Climate Change Advisory Council Secretariat

Carbon Budgets Working Group

Meeting No. 18
18th September 2024
14:00 – 17:15

Agenda

Time	Agenda Item
14:00	1. Opening of Meeting
14:05	2. Analysis of warming impact of selected core scenarios (3rd iteration)
14:40	3. Macroeconomic impacts of 3rd Iteration of Core Modelling Results
15:20	4. Macroeconomic effects of reaching net zero by 2050
15:55	**Break**
16:05	5. Energy additional modelling
16:20	6. Follow on discussion on Carbon Dioxide Removal Considerations
16:55	7. Next Steps
17:10	8. AOB
17:15	**Meeting Closed**

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
22	28/06/24	DS to provide guidance to JW for the 3rd iteration of analysis and ST to facilitate a bilateral call with the EPA inventories team regarding the revised soil emissions factor.	CBWG Members	Aug 2024	***Propose to Close*** ST facilitated a discussion on the latest update to the inventory with DS, CD, the Secretariat, and the EPA inventories and projections teams. DS to provide guidance to JW regarding the incorporation of the latest inventory refinement to the 3rd iteration of GOBLIN analysis.
28	29/08/24	The Secretariat to follow up with Teagasc to provide direction as to how to present emissions reductions i.e., changes from BAU vs changes from 2018 levels.	Secretariat	Sep 2024	***Propose to Close*** Secretariat have requested emissions reductions to be presented in the context of changes from a 2018 baseline in final reporting.
29	29/08/24	Hold discussion between Secretariat, GOBLIN and FAPRI on the appropriate combination of FAPRI and GOBLIN agriculture and land use scenarios	Secretariat and CBWG Members	Sep 2024	***Open*** Call scheduled for Monday the 23rd of September.

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
30	29/08/24	Secretariat to follow up with the TIM and GOBLIN teams to discuss the allocation of emissions savings from BECCS between the AFOLU and Energy sectors.	Secretariat CBWG Members	Sep 2024	***Open*** To be discussed at CBWG Meeting No.18 to develop a shared understanding allocation of emissions savings from BECCS with a follow up call to be scheduled if necessary.
31	29/08/24	Secretariat will liaise with each CBWG member individually on the submission their final outputs reports by the 30th of September	Secretariat and CBWG Members	Sep 2024	***Open*** Secretariat have been in contact with each CBWG member regarding the the submission their final outputs reports by the 30th of September. Secretariat request that CBWG members reach out if any further guidance on reporting is required or if they foresee any difficulty with submission by the requested deadline.

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Macroeconomic Impacts

- Secretariat facilitated a call with the CBWG economists on the 16th of September
- Request for guidance from CCAC as to which scenarios should be prioritized for macroeconomic analysis
- Issue raised regarding estimated grid investment costs
- Other data needs and clarifications to be discussed at today's CBWG meeting
- **Action:** Secretariat to schedule bilateral meetings with CBWG economists and core modelling teams for further discussions

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4. Carbon Budgets Workplan: Key Deliverables Q3 – Q4 2024

Description	2024					
	Jul	Aug	Sep	Oct	Nov	Dec
Modelling / Analysis Iteration 3						
Agree inputs, parameters and assumptions						
Core pathways development and modelling						
Paris Test Assessment						
Additional modelling and testing of results						
Post-hoc analysis						
Key Deliverables						
Modelling / Analysis Iteration 2 Results						
Modelling / Analysis Iteration 3 Results						
Carbon Budgets Working Group Outputs Report						
CCAC 2024 Carbon Budget Proposals						

4. Carbon Budgets Workplan: CBWG Outputs Report

1. Executive Summary
2. Introduction
    2.1. Establishment
    2.2. Terms of Reference
    2.3. Membership
    2.4. Memorandum of Understanding
    2.5 Methodology and Council Guidance
3. Carbon Budgets Workplan
4. Meeting Summaries
5. Reports Briefings and Submissions

6. Pathways development and analysis
  6.1. Pathways development and Modelling
      6.1.1. TIM
      6.1.2. GOBLIN
      6.1.3. FAPRI
  6.2. Warming Impact Analysis
  6.3. Additional Modelling and Analysis
      6.3.1. NEMF
      6.3.2. NTA
  6.4. Macroeconomic Impact of Carbon Budgets
      6.4.1. COSMO
      6.4.2. I3E
      6.4.3. Macroeconomic effects of reaching net zero by 2050
  6.5. Socioeconomic Impact of Carbon Budgets and Just Transition
  6.6. Climate Justice Considerations
  6.7. Biodiversity Considerations
  6.8. Assessment of overshoot and the role of negative emissions
  6.9. Inventories and Projections
  6.10 Scenario Dialogue Tool

Appendix 1: Action Log
Appendix 2: Risk Register
Appendix 3: Directory of CBWG Documents

Supplementary Information to be published on the CCAC website:

- All CBWG meeting materials
- Scenario Dialogue Tool

Actions:

- All CBWG members have been asked to provide a report by 30th September, with inclusion of an executive summary.
- Scenario Dialogue Tool is now on SharePoint for CBWG members to populate until 30th September.

6. Next Steps

- **Q4 2024: CCAC Deliberations**
  - The CCAC will deliberate on its proposal under the 2nd programme of carbon budgets.
  - Potential for CCAC to request for clarification from CBWG members on final output reports and for individual CBWG members to be invited to the October or November Council meetings for discussion as part of Council deliberations.
  - CCAC 2024 Carbon Budget Proposals due by the end of 2025.
- ***Section 6A of the Climate Act:***

  *‘Not more than **30 days** after submitting a proposed carbon budget programme, a proposed carbon budget or any proposed amendments to a provisional carbon budget to the Minister under this section, the Advisory Council shall publish the proposed carbon budget programme, the proposed carbon budget or any proposed amendments to the provisional carbon budget, as the case may be, in such manner as the Advisory Council considers appropriate.’*
- Secretariat will inform CBWG members on the publication of the CBWG proposal

6. Next Steps

- ***Section 6B (1) of the Climate Act:***

*'The Minister, **within four months** of the receipt of a carbon budget under section 6A (i.e., CCAC Proposal), shall*

(a) cause a copy of the carbon budget to be presented to both Houses of the Oireachtas,
(b) consider the carbon budget,
(c) amend, if appropriate, and finalise the carbon budget,
(d) submit the carbon budget to the Government for approval in accordance with subsection (6), and
(e)lay a copy of the carbon budget before both Houses of the Oireachtas for approval'

- ***Section 6B (2) of the Climate Act:*** *'Dáil Éireann may refer a carbon budget to a joint committee which shall consider the carbon budget and provide a report in writing containing its recommendations to both Houses of the Oireachtas **within two months** from the date it is presented to Dáil Éireann'*

- **Q1 2025:** Potential invitation for CCAC and CBWG to appear before the Joint Committee on Environment and Climate Action to discuss the CCAC Carbon Budget Proposal and the evidence base informing the proposal.

- **Q2-Q3 2025:** Following Government approval of a 2nd programme of carbon budgets in early 2025, the CCAC Secretariat will facilitate a review of the approach to the 2nd programme of carbon budgets with CCAC and CBWG members, with a view to lessons learned and recommendations for the approach to the 3rd programme of carbon budgets

8. AOB

UCD ENERGY INSTITUTE

UCD ENERGY INSTITUTE

Warming impact of national emissions scenarios 3

Joe Wheatley

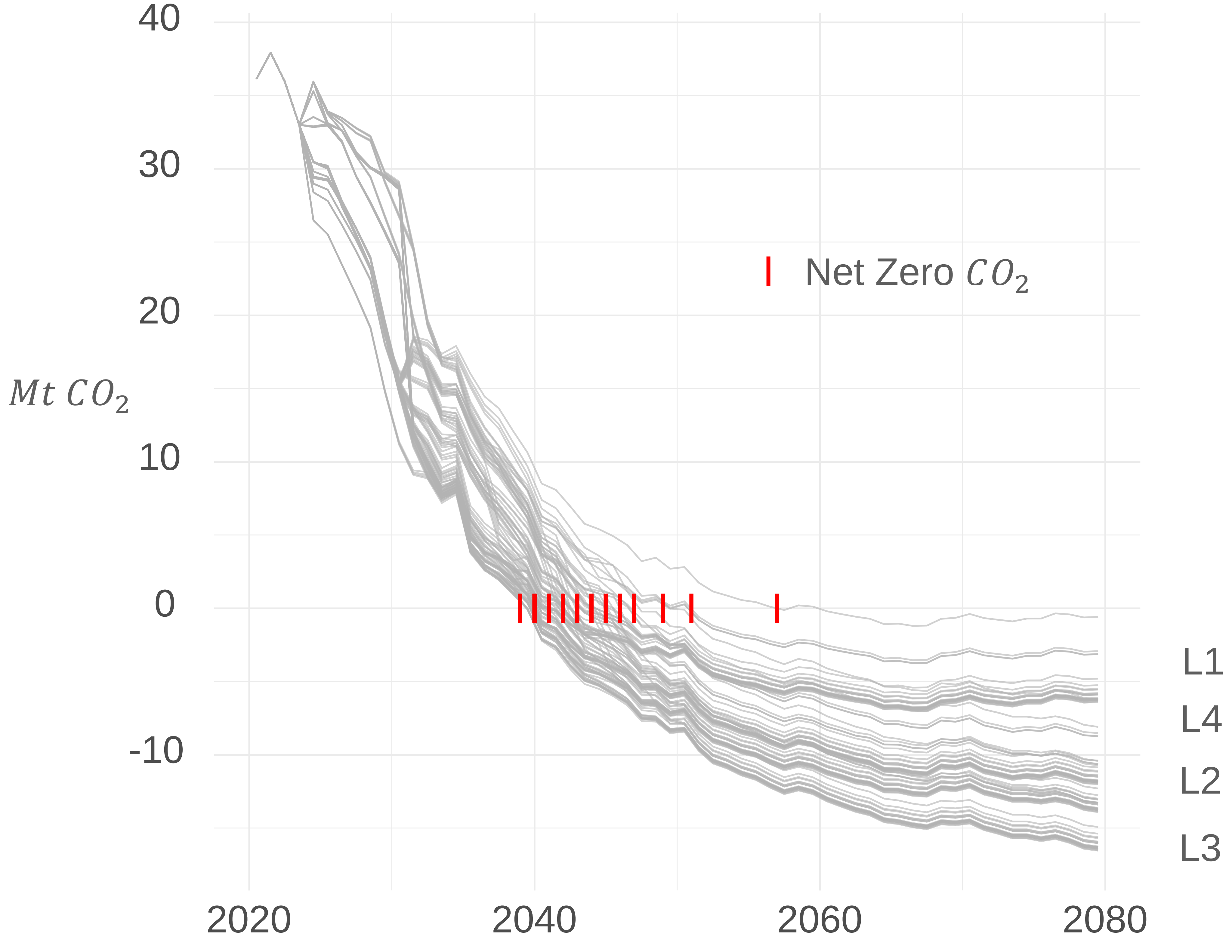
18 September 2024 CBWG

Balancing CO_2 & non-CO_2 GHGs

CBWG Scenarios

- Net Zero-CO_2 in 2040's
- Deep cuts in agriculture GHGs (CH_4 & N_2O) but not zero in 2050
- GWP100 Net Zero-GHG not reached in any scenario combination in 2050
- Evaluate warming impact using SCMs (MAGICC7 & FaIRv2.1)
- Rule out scenario combinations where warming does not stop by 2050

Iteration 3 Scenario Recap: CO_2



FFI ⊗ LULUCF

- Global scenario SSP126 Paris compatible (1.9°C in 2071)
- FFI CO_2 (TIM) (2^{nd} + 3^{rd} = 23 scenarios, 250mt – 450mt)
- LULUCF CO_2 (Goblin) (4 scenarios)
- WAM projections f-gases, WASTE (2^{nd} iteration)
- Aerosols, ozone precursors, historical (1^{st} iteration)

Re-label GOBLIN LULCF

Sc1 → L1	8 kha/y
Sc4 → L4	17 kha/y
Sc2 → L2	25 kha/y
Sc3 → L3	25 kha/y

200mt CO_2 ≡ 0.1 m°C

Iteration 3 Scenario Recap: non-CO_2

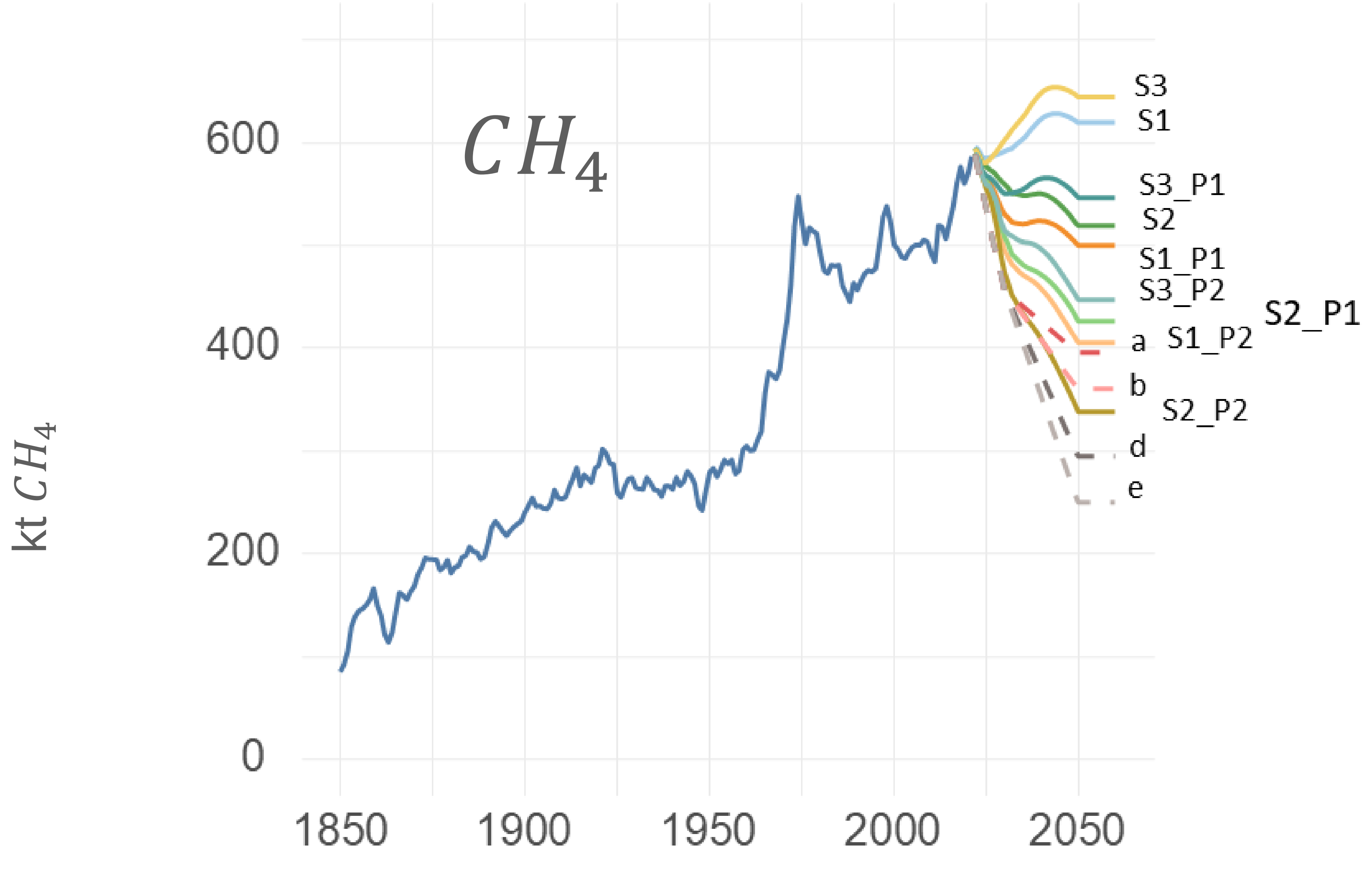
Agriculture (FAPRI, 9 new scenarios, Goblin, 4 scenarios)

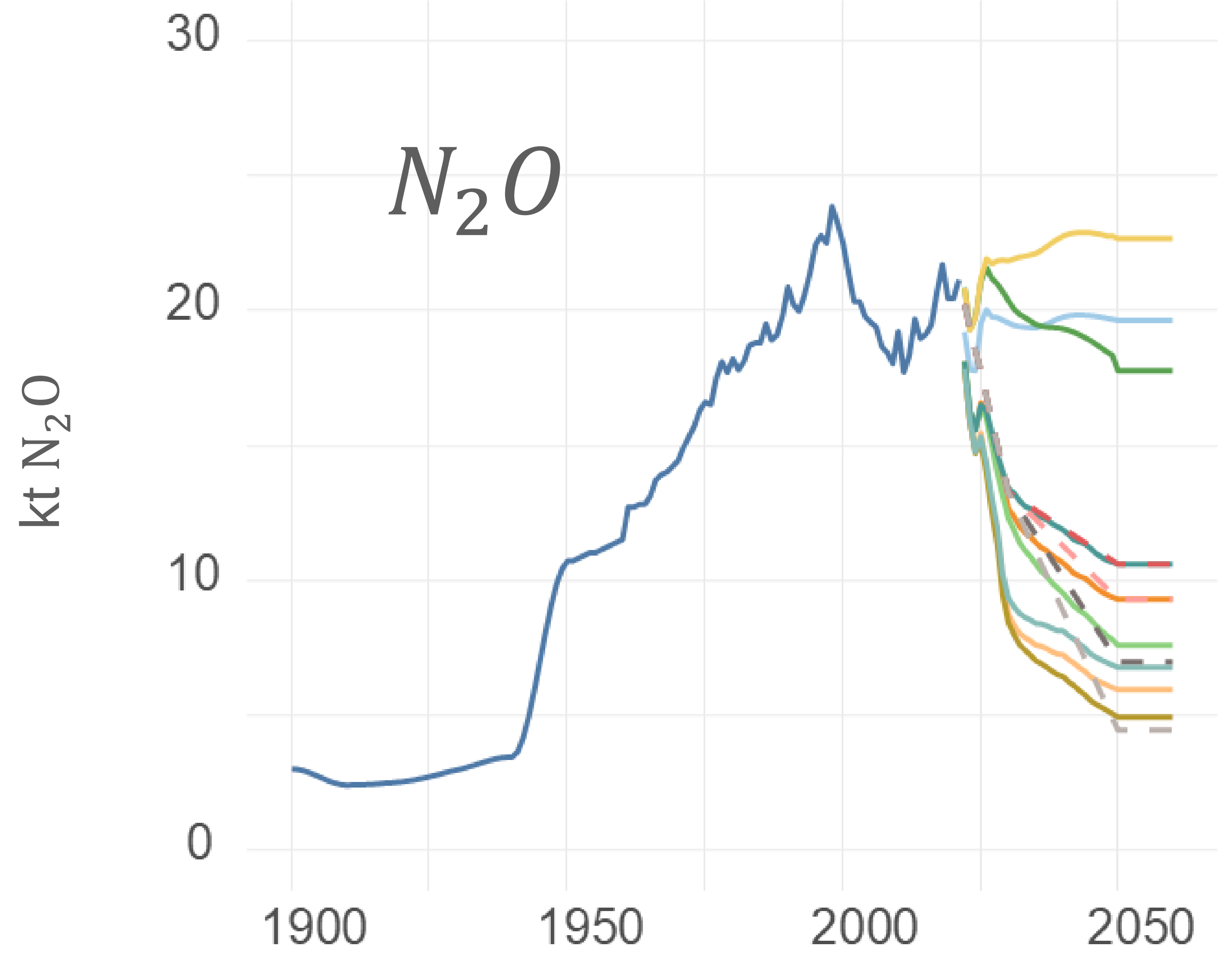
FAPRI: Activity ⊗ Measure

- S1 constant
- S2 lower
- S3 higher

-
- P1
- P2

GOBLIN	kt CH_4
a	-163
b	-201
d	-264
e	-309





FFI ⊗ LULUCF ⊗ AG

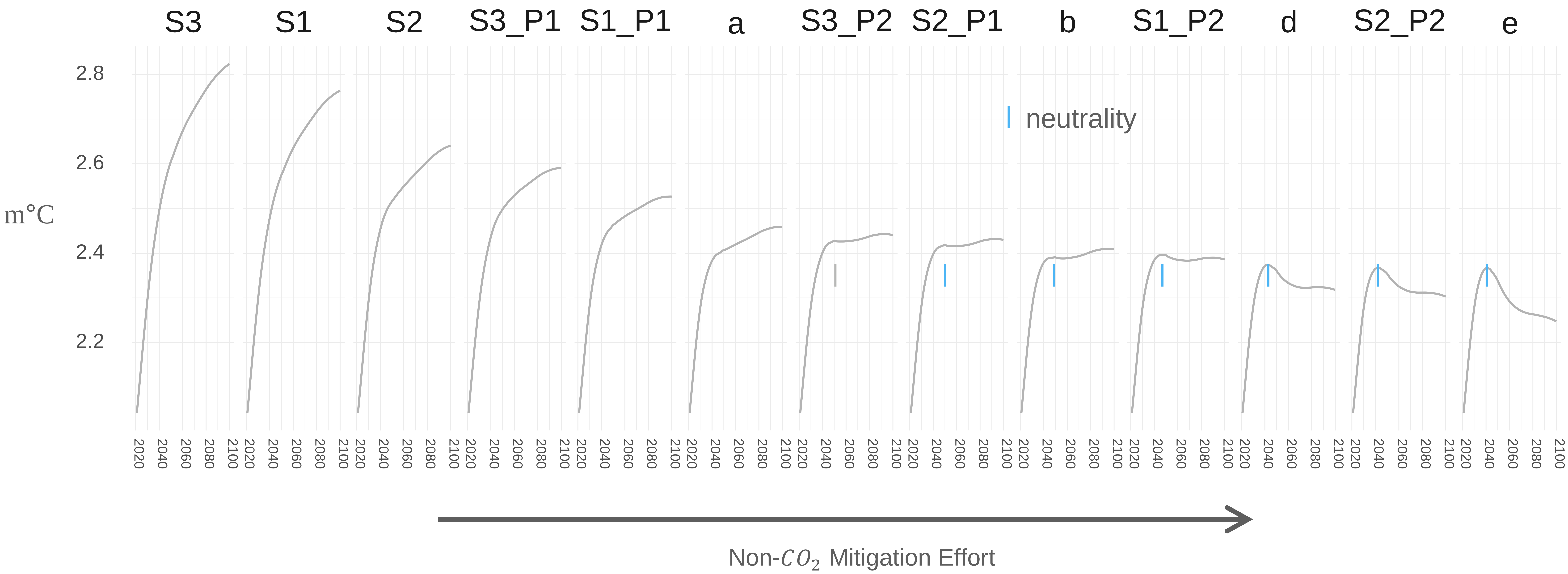
$$23 \times 4 \times 13 = 1196\ scenarios$$

Efficacy of non-CO_2 mitigation

<u>Example</u>

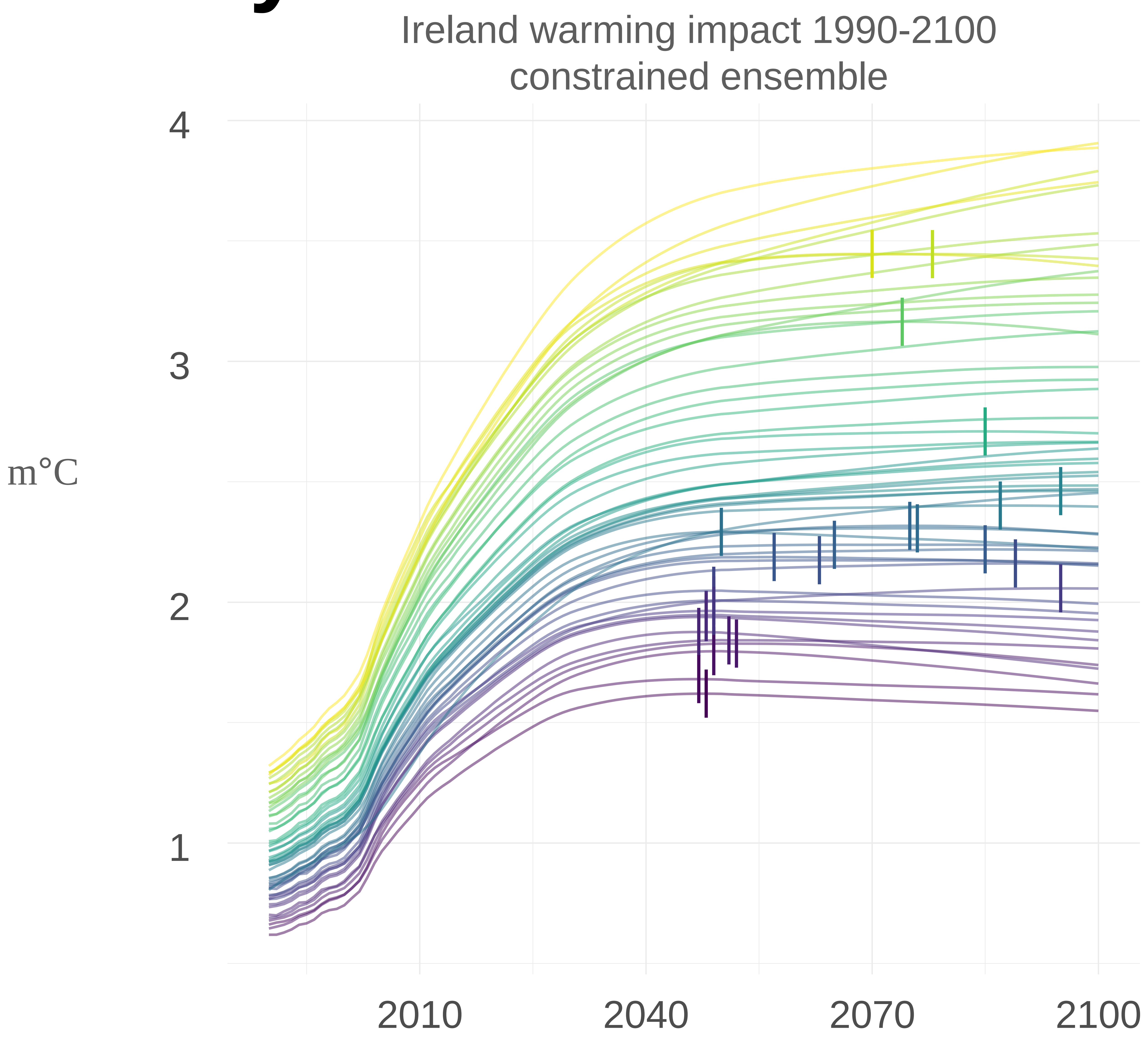
Net Zero-CO_2 2043 450mt-wam L4

median 2021-2100 warming FaIRv2.1 constrained SSP126



Climate System Uncertainty

- CMIP6 hot model problem
- FaIRv1.2 constrained ensemble
- SSP126 peak warming 1.9°C in 2071
- 53 model configurations



Example

Global: SSP126

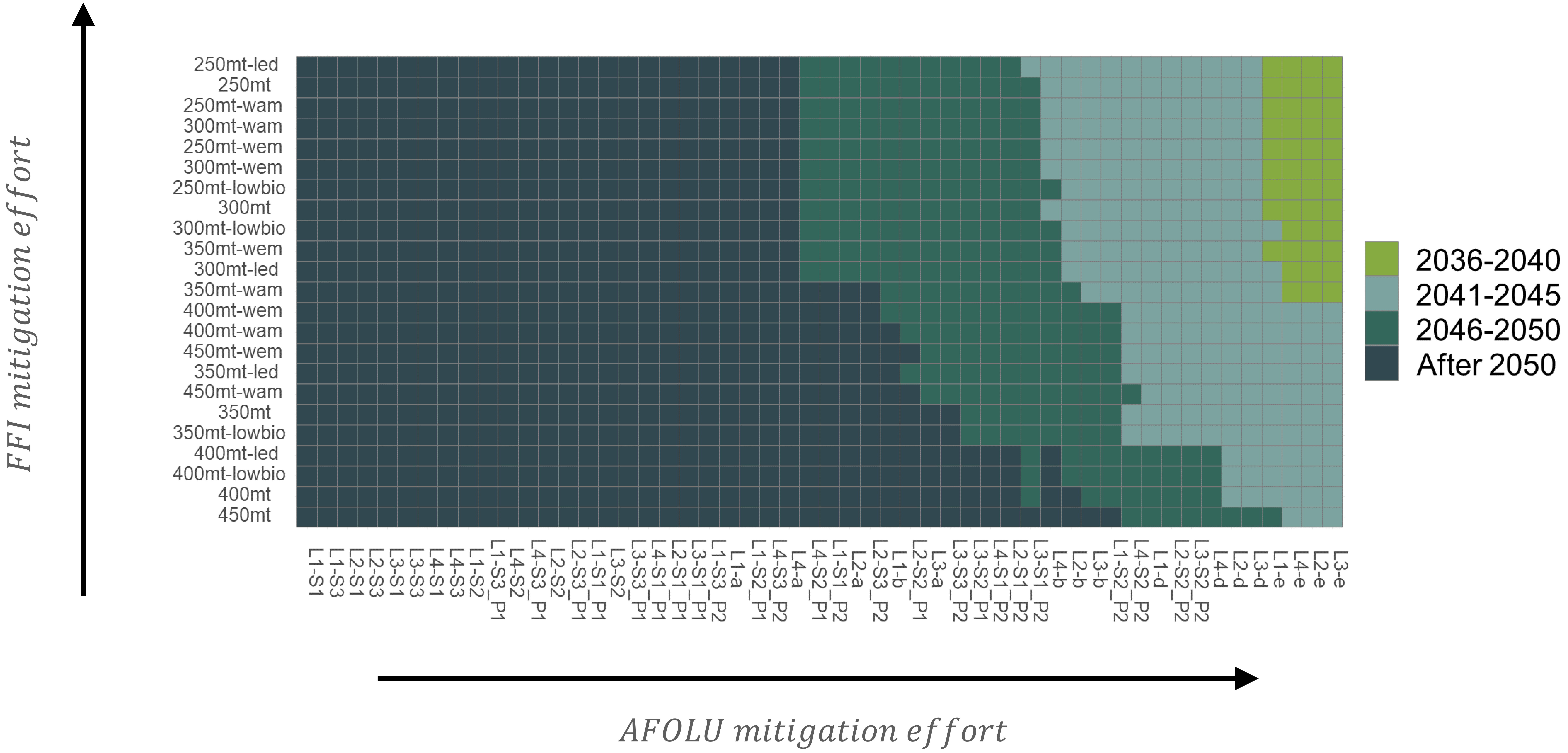
Ireland: 400mt L4 S1_P1

10/53 ≈20% ensemble members neutral by 2050

→ reject

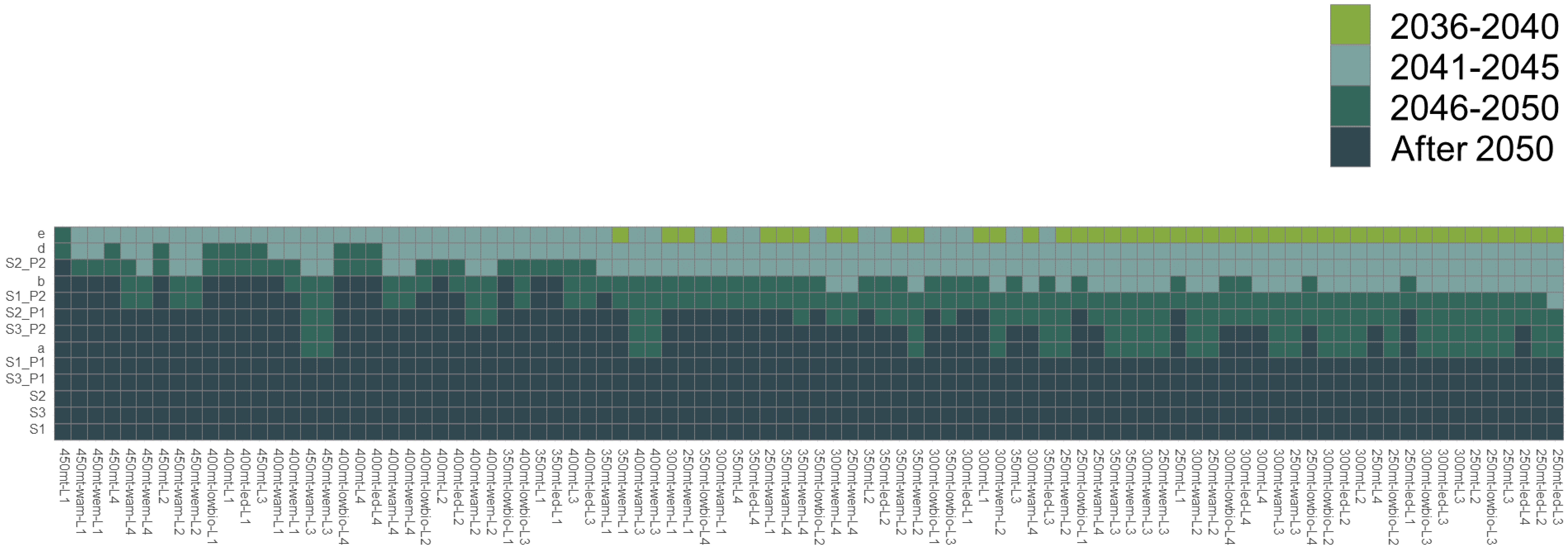
Neutrality Map 3rd Iteration

2/3 Probability SSP126



Neutrality Map by Gas

2/3 Probability SSP126



$CH_4, N_2O\ mitigation\ effort$

$CO_2 mitigation\ effort$

Based on same data as previous slide

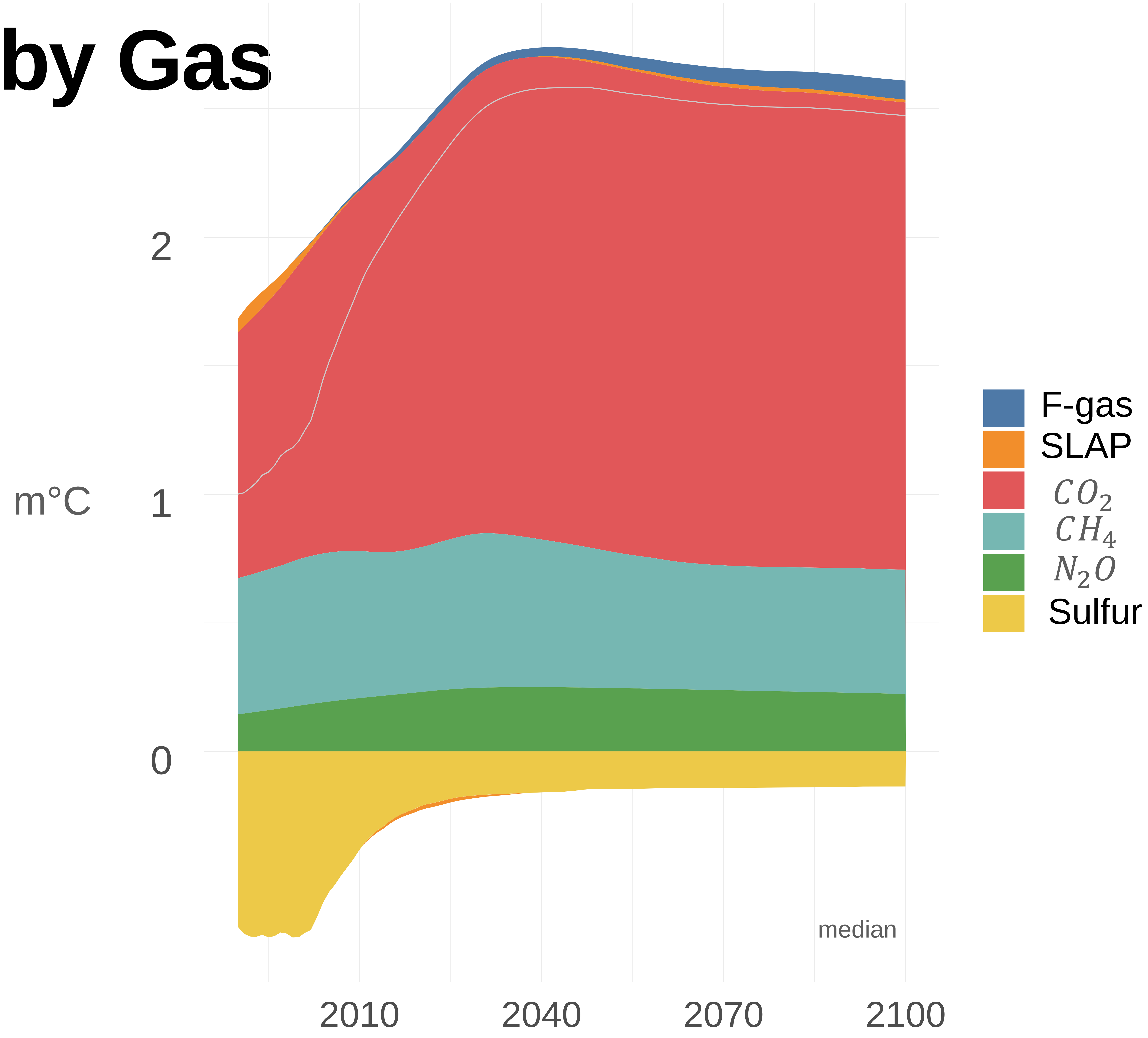
Warming Impact by Gas

<u>Example</u>

400mt-wam L4 S2_P2

Median peak

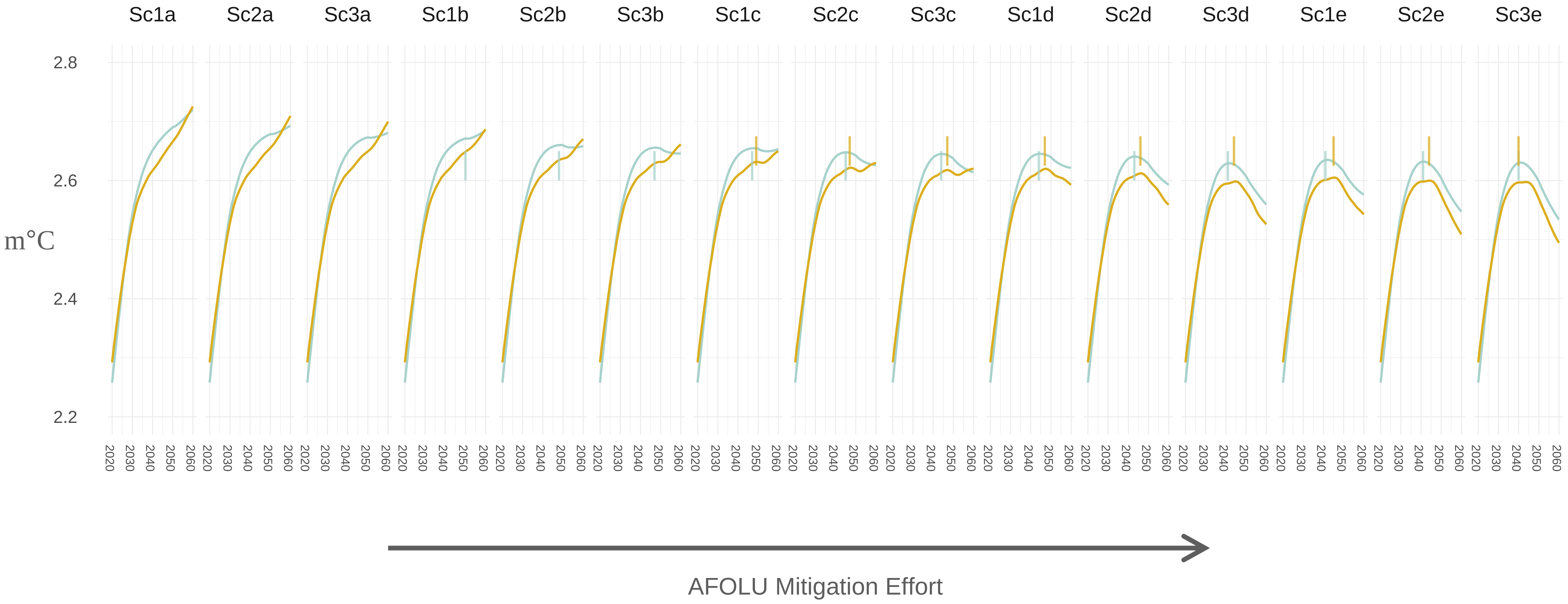
gas	year	m°C
CO_2	2048	1.9
CH_4	2031	0.6
N_2O	2038	0.3



MAGICC7 vs FaIR
2nd iteration scenarios median 2020-2080 warming

SSP126 350mt-bau

Good agreement!



Median peak marginal warming contribution

Range in CBWG scenarios neutral before 2050

Model	Iteration	Reference Year(s)	Warming to peak (m °C)
FaIR*	1st	1851-1900	2.6-2.8
MAGICC**	2nd	1851-1900	2.4-2.6
MAGICC**	2nd	1990	0.9-1.1
FaIR*	1st	2018	0.4-0.6
MAGICC**	2nd	2018	0.3-0.5
FaIR	3rd	1851-1900	2.3-2.5
FaIR	3rd	1990	1.3-1.5
FaIR	3rd	2018	0.3-0.5
FaIR	3rd	2021	0.2-0.4

* unconstrained
**aerosols excluded

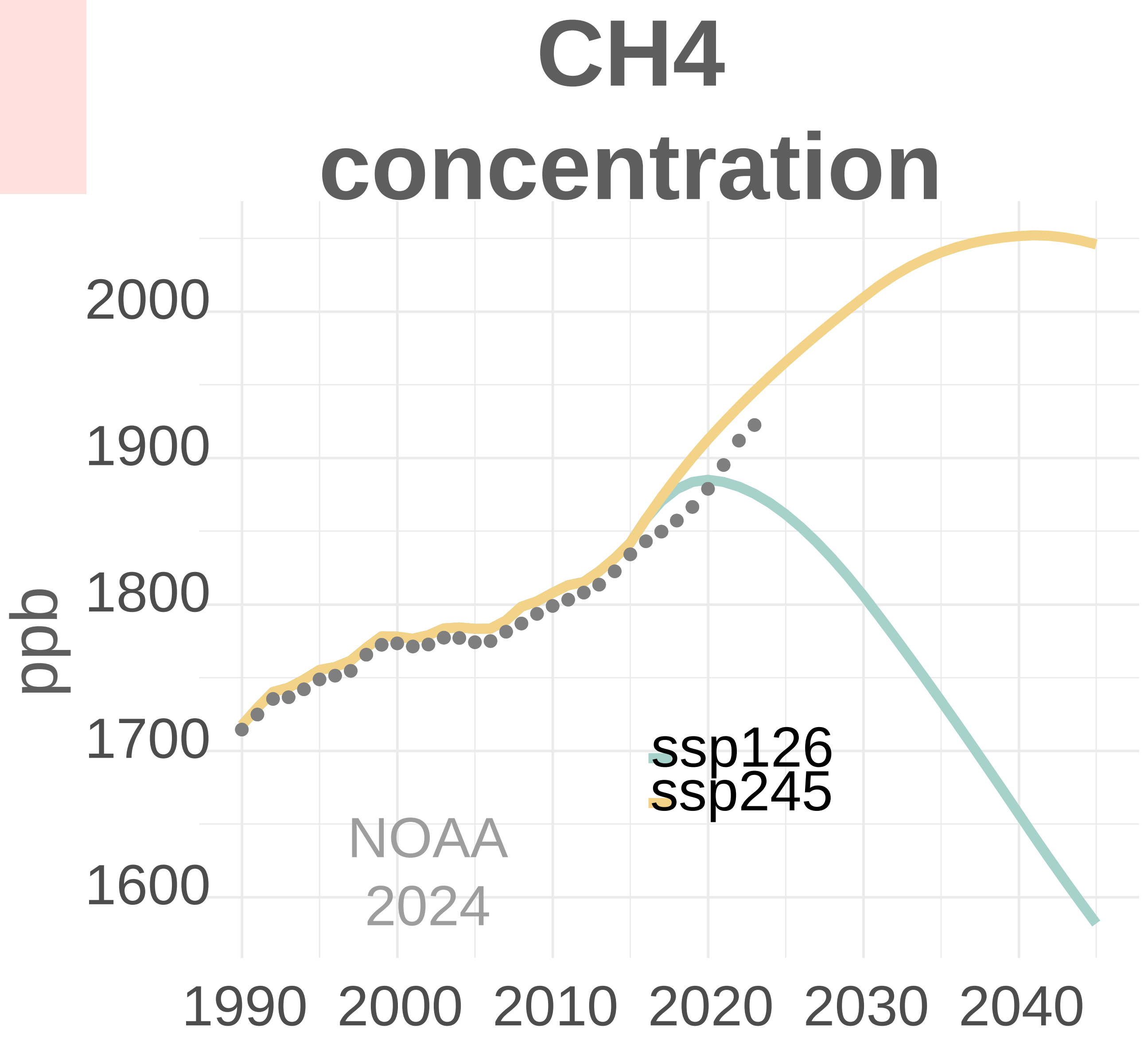
Good and bad observations

- Many routes to neutrality
- Can be achieved in 2040s (vs ~2070 SSP126)
- Nitrous oxide abatement has an overlooked positive role in achieving neutrality

> 20% neutral before 2046 with 2/3 probability

- Most warming impact is historical (~2.1 m°C in 2022)
- Scaling up on a per-capita basis, warming already exceeds 1.5°C (~ 3.5°C)
- 2050 warming difference between neutral scenarios is small < 0.1 m°C

… paradox



- Neutrality becomes easier to achieve if Paris goals are breached

Downscaling 1.5-2.0°C target to national level

No preferred method identified by IPCC

Per capita share of remaining GCB compatible with GSAT target

- Scaling principle – implicit ethical judgement
- Requires specific non-CO_2 gas assumptions (begs question)
- Grandfathering – disregards historical emissions before the reference year

CCAC method – national warming contribution estimate (TCRE, GWP*) scaled to global level

- Scaling principle - ethical judgement
- LOI method - does not take actions by rest of world into account
- Grandfathering relative to a selected reference year (e.g. 2020 GSAT baseline)

LOI: leave –one-in

Downscaling 1.5-2.0°C target to national level

Danish method – scale national emissions up to global and use SCM to evaluate warming

- Per capita scaling principle - ethical judgment
- LOI method – does not take global mitigation pathway into account
- Grandfathering relative to a selected reference year (2020 GSAT baseline)

This Approach - global and national emissions datasets in SCMs

- No scaling – no ethical judgement imposed before calculation
- Minimal grandfathering – warming relative to 1851-1900 (but uncertainty)
- National warming allocation ≈(LOO + LOI)/2
- Temperature neutrality - LOO (marginal) warming
- Sensitivity to global pathways

LOO: leave –one-out

Some limitations of this work

- Purely mechanical approach
- Economic analysis of scenario combinations is missing (easy)
- Just Transition, CBDR analysis of scenario combinations is missing
- Biodiversity impact differences between scenarios may be very large
- No Loss and Damage liability analysis
- Uncertainties in pre-1990 emissions remain

Thank
you!

Allocating warming responsibility using SCMs

Two parties A & B global warming $GSAT_{\{A+B\}}$

Leave one in

Warming by A in absence of B $GSAT_{\{A\}}$

Warming by B in absence of A $GSAT_{\{B\}}$

$$GSAT_{\{A\}} + GSAT_{\{B\}} > GSAT_{\{A+B\}}$$

Disadvantages entity with lower emissions

Leave one out

Warming by A $GSAT_{\{A+B\}} - GSAT_{\{\mathrm{B}\}}$

Warming by B $GSAT_{\{A+B\}} - GSAT_{\{\mathrm{A}\}}$

$$2\ GSAT_{\{A+B\}} - GSAT_{\{A\}} - GSAT_{\{B\}} < GSAT_{\{A+B\}}$$

Disadvantages entity with higher emissions

"Split the difference"

Warming by A $\frac{1}{2}\left(GSAT_{\{A\}} + GSAT_{\{A+B\}} - GSAT_{\{\mathrm{B}\}}\right)$

Warming by B $\frac{1}{2}\left(GSAT_{\{B\}} + GSAT_{\{A+B\}} - GSAT_{\{\mathrm{A}\}}\right)$

Warming sums to $GSAT_{\{A+B\}}$

Forcing-concentration convexity,
path dependence, aerosols….

Banc Ceannais na hÉireann
Central Bank of Ireland
Eurosystem

Using COSMO to assess Macroeconomic Impact of Carbon Budgets

Niall McInerney

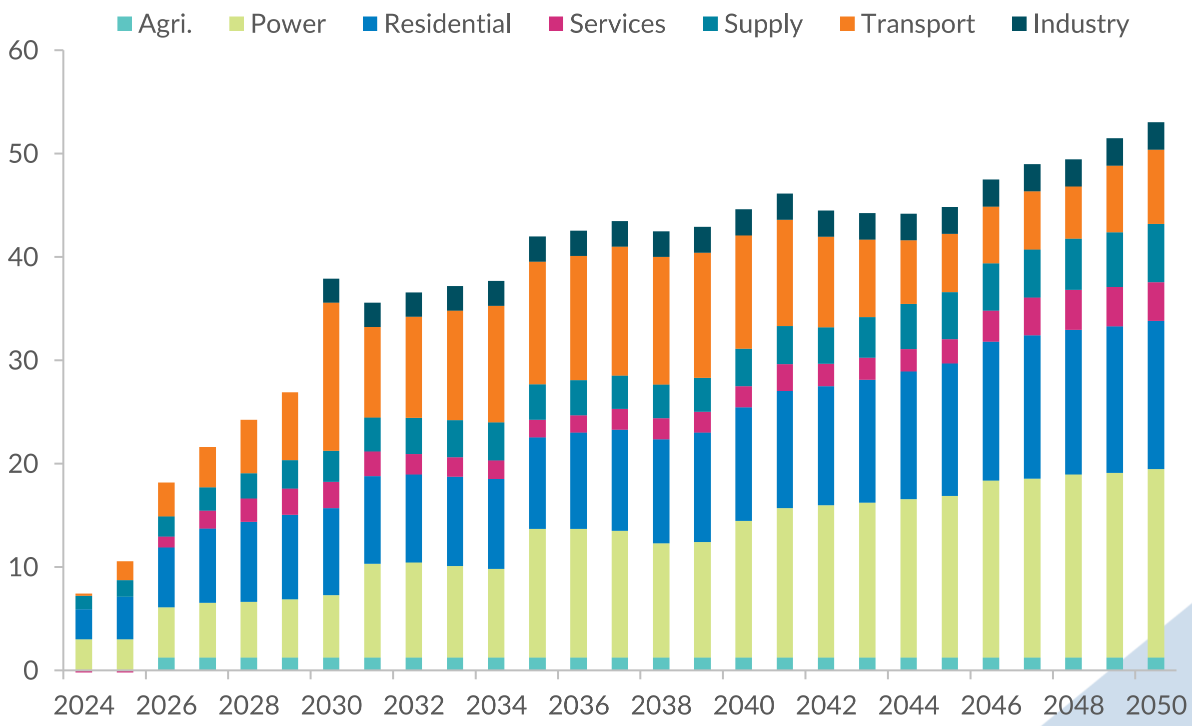
Overview

- Use **COSMO** to analyse the economic impact of transition-related investment on the Irish economy up to 2050
- Key input requirement is the level of investment required to meet decarbonisation targets as provided by **TIM**
- Implementing required investment path in COSMO presents several conceptual /technical issues relating to:
  - Appropriate baseline
  - Gross vs net costs
  - Valuing future energy savings
  - Public-private split and mode of public financing
  - Prevailing macroeconomic conditions
  - Changes in international macro-financial environment
- Focus on impact on key macroeconomic variables, implications for **public finances** and **competitiveness**

Investment Path for Decarbonisation

- TIM provides investment volumes consistent with different decarbonisation pathways.
- Previous analysis considered ‘350 mt-BAU’ **scenario**
  - e.g. Over €50 billion required up to 2050, mostly front-loaded in next decade.
- Provides in-year estimates of costs which are important for profile of macroeconomic response
- TIM also provides important information on paths for other variables such as consumption of different types of energy

Cumulative Additional Investment
(€bn diff in 350mt-BAU scenario)



Source: UCC TIM model

Investment shock in macro model: implementation issues

- **1) Infrastructure Investment**
- TIM investment estimates need to be supplemented with estimates for infrastructure investment
- Investment in **Energy Grid**
  - i) Some estimates for **EirGrid** from 2021-2030 of €3bn (€300mn per year)
  - ii) Scaling **European Commission** (2021) estimates from PRIMES model
    - 2021-2030: 0.05% GDP above baseline (€115mn using GNI*)
    - 20231-2050: 0.18% GDP above baseline (€500mn using GNI*)
- Investment in **transport-related infrastructure**
  - OBR/CCC (2021): 'car infrastructure' 10% of total transport investment
  - Corresponds to €700mn average annual investment over 2025-35 in '350mt' scenario
  - Using GDP (GNI*) share instead of cost share implies lower annual investment of €200mn per year

Investment shock in macro model: implementation issues

- **2) Appropriate baseline**
- Investment in energy systems would occur in absence of carbon budgets
- Is investment **additional** to baseline or is it **crowding out** productive investment
- Calibrating investment shock in macro model needs investment costs **net** of baseline
- Typically baseline in macro models is scenario with least change relative to BAU (e.g. climate neutral)
- Using both '**450mt-WEM**' scenario and **current level** of sectoral investment as alternative baselines

- **3) Evaluating energy costs savings**
  - Profitability of investment will depend on depend on potential reduction in **energy costs**
  - Calculations energy savings relative lump sum investment costs requires assumptions on **future energy prices**
  - Use **current fuel prices** to evaluate reduction in future energy costs
    - Alternatively, extrapolate current fuel prices with statutory path for **carbon taxes**

Investment shock in macro model: implementation issues

- **4) Optimal public-private investment mix**
  - **Public** intervention typically warranted only in cases where market failures and distortions exist
  - **Previous** analysis using COSMO had assumed particular public shares based on literature (~1/3)
- Public share now derived using assumption that private sector will invest where it is financially **cost effective**
- IFAC (2023) provides useful benchmark for public-private investment shares in each sector:
  - **Power Gen & Trans:** generation financed through **competitive auctions** and grid infrastructure costs borne by **EirGrid**
  - **Transport:** €9bn scrappage scheme for 900k cars at €10k per car over 2027-2030
  - **Residential:** assume 2/3 of retrofitting cost borne by state (FitzGerald, 2021)
  - **Industry:** assume ***all*** €2.4bn investment needed to 2030 publicly financed (FitzGerald, 2021)
  - **Agriculture:** income losses compensated by public transfers

Incorporating Impact of Capacity Constraints

- **5) Prevailing macroeconomic conditions**

- Irish **labour market** close to full employment for several years
  - Labour shortage particularly acute in construction
  - Additional investment in **capacity-constrained** economy could **crowd-out** other investment

- 24k approx. *additional* construction workers needed for energy investment up to 2030

- Unemployment/PALF data suggests limits to higher labour supply from higher **participation**

Additional required Capital and Labour 2023-2030

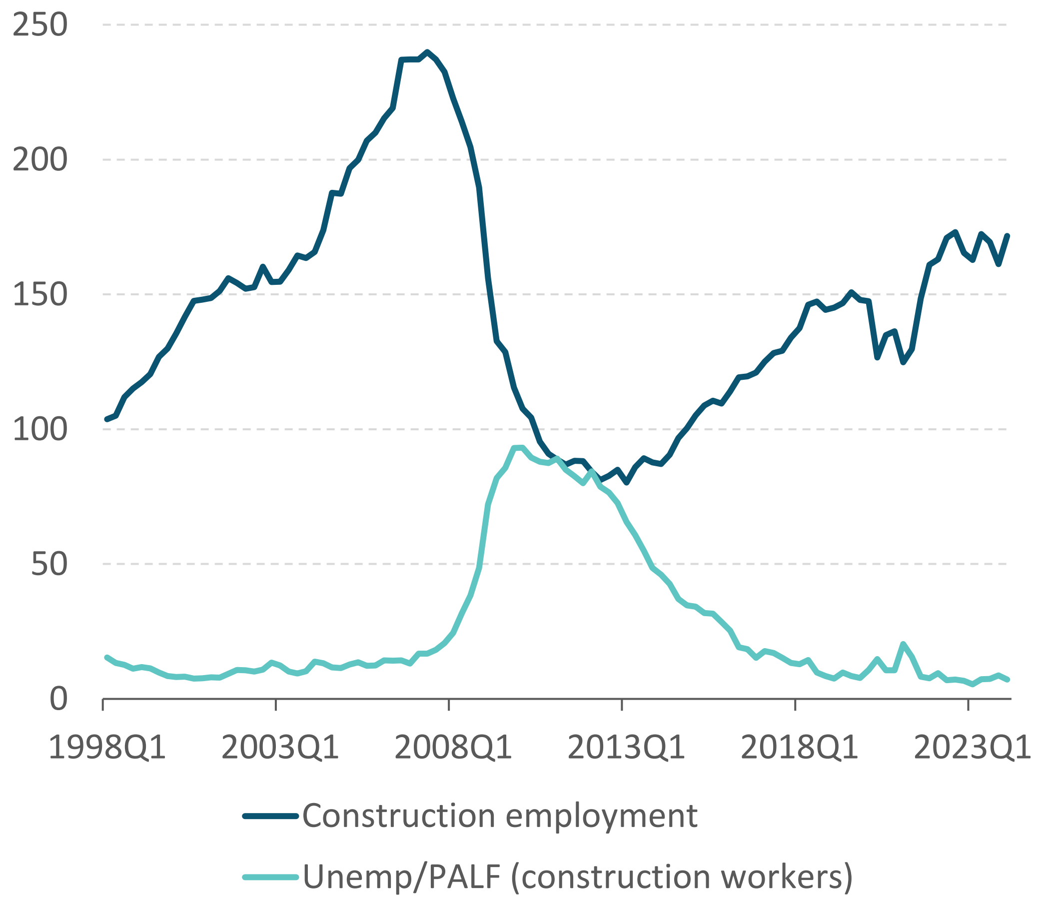
	Annual Dom. Investment (€bn)	Annual Employment (FTEs)
Onshore Wind	0.37	2,103
Offshore wind	0.53	1,469
Solar PV	0.29	4,392
Conv. Gen	0.18	867
Residential	2.80	15,000
Sum	4.17	23,831

Source: Kakkar, Farrell and Lynch (2024)

Capacity Constraints and Labour Scarcity

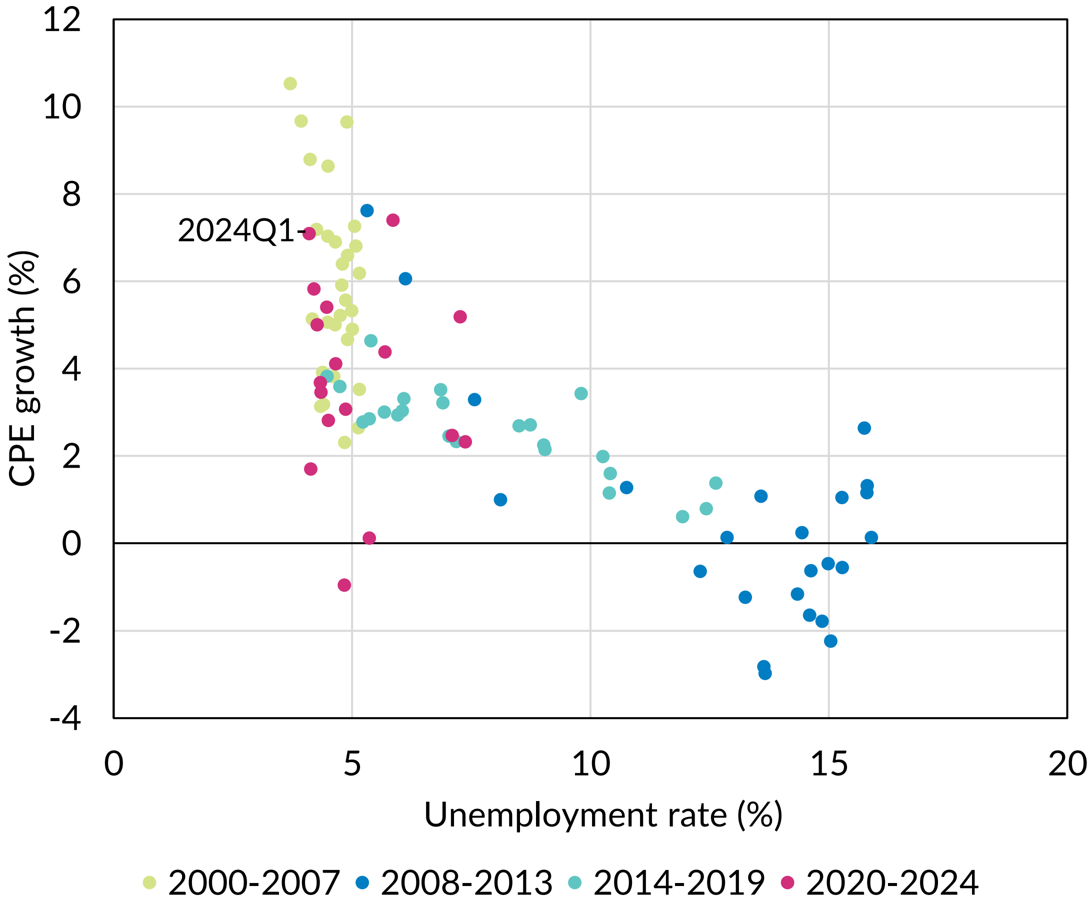
Construction Labour Market

(‘000s)



Source: CSO

Wage Growth and Labour Market Slack



Source: Central Bank of Ireland

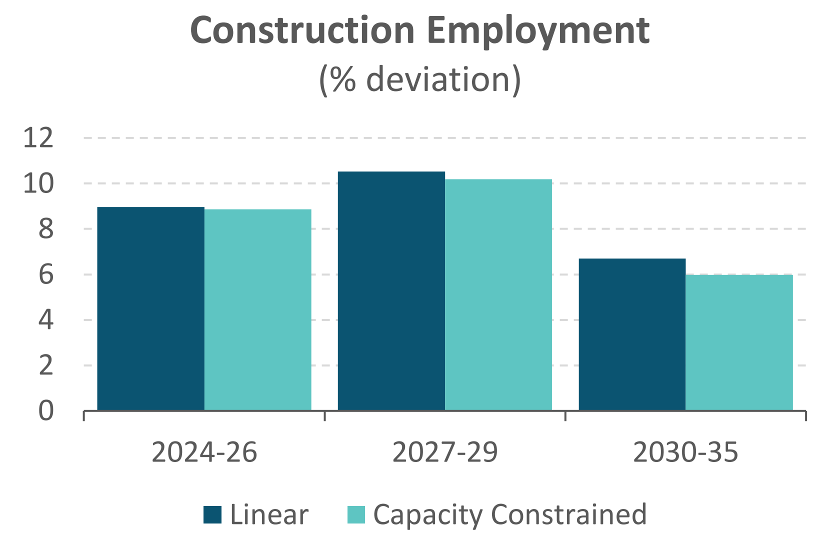
Incorporating Impact of binding Capacity Constraints

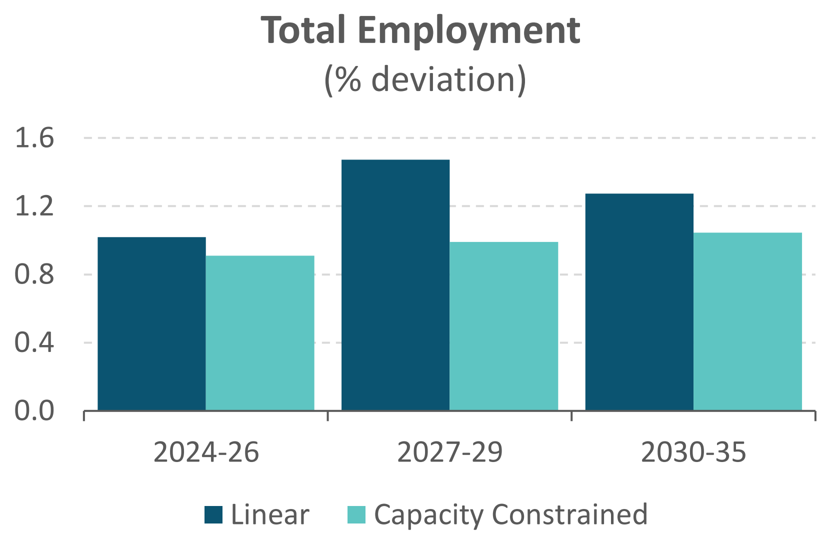
- Need to capture impact of investment stimulus in a **capacity-constrained** economy
- COSMO is essentially **a linear model** and thus does not generally allow 'state-dependent' analysis
- Potential solution: incorporate non-linearities in wage- and price-setting through a **'switch'** in COSMO
- Key parameters of the model change depending on **state** of the economy (output gap) i.e. two 'regimes'
  - Based on historical episodes when economy has been above potential
- Inflationary impact of additional investment is typically a **short- to medium-term** issue
  - Capacity constraints relaxed through higher immigration or retraining/upskilling

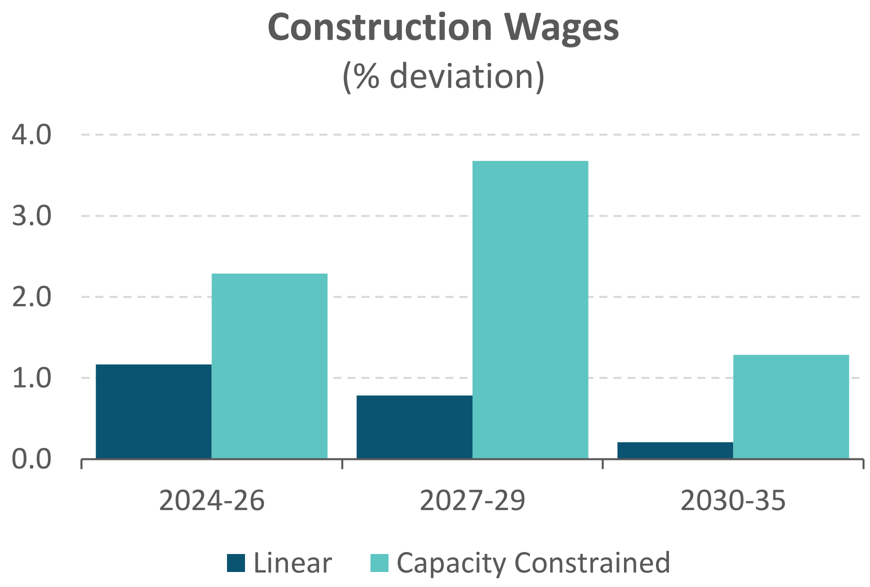
Incorporating 'Overheating' Mechanisms

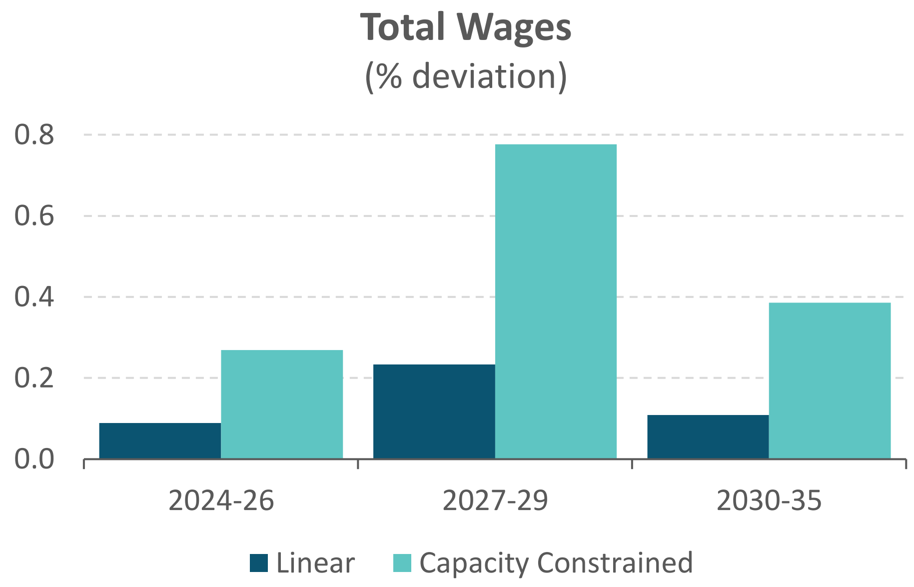
Sector	Equation	Variables	Linear	'Overheating'
Traded Sector	Wages	**LR:** Labour Productivity, UE Rate **SR:** ΔIncome Tax, ΔCPI, ΔUE Rate	0.13	0.27
	GVA deflator	**LR:** NT Wages, Labour Productivity **SR:** ΔEnergy Prices, ΔWages, YGap	0.54	0.61
Non-Traded	Wages	**LR:** Labour Productivity, UE Rate **SR:** ΔIncome Tax, ΔCPI, ΔUE Rate	0.22	0.36
	GVA deflator	**LR:** NT Wages, Labour Productivity **SR:** ΔEnergy Prices, ΔWages, YGap	0.54	0.75
Construction	Wages	**LR:** Labour Productivity, UE Rate **SR:** ΔIncome Tax, ΔCPI, ΔUE Rate	0.18	0.45
	GVA deflator	**LR:** Construction Wages, Labour Productivity **SR:** ΔEnergy Prices, ΔWages, YGap	0.09	0.21
Household	Consumer Prices	**LR:** Import prices, VAT rate, GDP Deflator **SR:** ΔGDP deflator, YGap	0.06	0.13

Shock raising Total Investment by 5%

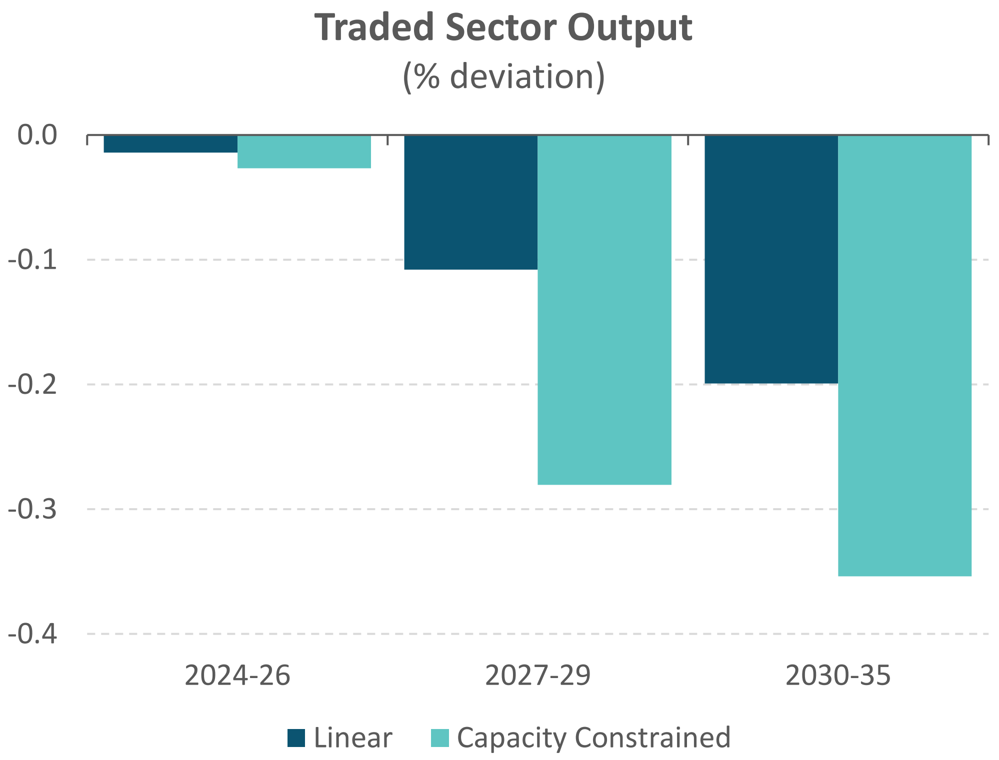


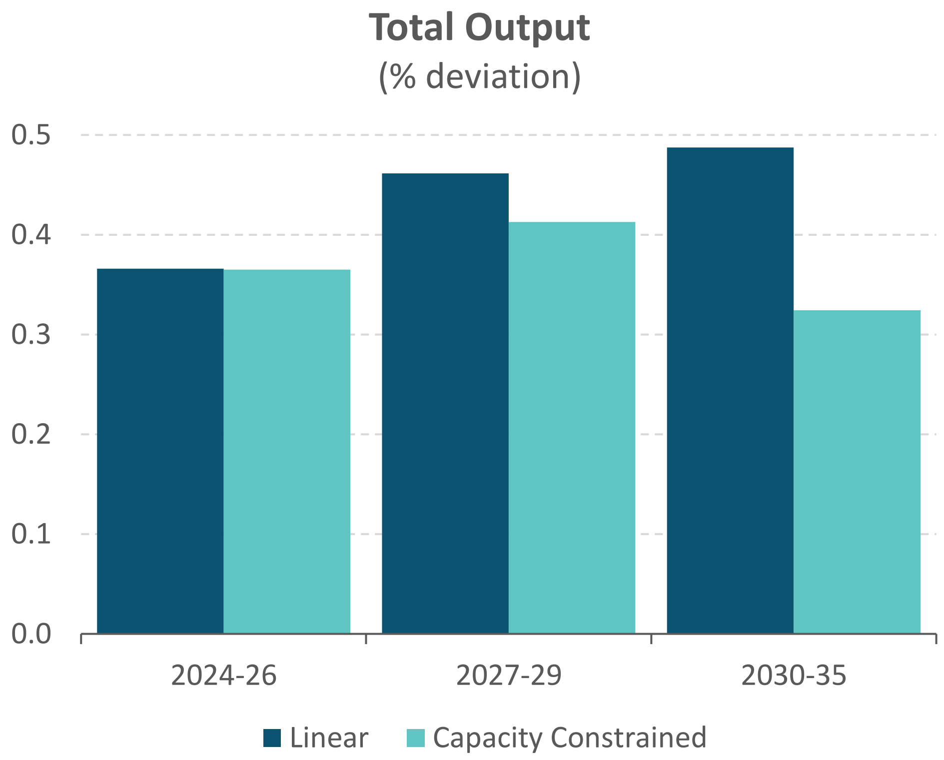






Shock raising Total Investment by 5%

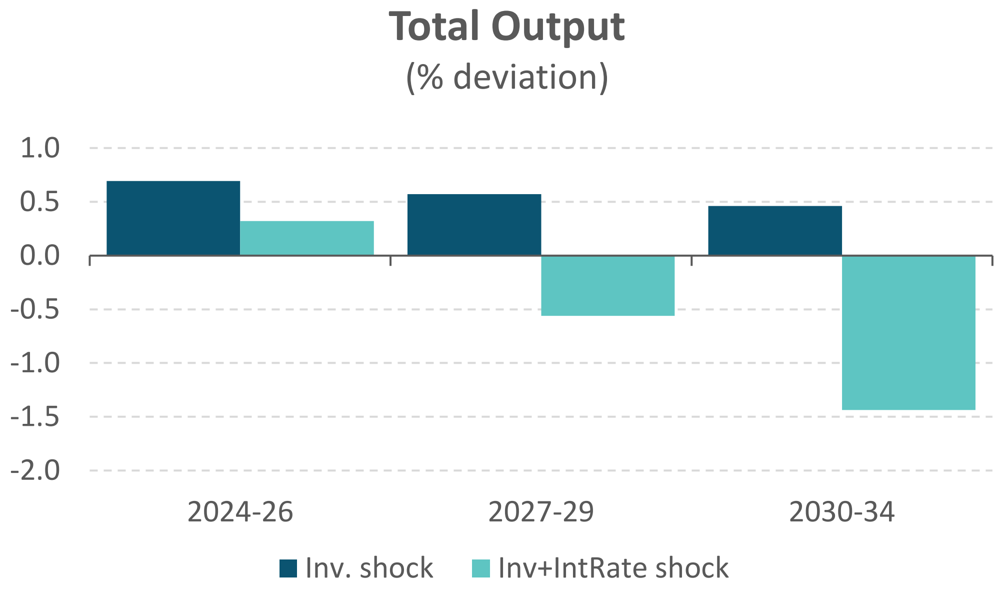


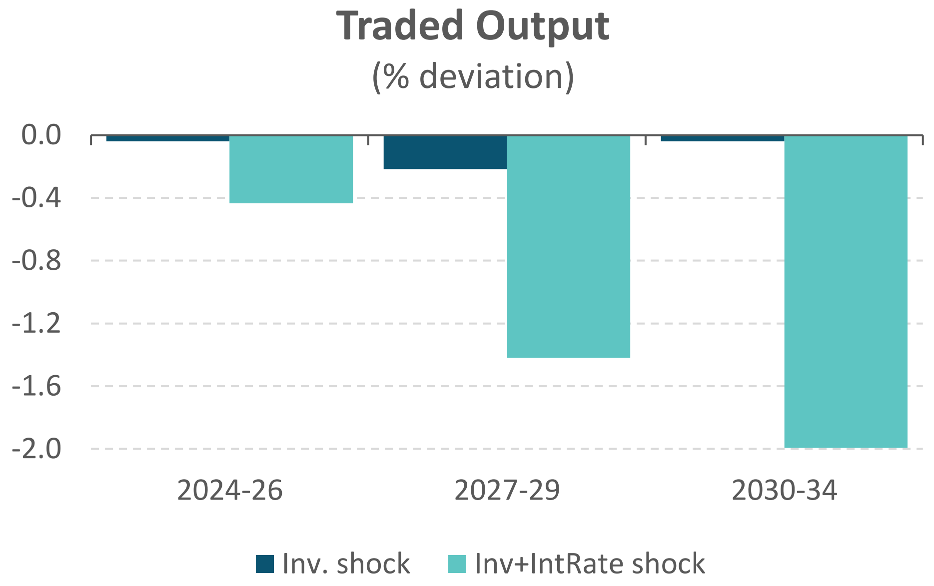


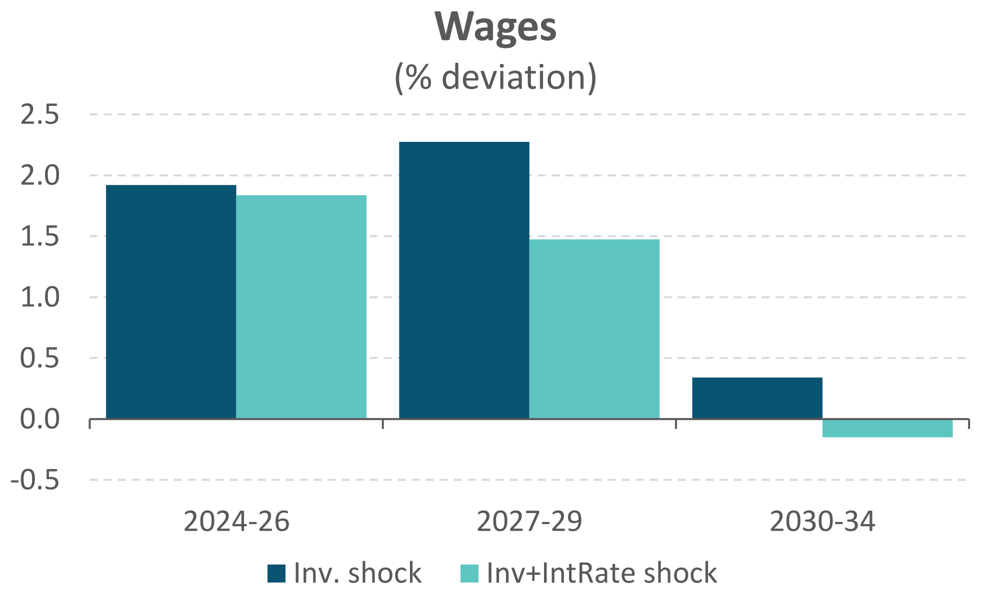
Spillovers from higher interest rates

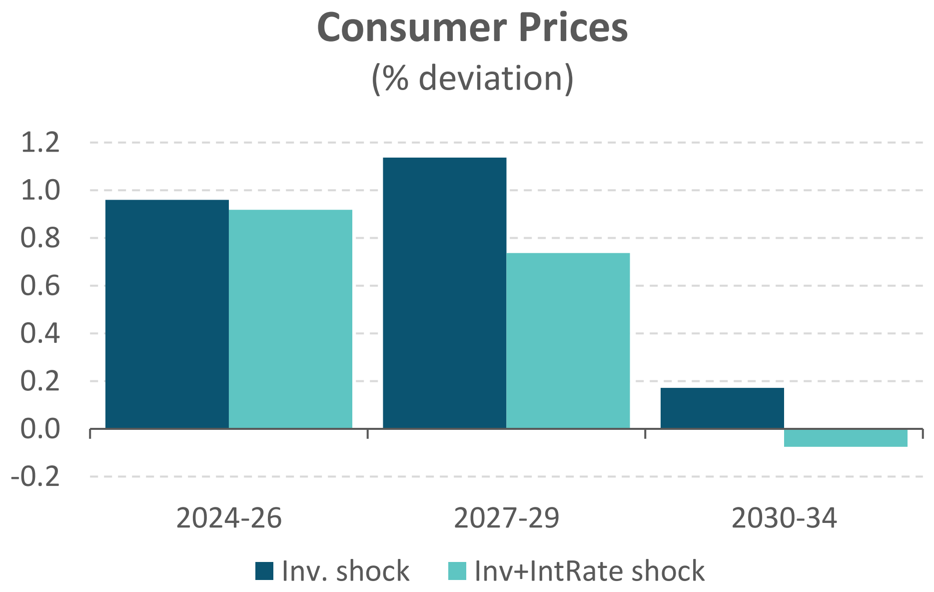
- **6) Uncertainty about international financial environment**
  - Additional required investment of 2-3% GDP (Pisani-Ferry, 2021)
  - Investment could push up **interest rates** if global saving fixed (FitzGerald, 2021)
- Our **previous analysis** looked at impact of assuming an interest rate
  - Path consistent with the with **rise in long rates** under NGFS Net Zero 2050 scenario
  - Interest rates rise by close to 50 bps even in **long run**
- Use NiGEM to simulate a **25bps** rise in global interest rates that **lasts for 10 years**
  - Impact on external demand for Irish goods, competitor prices, interest rates and equity prices
- Then simulate impact of **investment shock** in COSMO given paths of **external** variables and **domestic** interest rate shocks

Shock raising Total Investment by 5%

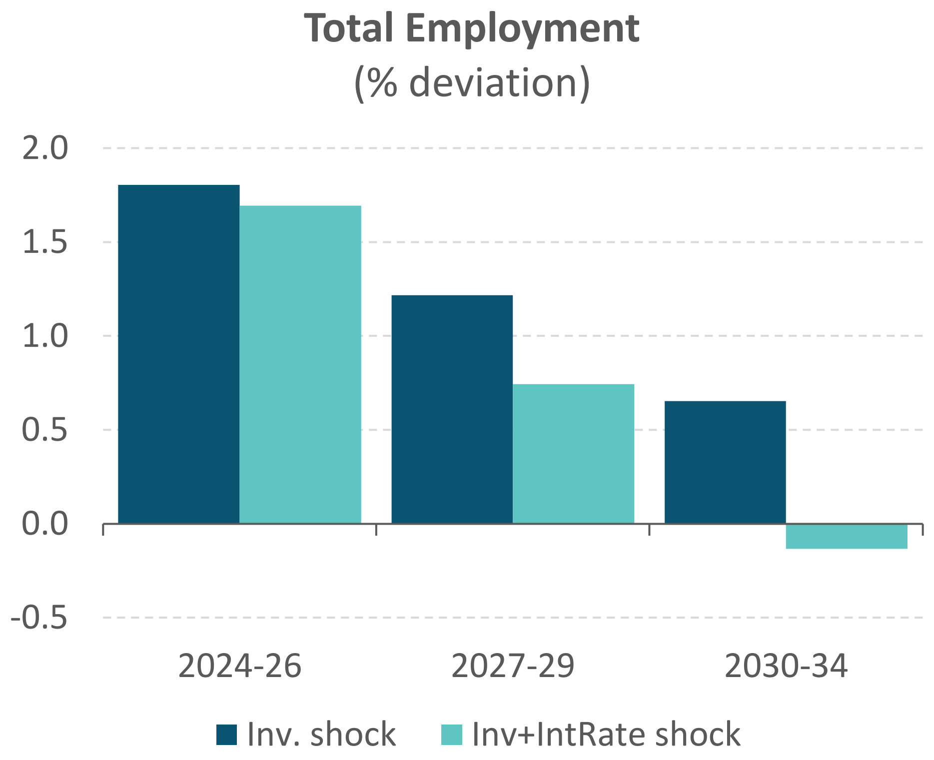


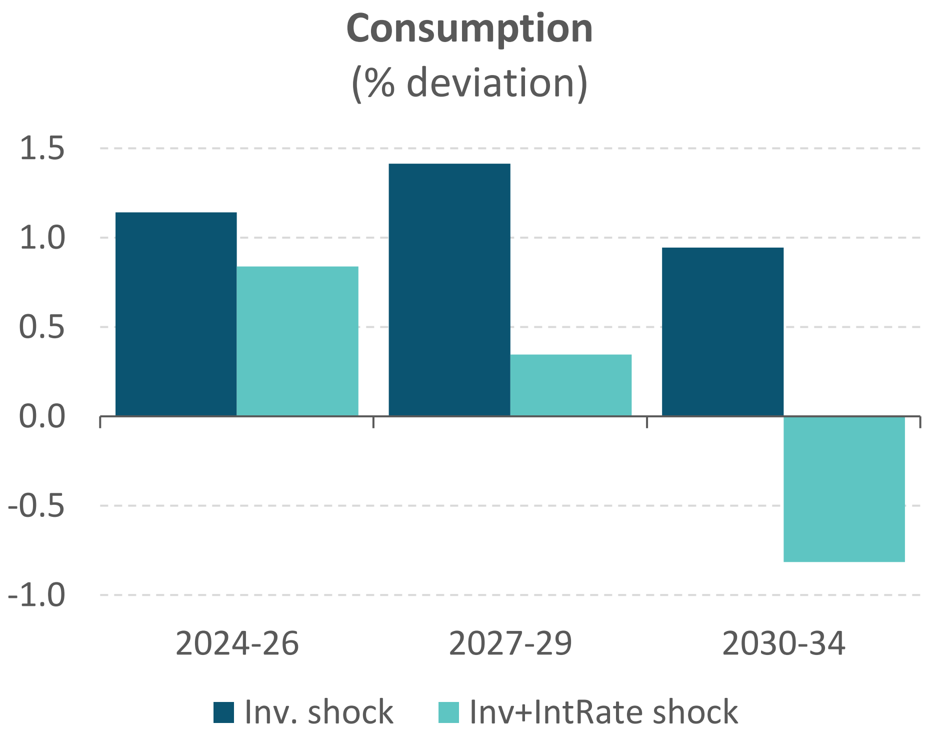






Shock raising Total Investment by 5%





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Climate Impacts and Adaptation in Ireland

Climate Impacts Ireland

1. **Assess** climate change impacts and adaptation for Ireland
   - based on the literature
   - additional econometric estimations
2. **Identify** impact ‘mechanisms’
   - who and how
3. **Assess secondary** impacts
   - Implementation into I3E model

Impacts:

- Coastal flooding
- Labour productivity
- Agriculture
- Riverine flooding
- Health

We do **not** examine many other impacts

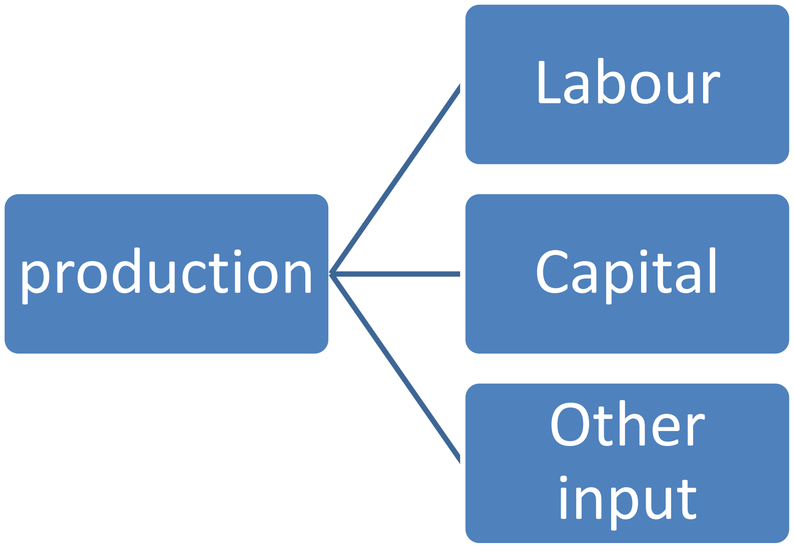
- Biodiversity loss
- Extreme weather
- Agricultural impacts from variable weather
- Wildfires

Overview of Initial Impacts sources

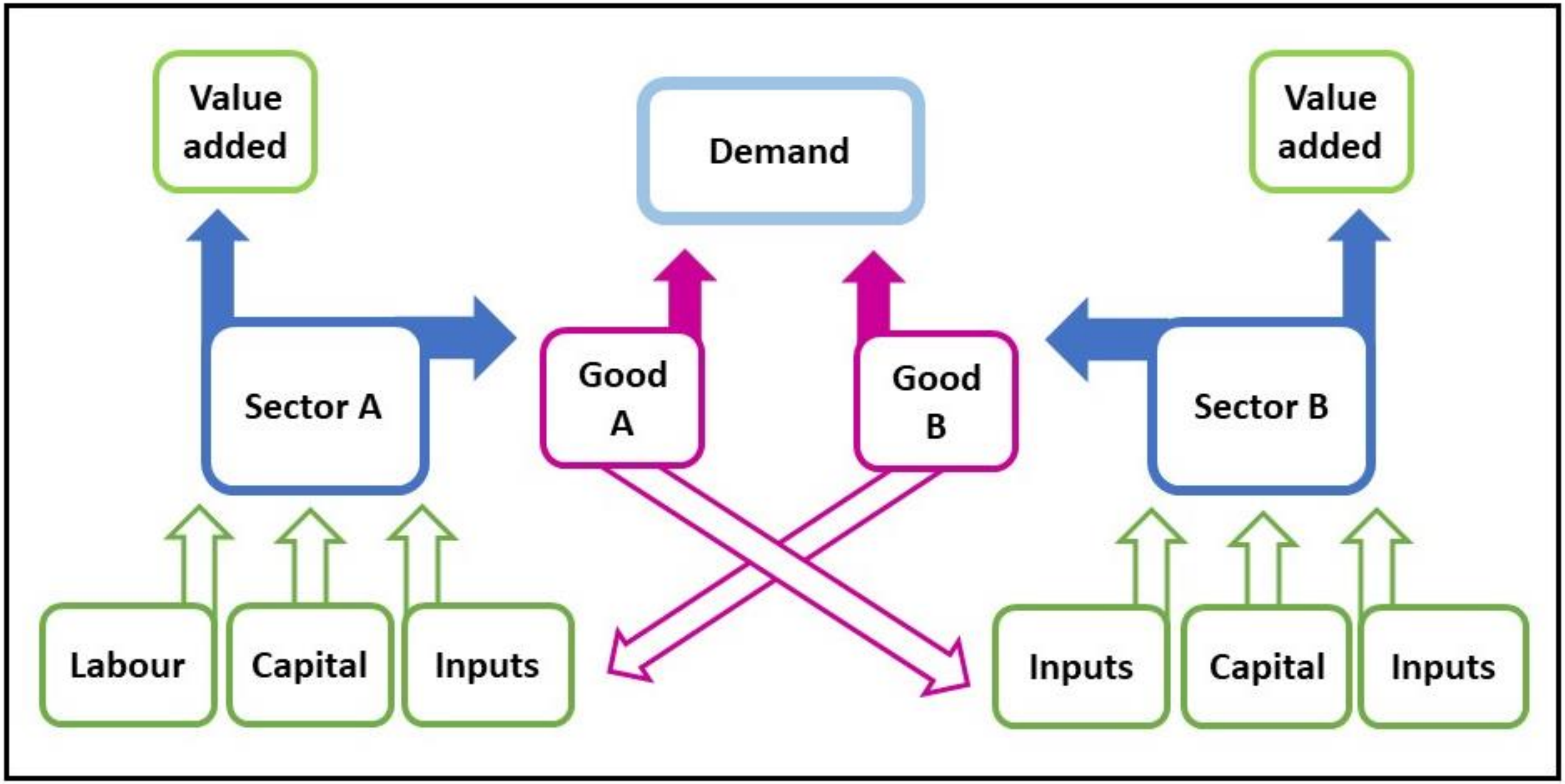
Impact	Source	Cost
Coastal Flooding	Coastal Climate Impact and Adaptation Model (CIAM)	Projected annual cost for the year 2050 is approximately €2 billion.
		Projected annual cost for the year 2100 is approximately €7 billion.
Labour productivity	Econometric analysis using Wet Bulb Globe Temperature (WBGT)	1.6% decline in labour productivity. Average annual loss that ranges from €700 and €3,100 per worker per season.
Agriculture	Environmental Policy Integrated Climate (EPIC) and Geographic Information System (GIS)-based EPIC	Major Irish crops such as barley, wheat, and potato will experience an increase in yields in the future. The expected increase in yields ranges between 15% to 20%, depending on the specific crop and scenario considered.
Riverine flooding	GLObal Flood Risks with IMAGE Scenarios (GLOFRIS)	Projected annual cost for the year 2070 is €95 million.
Health	Panel fixed effects	Higher temperatures above the reference scenario of [10°C, 13°C) contribute to an increase in emergency hospital admissions.

Secondary Impacts

- Identify how initial impacts will result in further impacts
- **Production function** approach



Secondary Impacts



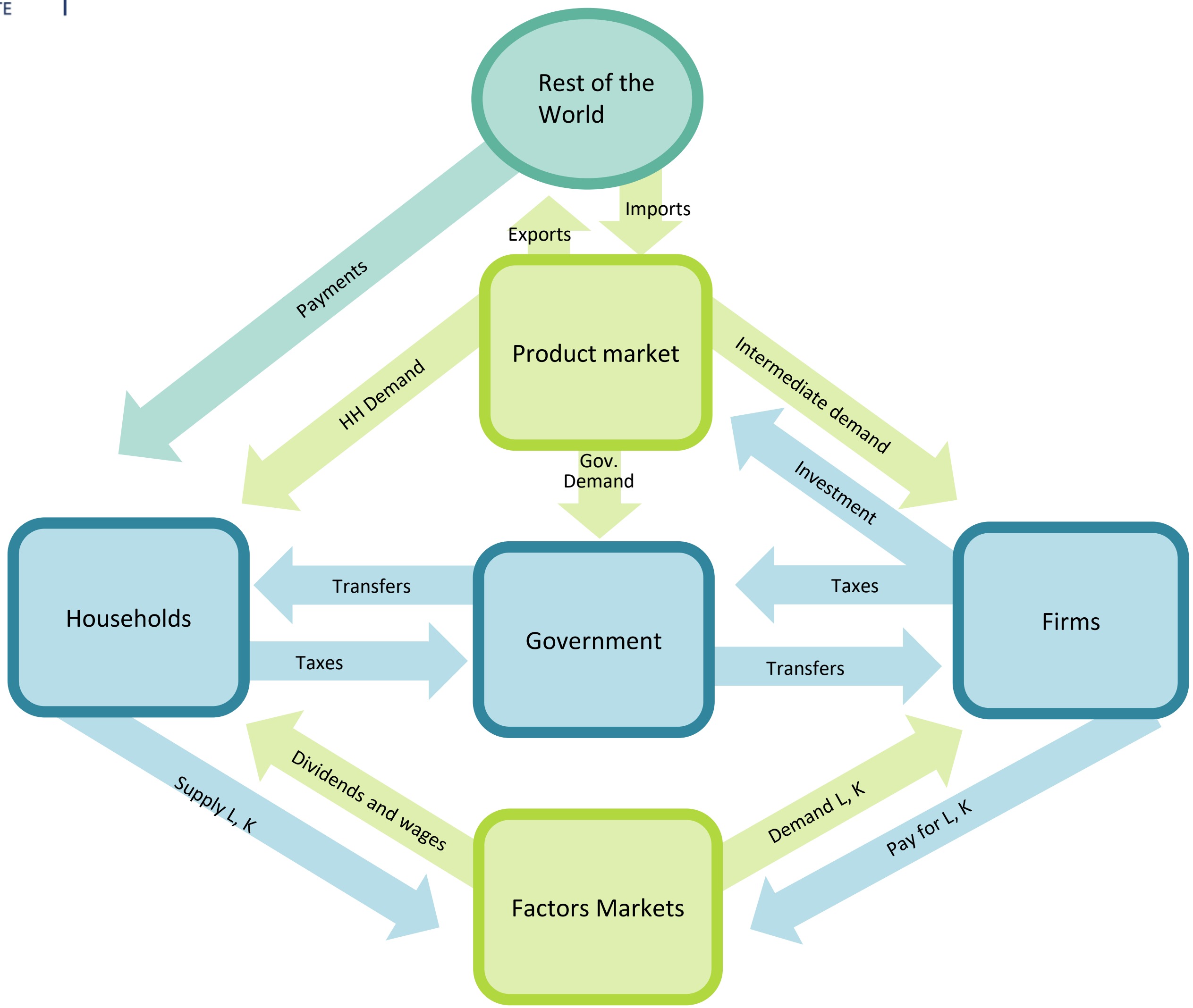
The I3E model

- Ireland Environment, Energy and Economy model
- https://www.esri.ie/current-research/the-i3e-model
- Dynamic Computable General Equilibrium model
- **Features**
  - Detailed representation of **production sectors** (37 sectors)
  - Detailed representation of **consumption goods** and services (42 commodities)
  - Inclusion of explicit **carbon commodities**
  - **Emissions** from combustion (ETS and non-ETS)
  - Detailed modelling of **government** sector
  - **Households** specification with 10 representative household groups (5 urban, 5 rural)
  - 3 **labour** types: low, medium and high skilled

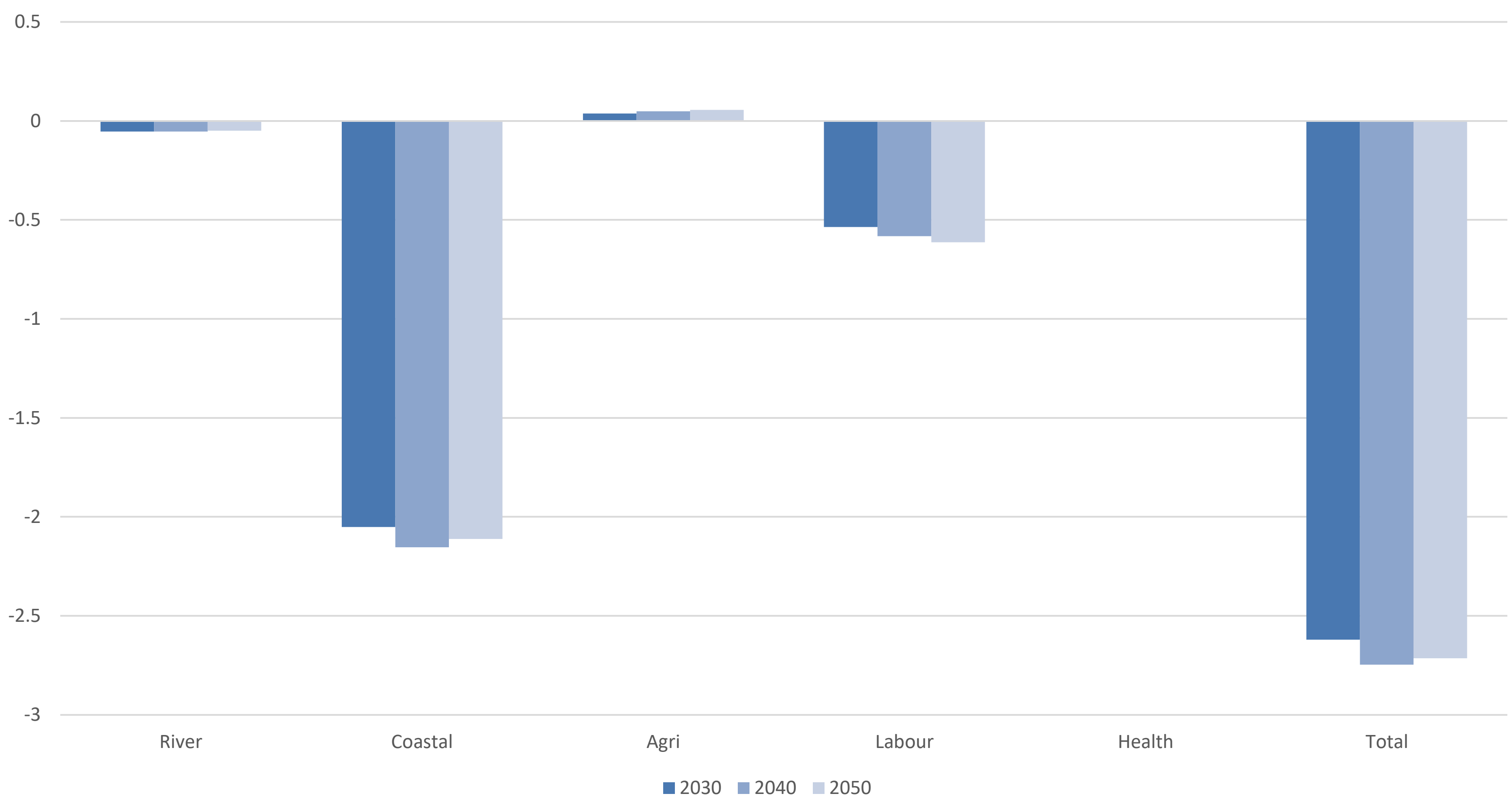
I3E: Agents

- **Households**: maximise utility through consumption demand, provide capital and labour. Receive government transfers (social benefits and pension), labour and capital income.
- **Production Sectors**: maximise dividends through production, consume labour and capital.
- **Government**: receives taxes (VAT, production, corporate, carbon, wage) and transfers to production sectors and households.
- **ROW**: Imports from and exports to Ireland.

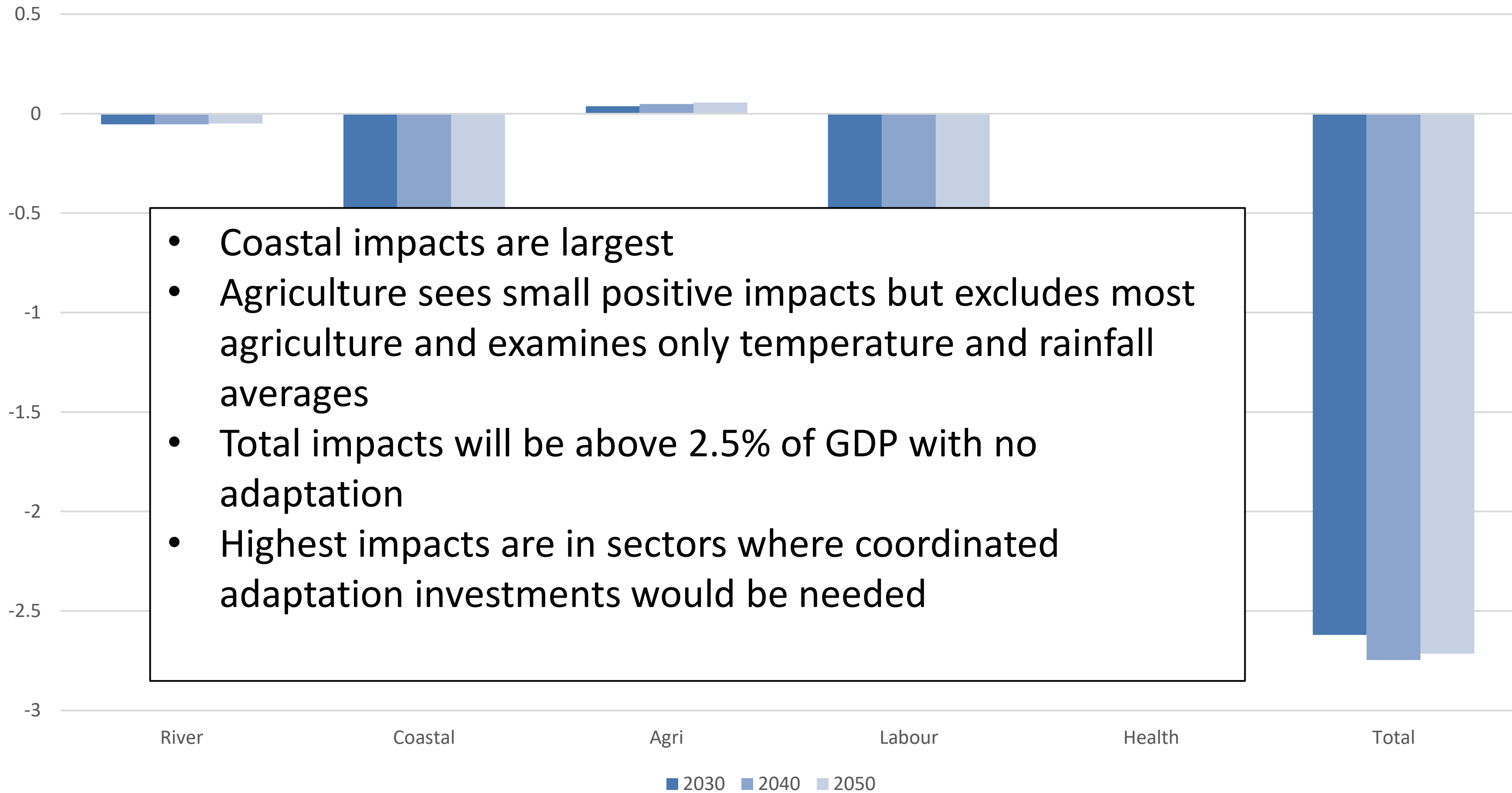
I3E overview



Results: change in GDP in % across impacts

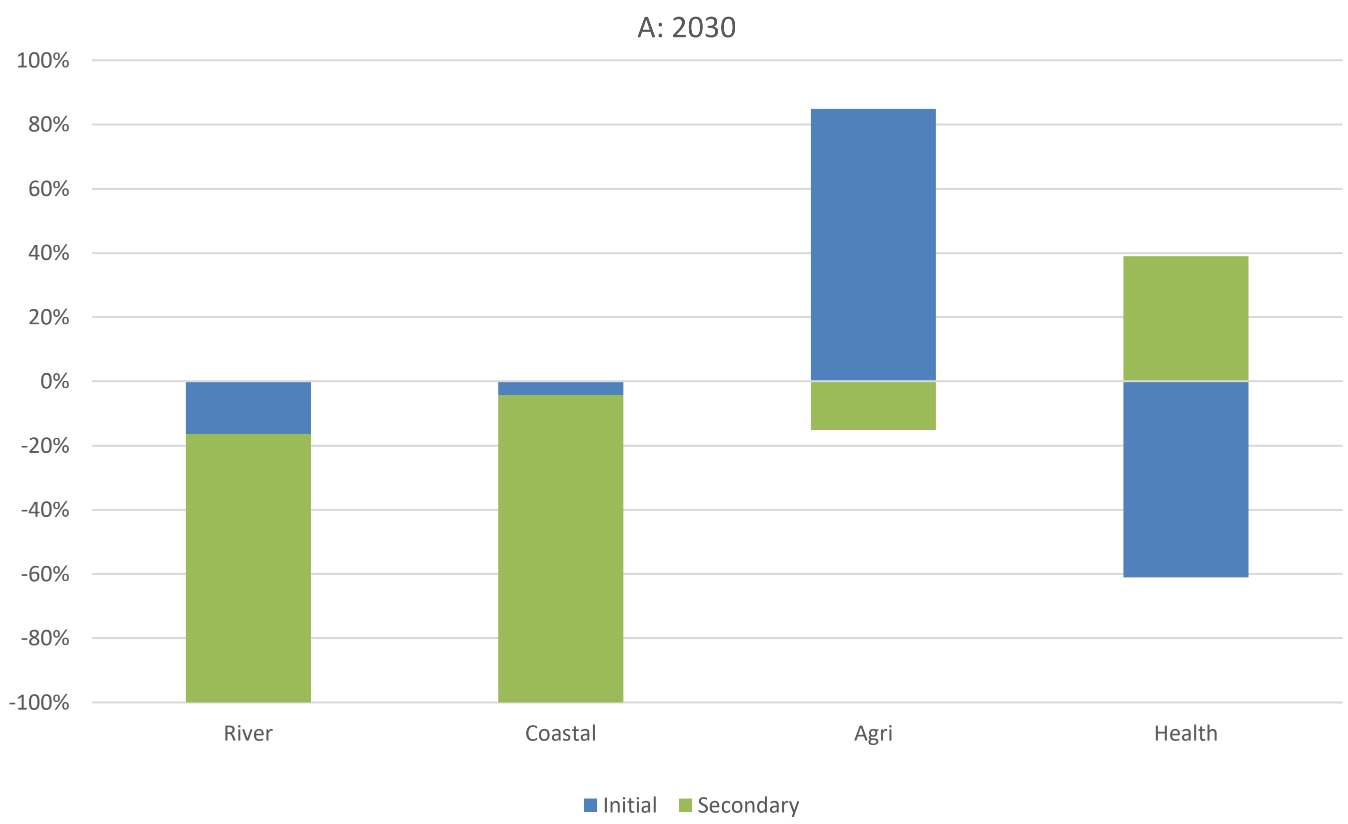


Results: change in GDP in % across impacts



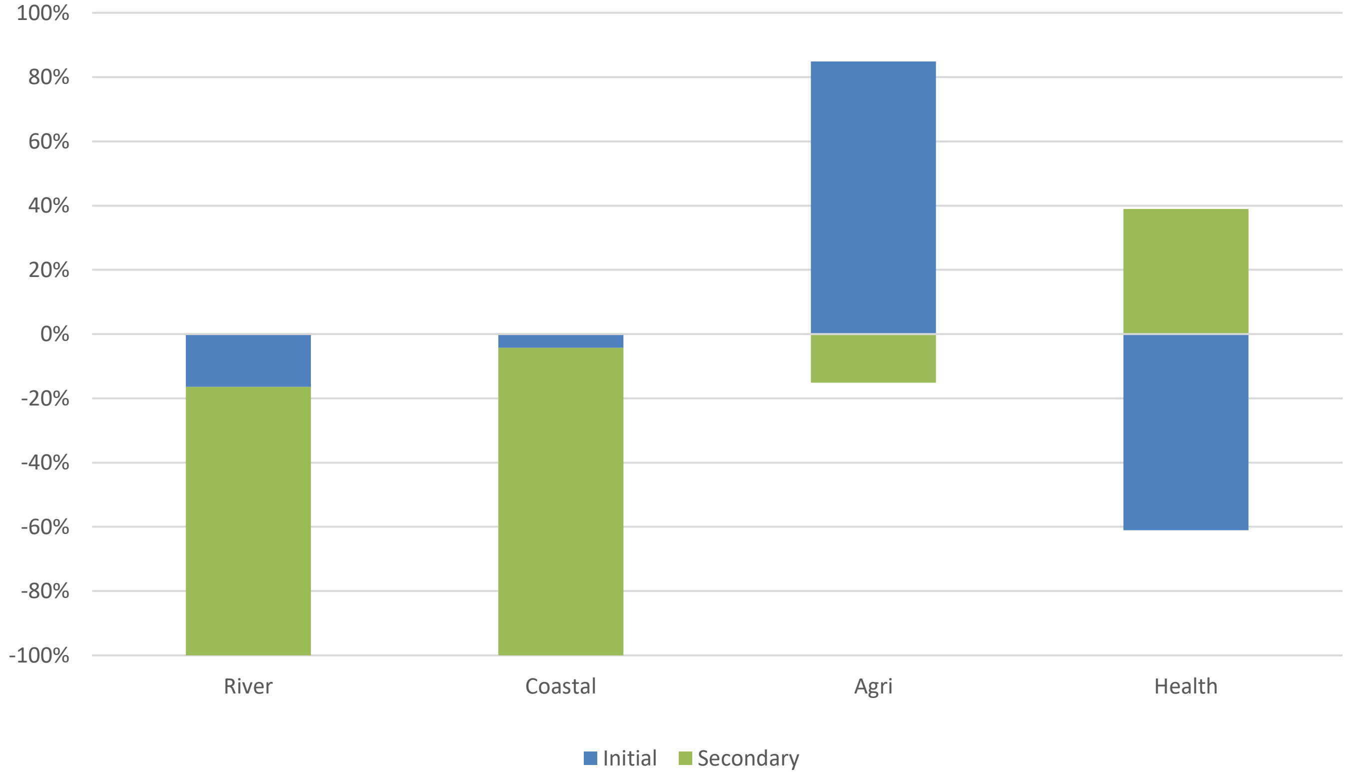
- Coastal impacts are largest
- Agriculture sees small positive impacts but excludes most agriculture and examines only temperature and rainfall averages
- Total impacts will be above 2.5% of GDP with no adaptation
- Highest impacts are in sectors where coordinated adaptation investments would be needed

Secondary Impacts

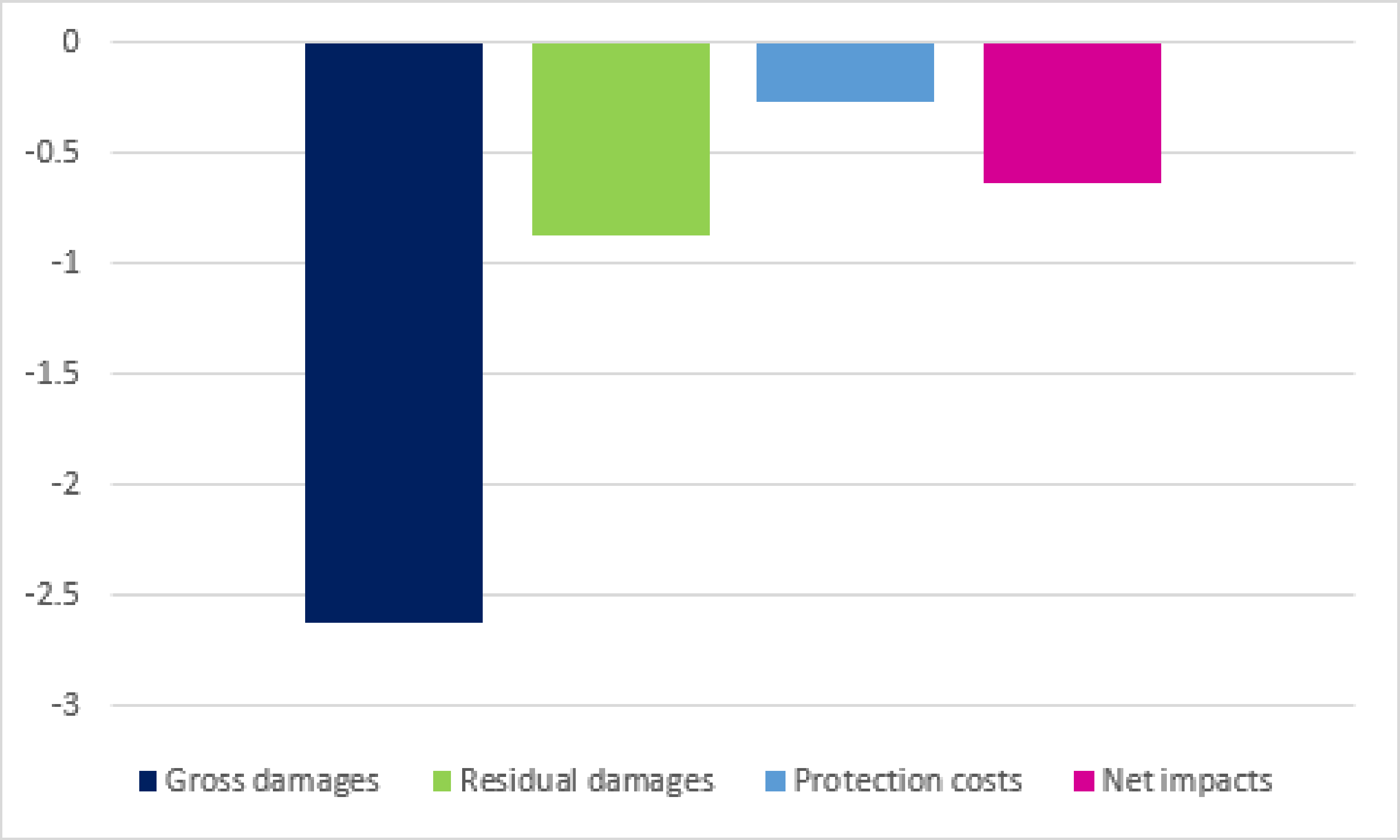


Secondary Impacts

- Secondary impacts are more important than initial
- Not considered in policy making



Including Adaptation



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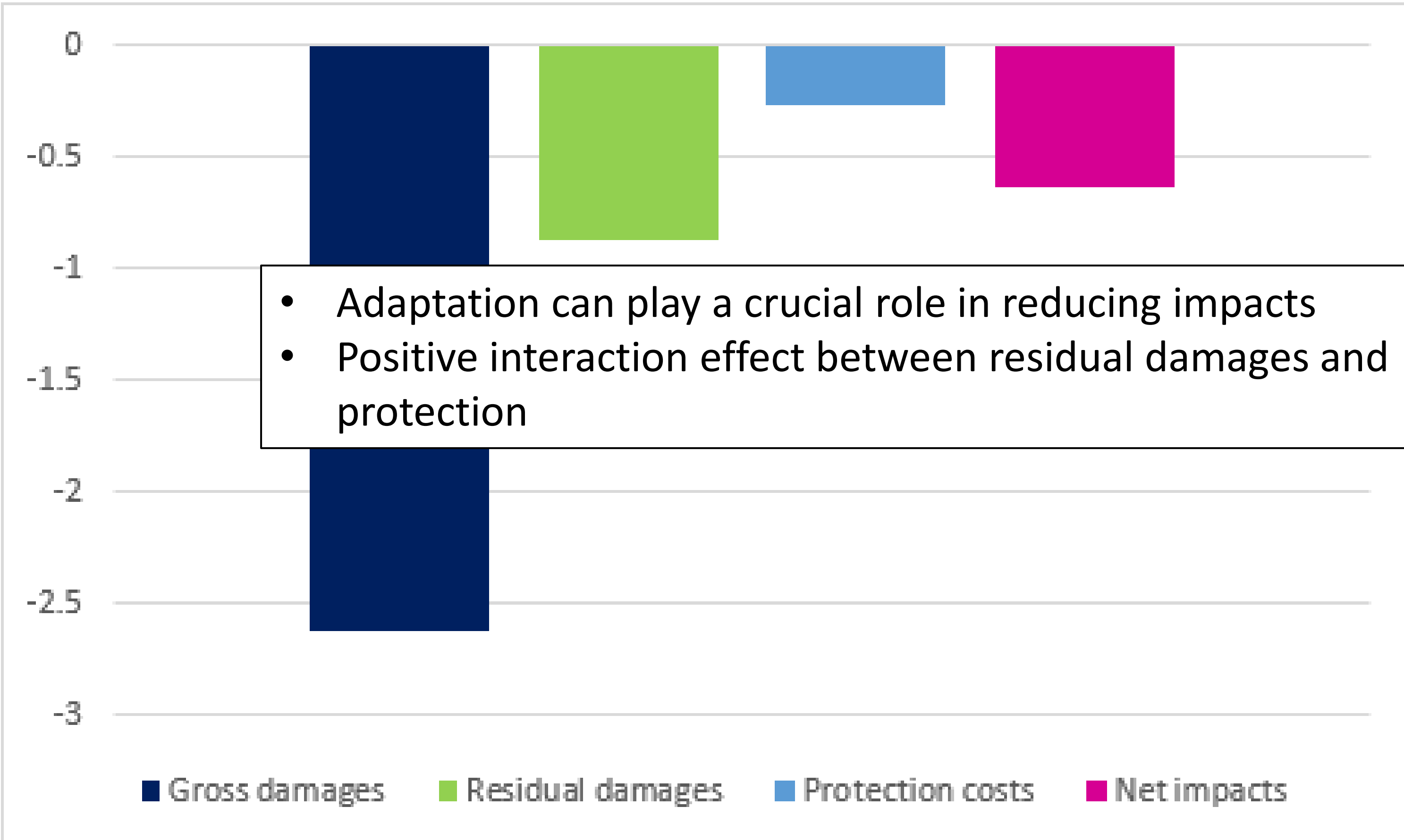
Including Adaptation



- Adaptation can play a crucial role in reducing impacts
- Positive interaction effect between residual damages and protection

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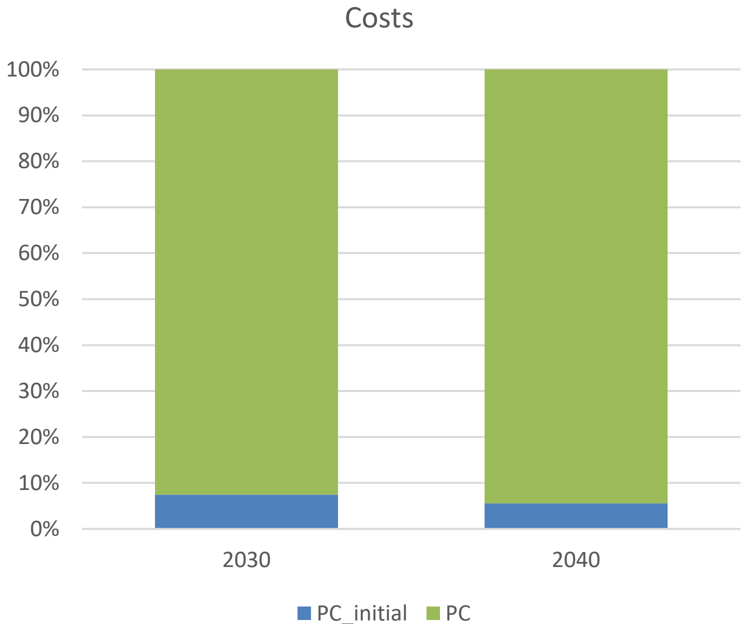
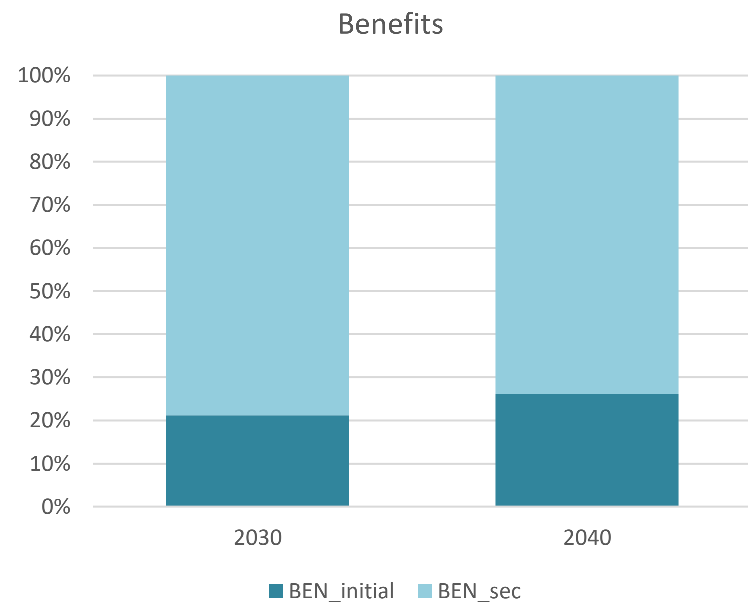
Adaptation Secondary Impacts





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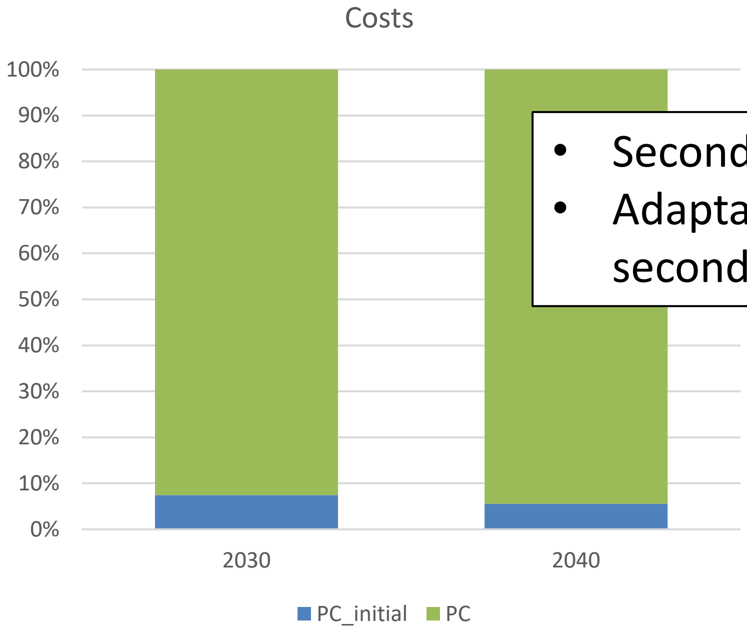
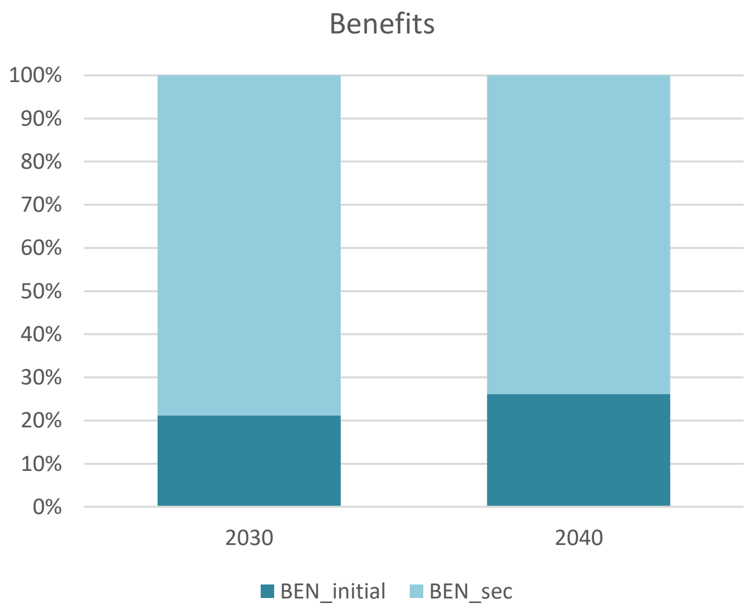
Adaptation Secondary Impacts



- Secondary impacts are higher than initial
- Adaptation option assessments would need to include secondary impacts



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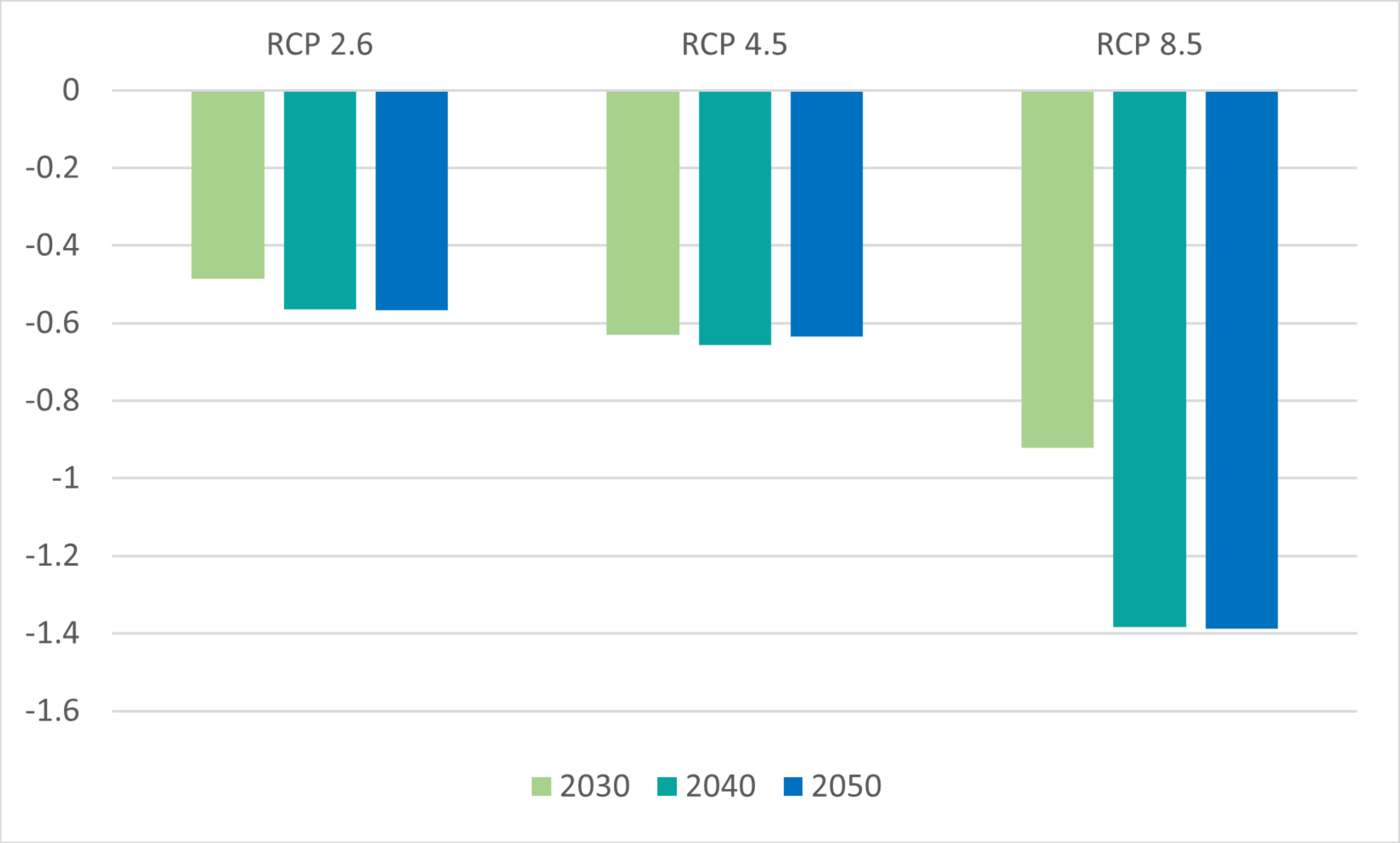
Across RCPs



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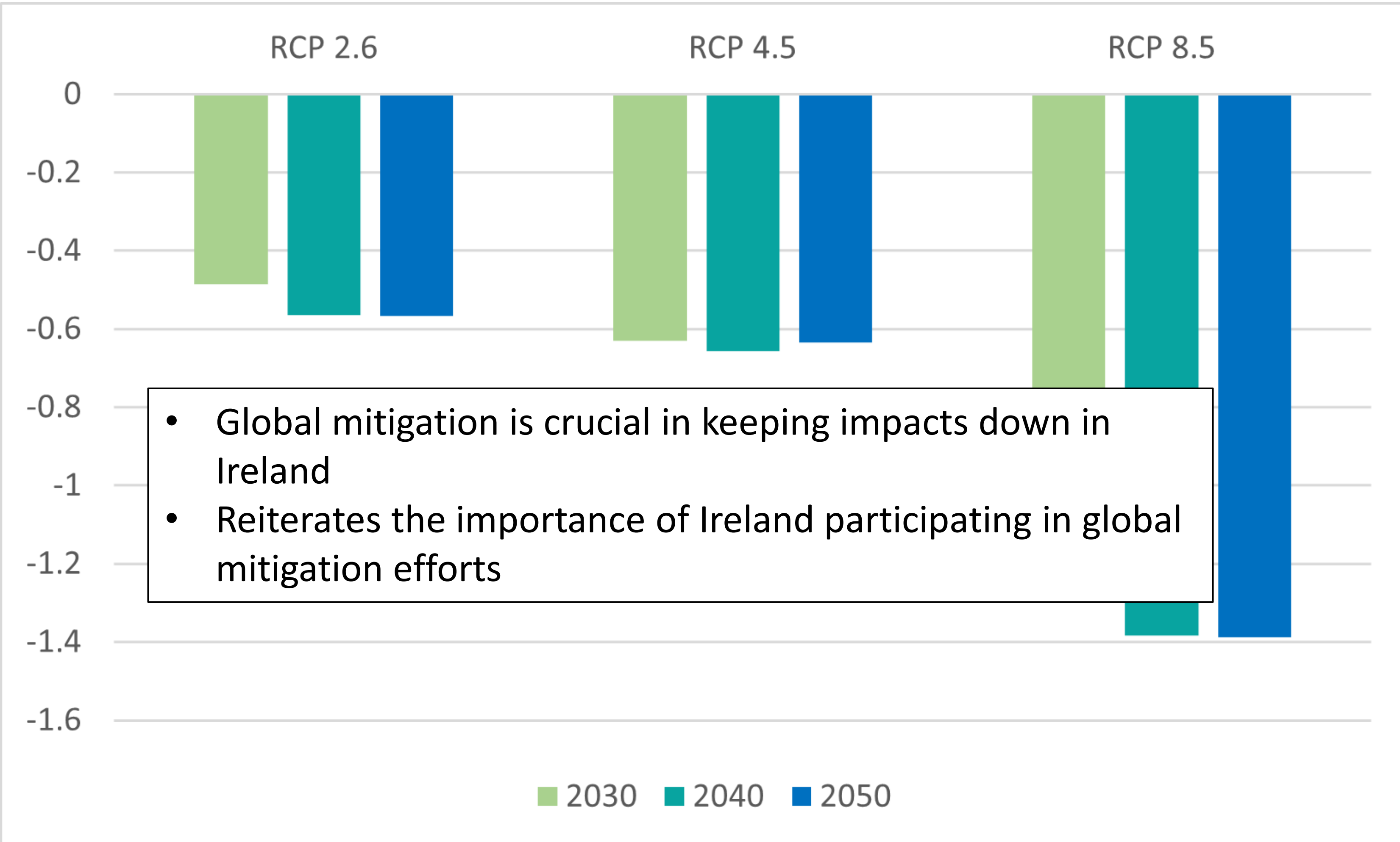
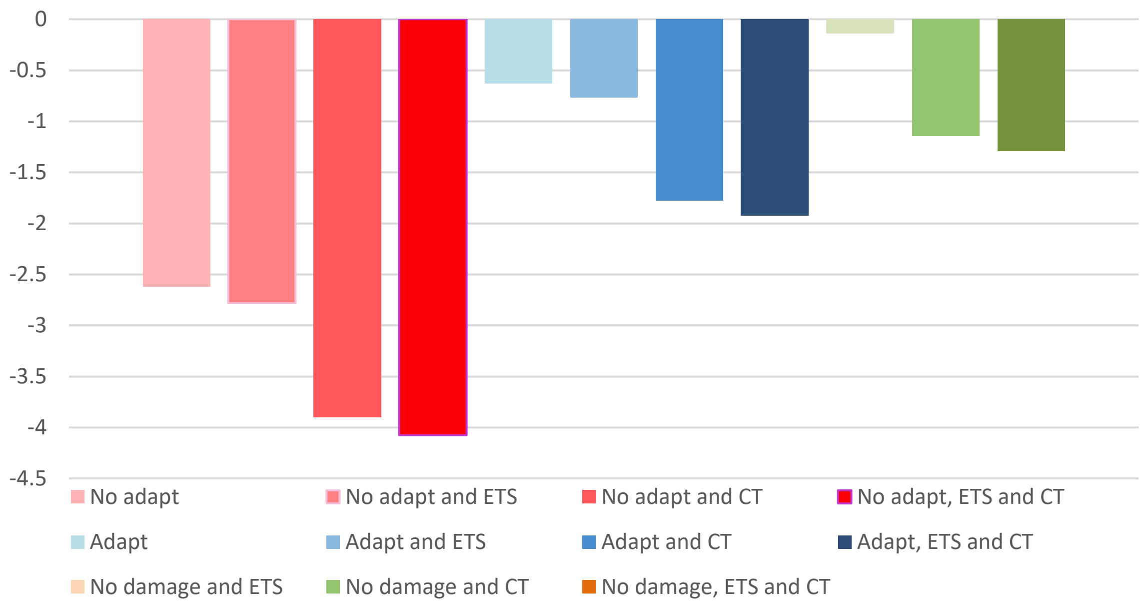
Across RCPs



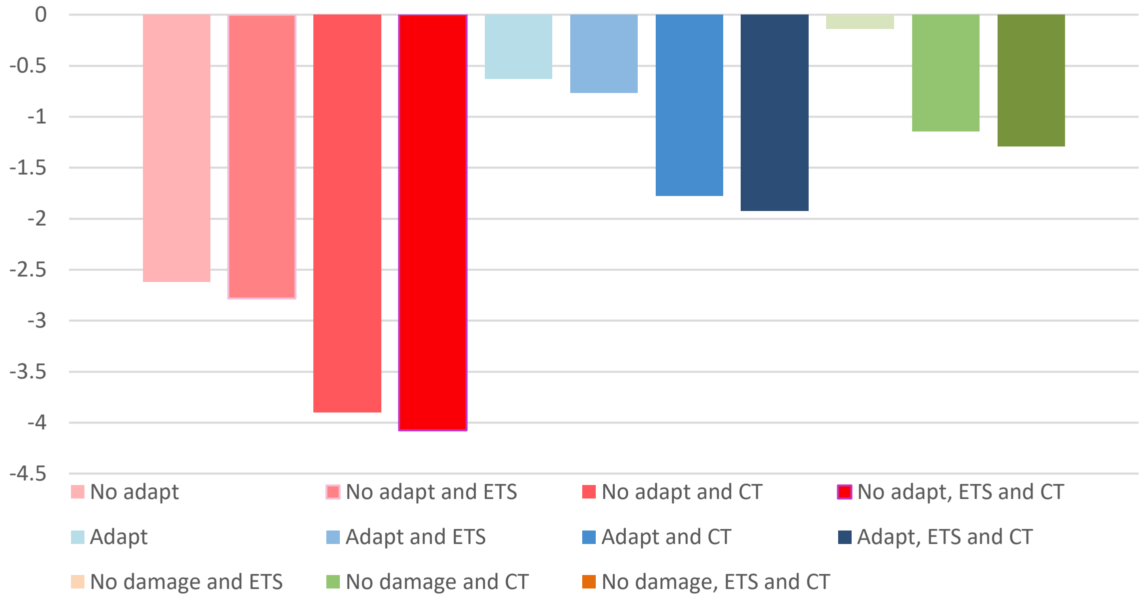
- Global mitigation is crucial in keeping impacts down in Ireland
- Reiterates the importance of Ireland participating in global mitigation efforts

Mitigation and Adaptation



Mitigation and Adaptation

- Highest impacts are without adaptation
- Mitigation costs
- Impacts with adaptation



Conclusions

- **Understanding** the impacts climate change is of paramount importance
- This project has focused on **five climate change impacts**: coastal flooding, heat effects on labour productivity, human health, agricultural productivity and river flooding.
- Climate change will result in **significant impacts** for Ireland
- Adaptation can significantly reduce the real **GDP losses** associated with a given level of climate change
- **Mitigation costs** outweigh climate change impacts costs when adaptation is applied but not when no adaptation is applied.
- Our results confirm the importance of Ireland's continued **commitment** to emission reduction helping to ensure a global effort to reduce emissions and hence climate change impacts
- We recommend that policymakers consider the **secondary impacts** when designing and implementing climate change policies.
- Stakeholders identified **education and planning** as barriers preventing industries from responding to climate change impacts.

Macroeconomic implications of implementing carbon budgets

CCAC committee, September 18, 2024

John FitzGerald

Introduction

- Outline here a simplified approach to quantifying the macroeconomic implications of the carbon budgets
  - Concentrating on economic costs and benefits – what the state must pay
- A full cost-benefit study would take account of all benefits:
  - Such as halting global warming, health benefits, increased comfort etc.
  - However, as the benefits of stopping global warming are so massive it is not very useful to do such an exercise
  - Having looked at the costs and benefits for the state / government sector, a future study could look at the health benefits, increased comfort etc.

Background

- Ireland is one of best-off economies in world
- There is currently full employment of people and other resources
- That means that to invest in decarbonising the economy either:
  - Resources have to be diverted from satisfying other needs or
  - Resources have to be acquired elsewhere (imported) to do the job
- Ireland has the resources to “buy” help from elsewhere but:
  - Much of what is needed has to be “constructed” in Ireland
  - Thus, imports of goods, equipment and people cannot solve all problems
- Making space in the economy to do the job means foregoing some other goods and services until decarbonisation is achieved
- Note: Dept. Public Expenditure cost of carbon 2024 €322, 2050 €890

Different components of the task

- Decarbonising the energy system
  - Requires investment to provide alternatives to fossil fuel energy
  - The costs will involve investment offset by savings in fossil fuel use
- Making agricultural & land-use sector consistent with net zero
  - Involves changes in agriculture
  - Involves using some land for forestry rather than traditional agriculture
  - Involves rewetting boggy land
  - Will affect agricultural output and income, require resources to invest in carbon sinks, and future alternative income streams
- In all cases there is the challenge that much of the cost will mature before the eventual financial benefits

To estimate macroeconomic effects need:

- Which TIM scenario? 300 mt, 350 mt, 400 mt etc.?
- Which agriculture scenario?
- Consistency of Agriculture and Goblin scenarios?
- Combine each into a joint "scenario"
- Could look at 2 or 3 such joint scenarios – as happened last time
    - e.g. energy reduces by -50% and agriculture by -33%, or energy -60% and agriculture -25%

TIM Model output: fundamental building block

- Provides details of how Ireland's energy needs will be met, while implementing the agreed carbon budgets, for five-year periods
  - Estimate of the investment in new capacity needed
  - Estimate of carbon-based energy used under different scenarios
  - Some things are missing:
    - e.g. investment in electricity grid, interconnection, and in alternatives to balance the system when renewables unavailable
  - Need to estimate the costs and savings by time period
  - Where costs – investment expenditure – is spent abroad, different from where construction happens in Ireland. Less problems with capacity

TIM Sectoral output

- Energy sector – investment and fossil fuel energy used
- Residential – investment and fossil fuel energy used
  - Some of cost will be normal renewal. Some of cost will be paid by savings for households. District heating may avoid household costs
- Industry – investment and fossil fuel energy used (CCS in cement)
  - If rest of EU has lower carbon price than Ireland, only way to implement CCS in cement is if state pays full cost. (Issue of the UK, including Northern Ireland.)
- Transport – investment and fossil fuel energy used
  - When EVs become the cheap option then no cost to society (or the state)
- Services – investment and fossil fuel energy used
- Illustrative example below:
  - Carbon-budget-400mt-bau-new. Should be 350?

Average annual investment required, € million (400 Mt scenario, should be 350 Mt)

Annual	2021-25	2026-30	2031-35	2036-40	2041-45
PRC_SUP	150	163	26	54	108
PRC_AGR	0	0	0	0	0
PRC_PWR	1570	4070	3626	1264	1347
PRC_RSD	2564	2123	1527	1803	1941
PRC_SRV	1530	646	479	630	1129
PRC_TRA	3409	5531	10066	6891	6221
PRC_IND	0	470	17	18	14
Total	9223	13003	15741	10659	10761

Investment as % of national income (GNI*)

	2021-25	2026-30	2031-35	2036-40	2041-45
GNI* Annual constant prices	275906	311412	344082	379894	419434
Annual Investment/GNI*%	3.3	4.2	4.6	2.8	2.6

How much of this is additional investment necessitated by decarbonisation?
A lot of it would happen anyway – and is not a cost of decarbonisation.
Pisani-Ferry et al. suggest 2% to 3% of GDP elsewhere. Possibly also for Ireland

Power Sector – an example

Necessary Investment, € million

	2021-25	2026-30	2031-35	2036-40	2041-45
Climate action	1570	4070	3626	1264	1347
Existing	1460	1460	1460	1460	1460
Increase	110	2610	2166	-196	-113
Increase % of GNI*	0.0	0.8	0.6	-0.1	0.0

Cost of continuing to use gas to generate electricity at the current rate would be around €2 billion a year.
In the TIM scenario gas usage for electricity is assumed to fall by 45% in the period 2026-30 compared to 2021-5 and fall to zero thereafter – extreme.
That would mean that the cost of fuel for electricity generation would fall to roughly €1.1 billion a year between 2026 and 2030 and fall to zero thereafter.
The discounted cost of the additional capital would be less than the savings on gas – representing a net saving to society after 2030.
Need to modify to take account of costs balancing system after 2030, costs of investment in grid etc.

Agriculture and land use

- In agriculture:
  - there are additional costs for farmers - e.g. switching type of fertiliser, investing in multi-species swards etc.
  - There will be loss of output from using less fertiliser.
  - There will be loss of output from reducing stocking levels.
  - There could be income from alternative crops
- Reduced cattle numbers / milk affects value added in food processing.
  - That will affect incomes in sector and profits (i.e. value added)
- Alternative land use in forestry
  - Investment to be followed, with a long delay, by a future income stream as wood is harvested
  - The use to which the wood is put matters. If used in building, locks in carbon for much longer. If burned, that releases the carbon immediately
- Alternative land use – rewetting. Only costs, including opportunity cost, with no significant future commercial income stream

Some initial questions

1. What is the counterfactual for this exercise? What are these investment requirements to be compared to?
2. What price of carbon should be used in valuing the savings on fossil fuel use avoided? This should probably be zero.

Conclusions

- How much of the costs paid by households and companies?
  - Households will pay when the benefits to them exceed the costs. They will not pay for the wider environmental benefits – a charge on the taxpayer
  - Companies will pay for necessary measures if it saves them money. The state will have to take up the rest of the costs – through subsidies or changing the cost through taxation
  - Without state intervention private sector will balance direct costs and benefits
- What will be the cost to the state?
  - Will have to be paid by higher taxation or reduced expenditure
  - This is the longer-term financial “cost” of tackling global warming

Carbon Budgets Modelling Third Iteration NEMF Additional Testing

Carbon Budgets Working Group 18

Emma Lynch - SEAI Energy Modelling – September 2024

NEMF Additional Testing – Approach for Third Iteration

- Reviewed outputs from TIM scenarios on web portal – data by scenario, sector, fuel and compared to NEMF assumptions and outputs

- Confirmed updates between iterations 2 and 3 and impact on outputs
  - Primary changes in industry, updates to starting point with latest data (2023 Energy Balance)
  - Addition of WEM/WAM scenarios
  - Many of critical considerations from iteration 2 still stand

- Reviewed combined risk scenario from SEAI energy projections for position to 2030 relative to WEM/WAM
  - assessed projected annual and cumulative emissions out to 2040 against potential reduction trajectory from TIM scenarios
  - reviewed impact of risk scenarios for potential delays from WAM achievement

- Summary of considerations for carbon budget scenarios relating to energy
  - to be provided in report for CCAC

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NEMF Additional Testing – Notes on Limiting Factors

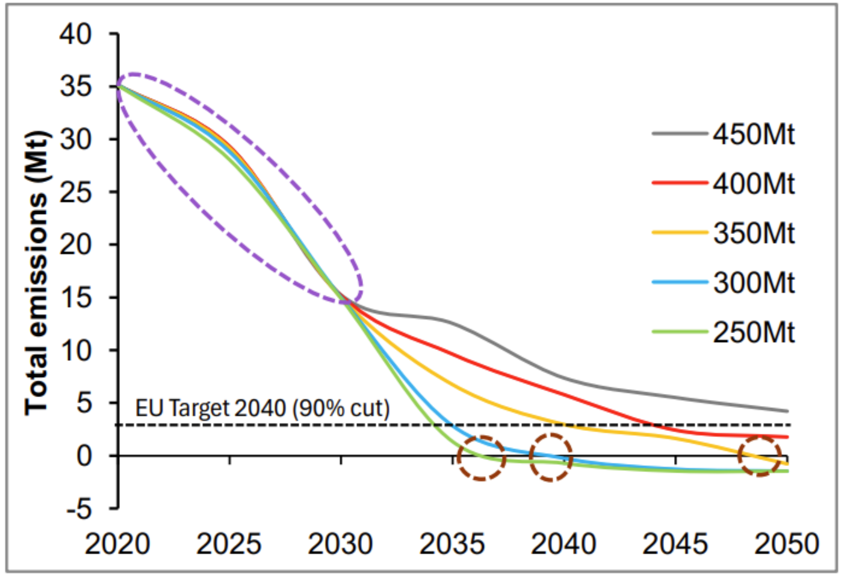
- The National Energy Modelling Framework has a policy focus and scenarios are primarily defined to reflect policies that are being implemented or discussed and their impact is assessed against targets
  - NEMF not typically used to solve for a carbon budget
  - Can be used to test outputs of optimisation approach as input assumptions to sense-check outcomes

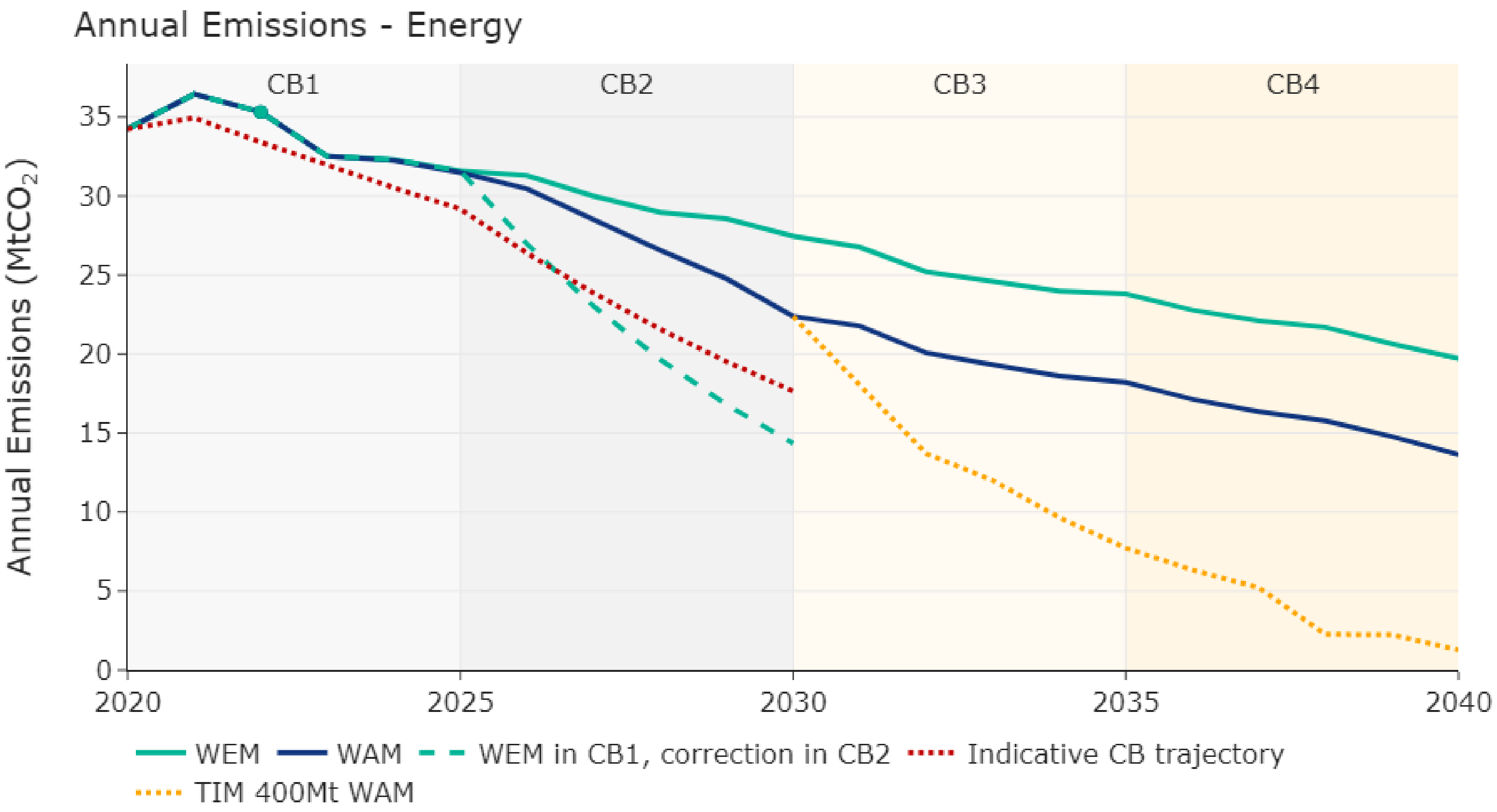
- Power module is at hourly granularity but is a day-ahead market model using unit commitment and economic dispatch
  - Does not account for some of the complexities of managing or expanding the grid etc.

- Hydrogen and CCS not currently included in the current projections modelled scenarios due to uncertainty over implementation pathway in policy

- Vaguer or limited policy assumptions especially post-2030 limit the robust representation of potential acceleration in policy later in time horizon

Implications of WAM trajectory to 2030





Rapid drop post-2030 if WAM trajectory followed to 2030 (this trajectory at risk under current planned policy) and 400Mt TIM scenario followed post-2030. Very accelerated in early 2030s testing limits of feasibility without tripling pace of measure implementation

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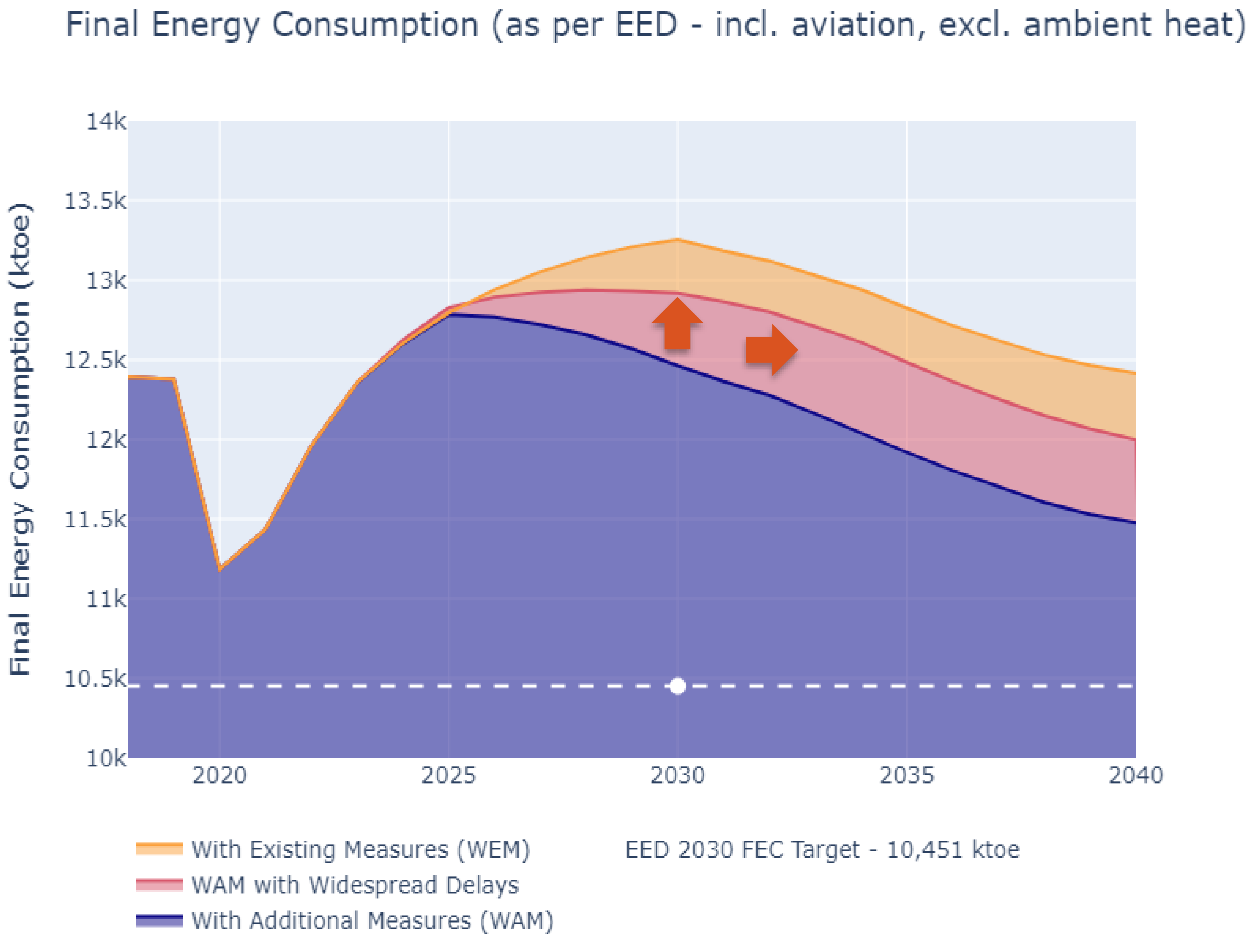
Risk Scenario Assumptions – Delayed Achievement

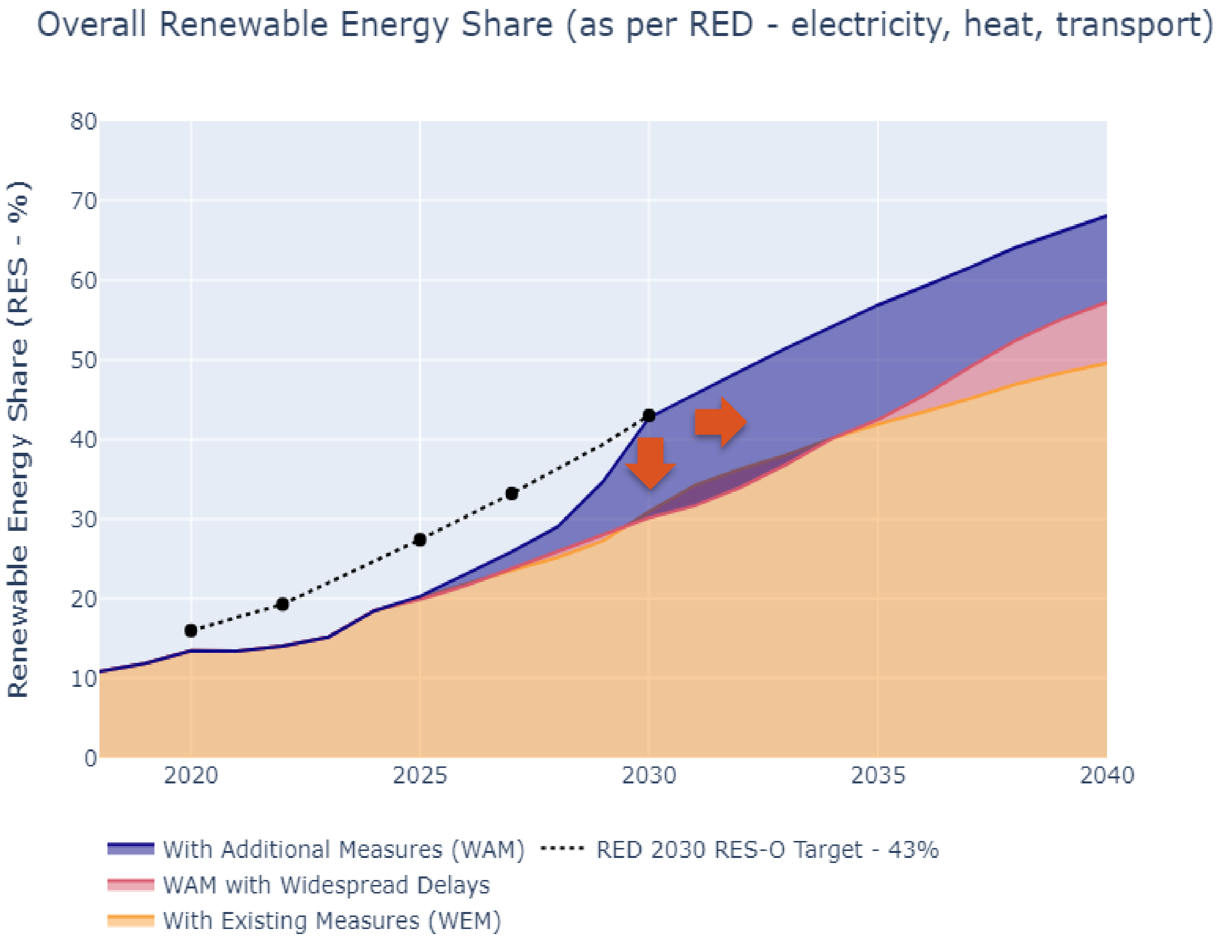
- Risk scenarios were evaluated both individually relative to WAM and combined to show potential trajectory with delays across multiple areas relative to WEM and WAM

- Select key assumptions with high ambition assumed in WAM and credible risk to implementation pathway for 2030 target achievement:
    - Biomethane: 1.9TWh by 2030 (vs 5.7 in WAM/CAP - assumed by 2040)
    - District Heating: 360 GWh by 2030 (vs 2.7 in WAM/CAP - assumed by 2040)
    - Transport Demand Reduction: CAP21 levels of activity reduction (-10% private car vkm vs 2019)
    - EVs: ~743k EVs by 2030 vs 944k
    - Offshore Wind: 0 GW new installed capacity by 2030
    - Onshore Wind: 6.2 GW by 2030 (vs 7.2 GW in WAM)
    - Solar PV: 5 GW by 2030 (vs 6.5 GW WAM)
    - Retrofits and Heat Pumps: uptake modelled under current grants/supports and budget allocation (vs assuming raised levels to meet 500k B2s and 400k heat pumps)

    - Note: risk scenarios for variable generation capacity developed using forecasts from surveys of expert stakeholders. The scenario represents a plausible worst case deployment scenario for each variable renewable technology, as judged by a pool of expert stakeholders in Q1 2024. A report documenting the methodology and results of the surveys will be published by SEAI in late 2024.

Risk Scenario Assumptions – Implication of Delayed Achievement





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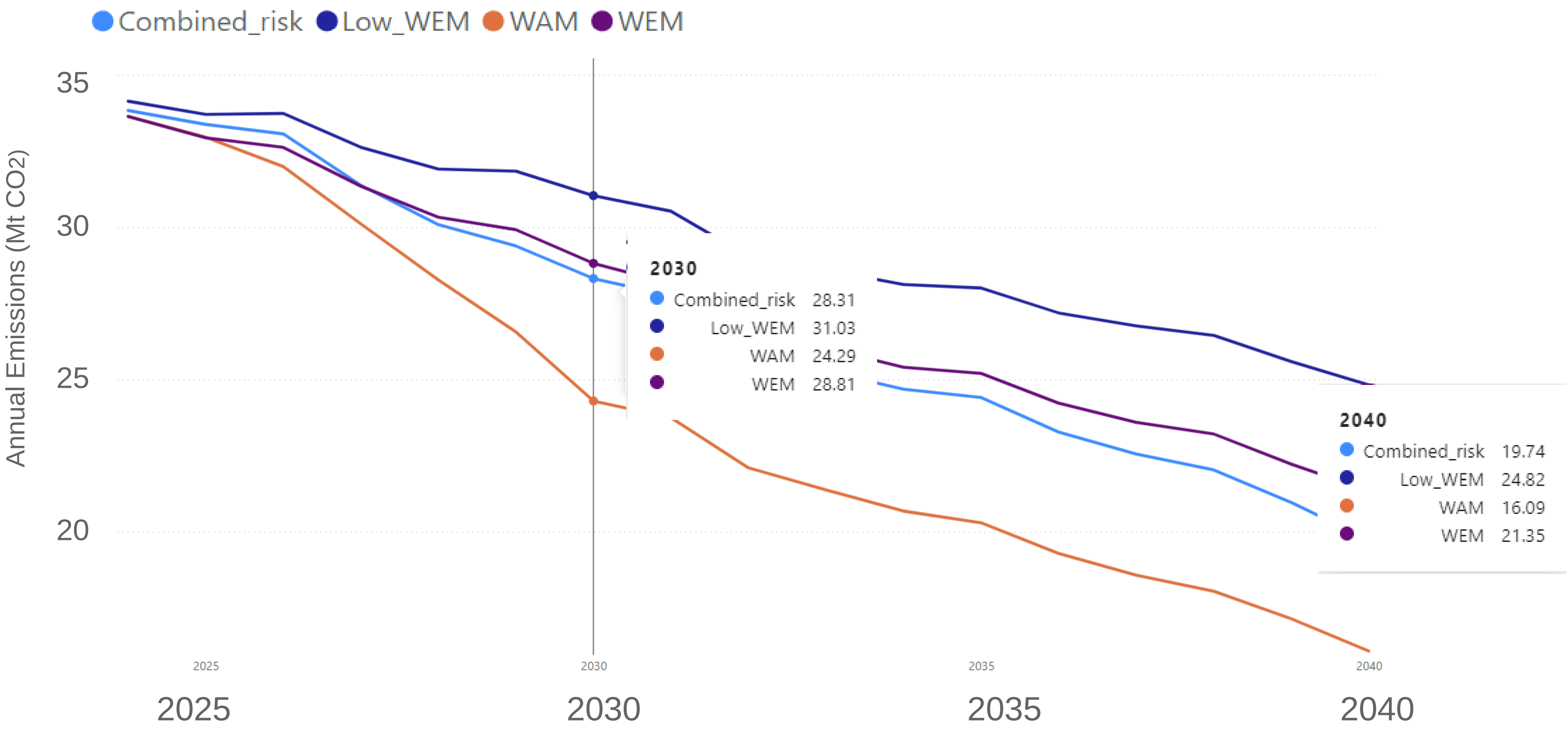
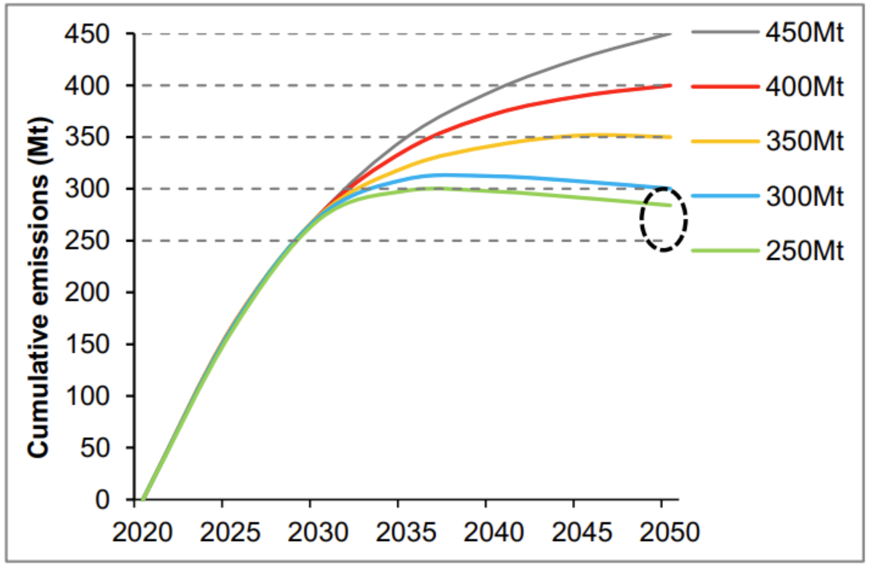
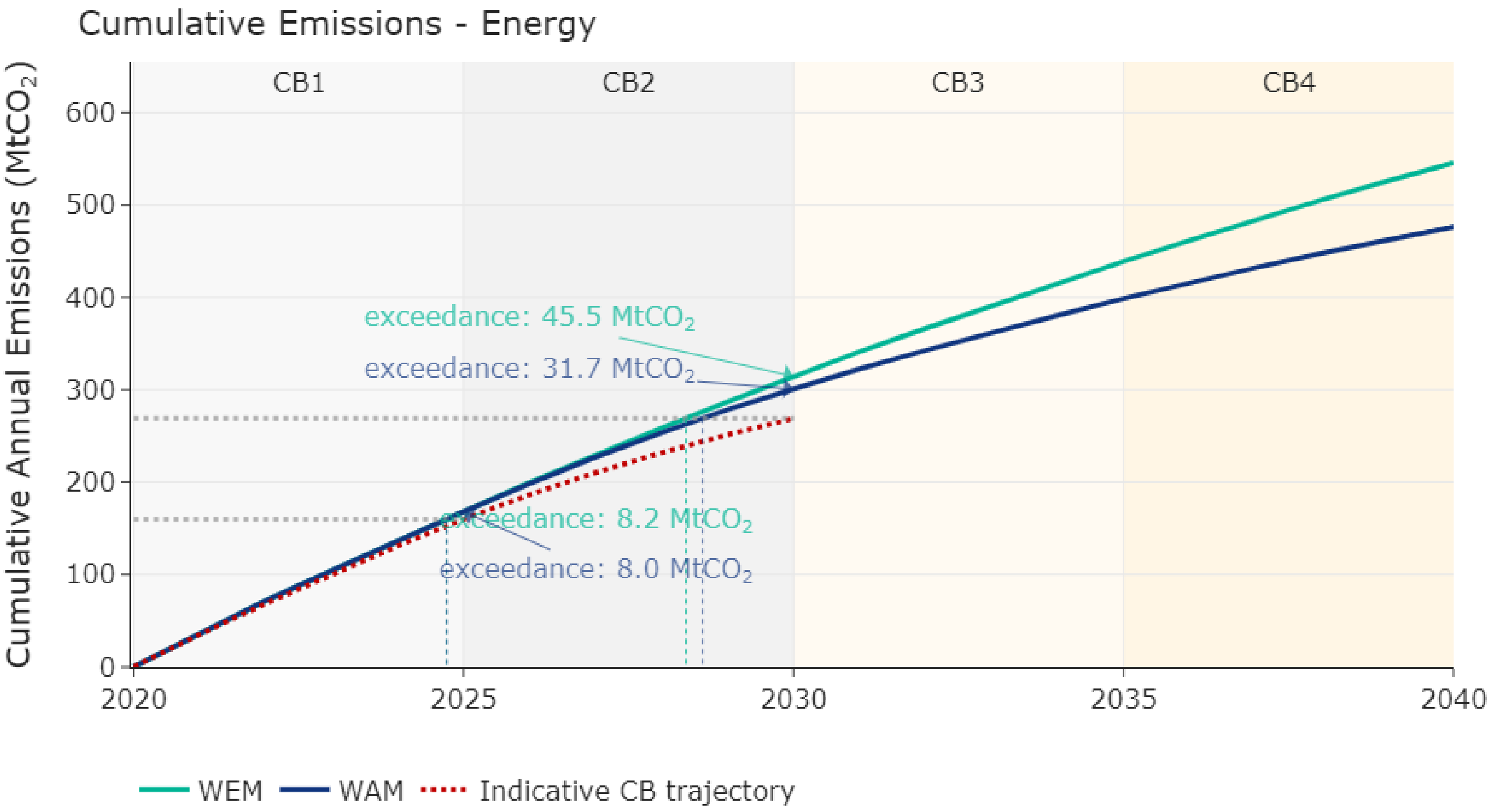
Energy-related emissions projections including risk scenarios



Implications of WAM trajectory to 2030





Accumulated impact of delay makes it increasingly difficult to get back on track, possibly necessitating negative emissions by 2040s

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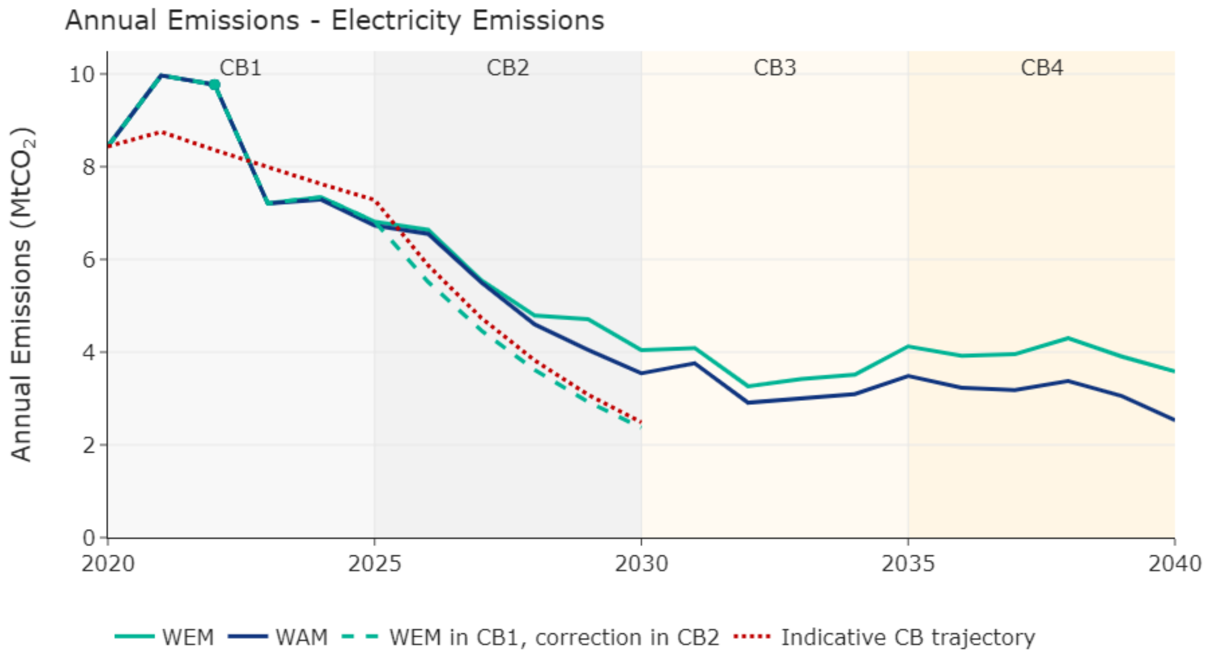
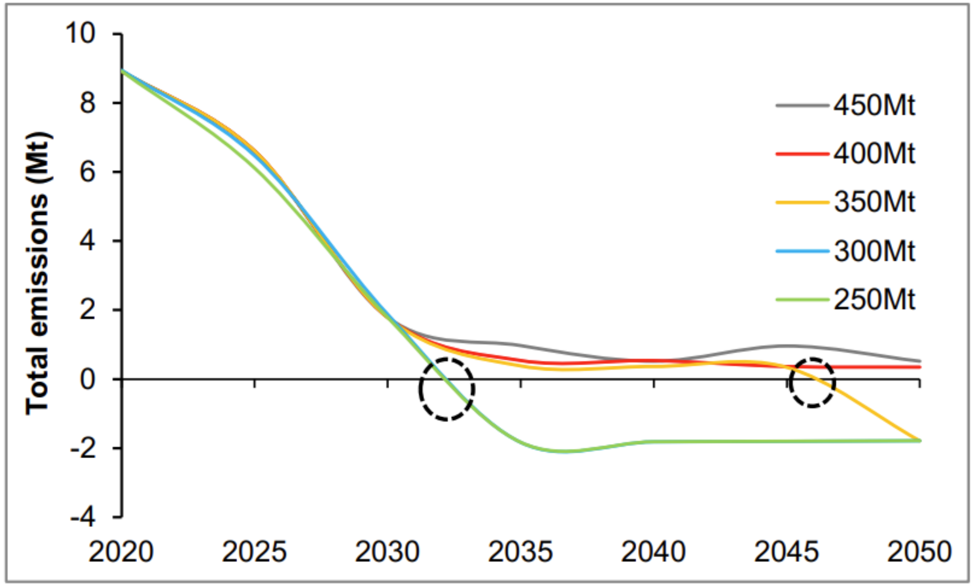
Power Sector



NEMF:
In most ambitious scenario with current planned policy – still 3Mt electricity generation emissions 2040

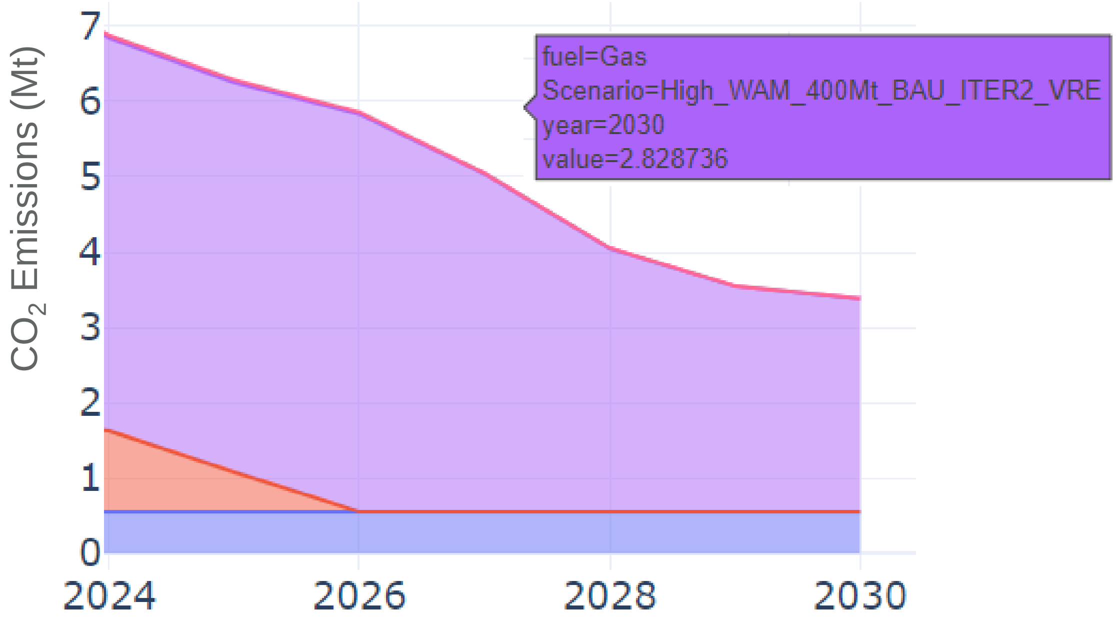
In TIM:
Near-zero generation in 2030s

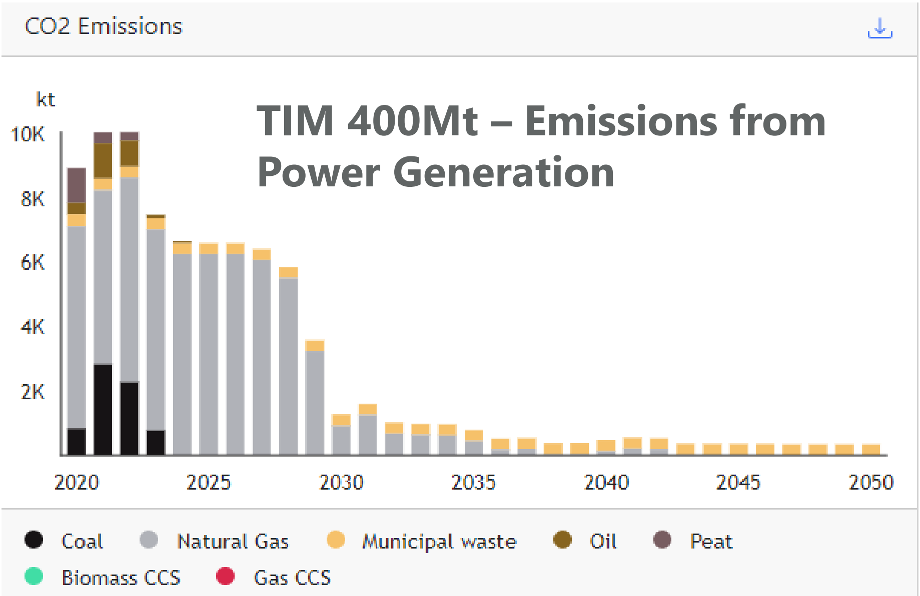


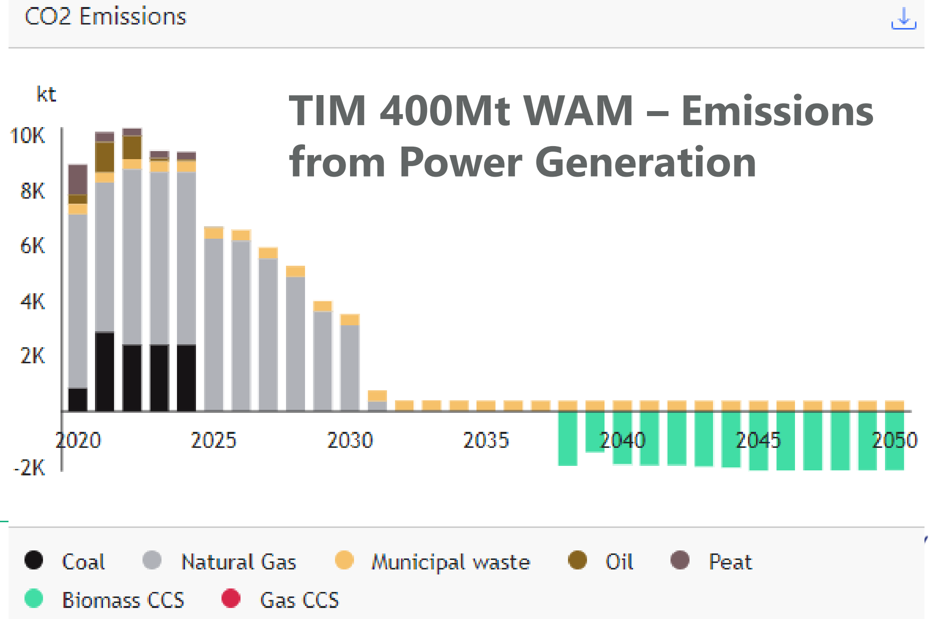
Power sector and Gas use in 2030

Remaining power sector emissions in 2030s

- Even if energy (MWh) could be covered by imports, rating of interconnectors not high enough to meet highest net load periods (MW).
- SEAI modelling shows ~3 Mt of emissions from gas-fired generation in 2030. This would be reduced if outturn net load peaks were lower and/or interconnector imports higher, though unlikely to be zero.

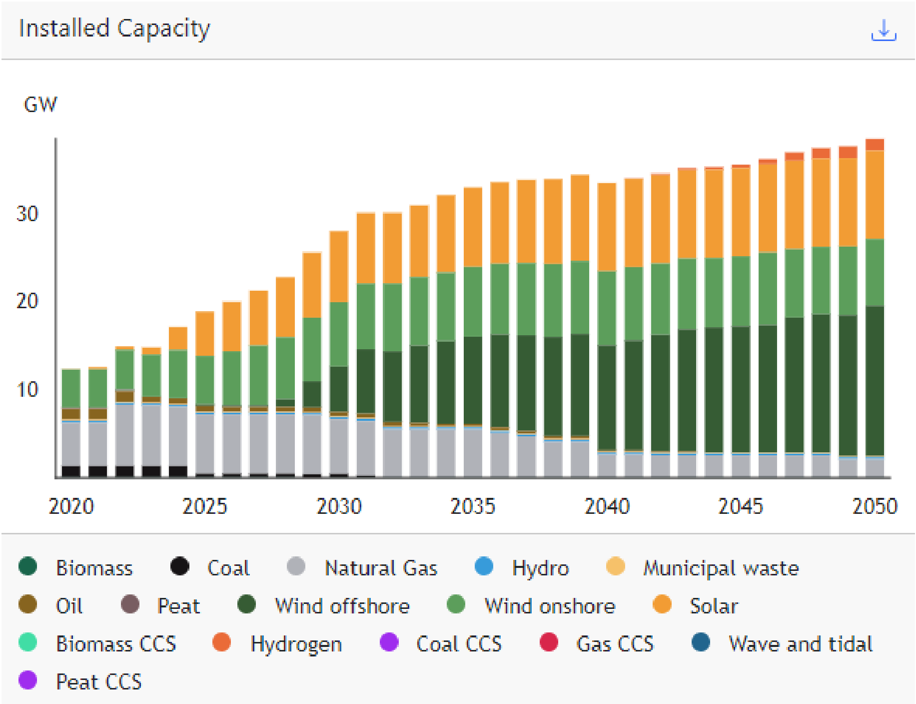






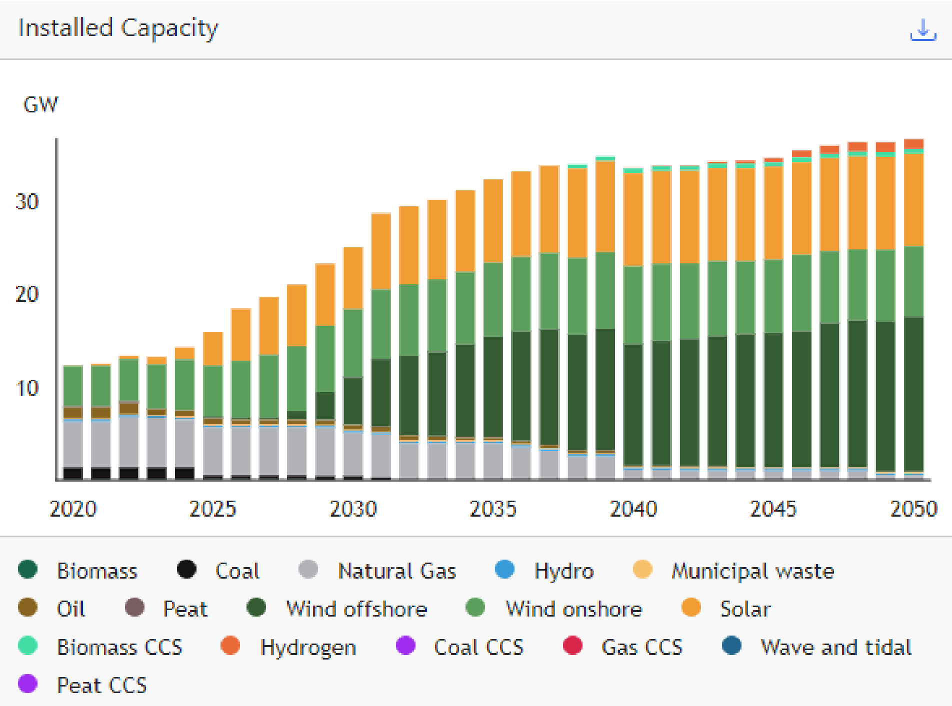
Variable renewable generation capacity deployment

TIM 400Mt - Variable renewable generation capacity deployment



400Mt Installed Capacity (GW)	2030	2040
Offshore wind	5.13	11.9
Onshore wind	7.32	8.36
Solar PV	8	10

TIM 400Mt WAM - Variable renewable generation capacity deployment

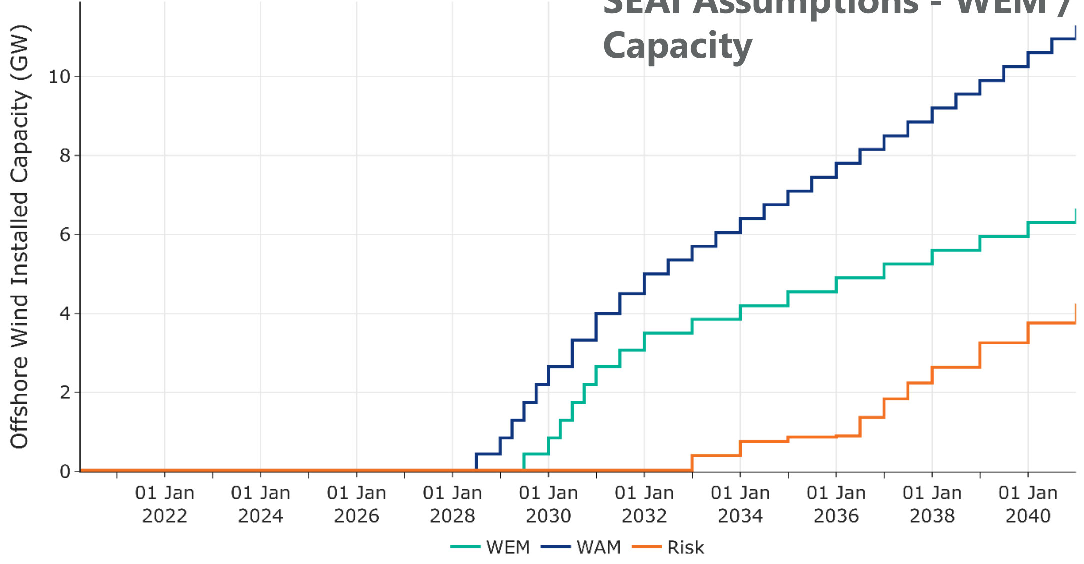


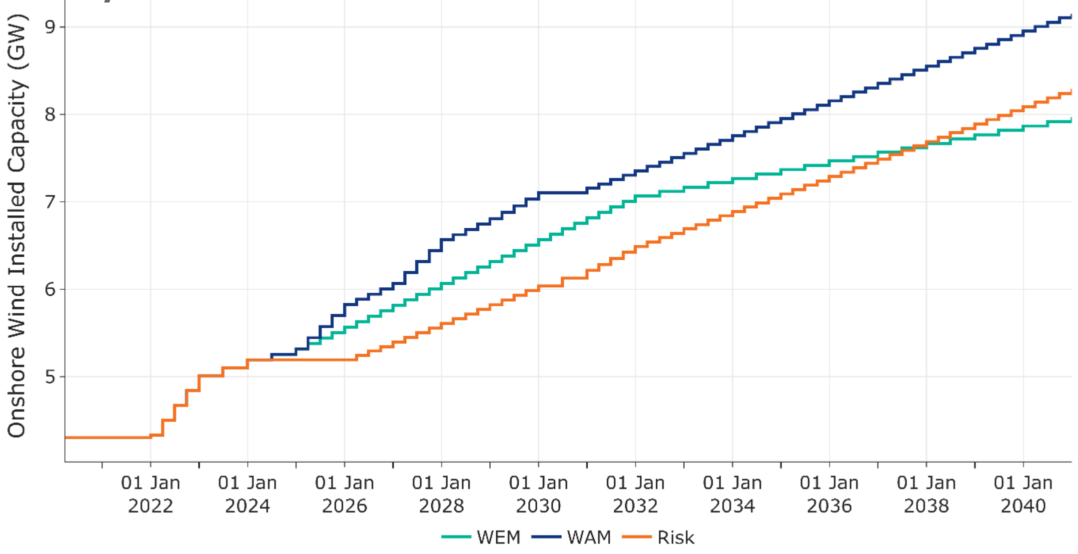
400Mt WAM Installed Capacity (GW)	2030	2040
Offshore wind	5.13	13.1
Onshore wind	7.32	8.36
Solar PV	6.63	10

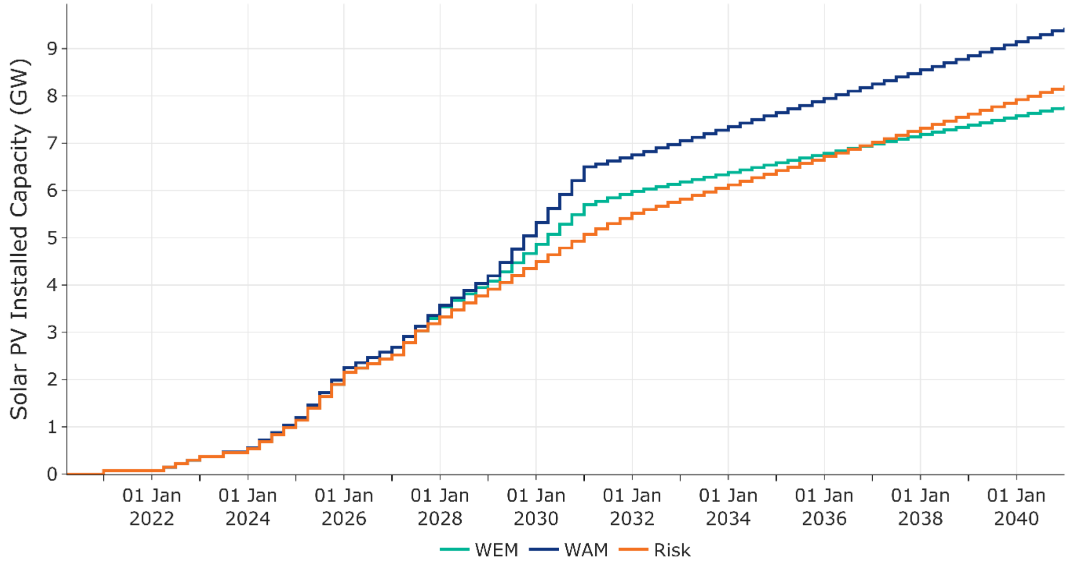
ITY

Variable renewable generation capacity deployment

SEAI Assumptions - WEM / WAM / Risk Cumulative Installed Capacity







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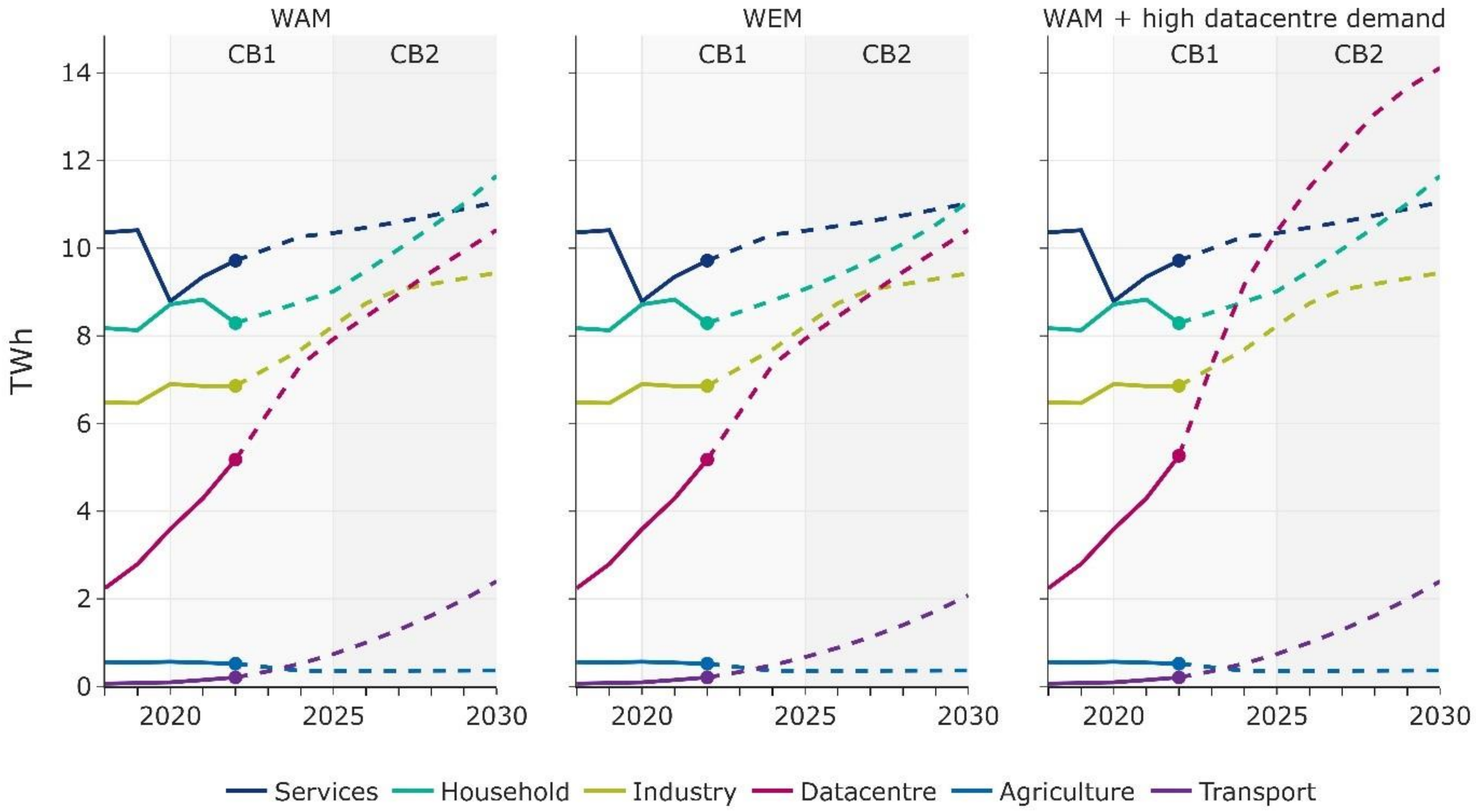
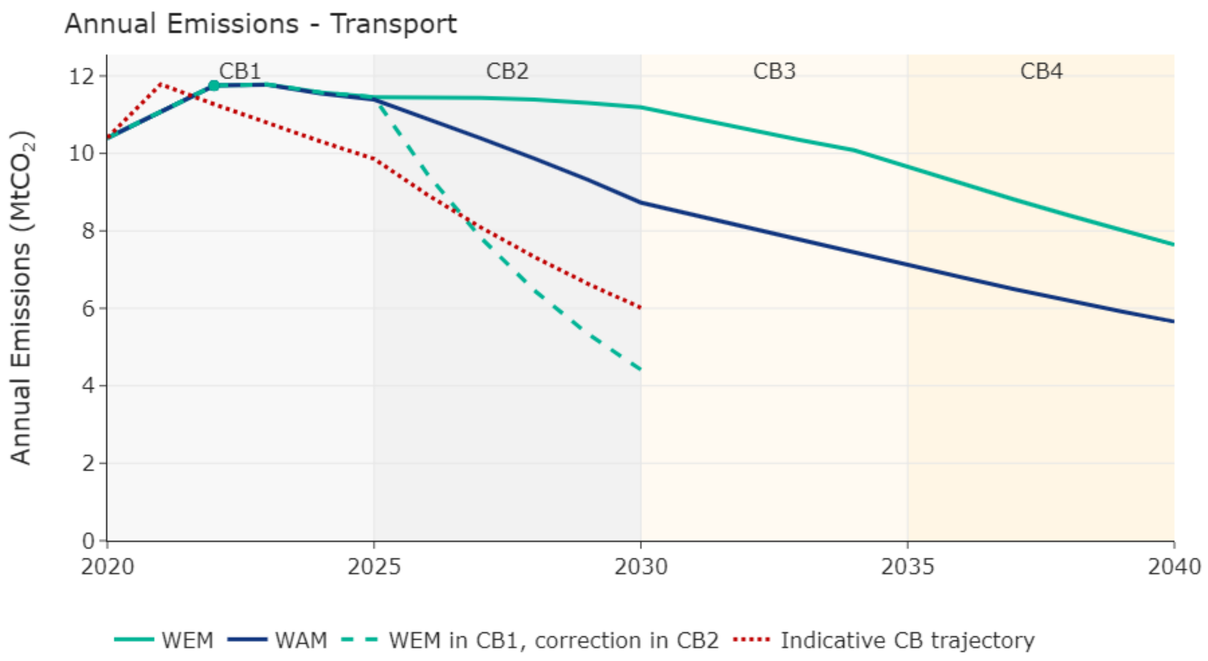
Demand Risk – Power Sector

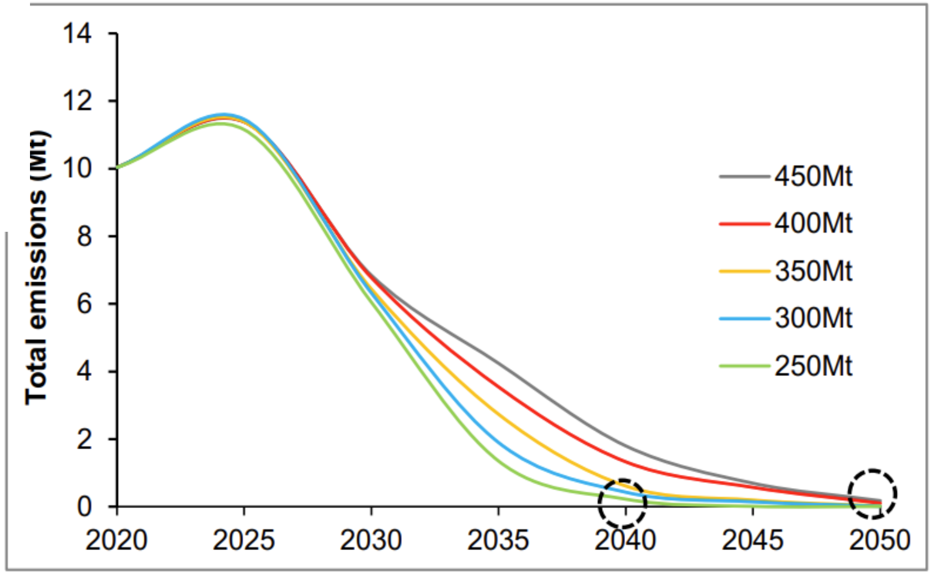


Transport



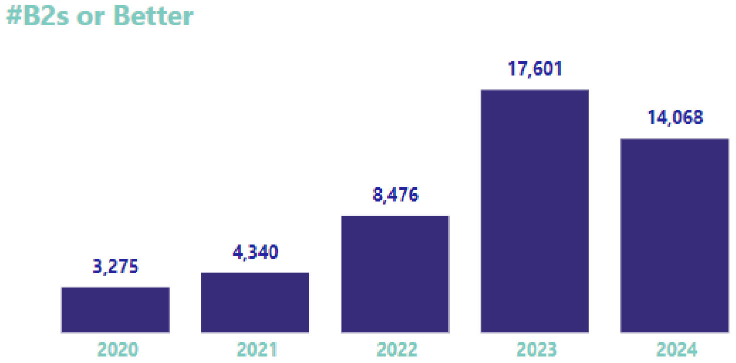
NEMF:
In most ambitious scenario with current planned policy – still 6Mt transport emissions 2040

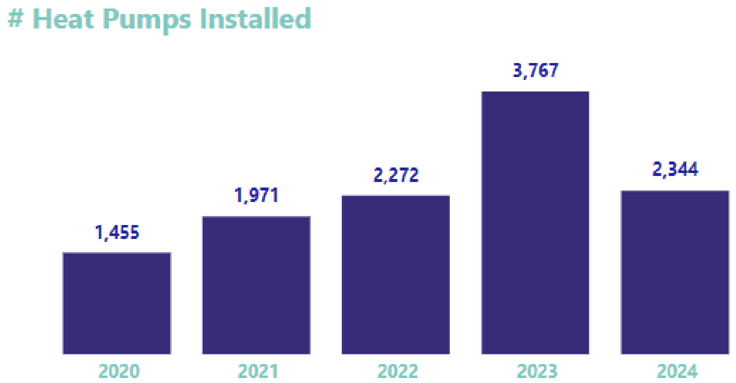
In TIM:
Stringent CB Nearly zero by 2040
Generous CB: Nearly zero by 2050



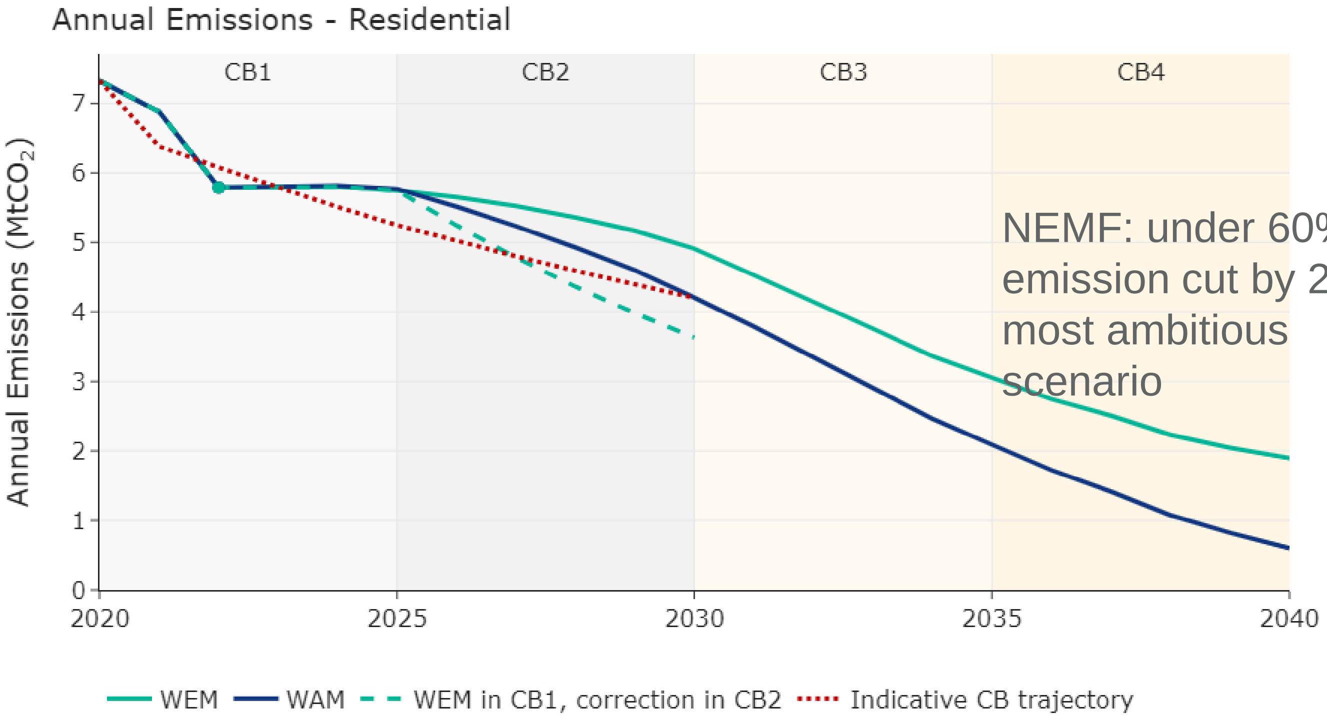
SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Residential

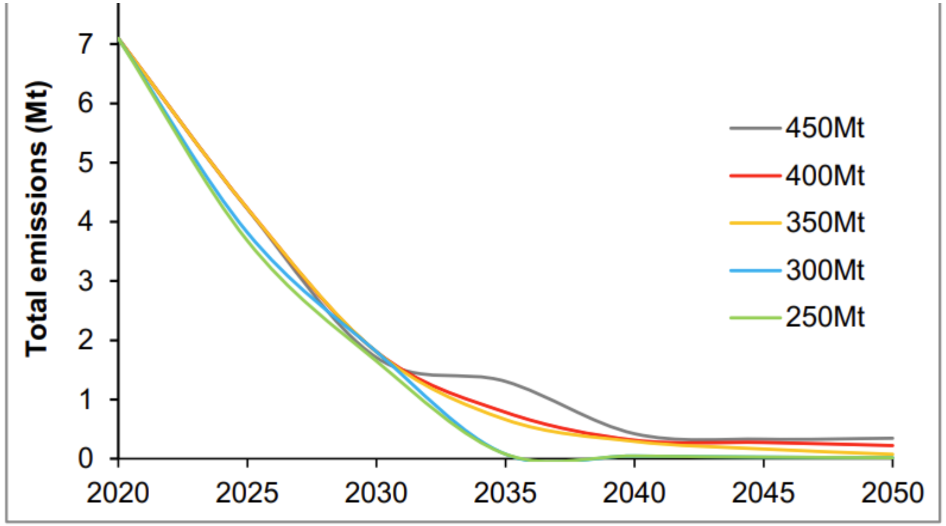




[Statistics for National Home Retrofit Programmes | SEAI]



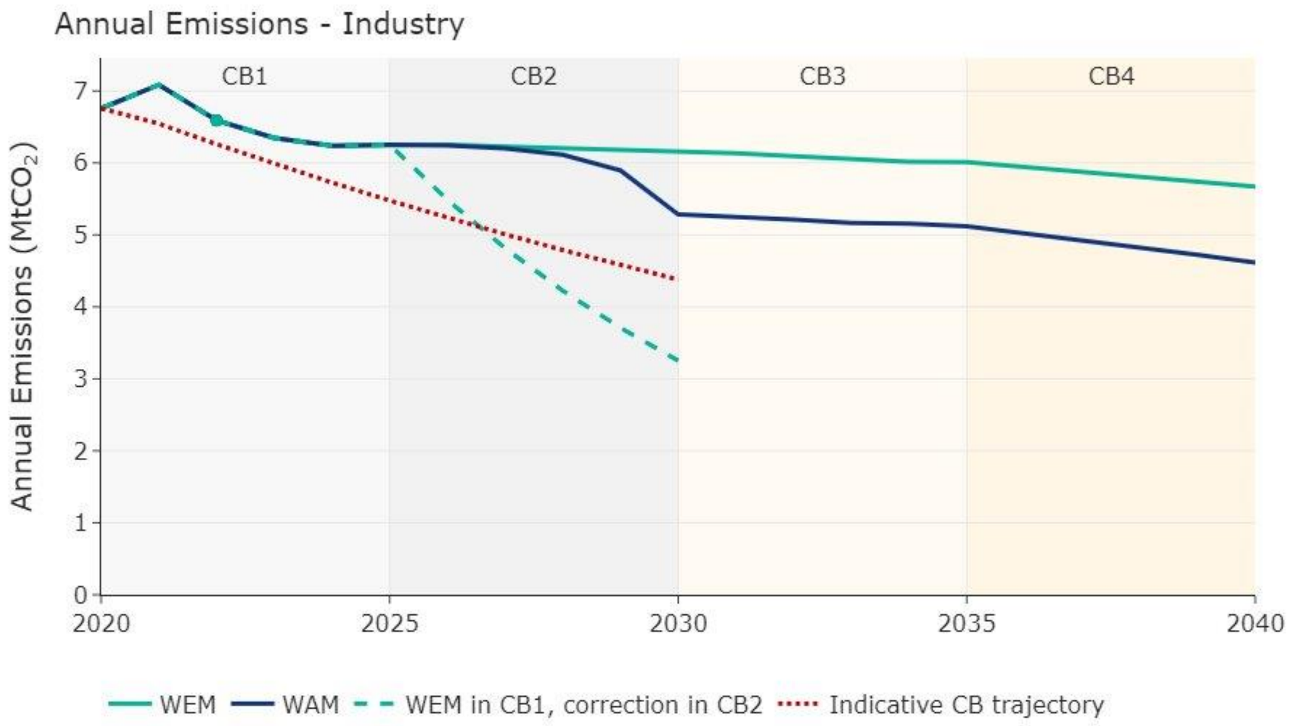
NEMF: under 60% emission cut by 2030 in most ambitious scenario



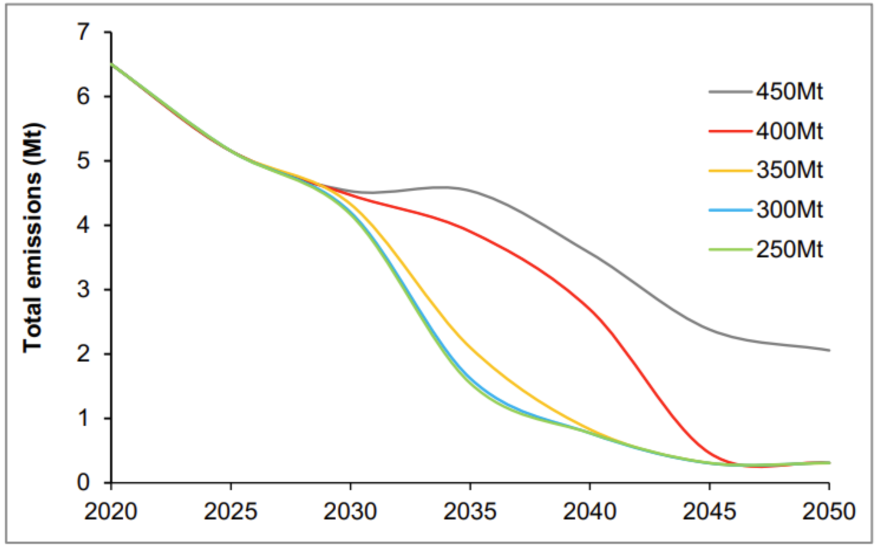
In TIM: 75% emission cut by 2030

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

Industry



NEMF: most ambitious scenario with current planned policy leaves 4Mt emissions by 2040 (75% reduction not assumed yet due to clarity)
CCS not assumed to be adopted based on current planned policy



In TIM:
Accelerated adoption of CCS and a doubling of electricity consumption by 2040

SUSTAINABLE ENERGY AUTHORITY OF IRELAND

NEMF Additional Testing – Summary of Key Challenges

- Near-zero power generation in early 2030s
  - SEAI hourly modelling of power sector shows gas use persists out to 2040 to meet net load
  - Risk scenarios derived from expert surveys show high pace of installed capacity required is at risk
- Immediate ICE vehicle phaseout
  - Pace of phaseout needs immediate strong regulatory measures not yet in place
- Sharp acceleration in retrofits and residential energy savings
  - Some supply chain easing can be assumed, but needs to remain within likely delivery bounds
- Demand reduction beyond transport
  - Definitely necessary especially as delays in renewable capacity likely, though shown very early on in LED scenarios and across other sectors
  - Very little evidence in current planned policy of demand reduction measures outside transport
- Consideration should be made for feasibility in the decision on appropriate scenario to adopt

Follow on discussion on Carbon Dioxide Removal Considerations

Dr Oliver Geden

Head, SWP Research Cluster Climate Policy and Politics
Vice-Chair, IPCC AR7 Working Group III

CCAC CBWG Meeting 18 September 2024

Stiftung Wissenschaft und Politik
German Institute for International and Security Affairs

Carbon Dioxide Removal methods and their main characteristics

Method	Capture process	Carbon storage pool	Category	Readiness	Mitigation potential	Storage timescale
Afforestation, reforestation, agroforestry, forest management	B	VSS	Conventional	High	Large	Decades to centuries
Peatland & coastal wetland restoration	B	VSS	Conventional	High	Small	Decades to centuries
Soil carbon sequestration in croplands & grasslands	B	VSS	Conventional	High	Large	Decades to centuries
Durable wood products	B	BE	Conventional	High	Small	Decades to centuries
Biochar	B	VSS	Novel	Medium	Moderate	Centuries to millennia
Mineral products	G	BE	Novel	Medium	Small	> Ten millennia
Enhanced rock weathering	G	M	Novel	Low	Large	> Ten millennia
Biomass burial	B	VSS	Novel	Low	Large	Centuries to millennia
Bio-oil storage	B	GF	Novel	Medium	Moderate	> Ten millennia
Bioenergy with carbon capture & storage	B	GF	Novel	Medium	Large	> Ten millennia
Direct air carbon capture & storage	G	GF	Novel	Medium	Large	> Ten millennia
Ocean fertilisation	B	MS	Novel	Low	Moderate	Centuries to millennia
Ocean alkalinity enhancement	G	M	Novel	Low	Large	> Ten millennia
Biomass sinking	B	MS	Novel	Low	Large	Centuries to millennia
Direct ocean carbon capture & storage	G	GF	Novel	Low	Large	> Ten millennia

Legend:

B Biological
G Geochemical

VSS Vegetation, soils and sediments
BE Built environment
GF Geological formations
MS Marine sediments
M Minerals

Conventional
Novel

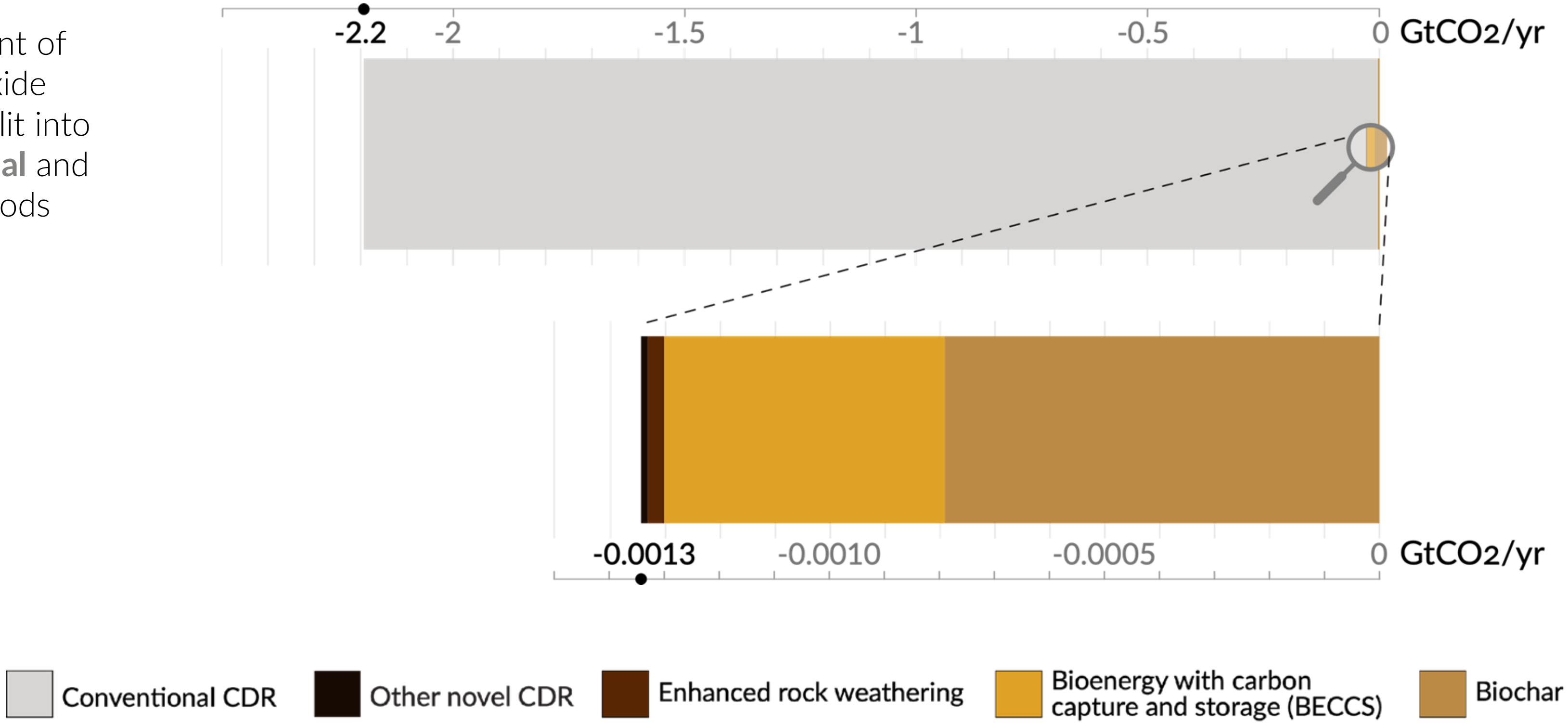
High
Medium
Low

Large
Moderate
Small

> Ten millennia
Centuries to millennia
Decades to centuries

Currently, only a tiny fraction of CDR results from novel methods

Total amount of carbon dioxide removal, split into **conventional** and **novel** methods ($GtCO_2$/yr)



Emerging diversity in indicators of CDR development, but not yet seen in current deployment or national proposals (UNFCCC NDCs)

Conventional CDR methods

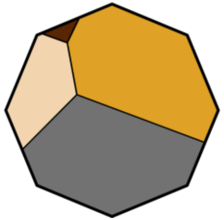
- Afforestation/reforestation & forest management
- Peatland and coastal wetland restoration
- Soil carbon sequestration

Novel CDR methods

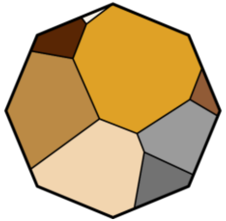
- Ocean fertilisation
- Direct air carbon capture and storage (DACCS)
- Bioenergy with carbon capture and storage (BECCS)
- Biochar
- Ocean alkalinity enhancement
- Enhanced rock weathering

Research & innovation

Scenarios
% scenarios with CDR method (2023)
total: 630 scenarios

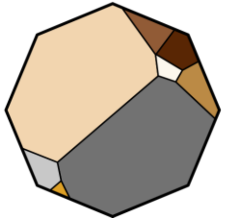


Grant funding
$ million per year (2018-2022)
total: $685 million

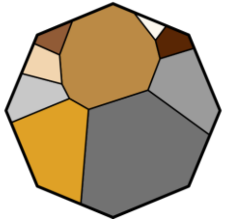


Demonstration & upscaling

Investments
$ billion per year (2018-2022)
total: $2.8 billion

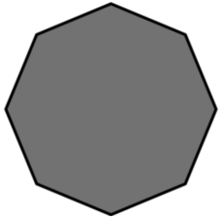


High value patents
№ patents per year (2018-2021)
total: 201 patents

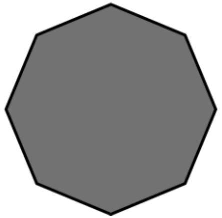


Deployment & proposals

Deployment of CDR
$GtCO_2$ (2023)
total: -2.2 $GtCO_2$



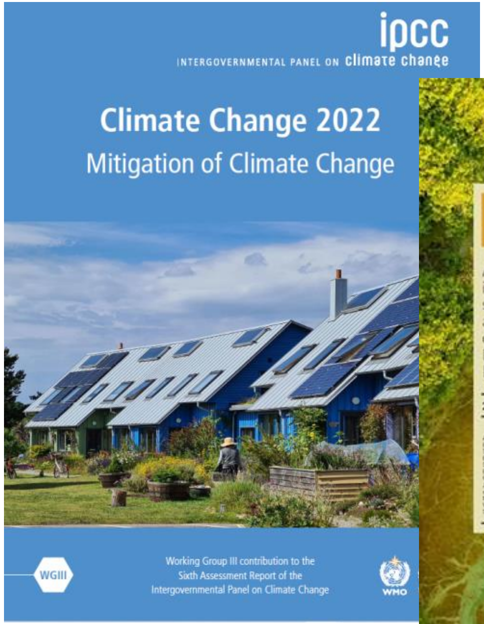
National proposals of CDR
$GtCO_2$ (2030)
total: -2.6 $GtCO_2$



CDR (modelling & policy) issues related to GOBLIN and TIM scenarios

- Sectoral allocation & representation of BECCS
  - Should be reported in sectors using BECCS installations, not AFOLU (= LULUCF burden)
  - Only represented in Energy sector (incl Waste-to-Energy?) so far, but what about Industry (e.g. bioenergy in Cement production with CCS, or pulp and paper mills with CCS)?
- Sustainability and availability of biomass feedstocks (domestic & international)
- Future representation of novel CDR methods beyond BECCS (& DACCS) in TIM?
- Cross-sectoral flexibilities vs. sectoral responsibility for CDR
  - Does Energy sector have to go net-negative for others (incl. AFOLU)?
  - Should AFOLU sector come up with own removals to reach net-zero (e.g. biochar or enhanced rock weathering)?
- Returning from overshooting/exceeding national carbon budgets (1&2, and beyond?) vs. EU net-negative GHG trajectory post-2050
- Bonus non-CDR feature: future NIR inclusion of cement carbonation

Thank you!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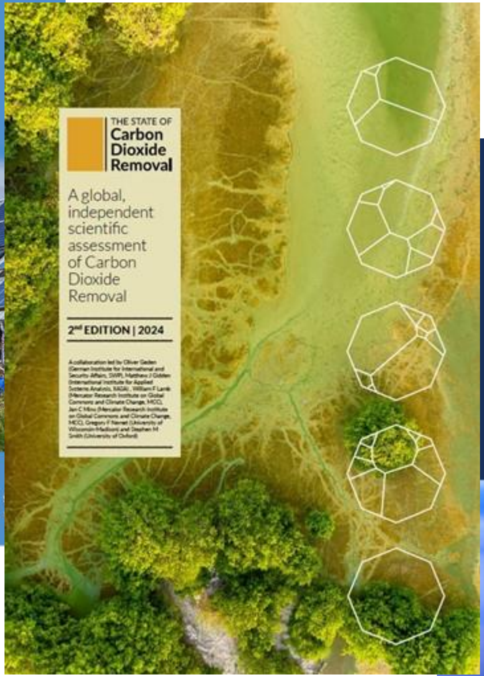
Climate Change 2022
Mitigation of Climate Change
WGIII
Working Group III contribution to the
Sixth Assessment Report of the
Intergovernmental Panel on Climate Change
WMO


THE STATE OF
Carbon
Dioxide
Removal
A global, independent scientific assessment of Carbon Dioxide Removal
2nd EDITION | 2024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INTERGOVERNMENTAL PANEL ON climate change
CLIMATE CHANGE 2023
Synthesis Report
A Report of the Intergovernmental Panel on Climate Change
WMO
UNEP


UN environment programme
Broken Record
Temperatures hit new highs, yet world
fails to cut emissions (again)
Emissions Gap Report 2023