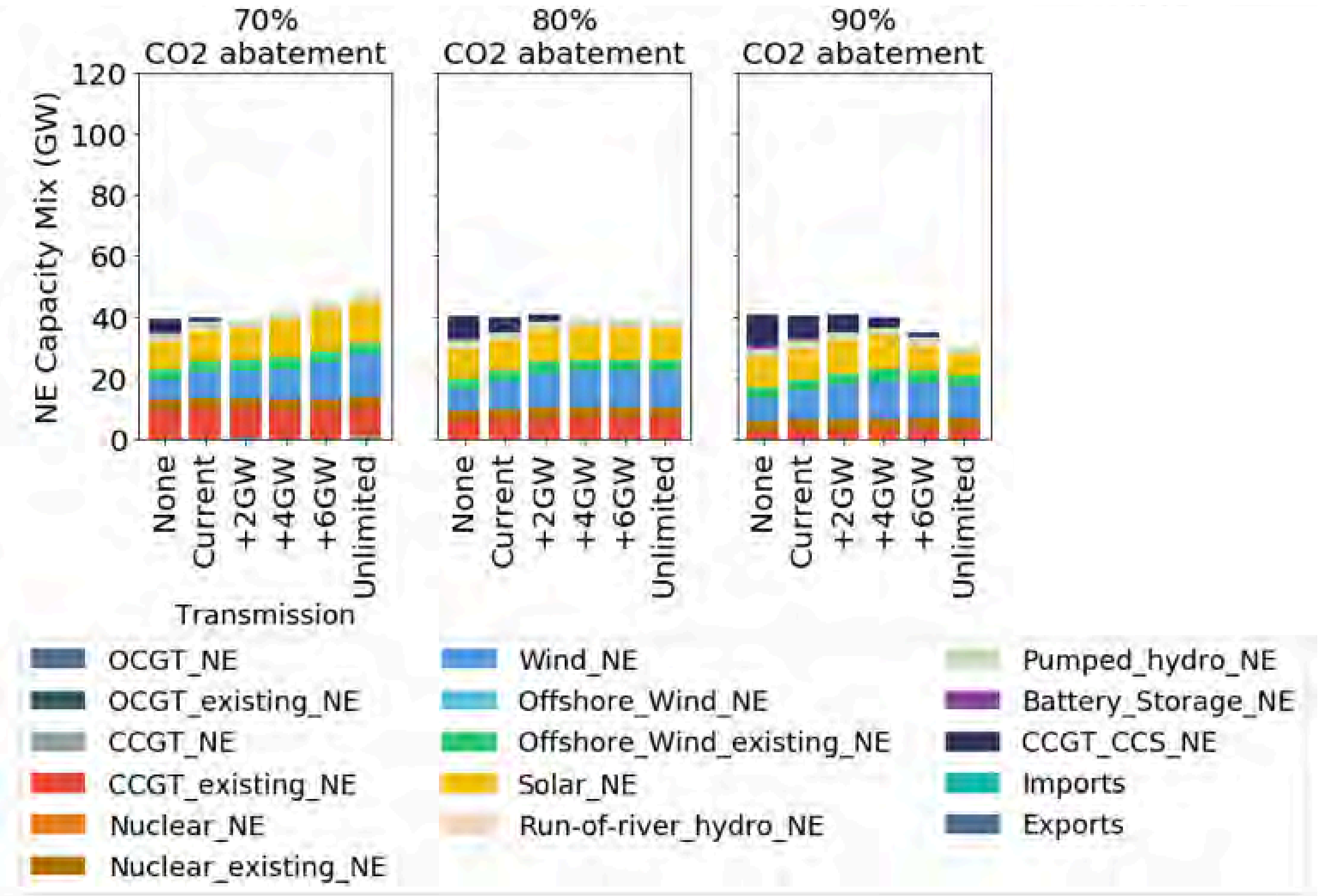


A RISK MANAGEMENT APPROACH

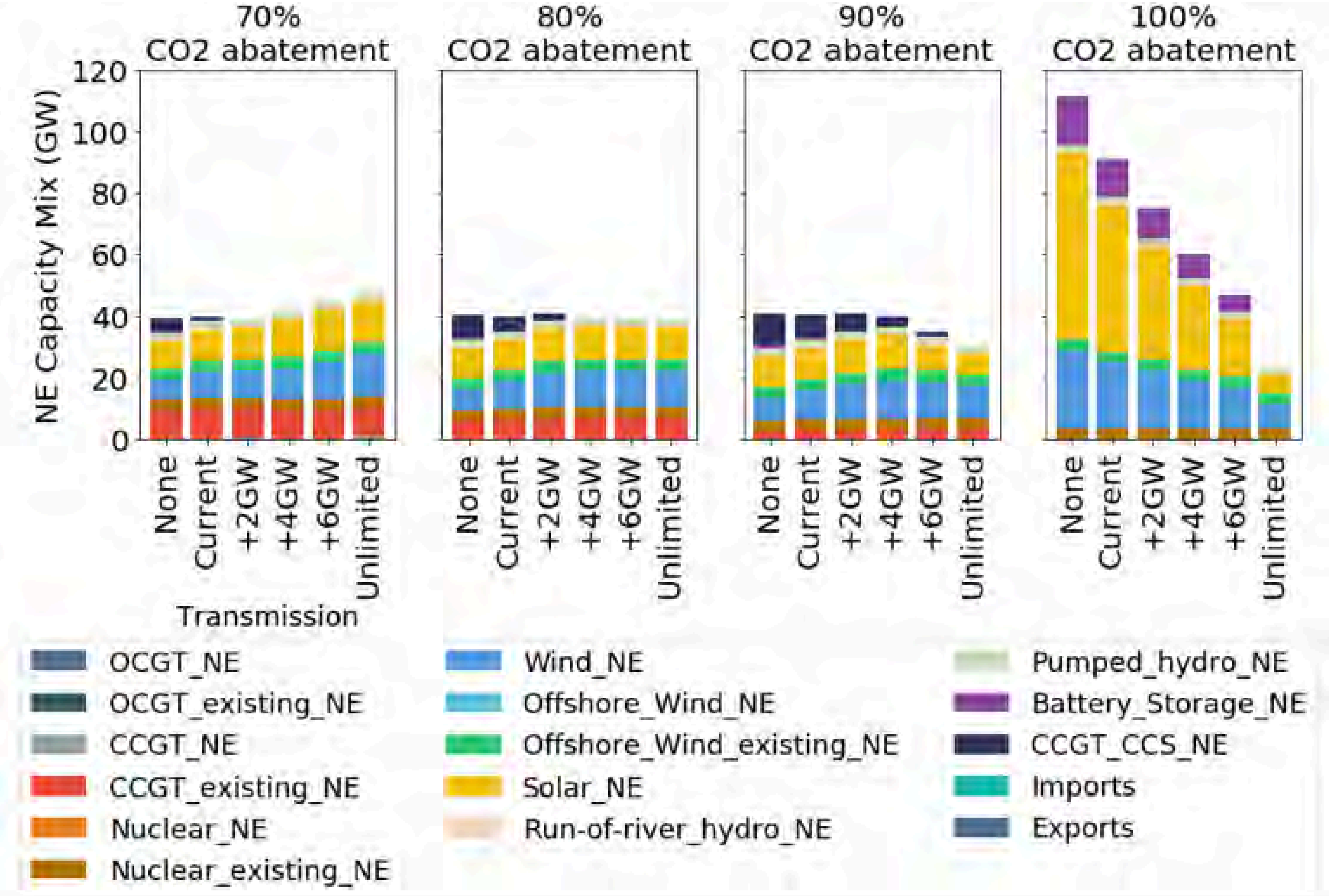
Big Uncertainties

- **Costs and availability of competing technologies.**
- **Acceptability of competing technologies.**
  - e.g., land use for large scale wind and solar expansion (wind=35x 2018 capacity, solar=14x; 3.4 or 5x capacity now planned for 2027)
- **State action, e.g., for off-shore permits and transmission connections.**
- **Pace of decarbonization policies and implementation.**
  - in electricity
  - in other sectors which impact electricity, such as transport and building
- **Energy efficiency.**
- **Social changes, such as demand response, vehicle charging, building management.**

CCS & Hydro Compete



100% Decarb Changes Everything



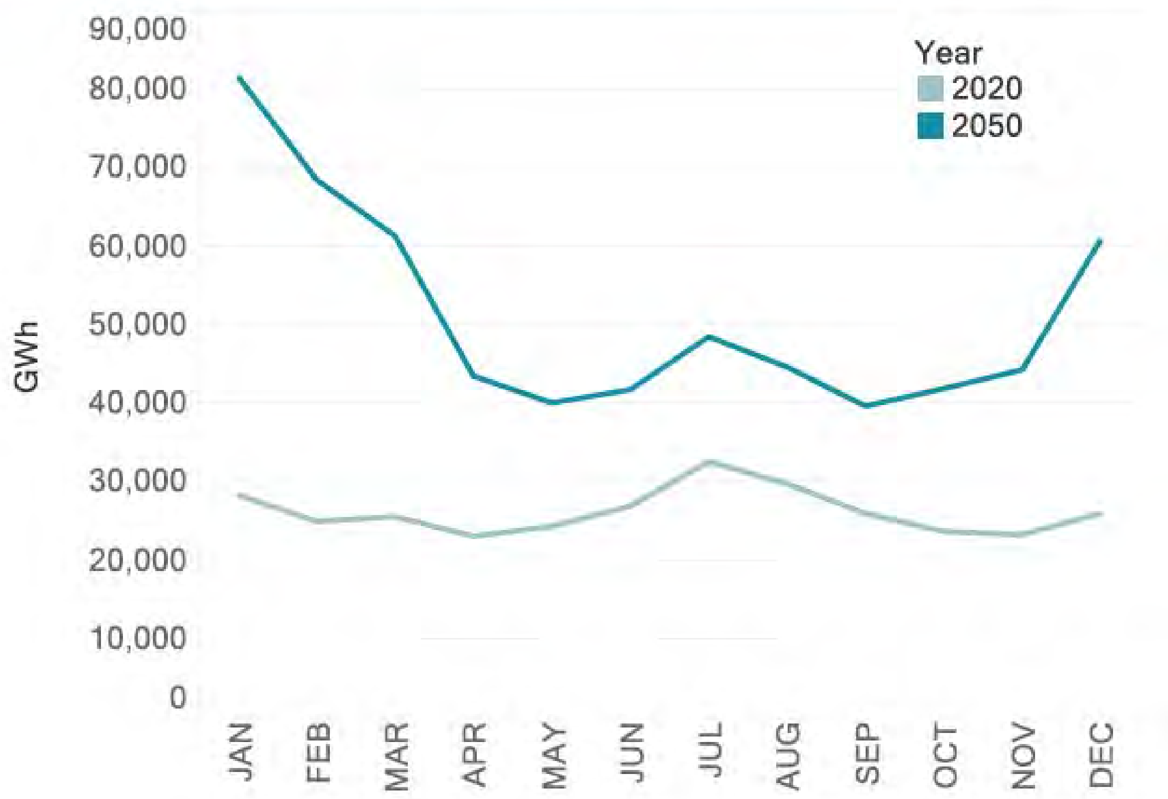
Canadian Hydro

- Quebec is a winter peaking system
- New England and New York are summer peaking

- ...but, with a shift to electrical home heating, do New England and New York become winter peaking?

One Forecast

Figure 3. Base DDP Case Monthly Electricity Consumption for the Northeast



Source: Williams, J.H., et al., (2018). Deep Decarbonization in the Northeastern United States and Expanded Coordination with Hydro-Québec. A report of the Sustainable Development Solutions Network in cooperation with Evolved Energy Research and Hydro-Québec. April 8, 2018

Some principles...

- **We're not in the prediction business...**
  - insight about the future only matters if it can inform public policy and industrial strategy
  - which technology wins is not the question
    - with a price on carbon, may the best technology win
- **However, it is useful to ask which public investments are needed to enable winning technologies.**
    - e.g., transmission for hydro, for off-shore wind, etc.
  - and it may be useful to ask where public R&D funding is most needed

Some principles... (2)

- **Timing is a critical issue.**
- **When are public investments or other policies absolutely needed?**
- **Experimentation is a valuable way to reduce costs.**
  - E.g., in optimizing transmission investments for off-shore wind.
  - Also waiting has information value, e.g., about which technologies will be most useful, reshaping which public investments are needed.
- **The biggest uncertainty is perhaps the pace of decarbonization.**
  - That has a big implication for the right investments, when.
  - If we were really going to get there by 2050, we need to be doing things now that we would not do now if we are going to move more slowly.
  - But which ones?

Financing Investments

- A large amount of existing low carbon generation was pushed onto the system with dedicated revenue streams.
- Investors are anxious about creating sunk investments.
- The value of competing investments depend upon the realized pace of decarbonization and various policies. Creates reluctance to commit large sums.
- Will states continue to fund investments with dedicated revenues?