sustainability

Supplementary Information

Changing Personal Transportation Technology or Behavior? Impacts of a Behavioral Disruption

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1. Electricity SupplY

1.1. Hourly Electric Demand

Electricity demand has been broken down into four time slices and four seasons as detailed in Table S1. By defining a peak of demand as the highest 10%, the peaks of demand are between 7am and 10am and between 5pm and 9pm in the evening. The data in the table are based on Hydro Québec Distribution's hourly and daily electricity consumption data for the years 2016 to 2018 [1–3], shown in Figure S1. The objective of implementing an hourly electricity demand in NATEM is to be able to have results on the increase in peak demand, particularly winter peak demand.

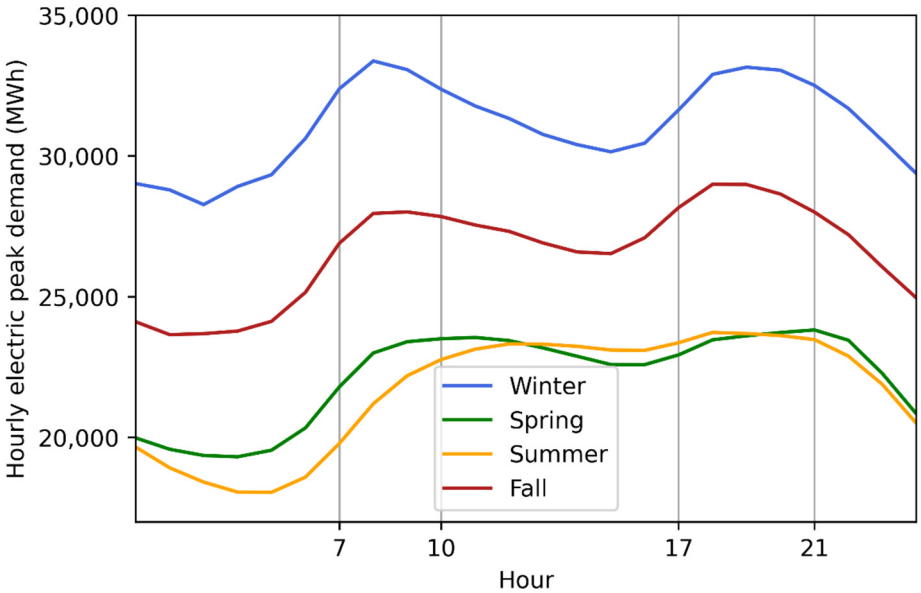

Figure S1. Hourly and seasonal electricity demand in Quebec.

Table S1. Time slices and associated part of the electricity consumption implemented in NATEM.

Hour	Winter	Spring	Summer	Fall
Peak 1	7.97%	5.57%	5.22%	6.72%
Day	7.48%	5.59%	5.63%	6.56%
Peak 2	7.93%	5.71%	5.73%	6.94%
Night	7.19%	4.98%	4.77%	6.01%

1.2. Hourly Availability Factors

In line with the definition of hourly electricity demand, availability factors for power plants have been taken from the study of [4]. They are presented in Figure S2.

Daily	FD	FN	FP1	FP2	RD	RN	RP1	RP2	SD	SN	SP1	SP2	WD	WN	WP1	WP2
Wind	0.42	0.44	0.45	0.36	0.33	0.36	0.42	0.31	0.31	0.36	0.41	0.29	0.39	0.41	0.42	0.34
Solar	0.34	0.00	0.11	0.09	0.37	0.00	0.10	0.10	0.45	0.00	0.23	0.22	0.20	0.00	0.01	0.00
Run of river	0.57	0.57	0.57	0.57	0.62	0.62	0.62	0.62	0.57	0.57	0.57	0.57	0.57	0.57	0.57	0.57
Seasonal	fall				spring				summer				winter			
Run of river	0.57				0.62				0.57				0.57			
Annual																
Run of river	0.53															
Dam hydro	0.53															

The first letter of the time slice code indicates the season (F: fall, R: spring, S: summer, W: winter), the second the fraction of the day (D: 9am-4pm, N: 8pm-5am, P1: 6am-8am, P2: 5pm-7pm).

Figure S2. Availability factors of renewable electricity production technologies.

1.3. Incremental Electricity Costs

With the increase in electricity demand, the model must invest in new infrastructure. The incremental electricity processes are derived from [5–9] and presented in Table S2 below.

Table S2. Costs of the incremental electricity processes updated in NATEM.

Technology	Year	Investment Costs ($/kW)	Fixed O&M ($/kW)	Capacity Limit (GW)
Dam 1	2015	6035	17.10	7
Dam 2	2015	6733	17.10	10
Dam 3	2015	7481	17.10	∞
Run of river	2015	5486	24.00	∞
Wind onshore	2015	2480	68.40	∞
	2030	2252		
	2050	2041		
Wind offshore fix	2015	4103	114.00	∞
	2030	3975		
	2050	3848		
Wind offshore floating	2020	5094	148.20	∞
	2030	4956		
	2050	4815		
Photovoltaic Fix 1MW	2015	2702	54.72	∞
	2030	2170	51.30	
	2050	1529	49.02	
Photovoltaic Fix 10MW	2015	2456	54.72	∞
	2030	1795	51.30	
	2050	1349	49.02	
Photovoltaic Fix 100MW	2015	2210	54.72	∞
	2030	1195	51.30	
	2050	1167	49.02	
Photovoltaic 1 axis 1MW	2015	3106	54.72	∞
	2030	2358	51.30	
	2050	1624	49.02	
Photovoltaic 1 axis 10MW	2015	2824	54.72	∞
	2030	1945	51.30	
	2050	1421	49.02	
Photovoltaic 1 axis 100MW	2015	2541	54.72	∞
	2030	1862	51.30	
	2050	1370	49.02	

2. Supplementary Analysis

2.1. Carbon Capture and Storage

This section presents additional results. In the main study, all scenarios reach 80% GHG reduction by 2050, with the help of carbon capture and sequestration (CCS) technologies. These scenarios do not take into account the social acceptability and slow maturation rate of these technologies. Considering a limited use of CCS (2,500 Mt CO2eq), the model is able to achieve a 65% reduction in GHG emissions by 2050 (The assumptions about the availability and techno-economic parameters of technologies may not be identical to [10]). The reduction targets achieved are presented in Table S3 below. Carbon capture and sequestration and the negative emissions generated in the different scenarios are presented in Figure S3.

Table S3. Quebec 65% GHG emissions reduction 2030 and 2050 targets.

Year	Reduction (Compared to 1990)	Emissions (Mt CO2eq)
1990	-	86.5
2030	−25%	68.2
2050	−65%	31.8

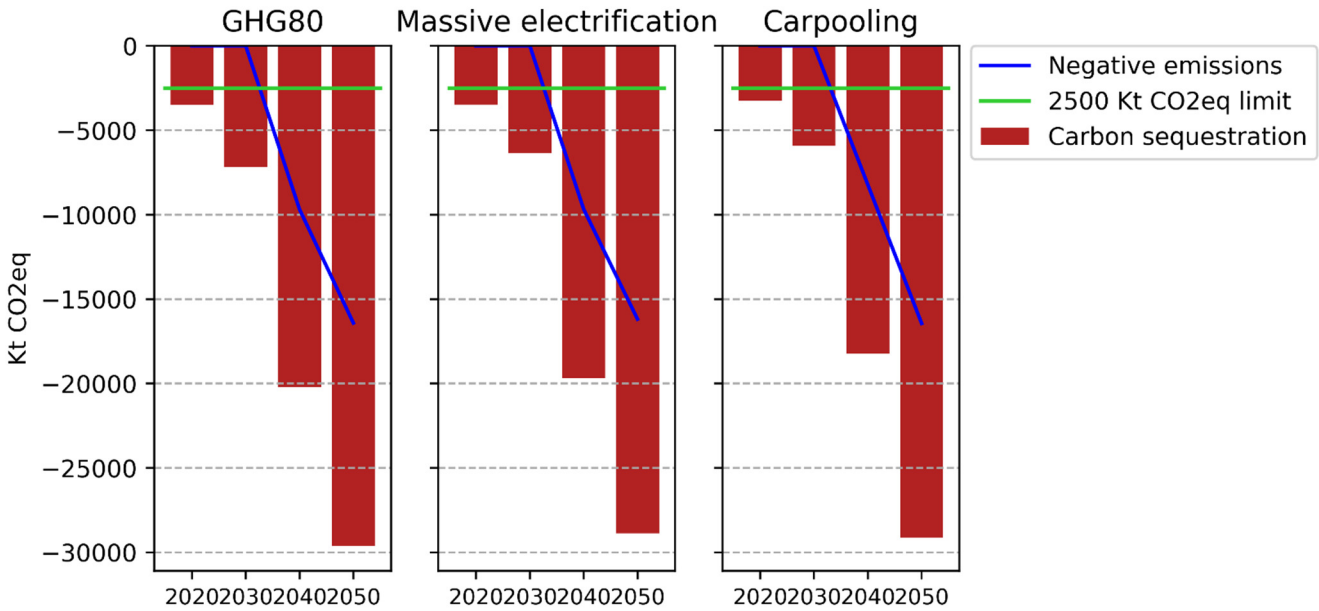

Figure S3. Required potential of sequestration and negative emissions with 80% GHG emissions reduction and the scenarios considered.

The emissions associated with a 65% GHG emissions reduction and each scenario are presented in Figure S4.

The advantage of this figure is that with the lower constraint on GHG emission reductions (only 65% by 2050), it allows us to see the real avoided emissions generated by a behavioural disruption policy or a massive electrification policy. According to our model, the effects of a massive electrification policy would permit to avoid between 1.8 Mt of CO2eq in 2030, 3.2 Mt of CO2eq in 2030 and 1.1 Mt CO2eq in 2050 relative to the GHG emissions reduction scenario. The effects of a behavioral disruption alone would permit to avoid between 5.9 Mt of CO2eq in 2030 and 0.7 Mt CO2eq in 2050 relative to the GHG emissions reduction scenario.

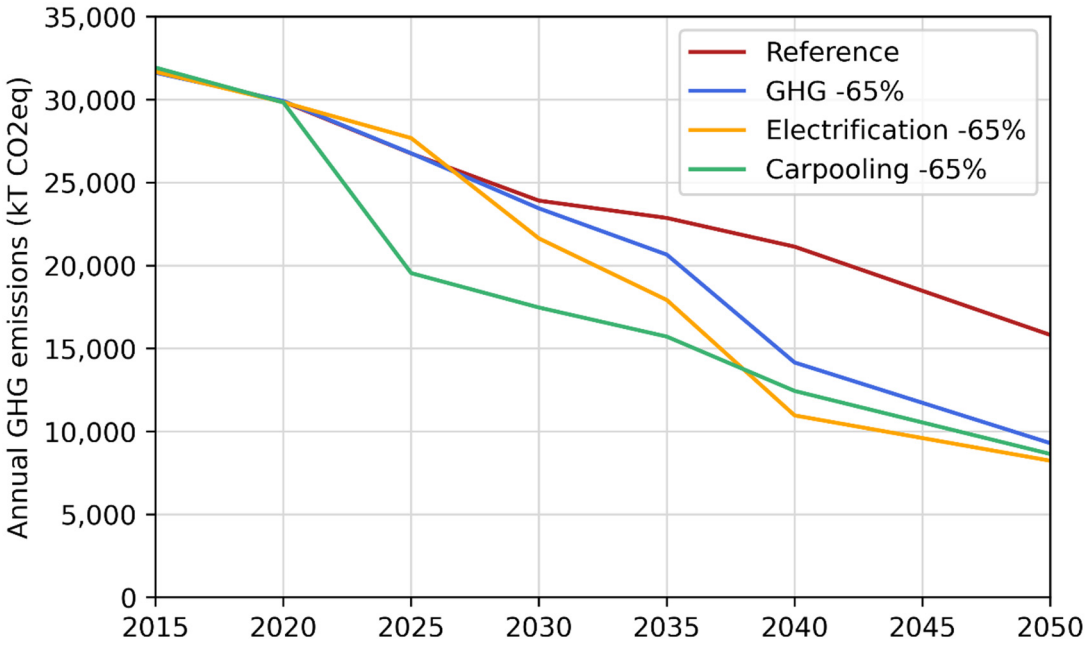

Figure S4. Total GHG emissions with 65% GHG emissions reduction target and the four scenarios considered.

2.2. Peak Demand

In the main document, we focused on the increase in electrical capacity related to the different scenarios, and the constraint of reducing GHG emissions by 80% by 2050. We pointed out that the increased electricity demand could be all the more important when happening at peak times, and especially in winter. Figure S5 shows net winter electricity imports (in PJ). With the hourly definition of electricity demand detailed in Section 2.1, imports are also broken down into four time slices.

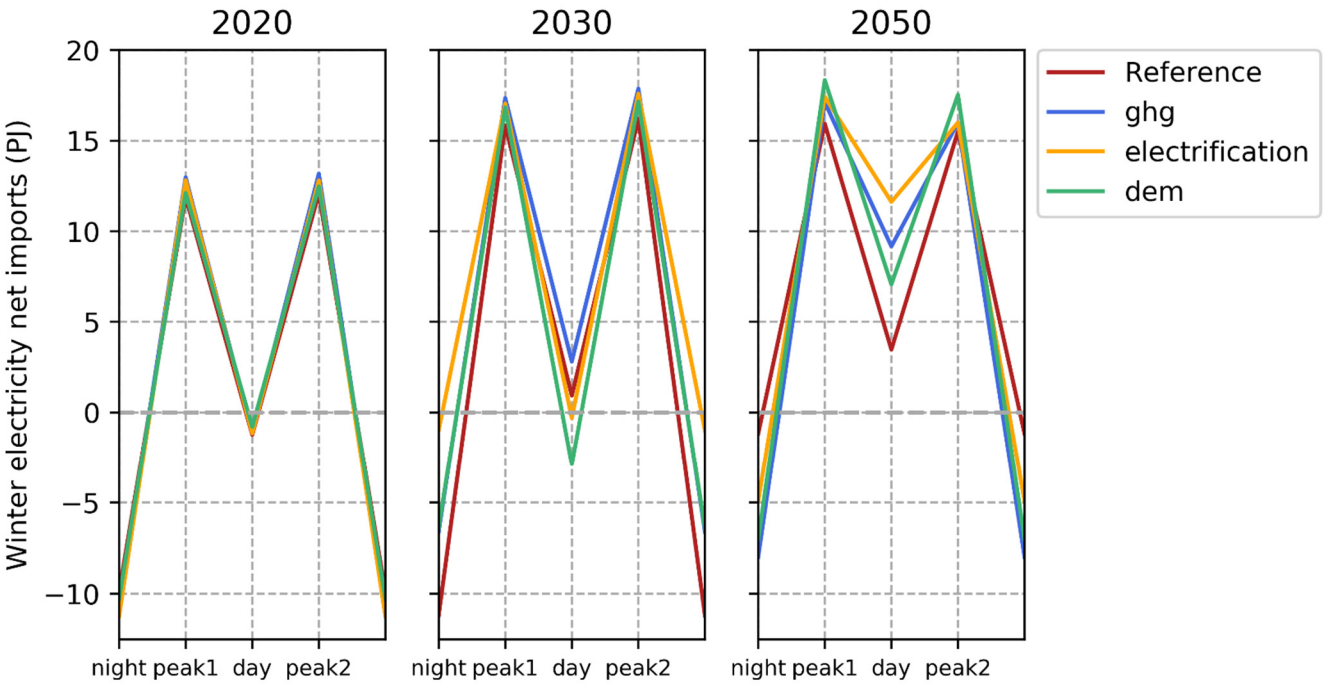

Figure S5. Winter net electricity imports under the four scenarios and the four time slices considered.

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