

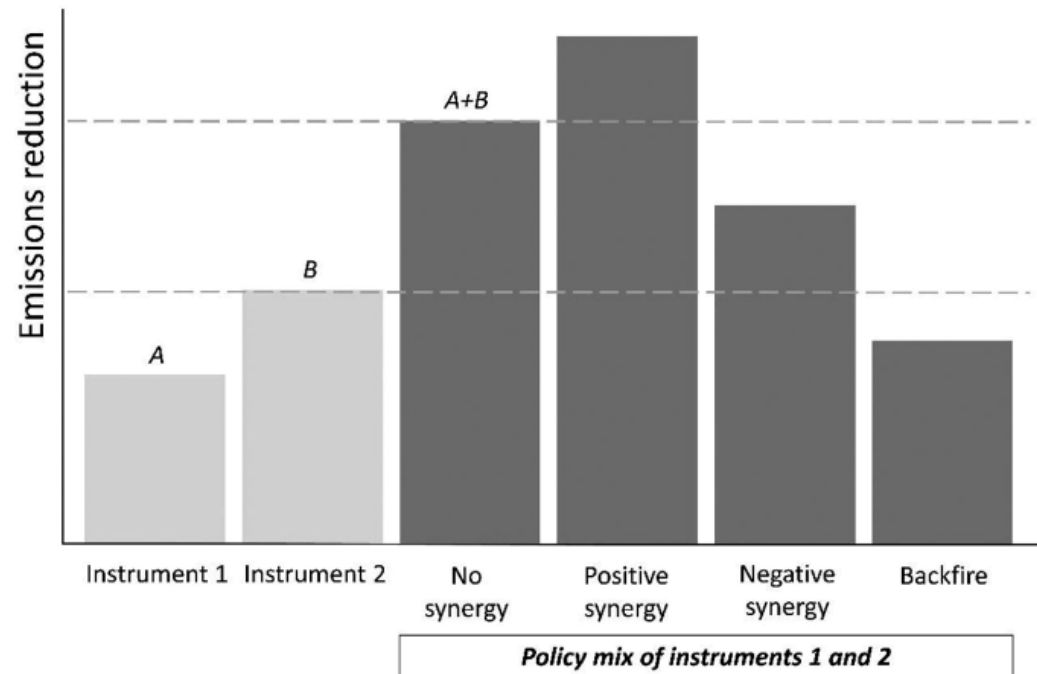
The interaction effect of decarbonisation policy measures: quantifying the impact on energy and CO₂ emissions

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Context

- “There’s no silver bullet... but we need lots of silver buckshot”
- *How do all the different pieces of silver buckshot interact?*



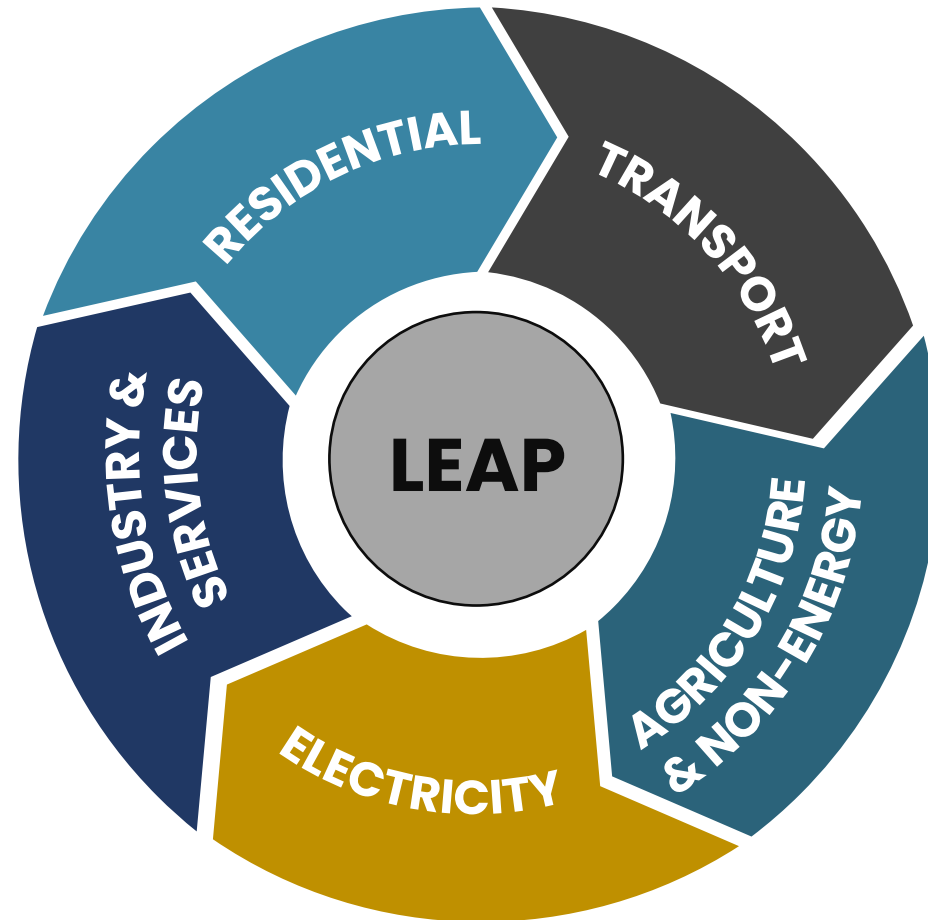
Source: (Van den Bergh et al, 2021)

Literature Review & Research Question

- *“....research is welcome beyond dual instrument interactions, namely on the magnitude of synergy between three or more instruments.” (Van den Bergh et al, 2021)*
- *“... the number of permutations for subsets of three or more measures is such that the analysis becomes very cumbersome” (Boonekamp, 2006)*
- What is the interaction effect of two or more policy-measures aimed at reducing energy and CO₂ emissions in Ireland?

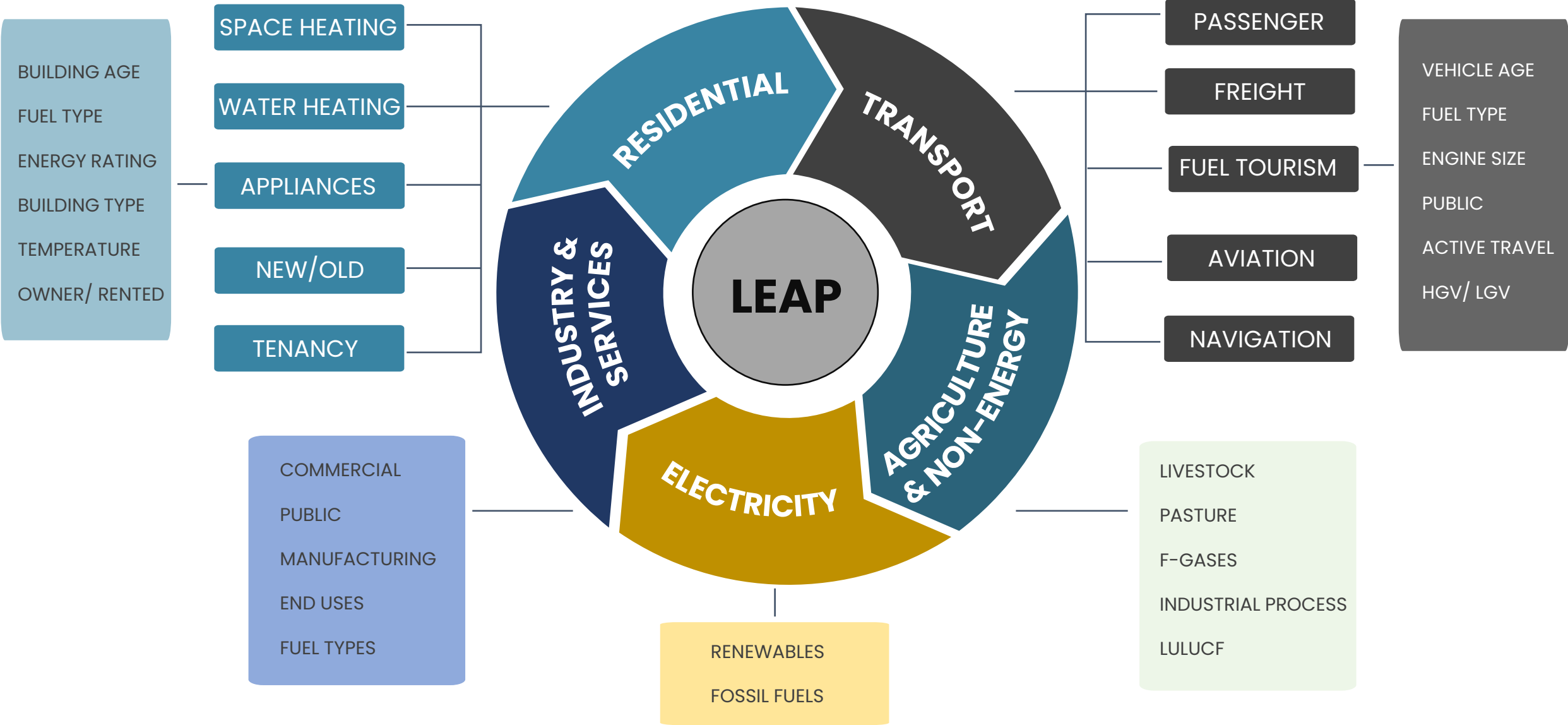
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LOW EMISSIONS ANALYSIS PLATFORM



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What's the impact of policy measures on energy and CO₂ emissions?

Ireland's Climate Action Plan 2021

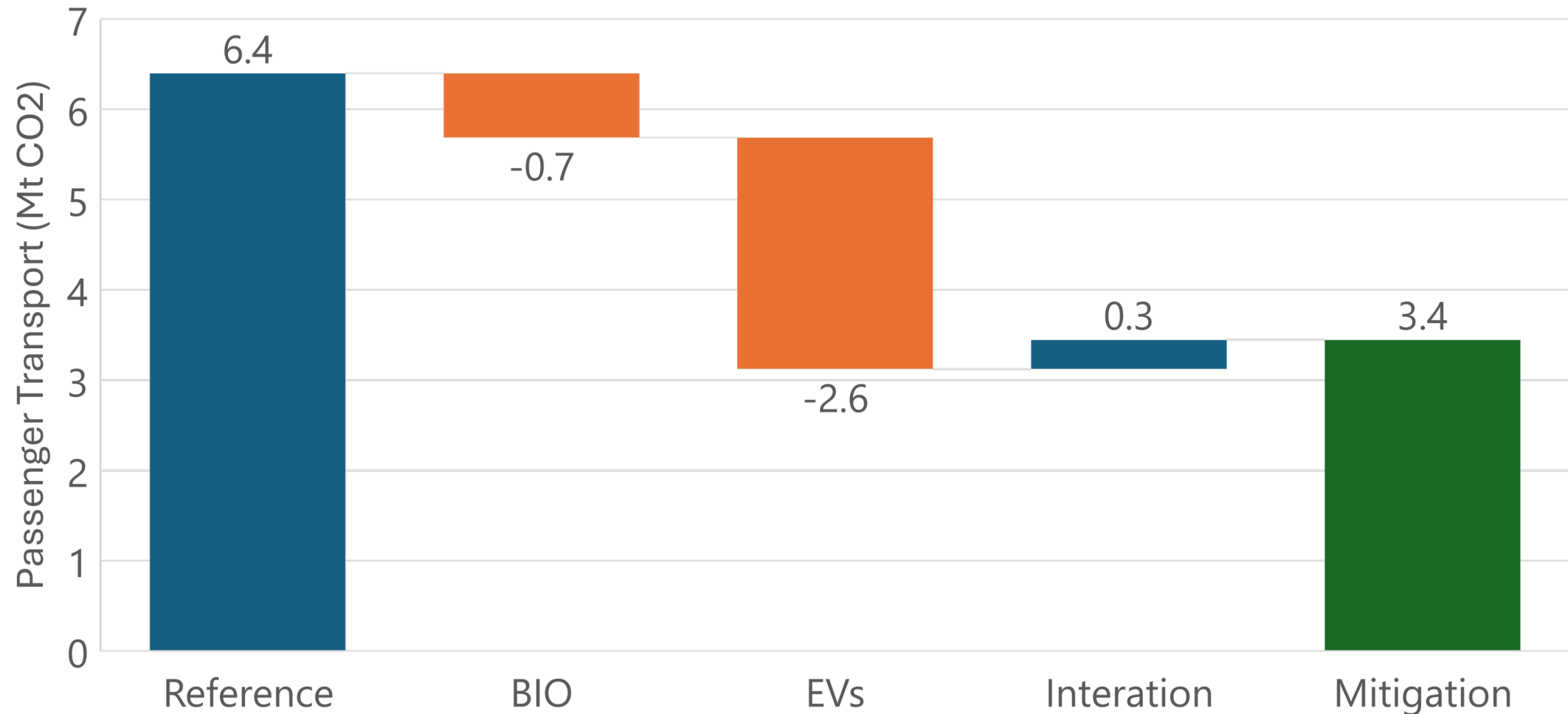
	Core measures	Technology	Climate Action Plan 2021
Electricity 	E1 Build-out renewable generation capacity	Total RES in generation mix, % ¹	80
		Onshore wind, GW ¹	Up to ~8
		Offshore wind, GW ¹	~5
		Solar PV, GW ¹	~1.5-2.5
Transport 	T1 Electrify road transport	Passenger EVs, #	845k with a focus on BEVs
		Zero emissions vans and heavy goods vehicles, #	~95k vans and ~3.5k heavy goods vehicles
	T2 Increase biodiesel blend-rates	Bioethanol blend, Vol%	E10
		Biodiesel blend, Vol%	B20
	T3 Transition to zero emission mass transportation	Transport modes transitioned to low-carbon	1.5k EV buses and expanding electrified rail services
Buildings 	T4 Sustainable Transport Journeys and Demand Management Measures	Demand shifts	500,000 (14%) additional public transport and active travel journeys per day
	Retrofit residential dwellings	Retrofitted homes ² , # dwellings	500,000 (B2 BER /cost optimal equivalent or carbon equivalent) →
	Deploy zero-emission heating in existing homes	Existing homes with zero-emission heating ¹ , # dwellings	400,000 →
	B1 Continue to phase out fossil fuels in new homes	New homes with zero-emission heating, # dwellings	250,000-280,000
	B2 Ramp-up zero-emission heat in commercial buildings	Commercial buildings with zero-emission heating ¹ , # buildings	50,000-55,000
	B3 Increase targets for roll-out of district heating	District heating demand, TWh	~2.7 TWh
	B4 Increase targets for public sector buildings	Emission abatement from public buildings, %	50

Results

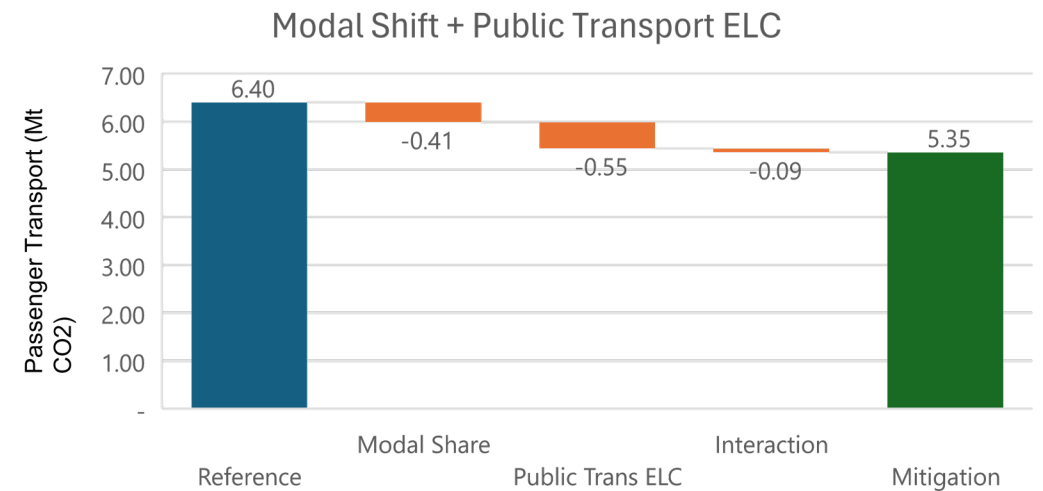
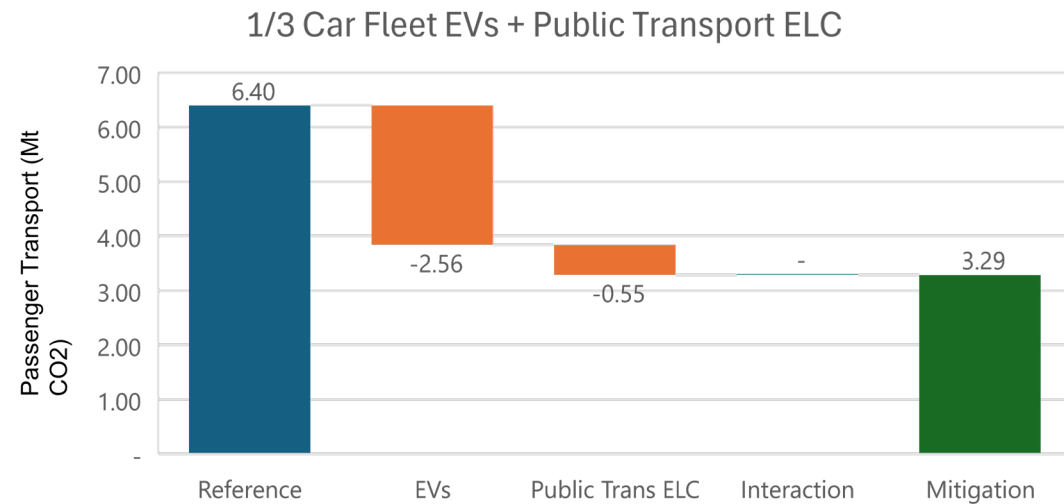
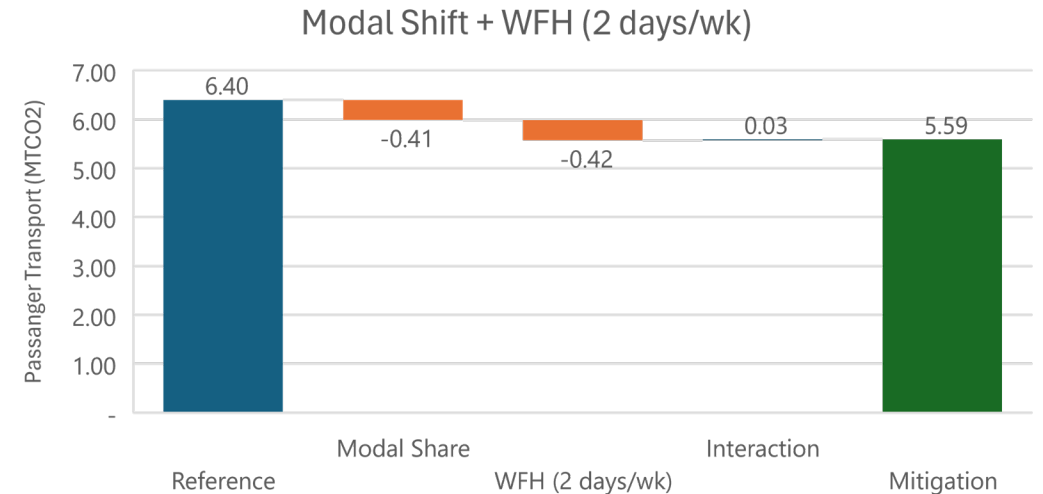
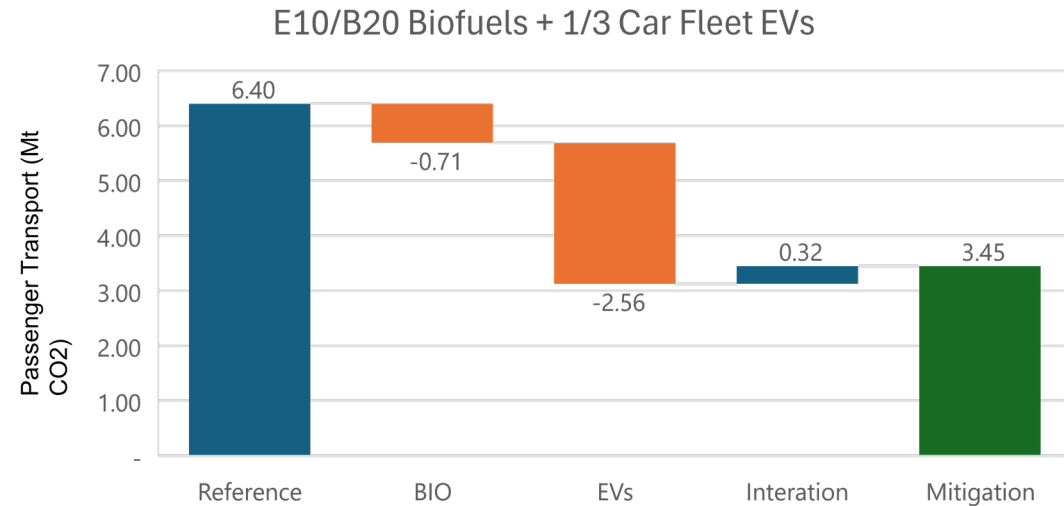
- Pair-wise interaction (2 policy measures)
 - Passenger Transport
 - Residential Sector
 - Industry Sector
- Wedge chart (>2 policy measures)
- Decomposition analysis of marginal impact

Pair-wise interaction (passenger transport)

E10/B20 Biofuels + 1/3 Car Fleet EVs



Pair-wise interaction (passenger transport)



Interaction matrix – Passenger Transport (2021-2030)

	EVs	Modal Shift	Public Trans ELC	WFH (2 days/wk)
E10/B20 (Biofuels)	0.94	0.97	0.98	0.97
1/3 Fleet EVs		0.94	1.00	0.95
Modal Shift			1.09	0.98
Public Trans ELC				0.97

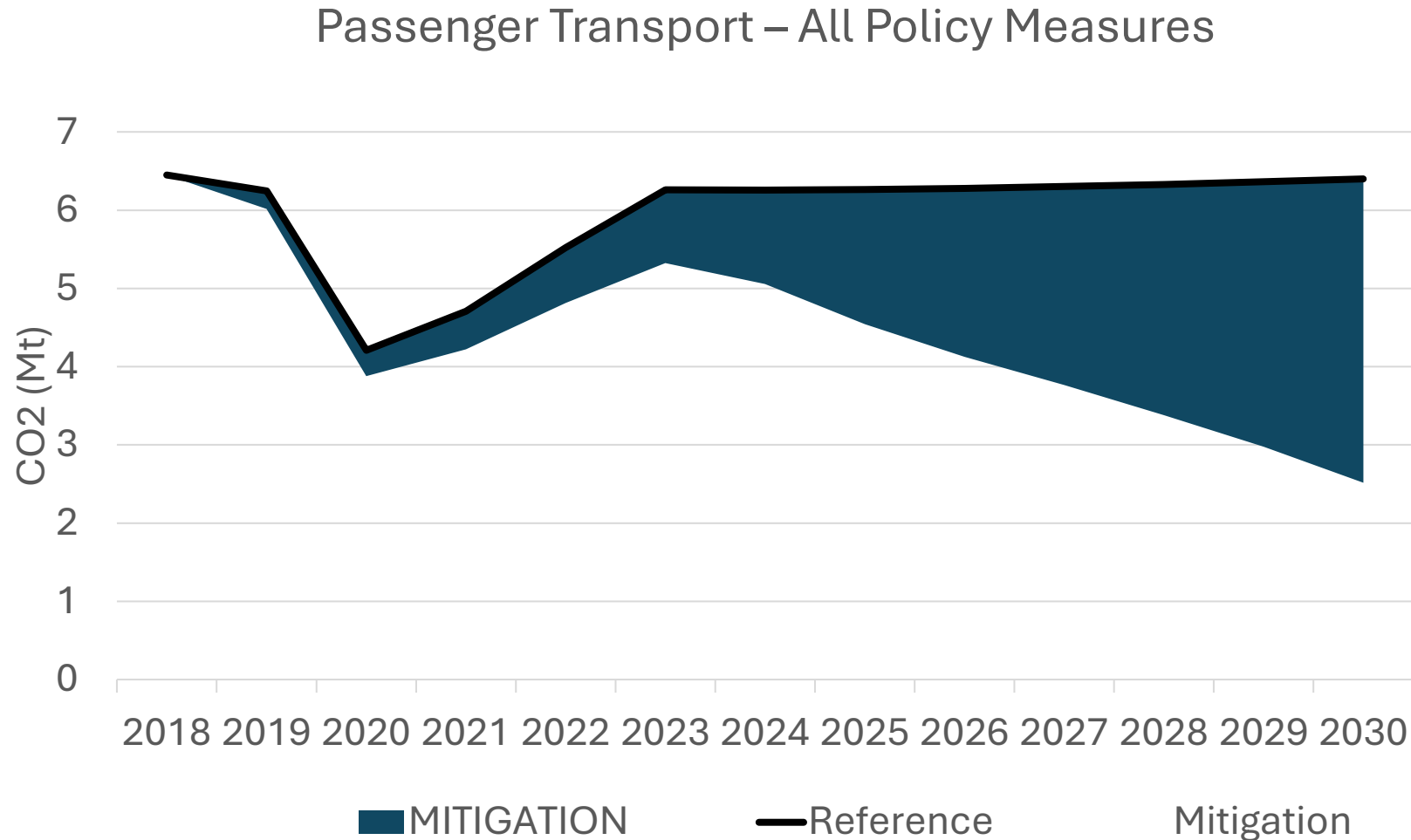
Interaction matrix – Residential Sector (2021-2030)

	Fossil Fuel Ban in New Dwellings	NZEBs	Biogas 20% Blending
Deep Retrofit (1/3 housing stock)	1.00	1.00	0.98
Fossil Fuel Ban in New Dwellings		0.80	0.79
NZEBs			0.94

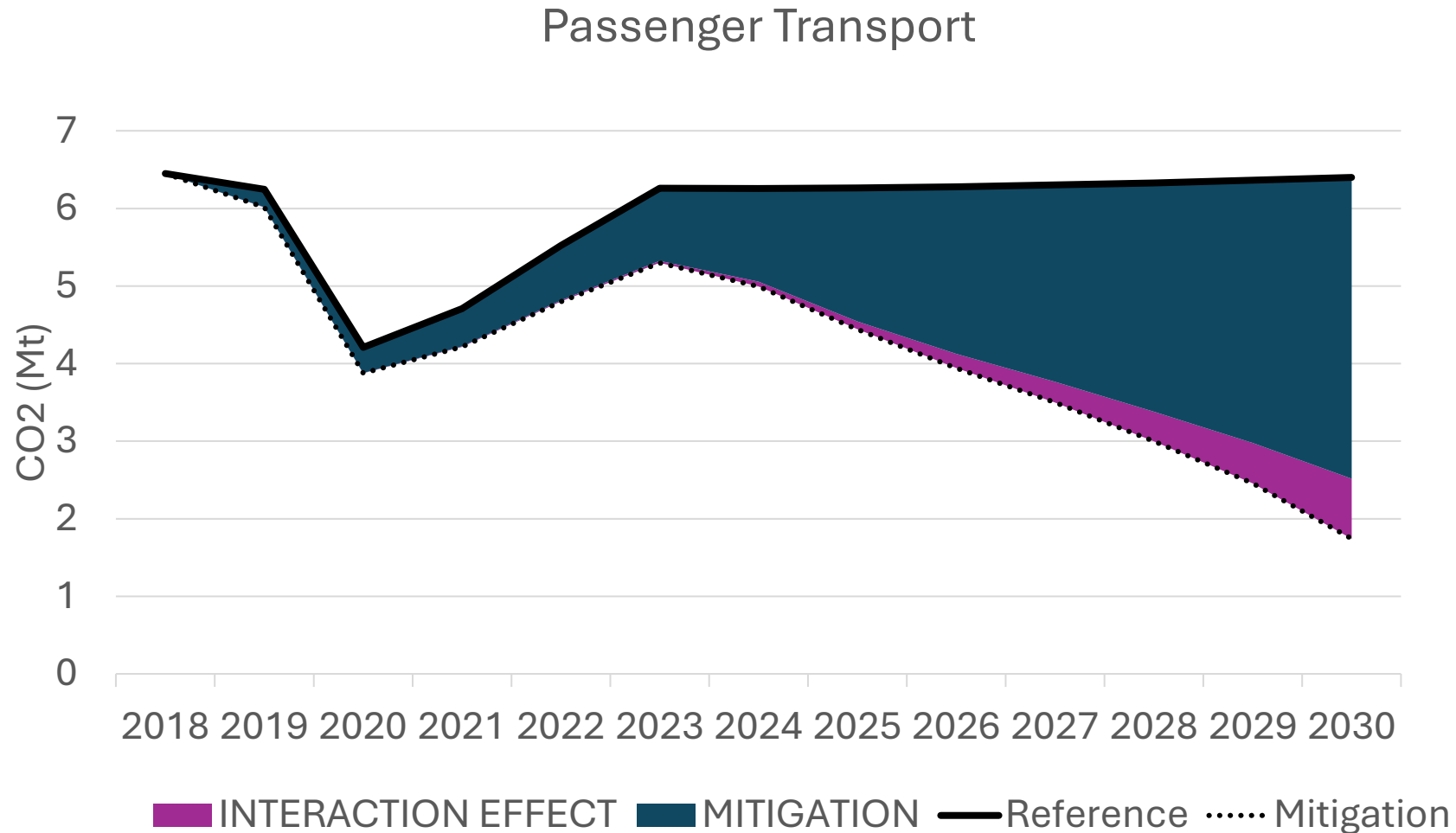
Interaction matrix – Industry Sector (2021-2030)

	HVO Blending	Biogas Blending
Carbon Neutral Heating	0.94	0.97
HVO Blending		1.00

CO₂ mitigation over time > 2 policy measures



CO₂ mitigation & interaction effect over time



How much does interaction effect reduce CO2 emissions mitigation each year?

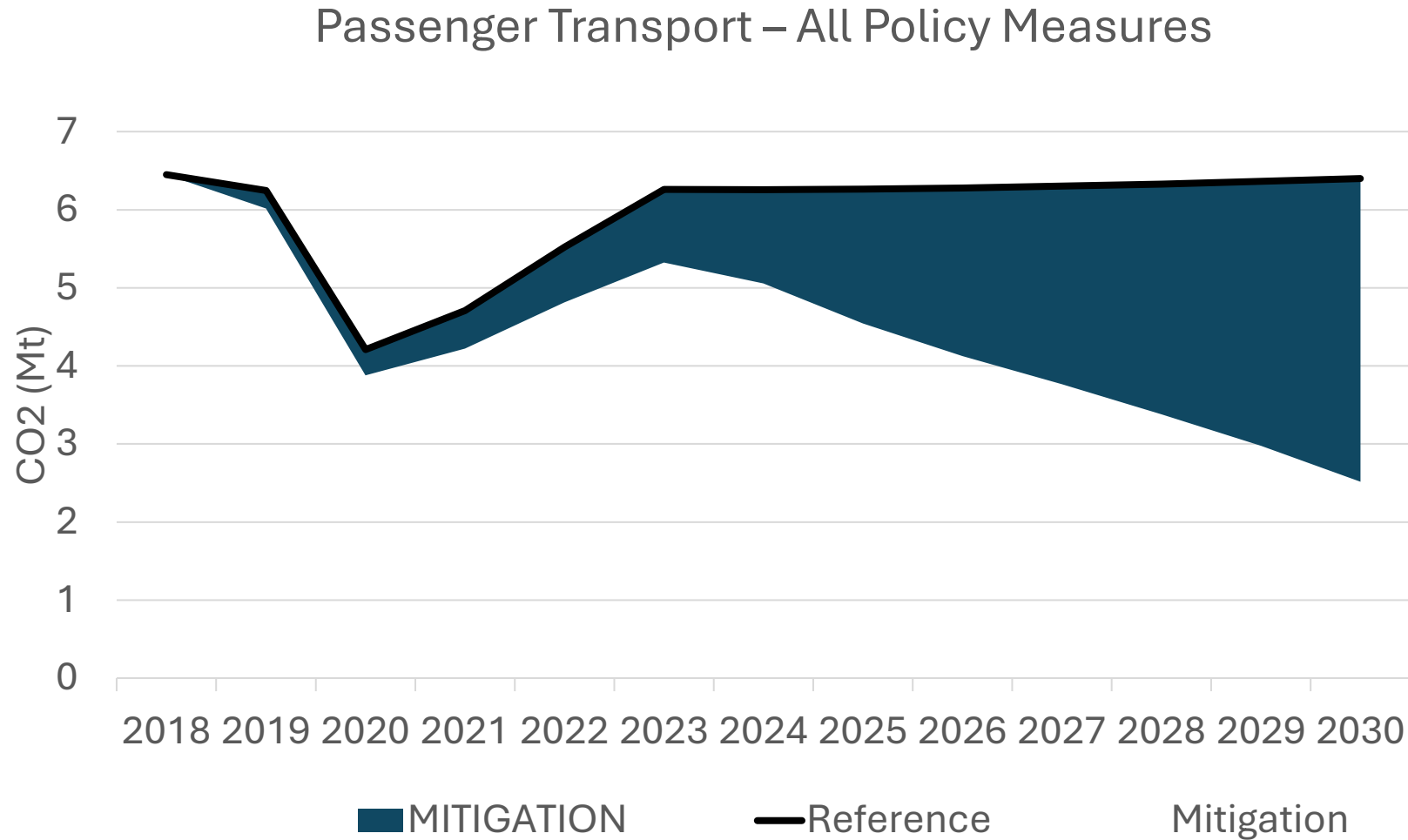
	2025	2026	2027	2028	2029	2030
Passenger Transport	4%	6%	8%	10%	12%	14%
Industry	6%	8%	11%	13%	15%	20%
Residential	12%	12%	12%	11%	11%	11%

How to quantify the interaction effect for more than 3 policy measures?

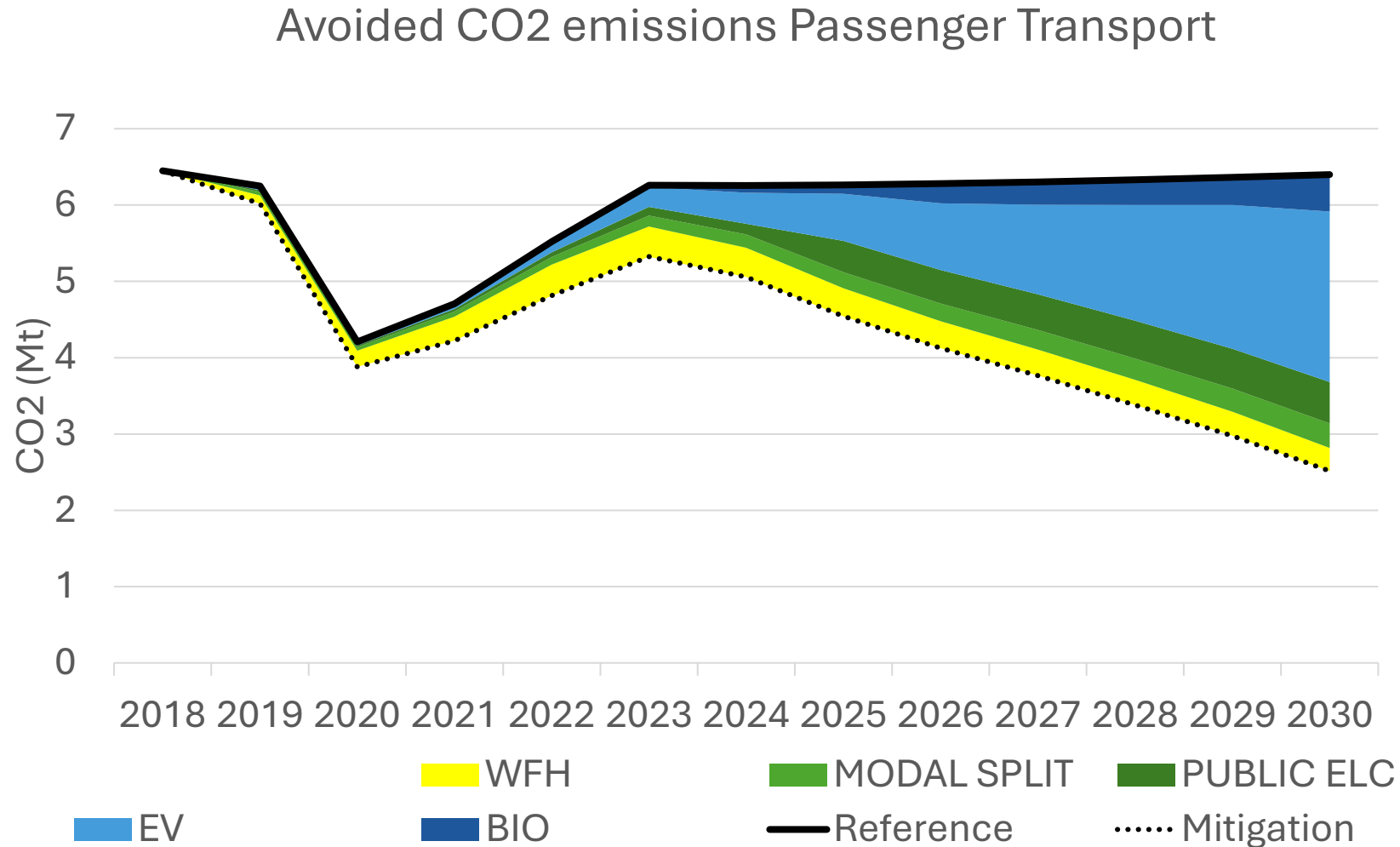
$$\bullet \quad PM_{i_ALL}^{CO2_AV} = PM_i^{CO2_AV} - \left(\frac{LN(Act_{PM_i}^{CO2_AV})}{LN(Act_{PM_{ALLNO_i}}^{CO2_AV})} \right) \times \frac{(PM_i^{CO2_AV} - PM_{ALLNO_i}^{CO2_AV})}{2}$$

- *ALL = The full set of Policy Measures (i...n)*
- *$PM_{i_ALL}^{CO2_AV}$ = Avoided CO₂ emissions for Policy Measure i within set of All Policy Measures*
- *$PM_i^{CO2_AV}$ = Avoided CO₂ emissions for Policy Measure i*
- *$LN(Act_{PM})$ = Natural Log of Activity Driver*
- *$PM_{ALLNO_i}^{CO2_AV}$ = Avoided CO₂ emissions for all Policy Measures except Policy Measure i*

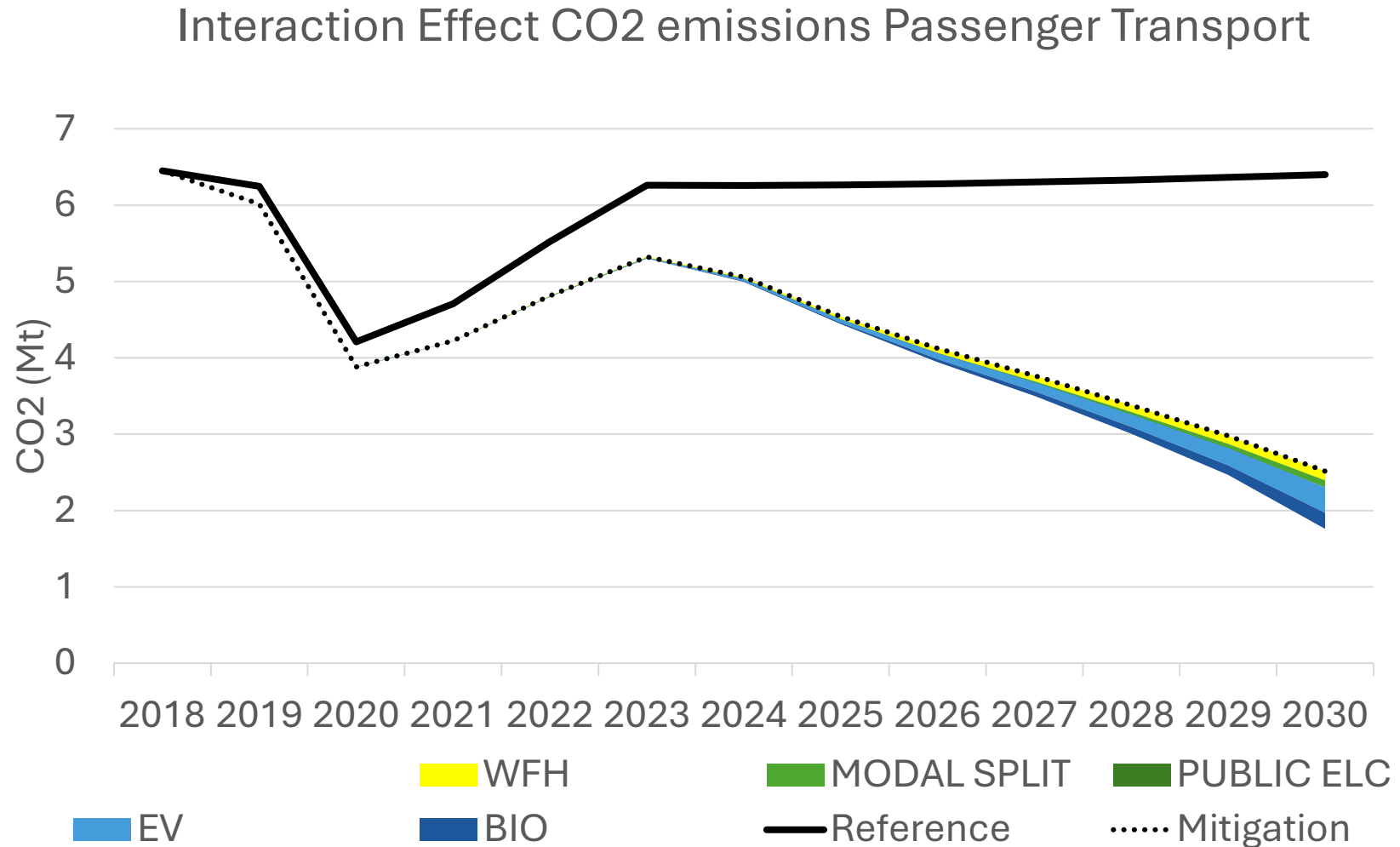
CO₂ mitigation over time > 2 policy measures



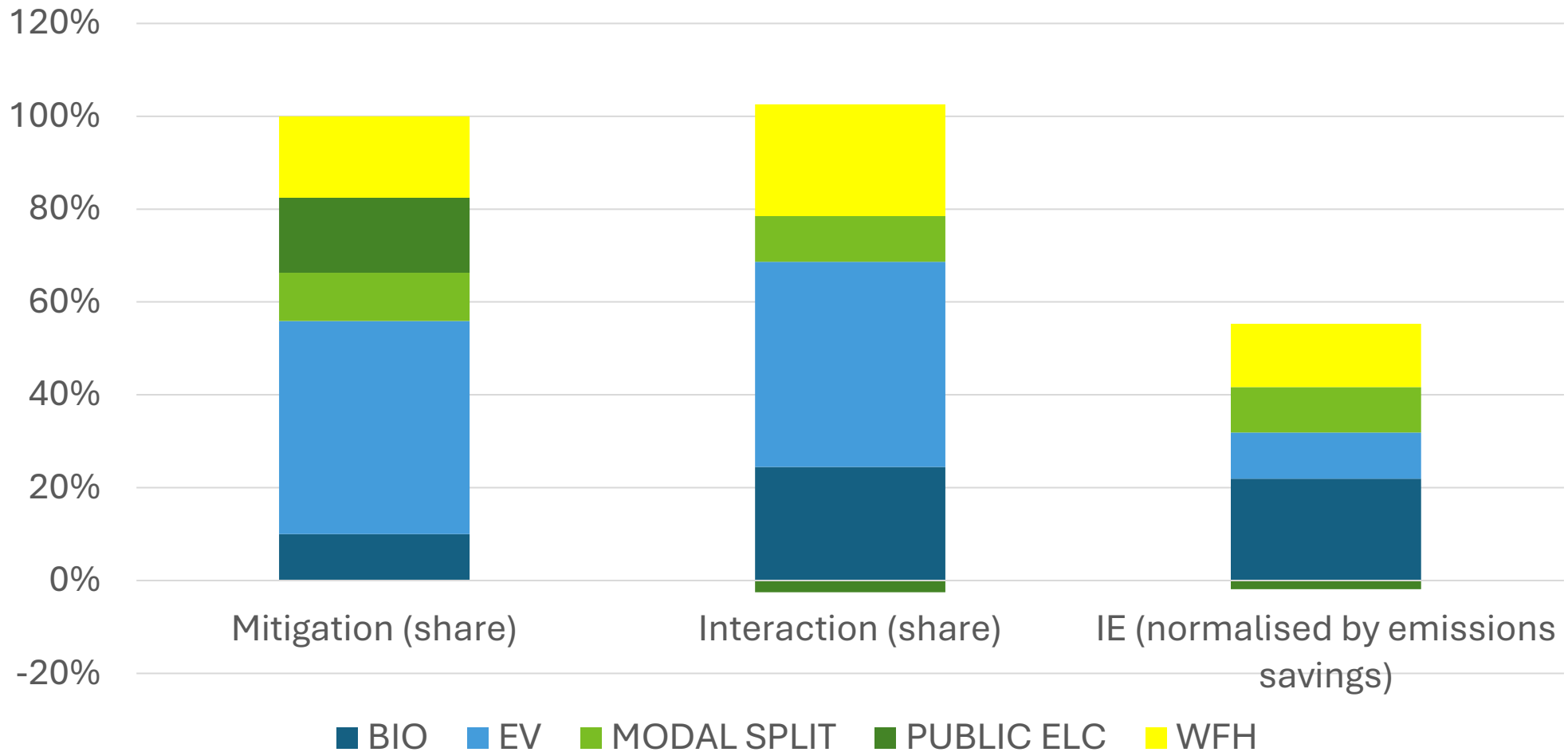
CO₂ mitigation over time (passenger transport)



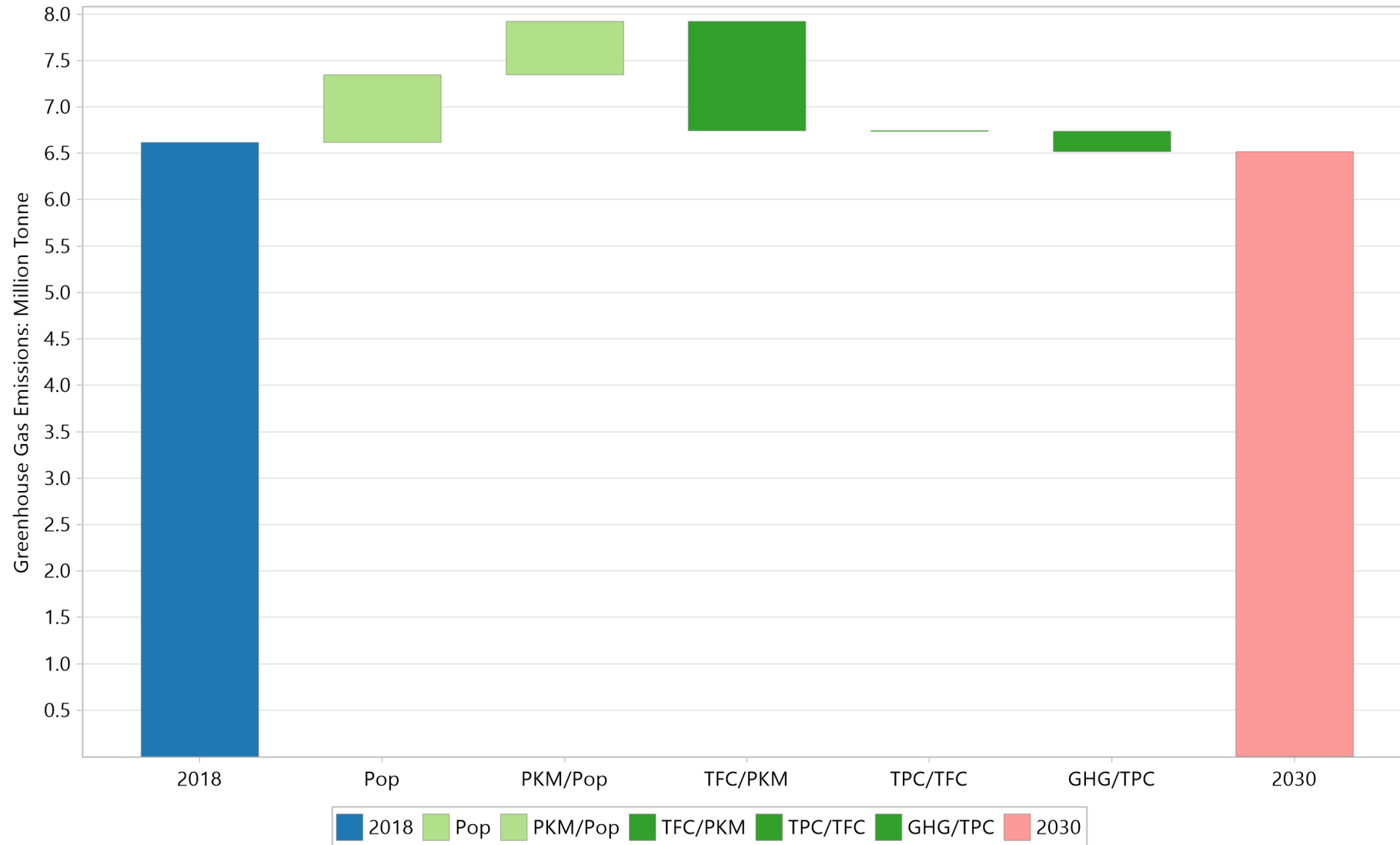
CO₂ mitigation over time (passenger transport)



What is share of mitigation & interaction effect? (2021-2030)



Passenger Transport: Reference Scenario (2030)



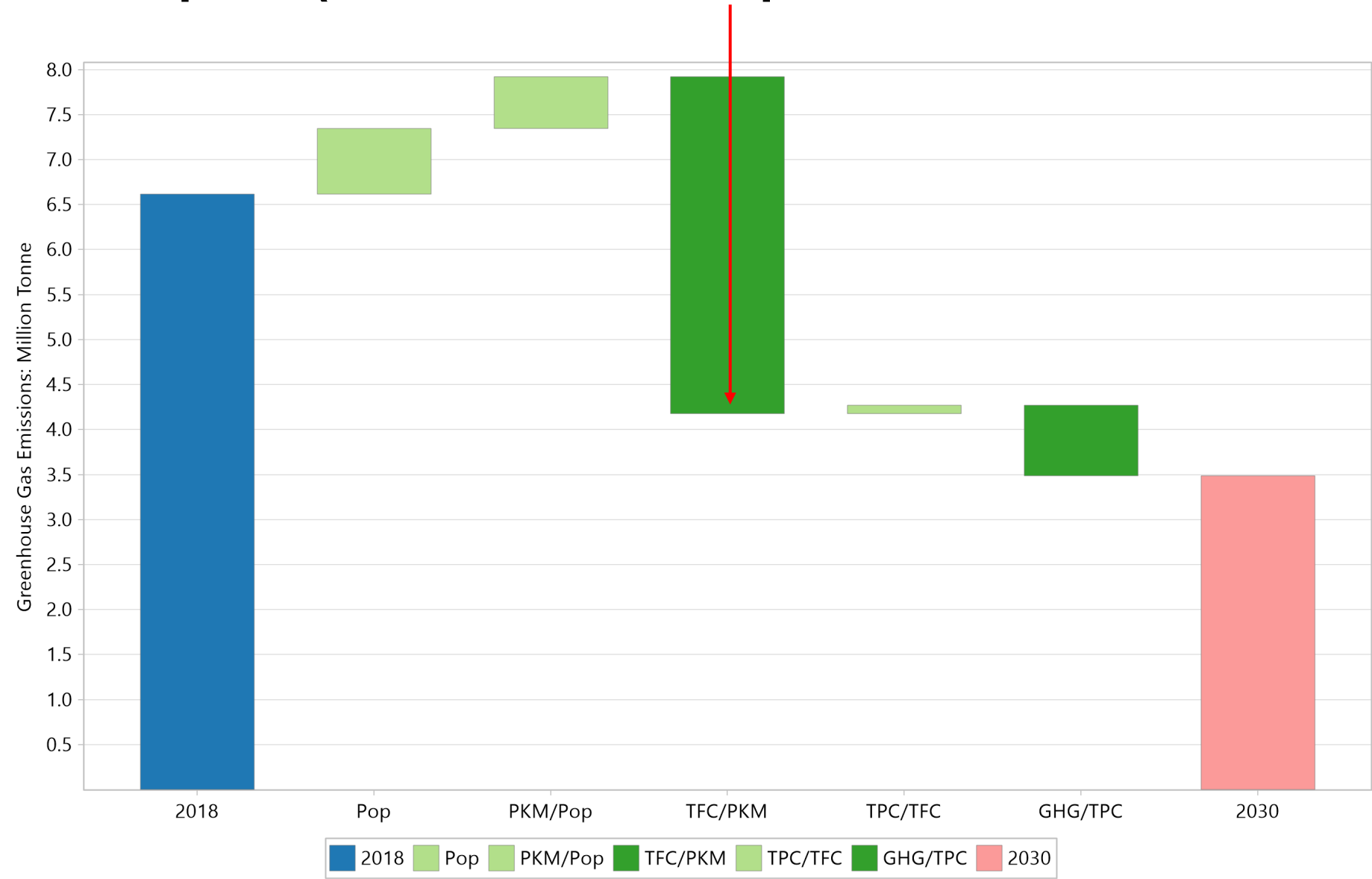
1/3 Fleet Electric Cars



E10/B20 Biofuels Blending



Modal Split (Public Transport + Active Modes)



Public Transport Electrification



WFH (2 days/week)

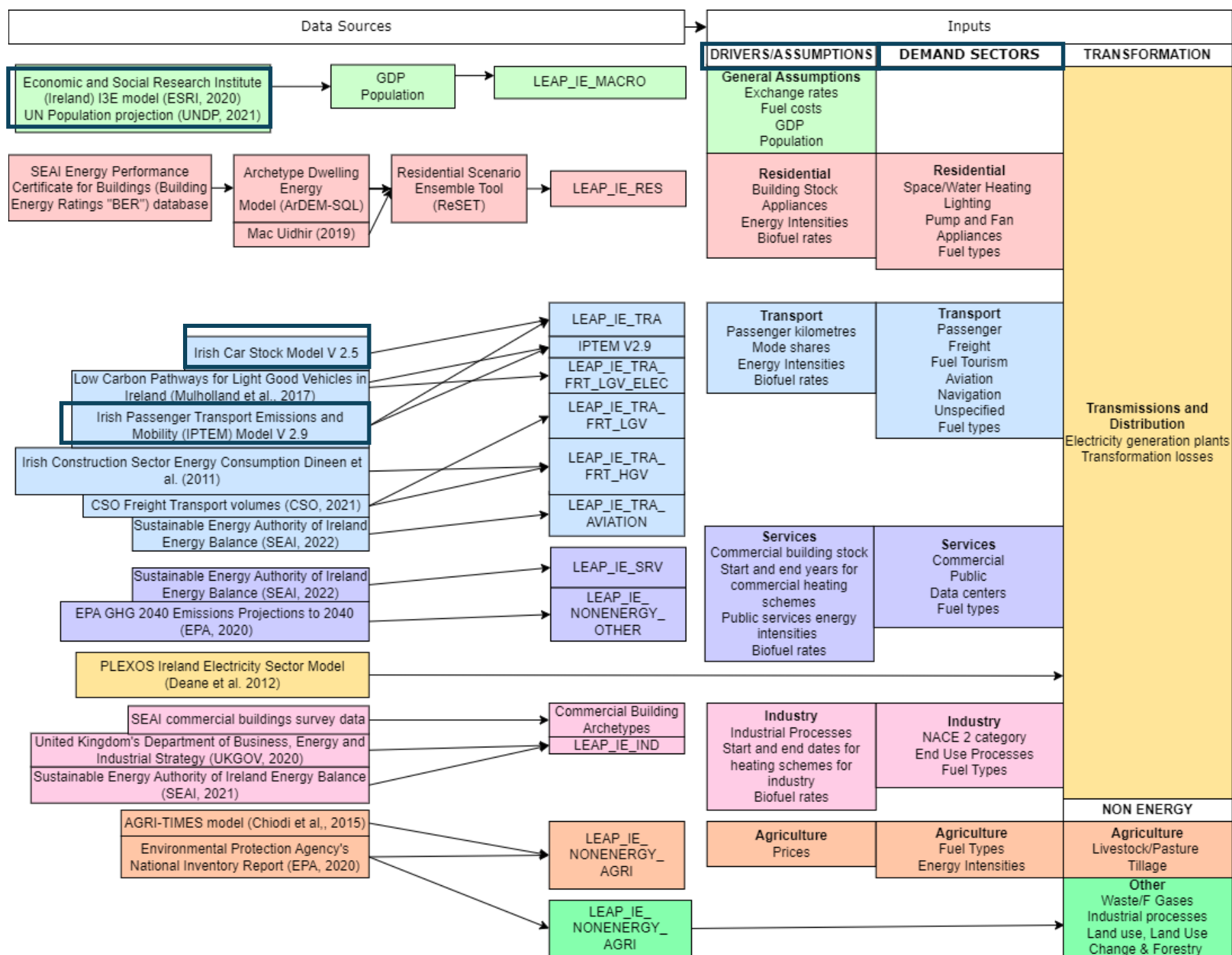


Some conclusions...

- Pairwise analysis of policy measures reveals positive & negative synergies
 - Positive synergies are relatively rare (just 1 example in this analysis)
 - Negative synergies reduce emission savings 4-5% (average), range 20%
- For combinations of 3-5 policy measures, interaction effect can reduce emissions by 5-20%. Positive synergies can be cancelled out
- Policy mixes that emphasize policy combinations which minimize negative synergies likely to yield greatest savings
- Decomposition analysis + suites of scenarios can quantify the marginal impact of policy measures in terms of demand reduction, efficiency & technology switching

Research question

- Climate mitigation policy is about reducing cumulative GHG emissions over time
- Decarbonisation is getting more difficult over time, i.e. no more low-hanging fruit
- *What is the interaction effect of two or more policy-measures aimed at reducing energy and CO₂ emissions in Ireland?*



Waterfall

