

Canada's Net Zero Future: Finding our way in the global transition

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REPORT OBJECTIVES

- Explore what a net zero 2050 means in practical terms and the pathways Canada can take to get there
- Assess uncertainty on the path to net zero, including the effects of factors Canada does – and does not – control
- Provide an evidence-based touchstone for net zero policy conversations
- Provide clarity for decision-makers on the role different solutions will – or might – play, and what that means for policy





OUR METHODS

Modelling

- Computable general equilibrium model (Navius Research's gTech)
- Technology, macroeconomy, behaviour
- + Air pollution and health impact modelling
- Literature review
- Expert input
- Stakeholder consultation
- Scenario analysis



REPORT SUMMARY

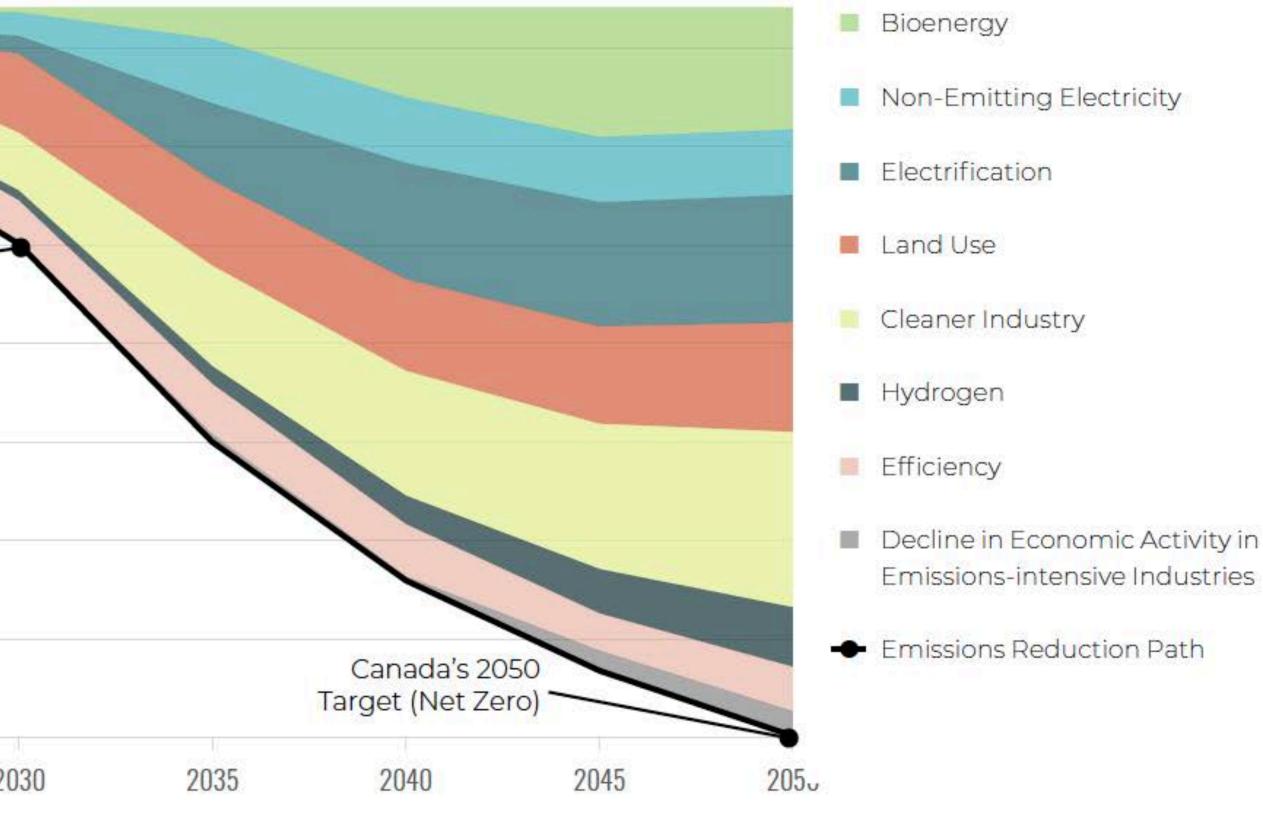


Net zero is achievable, and there are many potential pathways to getting there

Figure 1: One of the many potential pathways that Canada could take to net zero

Greenhouse Gas Reductions (Mt CO ₂ eq)	700		
	600		
	500	Canada's Paris Target (30% below 2005 levels by 2030)	
	400		
	300		
	200		
	100		
	0	020 2025	2









"SAFE BETS"

- Solutions that are commercially available and have no major constraints to scaling
- Show up consistently across all our scenarios

Examples of safe bets include:

- Non-emitting electricity
- Electric vehicles in transportation
- Heat pumps in buildings
- Methane management, changes in production processes, and electrification in industry



"WILD CARDS"

- Solutions that are demonstr concerns
- Only play a role in our analysis under particular conditions
- Examples of wild cards include:
 - 2nd generation liquid biofuels in transportation
 - RNG and hydrogen in buildings
 - Negative emissions solutions in industry



Solutions that are demonstration-stage only and/or face scalability

Canada's winning hand will require a combination of safe bets and wild cards

zero

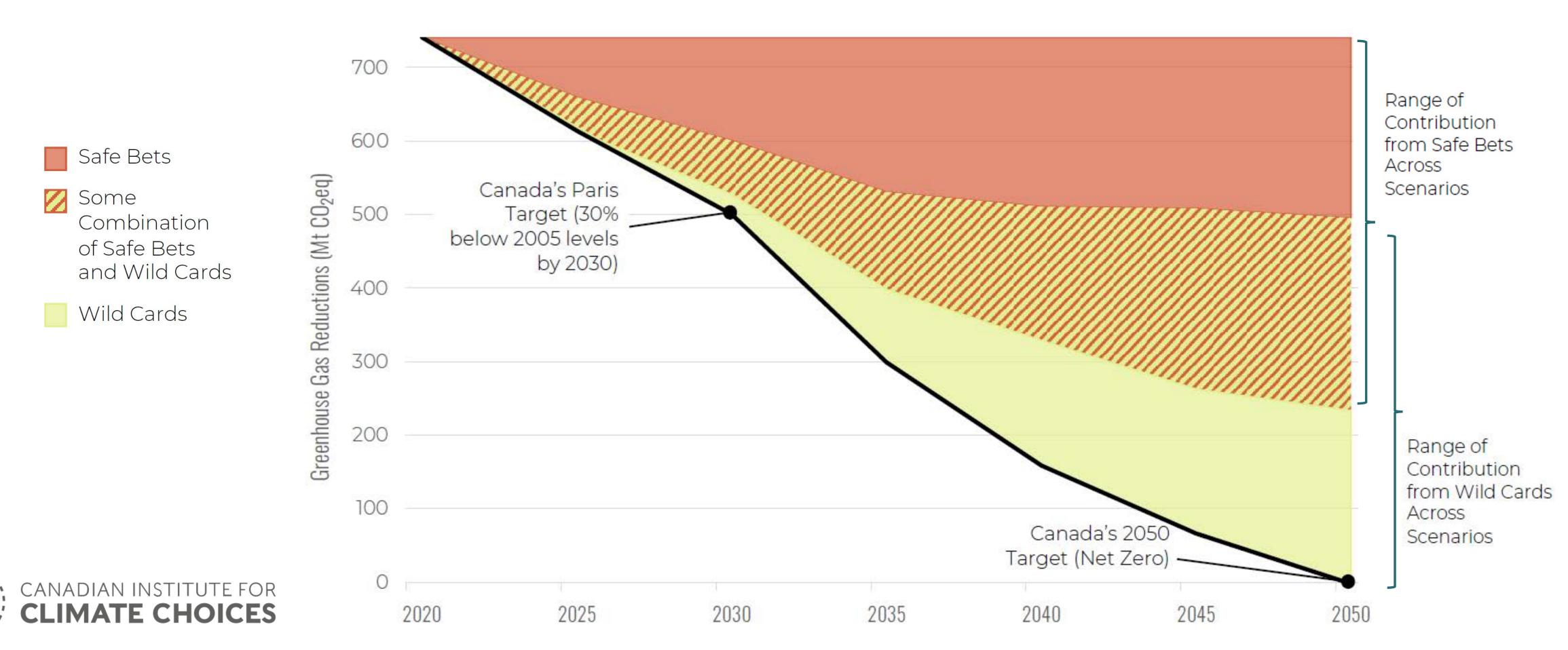


Figure 18: Contribution of safe bets to emissions reductions across pathways to net



Meeting 2030 target is about scale, speed and safe bets

SAFE BETS

Electric vehicles

Energy-efficiency equipment

Non-emitting electricity

Electric heat pump and baseboard

Hydrofluorocarbon (HFC) reductions

Other elecrification

Carbon capture, utilization, and storage (high concentration)

Methane capture (oil and gas)

Renewable Natural Gas (1st generation)

Liquid biofuels (1st generation)

Natural gas fuel switching

Minimum contribution across scenarios

Full potential across scenarios WILD CARDS

Carbon capture, utilization, and storage (unconcentrated)

Land use

Hydrogen (fuel cells and heating)

Other industrial decarbonization



Wild cards are key to long-term success

SAFE BETS

Electric vehicles

Energy-efficiency equipment

Non-emitting electricity

Electric heat pump and baseboard

Hydrofluorocarbon (HFC) reductions

Other elecrification

Carbon capture, utilization, and storage (high concentration)

Methane capture (oil and gas)

Renewable Natural Gas (1st generation)

Liquid biofuels (1st generation)

Minimum contribution across scenarios

Full potential across scenarios WILD CARDS

Direct air capture

Carbon capture, utilization, and storage (unconcentrated)

Land use

Liquid biofuels (2nd generation)

Hydrogen (fuel cells and heating)

Renewable Natural Gas (2nd generation) Other industrial decarbonization

Final energy demand in Canada

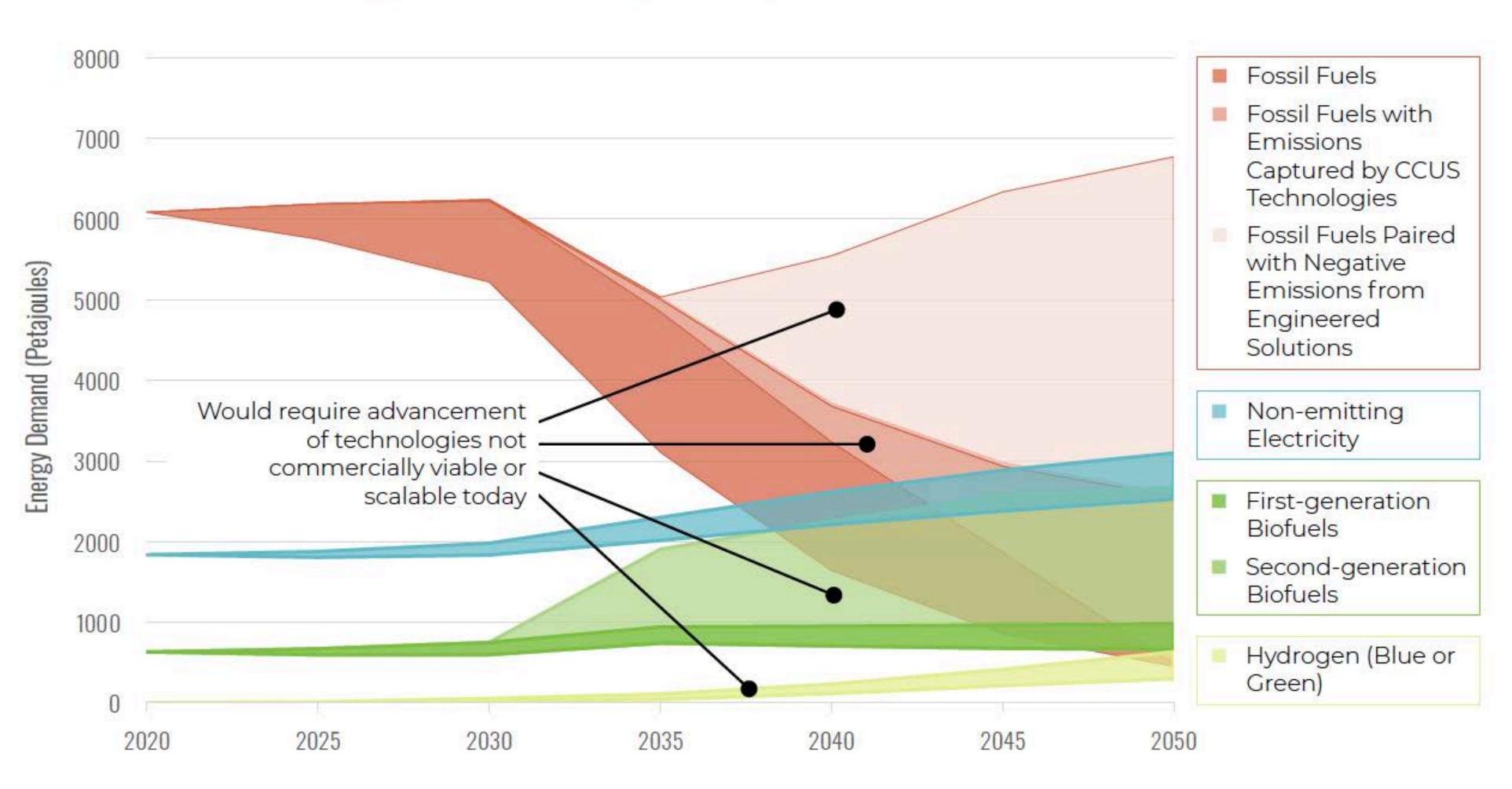
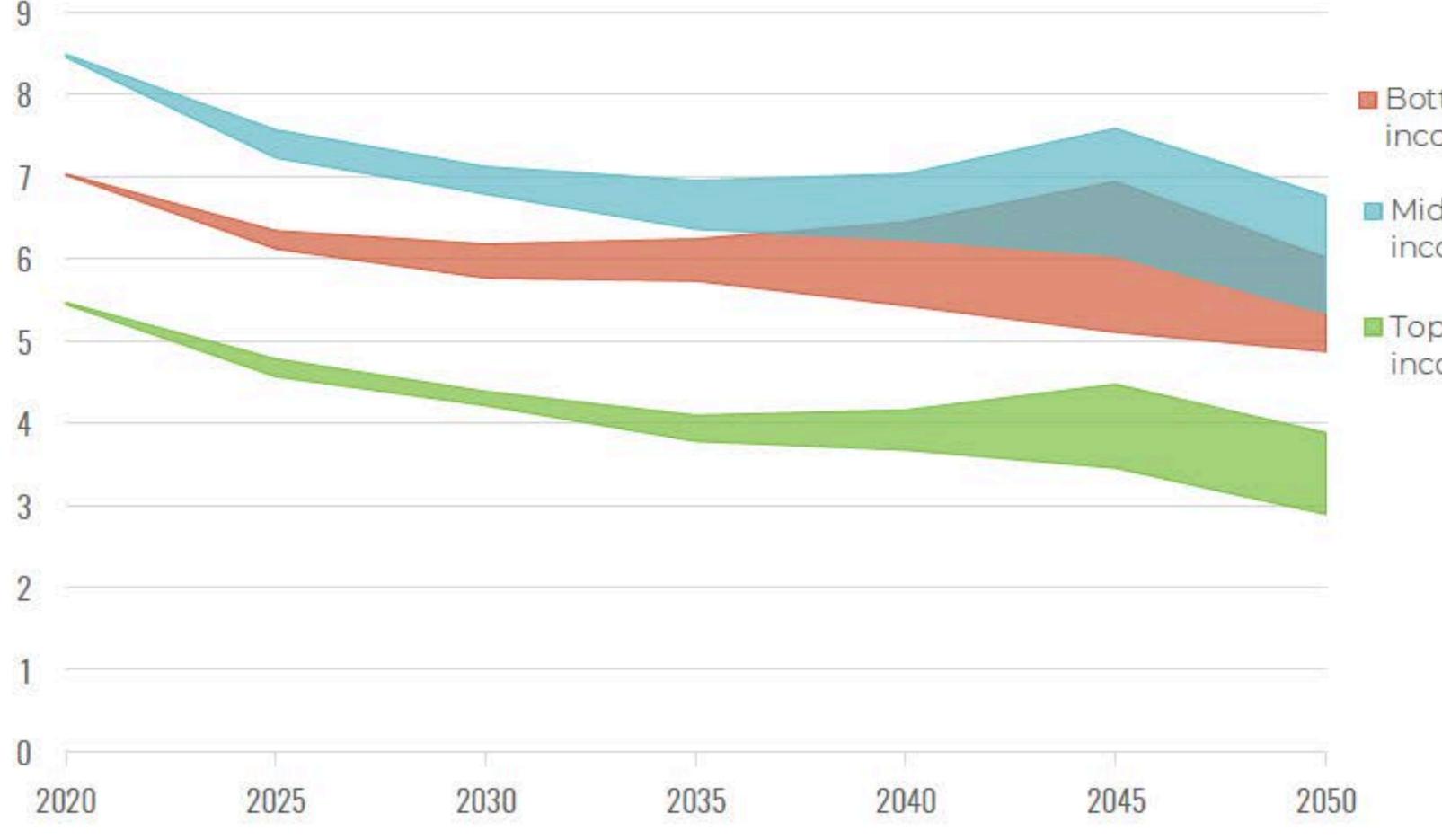
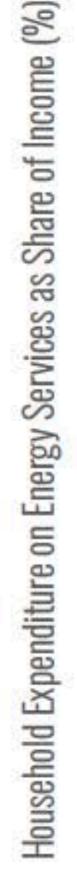




Figure 3: The contribution of different types of energy and energy carriers to Canadian final energy demand on pathways to net zero

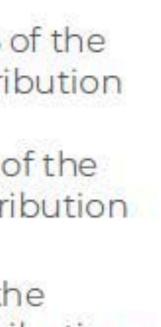
Households **spend less** on energy as a share of income





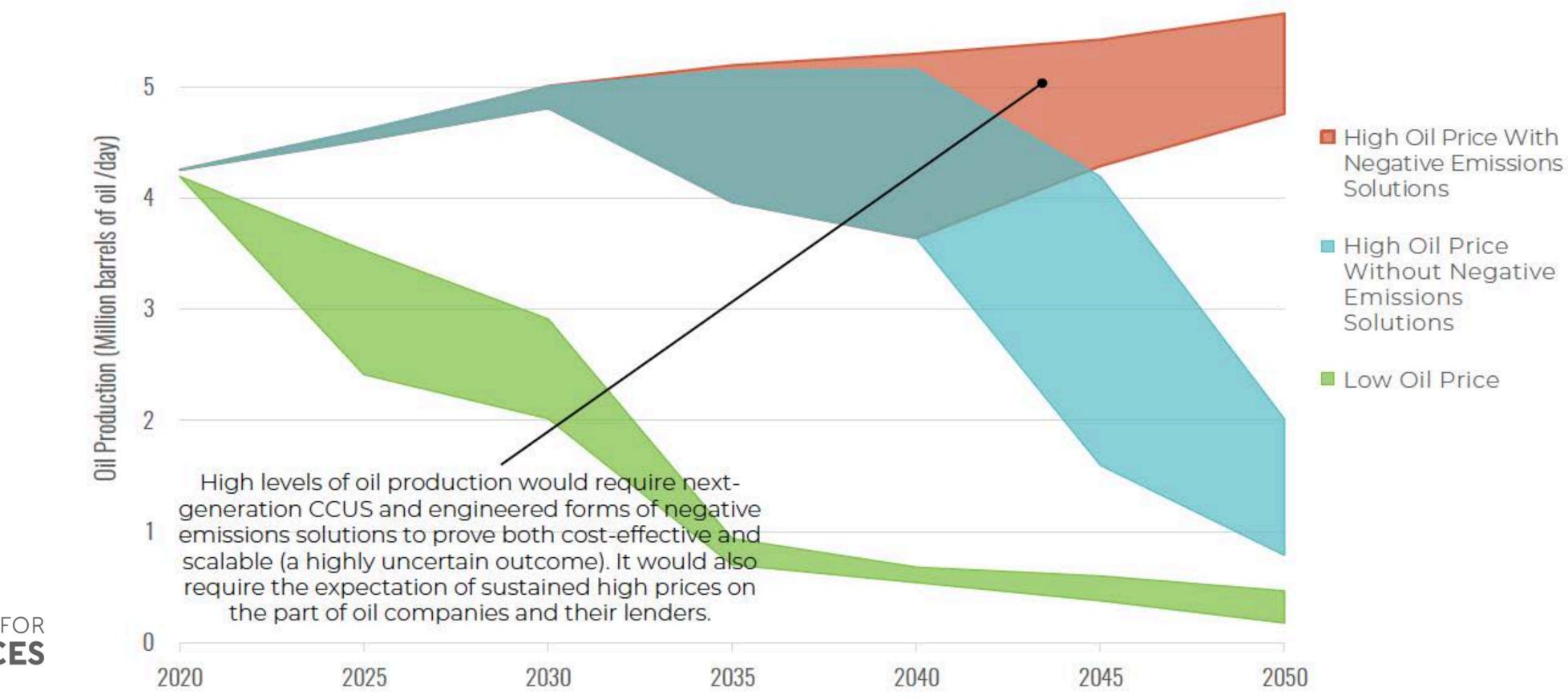


- Bottom 20% of the income distribution
- Middle 60% of the income distribution
- Top 20% of the income distribution



Factors beyond Canada's control have big implications

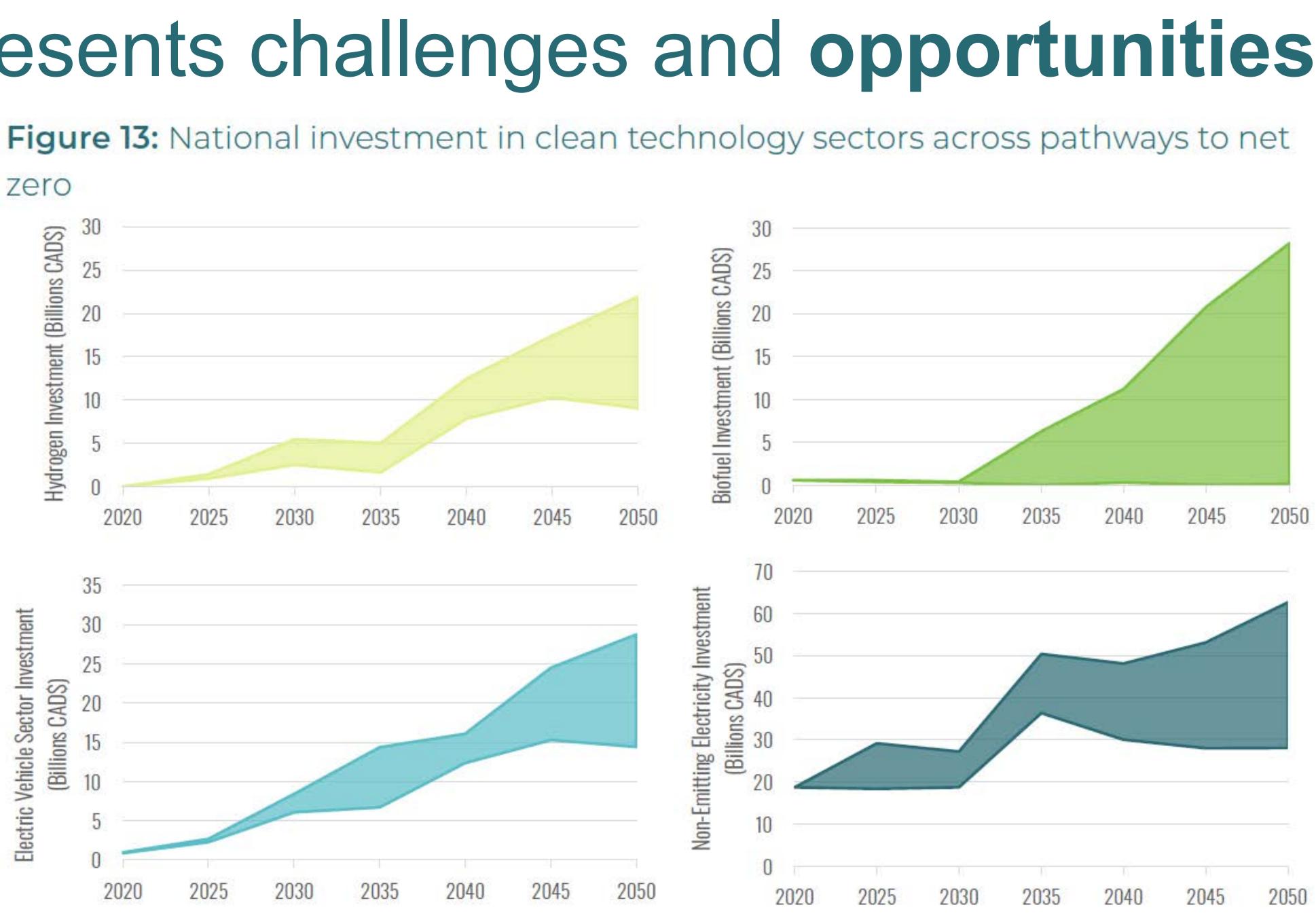
Figure 14: Canadian oil production under low and high global price scenarios for oil across pathways to net zero







Net zero presents challenges and opportunities





THREE ILLUSTRATIVE NET ZERO ENERGY SYSTEMS

Fossil fuels + negative emissions



Credit: Carbon Engineering









Biofuels

Electrification + hydrogen









OVERVIEW OF KEY FINDINGS

- Net zero is achievable, but requires strong policy
- Big transitions are inevitable especially due to global trends
- Canada has significant competitive advantages
- We need both safe bets and wild cards, but they are different policy conversations
- Engineered forms of negative emissions are best viewed as a complement, not a substitute
- Pathways to 2050 have far-reaching implications for the well-being of Canadians





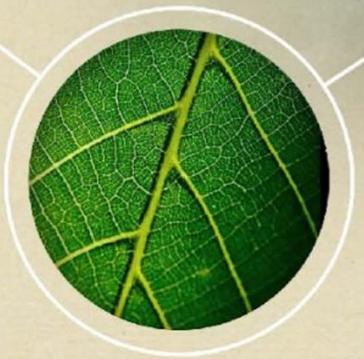
RECOMMENDATIONS

- Governments at all levels should increase the stringency of existing policies to create incentives for widespread deployment of "safe bet" solutions
- 2. Governments should manage the risks and opportunities posed by wild card solutions through a portfolio approach
- 3. Governments should increase policy certainty by implementing robust climate accountability frameworks
- 4. Governments should work to ensure that the transition to net zero is fair and inclusive



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Figure 2: Comparing Canada's Historical Greenhouse Gas Emissions and the Path to Net Zero

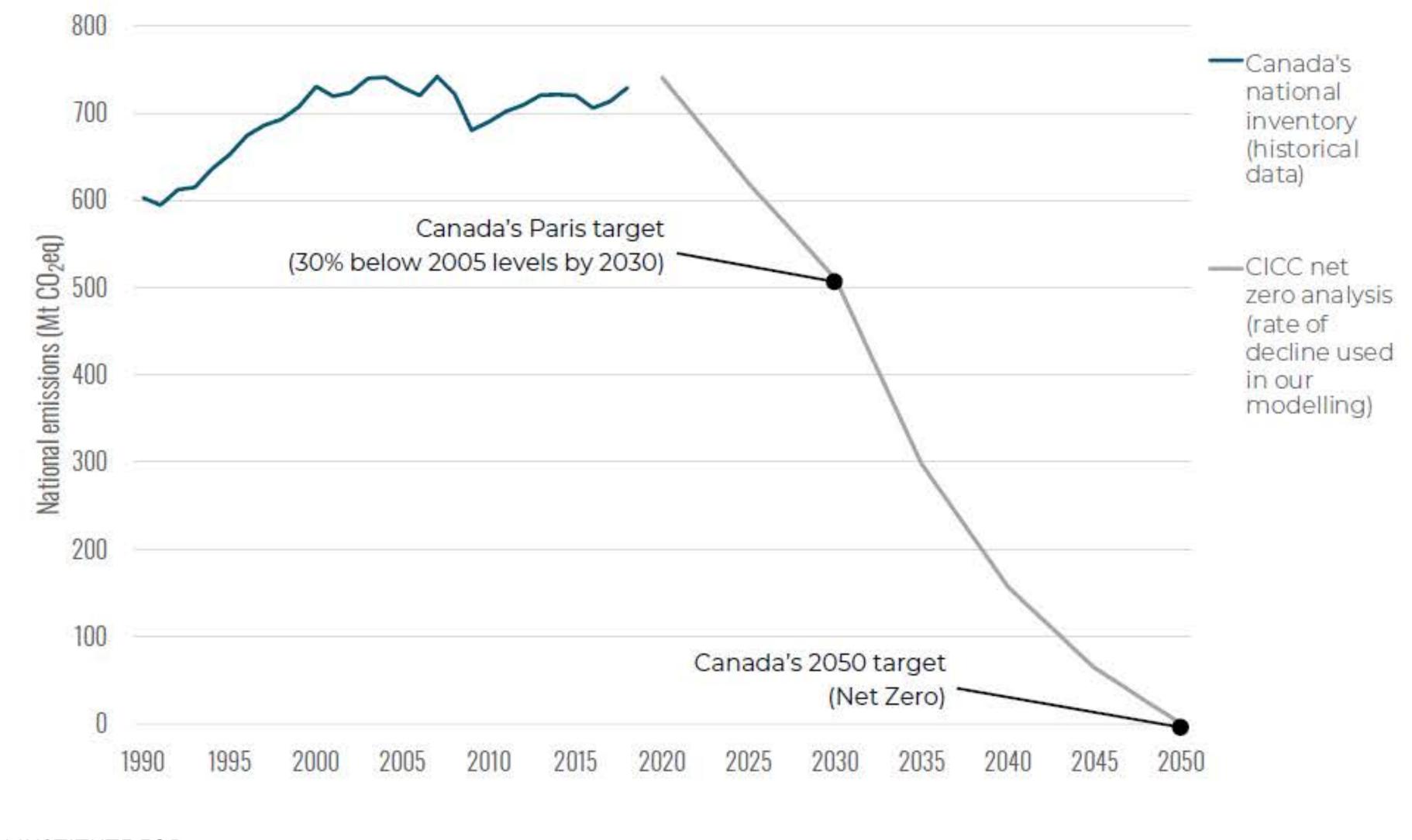




Figure 4: The effect of direct energy efficiency improvements and fuel switching on energy use on pathways to net zero

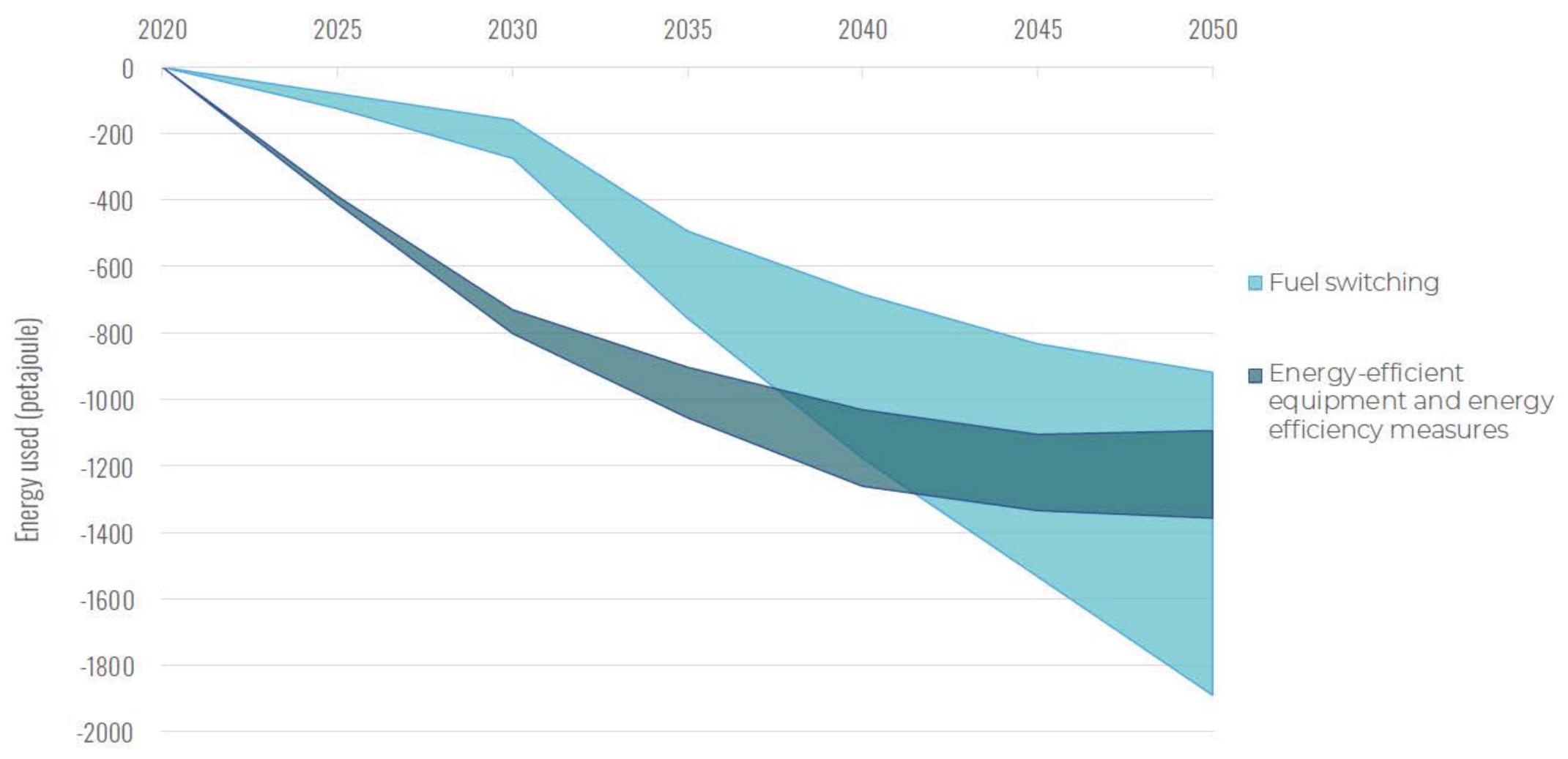
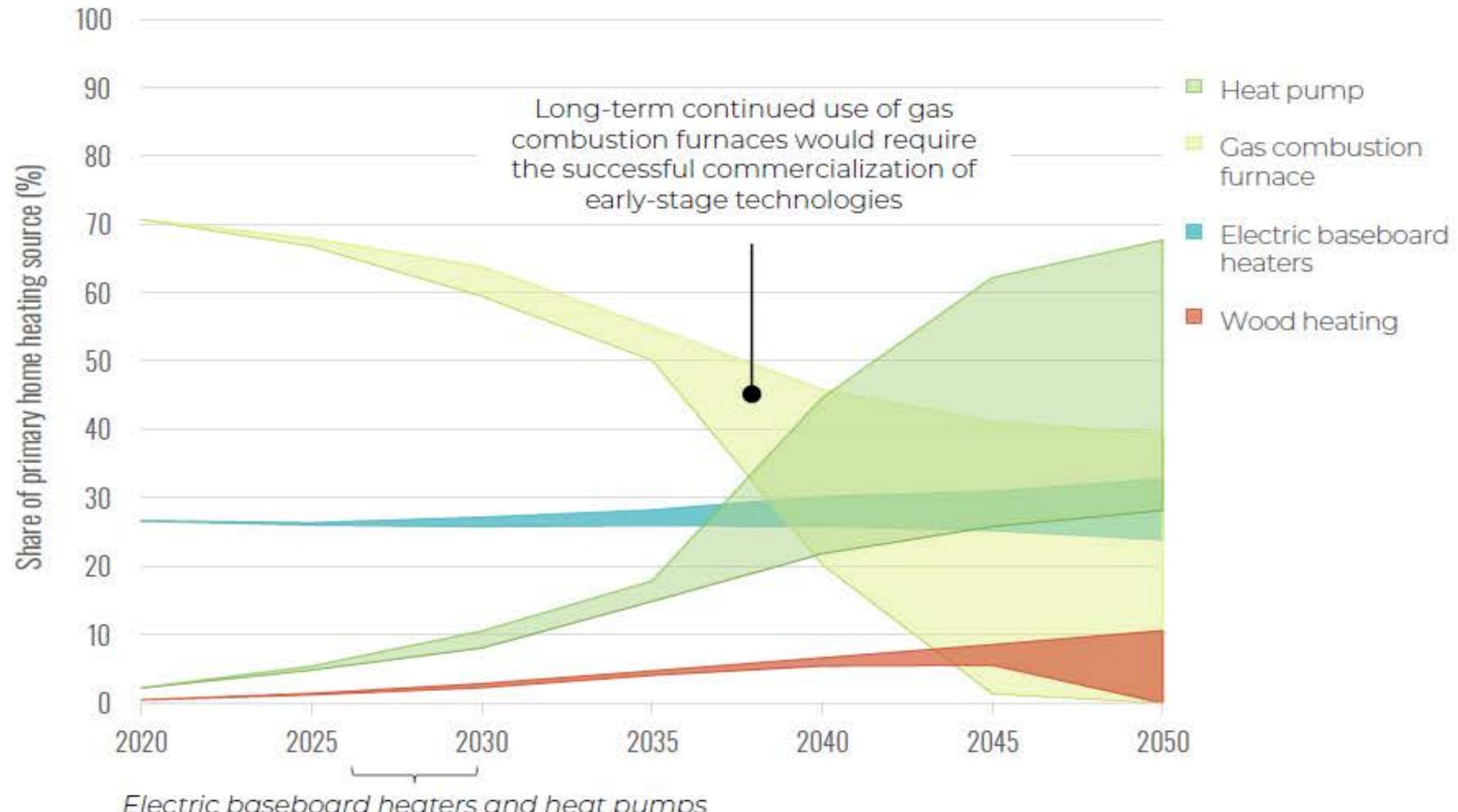




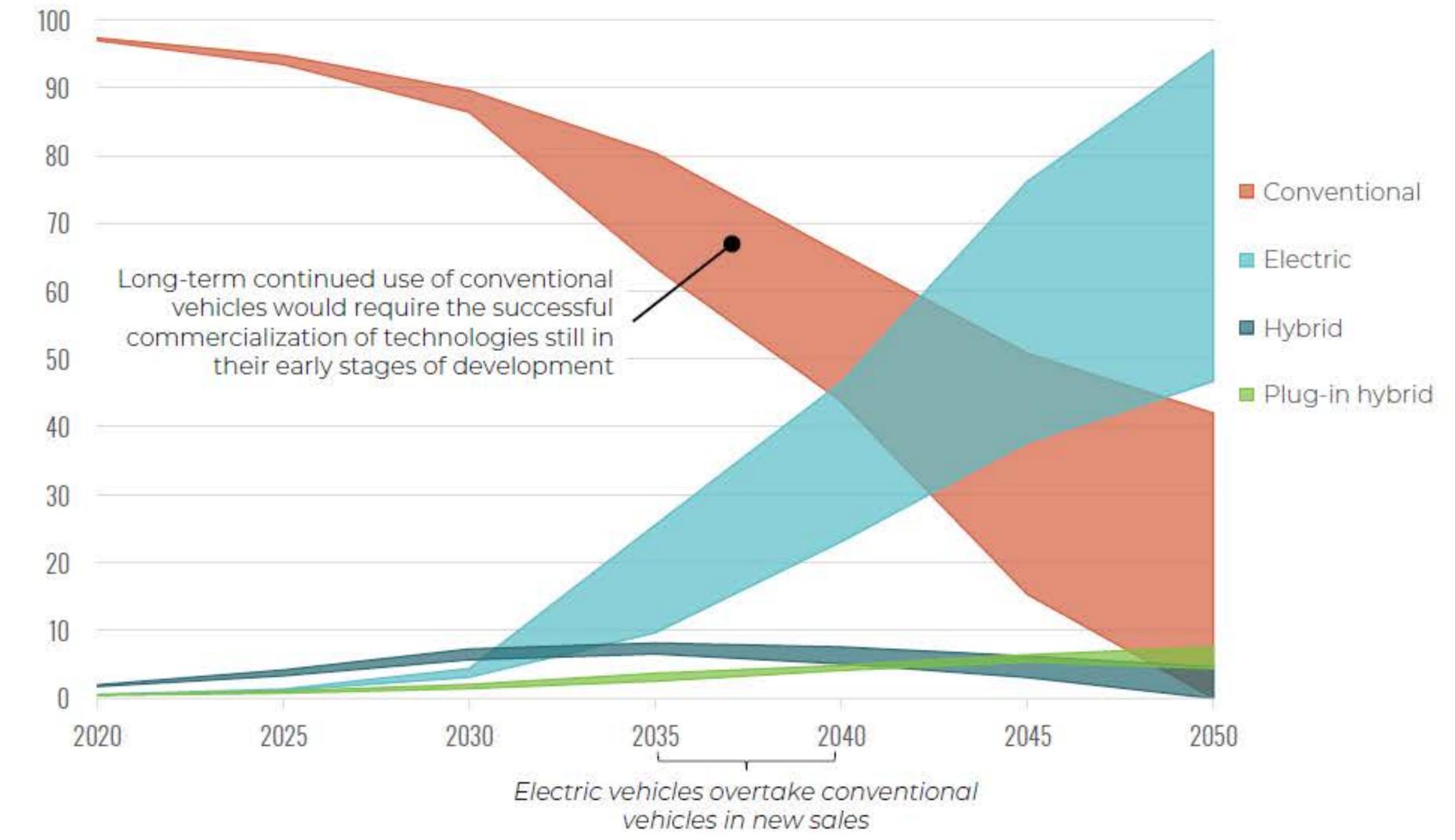
Figure 6: Share of heating technologies installed as a primary source of home heating across pathways to net zero



Electric baseboard heaters and heat pumps overtake gas combustion furnaces in new sales



Figure 7: The total market share of different vehicle types in Canada's personal transportation fleet across pathways to net zero



Fleet share (%)



Figure 8: National annual estimated economic burden due to mortality associated with air pollution emissions from energy production and use on pathways to net zero

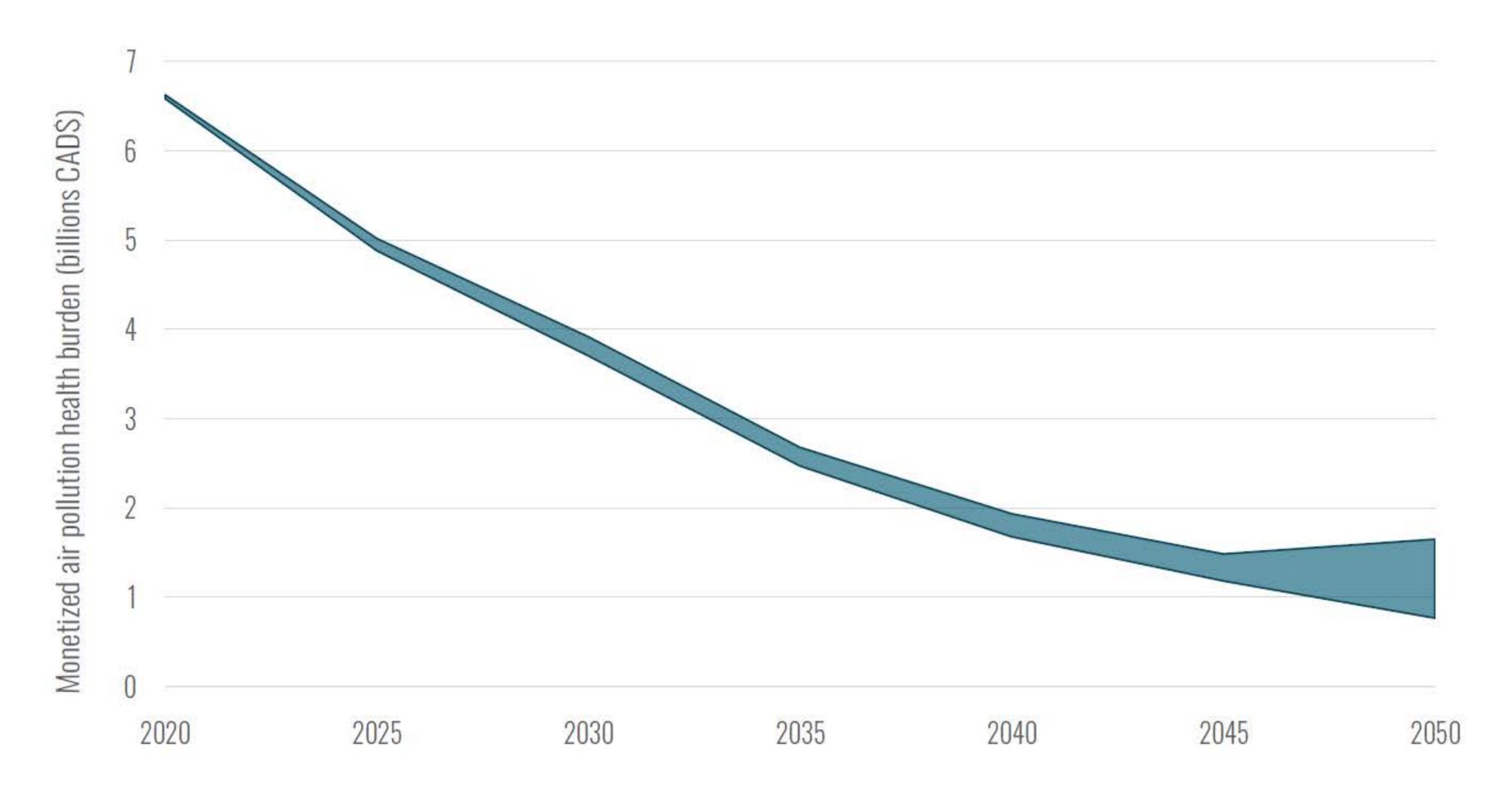




Figure 9: The total market share of different vehicle types in Canada's freight transportation fleet across pathways to net zero

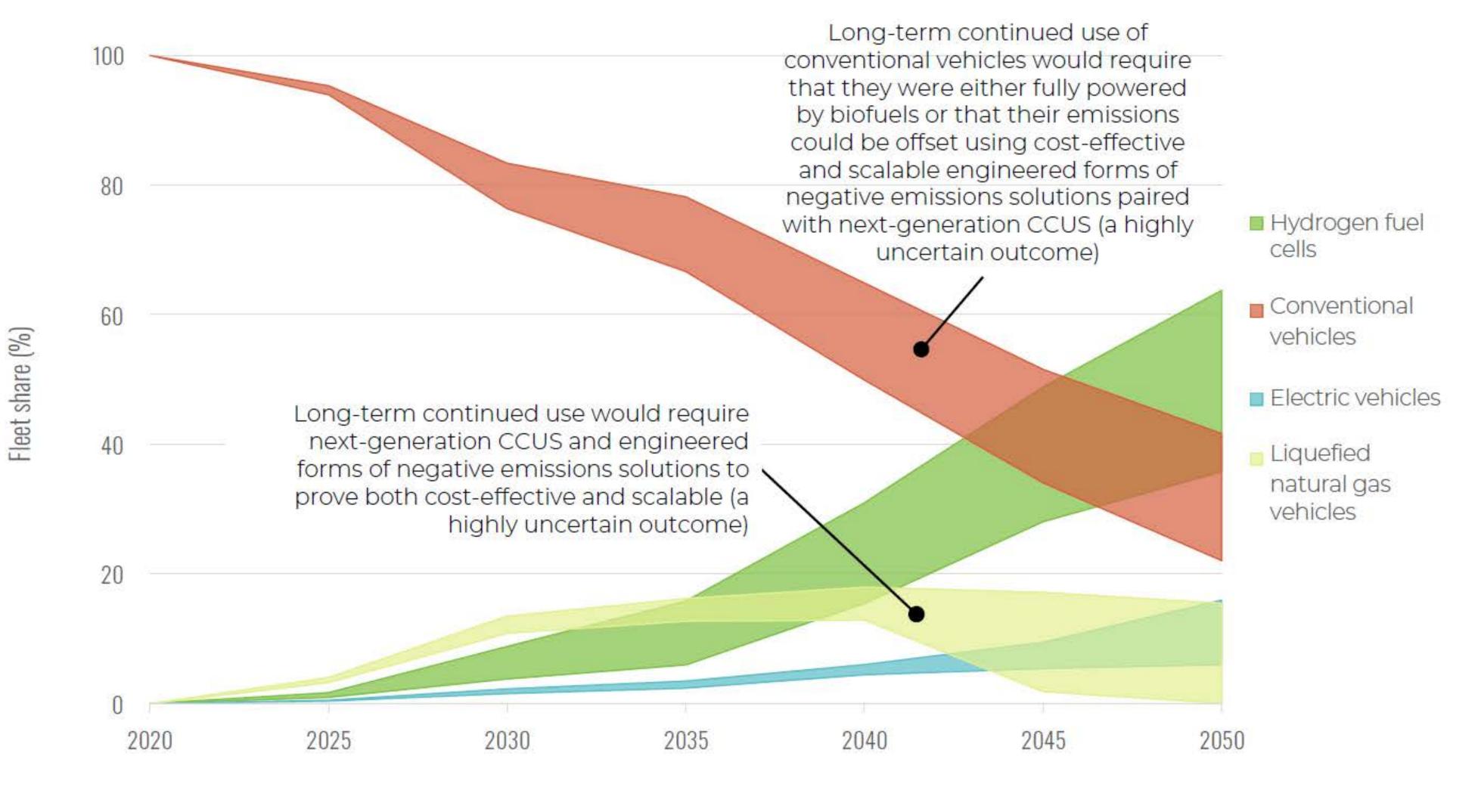




Figure 10: Consistent versus variable emissions reduction pathways for industry across pathways to net zero

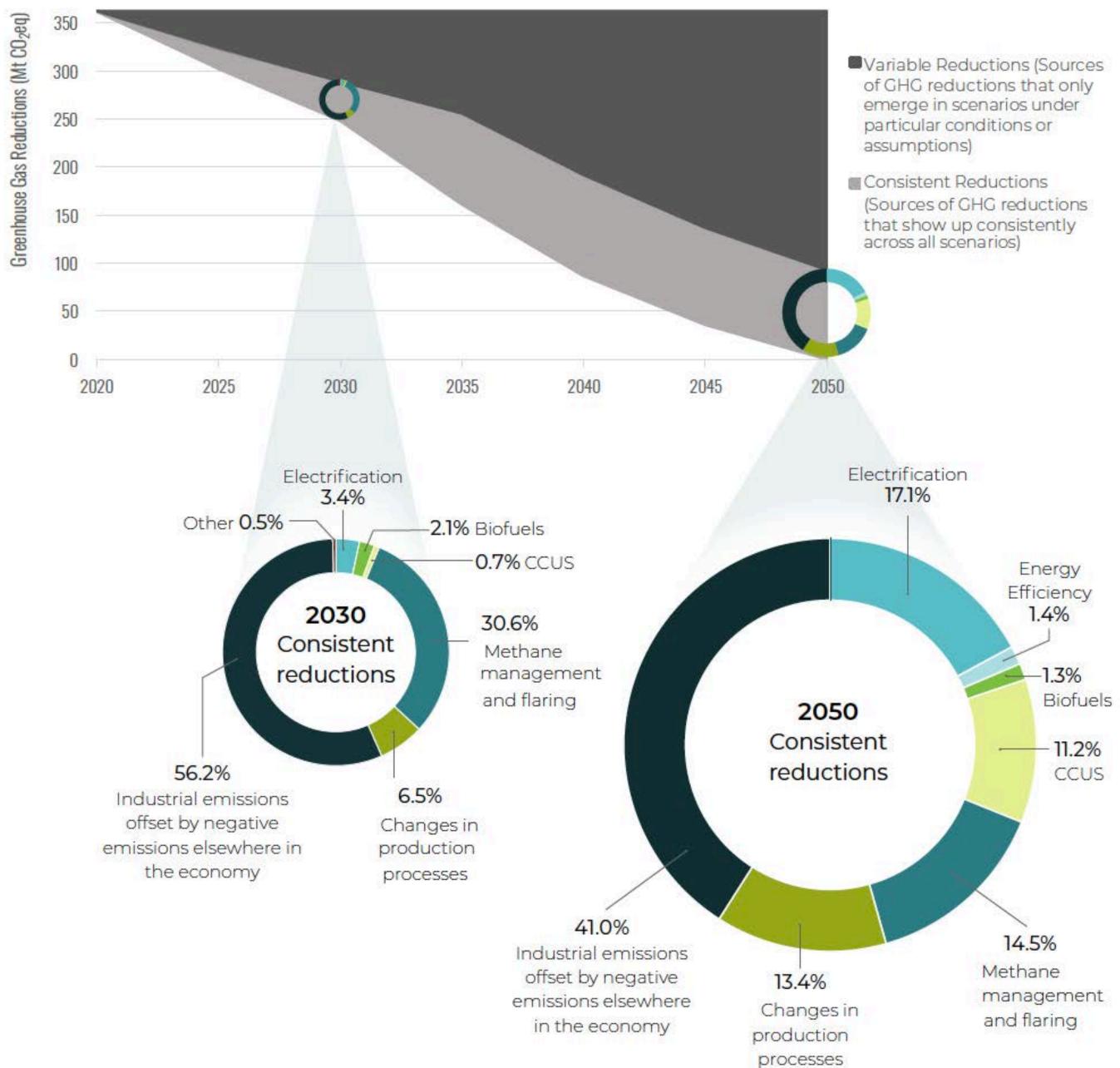




Figure 11: Resource output across pathways to net zero

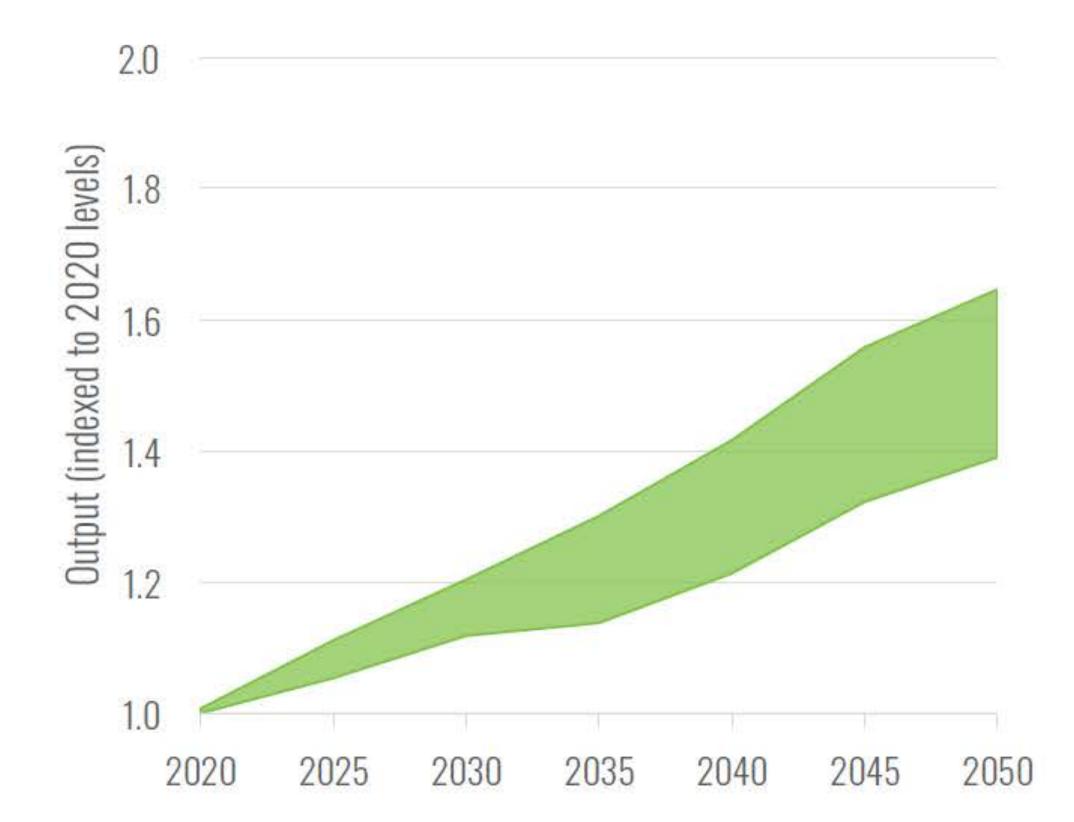




Figure 12: Manufacturing output across pathways to net zero

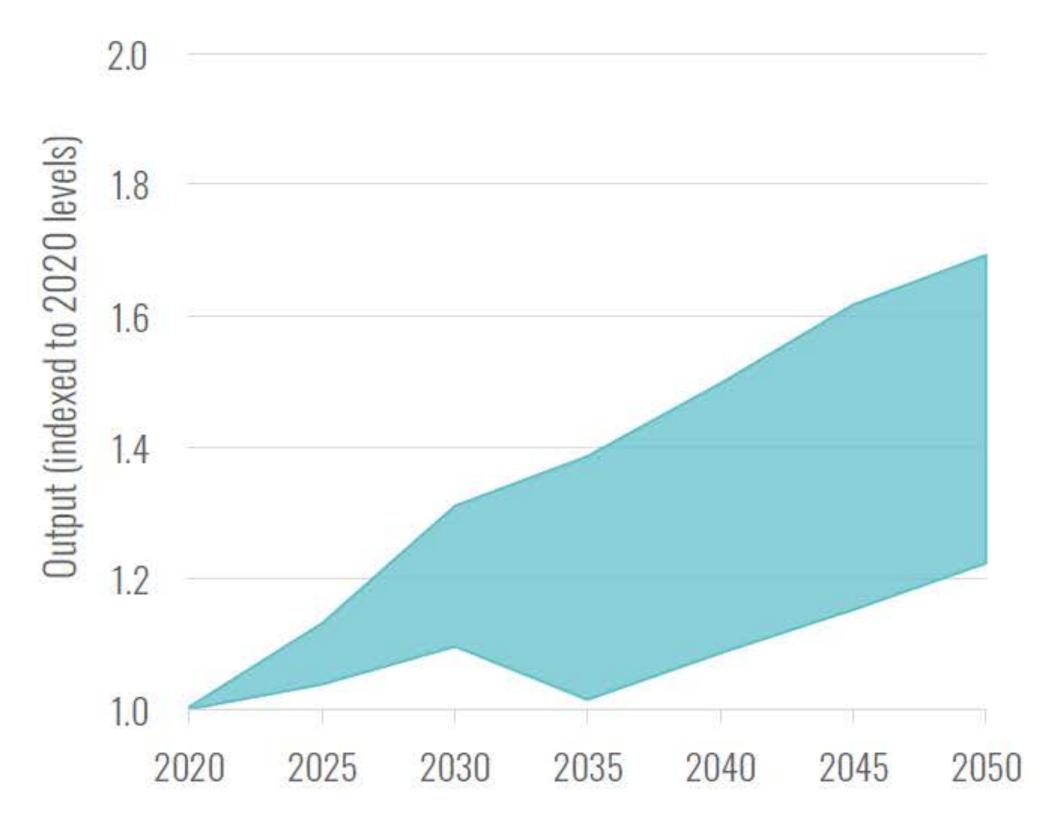


Figure 16: The high uncertainty surrounding the potential of negative emissions from nature-based and engineered solutions across pathways to net zero

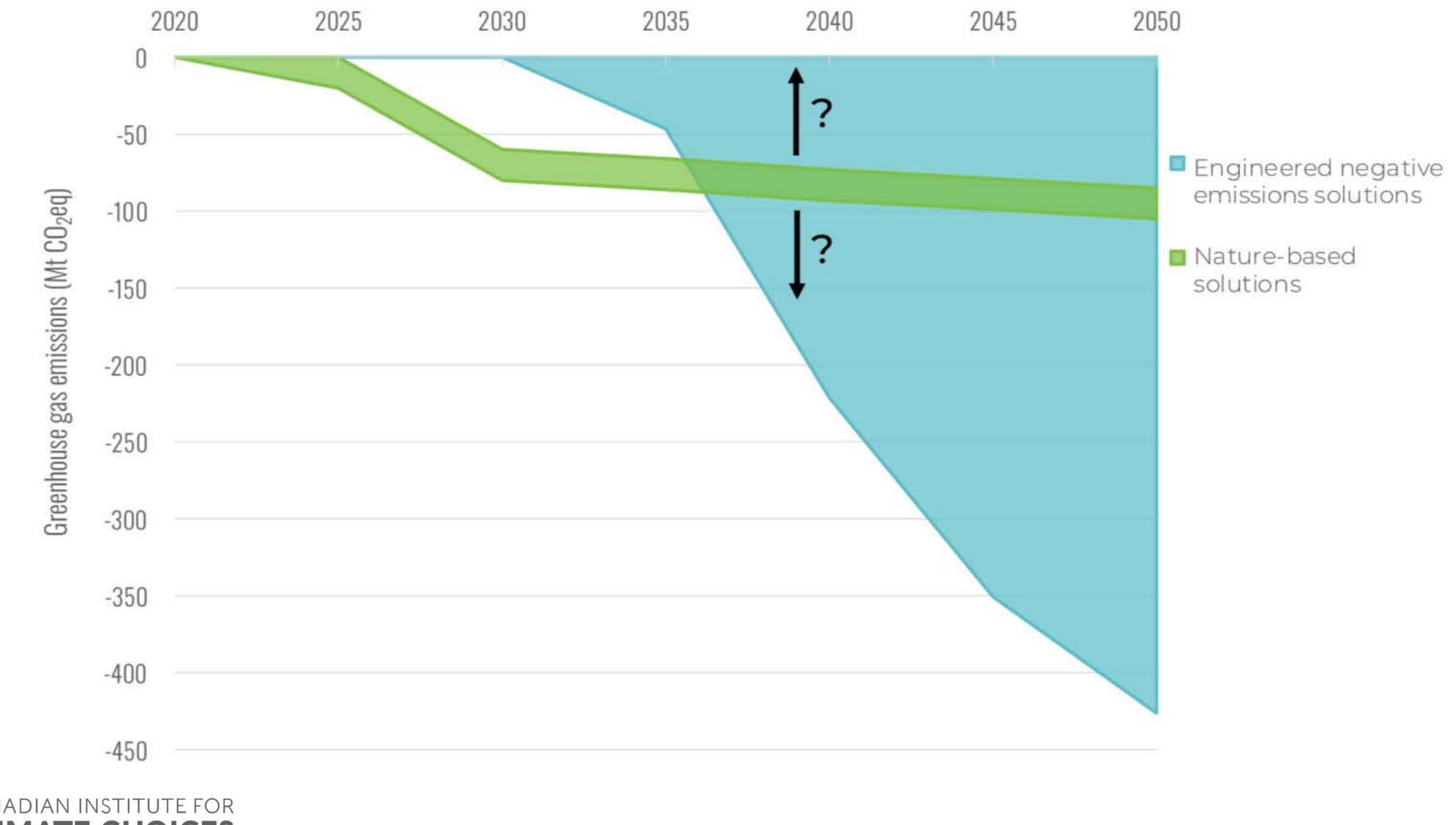




Figure 17: Domestic final energy demand (for all energy types) under differing assumptions for the ultimate cost-effectiveness and scalability of engineered forms of negative emissions

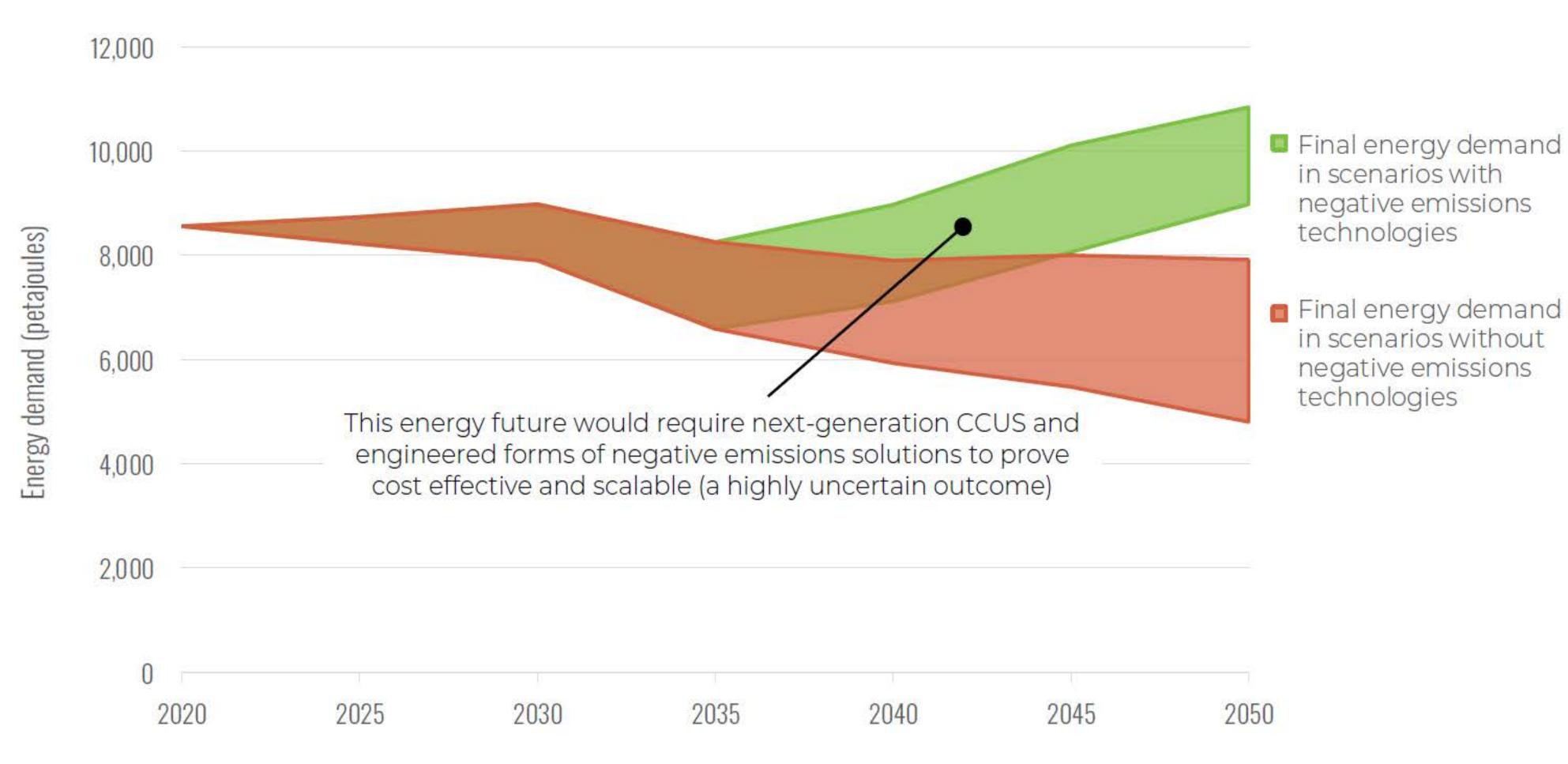
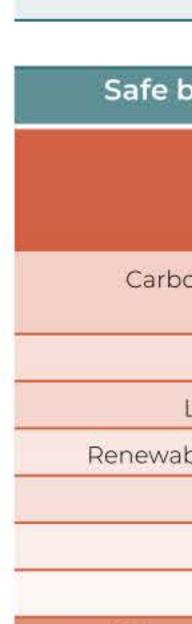




Figure 19: Projected contributions to 2030 emissions reductions by different solutions across pathways to net zero



Wild

Electric h



2030 SAFE BETS - CC Methane capture—oil and gas			ND SCA				
Hydrofluorcarbon reductions	н				-		
Natural gas fuel switching	F						
Non-emitting electricity	,	-1					
Energy efficient equipment		-					
Carbon capture, utilization and storage, high concentration							
Electric vehicles	н						
ctric heat pumps and baseboard heaters	н						
Other electrification	н						
Liquid biofuels, first generation	н						
RNG, first generation	Ú.						
Safe bets range across scenarios			i.				
2030 WILD CARDS - DEMONSTRATION STAGE AND/OR SCALABILITY CONCERNS							

bon capture, utilization and storage, unconcentrated	н						
Hydrogen (fuel cells and heating	н						U
Liquid biofuels, second generation	~Ø						
able natural gas, second generation	~Ø						
Other industrial decarbonization	I.						
Land use*			H				
Direct air capture	•						
cards range across scenarios							
	0	50	100	1	50	200	250

Mitigation range (MtCO_eq/yr)

Figure 20: Projected contributions to 2050 emissions reductions by different solutions across pathways to net zero

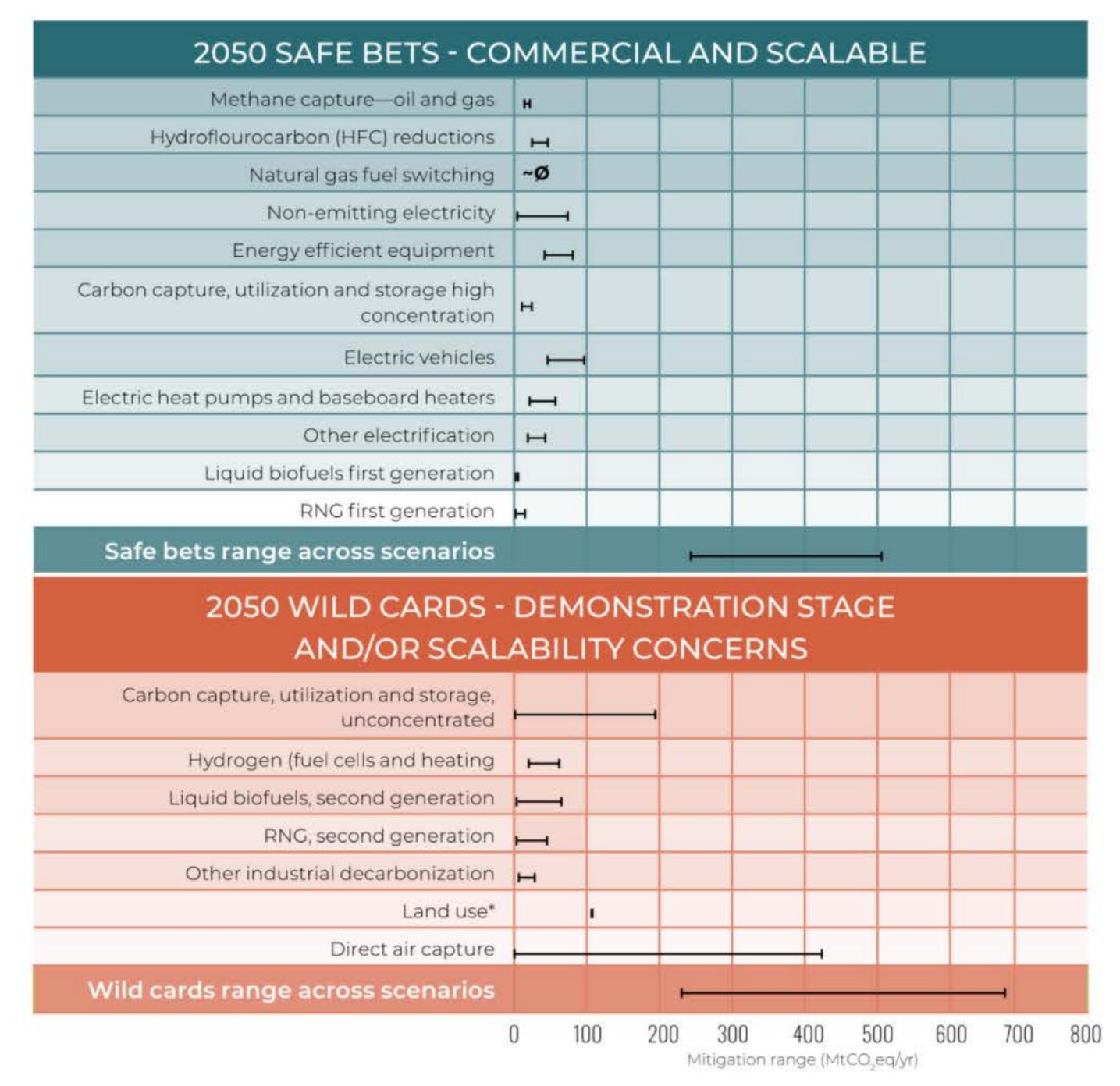




Figure 21: Buildings

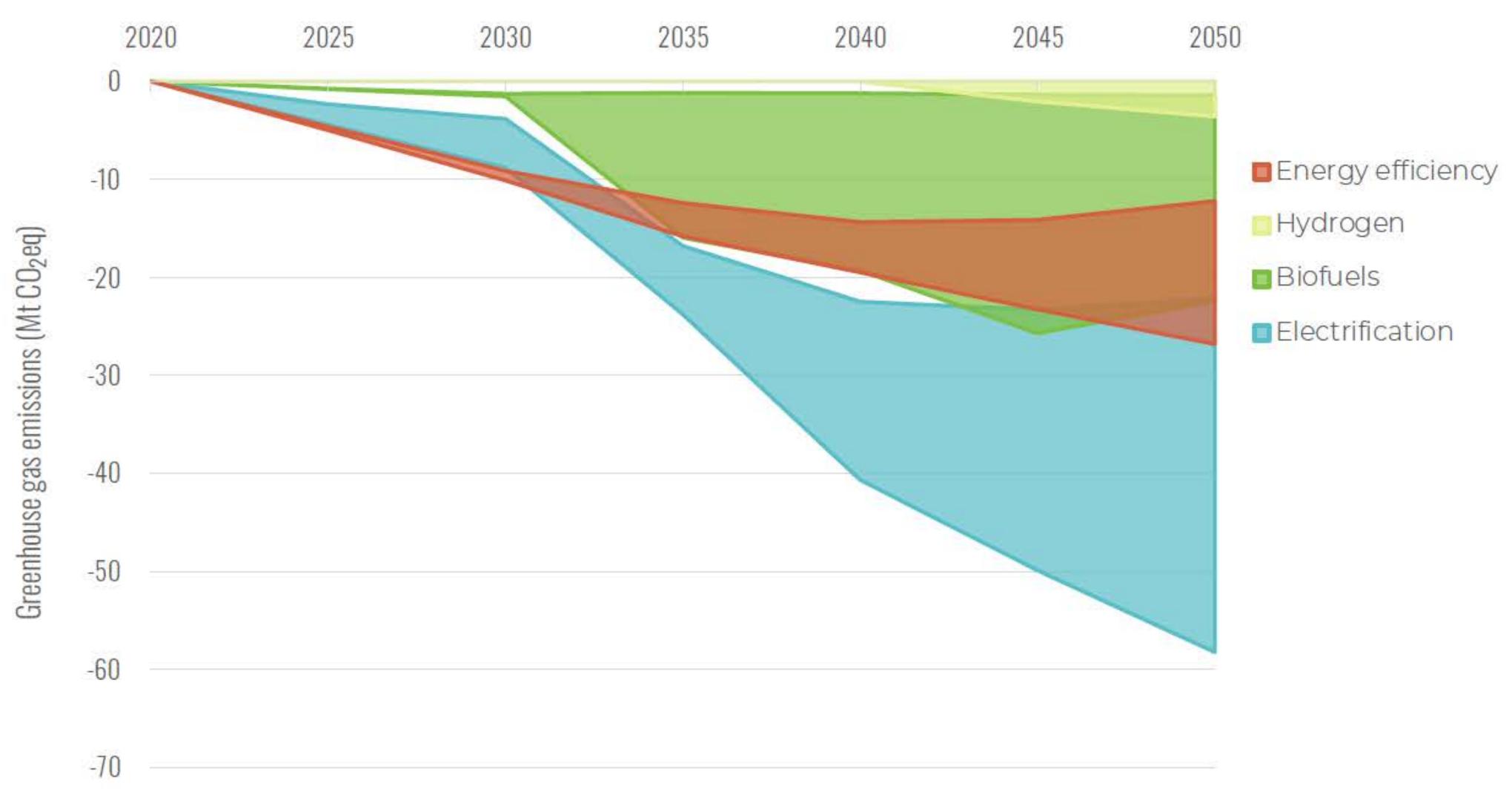




Figure 22: Personal Transportation

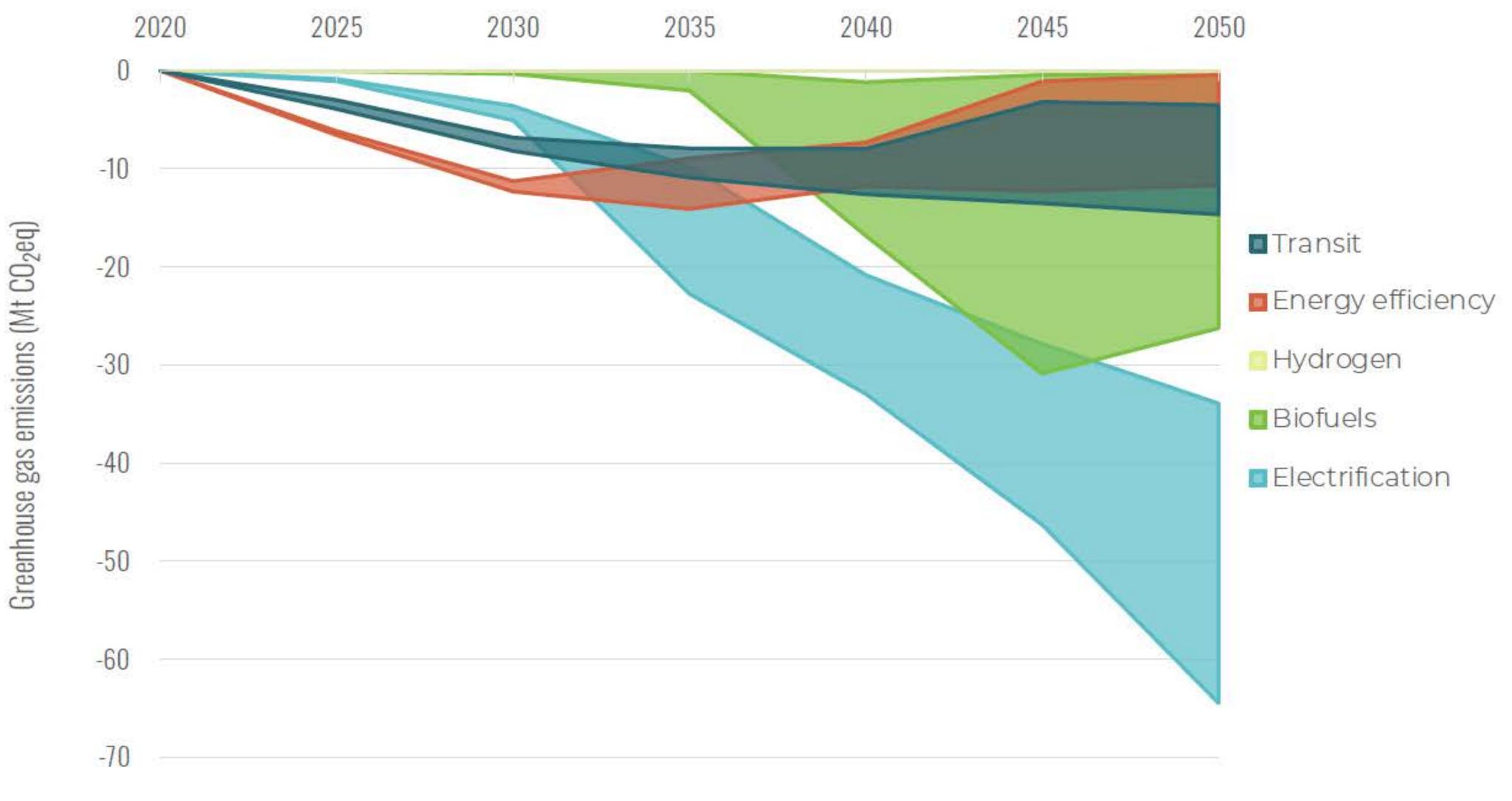




Figure 23: Medium- and Heavy-Duty Transportation

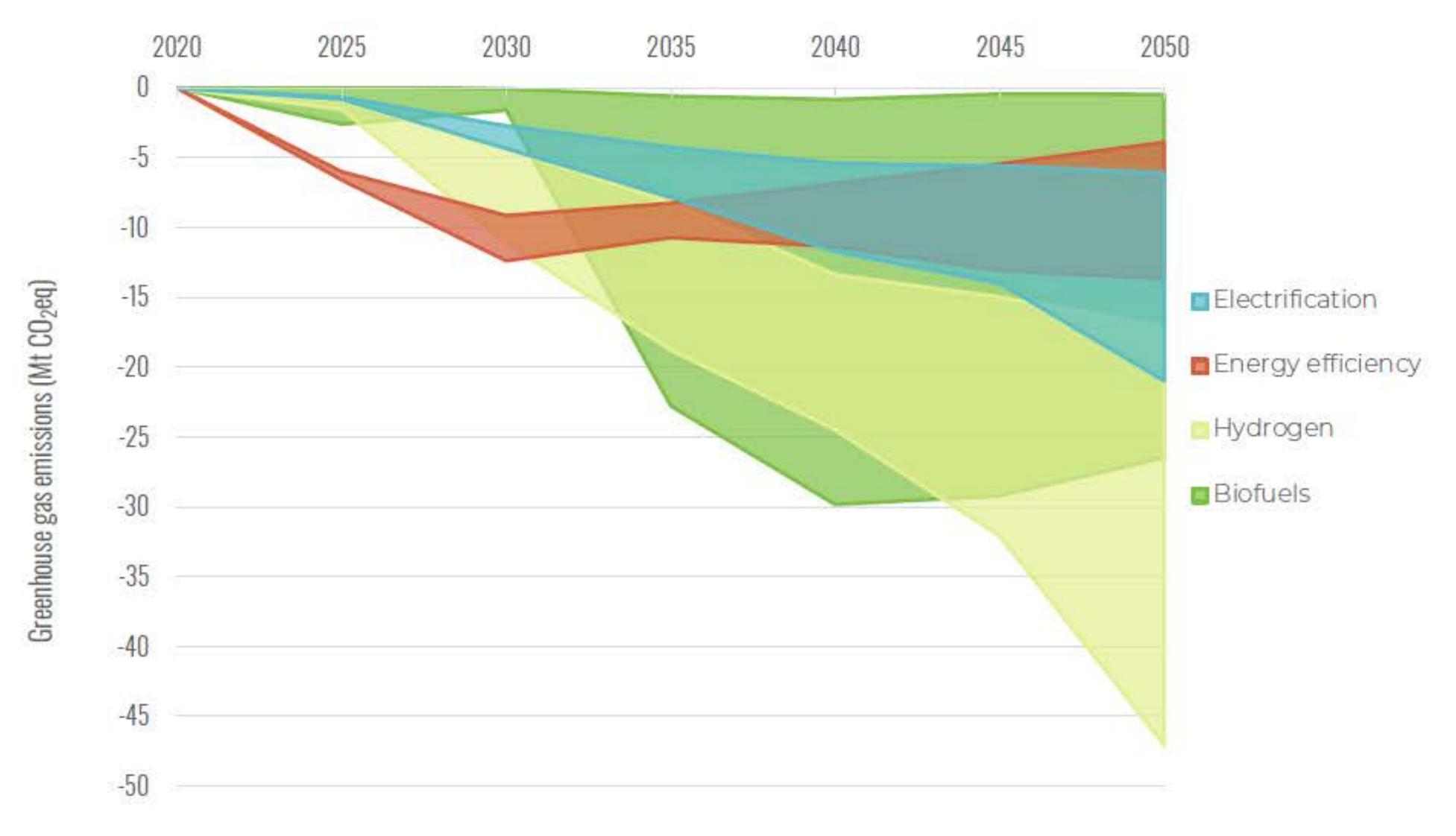
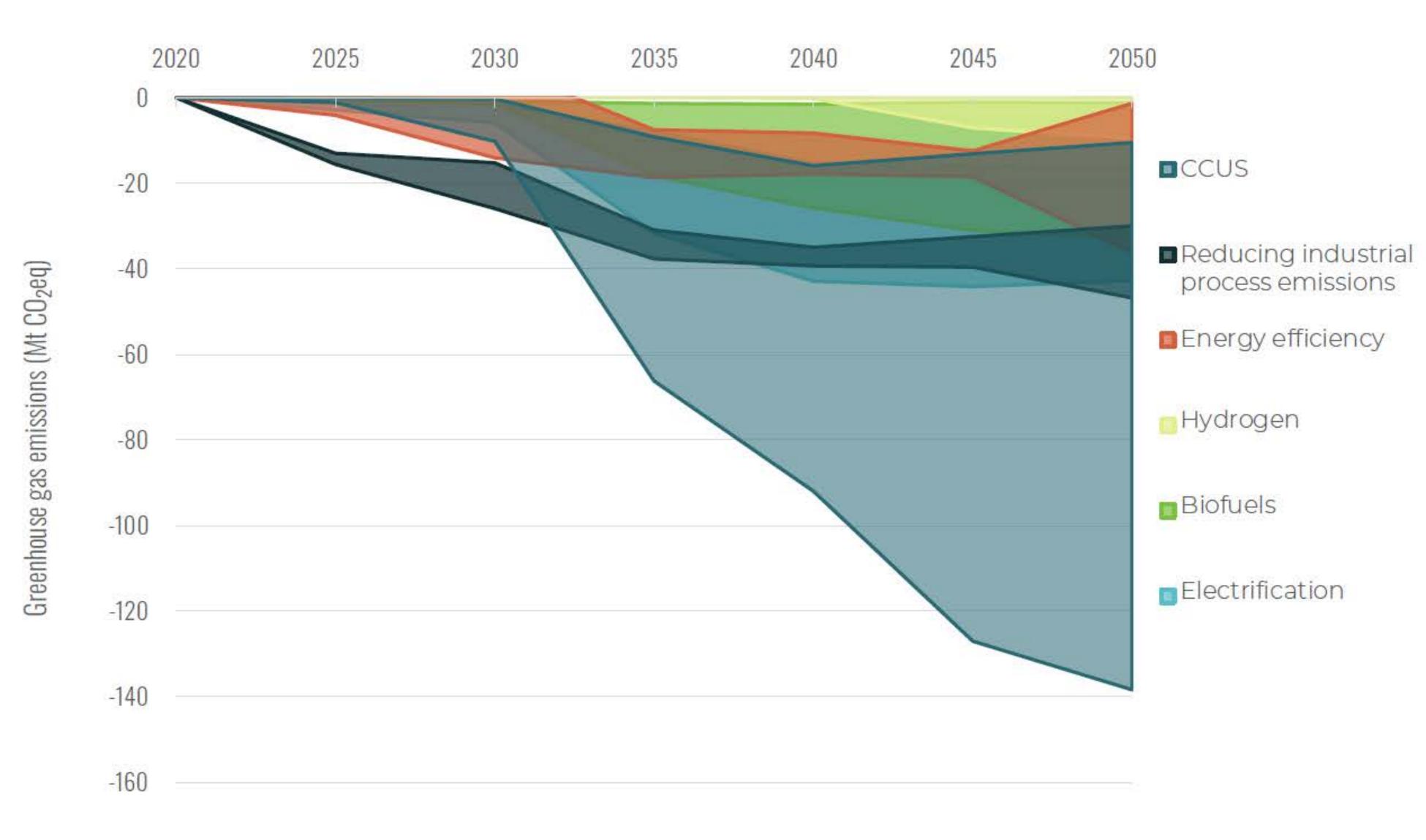


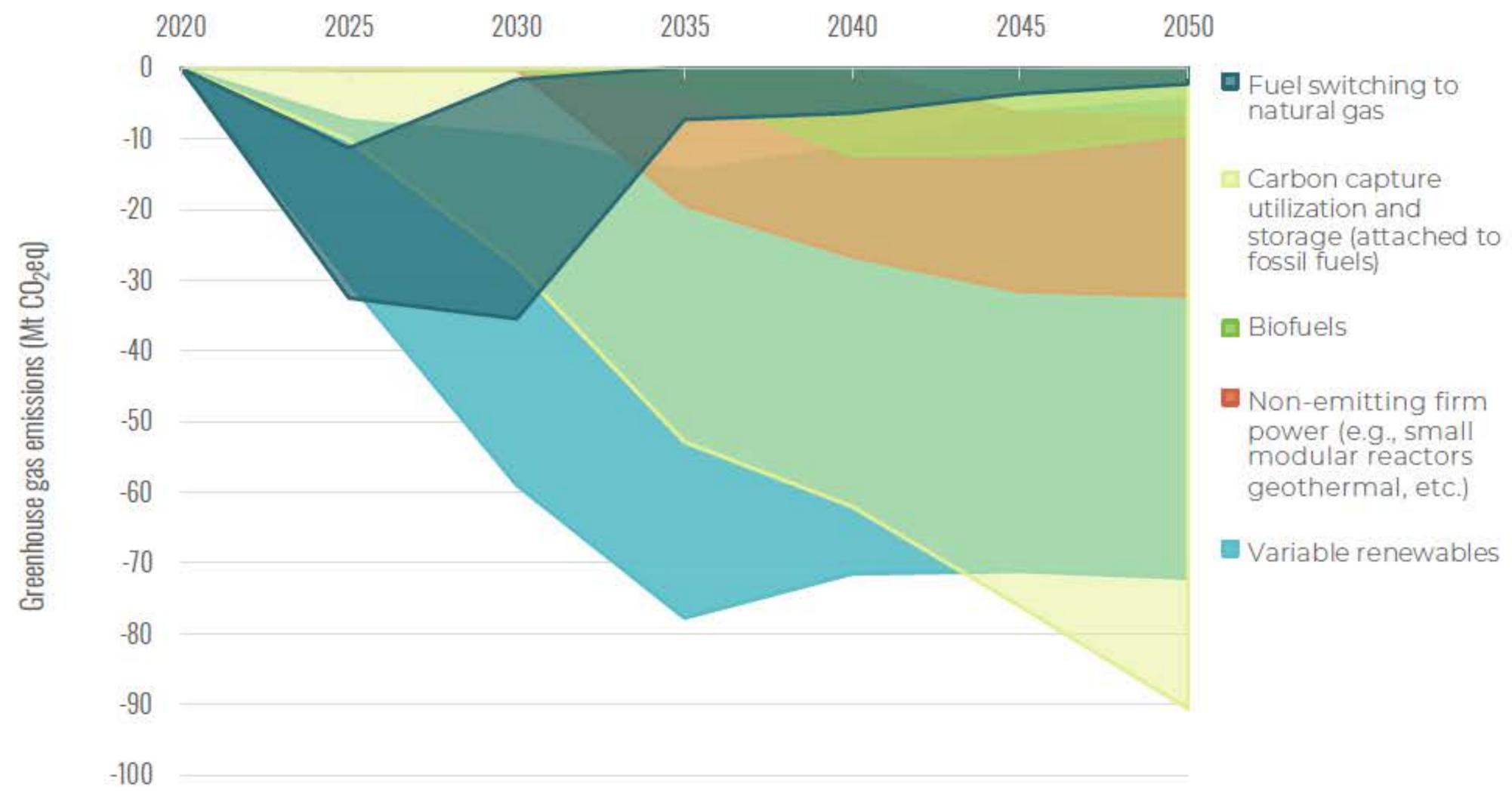


Figure 24: Industry



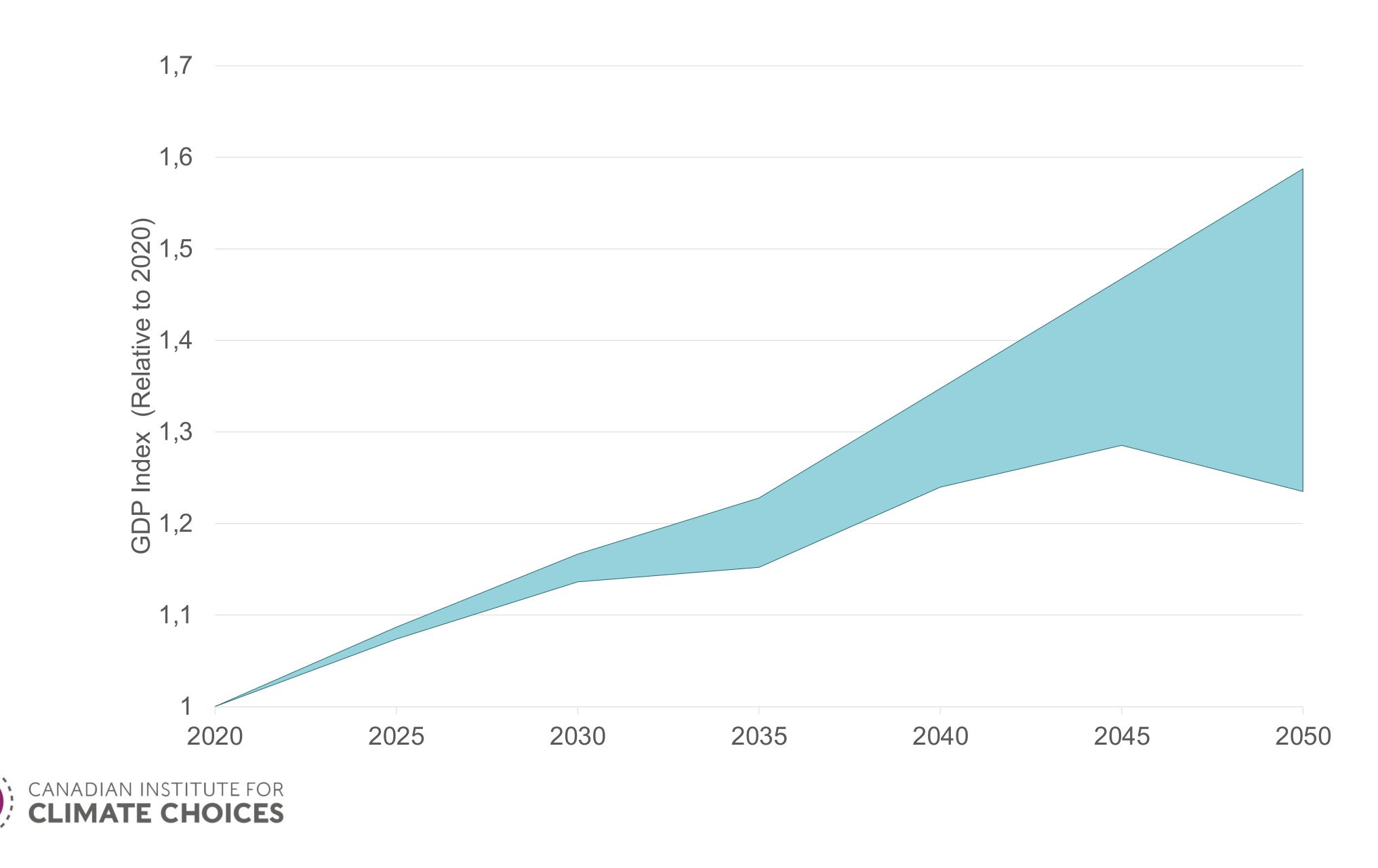






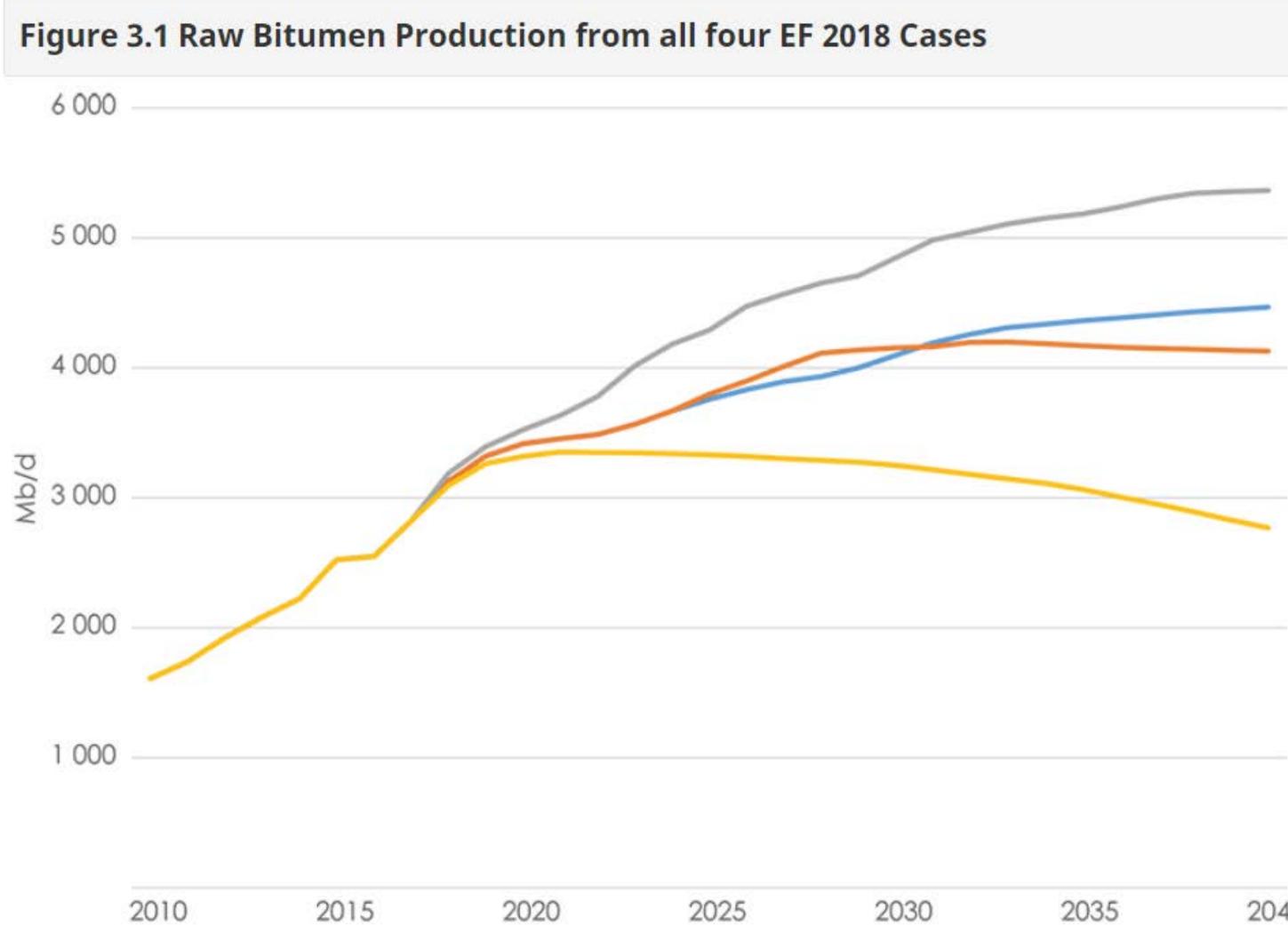


Additional Figure: National gross domestic product across pathways to net zero

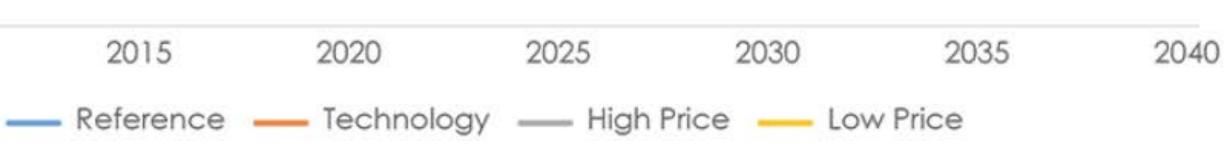


Additional Figure: Canada's Energy Futures 2018

Chapter 3: Results - All Cases







Additional Figure: Global oil production cost profile

