Climate Change Advisory Council Secretariat

Carbon Budgets Working Group

Meeting No. 11
29th February 2024

Agenda

Time	Agenda Item
9:30	1. Opening of Meeting
9:35	2. Quantitative approaches to carbon budgeting for Parties to the Paris Agreement
10:30	3. Energy and Power Systems Modelling
11:30	4. ESAB Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050
12:30	5. Council Feedback on the first iteration of modelling
13:00	6. Carbon Budgets Work Plan
13:15	7. Next Steps and Agenda for next meeting
13:20	8. AOB
13:30	Meeting Close

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
11	15/12/23	Modelling groups to provide projected GHG emission data for temperature analysis	CBWG core modelling groups	Dec 2023	*Closed* *Modelling groups provided data by 18/12/23 and shared with Joe Wheatly for temperature impact analysis*
12	18/01/24	Secretariat to follow up on planetary boundaries as thematic topic	Secretariat	Mar 2024	Open
13	18/01/24	Secretariat to provide guidance from the Council with regards to the 2nd iteration of modelling and analysis following the February CCAC meeting	Secretariat	Feb 2024	Open

Agenda

Time	Agenda Item
9:30	1. Opening of Meeting
9:35	2. Quantitative approaches to carbon budgeting for Parties to the Paris Agreement
10:30	3. Energy and Power Systems Modelling
11:30	4. ESAB Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050
12:30	5. Council Feedback on the first iteration of modelling
13:00	6. Carbon Budgets Work Plan
13:15	7. Next Steps and Agenda for next meeting
13:20	8. AOB
13:30	Meeting Close

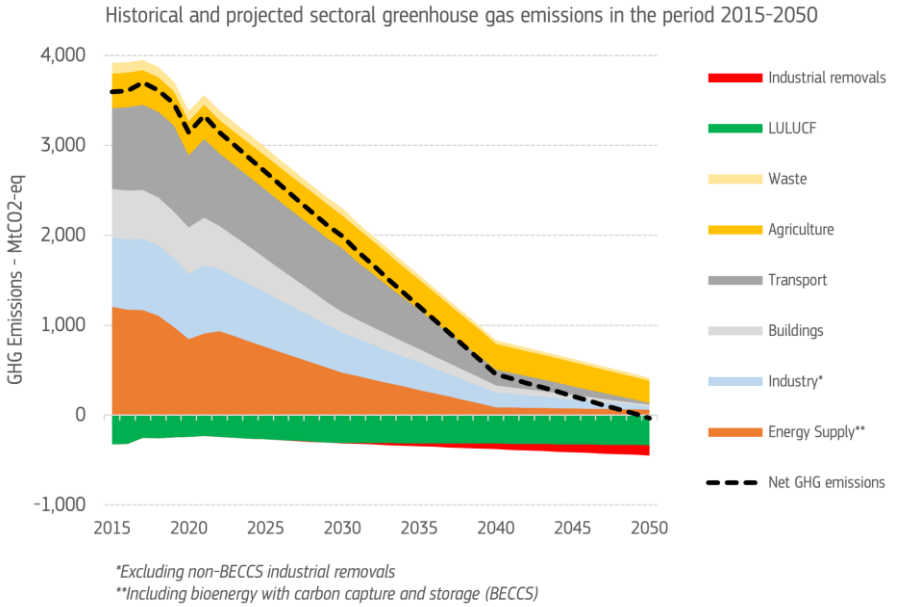
5. Council Feedback on the first iteration of modelling

- Secretariat briefed Council on the Carbon Budgets Core Model Outputs on 11/01/24
- Secretariat briefed Council on the warming impacts of the first iteration outputs from the core models on 14/02/24
    - *Core modelling teams joined the discussion for the final 30mins of the call*
- Council discussed feedback and guidance for the CBWG at the February CCAC meeting on 15/02/24
- Council Guidance being presented by the Secretariat and discussed at the February CBWG meeting on 29/02/24
- **New Action:** Secretariat to schedule bi-laterals to discuss guidance with core modelling teams following the February CBWG meeting
- Follow up guidance to be provided at the March CBWG meeting on 22/03/24 if necessary

5. Council Feedback on the first iteration of modelling

General Guidance Points

- Request for additional scenarios to widen the scope of modelling for the next iteration
- Request for modelled scenario(s) for the next iteration to consider the European Commission's 2040 Proposal
- Note the emissions gap for Waste and F-gases that will need to be addressed. Proposing to use the EPA Projections and/or the EU 2040 Scenarios?
- Request for accompanying descriptive narrative of the modelled scenarios outlining the technologies, rates of deployment, cost etc.



The European Commission *recommended* reducing the EU's net greenhouse gas emissions by 90% by 2040 relative to 1990 (February 2024).
2040 climate target - European Commission (europa.eu)

5. Council Feedback on the first iteration of modelling

TIM Guidance Points

- Endorsement of the approach for the remaining carbon budget assumptions in terms of downscaling the remaining Global Carbon Budgets on a per-capita basis to estimate Ireland's share
- Acknowledgement of downscaling on a per-capita basis as conservative in the sense that it is favourable to Ireland (Irish Carbon Budgets: Some Moral Considerations, Kian Mintz-Woo, *in prep*)
- Request for additional carbon budget scenarios to be modelled for the next iteration based on the IPCC assessment of the Global Remaining Carbon Budgets
  - First Iteration
    - 400 Mt: 2.0ºC (83%) & 1.5ºC (17%) (IPCC AR6 900 Gt CO_2 RCB)
    - 300 Mt: 1.7ºC (67%) & 1.5ºC (33%) (IPCC AR6 700 Gt CO_2 RCB)
  - Additional carbon budget scenarios requested for second iteration
    - *~450 Mt scenario aligned with 67% 2ºC* (IPCC AR6 1150 Gt CO_2 RCB)
    - *~350 Mt scenario aligned with ~25% 1.5ºC* (IPCC AR6 ~800 Gt CO_2 RCB)
    - *~250 Mt scenario aligned with 50% 1.5ºC* (IPCC AR6 500 Gt CO_2 RCB)
- Question of how TIM might take account of NCAP biomethane targets?

5. Council Feedback on the first iteration of modelling

FAPRI Guidance Points

- FAPRI scenario modelling out to 2050 is required for the 2nd iteration of modelling and analysis
- Request for a series of scenarios to be developed to explore what the composition of agriculture at the following scenarios?
  - Levels of emission reduction in agriculture achieved by 2050
    - 30%
    - 40%
    - 50%
    - 60%
  - Suggest exploring a range of adoption rates of MACC Mitigation Measures
    - High ~95%
    - Medium ~75%
    - Low ~50%

		MACC Adoption Rates		
		50%	75%	95%
Ag 2050 Emission Reduction	30%	S1	S4	S7
	40%	S2	S5	S8
	50%	S3	S6	S9
	60%	S10	S11	S12

An illustrative example of the range of FAPRI scenarios required

- Question of how might FAPRI reflect on market signals that relate to carbon farming in terms of AFOLU?

5. Council Feedback on the first iteration of modelling

GOBLIN Guidance Points

- Question of potential to incorporate new 2024 inventory emission factors/ activity data for the next iteration of modelling?
- Request for the development of scenarios to be developed in line with the guidance provided to FAPRI i.e., to explore the following levels of emission reduction in agriculture achieved by 2050:
  - 30%
  - 40%
  - 50%
  - 60%
- How might FAPRI and Goblin interact – sequencing required?

Agenda

Time	Agenda Item
9:30	1. Opening of Meeting
9:35	2. Quantitative approaches to carbon budgeting for Parties to the Paris Agreement
10:30	3. Energy and Power Systems Modelling
11:30	4. ESAB Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050
12:30	5. Council Feedback on the first iteration of modelling
13:00	6. Carbon Budgets Work Plan
13:15	7. Next Steps and Agenda for next meeting
13:20	8. AOB
13:30	Meeting Close

6. Carbon Budgets Workplan: 2024 Meeting Schedule and Proposed Topics

CB WG Meeting No.	Proposed Date and Time	Topic(s) for Consideration
10	Thursday 18th January 2024, 13:30 – 16:30	IEA Net Zero Roadmap 2023 Update/ Analysis of warming impact of selected core scenarios (1st iteration)/ Update on economic & macroeconomic analysis
11	Thursday 29th February 2024, 9:30 – 13:30	Quantitative approaches to carbon budgeting for Parties to the Paris Agreement (Victorian Government Report)/ Energy and Power systems modelling (Paul Deane)/ Scientific advice for the determination of an EU-wide 2040 climate target and a greenhouse gas budget for 2030–2050 (ESAB)
12	Friday 22nd March 2024, 13:30 – 16:30	Agree inputs, parameters and assumptions for 2nd Iteration of Modelling/ *Follow on discussion on methane and climate neutrality (Joeri Rogelj)/* *Discussion of potential NTA analysis for Carbon Budgets (TBC)*
13	Friday 19th April 2024, 13:30 – 16:30	Just Transition principles and considerations in the Carbon Budget Process (NESC)/ *Decarbonised Electricity System Study (SEAI)* Teagasc research and implications for Carbon Budgets (Karl Richards, Teagasc)
14	Thursday 23rd May 2024, 13:30 – 16:30	*2nd Iteration of Core Modelling Results/*
15	Friday 28th June 2024, 13:30 – 16:30	Analysis of warming impact of selected core scenarios (2nd iteration)/ *Macroeconomic and Economic Modelling Results (based on 1st and 2nd iteration)*
16	Thursday 25th July 2024, 13:30 – 16:30	Agree inputs, parameters and assumptions for 3rd Iteration of Modelling/ Follow on discussion on CDR and Carbon Budgets (Oliver Geden)
17	Thursday 29th August 2024, 13:30 – 16:30	*3rd Iteration of Core Modelling Results/*
18	Wed 18th September 2024, 13:30 – 16:30	*Macroeconomic and Economic Modelling Results (based on the 3rd iteration)* Analysis of warming impact of selected core scenarios (3rd iteration)

6. Carbon Budgets Workplan: Other Proposed Topics for Consideration

- Follow on discussion on biodiversity considerations (Yvonne Buckley/ Secretariat)
- Discussion on various aspects of aviation and maritime (Secretariat – June TBC)
- Greenhouse gas - air pollution interactions and synergies (Andrew Kelly)
- Economic assessment of climate change impacts and adaptation options in Ireland (ESRI)
- Discussion on Planetary Boundaries (TBC)

6. Carbon Budgets Workplan: 2nd Iteration of Modelling & Analysis

Item	Description	2024											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	**Modelling / Analysis Iteration 2**												
2.1	Agree inputs, parameters and assumptions												
2.2	Core pathways development and modelling												
2.3	Paris Test Assessment												
2.4	Additional modelling and testing of results												
2.5	Post-hoc analysis												

- **March Week 1:** Secretariat to schedule bi-laterals to discuss Council guidance with core modelling teams
- **CBWG Meeting No. 12, CBWG Friday 22nd March 2024, 13:30 – 16:30:**
  - Agree inputs, parameters and assumptions for 2nd Iteration of Modelling
- **CBWG Meeting No. 14, Thursday 23rd May 2024, 13:30 – 16:30:**
  - 2nd Iteration of Core Modelling Results - *potential sequencing of FAPRI and GOBLIN to be discussed*
- **CBWG Meeting No. 15, Friday 28th June 2024, 13:30 – 16:30:**
  - Analysis of warming impact of selected core scenarios (2nd iteration),
  - Additional Testing of Scenario Results (SEAI & NTA)
  - Macroeconomic and Economic Modelling Results (based on 1st and 2nd iteration)

New Action: *Core and Additional modelling teams to confirm delivery timelines in line with Carbon Workplan*

7. Agenda for Meeting No. 12: Friday 22nd March 2024, 13:30 – 16:30

1. Follow on discussion on methane and climate neutrality

- Updated Secretariat working paper to be presented
- Joeri Rogelj to present a recent publication: *Substantial reductions in non-CO_2 greenhouse gas emissions reductions implied by IPCC estimates of the remaining carbon budget* (Rogeli and Lamboll, 2024)

2. Discussion of potential NTA analysis Carbon Budgets

- NTA to present an update on proposed analysis

3. Agree inputs, parameters and assumptions for 2nd Iteration of Modelling

- CBWG to develop a shared understanding of model inputs and expected outputs for the 2nd iteration of modelling and analysis

7. Agenda for Meeting No. 13: Friday 19th April 2024, 13:30 – 16:30

1. Just Transition principles and considerations in the Carbon Budget Process (NESC)/

- NESC to present on Just Transition principles to inform a follow-on discussion on their consideration as part of the Carbon Budgets Process

2. Decarbonised Electricity System Study (SEAI)

- Kerrie Sheehan and John McCann to present on SEAI's work to cary out a Decarbonised Electricity System Study (DESS) to aid in the determination of Ireland's pathway to achieve a net-zero electricity system.

3. Research on feed additives and nitrous oxide emissions (Teagasc)

- Karl Richards to present latest research on mitigation technologies and their implications for carbon budgets

8. AOB

- Update on Carbon Budgets Working Group Membership

Climate Resource

Victorian Emission Budgets

Prof. Malte Meinshausen (Climate Resource & The University of Melbourne)
The Climate Change Advisory Council, Ireland
Thursday, 29 March 2024

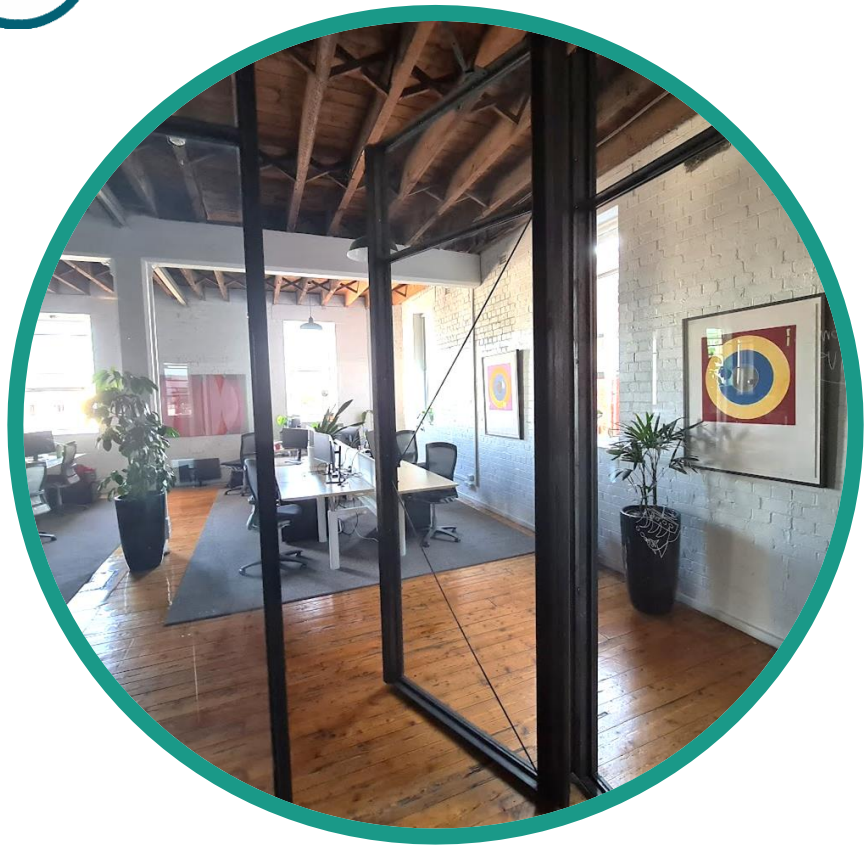
Malte Meinshausen

Former scientific advisor on German UNFCCC / IPCC negotiation teams (2005-2015)

Professor Climate Science at The University of Melbourne

IPCC AR6 Lead Author WG1 & Synthesis Report

malte.meinshausen@climate-resource.com



Climate Resource

- Boutique consultancy
- Setup in COVID times, after Morrison government cancelled our big University project on Australian Energy Transition
- Melbourne and soon Berlin

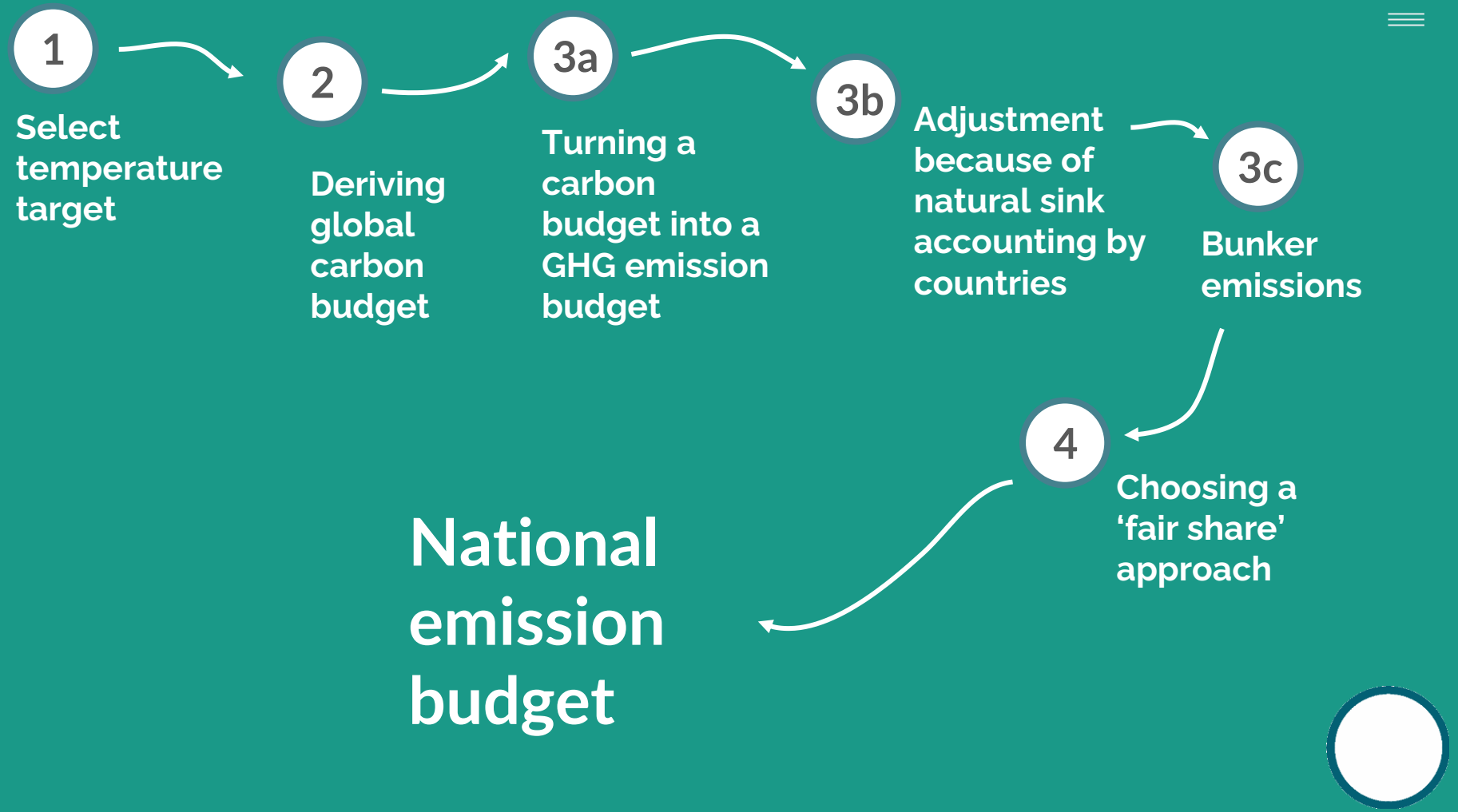
climate-resource.com

Overview

1. Derivation of the Victorian carbon budgets

2. From emission scenarios to global-mean temperatures: MAGICC

Victorian Emission budgets


1
Select temperature target
2
Deriving global carbon budget
3a
Turning a carbon budget into a GHG emission budget
3b
Adjustment because of natural sink accounting by countries
3c
Bunker emissions
4
Choosing a ‘fair share’ approach
National emission budget

Framing "well below 2°C"

Table 1 - Temperature targets and probabilities - examples of options

Temperature target + assumptions about probability and overshoot	Comment
1) "Well-below 2°C" meaning 2°C with a (@) 67% chance	Many studies equate a 2°C target with 2°C @ 67%[21,22] Not in line with global emphasis on 1.5°C (more like 1.8°C of warming in the median)
2) "Well-below 2°C" meaning 2°C @ 83% chance	High chance that emission budgets will be revised upward (Section 3.2). Not likely to be considered in line with global emphasis on 1.5°C IPCC AR6 also reports carbon budgets for 83%
3) "Well-below 2°C" meaning, say, 1.6°C @ 50%	Aligning to a median temperature outcome likely avoids the issue of revision over time (Section 3.2). Such a framing can still provide a line of sight to higher probabilities today (e.g. 1.6°C @ 50% is roughly 2°C @ 90%, which has been suggested as the appropriate definition of well below in the literature[23]) There is no consensus on what the appropriate temperature level in between 1.5°C and 2°C should be. One guide is that the lower class of mitigation scenarios in IPCC WG3 peak at around 1.6°C. Some others - e.g. the German SRU[24] define "well-below 2°C" as a 67% chance to stay below 1.75°C (and also presents a 1.5°C target)

1

Framing: 1.5˚C with limited overshoot

Temperature target + assumptions about probability and overshoot	Comment
4) 1.5°C with limited overshoot, i.e., limiting peak temperatures below 1.6°C @ 50%	Consistent with many ambitious NDC and LT-LEDS targets that emphasise the 1.5°C goal (see Appendix 2) Most mitigation scenarios labelled as 1.5°C include some limited (around 0.1°C) overshoot.[25] The IEA Net-Zero scenario[26] peaks very close to 1.5°C as does the lowest of the IPCC WG1 assessed scenarios (SSP1-1.9), although some scenarios in IPCC WG3 have no overshoot. The inclusion of a small overshoot is also followed in IPCC AR6 WG3 The concept of "overshoot" relies on net-negative CO_2 and net-zero GHG emissions in the second-half of the century, with associated challenges for finding sustainable net-negative emissions options in Victoria

1

Framing: 1.5˚C without overshoot

Temperature target + assumptions about probability and overshoot	Comment
5) 1.5°C without overshoot @ 50%	Consistent with Victoria adopting a global leadership position - few other jurisdictions have interim targets that are clearly in line with a 1.5°C @ 50% goal although there is some international precedent: • The German SRU[27] also derives targets @ 50% probability for 1.5°C of warming • Scotland's legislated targets for 2030 are stronger than what Scotland assessed as being required to meet the lower bound of the UK target range consistent with pathways with a 50% probability of limiting warming to 1.5°C.[28] Reduces the reliance on negative emissions technologies compared to a 1.5°C with overshoot budget. The time for strictly staying below "1.5°C" is rapidly closing and it is difficult to find feasible global pathways consistent with this. Without strongly enhanced mitigation action this decade at a global level, the current assessment is that 1.5°C without overshoot and with higher than 50% probabilities will not be achievable any more.

Deriving global carbon budget I

Table 2 – Step 1: Global remaining carbon from 2013

Temperature level and likelihood of staying below	The remaining global carbon budget from Jan 2020 onwards listed in IPCC AR6 WG1 Table 5.8 for warming relative to 1850-1900	Adjustments so the starting year is 2013 (to account for global emissions from 2013 to 2020)	Earth – system feedbacks*	Reduction so warming targets are relative to pre-industrial levels not relative to 1850-1900 (0.1°C adjustment)	The remaining global carbon budget from Jan 2013 onwards for warming relative to pre-industrial levels
<1.6°C @ 50%	650 $GtCO_2$	+ 277 $GtCO_2$	- 0 $GtCO_2$	- 150 $GtCO_2$	= 777 $GtCO_2$
<1.5°C @ 50%	500 $GtCO_2$	+ 277 $GtCO_2$	- 0 $GtCO_2$	- 150 $GtCO_2$	= 627 $GtCO_2$

**No adjustments necessary. The IPCC AR6 WG1 remaining carbon budget already includes permafrost and other biogeochemical feedbacks.

-> Adjustment for carbon budget with earlier/later start year than IPCC

WG1 carbon budget on higher side

nature climate change

Article

Assessing the size and uncertainty of remaining carbon budgets

https://doi.org/10.1038/s41558-023-01848-5

Received: 5 August 2022

Accepted: 20 September 2023

Published online: 30 October 2023

Check for updates

Robin D. Lamboll, Zebedee R. J. Nicholls, Christopher J. Smith, Jarmo S. Kikstra, Edward Byers & Joeri Rogelj

The remaining carbon budget (RCB), the net amount of CO_2 humans can still emit without exceeding a chosen global warming limit, is often used to evaluate political action against the goals of the Paris Agreement. RCB estimates for 1.5 °C are small, and minor changes in their calculation can therefore result in large relative adjustments. Here we evaluate recent RCB assessments by the IPCC and present more recent data, calculation refinements and robustness checks that increase confidence in them. We conclude that the RCB for a 50% chance of keeping warming to 1.5 °C is around 250 $GtCO_2$ as of January 2023, equal to around six years of current CO_2 emissions. For a 50% chance of 2 °C the RCB is around 1,200 $GtCO_2$. Key uncertainties affecting RCB estimates are the contribution of non-CO_2 emissions, which depends on socioeconomic projections as much as on geophysical uncertainty, and potential warming after net zero CO_2.

The remaining carbon budget (RCB) is the net amount of carbon dioxide (CO_2) humans can still emit while keeping global warming below a given limit with a given probability, taking into account the effect of other anthropogenic climate forcers[1,2]. The concept is key when considering the speed of decarbonization required to meet the goal of the Paris Agreement to keep global warming to well below 2 °C relative to pre-industrial levels and pursuing efforts to limit it to below 1.5 °C (ref. 3). Many approaches to equitable international climate action involve estimating the global RCB and dividing it among nations according to various principles of equity[4,5]. However the RCB for the Paris-relevant temperature targets (generally interpreted as a 50% chance of keeping global warming below 1.5 °C and anywhere from a 66% to 90% chance of 2.0 °C (ref. 6)) is small compared with the uncertainty in their values. This means subtle updates to the assessments can substantially affect the values, which makes their use challenging.

Previous work shows that the temperature rise is, to first order, not strongly dependent on when carbon emissions occur, only on their cumulative sum[7–11]; however, the RCB is strongly dependent on both how much and when different types of non-CO_2 emissions occur[12–18]. As a result, the RCB requires some set of scenarios describing co-evolutions of CO_2 and other emissions to estimate.

In the Working Group I (WGI) report for the IPCC Sixth Assessment Report (AR6)[1], a set of values were established using the approach presented in refs. 19,20, decomposing the RCB into CO_2 and non-CO_2 parts. The CO_2 part was assessed analytically by integrating information from multiple lines of evidence, while the non-CO_2 part was assessed using a reduced-complexity climate model (or emulator). MAGICC 7.5.1[21–23], calibrated to the IPCC AR6 assessment[24], was used to estimate the relationship between future non-CO_2 and future total warming at net zero CO_2 emissions on the RCB was estimated by fitting a linear trend to the relation-ship between future non-CO_2 and future total warming at net zero CO_2 emissions for available scenarios in the database accompanying the IPCC Special Report on Global Warming of 1.5 °C (SR1.5)[25]. Following an update to historical data, an updated version of MAGICC (7.5.3) was available and used in the WG3 report[26,27].

The WG3 report discusses how updates to the non-CO_2 contribution at the time of net zero reduce the 1.5 °C RCB by about 100 $GtCO_2$ (about one-fifth) relative to estimates reported in WG1, although it did not tabulate values. It also makes comparisons between the RCB and the cumulative emissions until net zero of scenarios meeting a given temperature goal, which it finds approximately consistent with each other, although with less consistency for 1.5 °C of global warming than for higher levels. While this 20% change in the RCB estimate

[1]Centre for Environmental Policy, Imperial College London, London, UK. [2]School of Geography, Earth and Atmospheric Sciences, The University of Melbourne, Melbourne, Victoria, Australia. [3]International Institute for Applied Systems Analysis, Laxenburg, Austria. [4]Met Office Hadley Centre, Exeter, UK. [5]School of Earth and Environment, University of Leeds, Leeds, UK. [6]Grantham Institute – Climate Change and Environment, Imperial College London, London, UK. e-mail: r.lamboll@imperial.ac.uk

Ps: but implied IPCC AR6 WGIII cumulative emissions in relation to temperatures are ‘all good’

https://www.nature.com/articles/s41558-023-01848-5

Deriving global carbon budget II

Table 3 – Step 2: Turning the remaining carbon budget until net zero into one up to 2050

Temperature level and likelihood of staying below	The remaining global carbon budget from Jan 2013 onwards for warming relative to pre-industrial levels (Table 2)	Given the 1.5°C scenarios in IPCC AR6 WG3, it is reasonable to assume net zero is reached around 2050. No adjustment is required to turn carbon budgets until net zero into carbon budgets to 2050	The remaining global carbon budget from Jan 2013 until 2050 for warming relative to pre-industrial levels
<1.6°C @ 50%	777 $GtCO_2$	+ 0 $GtCO_2$	= 777 $GtCO_2$
<1.5°C @ 50%	627 $GtCO_2$	+ 0 $GtCO_2$	= 627 $GtCO_2$

-> No adjustment for 2050 time horizon

3a

Turning a carbon budget into a GHG emission budget

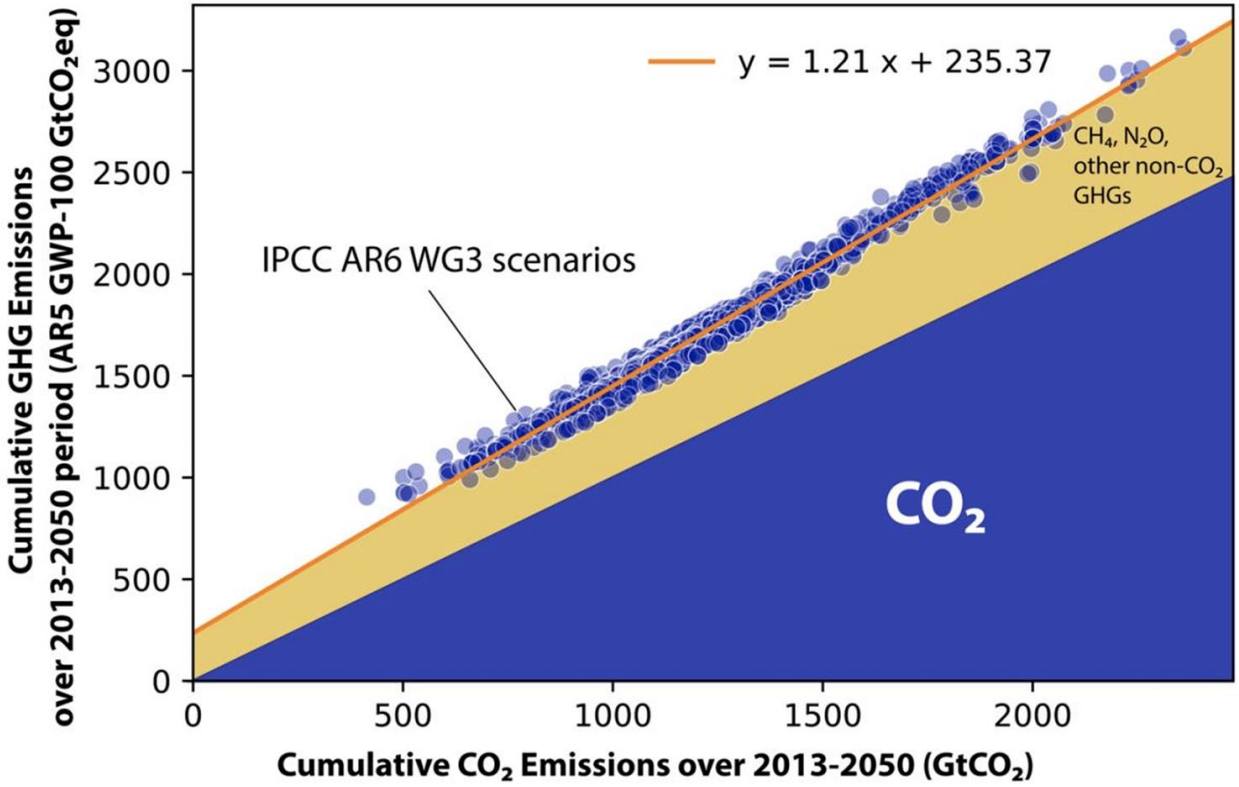


Figure 2 - The relationship between cumulative CO_2 emissions and cumulative GHG emissions between 2013 and 2050 within the IPCC AR6 WG3 database of emission scenarios.

Compare: IPCC AR6 WG1, Figure 1.29

3a

Turning a carbon budget into a GHG emission budget

Table 4 – Step 3a: Turning the global carbon budget into a GHG emission budget

Temperature level and likelihood of staying below	The remaining global carbon budget from Jan 2013 until 2050 for warming relative to pre-industrial levels (Table 3)	Additional **non-CO_2** GHG emissions when converting from a carbon budget to an emissions budget, derived on the basis of the AR6 WG3 scenarios	The remaining global emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels
<1.6°C @ 50%	777 $GtCO_2$	+ 402 $GtCO_2eq$	= 1179 $GtCO_2eq$
<1.5°C @ 50%	627 $GtCO_2$	+ 370 $GtCO_2eq$	= 997 $GtCO_2eq$

3b

Adjustment because country emission inventories take credit for some natural (indirect anthropogenic) sinks

Table 5 – Step 3b: Accounting for the fact that IPCC methodologies for LULUCF include natural sinks

Temperature level and likelihood of staying below	The remaining global emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels (Table 4)	15% adjustment to the carbon part of the emission budget to account for different **CO_2** sink accounting in IPCC methodology for national inventories and IPCC methodology for carbon budgets	The remaining global emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels after LULUCF adjustment
<1.6°C @ 50%	1179 $GtCO_2eq$	- 117 $GtCO_2$	= 1063 $GtCO_2eq$
<1.5°C @ 50%	997 $GtCO_2eq$	- 94 $GtCO_2$	= 903 $GtCO_2eq$

3c

Adjustment for bunker emissions

Table 6 – Step 3c: Accounting for international aviation and shipping

Temperature level and likelihood of staying below	The remaining global emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels after LULUCF adjustment (Table 5)	Removal of international aviation and shipping emissions	The remaining global emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels after LULUCF adjustment and international aviation and shipping is removed
<1.6°C @ 50%	1063 $GtCO_2eq$	- 50 $GtCO_2$	= 1013 $GtCO_2eq$
<1.5°C @ 50%	903 $GtCO_2eq$	- 50 $GtCO_2$	= 853 $GtCO_2eq$

Fair Shares

Table 7 – Allocation approaches investigated, based on Robiou du Pont (2017) and IPCC AR5 categories[42]

Allocation type	Corresponding AR5 IPCC Category	Description
Equal per capita	Equality	For all nations, annual emissions per person converge towards an equal value in 2040 (or other date).
Equal cumulative per capita	Equal cumulative per capita	Each nation has the same ratio of cumulative emissions to population over the 1990-2050 period. As a result, nations with high historical per capita emissions have lower future emissions allocations.
Capability	Capability	Allocation is based on nations' abilities to pay for emissions reductions. Nations with higher GDP per capita have lower emissions allocations.
Greenhouse Development Rights	Responsibility-capability-need	This approach preserves a "right to development" through the allocation of required emissions reductions.
Constant emissions ratio	Staged approaches	Maintains current emissions ratios (preserves status-quo in emissions allocations). This approach, often referred to as "grandfathering", is generally not considered an equitable option and is not supported as such by any country for dividing a global budget between nations.

3c

Fair Shares

Table 8 –Deriving the Australian emission budget

Temperature level and likelihood of staying below	Australian share of global emissions budget from 2013 until 2050 based on a) CCA, 2014 and b) equal per capita shares	The remaining global emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels after LULUCF adjustment and international aviation and shipping is removed (Table 6)	The remaining Australian emissions budget from Jan 2013 until 2050 for warming relative to pre-industrial levels
<1.6°C @ 50%	**(a) 0.97%**	x 1013 $GtCO_2eq$	= 9.83 $GtCO_2eq$
<1.5°C @ 50%	**(a) 0.97%**	x 853 $GtCO_2eq$	= 8.27 $GtCO_2eq$
<1.6°C @ 50%	**(b) 0.33%**	x 1013 $GtCO_2eq$	= 3.34 $GtCO_2eq$
<1.5°C @ 50%	**(b) 0.33%**	x 853 $GtCO_2eq$	= 2.81 $GtCO_2eq$

Examples from other jurisdictions

Table A1 – Examples of approaches to calculating local emissions budgets in different jurisdictions

Jurisdiction	Broad approach and use of global carbon budget	Temperature goals and probabilities	Effort sharing	Overshoot
UK	Highest possible ambition, with consideration given to where this sits in the range implied by global emissions budgets consistent with the Paris Agreement goal and effort sharing approaches	The global carbon budget range uses pathways with at least a 66% probability of keeping peak warming below 2°C and a 50% probability of 1.5°C as upper and lower bounds[51]	Consistency with a range of effort sharing approaches is considered but no single approach is adopted (consistent with the focus on highest ambition as the starting point)	The lower bound of the range for global carbon budgets is based on pathways with no or low overshoot[52], although the UK CCC notes that it considers it "not prudent to plan for an intentional temporary overshoot"
France	5-yearly carbon budgets are not explicitly tied to a global carbon budget or effort sharing approach	Recent work on France's carbon footprint (domestic and imported emissions) asserts that the targets set are consistent with global pathways for 1.5°C, but no probability is discussed[53]	Not explicitly addressed in public material supporting policy to our knowledge	Overshoot not explicitly discussed
New Zealand	An obligation to set emissions budgets consistent with limiting temperature rise to 1.5°C is in legislation[54]	Interquartile range of SR1.5 pathways consistent with 50-66% chance of limiting warming to 1.5°C[55]	Consistency with a range of effort sharing approaches is considered, but no single approach is proposed by the NZ CCC[56]	Based on pathways from IPCC SR1.5 with no or limited overshoot[57]

Examples from other jurisdictions

Jurisdiction	Broad approach and use of global carbon budget	Temperature goals and probabilities	Effort sharing	Overshoot
Ireland	Top-down allocation of the global carbon budget provided context for five yearly carbon budgets that would deliver emissions reductions required in regulations/legislation for 2030 and 2050	50% probability of 1.5°C and 67% of staying below 2°C[58]	Population (equal per capita emissions) with some context specific adjustments	Overshoot not explicitly discussed. Land based negative emissions and methane reductions included as an adjustment to Ireland's share of the global carbon budget to 2050[59]
Denmark	Emissions reductions targets of a 70% reduction on 1990 levels by 2030 and net zero by 2050 set in legislation. The Danish CCC asserts these goals are consistent with its share of a global carbon budget. Carbon budgets not required to be used in setting interim 5-yearly targets[60]	50%-67% probability of 1.5°C[61]	Population (equal per capita emissions) adopted as the starting point, noting other effort sharing approaches would support a smaller budget for Denmark, or it contributing more to global mitigation efforts (including via climate finance)[62]	Overshoot not explicitly discussed
Scotland	Legislated requirement to set targets that do not exceed a fair and safe Scottish emissions budget to 2050.[63]	The UK CCC (the entity required to advise on a fair and safe emissions budget) did not detail the temperature goal or probability.[64] Targets of 75% on 1990 levels by 2030 and net zero by 2045 are reported as going beyond what the IPCC says is needed globally to	No single effort sharing method referenced, but clearly recognise the need to do better than the global average	Overshoot not explicitly discussed

From a national emission budget to a target for 2035 or 2040

From an emission budget to an emission trajectory

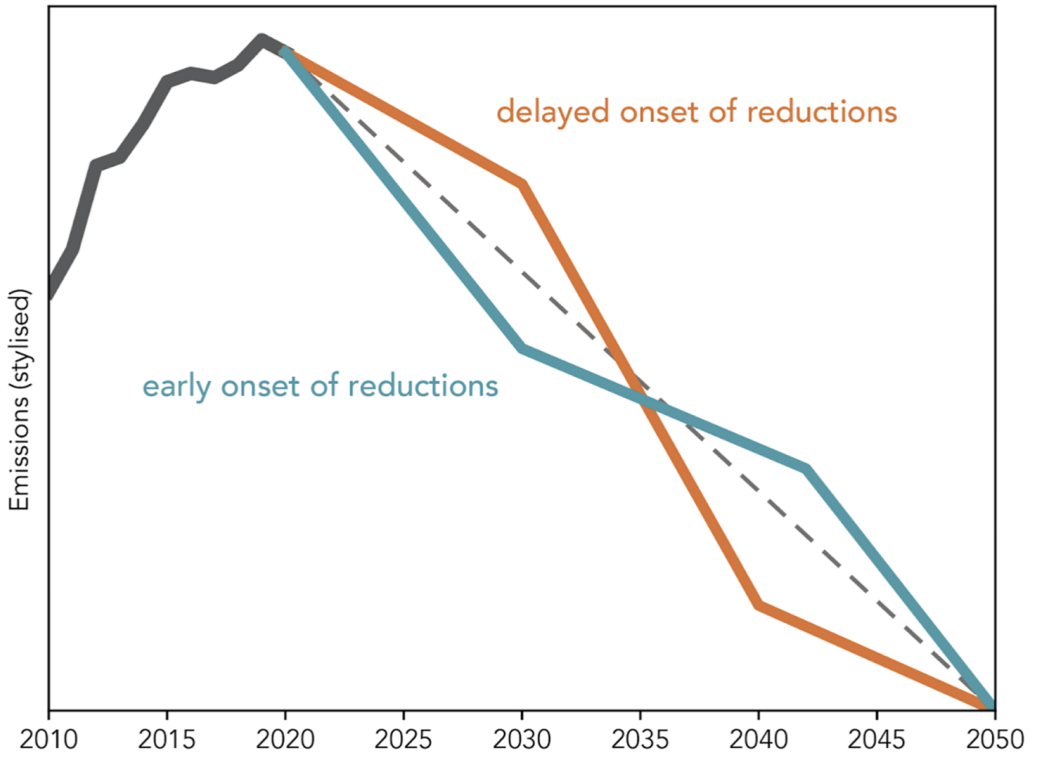
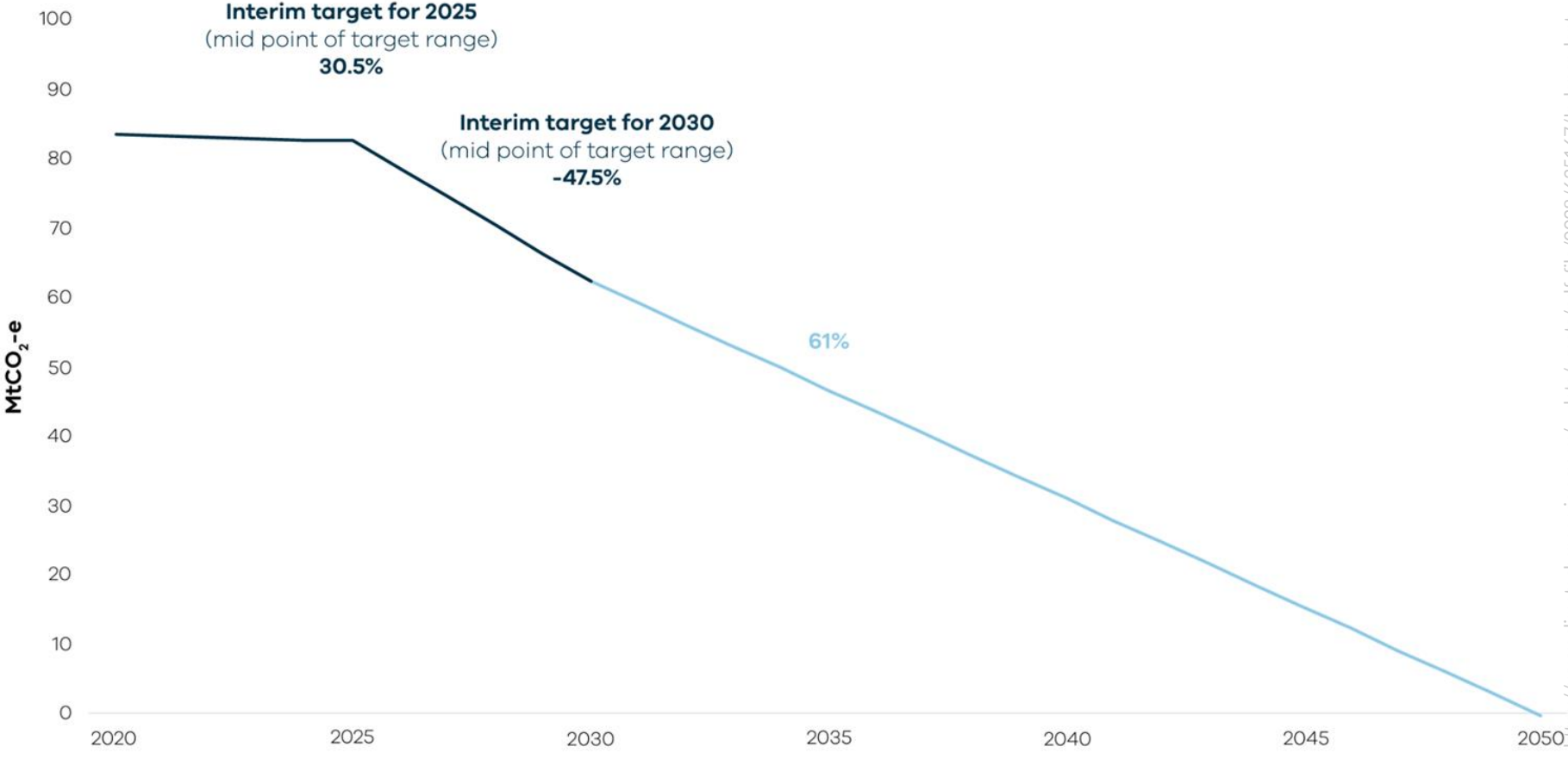


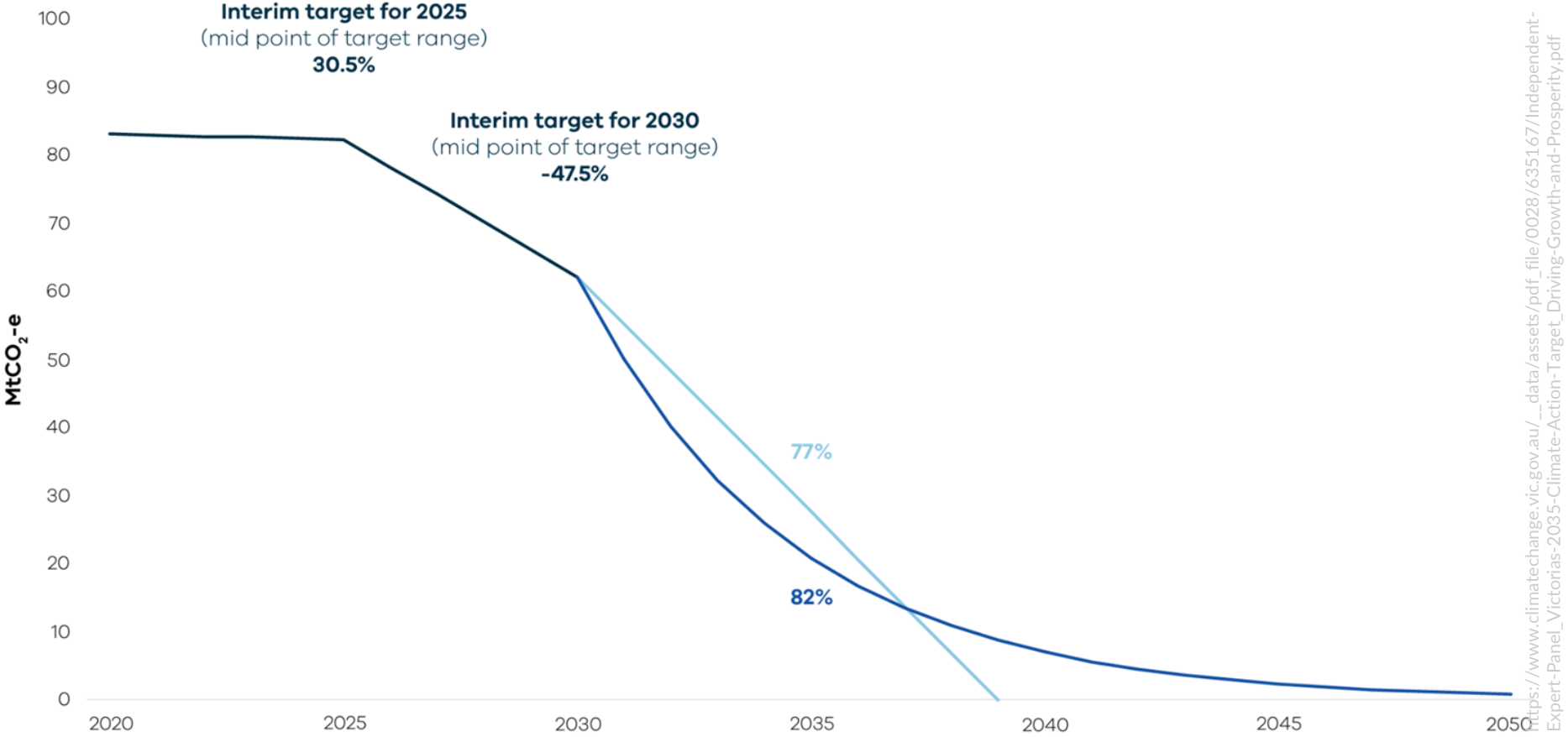
Figure 1 - Stylised illustration of the impact of early reductions compared to delayed reductions in emissions. Both pathways have the same cumulative emissions, i.e., they are consistent with the same emissions budget. The pathway that features early reductions has a slower rate of reductions at later points in time. Conversely, the pathway that has a delayed start to reductions features much more rapid cuts between 2030 and 2040. The dashed grey line is a straight line from 2020 emissions levels to net zero in 2050.

Figure 11. An illustrative trajectory under Victorian emissions budget 4: Victoria's share of a 1.5°C budget with limited overshoot / 'well-below 2°C' budget (global emissions budget 2), using a contraction and convergence sharing approach



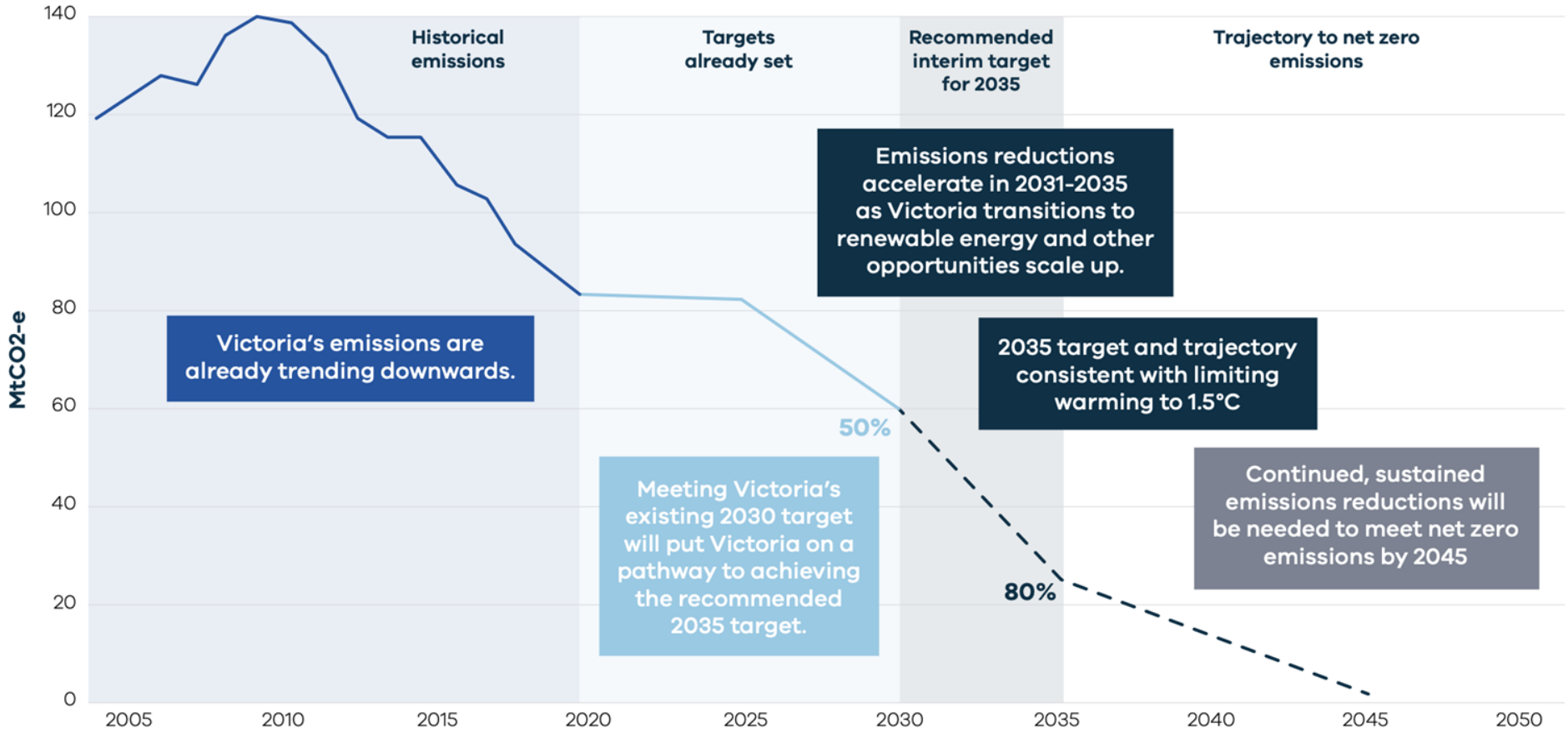
https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0028/635167/Independent-Expert-Panel_Victorias-2035-Climate-Action-Target_Driving-Growth-and-Prosperity.pdf

Figure 10. Two illustrative trajectories under Victorian emission budget 3: Victoria's share of a 1.5°C budget without overshoot (global emissions budget 1), using a contraction and convergence sharing approach



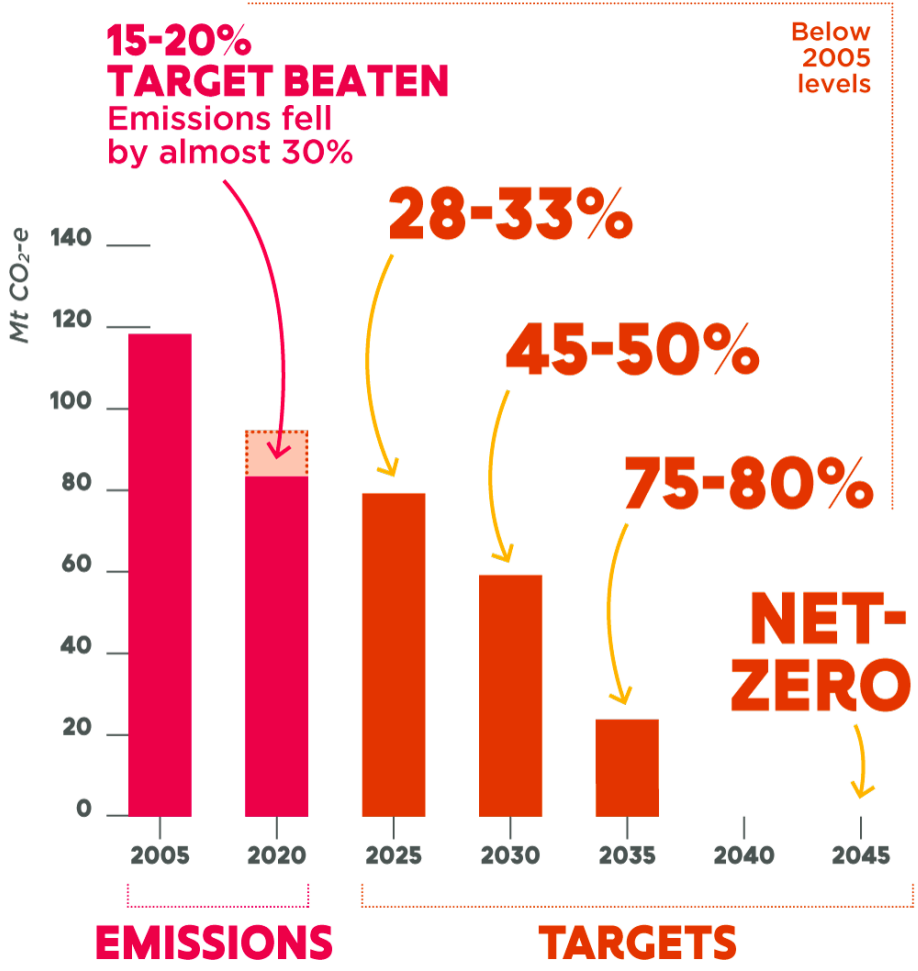
https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0028/635167/Independent-Expert-Panel_Victorias-2035-Climate-Action-Target_Driving-Growth-and-Prosperity.pdf

Figure 1. The Panel's recommended target for 2035 and indicative trajectory to net zero emissions



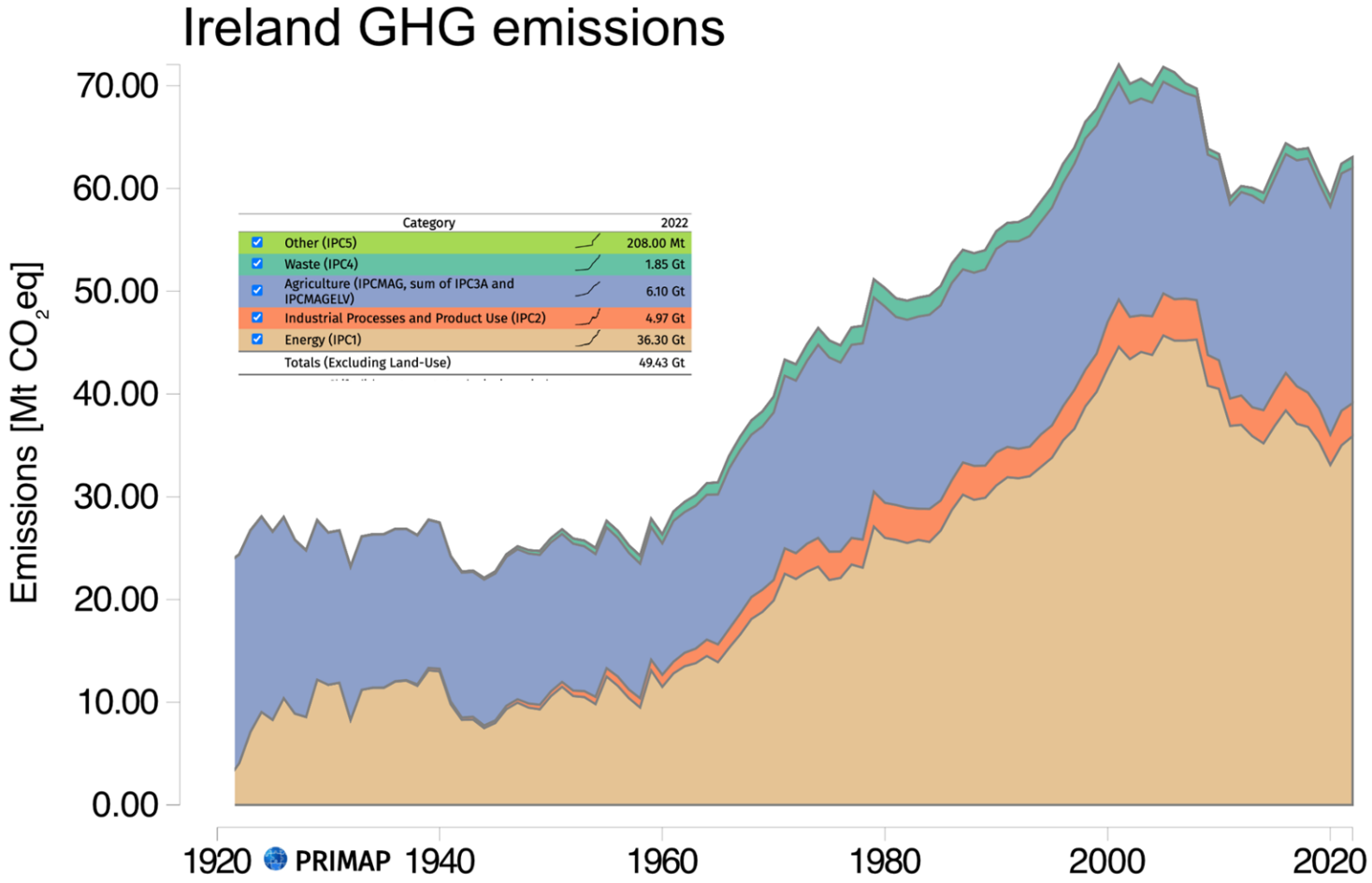
https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0028/635167/Independent-Expert-Panel_Victorias-2035-Climate-Action-Target_Driving-Growth-and-Prosperity.pdf
Available at: https://www.climatechange.vic.gov.au/climate-action-targets

Victorian Emission Targets



Source:
https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0028/635590/Victorias-2035-Climate-Target_Driving-Real-Climate-Action.pdf
Available at:
https://www.climatechange.vic.gov.au/climate-action-targets

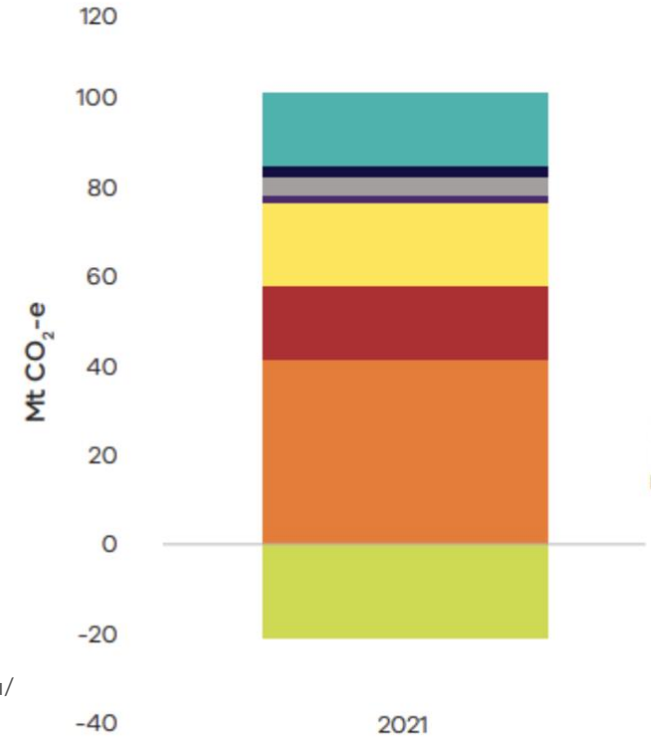
Ireland has slightly less emissions than Victoria



Source: Primap.org (Climate Resource and PIK)

Victoria's greenhouse gas emissions by sector in 2021

Agricultural emissions ~20%



		Share	Mt CO_2-e
	Agriculture	20.5%	16.4
	Waste	3.4%	2.7
	Industrial processes and product use	4.9%	3.9
Energy	Fugitive emissions from fuels	2.2%	1.7
Energy	Transport	23.2%	18.6
Energy	Fuel combustion	20.4%	16.3
Energy	Electricity generation	51.8%	41.4
	LULUCF	-26.4%	-21.1
	Total	100%	80.1

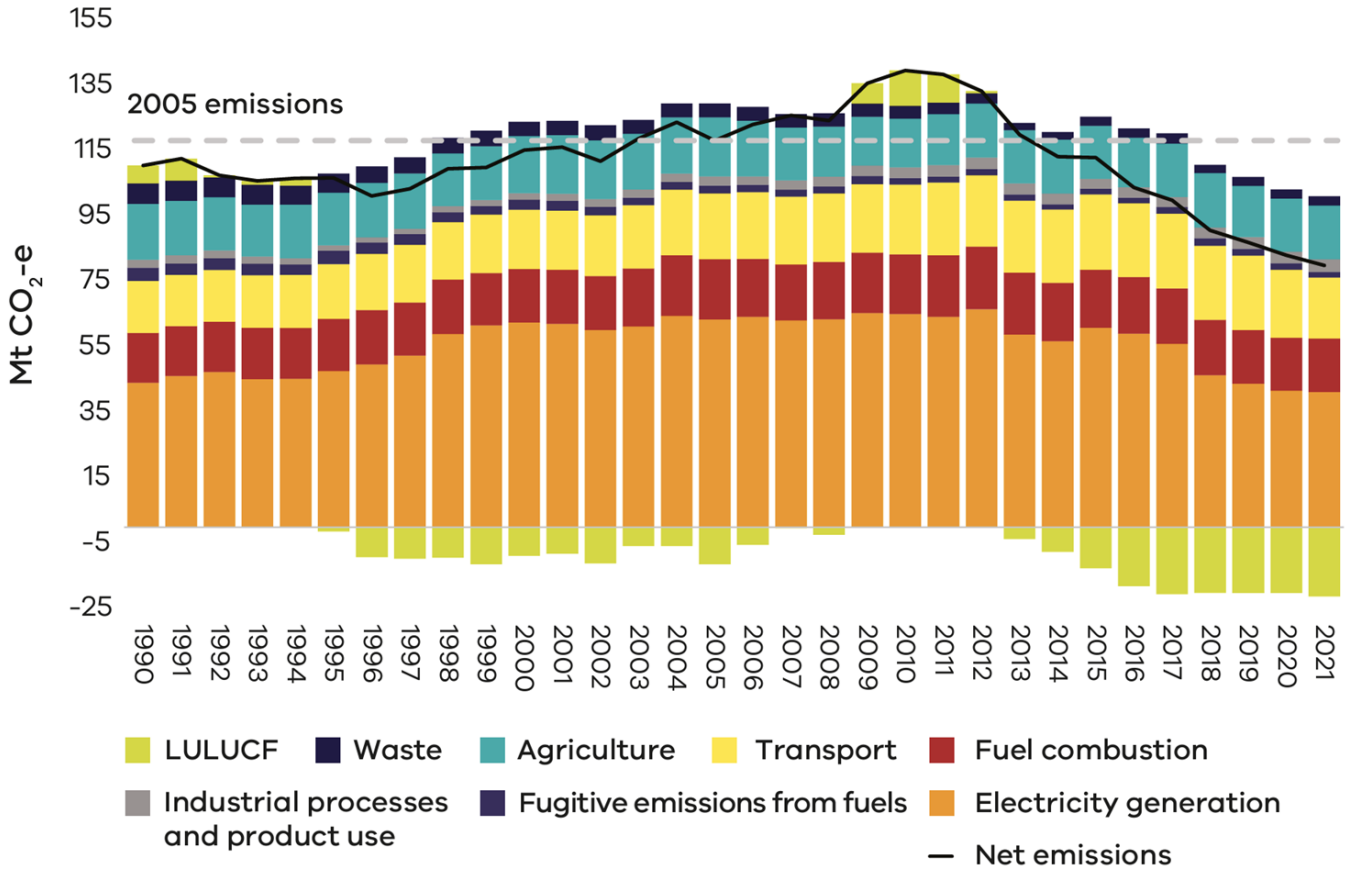
https://www.climatechange.vic.gov.au/greenhouse-gas-emissions

Reasons for Victorian energy emissions to fall…

Energy sector and LULUCF

Source: https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0036/687825/Victorian-Greenhouse-Gas-Emissions-Report-2021.pdf

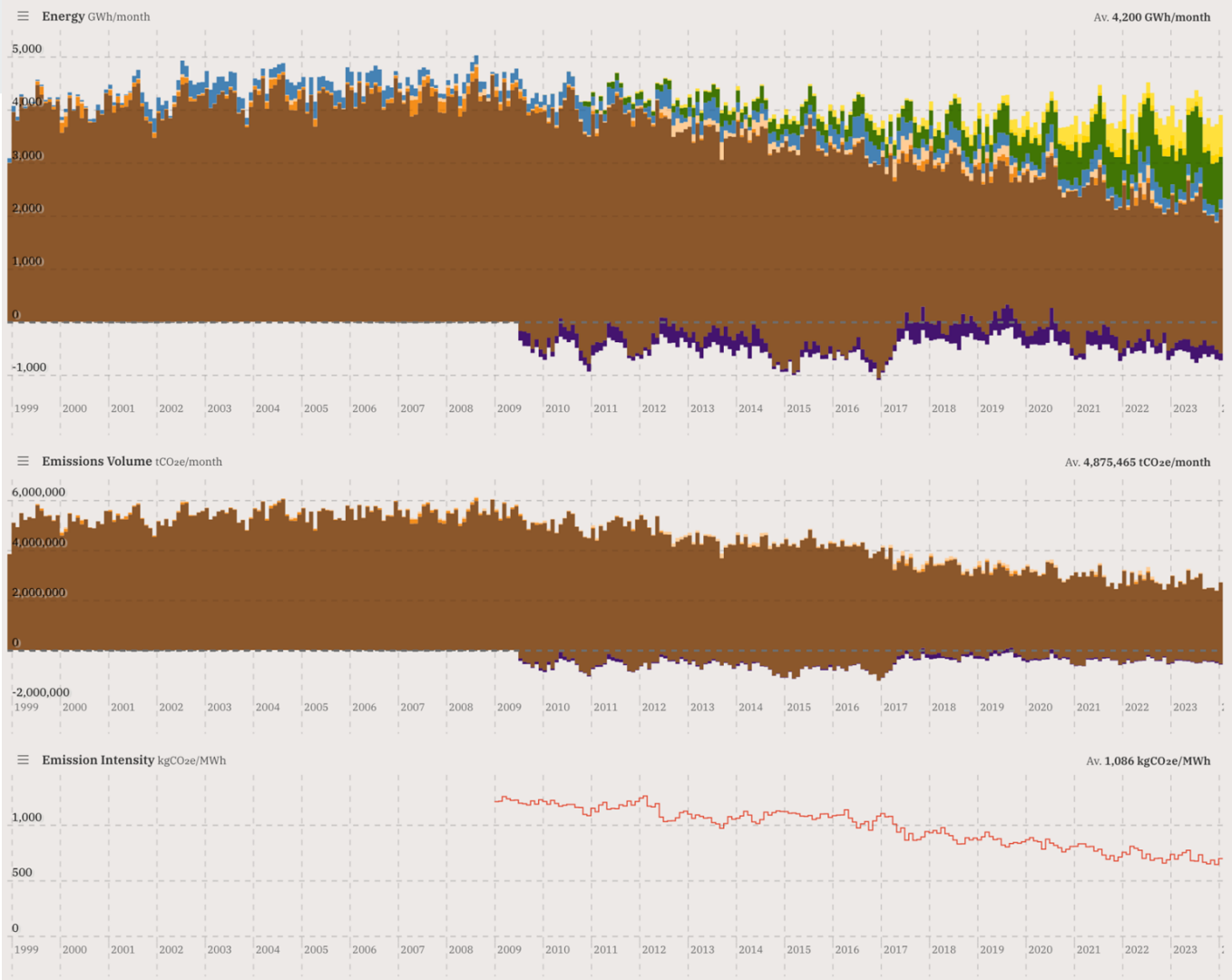
Figure 4: Total net emissions and emissions by sector – Victoria, 1990 to 2021



Source: State and Territory Greenhouse Gas Inventories 2021 (DCCEEW, 2023e)

Reasons for Victorian energy emissions to fall…

… Electricity sector: Lignite replaced by energy efficiency and renewables



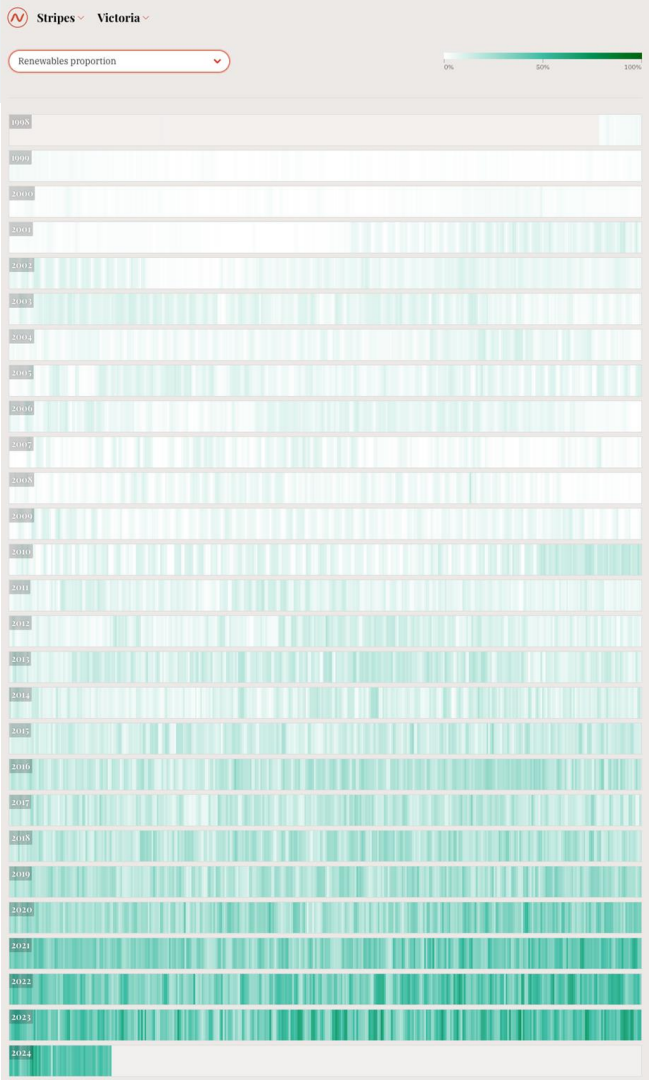
Source: Opennem.org.au

Renewables proportion increased from 1998 (top row) to 2024 (last row, 42%)

Tue, 28 Feb 2023 – Wed, 28 Feb 2024

Detailed	Energy GWh	Contribution to demand	Av.Value $/MWh
Sources			
Solar (Rooftop)	4,809	10.1%	$2.32
Solar (Utility)	1,555	3.3%	$21.52
Wind	11,086	23.4%	$37.05
Hydro	2,498	5.3%	$135.84
Battery (Discharging)	168	0.4%	$116.83
Gas (OCGT)	464	1.0%	$259.61
Gas (Steam)	176	0.4%	$196.40
Coal (Brown)	31,652	66.8%	$62.46
Imports	2,529	5.3%	–
Loads	**-7,762**		
Exports	-7,557	-15.9%	–
Battery (Charging)	-205	-0.4%	$8.08
Net	**47,176**		
Renewables	**19,948**	**42.1%**	

Source: Opennem.org.au



More background on Victorian targets

https://www.climatechange.vic.gov.au/climate-action-targets

https://engage.vic.gov.au/climate-action-target-2035

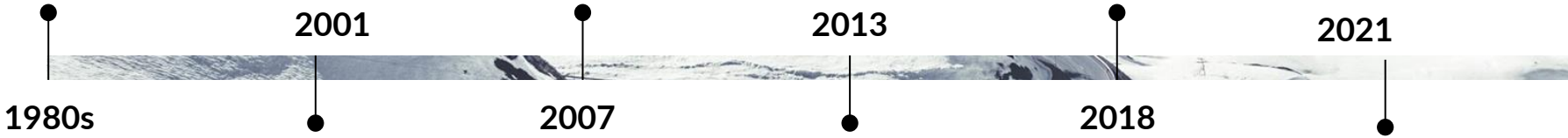
https://www.climatechange.vic.gov.au/greenhouse-gas-emissions

MAGICC

Live.magicc.org

Maintained by Climate Resource

MAGICC - trusted for decades by IAMs and IPCC and at the heart of our machinery



1980s

Before IPCC

Even before IPCC, the upwelling diffusion core was developed by Tom Wigley, Sarah Raper and many others to be one of the most successful simple model architectures.

2001

IPCC Third Assessment Report

Key projections of temperature and sea level rise were performed with MAGICC4 and MAGICC5 - in both WG1 and WG3

2007

IPCC Fourth Assessment Report

A range of reduced complexity models was used to assess mitigation scenarios in WG3, but most IAMs started to include MAGICC as its core (IMAGE, MESSAGE, etc.)

2013

IPCC Fifth Assessment Report

For the first time, a single consistent approach was chosen to assess all of the hundreds of scenarios in WG3 - using a single reduced complexity model: MAGICC6 based on the probabilistic methodology by Meinshausen et al. (2009).

2018

IPCC Special Report on 1.5

Again, the probabilistic MAGICC6 was used to assess and classify 1.5C scenarios - with other models providing sensitivity tests.

2021

IPCC AR6

Probabilistic MAGICC7 is being used to assess and classify AR6 pathways- with other models providing sensitivity tests.

MAGICC

MAGICC is a hemispheric, land/ocean model

- Best in class for global-mean probabilistic projections based on emissions pathways
- No regional information (e.g. no Australian temperatures)

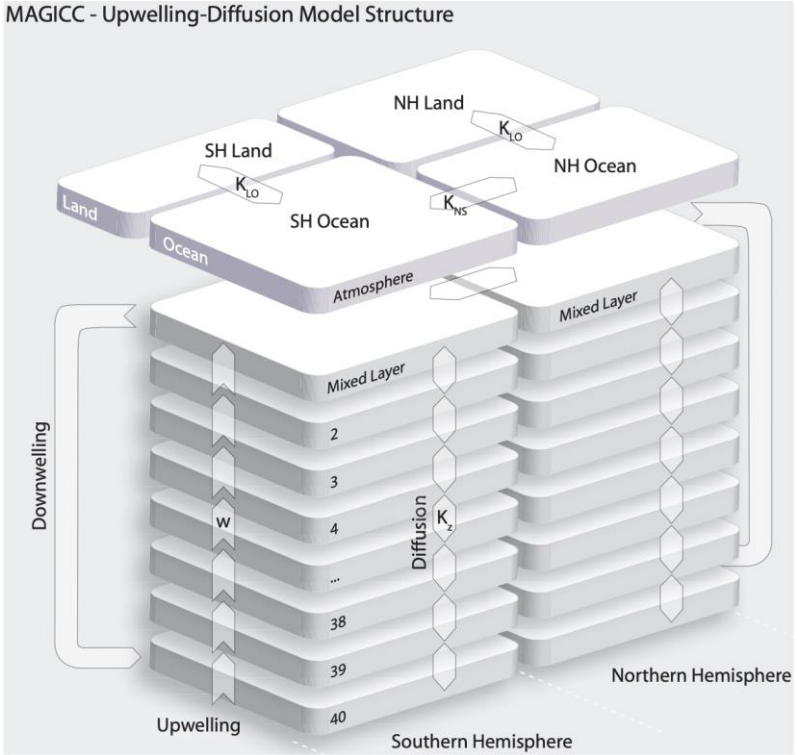


Fig. A1, Meinshausen et al., *GMD* 2011

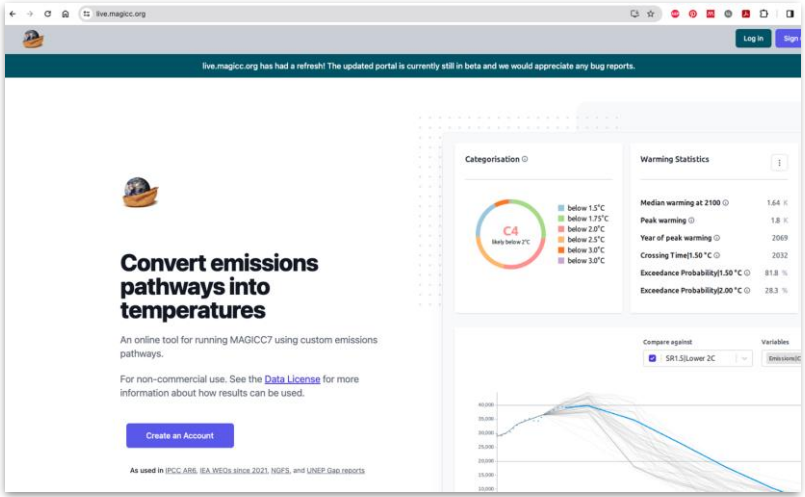
MAGICC - used for assessing 1.5C and Paris Agreement inter alia by…

- IEA (Word Energy Outlooks, Net-zero scenario)
- UNFCCC Synthesis reports
- IPCC WGIII scenario classification
- Countless scientific research projects

Open-source:

https://gitlab.com/magicc/magicc

Web-interface: https://live.magicc.org



Thank you.

MaREI
Energy · Climate · Marine

A World Leading SFI Research Centre

Science Foundation Ireland sfi For what's next

Overview of Research on Ireland's Power Sector

Paul Deane|
Senior Lecturer in Clean Energy Futures

HOST INSTITUTION

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

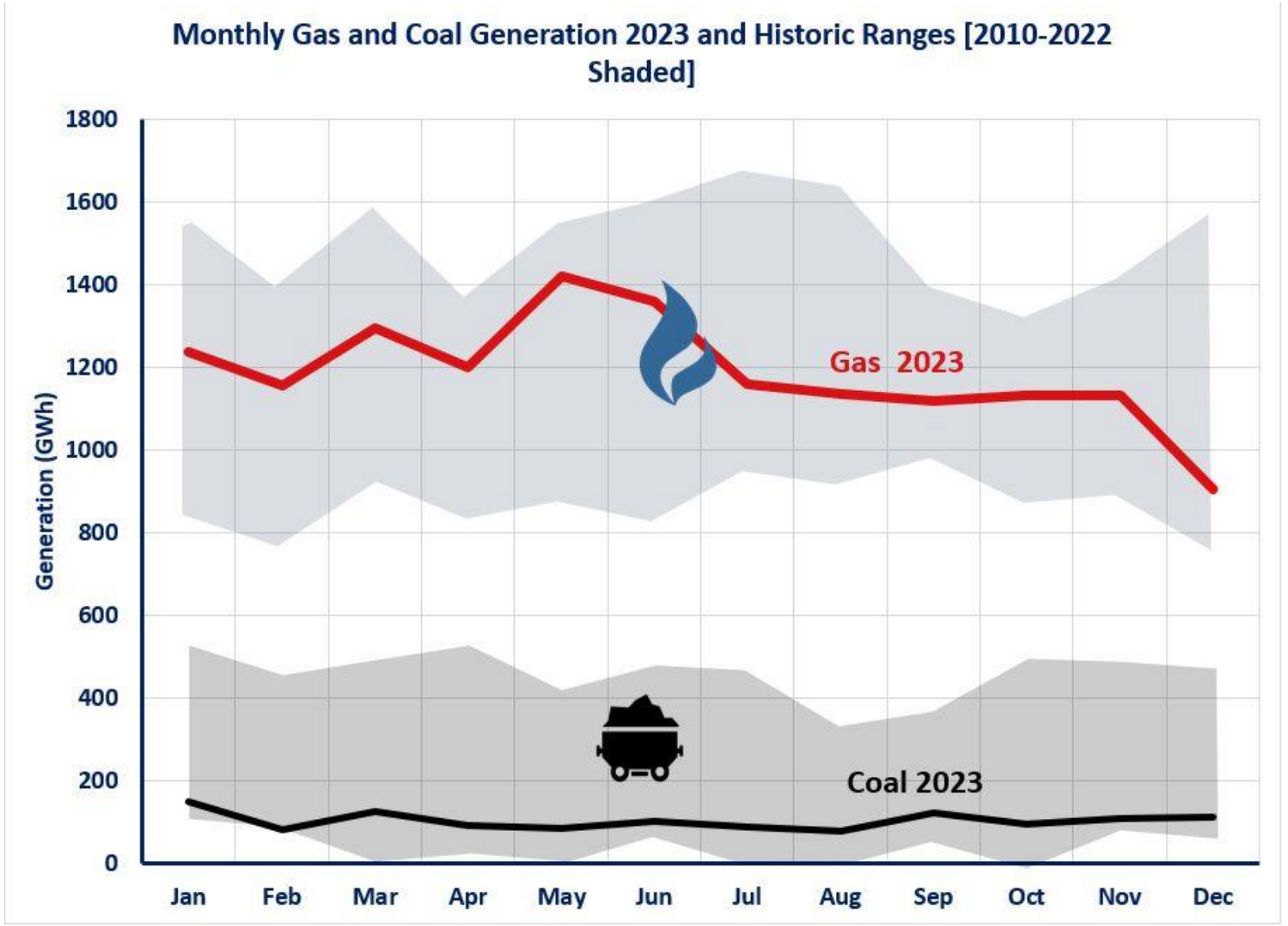
PARTNER INSTITUTIONS

CIT Cork Institute of Technology
DIAS
Dundalk Institute of Technology
ESRI Economic & Social Research Institute
Maynooth University
NUI Galway
Trinity College Dublin
DUBLIN
Tyndall National Institute
UCD Dublin
University of Limerick

FUNDED BY:

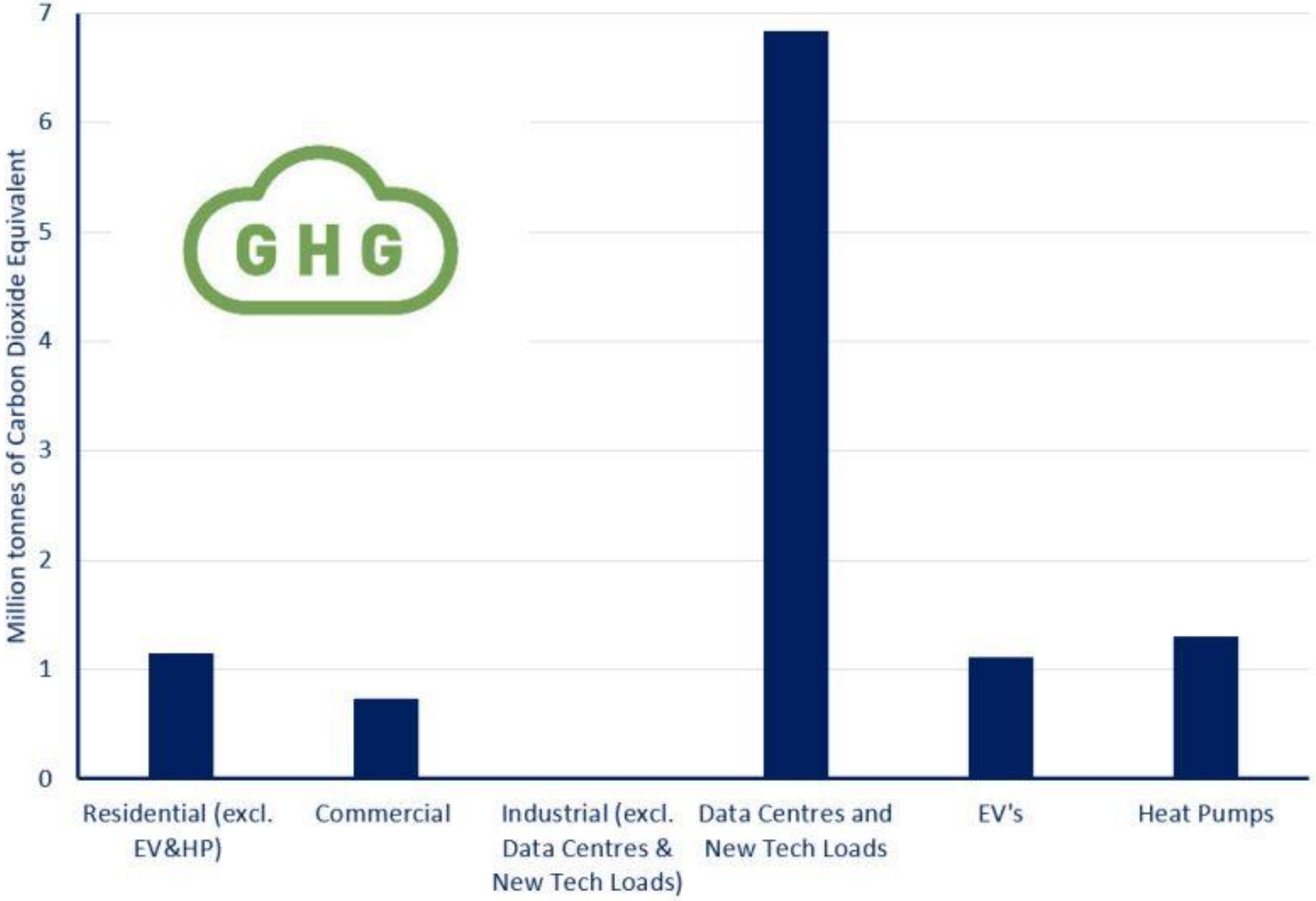
Ireland's European Structural and Investment Funds Programmes 2014-2020
European Union
European Regional Development Fund
Science Foundation Ireland sfi For what's next

Power Sector Sectorial Ceilings: We are doing much better than expected…but not as good as we hoped

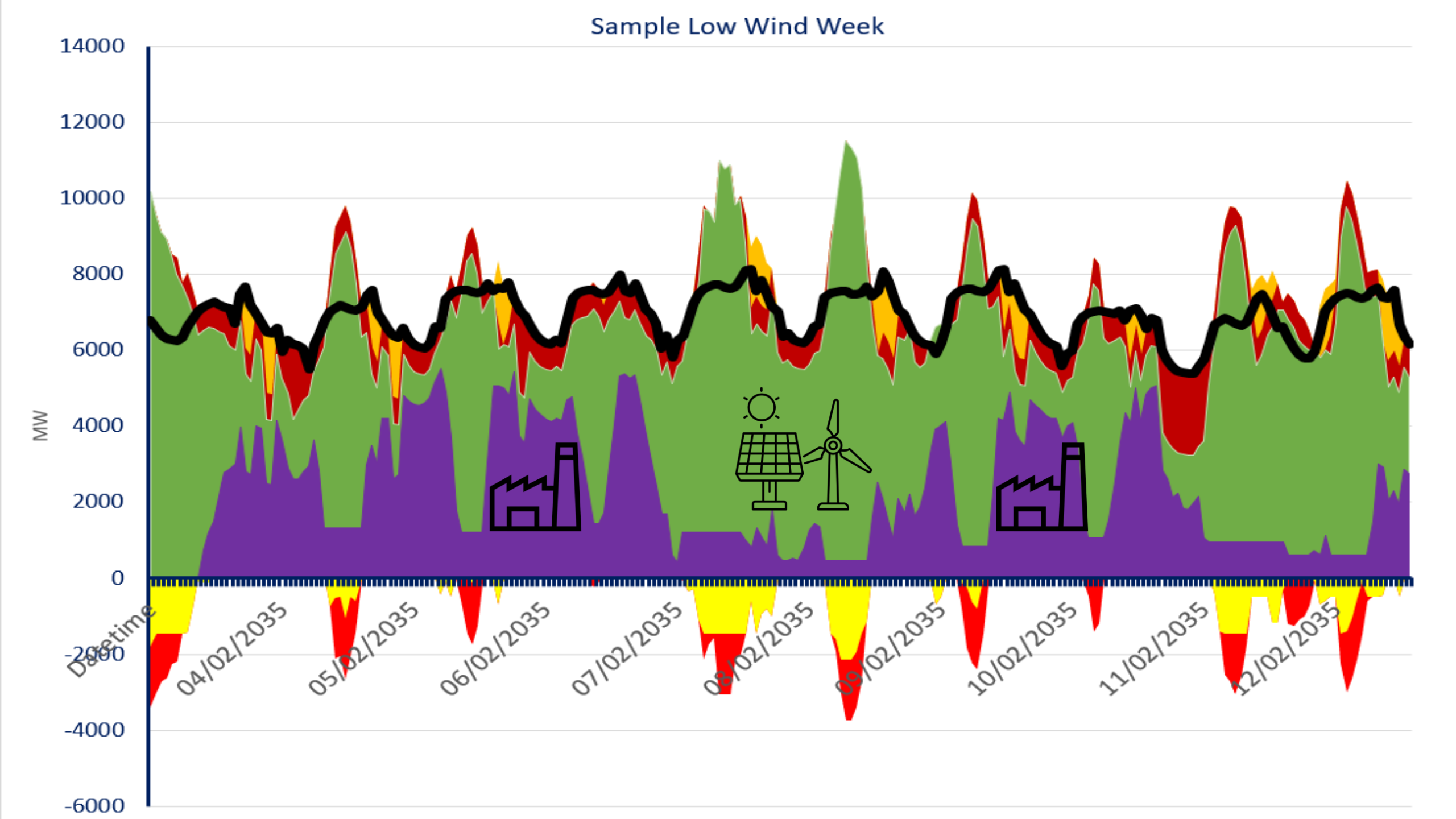

Monthly Gas and Coal Generation 2023 and Historic Ranges [2010-2022 Shaded]
Generation (GWh)
1800
1600
1400
1200
1000
800
600
400
200
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Gas 2023
Coal 2023

Power Sector Sectorial Ceilings: We cannot meet targets with medium/high demand growth from Data Centres

Ireland | Cumulative Greenhouse Gas Impact of New Electricity Loads to 2030



Power System Reliability| Operating the power system during times with 100% **renewable generation is key to reducing emissions**, beyond that being able to operate the system at times with close to **0% renewable generation is essential for reliability**

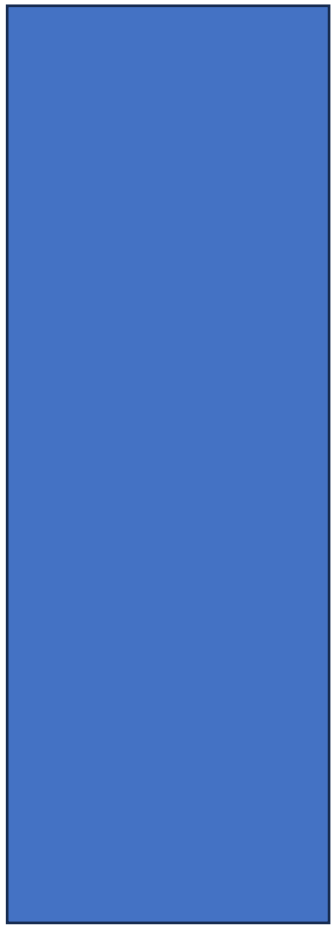

Sample Low Wind Week
14000
12000
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
MW
Datetime
04/02/2035
05/02/2035
06/02/2035
07/02/2035
08/02/2035
09/02/2035
10/02/2035
11/02/2035
12/02/2035

Key Points

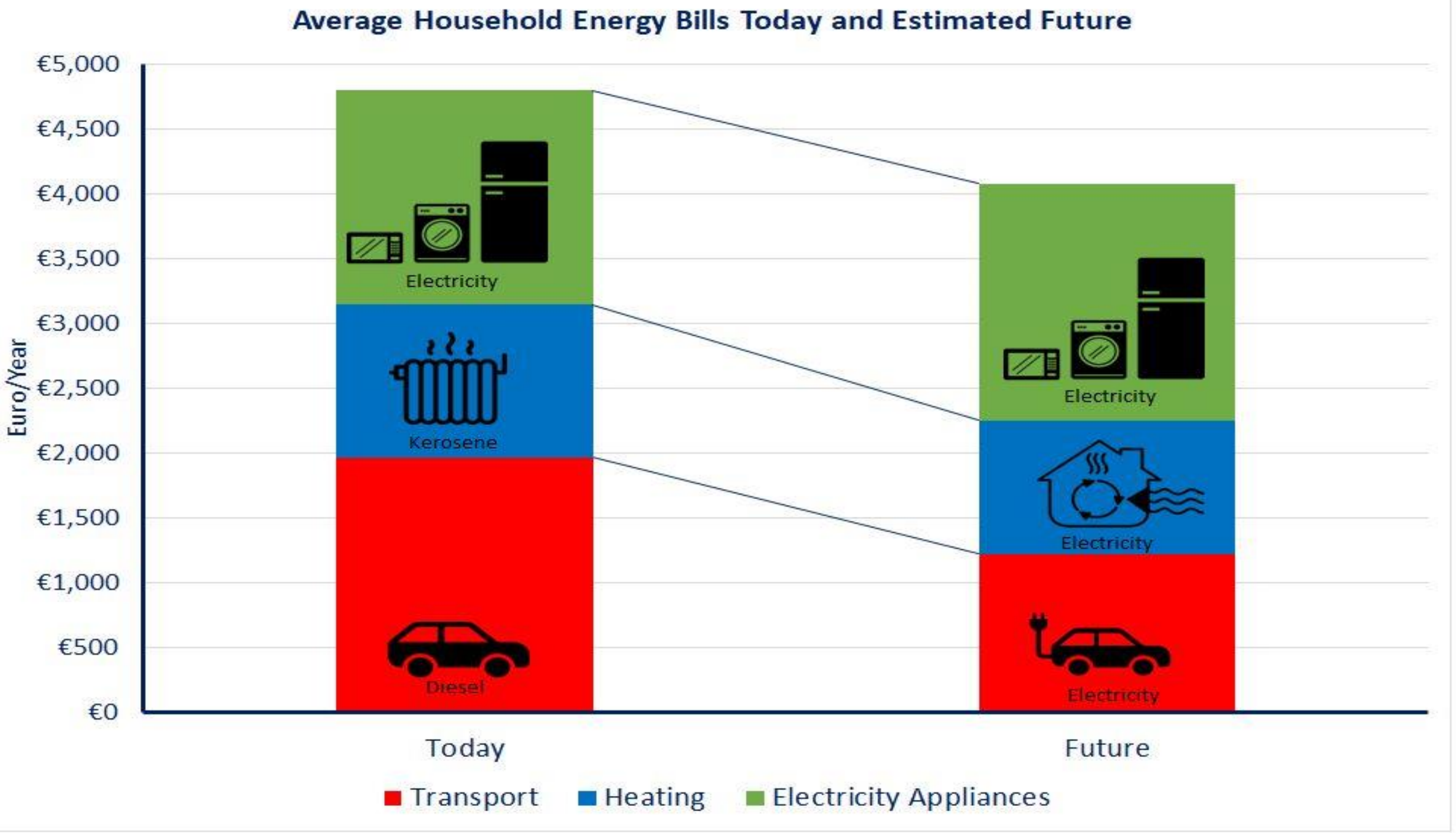
Strategic Storage as well as **Seasonal Storage** of zero carbon energy is needed in Ireland to deliver a reliable decarbonized energy system.

Power System Planning| We need a plan for a net zero power system by 2035 and understand how much grid is needed

From a Natural Gas to a Weather Driven System



In a well managed energy transition away from fossil fuels, electricity bills will go up, but energy bills will come down


Average Household Energy Bills Today and Estimated Future
€5,000
€4,500
€4,000
€3,500
€3,000
€2,500
€2,000
€1,500
€1,000
€500
€0
Euro/Year
Electricity
Kerosene
Diesel
Electricity
Electricity
Electricity
Today
Future
Transport
Heating
Electricity Appliances

Net Zero and Net Export| We need 10-15 GW of Offshore wind to meet Net-Zero targets, additional wind is for Net Export

Appendix of Results-Electricity Requirement and associated Offshore Capacity needed. All scenario assume 11.5 GW of onshore wind by 2050.

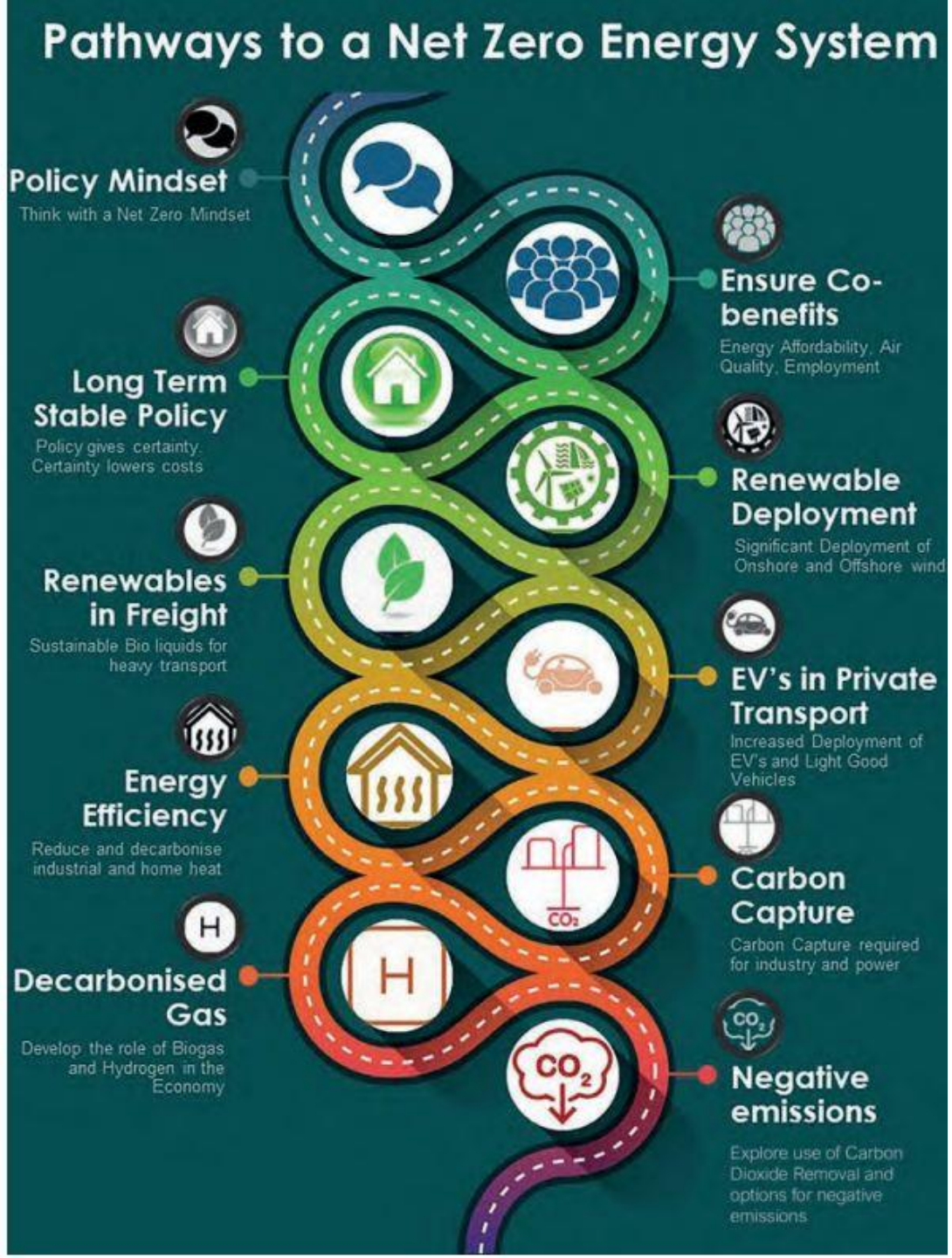
Note figures are ROI only.

Scenario	2020	2030	2040	2050	Unit
Electricity Needs (Max)	32	58	86	107	TWh
Electricity Needs (Min)	32	48	71	90	TWh
Electricity Needs (Low Demand)	32	40	48	53	TWh
Offshore Capacity (Max)	0	6	11	15	GW
Offshore Capacity (Min)	0	4	8	11	GW
Offshore Capacity (Low Demand)	0	2	3	4	GW

WIND ENERGY IRELAND

MaREI Energy · Climate · Marine

Both emissions **reductions**, and **removals** are needed


Pathways to a Net Zero Energy System
Policy Mindset
Think with a Net Zero Mindset
Long Term Stable Policy
Policy gives certainty. Certainty lowers costs
Renewables in Freight
Sustainable Bio liquids for heavy transport
Energy Efficiency
Reduce and decarbonise industrial and home heat
Decarbonised Gas
Develop the role of Biogas and Hydrogen in the Economy
Ensure Co-benefits
Energy Affordability, Air Quality, Employment
Renewable Deployment
Significant Deployment of Onshore and Offshore wind
EV's in Private Transport
Increased Deployment of EV's and Light Good Vehicles
Carbon Capture
Carbon Capture required for industry and power
Negative emissions
Explore use of Carbon Dioxide Removal and options for negative emissions

The EU Climate target for 2040

presentation to Ireland Climate Change Advisory Council: Carbon Budgets Working Group

29 February 2024

Miles Perry
European Scientific Advisory Board on Climate Change, secretariat

The Advisory Board

European Scientific Advisory Board on Climate Change

Ottmar Edenhofer
(Chair)
Technische Universität in Berlin

Jette Bredahl Jacobsen
(Vice-Chair)
University of Copenhagen

Laura Diaz Anadon
(Vice-Chair)
University of Cambridge

Maarten Van Aalst
University of Twente

Constantinos Cartalis
National and Kapodistrian University of Athens

Suraje Dessai
University of Leeds

Vera Eory
Scotland's Rural College

Edgar Hertwich
Norwegian University of Science and Technology in Trondheim

Lena Kitzing
Technical University of Denmark

Elena Lopez-Gunn
ICATALIST

Lars J. Nilsson
Lund University

Keywan Riahi
International Institute for Applied Systems Analysis

Joeri Rogelj
Grantham Institute of the Imperial College London

Nicolaas Schrijver
Leiden University

Jean-François Soussana
French National Research Institute for Agriculture, Food…

Update on Advisory Board activities in 2024

European Scientific Advisory Board on Climate Change

Main activities outlined in the 2024 work programme:

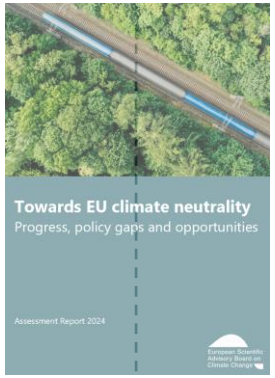
- EU 2040 target – follow up on the Advisory Board's contribution of June 2023 and the (upcoming) European Commission's communication
- Towards EU climate neutrality: progress, policy gaps and opportunities
- Carbon dioxide removals in the EU
- Strengthening climate mitigation and resilience of EU agriculture
- Climate adaptation and resilience
- Scenarios for the planning and development of EU's energy-system wide infrastructure
- Expert and stakeholder engagement

The intersection of two policy cycles

European Scientific Advisory Board on Climate Change

2030 policy framework: from legislation to implementation

Climate target plan 2030 → Fit for 55 proposals → Legislative process → Implementation

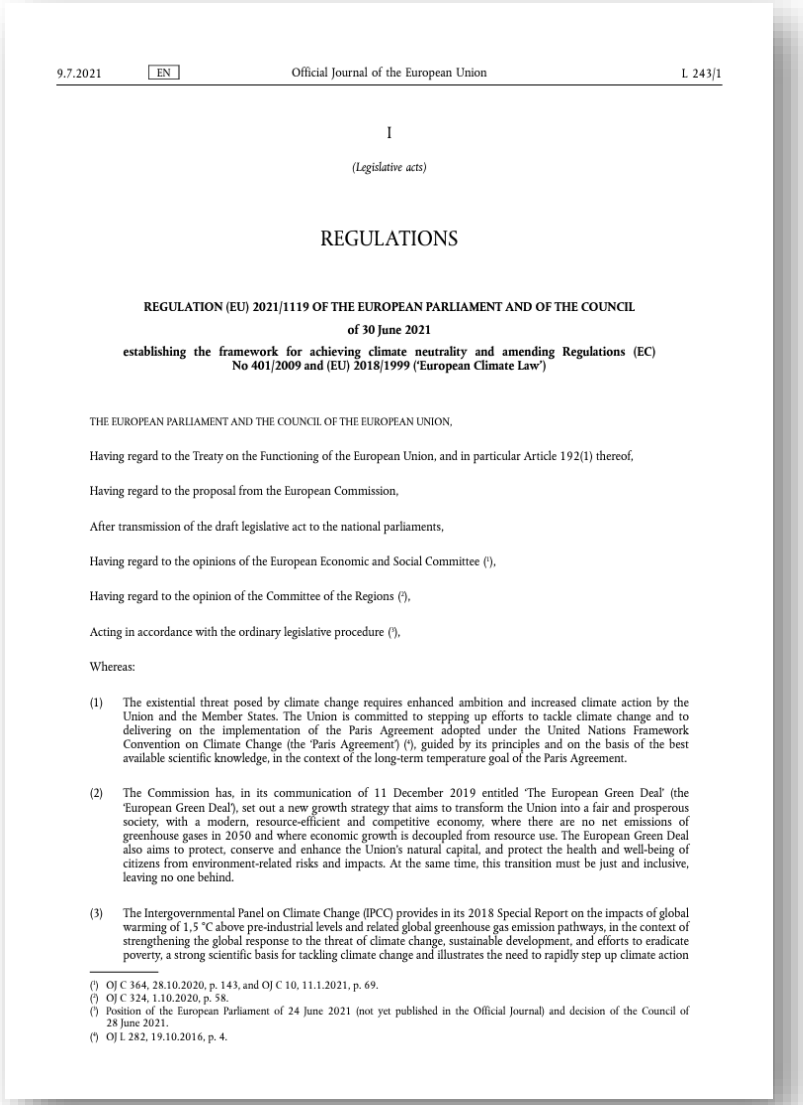


2040 public consultation → 2040 Communication → Climate target plan 2040 → Legal proposals

Post-2030 policy framework: discussion on 2040 target ongoing

EU climate objectives in the European Climate Law

European Scientific Advisory Board on Climate Change



9.7.2021 EN Official Journal of the European Union L 243/1

I

(Legislative acts)

REGULATIONS

REGULATION (EU) 2021/1119 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 30 June 2021

establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law')

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 192(1) thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinions of the European Economic and Social Committee [1],

Having regard to the opinion of the Committee of the Regions [2],

Acting in accordance with the ordinary legislative procedure [3],

Whereas:

(1) The existential threat posed by climate change requires enhanced ambition and increased climate action by the Union and the Member States. The Union is committed to stepping up efforts to tackle climate change and to delivering on the implementation of the Paris Agreement adopted under the United Nations Framework Convention on Climate Change (the 'Paris Agreement') [4], guided by its principles and on the basis of the best available scientific knowledge, in the context of the long-term temperature goal of the Paris Agreement.

(2) The Commission has, in its communication of 11 December 2019 entitled 'The European Green Deal' (the 'European Green Deal'), set out a new growth strategy that aims to transform the Union into a fair and prosperous society, with a modern, resource-efficient and competitive economy, where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use. The European Green Deal also aims to protect, conserve and enhance the Union's natural capital, and protect the health and well-being of citizens from environment-related risks and impacts. At the same time, this transition must be just and inclusive, leaving no one behind.

(3) The Intergovernmental Panel on Climate Change (IPCC) provides in its 2018 Special Report on the impacts of global warming of 1,5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty, a strong scientific basis for tackling climate change and illustrates the need to rapidly step up climate action

[1] OJ C 364, 28.10.2020, p. 143, and OJ C 10, 11.1.2021, p. 69.
[2] OJ C 324, 1.10.2020, p. 58.
[3] Position of the European Parliament of 24 June 2021 (not yet published in the Official Journal) and decision of the Council of 28 June 2021.
[4] OJ L 282, 19.10.2016, p. 4.

In pursuit of the **Paris Agreement temperature goal**:

- EU climate neutrality by **2050**
- 55% net reduction by **2030** compared to 1990

European Commission to propose a milestone **2040 target** (and indicative **2030-2050 emissions budget**):

- within 6 months of first Global Stocktake
- considering the best available and most recent scientific evidence, **including reports of the IPCC and the Advisory Board**

1.5 °C, ‘North Star’ of the Paris Agreement Global Stocktake

European Scientific Advisory Board on Climate Change

The Conference of the Parties

(…)

*Underscores that the **impacts** of climate change will be **much lower** at the temperature increase of **1.5 °C** compared with 2 °C*

*and resolves to pursue efforts to **limit the temperature increase to 1.5 °C***

#1

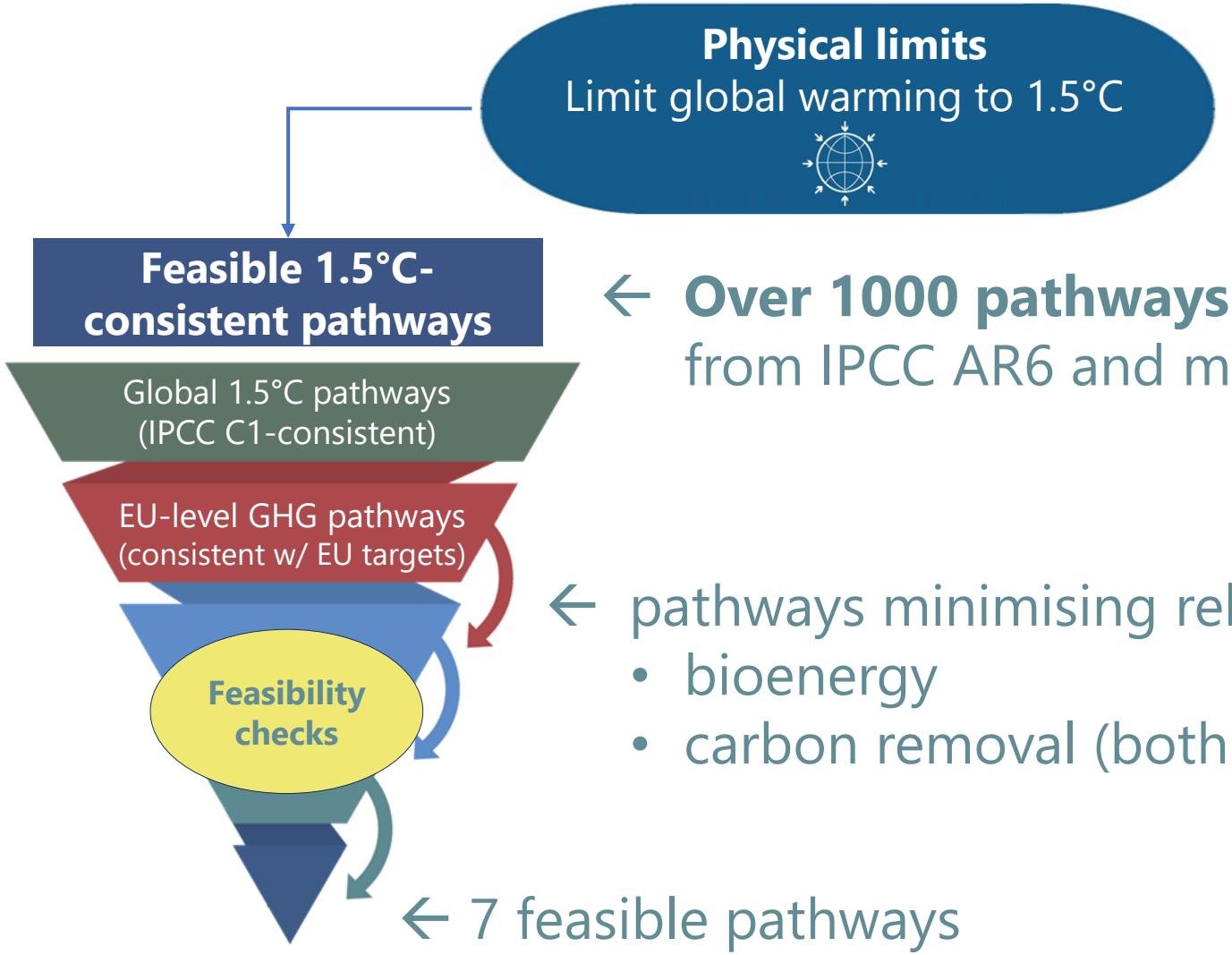
The Advisory Board recommends keeping the EU's greenhouse gas emissions **budget** within a limit of **11 to 14 Gt CO_2e** between 2030 and 2050.

Staying within this budget requires emission reductions of **90–95% by 2040**, relative to 1990.

This range considers multiple dimensions of **fairness and feasibility** of the emission reductions.

EU Advisory Board advice: feasible target ranges

European Scientific Advisory Board on Climate Change



← **Over 1000 pathways** considered, including from IPCC AR6 and more recent pathways

← pathways minimising reliance on:

- bioenergy
- carbon removal (both land sink and CCUS)

← 7 feasible pathways

➔ **Feasible range for 2040: 88% to 95% net reductions** vs 1990

Feasibility: implied EU GHG emission budgets for 2030-2050 and 2040 reductions by different ranges of scenarios

European Scientific Advisory Board on Climate Change

Range of scenarios	Number of scenarios	Implied range for an EU budget for 2030-2050 (Gt CO_2e)	Implied range for an EU 2040 reduction target (% reduction vs. 1990)
Scenarios	36	8-19	83-96%
within **environmental risk levels** (less reliance on CCUS, carbon removals from land, and bioenergy)	7	11-16	88-95%
within environmental risk levels **and technological deployment challenge levels** (more cautious scale-up of non-biomass renewables)	5	13-16	88-92%

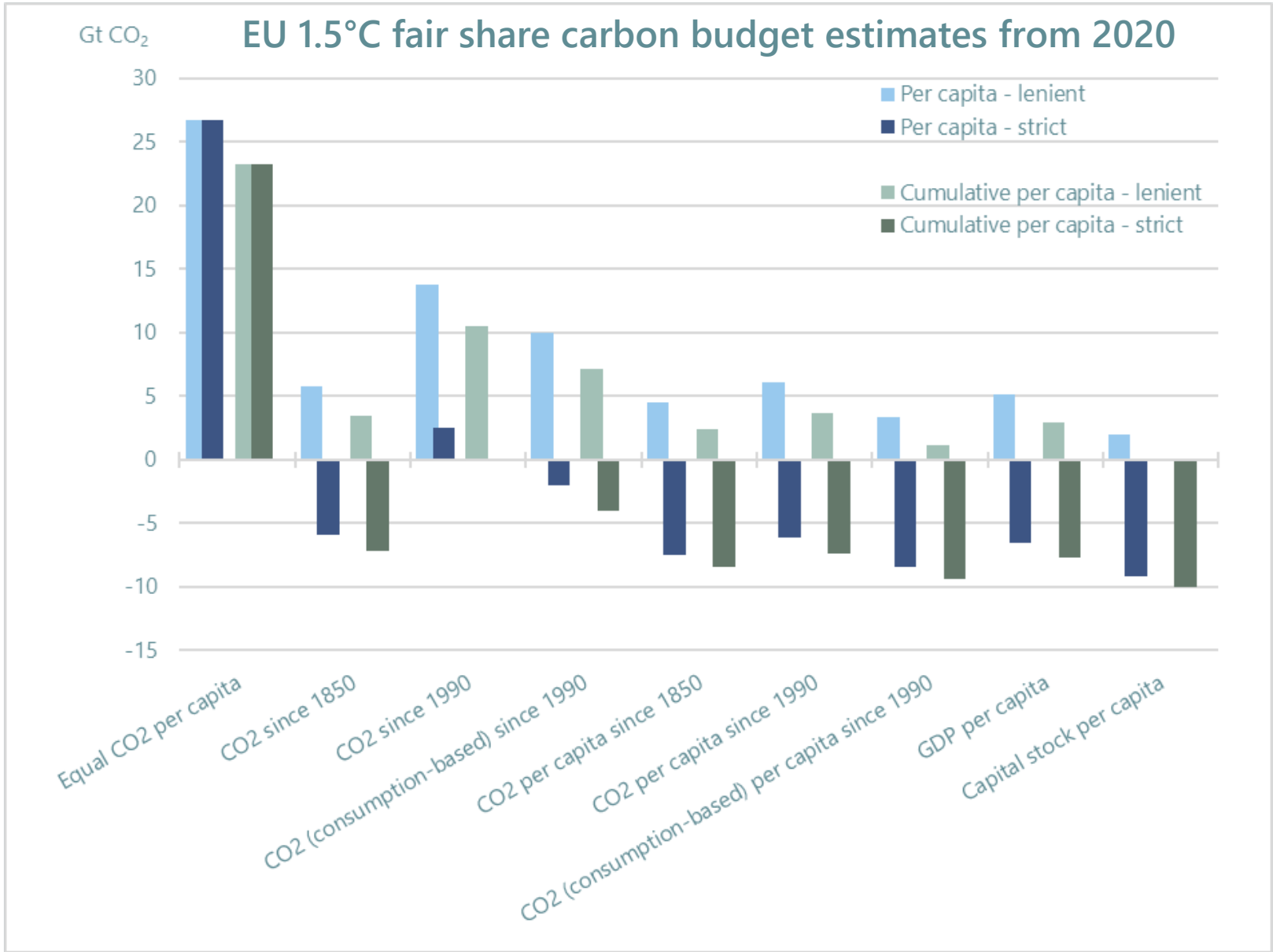
EU Advisory Board advice: applying fairness principles

European Scientific Advisory Board on Climate Change

- **1.5°C 'fair share' budgets:**
  - principles and approaches from scientific literature (IPCC)
  - applied to EU and all world regions
  - calculated separately from feasibility

- Fair share estimates vary…
  …but all are smaller than the feasible budgets

➔ **High domestic ambition as a minimum**



Feasibility and fairness

	2040 reduction	2030-2050 budget
*Range informed by **feasibility***		
Achieving the more ambitious end of this range implies challenging levels of energy technology scale-up	88% **to 95%**	**11** to 16 Gt CO_2e
*Minimum ambition informed by **fair share** estimates*		
Emissions in the climate neutrality pathways exceed equity-based fair share estimates	**At least 90%**	**Up to 14** Gt CO_2e

-90% to -95% by 2040

#2

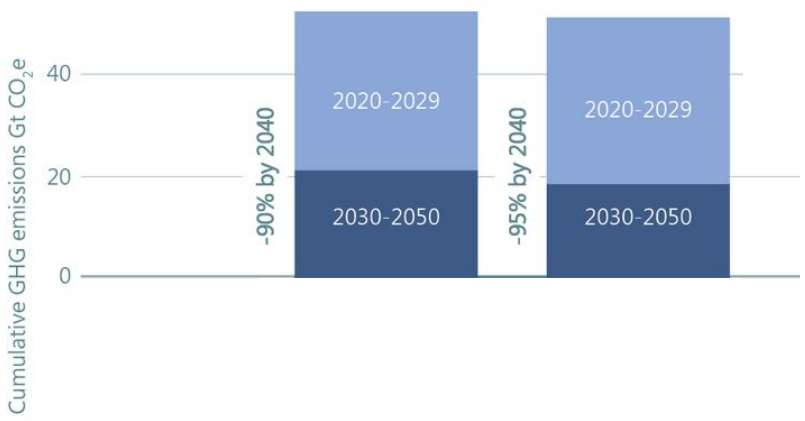
Pursuing the **more ambitious end** of the 2040 target range improves the **fairness** of the EU's contribution.

Ambitious domestic emission reductions need to be complemented by **measures outside the EU** to achieve a fair contribution to climate change mitigation.

Reconciling feasible and fair EU contributions to global climate change mitigation

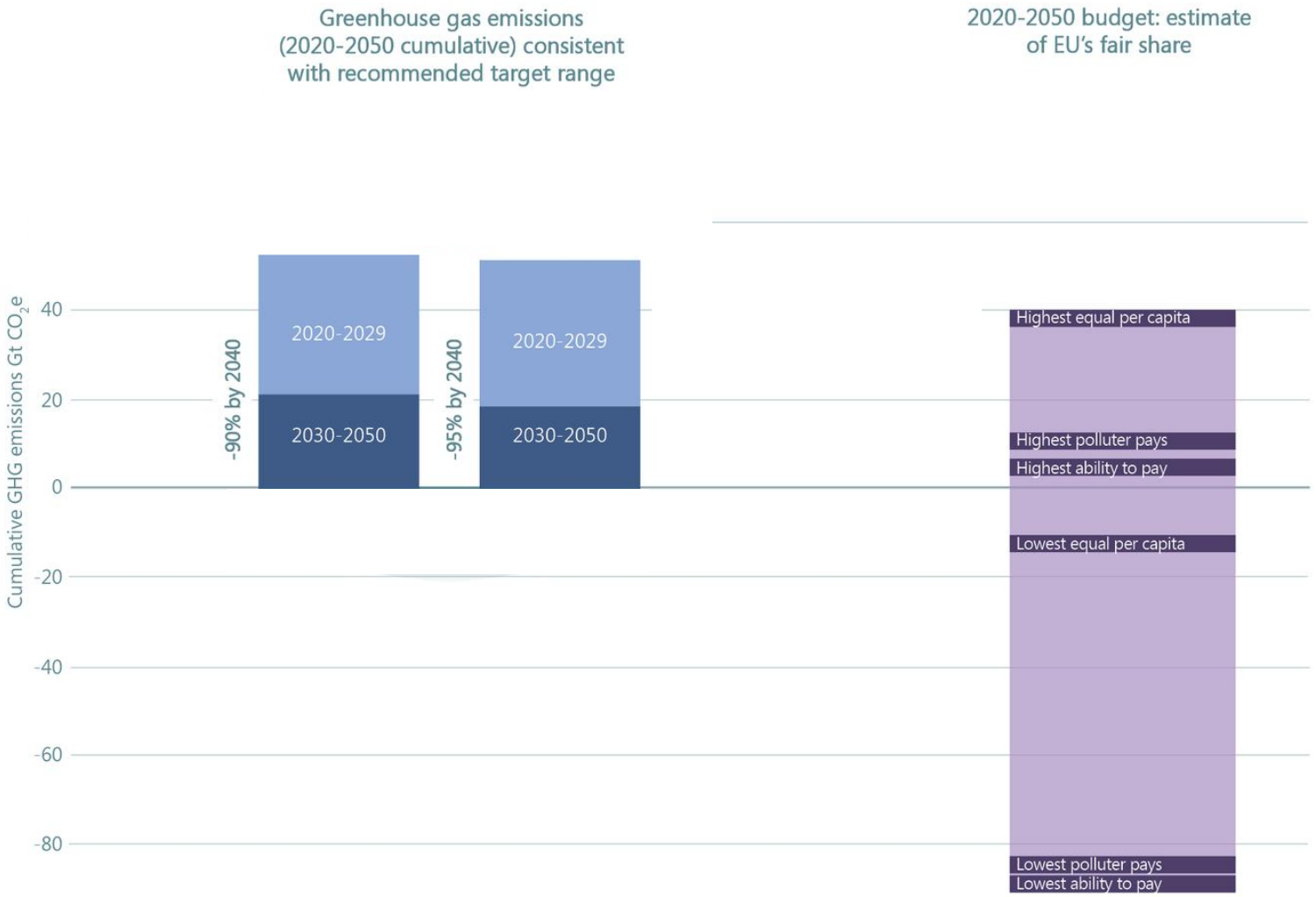
European Scientific Advisory Board on Climate Change

Greenhouse gas emissions (2020-2050 cumulative) consistent with recommended target range



Reconciling feasible and fair EU contributions to global climate change mitigation

European Scientific Advisory Board on Climate Change



Reconciling feasible and fair EU contributions to global climate change mitigation

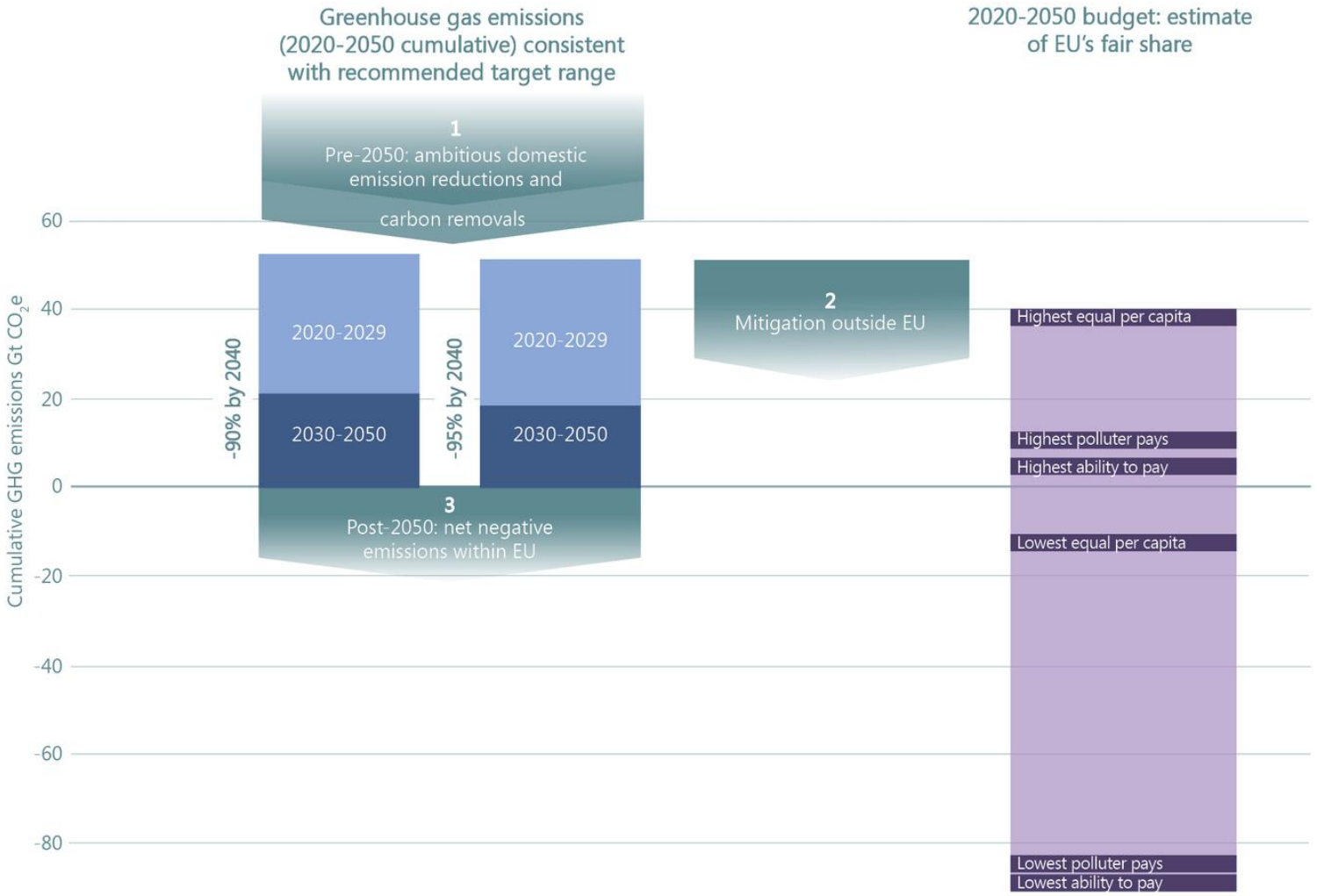
European Scientific Advisory Board on Climate Change

Reconciling feasible and fair EU contributions to global climate change mitigation

European Scientific Advisory Board on Climate Change

Reconciling feasible and fair EU contributions to global climate change mitigation

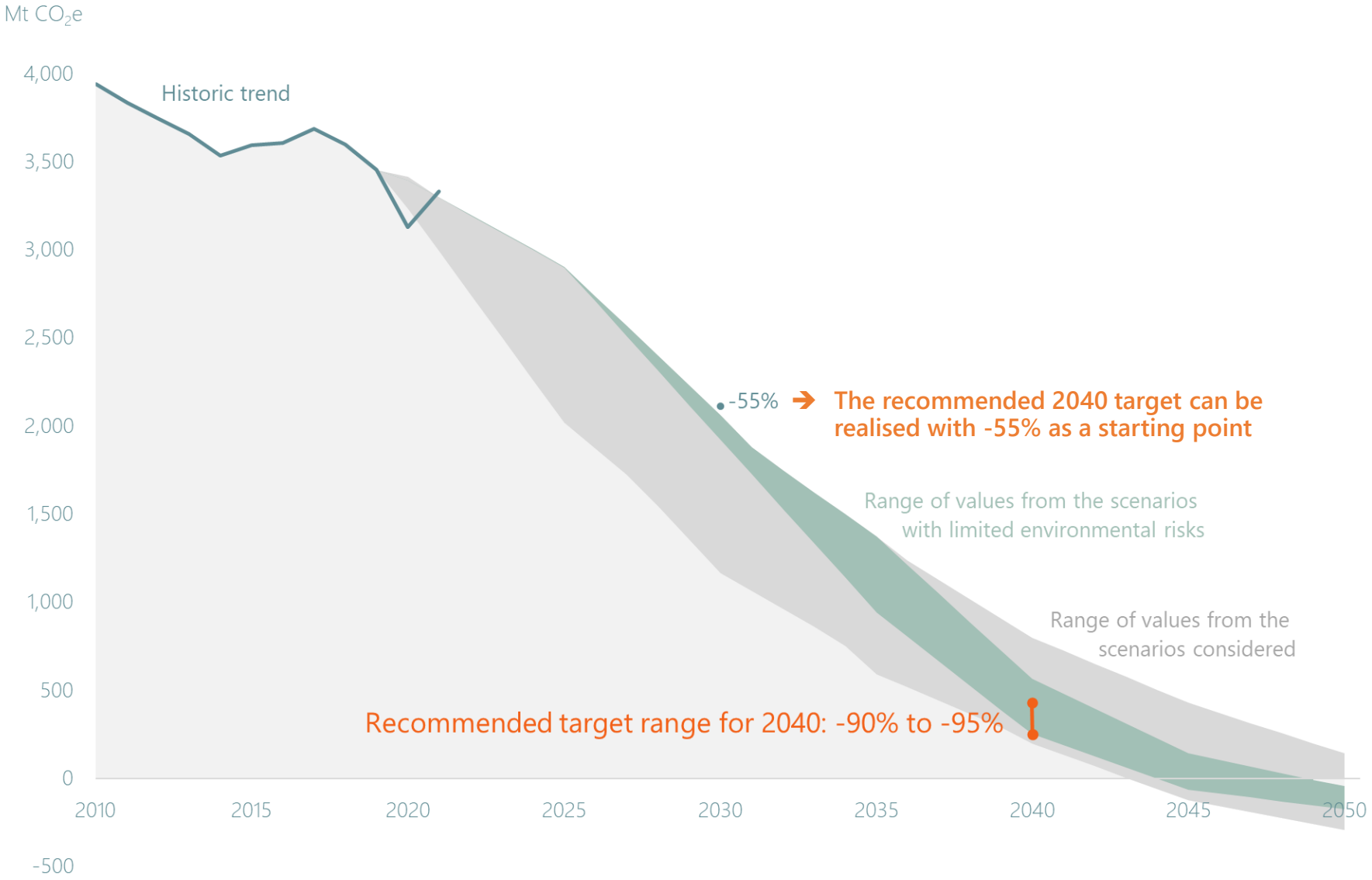
European Scientific Advisory Board on Climate Change



#3

The **EU 2030 target of at least 55%** reduction compared to 1990 **enables reaching the recommended 2040 target range** and climate neutrality by 2050.

55% is an appropriate milestone towards climate neutrality



#4, #5

The recommended 2040 target requires **rapid, inclusive and well-managed transitions** to address **environmental risks** and **technology scale-up challenges**.

Achieving climate neutrality within the EU is to be supported through **investments in innovation** and **wider capacity development**.

#6

The required transitions can be achieved by distinct **combinations of demand management and technology deployment**.

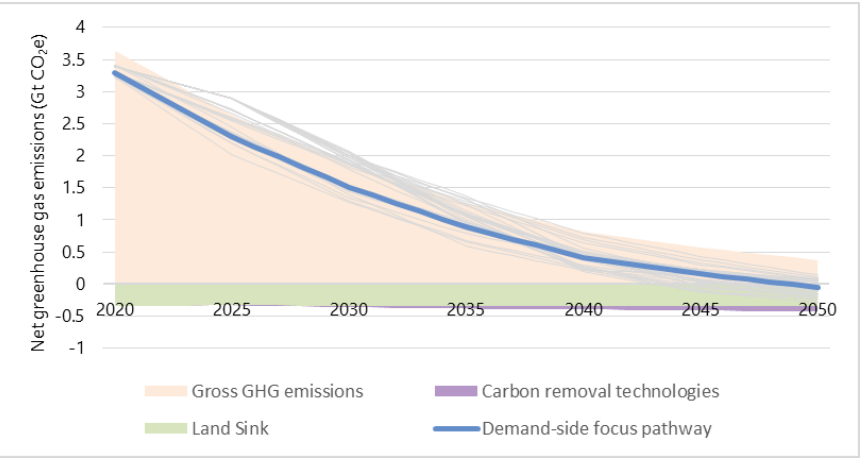
Compared to pathways that prioritise supply-side technological solutions, **pathways with lower energy and natural resource use**:

- advance progress on the Sustainable Development Goals,
- enhance energy security,
- lower other risks.

Iconic pathways illustrating choices and strategies to achieve climate neutrality by 2050

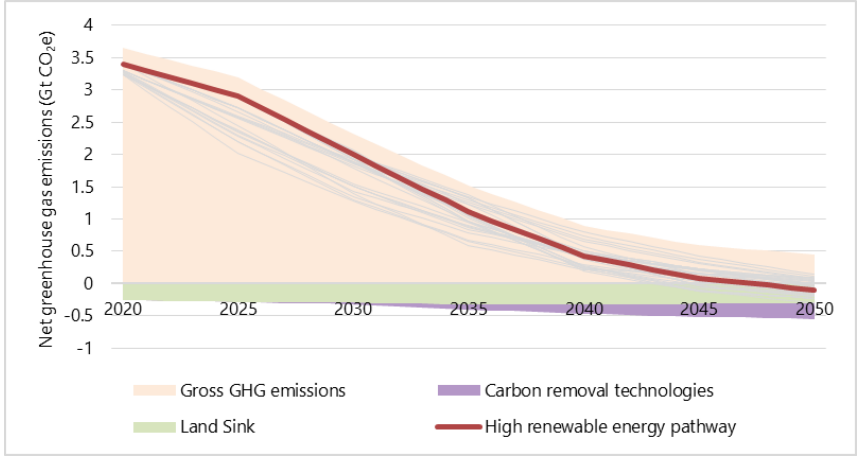
European Scientific Advisory Board on Climate Change

Demand-side focus pathway



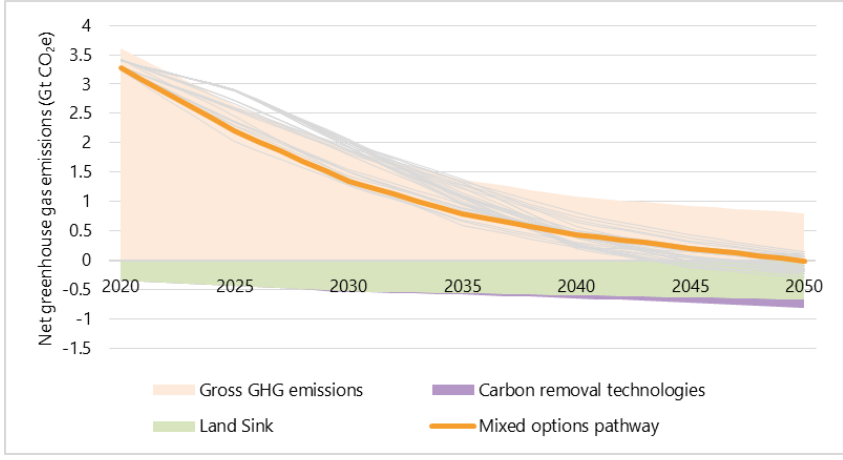
- Less resource-intensive lifestyles
- Lowest final energy demand in 2040
- Lowest reliance on carbon removals (from CCS and the land sink combined) by 2050

High renewable energy pathway



- Largest greenhouse gas budget
- High renewable energy deployment
- Highest deployment of non-biomass renewable energy
- Highest rate of electrification by 2040

Mixed options pathway



- Lowest cumulative emissions in the 2030-2050 period
- Greatest deployment of carbon removals (with specific focus on sustainable land-based removals)
- Increase in the contribution of nuclear power over time (as opposed to the two other iconic pathways)

#7

There are **different pathways** to achieve climate neutrality. **Decisive choices** between various policy options therefore have to be made.

Common features shown in the assessed scenarios could helpfully guide further policy developments.

Key common features of the scenarios underpinning the recommended reduction

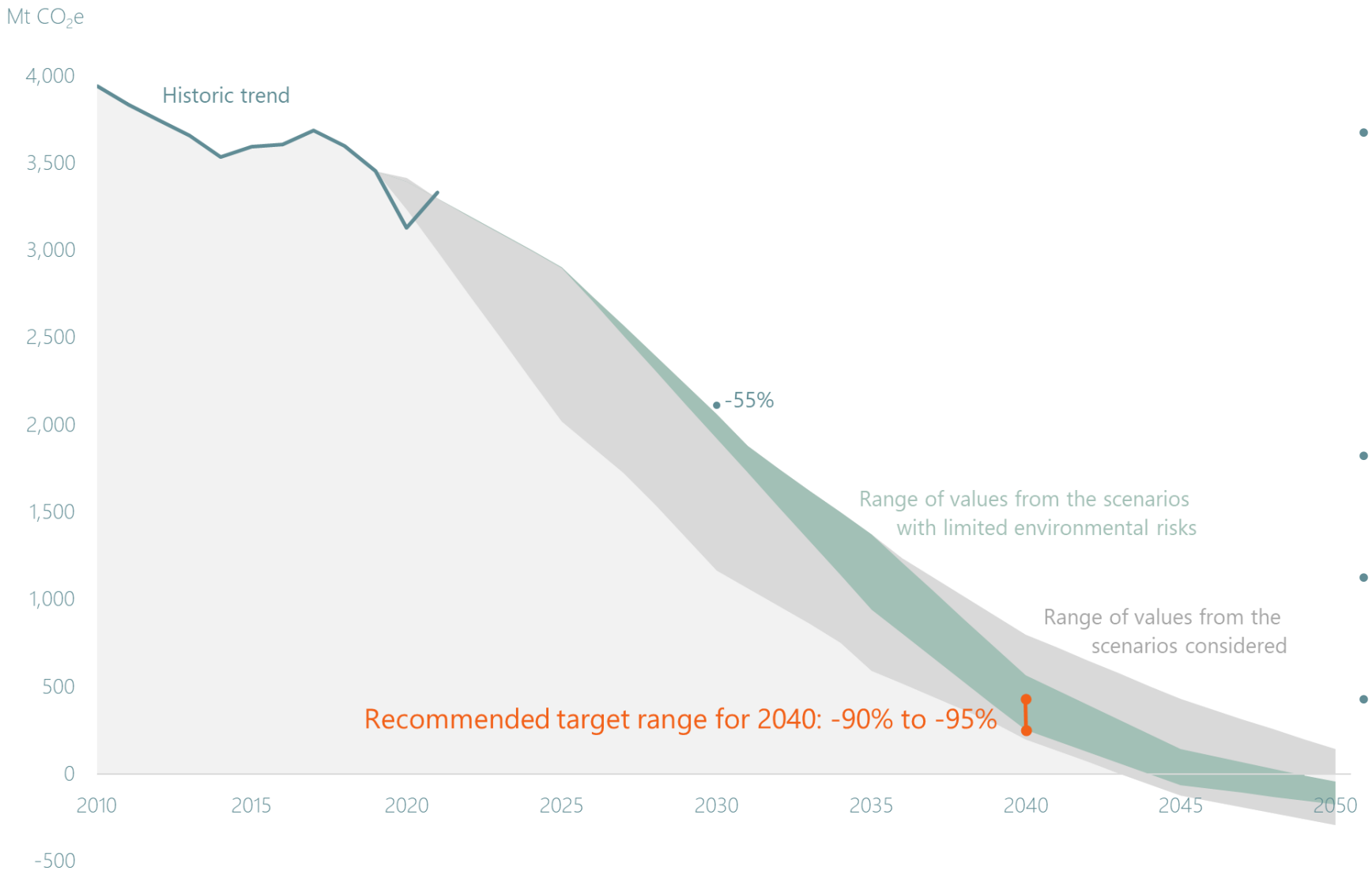
European Scientific Advisory Board on Climate Change

- Decarbonisation of the power sector
- Electrification and energy efficiency reduce total energy demand
- Reduction of non-CO_2 emissions
- Scale up of carbon removals, mindful of their risks and limitations

Conclusions

EU emissions pathways

European Scientific Advisory Board on Climate Change



- **EU domestic reductions of 90% to 95% are feasible**
  but insufficient for a *fair* budget

- **Bridging the fairness gap** requires:
  1. **Pre-2050**: ambitious domestic emission reductions and carbon removals
  2. Mitigation **outside EU**
  3. **Post-2050**: net negative emissions within the EU

- **Short-term measures** can further decrease cumulative emissions

- Multiple **benefits of climate action**: health, air quality, energy security

- The transition must be **rapid, inclusive and well-managed**

Thank you

secretariat.advisoryboard@esabcc.europa.eu

https://climate-advisory-board.europa.eu

European Scientific Advisory Board on Climate Change

Additional slides:

Towards EU climate neutrality: progress, policy gaps and opportunities

European Scientific Advisory Board on Climate Change

A report at the intersection of two policy cycles

European Scientific Advisory Board on Climate Change

2030 policy framework: from legislation to implementation

Climate target plan 2030 → Fit for 55 proposals → Legislative process → Implementation

2040 public consultation → 2040 Communication → Climate target plan 2040 → Legal proposals

Post-2030 policy framework: discussion on 2040 target ongoing

A report on policy consistency and opportunities

European Scientific Advisory Board on Climate Change

The report identifies:

- **needs**: what needs to happen for the EU to remain on track to climate targets?

- **gaps**: are there any gaps in the current policy framework?
    - **policy gap** = no policy in place
    - **ambition gap** = policy in place but insufficiently ambitious
    - **implementation gap** = ambitious policy in place but poor implementation
    - **policy inconsistency** = policy in place is counterproductive

- **recommendations** to address these gaps

I. Short-term actions to support -55%

European Scientific Advisory Board on Climate Change

	Now or well before 2030	By 2031 at the latest
Towards a 55% net reduction by 2030	a. **Implement Fit for 55** fully and swiftly b. Conclude revision of the **Energy Taxation** Directive and other **European Green Deal** initiatives c. Provide **stable investment outlook** for renewables d. Phase out **fossil fuel subsidies**	
Towards net zero by 2050	II. Short-term actions to support the achievement of the climate neutrality objective (5 recommendations)	III. Actions to be prepared for implementation by 2031 to support the achievement of the climate neutrality objective (4 recommendations)

II. Short-term actions to support net-zero

European Scientific Advisory Board on Climate Change

Now or well before 2030 → **By 2031 at the latest**

Towards a 55% net reduction by 2030

Towards net zero by 2050

I. Short-term actions to support the achievement of the -55% objective by 2030 (4 recommendations)

a. Align EU policies with a **phase-out of fossil fuels** (by 2040 for public electricity and heat generation)
b. Assess and address **socio-economic impacts** of climate policies
c. Align the **common agricultural policy** with climate objectives
d. Target **deployment of carbon capture and utilisation or storage, hydrogen, and bioenergy** towards activities with no or limited alternatives
e. Support **public and private climate investments**

III. Actions to be prepared for implementation by 2031 to support the achievement of the climate neutrality objective (4 recommendations)

III. Actions to prepare for implementation by 2031

European Scientific Advisory Board on Climate Change

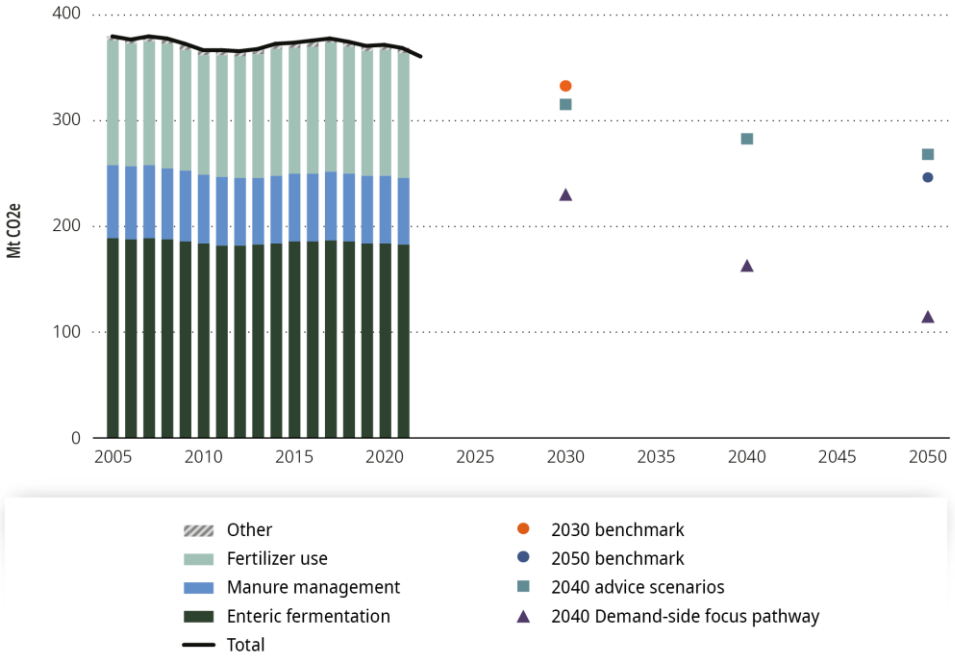
	Now or well before 2030	By 2031 at the latest
Towards a 55% net reduction by 2030	I. Short-term actions to support the achievement of the -55% objective by 2030 (4 recommendations)	
Towards net zero by 2050	II. Short-term actions to support the achievement of the climate neutrality objective (5 recommendations)	

a. Strengthen **governance and compliance** frameworks
b. Make **EU emissions trading systems** fit for net zero
c. Address **energy and material demand**
d. Expand **emissions pricing** to all major sectors (especially agriculture/food and LULUCF) and **incentivize carbon removals**

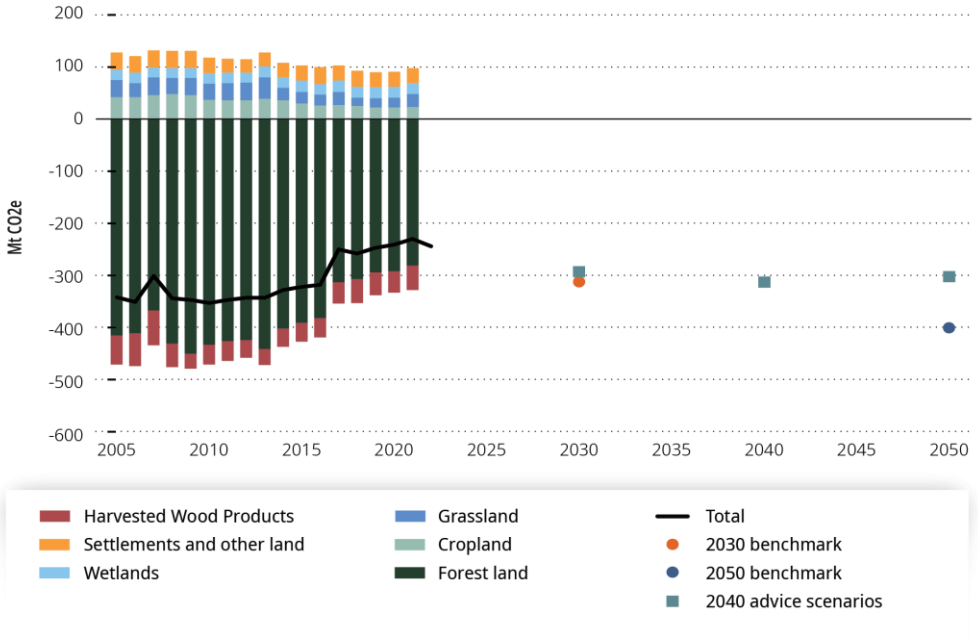
European Scientific Advisory Board on Climate Change

III.d Expand GHG pricing to all major sectors and provide incentives for carbon removals

No structural GHG reductions in agriculture since 2005



Rapid decline of the EUs' net carbon sink since 2010



Source: Advisory Board based on GHG inventories , European Commission scenarios and Advisory Board advice for a 2040 reduction target

- Insufficient incentives for climate action in these sectors:
  - → **Agriculture and LULUCF**: consider **pricing emissions and rewarding removals**, considering these sectors' specificities (e.g. monitoring challenges, permanent vs. non-permanent carbon removals)
  - → **Fossil fuel industries**: consider expanding EU ETS and CBAM to **fugitive CH_4 emissions**

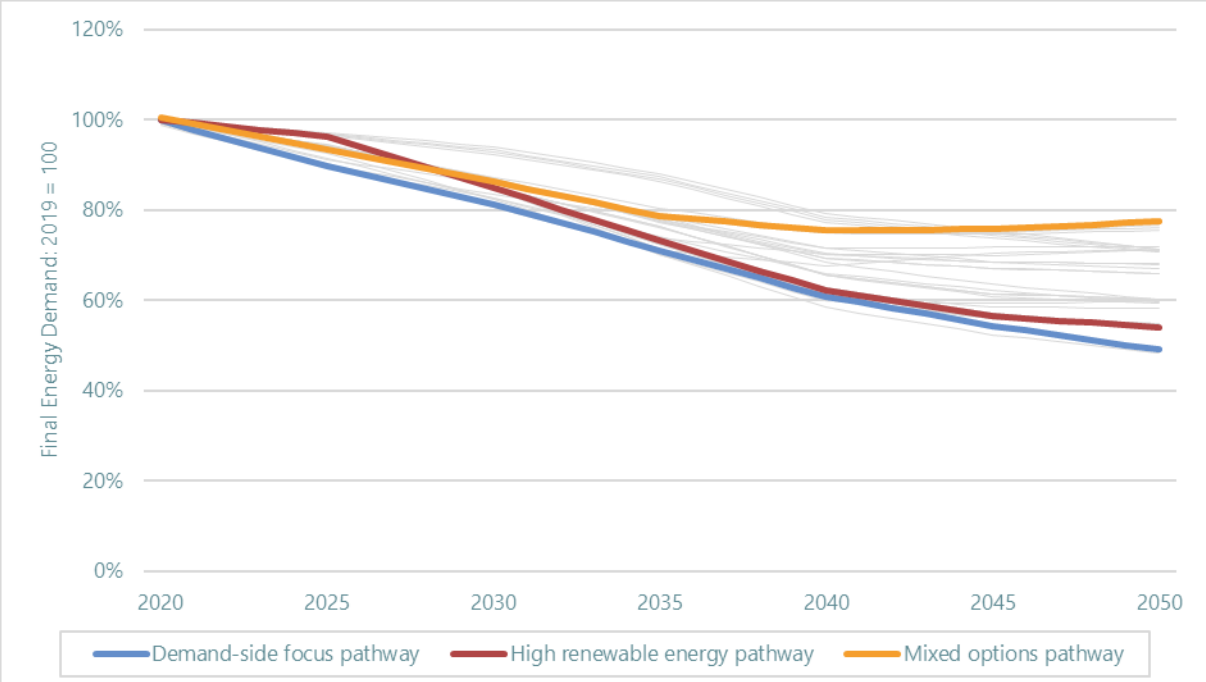
Additional slides

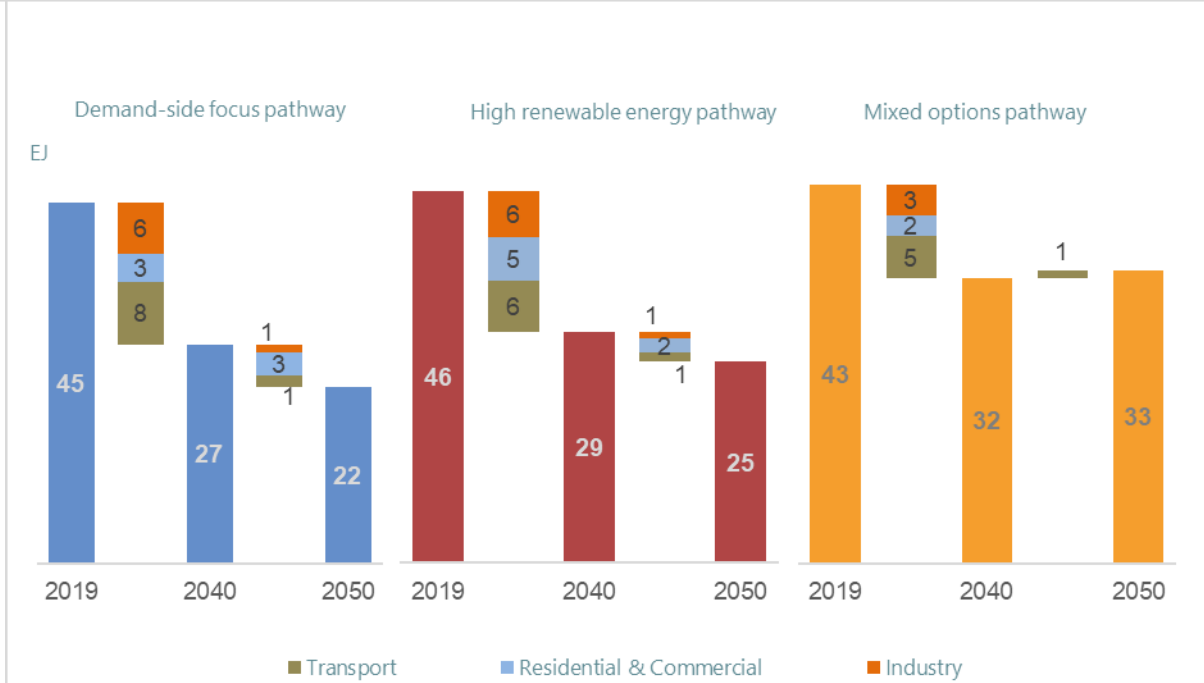
Key trends in the 2040 advice scenarios

Reduction of total energy demand

European Scientific Advisory Board on Climate Change

Change in final energy demand in iconic pathways





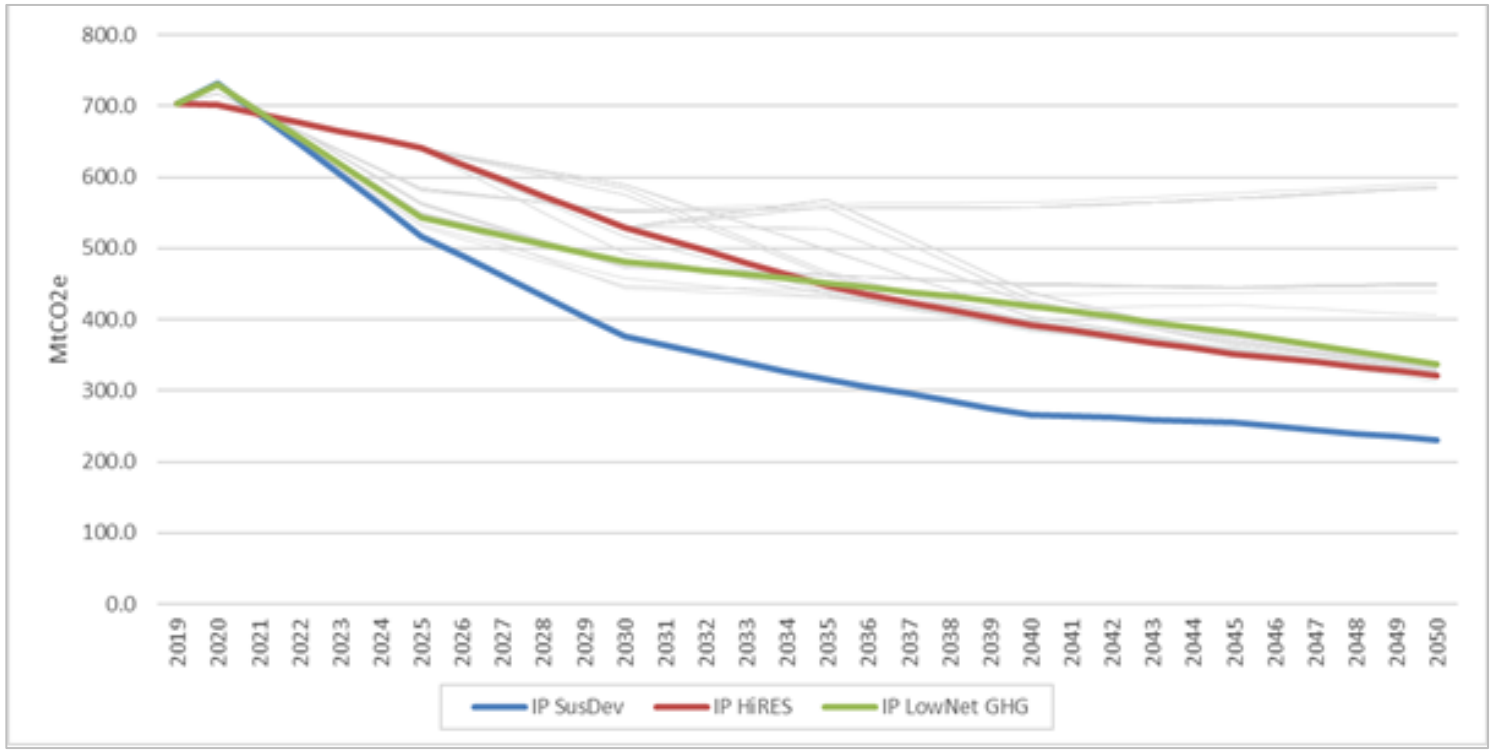
Source: European Scientific Advisory Board on Climate Change's scenario database.

- 20% to 40% reduction energy use compared to today
- High electrification rates in transport, industry and residential/tertiary sectors

Non-CO_2 emission reductions

European Scientific Advisory Board on Climate Change

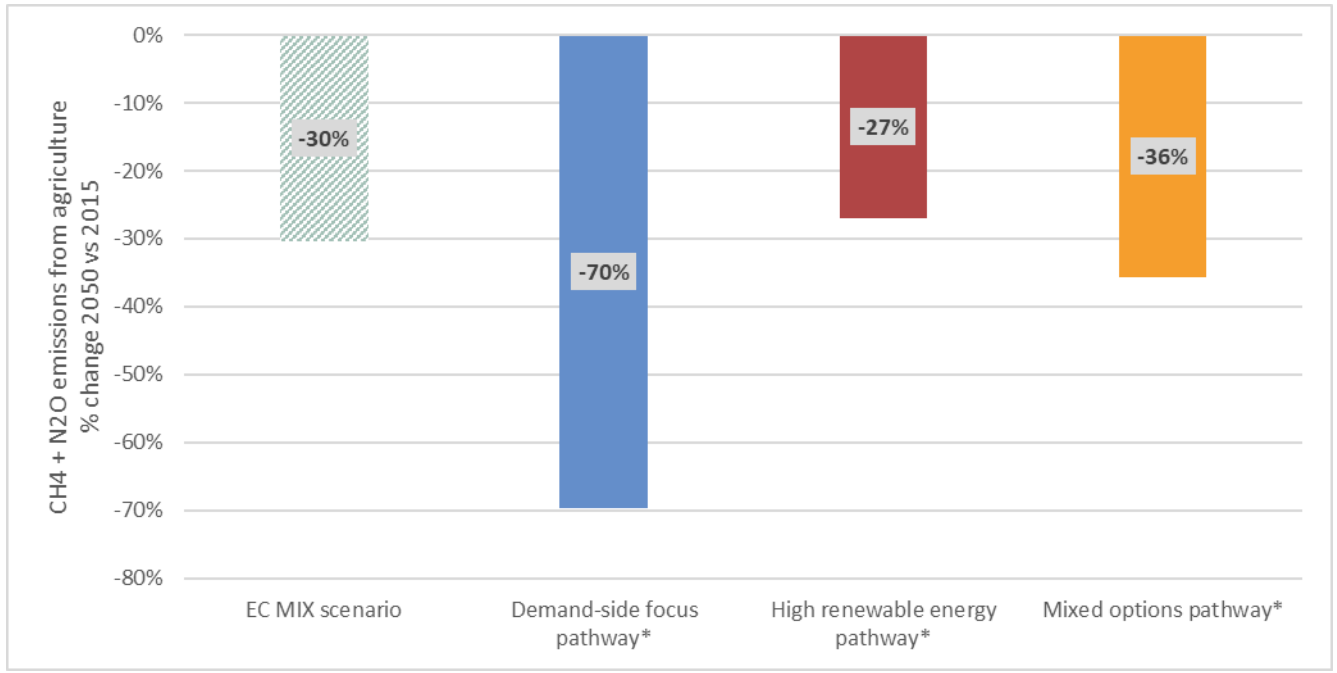
Total non-CO_2 emissions in iconic pathways



- Non-CO_2 emission reductions: 20-60%
- Some pathways assume:
  - around 50% reduction in livestock demand,
  - reduction of food waste, reduction of nitrogen fertiliser use
- CH_4 emission reductions in waste: 45-60%
- CH_4 emission reductions in energy: 70-90%

Source: European Scientific Advisory Board on Climate Change's scenario database.

Agricultural sector: emissions reductions



- **All scenarios reduce agriculture emissions**
  - Scenarios with greatest reductions in the sector assume widespread behavioural change: e.g. diet.
  - Others rely more on technological solutions
- **Emissions from agriculture decline at a slower rate than overall greenhouse gas emissions:**
  - Methane and nitrous oxide emissions from agriculture account for 10% of overall greenhouse gas emissions today
  - By 2040, this share rises to over 40%

Note: * denotes results at wider-Europe level (not EU-27)

Agricultural sector: mitigation options

European Scientific Advisory Board on Climate Change

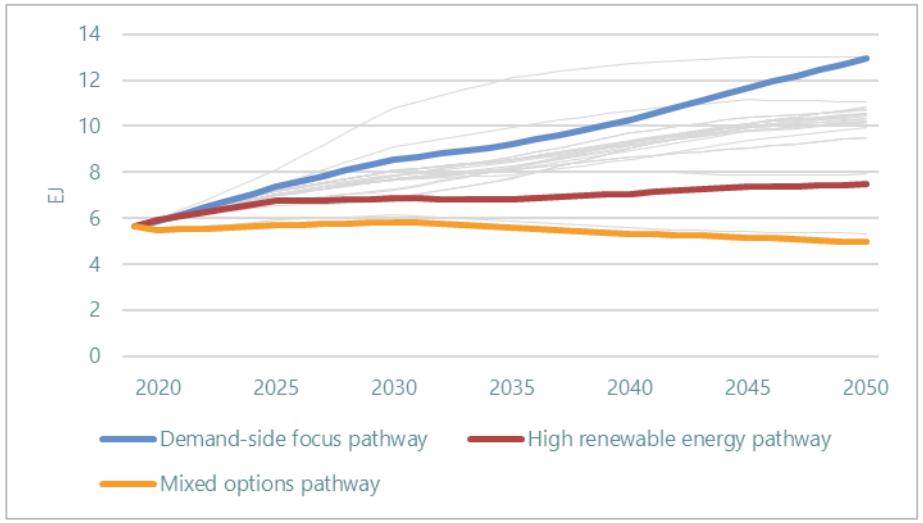
Pathways use the following mitigation options, with different emphasis:

1. Shift in diets and increased efficiency in livestock production
2. Lower nitrogen fertiliser use, resource-efficient agricultural practices and climate adaptation measures
3. Lower food waste
4. Balanced share of bioenergy crops and biomethane production

Scale-up of other, non-fossil energy carriers

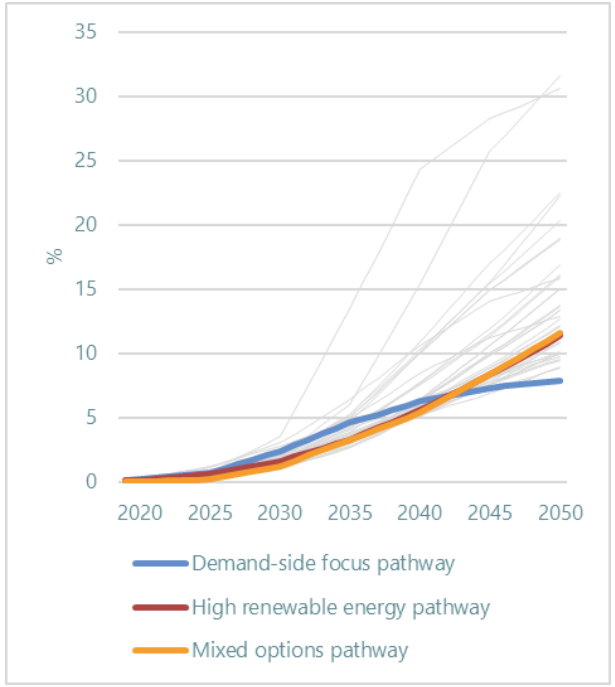
European Scientific Advisory Board on Climate Change

Primary bioenergy use in iconic pathways



Source: European Scientific Advisory Board on Climate Change's scenario database.

Hydrogen production expressed as a % of final energy consumption in iconic pathways

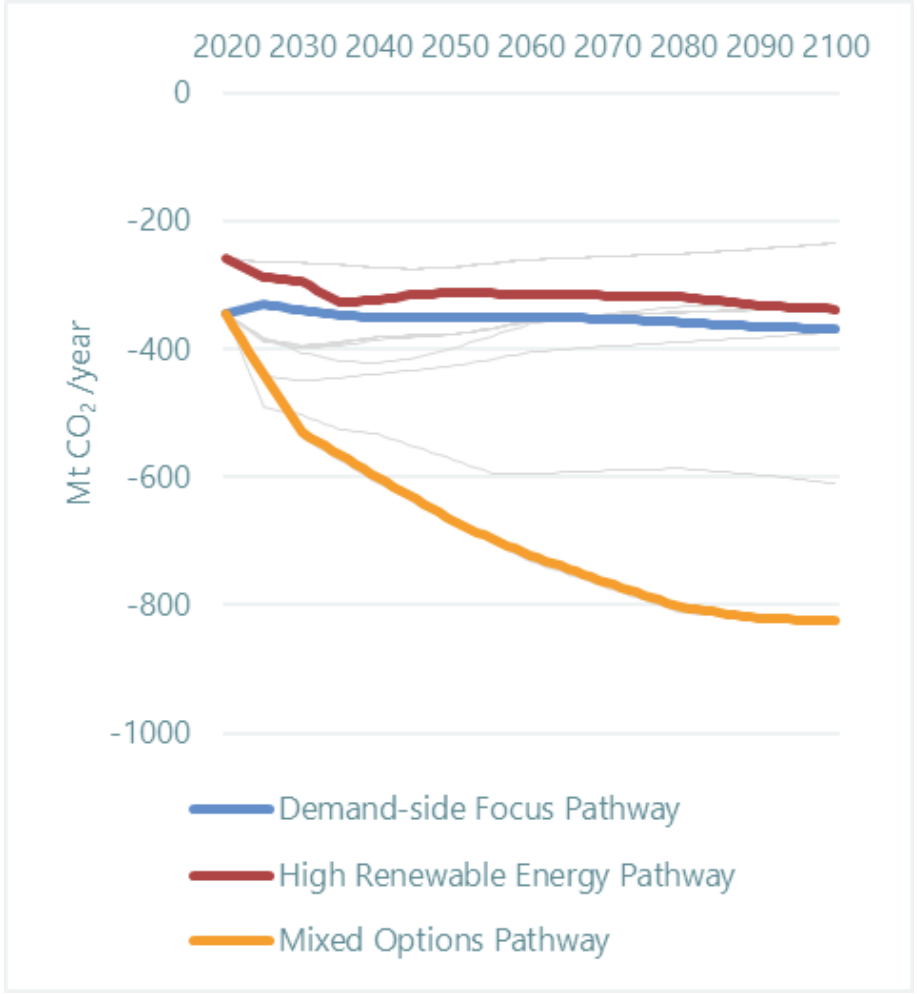


- Bioenergy varies depending on scenarios
- Hydrogen scaled up at min 5-10 Mt by 2040

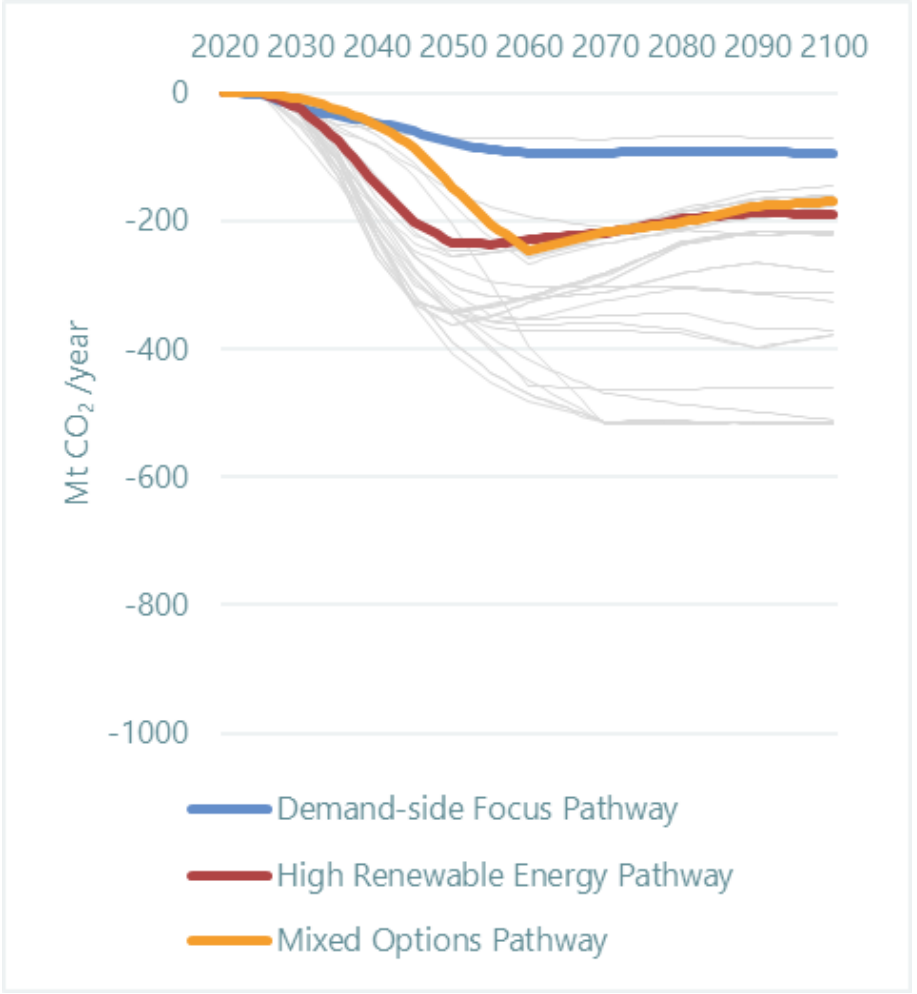
Carbon removals

European Scientific Advisory Board on Climate Change

Net LULUCF removals in iconic pathways



BECCS and DACCS in iconic pathways



Carbon removals in 2040:

- Land sink: 100-400 Mt CO_2 (limited by climate impacts)
- BECCS: 46-207 Mt CO_2
- Total: 170-758 Mt CO_2

Source: European Scientific Advisory Board on Climate Change's scenario database.

Effects of international aviation and maritime emissions

		2040 objective (% vs 1990)	**2030-2050 budget (Gt CO_{2e})**
1	excl. international transport	91.1-96.0%	9.5-13.4
2	1 + Intra-EU aviation	90.7-95.5%	10.0-13.9
3	**2 + Intra-EU maritime**	**90.2-94.7%**	**10.9-14.4**
4	3 + Extra-EU maritime	89.3-94.1%	11.5-15.5
5	4 + Extra-EU aviation	88.3-92.0%	13.7-16.5

Filtering out scenarios raising high feasibility concerns (indicators and 'high' thresholds)

European Scientific Advisory Board on Climate Change

Level	Dimension	Indicator	Threshold
Global	Geophysical: sustainability	Primary bioenergy use	240 EJ/year
	Technological: geological storage capacity	CO_2 sequestration	8.6 Gt CO_2/year
EU-27	Geophysical: sustainability	Primary energy from biomass	20 EJ/year in 2050
	Technological: deployment potential	Carbon capture utilisation and storage	500 Mt CO_2/year
	Technological	Hydrogen production capacity	150 GW in 2030
	Sociocultural	Final energy demand decline	20% decline between 2020 and 2030

Assessing pathways' environmental risks from their reliance on CCUS, carbon removals and bioenergy use

European Scientific Advisory Board on Climate Change

	Environmental risk level
Carbon capture, utilisation and storage	425 Mt CO_2 annually by 2050
Carbon removals from the land sink	A net sink of 400 Mt CO_2 per year by 2050
Bioenergy	9 EJ of annual primary bioenergy use by 2050

Pathways must also overcome technological deployment challenges

European Scientific Advisory Board on Climate Change

	Technological scale-up challenge level
Solar photovoltaic	600-900 GW by 2030, with 20% annual growth rate
Wind power	520-623 GW by 2030, with 15% annual growth rate
Hydrogen	50-100 GW by 2030

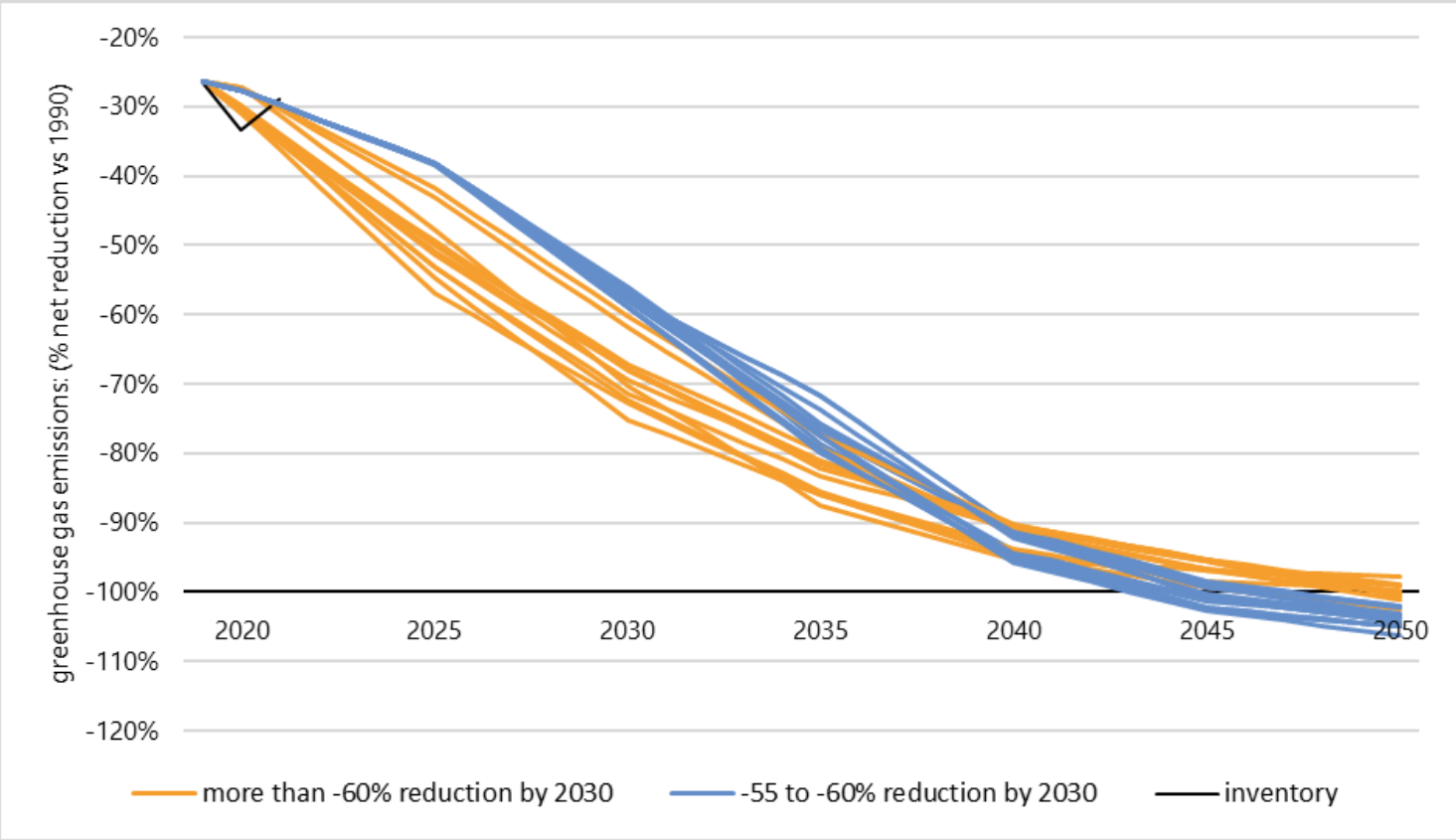
Feasible domestic budgets insufficient to reach equity-based fair shares

European Scientific Advisory Board on Climate Change

	95% emission reduction pathway	Equity-based fair shares	
		Highest estimate	Lowest estimate
2030-2050			
Cumulative net greenhouse gas emissions (including intra-EU aviation and maritime)	11	N/A	N/A
2020-2050			
Net CO_2 emissions: GHG inventory basis (including all aviation and maritime)	30	27	-99
Inventory scope adjustment (land sink)	8	N/A	N/A
Non-CO_2 emissions	14	14	14
Greenhouse gas emissions	**52**	**40**	**-85**

Emissions profile over time for scenarios with 88–95% emission reductions by 2040

European Scientific Advisory Board on Climate Change

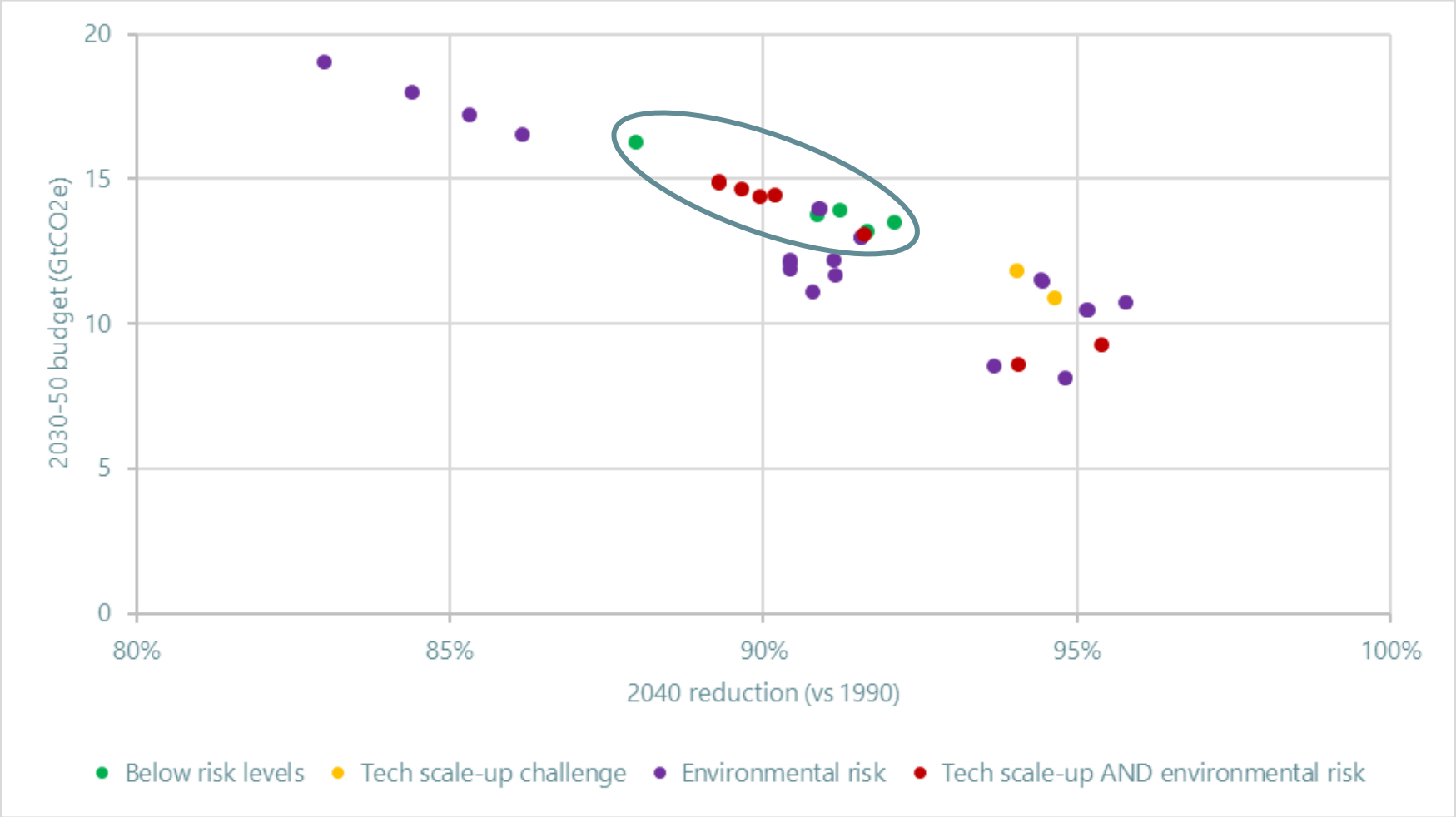


Greenhouse gas reduction by 2030 (% below 1990)	**Greenhouse gas reduction (% below 1990 levels)**				**Cumulative greenhouse gas emissions (Gt CO_2e)**		
	2030	**2035**	**2040**	**2050**	**2020-2029**	**2030-2050**	**2020-2050**
56-60%	56-60%	71-80%	88-95%	99-105%	29-30	10-16	41-44
Above 60%	60-75%	77-87%	90-95%	99-104%	24-29	8-15	32-44

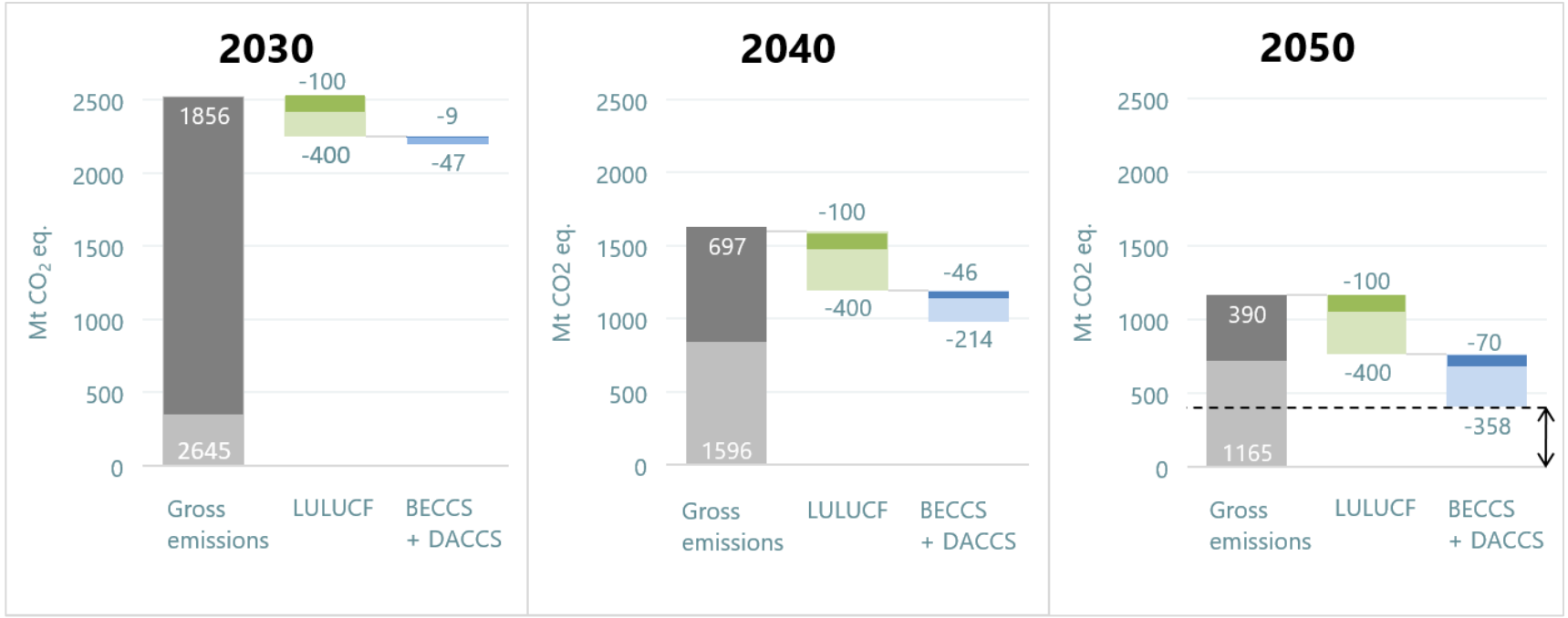
Feasibility

European Scientific Advisory Board on Climate Change

Implications of environmental precautions and technological deployment challenges

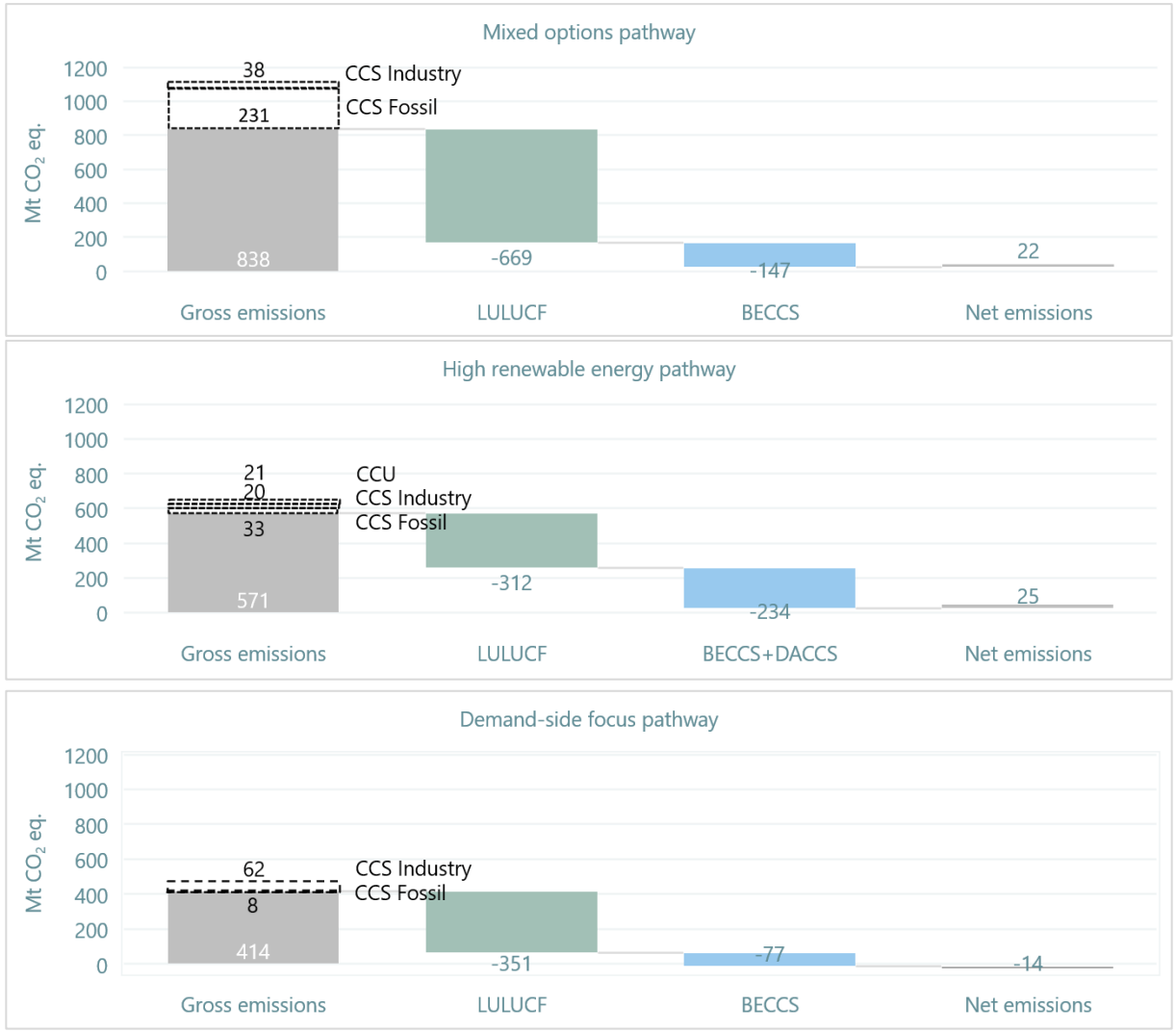


Comparison of gross emissions with removals capacities



Source: European Scientific Advisory Board on Climate Change's scenario database.

Comparison of gross emissions with removals in iconic pathways



Source: European Scientific Advisory Board on Climate Change's scenario database.