Climate Change Advisory Council Secretariat

Carbon Budgets Working Group

Meeting No. 17
29th August 2024
13:30 – 16:30

SEAI Head Office, Dublin

NEW Agenda

Time	**Agenda Item**
13:30	1. Opening of Meeting
13:35	2. Biodiversity Report – Impacts to Carbon Budgets
14:15	3. Presentation of the 3rd Iteration of Core Modelling Results
16:15	4. Carbon Budgets Work Plan
16:20	5. Next Steps and Agenda for next meeting
16:25	6. AOB
17:00	Meeting Close

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	***Open*** 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.
23	28/06/24	Secretariat to follow up with potential sources on assumptions regarding the required grid investment for NMcI to consider as part of the next iteration of COSMO analysis	Secretariat	July 2024	***Closed*** Secretariat followed up to flag EU Reference Scenarios information on likely scale of investments in power grids required at EU27 level along with relevant EirGrid publications on grid investment projects.
24	28/06/24	JF to follow up with NMcI regarding comments on the macro analysis	CBWG Members	July 2024	***Closed*** JF followed up to provide a note outlining his comments on the macroeconomic analysis.

1. Opening of Meeting

Action Number	Date Raised	Description	Owner	Due	Status
25	28/06/24	Secretariat to circulate the supplementary brief on the factors influencing power generation technology deployment in Ireland that was prepared by SEAI.	Secretariat	July 2024	***Closed*** Supplementary brief provided to Secretariat and circulated to CBWG members via Sharepoint
26	28/06/24	Each member was asked to fill at least one scenario in the dialogue tool before the July 25th meeting. The Secretariat will set up a call with each member to walk through the tool in more detail and address any questions the members might have.	CBWG members and Secretariat	July 2024	***Closed*** Secretariat had calls with individual CBWG members to discuss the approach to the scenario dialogue tool. The CBWG members were asked to fill one scenario and to report any user issues with the tool by the 25th of July meeting.
27	28/06/24	Secretariat will schedule a call with KH and TD to discuss FAPRI scenario results the week of 8th of July.	Secretariat	July 2024	***Closed*** Secretariat had a call with KH and TD to discuss the next steps for the FAPRI analysis on the 11th of July.

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4. Carbon Budgets Workplan

CB WG Meeting No.	Proposed Date and Time	Topic(s) for Consideration
17	Thursday 29th August 2024, 13:30 – 16:30 ***In person: SEAI Head Office, 3 Park Place, Hatch Street, D02 FX65***	*3rd Iteration of Core Modelling Results* *Follow on discussion on Biodiversity Considerations (James Moran)*
18	Wed 18th September 2024, 13:30 – 17:00* **meeting extended by 30mins*	Analysis of warming impact of selected core scenarios (3rd iteration) *Additional Analysis & Macroeconomic Modelling Results (based on the 3rd iteration)* Economic assessment of climate change impacts and adaptation options (ESRI) Follow on discussion on CDR and Carbon Budgets (Oliver Geden)

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

Supplementary Information to be published on the CCAC website:

- All CBWG meeting materials
- Scenario Dialogue Tool

5. Carbon Budgets Workplan: Scenario Dialogue Tool

Scenario Dialogue Tool

- Dialogue tool will be updated by the Secretariat to reflect additional scenario results from the 3rd and final iteration of modelling and analysis after the 29th August CBWG meeting
- Character limit will be extended from a 300 character limit to a 1200 character limit
- A notification email will be circulated on Monday the 2nd of September once the tool is updated and is open to CBWG members to populate
- Please populate the tool in the shared version on SharePoint
- Scenario Dialogue Tool to be completed and finalized by the 30th of September

6. Next Steps

1. **3rd Iteration Modelling Results:** Core modelers share the raw data for Joe Wheatley's subsequent warming impact analysis by COB on Friday the 30th of August
2. **Scenario Dialogue Tool:** A notification email will be circulated on Monday 2nd September once the tool is updated and is open to CBWG members to populate until 30th September
3. **Macroeconomic Analysis:** Secretariat to schedule a call with the CBWG economists to discuss outputs in advance of the September CBWG meeting.
4. **CBWG Meeting:** Final CBWG meeting to take place on Wed 18th September, 13:30 – 17:00
5. **Final Output Reports:** All CBWG members asked to include an executive summary at the outset of their report and to conclude and submit their final reports by 30th September. Secretariat will liaise with each CBWG member individually on this in the meantime.

8. AOB

Biodiversity Considerations for Carbon Budgets- Current State of Play!

CCAC Carbon Budgets Working Group, Meeting 17 _29/8/2024

Ollscoil Teicneolaíochta an Atlantaigh

Atlantic Technological University

Mayo

Dr. James Moran (ATU)

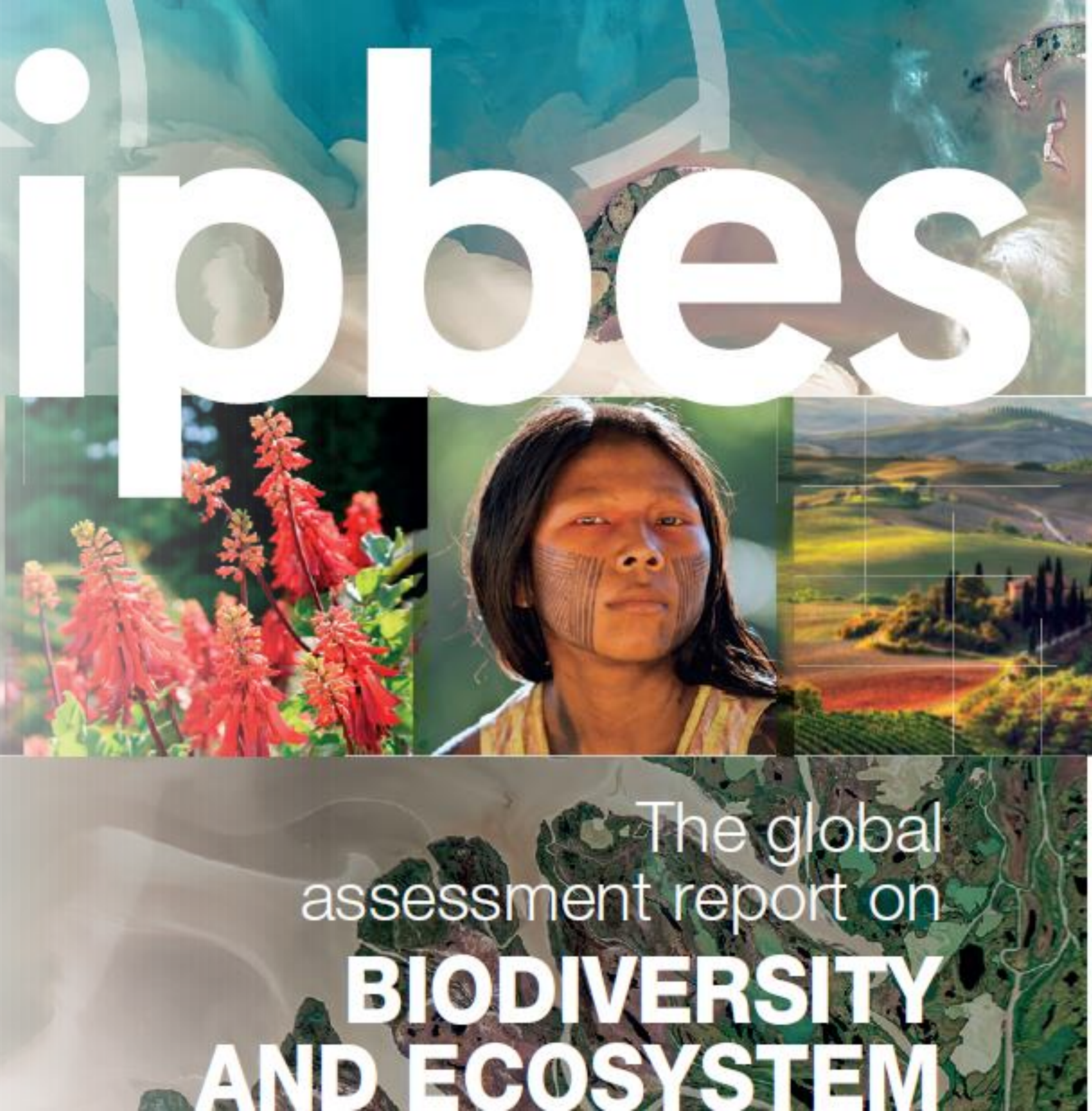
Agroecology and Rural Development Research Group

Outline

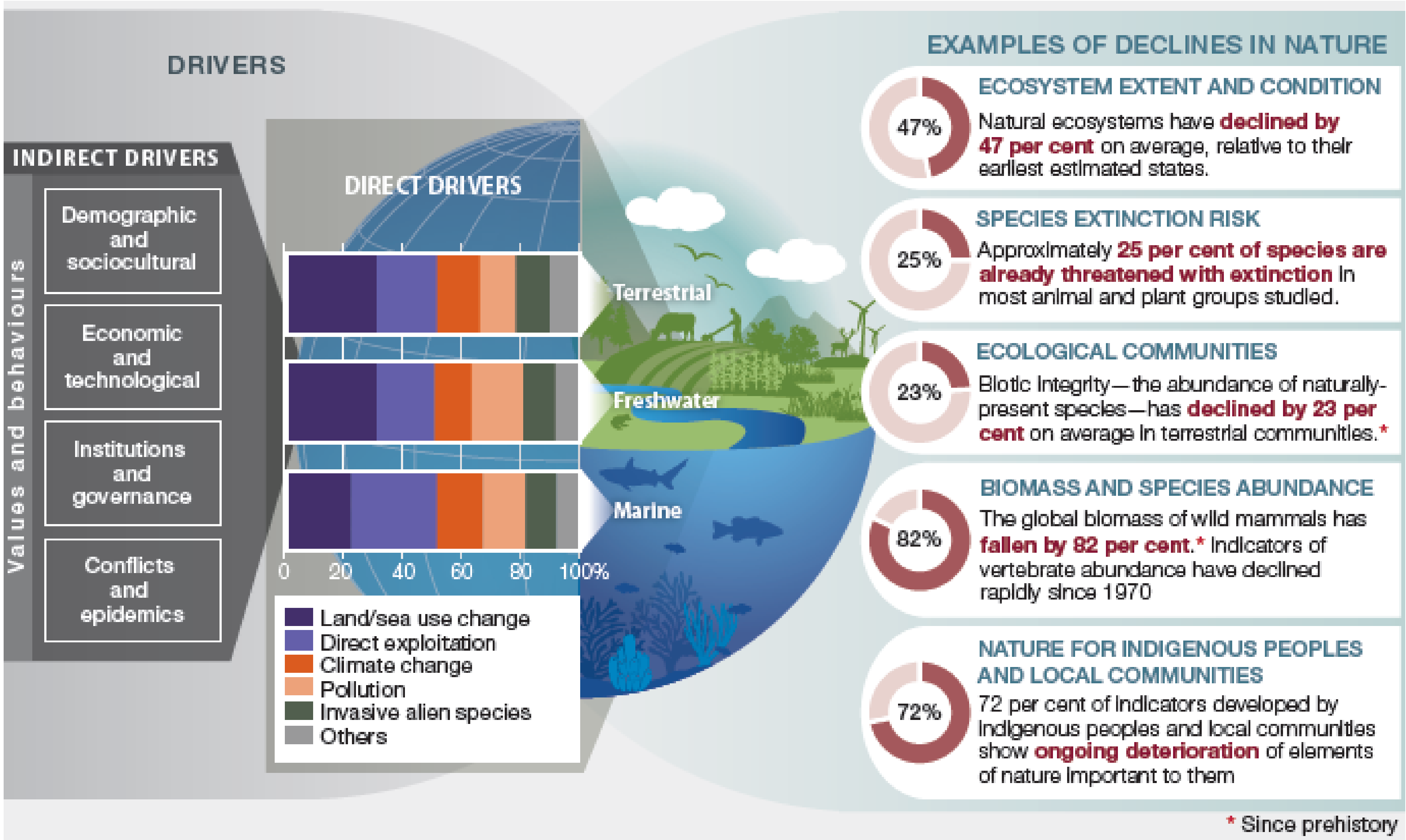
- Biodiversity and Climate Change interrelated issues
- Recap Biodiversity small scale studies: Biodiversity considerations in carbon budget process
- Biodiversity considerations in context of emerging core modelling results
- Some key messages/questions/ discussion

Biodiversity

- Biodiversity is the variety of all life on earth
- Humans just one component or species among millions.
- Biodiversity = earths life system
- Human depend on functioning system for their existence
- Biodiversity loss and evolution ongoing
    - Loss accelerated by human activities
    - Trajectory towards mass extinction event?
- Ensuring humans aren’t among biodiversity component lost!
- Local/regional extinctions driven by resource use by humans and climate change



Global declines in Biodiversity



Source: IPBES The Global Assessment Report on Biodiversity and Ecosystem Services

An Tionól Saoránach The Citizens' Assembly

Biodiversity loss in Ireland

85% Protected Habitats in unfavourable condition; 46% with a declining trend.

Overwintering waterbirds declined by 40% (500,000) since 90s

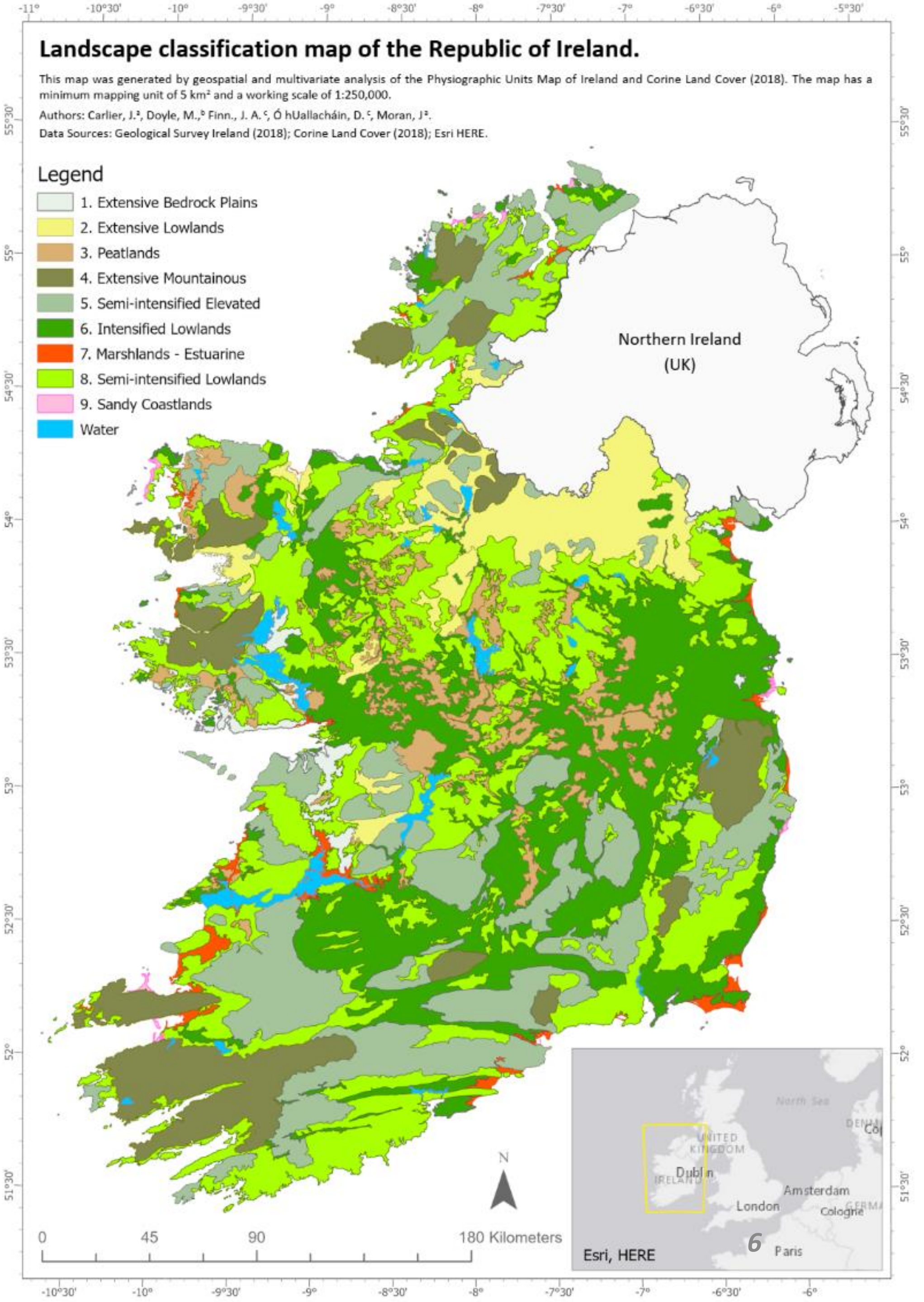
20% breeding birds in long term decline; 30% are stable/increased

Semi-natural grasslands: ~30% of area monitored lost in last 10-15 yrs

HNV FARMLAND & FORESTRY
FARMFORBIO

Landscape Diversity

- Broad landscape classification of the country; 9 landscape classes
- Range from intensified lowlands to extensive mountainous areas
- Characterised by difference in geology, soils, climatic variation and land cover with a wide range in land use capacity.
- All land cannot be all things to all people!
- One size does not fit all!



Diverse land base -provides range of Ecosystem Services

- Diversity of Irish farmed landscapes
- Need to provide range of goods and services
- Under supply of non-market ecosystem services/public goods

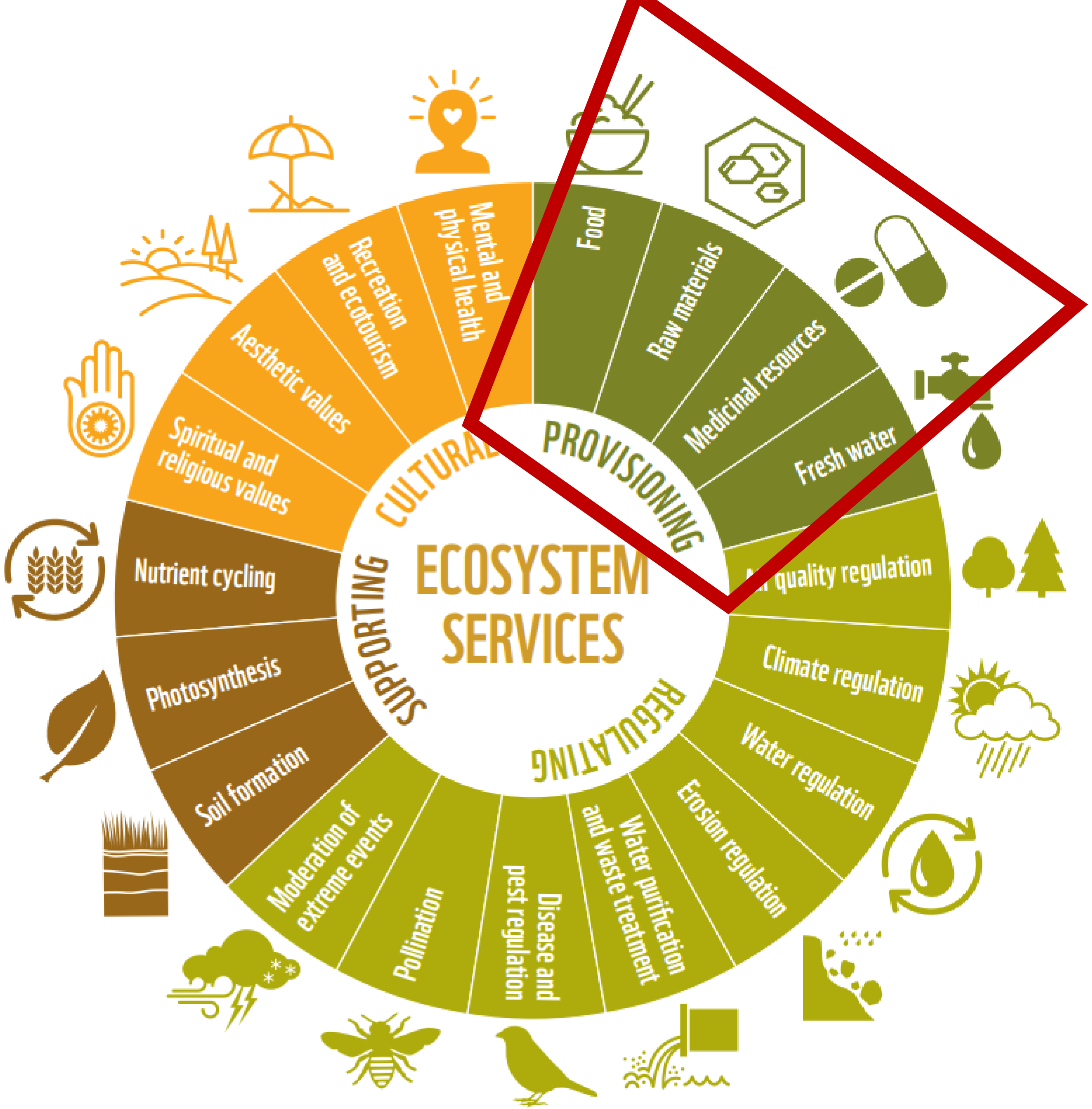


Image Source: WWF 2016

Biodiversity and Climate Change

- ***Recognition in policy of interconnectedness…..rarely addressed in integrated manner in practice***
- *Limiting global warming to ensure a habitable climate and protecting biodiversity are mutually supporting goals, and their achievement is essential for sustainably and equitably providing benefits to people*
- *Several land- and ocean-based actions to protect, sustainably manage and restore ecosystems have co-benefits for climate mitigation, climate adaptation and biodiversity objectives.*
- *Measures narrowly focused on climate mitigation and adaptation can have direct and indirect negative impacts on nature and nature's contributions to people.*
- *Measures narrowly focusing on protection and restoration of biodiversity have generally important knock-on benefits for climate change mitigation, but those benefits may be sub-optimal compared to measures that account for both biodiversity and climate.*
- *Treating climate, biodiversity and human society as coupled systems is key to successful outcomes from policy interventions.*
- *Transformative change in governance of socio-ecological systems can help create climate and biodiversity resilient development pathways.*

https://www.ipcc.ch/site/assets/uploads/2021/07/IPBES_IPCC_WR_12_2020.pdf

Nature Restoration Law

Objectives

- *(a) the long-term and sustained recovery of biodiverse and resilient ecosystems across the Member States' land and sea areas through the restoration of degraded ecosystems;*
- *(b) achieving the Union's overarching objectives concerning climate change mitigation, climate change adaptation and land degradation neutrality;*
- *(c) enhancing food security;*
- *(d) meeting the Union's international commitments.*

Restoration of terrestrial, coastal and freshwater ecosystems (Article 4).

Restoration of marine ecosystems (Article 5) including coordination of restoration of measures in marine ecosystems (Article 18).

Exemption for energy from renewable sources (Article 6).

Exemptions for national defence (Article 7).

Restoration of urban ecosystems (Article 8).

Restoration of the natural connectivity of rivers and natural functions of the related floodplains (Article 9).

Restoration of pollinator populations (Article 10).

Restoration of agricultural ecosystems (Article 11).

Restoration of forest ecosystems (Article 12).

Planting three billion additional trees as part of obligations in articles 4 and 8 to 12 (Article 13).

Need for policy target alignment.

Example: Restoring degraded ecosystems

https://ort.cbd.int/national-targets/my-country/part-1/8E6B9455-AFAA-5E31-478A-9BD53A8EA1DB/view

Carbon Budgets Working Group and Biodiversity Considerations

National climate objective: *'climate resilient, biodiversity rich, environmentally sustainable and climate neutral economy'.*

- Timeframe CB 3 2031-35, CB 4 2036-40
- Evidence base and recommendations to support CCAC carbon budget proposals
- Biodiversity considerations a key component of national climate objectives
- Carbon Budget Programme 2 Methodology
  - Small scale studies
  - Post hoc analysis of proposed carbon budgets on biodiversity

Recap on previous reports on biodiversity to CCAC

Gorman et al 2021:

- Impacts of climate change mitigation measures on biodiversity
- Possible to implement CB while protecting biodiversity… appropriate siting key….. measures including land use change managed to deliver synergistic gains
- Impact arising from land use change-water quality and biodiversity
- Right measure in right place

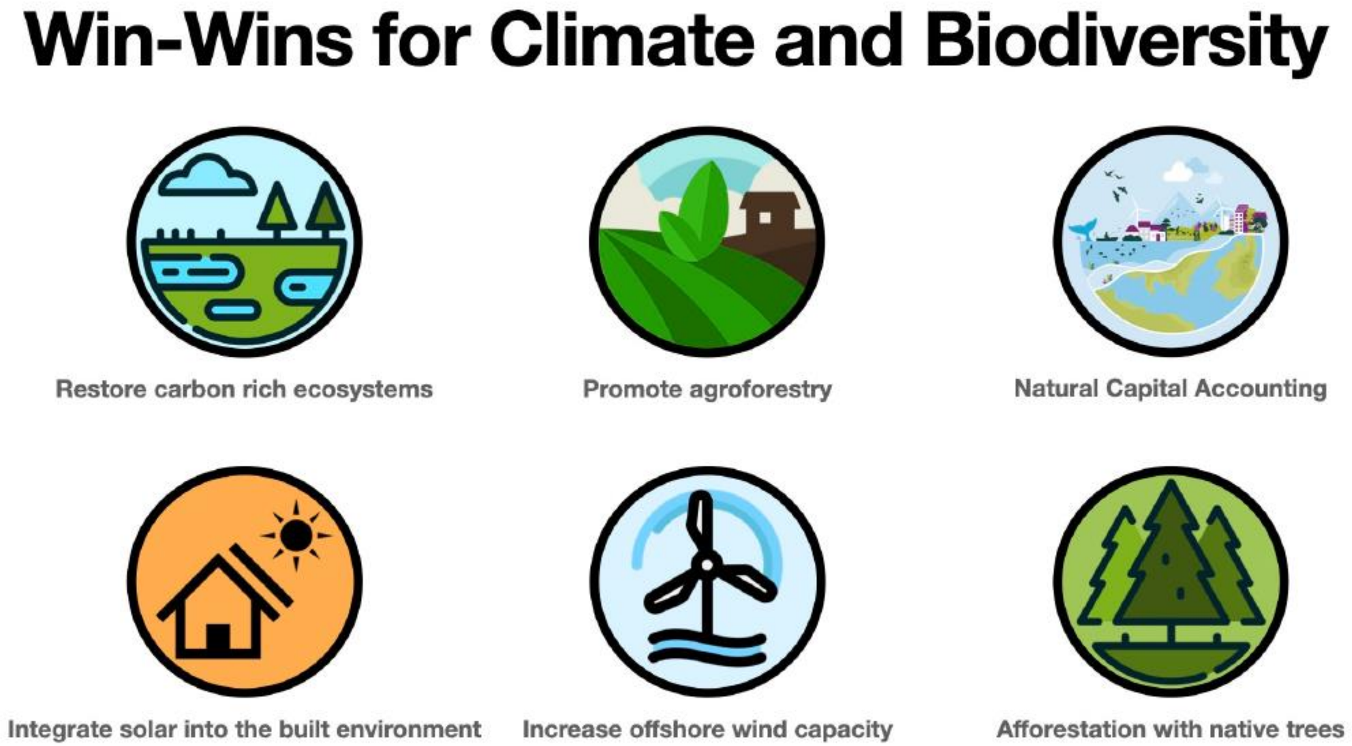
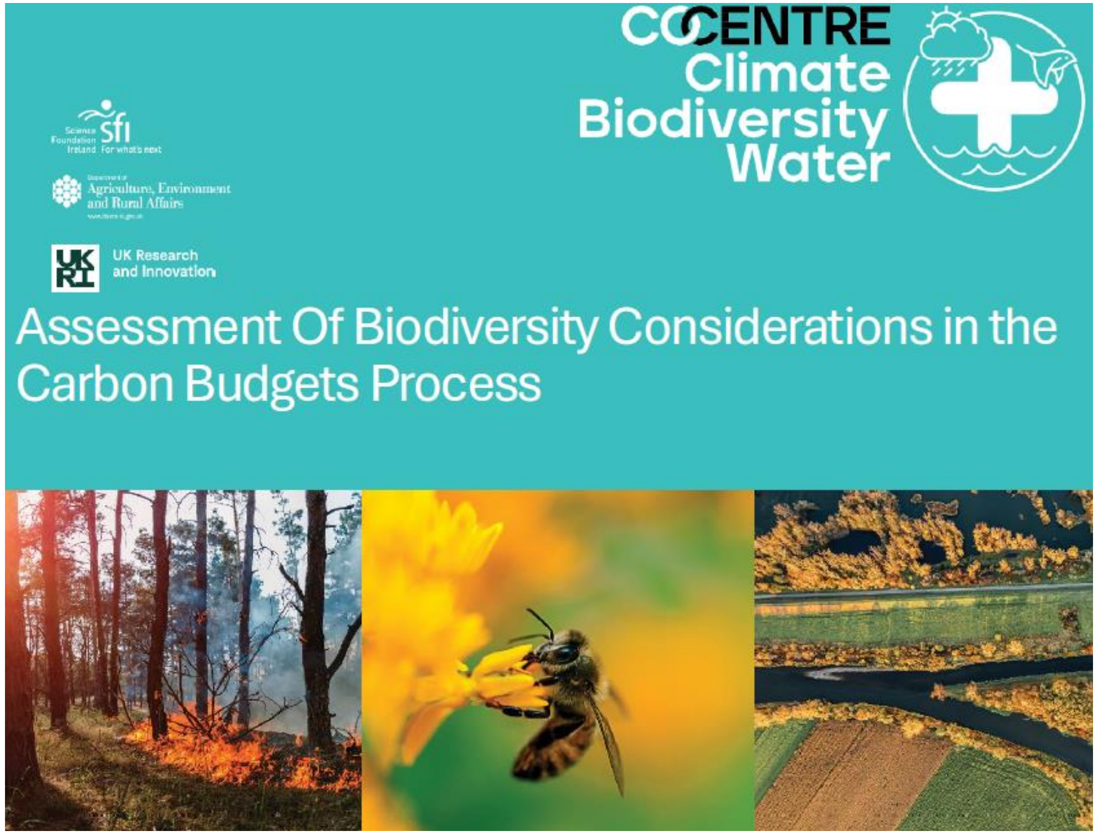


Figure 1. Infographic representing key "win-win" strategies for both climate mitigation and biodiversity

Recap on previous reports on biodiversity to CCAC

Molloy et al 2024:

- Assessment of impact potential of CB measures
- Climate mitigation-biodiversity interrelationship complex and conditions-specific: plot or field condition, spatial location and implementation practices



CODE	Biodiversity impact potential	Climate mitigation potential
	Positive (or neutral) impacts on biodiversity	Greenhouse gas emission reductions or active carbon sequestration
	Negative impacts on biodiversity that can be controlled/mitigated to maintain biodiversity	Maintain greenhouse gas emission sinks (no change in carbon stock)
	Negative impacts on biodiversity that cannot be reasonably controlled/mitigated to maintain biodiversity	Reduce carbon store

Key messages to date

- CC major impact on biodiversity in terms of ecosystem extent, distribution, condition, functioning and resultant services to society (e.g. provisioning, regulatory and supporting services)
- Measures to achieve C budgets will have significant impacts on biodiversity (positive /negative). Impacts vary depending on ecosystem/landscape context
- Climate mitigation and adaptation measures need to be implemented with co-benefits for nature restoration and vice versa (to meet legislative targets).
- Results to date from modelling suggest substantial land use change will be required across forestry, agriculture and renewable energy generation. Challenge: implementation of measures to meet CB while meeting NRL requirements and vice versa
- As scale and rate of implementation increases risks of potential negative impact and trade-offs increase. Impacts vary depending on ecosystem/landscape context plus management/mitigation practices employed
- National integrated land use strategy essential
- Off-shoring climate and biodiversity impacts needs to be avoided (e.g. biofuels targets to 2030 requires >400k ha land (UCC work), competition with food production?)
- Caution: reversibility of restoration of carbon rich ecosystems under climate change scenarios-vulnerability to drought, wildfires, pest and disease.

Questions

- **FEASIBILITY** of land use change required? (cognisant of land capacity and land use targets to meet current national and international commitments)
- Will answer be informed by work of Land Use Evidence Review?
- Moving from national/sectoral targets to regional/local implementation?
- Financing and realising a just transition?
- Learning while doing-monitoring essential

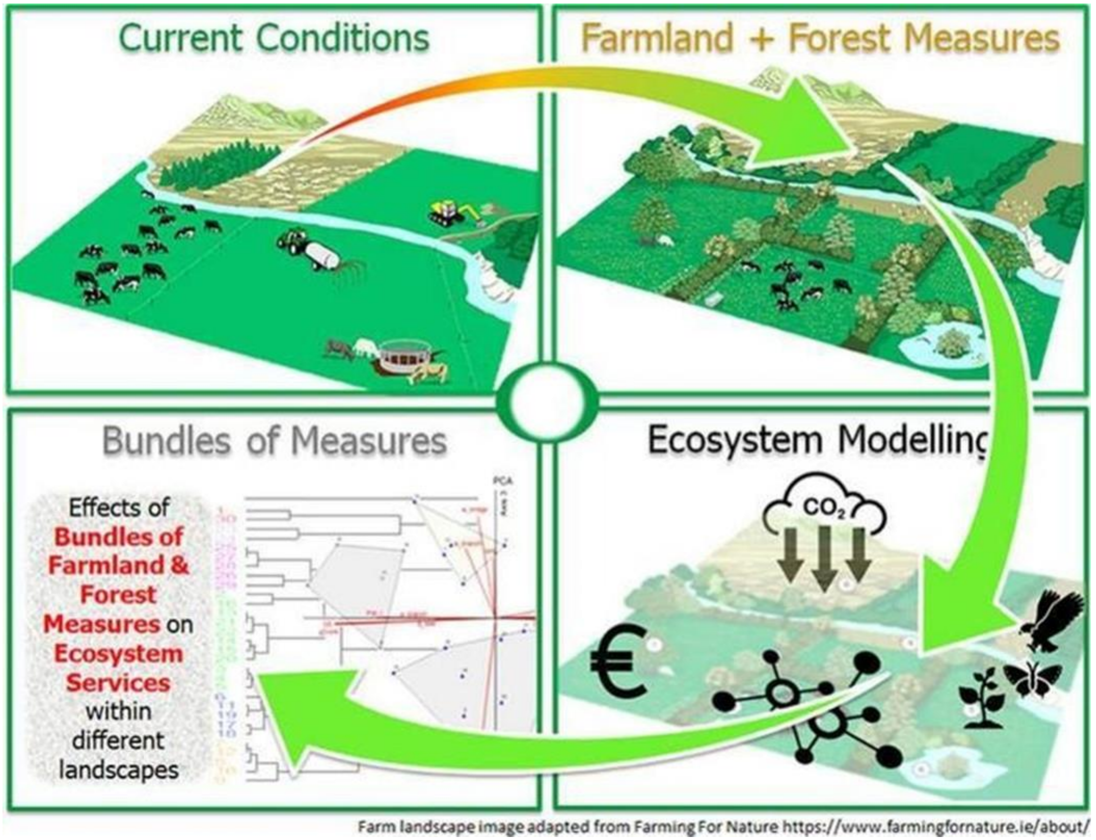
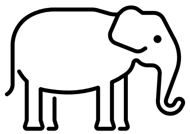


Image: Carlier, J., Doyle, M., Finn, J.A., Ó hUallacháin, D., Ruas, S., Vogt, P. and Moran, J., 2024. Modelling enhancement of Ecosystem Services provision through integrated agri-environment and forestry measures. Science of The Total Environment, 948, p.174509.



Increasing energy consumption, overexploitation of natural resources and land- and seascapes change over last 150 years has got us where we are today (IPBES-IPCC 2020)

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fers

FORESIGHT Scenarios for carbon budgets towards 2050

David Styles, Colm Duffy, Kevin Black, Daniel Henn, Andres Martinez, Mayra Sanchez

An Roinn Comhshaoil, Aeráide agus Cumarsáide
Department of the Environment, Climate and Communications

Main changes round 3

- Organic soils and peatlands: 2024 NIR areas and EF
- Updated Ag scenarios and removed “c” scenarios
- Included a new (interpolated) forestry time series
- Disaggregated results for AD & forest value chains

Modelling Approach

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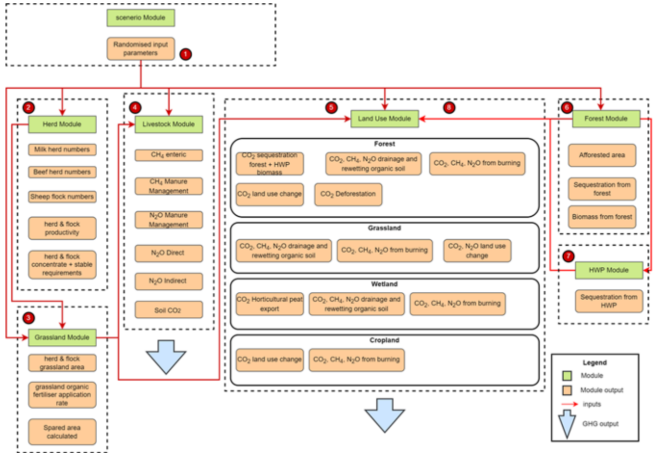
1. Scenarios

- Current data (baseline)
- MACC assumptions (2030)
- Animal number/productivity scenarios
- Land use choices

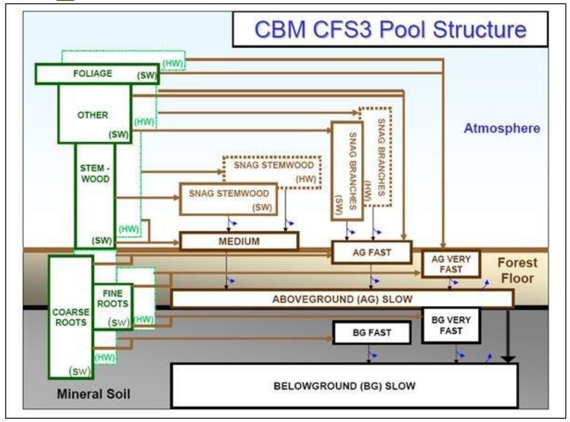
2. GOBLIN



Areas
Soils
Forest types

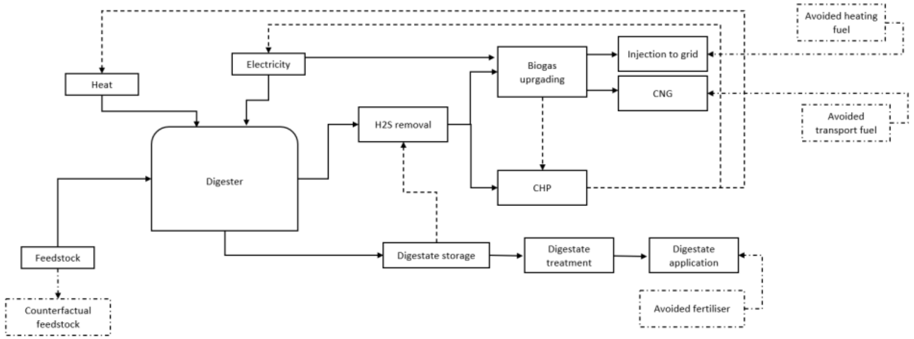
3. FERS-CBM

fers



Areas
Grass yields
Manure

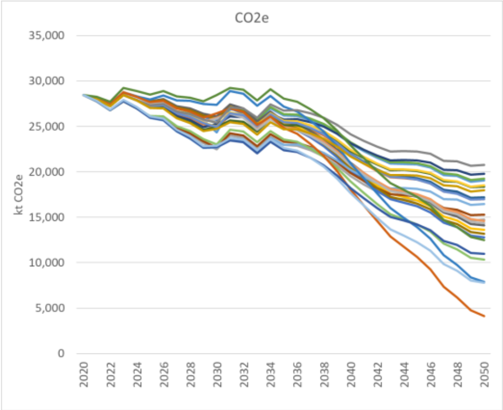
4. LCAD 2.0



5. Aggregation

- Time series 2020-2050
- Fixed 2030 waypoints
- Progressive technical abatement (ag)
- Deployment (AD)
- GWP_{100} (w/wo CH_4)

6. Results



CO_2
CH_4
N_2O

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Scenario rationale

- Emphasis on dairy specialisation & "sustainable intensification"
  - Profitability vs beef & sheep (NFS, 2022)
  - Maintain bovine protein output
  - Aligned with more sustainable diet dairy to beef ratio (Soteriades et al., 2020 https://doi.org/10.1016/j.jenvman.2020.111054; Mazzetto et al., 2020 https://doi.org/10.1016/j.jclepro.2020.124108; Porto-Costa et al., 2023 https://doi.org/10.1016/j.jclepro.2023.138826)
- Ambitious abatement
  - MACC+++ (extensive deployment of upper-end technical abatement)
  - AD: Future-oriented low-emission deployment (food waste > slurry > grass-clover) (Styles et al., 2022 https://doi.org/10.1016/j.jclepro.2022.130441; O'Donnell et al., 2021 https://www.sciencedirect.com/science/article/pii/S0048969721023226)
- Organic soils & peatland rewetting (90% of drained area)
- Forestry
  - Commercial afforestation plus future wood use = "carbon pump" (Forster et al., 2021 https://www.nature.com/articles/s41467-021-24084-x)
  - Long-term forest strategy (2100+) critical to avoid future carbon cliffs (Duffy et al., 2022 https://www.nature.com/articles/s41893-022-00946-0)
  - Doubling temperate forest area need to meet future wood demand (Forster et al., in review)
  - Current policy > post 2050, or max historic rate for 50 years, tailing off (30% forest cover by 2125)

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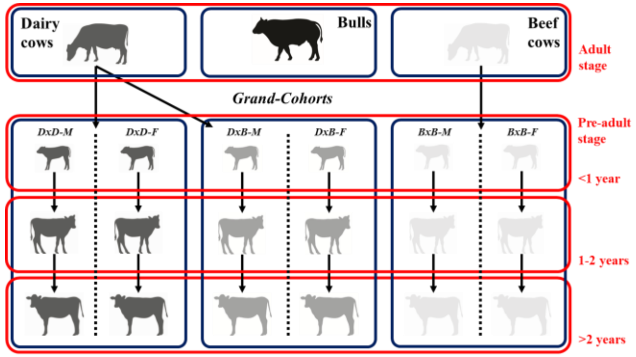
Agriculture



Aspect	2020 Baseline (Ambition 0)	Ambition 1	Ambition 2
Livestock protein output	• 2020 cattle herd • 2020 sheep flock • 2020 dairy cow productivity (14.85 L/day) AG-34%	• 2020 protein outputs (1.725m dairy cows and 150k beef cows) • 2020 sheep flock decreases by 20% • Increased dairy cow productivity (15.3 L/day) AG-45%	• 2020 protein outputs (1.418m dairy cows and 150k beef cows) • 2020 sheep flock decreases by 20% • Increasing dairy cow productivity strongly (19.2 L/day) AG-50% & AG-60%
Livestock management	• 2020 mean slaughter ages • 2020 mean slaughter weights	• Mean slaughter ages decrease by 50 days • 2020 mean slaughter weights	• Mean slaughter ages decrease by 100 days • 2020 mean slaughter weights
Grassland sward composition and management	• 0% white clover swards (WCS) • 100% perennial ryegrass swards (PRS) with 2020 inorganic N fertilisation rates	• 50% WCS without inorganic N fertilisation • 50% PRS with 2020 inorganic N fertilisation rates	• 75% WCS without inorganic N fertilisation • 25% PRS with 2020 inorganic N fertilisation rates
Fertiliser type	• 0% inorganic N fertiliser spread as protected urea	• 50% inorganic N fertiliser spread as protected urea	• 100% inorganic N fertiliser spread as protected urea
Grassland use efficiency	• 2020 dairy farm GUE (72%) • 2020 beef farm GUE (55%)	• Dairy farm GUE increase (75%) • Beef farm GUE increase (60%)	• Dairy farm GUE increase (75%) • Beef farm GUE increase (65%)
Afforestation	• 75% deciduous trees • 25% coniferous trees	• 50% deciduous trees • 50% coniferous trees	• 25% deciduous trees • 75% coniferous trees
Methane inhibition	• 0%	• 15% enteric fermentation • 38.5% manure management	• 30% enteric fermentation • 75% manure management

- Ambitious deployment of proven technologies
- Conservative approach: maintain bovine protein output (but 18% reduction for AG-60% scenario)
- 2050 end-points, interpolated via a 25% Ag emission reduction by 2030 (CAP target)

Agriculture

Scenario climate targets		kt CO_2e	Dairy Cows	Suckler Cows	% change adult herd	Sheep	Bovine protein (kt yr^{-1})
Baseline	2020	22,366	1,555,000	915,000		2,556,000	440
A	**-34%**	14,800	1,555,000	915,000	0	2,556,000	440
B	**-40%**	13,438	1,643,651	516,068	-13%	2,289,420	440
D	**-52%**	10,714	1,418,000	150,000	-37%	2,044,800	440
E	**-60%**	8,946	1,151,647	121,824	-48%	1,660,710	361

- Protein output can be maintained with smaller herd

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Soils

- Organic soils & Peatlands
  - New (2024 NIR) areas and EFs incorporated
  - Much higher CH_4 fluxes from rewetted soils
  - New "near natural" wetland land use category
  - 90% drained organic soils under grass rewetted (via 80 kha rewetted by 2030 – CAP)
  - 90% exploited (industrial & domestic) peatlands restored (via 33 & 30 kha targets by 2030 - CAP)
- Mineral soils
  - Current NIR approach (simple & conservative)
  - SOC accumulation from "improvement" drops out of inventory after transition period (i.e. zero mineral SOC accumulation by 2050).
  - High uncertainty

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Anaerobic digestion

Indicative calculations of:

- Avoided energy sector emissions (progressive decarbonisation through time)
- Negative emissions potential via BECCS (progressive deployment through time)
- Avoided manure management emissions

- Feedstock
  - 75% of national food waste
  - 75% pig & poultry slurry
  - Housed dairy slurry (equivalent)
  - Grass-clover @ 9 t DM ha^{-1} (134 kha)
  - 5.7 TWh bio-CH_4 gross

Anaerobic digestion cont…

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Digester temperature	Mesophilic (35 - 37°C)
Digester size	Large (≥1000 kWe)
Type of digester	Double membrane dome
CHP electric efficiency	42%
CHP thermal efficiency	41%
Biogas boiler efficiency	80%
CH4 content in biogas (%)	61%
CO2 content in biogas (%)	33%
Digester CH4 loss (%)	0.2%
CHP CH4 loss (%)	2.4%
Biogas upgrading CH4 loss (%)	2.1%
Boiler CH4 loss (%)	0.1%
Biomethane compression loss (%)	2.1%
Biogas upgrading technology	Water scrubbing
Carbon capture	Progressive combustion (BE)CCS
Digestate storage	Closed tank
Digestate application method	shallow injection

Outside temperature	9.8°C
Feedstock temperature	9.8°C
Electricity displaced by CHP	Combined cycle (NG) (progressive CCS)
Grid fuel being displaced	Natural gas (progressive CCS)
Biomethane displacement to 2040	Diesel
Biomethane displacement 2040+	Natural gas with progressive CCS

Carbon Capture & Storage

% bioenergy-C to which applied

- 3% in 2035
- **48% by 2050**
- 90% by 2064
- (Equal CCS applied to avoided fossil energy – LCA perspective)

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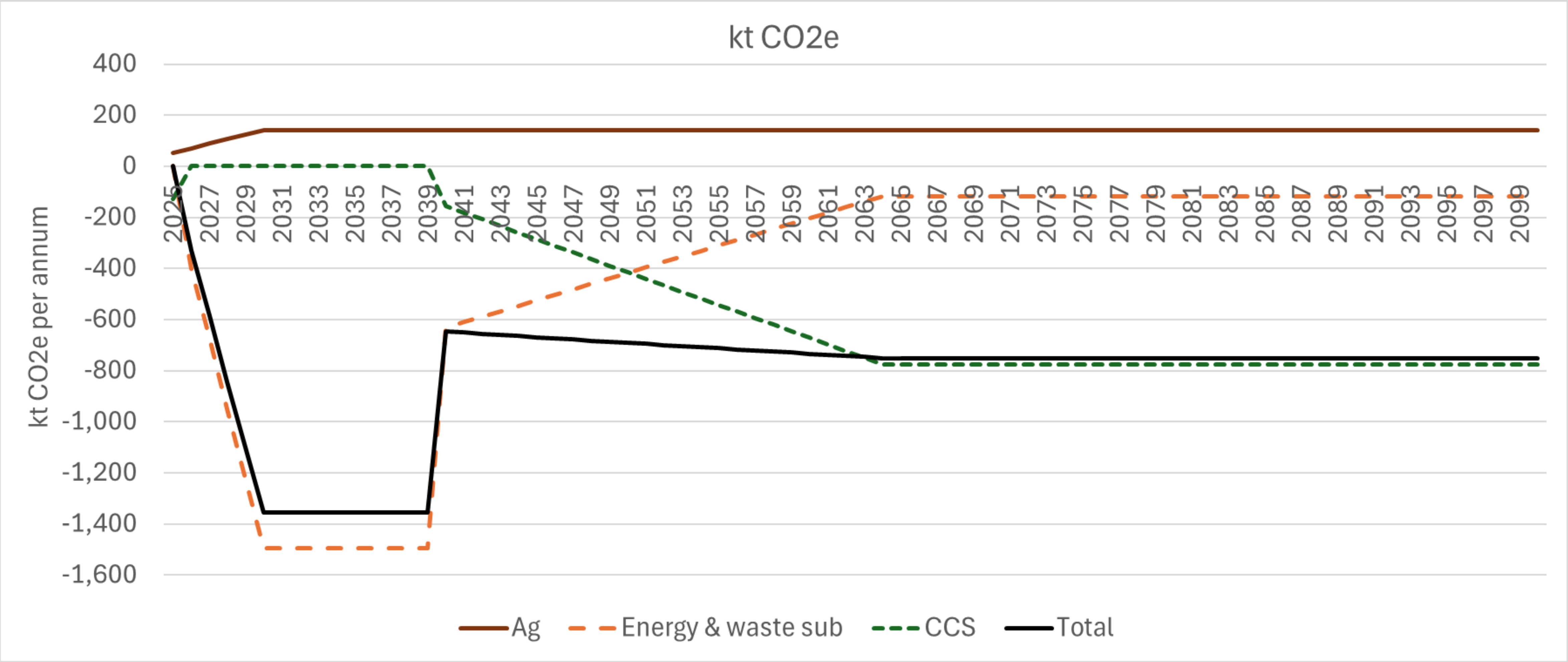
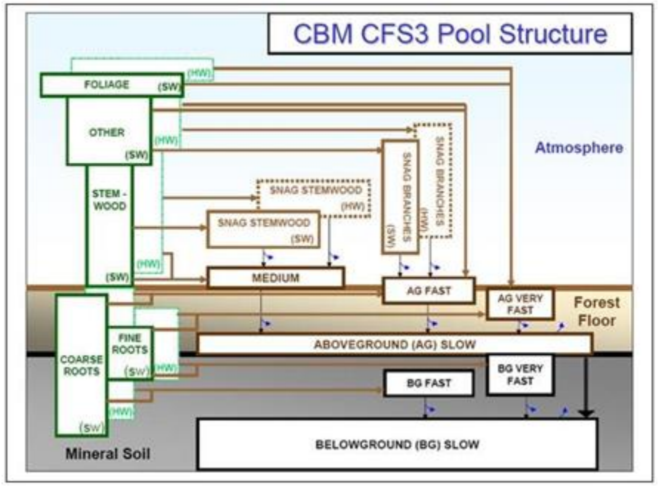
AD GHG time series



Forestry



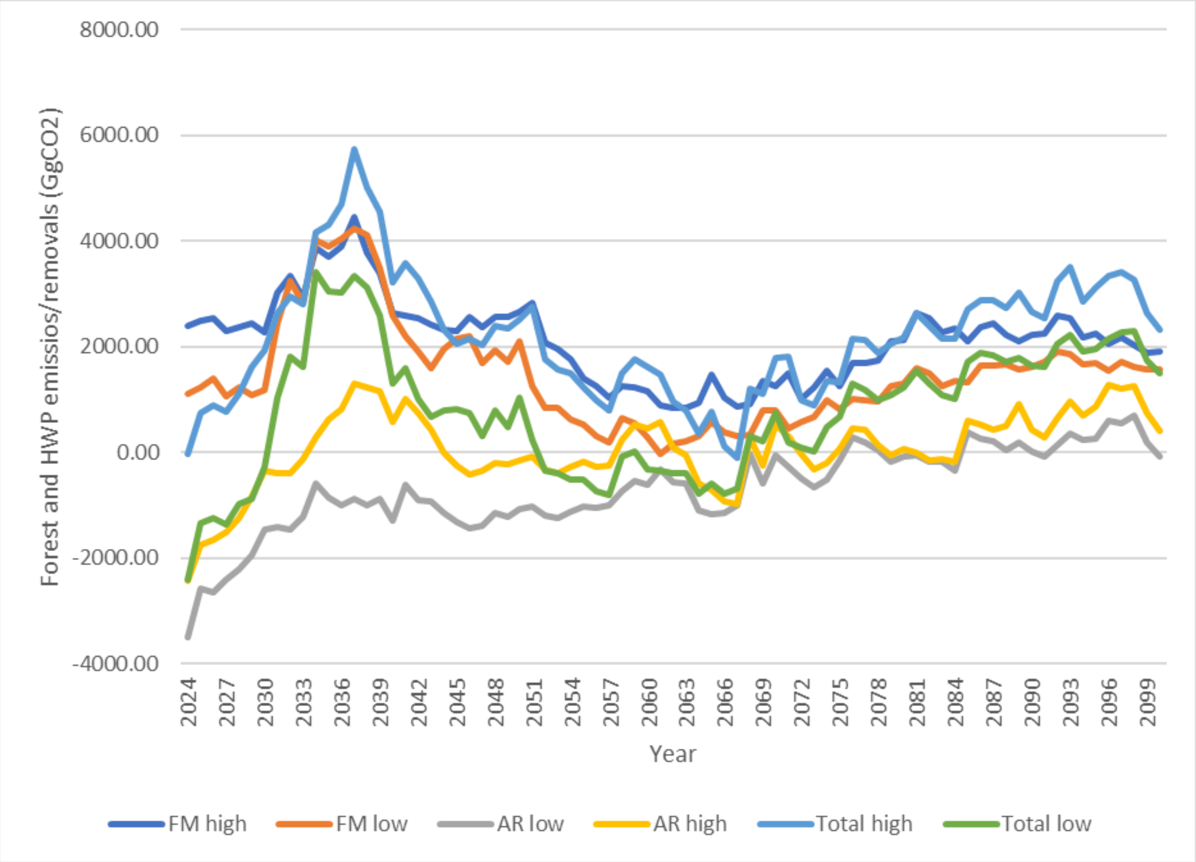
- Soils
  - 15% organo-mineral; 85% mineral
  - 100% mineral
- Management
  - Current silvicultural management
  - More sustainable man. (longer rotations, more continuous cover forestry)
- Planting rate
  - Current policy >>>
  - 50yr @ historic max
  - Capped 30% land by 2100

	2027-2030	2031-2080	2081-2100	AR area by 2100
		kha yr-1		ha
Standard planting rate	8,000	**8,000**	8,000	596,000
Maximum planting rate	16,000	**25,000**	10,140	1,518,743
Intermediate NZ rate	11,200	**17,00**	7,101	1,260,700

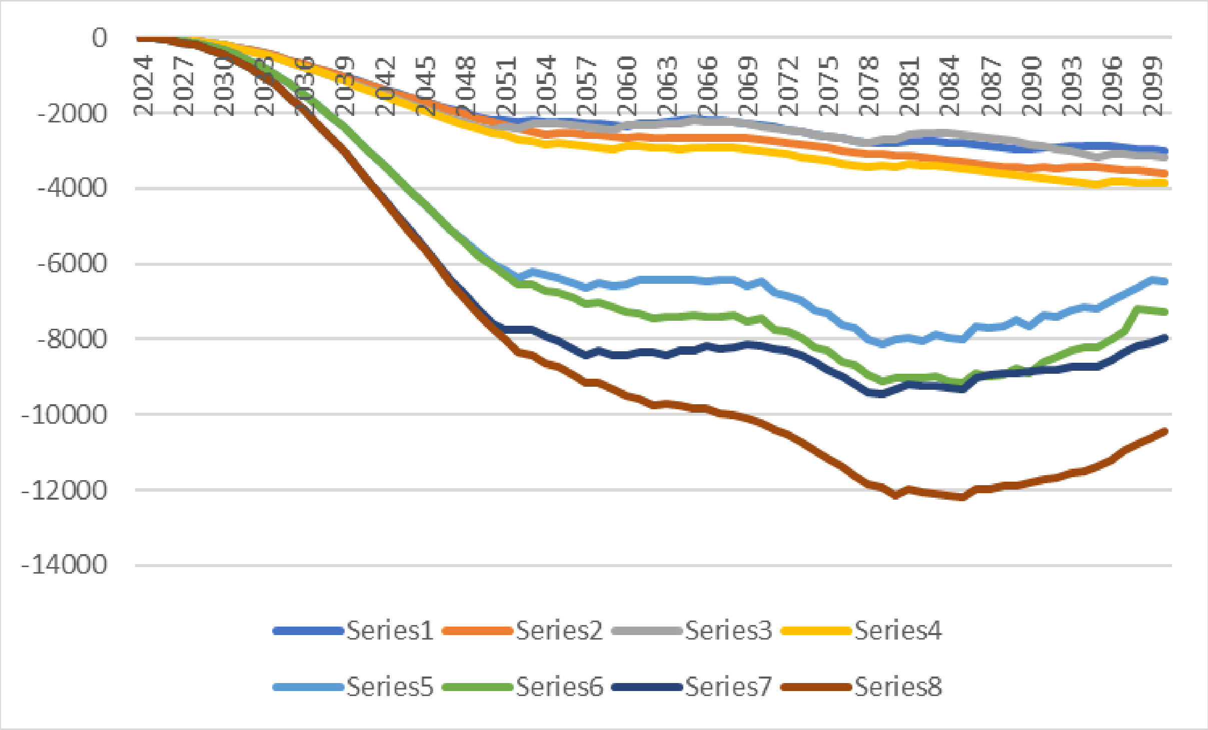
Forestry to 2100

Ex. BECCS

Existing forest

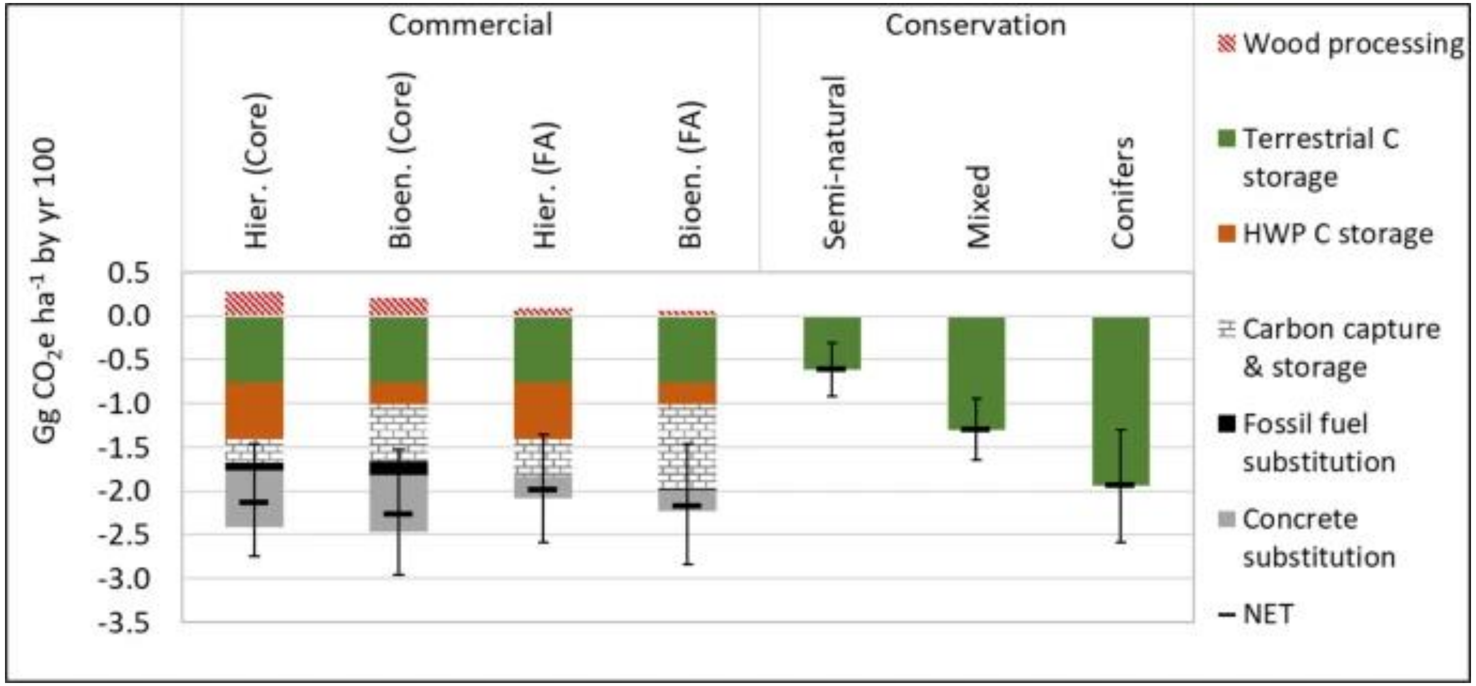


Afforestation 2025+



Range = rates, tree species & soils

HWP accounting

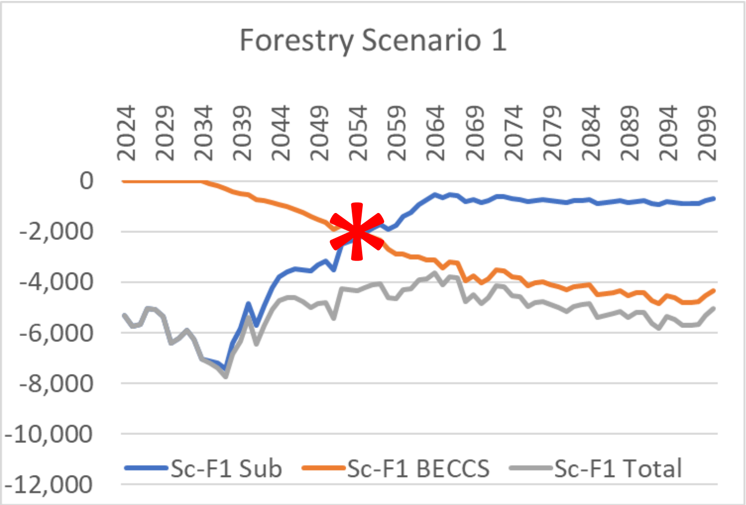


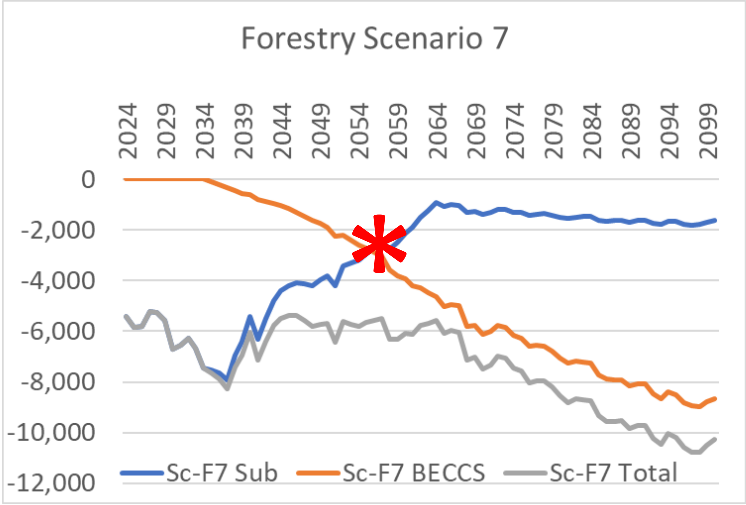
- Forster et al., 2021 https://www.nature.com/articles/s41467-021-24084-x
- Cascading uses and future CCS = substantial, ongoing mitigation potential (“carbon pump”)
- Inventory reports carbon storage in first products (sawn wood and wood based panels)
  - Substitution credits elsewhere
  - Holmgren (2021) estimated 3.7 Mt CO_2e annually displaced by HWPs from Coillte forest
- Instant oxidation assumed at end-of-life via stock decay function

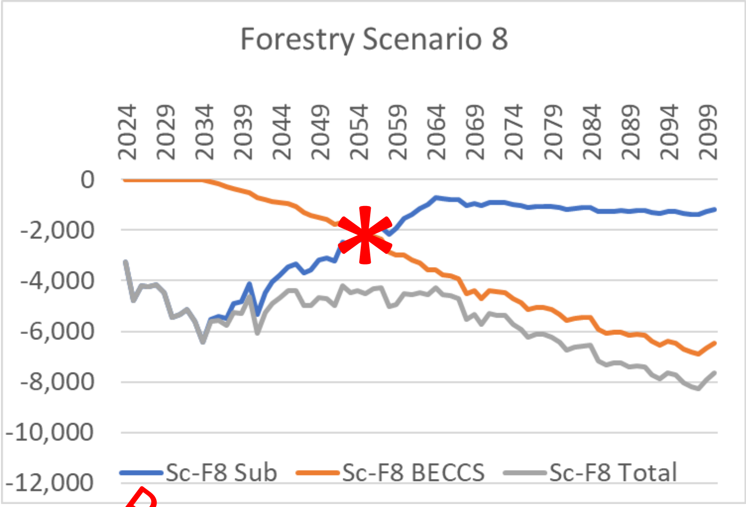
Wood products

- Current product NIR breakout assumed constant
  - 10% bioenergy, 30% sawn wood, 20% panels
  - HWP CO_2 storage factors in core forestry numbers
- Indicative product substitutions for sawn-wood & panels
  - Holmgren (2021) factors: 1.5 and 1 t C per t C (but decline as economy decarbonises – coupled with CCS deployment)
- Indicative (future, 2030+) fossil energy substitution: natural gas
  - 10% harvest plus 20% from sawmill residues plus HWP outflow (wastes)
- Indicative (future) BECCS from above bioenergy
  - Same estimated CCS deployment rates used for AD (3-90%)

Indicative substitution & BECCS (LCA perspective)







- Sc-F1 = current policy planting, high harvest
- Sc-F7 = high planting rates, high harvest
- Sc-F8 = high planting rates, reduced harvest (as per overall Sc-3)

Preliminary tentative potentials - not necessarily reflected in NIR

* c.2 Mt CO_2e CCS estimates included in 2050 forestry balance (48% CCS deployment, on c.1 GW heat capacity, 9TWh heat)

Holmgren (2021) factors applied for substitution - may be abroad (exported wood, or displacing imported steel, etc). Not included in forestry CB balance.

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Scenario summary

- Spared land areas assigned to: (i) organic soil rewetting; (ii) AD for 5.7 TWh yr^{-1} biomethane (prioritising food waste and slurry); (iii) afforestation as specified below; (iv) biodiversity & other ES on remaining area

Scenario	Agriculture	Forestry
1a 1b 1d 1e	• AG-34% (current herd structure, MACC+, 34% GHG reduction) • AG-40% (intermediate herd, MACC+, 40% GHG reduction) • AG-52% (dairy specialisation, high yield, MACC+, 52% GHG reduction) • AG-60% (dairy specialisation, high yield, MACC+, scaled to 60% GHG reduction)	Forest management: More sustainable management (longer rotations, more continuous cover forestry) Afforestation: BAU mix (50:50 C:BL), 15% on organo-mineral soils: 8 kha per year planting > 2030
2a 2b 2d 2e	• AG-34% (current herd structure, MACC+, 34% GHG reduction) • AG-40% (intermediate herd, MACC+, 40% GHG reduction) • AG-52% (dairy specialisation, high yield, MACC+, 52% GHG reduction) • AG-60% (dairy specialisation, high yield, MACC+, scaled to 60% GHG reduction)	Forest management: More sustainable management (longer rotations, more continuous cover forestry) Afforestation: BAU mix (50:50 C:BL), 15% on organo-mineral soils: 25 kha per year 2030-2080
3a 3b 3d 3e	• AG-34% (current herd structure, MACC+, 34% GHG reduction) • AG-40% (intermediate herd, MACC+, 40% GHG reduction) • AG-52% (dairy specialisation, high yield, MACC+, 52% GHG reduction) • AG-60% (dairy specialisation, high yield, MACC+, scaled to 60% GHG reduction)	Forest management: More sustainable management (longer rotations, more continuous cover forestry) Afforestation: 70:30 C:BL mix, 100% mineral soils: 25 kha per year 2030-2080
4d	• AG-52% (dairy specialisation, high yield, MACC+, 52% GHG reduction)	Afforestation: 70:30 C:BL mix, 100% mineral soils: 17,500 ha per year 2030-2080

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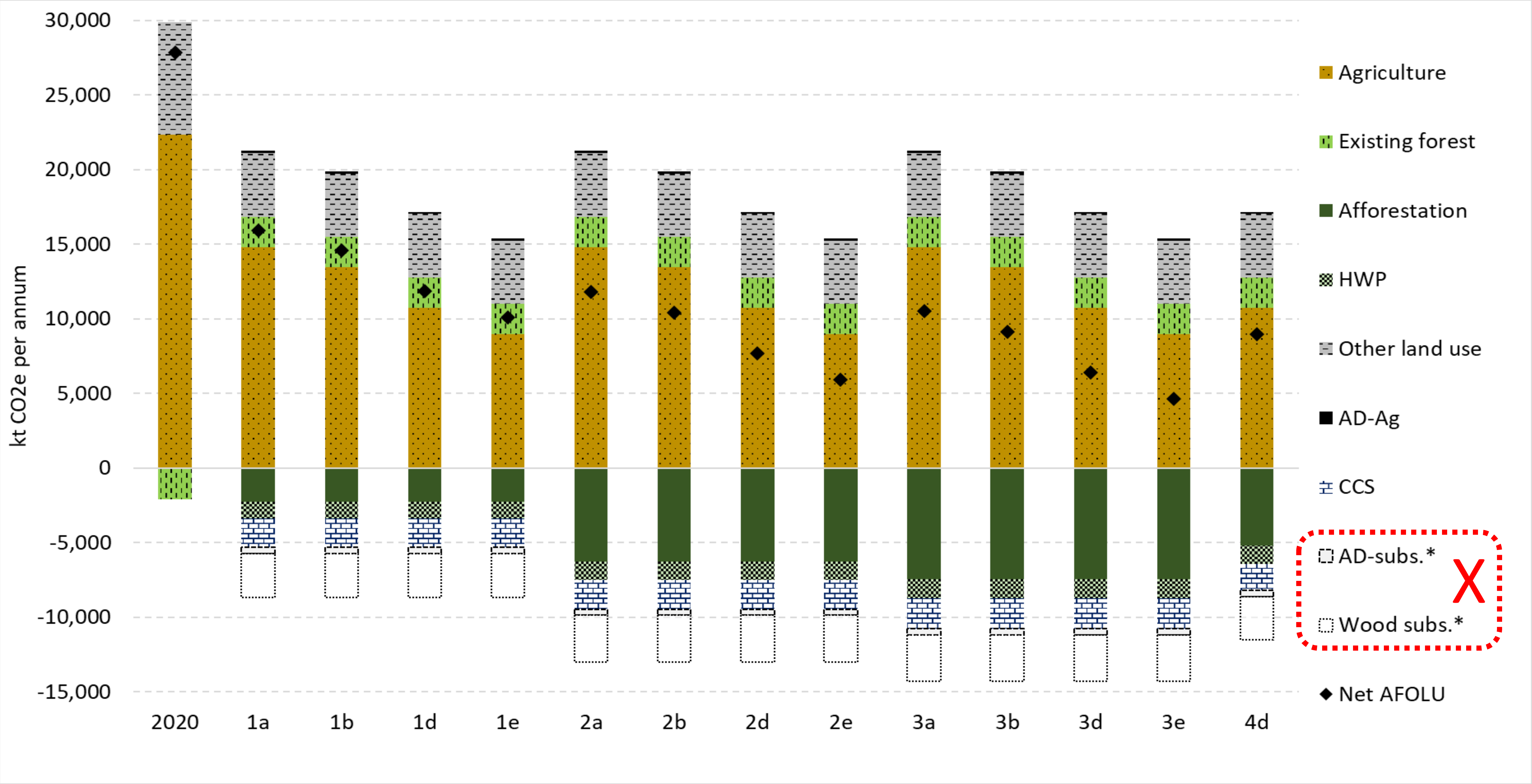
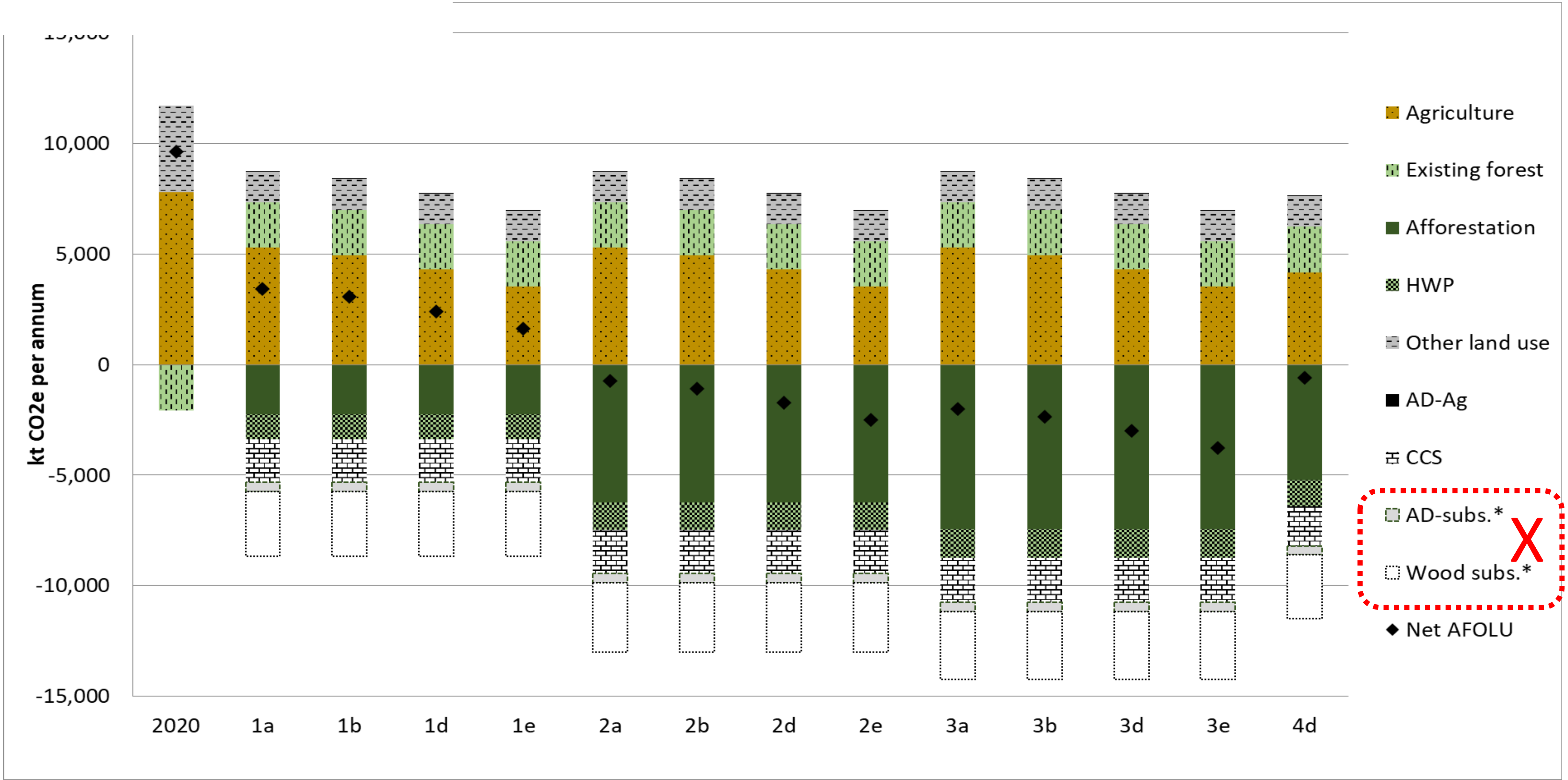
2050 GWP_{100} balance



2050 GWP_{100} ex. CH_4



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Carbon Budgets

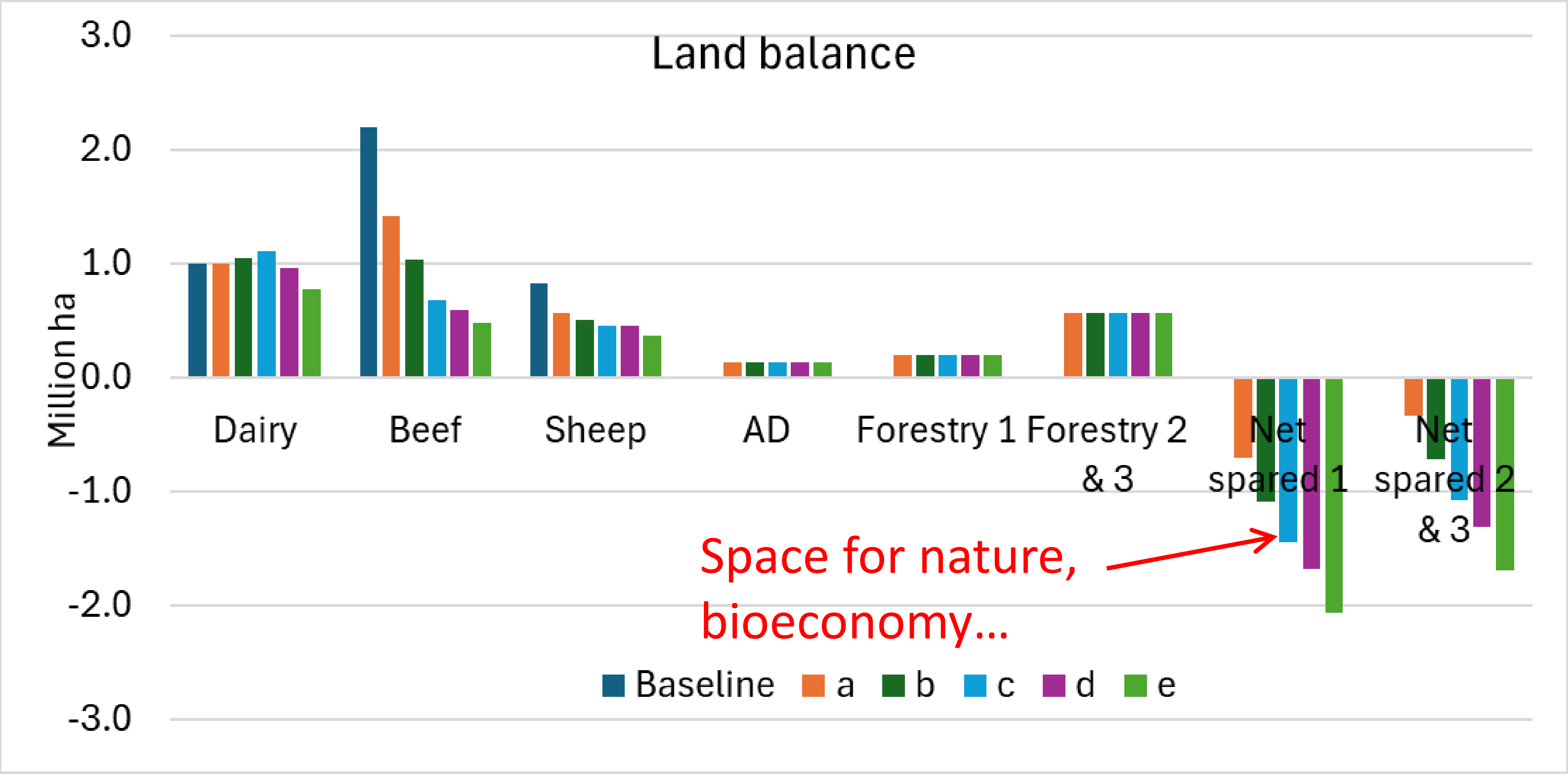
Scenario 1a (lowest ambition)

	Ag-CO_2	Ag-CO_2e	LULUCF-CO_2	LULUCF-CO_2e
2031-2035	2.0	82.4	11.8	32.3
2036-2040	2.2	79.9	10.8	29.7
2041-2045	2.4	77.5	-3.0	14.3
2046-2050	2.6	75.0	-9.5	6.3

Scenario 3e (highest ambition)

	Ag-CO_2	Ag-CO_2e	LULUCF-CO_2	LULUCF-CO_2e
2031-2035	1.9	78.0	8.8	29.3
2036-2040	1.9	68.2	2.6	21.4
2041-2045	2.0	58.4	-18.8	-1.5
2046-2050	2.0	48.6	-33.4	-17.7

Land balance & biodiversity



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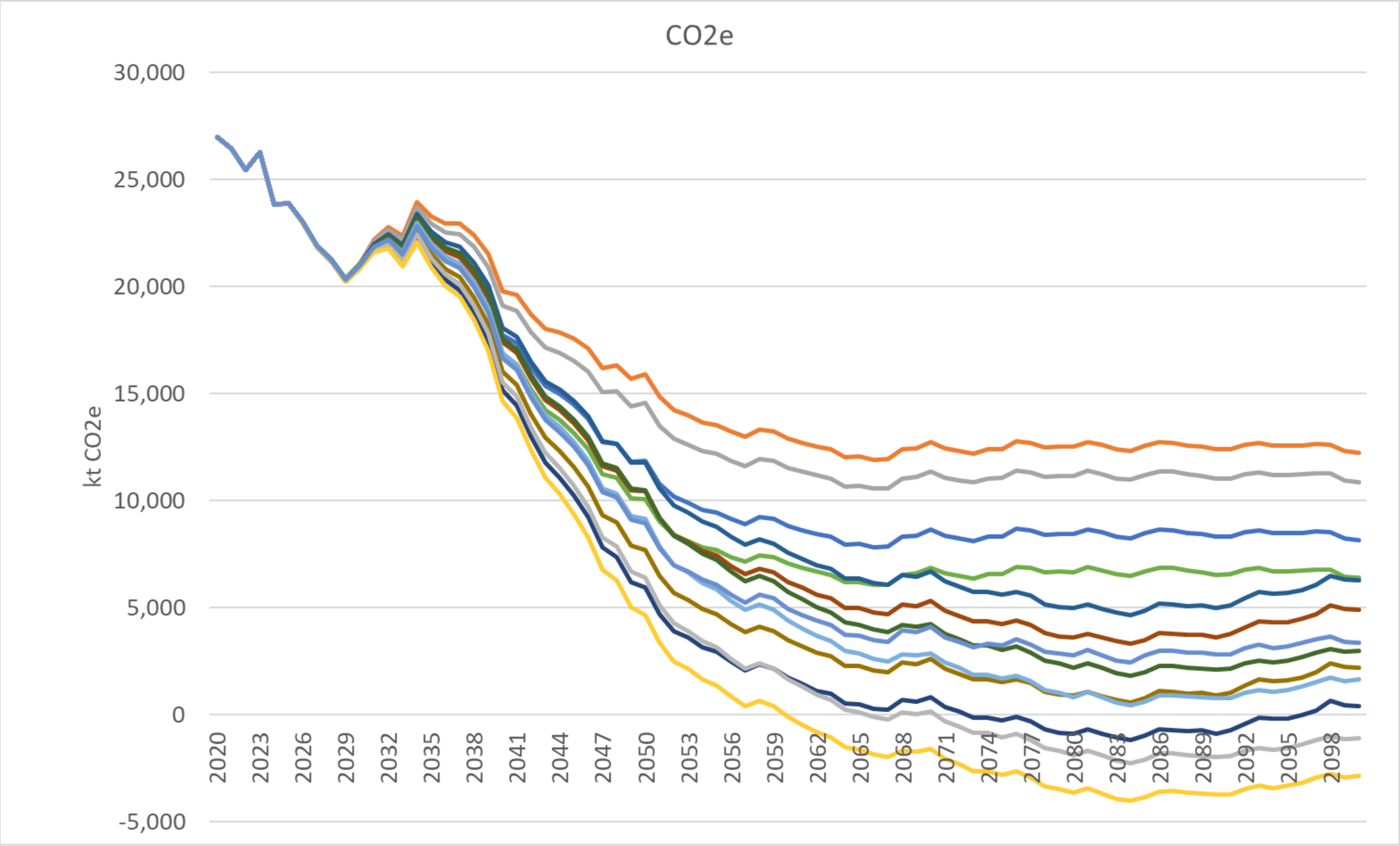
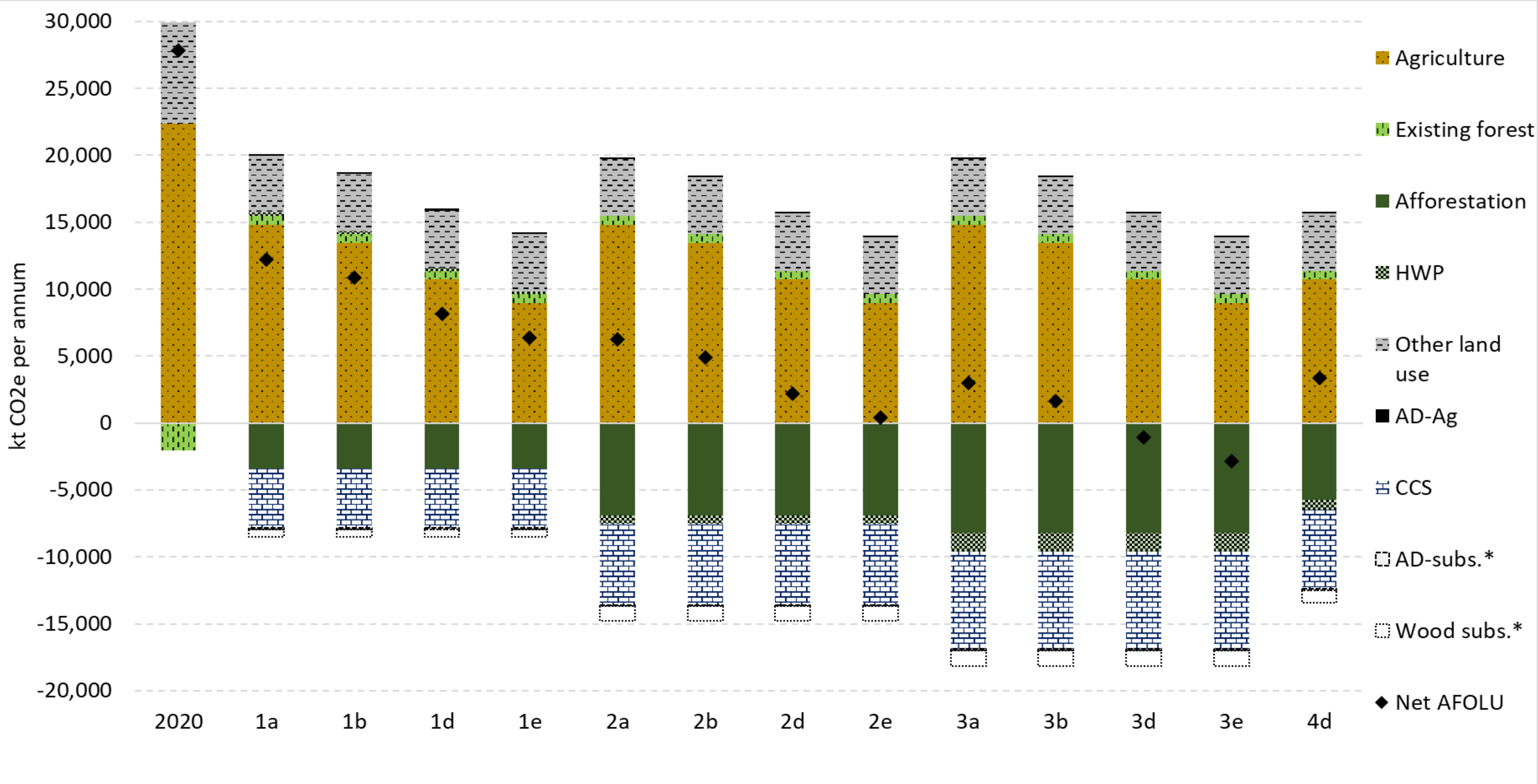
Post 2050….

Land use & bioeconomy

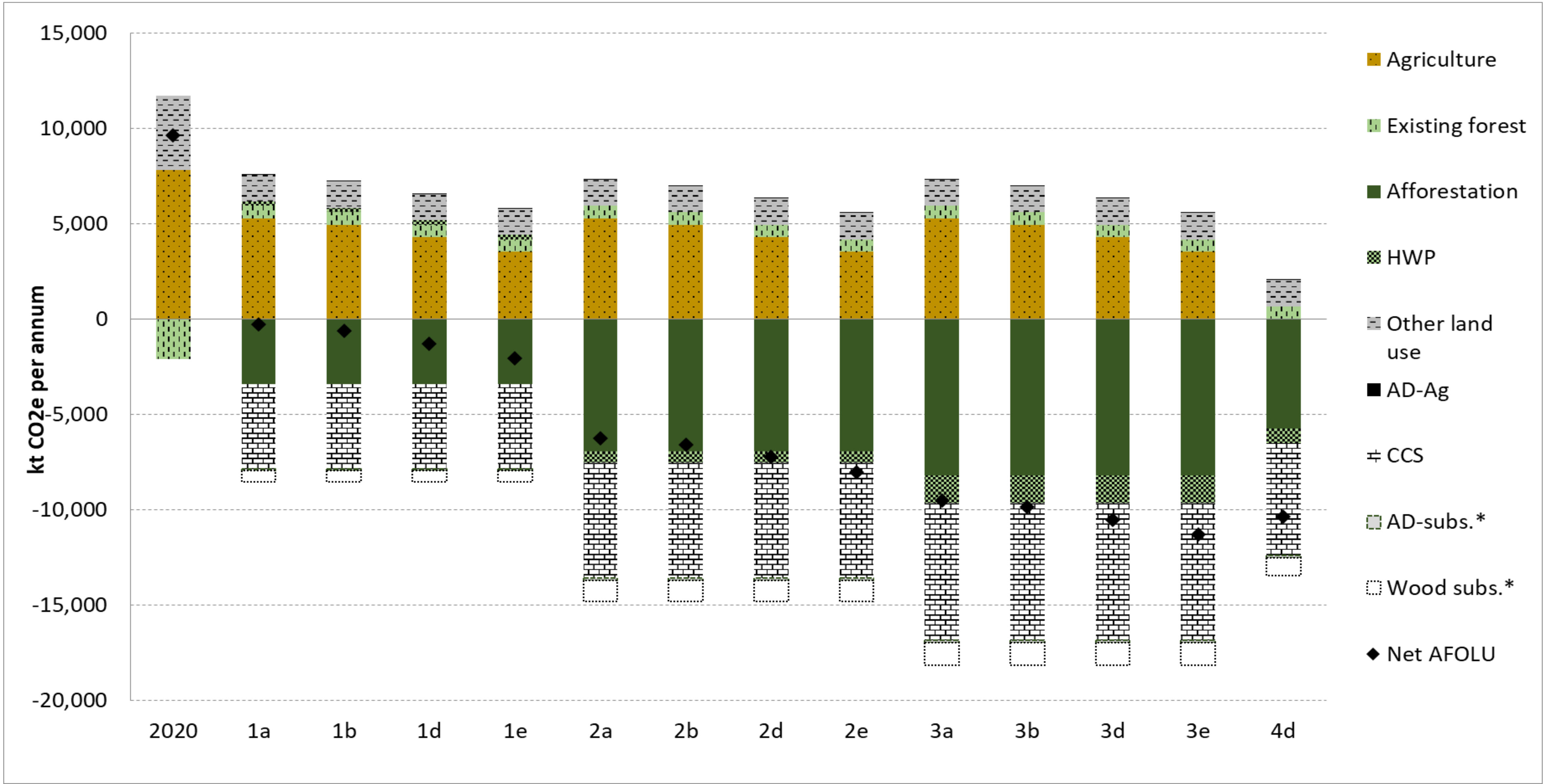
Long-term (GWP_{100})



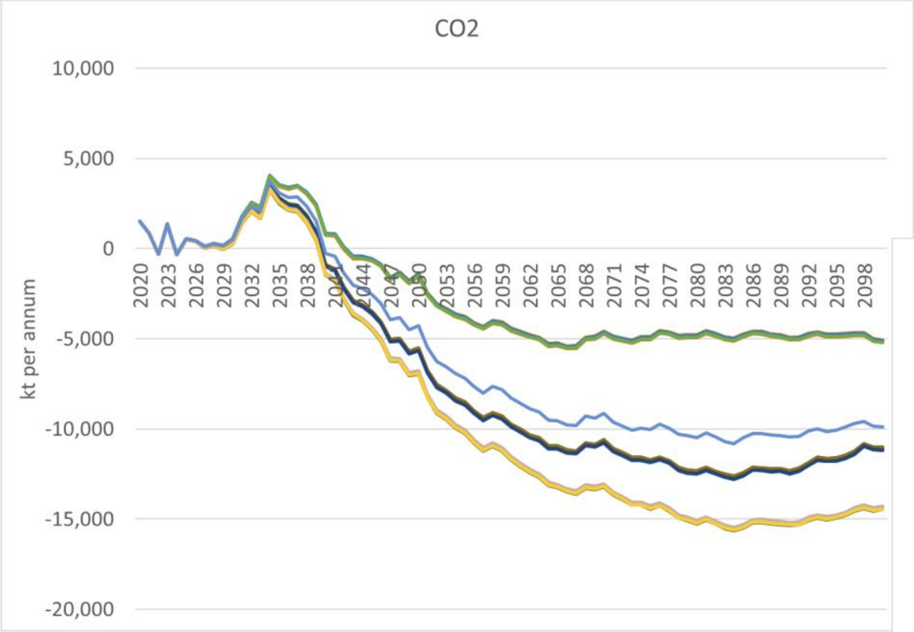
2100 GWP_{100} snap shot (negative emissions!)

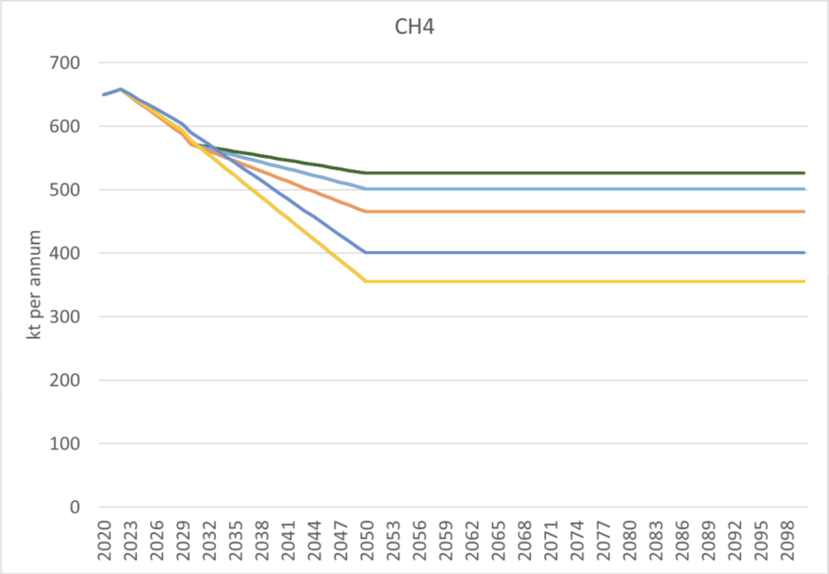


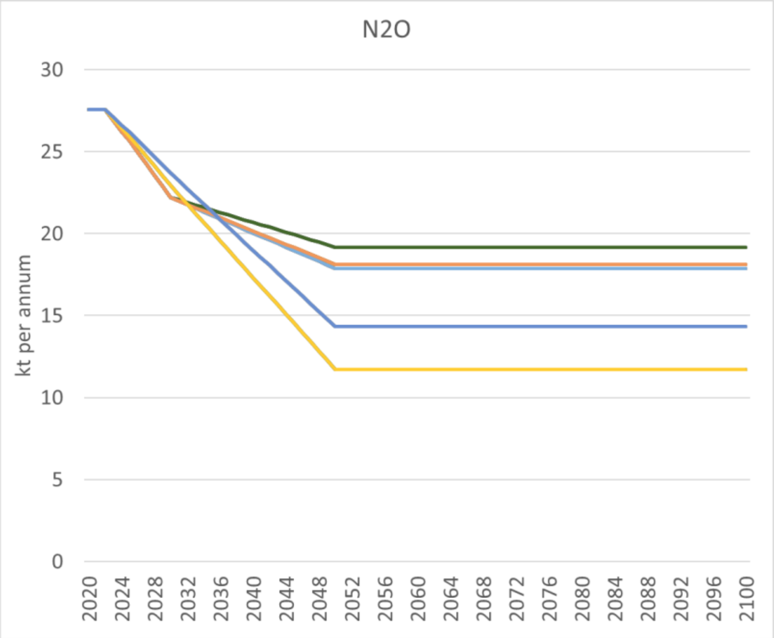
2100 GWP_{100} ex. CH_4



Gas time series







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Scenario context

- Predicated on maintaining high bovine protein output
  - Did not consider more transformative diversification within Ag sector (conservative)
- Sustainable intensification / land sparing approach
  - Implies consolidation of farms
  - Potential space for nature and space for bioeconomy
  - Land management could vary substantially within these scenarios (multifunctionality etc) > deeper spatial and posthoc analyses needed
- LCA & long-term perspective: bioeconomy important for national GHG mitigation
  - Could contribute to diversification and multifunctional land use (with careful integration) – cascading value chains

Summary

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- Even with dairy specialisation and maximum abatement, net zero a massive challenge for AFOLU
  - Not achieved with afforestation 25 kha/yr from 2030 with GWP_{100}
  - However, net zero possible if CH_4 set a separate target
  - Productivity improvements reduce animals & spare large areas (for biodiversity, dairy-beef extensification?)

- AD can make a useful contribution to GHG mitigation if fed with wastes
  - Max mitigation when replacing diesel, up to 1.6 Mt CO_2e yr^{-1}
  - Mitigation wanes as economy decarbonises > inefficient land use also for BECCS (biorefineries?)

- Commercial forestry drives large downstream mitigation (carbon pump)
  - Substitution effect up to 7 Mt CO_2e yr^{-1} (not necessarily all in Ireland though!)
  - HWP C storage (change) effect up to 4 Mt CO_2e yr^{-1}
  - BECCS potential circa 2 Mt CO_2 by 2050, and 7 Mt CO2 by 2100 (if waste streams cleaned and diverted - which country & sector gets credit?) Worth €bns @ future CO_2 prices
  - Could help mitigate risk of large AFOLU C losses in soils and forests (extreme events)

- 50-100 yr land sector planning needed for a climate neutral (bio)economy
  - Long-term forestry dynamics
  - Improved biogenic C management and accounting critical (along with water, biodiversity assessments….)

CAPACITY
CLIMATE ACTION PATHWAYS & ABSORPTIVE CAPACITY

Energy system pathways for carbon budgets: Third iteration of TIM scenarios

CCAC Carbon Budgets Working Group; August 29th, 2024

Hannah Daly, Vahid Aryanpur & Bakytzhan Suleimenov

MaREI
Energy · Climate · Marine

Environmental Research Institute

UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Overview of Iterations

1st	2nd	3rd
December 2023	**May 2024**	**August 2024**
• CB: 315 to 400 Mt • Demand: BAU & LED • Accelerated vs Delayed action • Overshoot & CDR reliance • Results (link)	• CB: 250 to 450 Mt • Demand: BAU & LED • EU target 2040 • Increased calibration • Interim report & peer review • Results (link)	• CB: 250 to 450 Mt • Overshoot: WEM & WAM • Industry sector redevelopment • High solar & lower biomass sensitivity • Results (link)

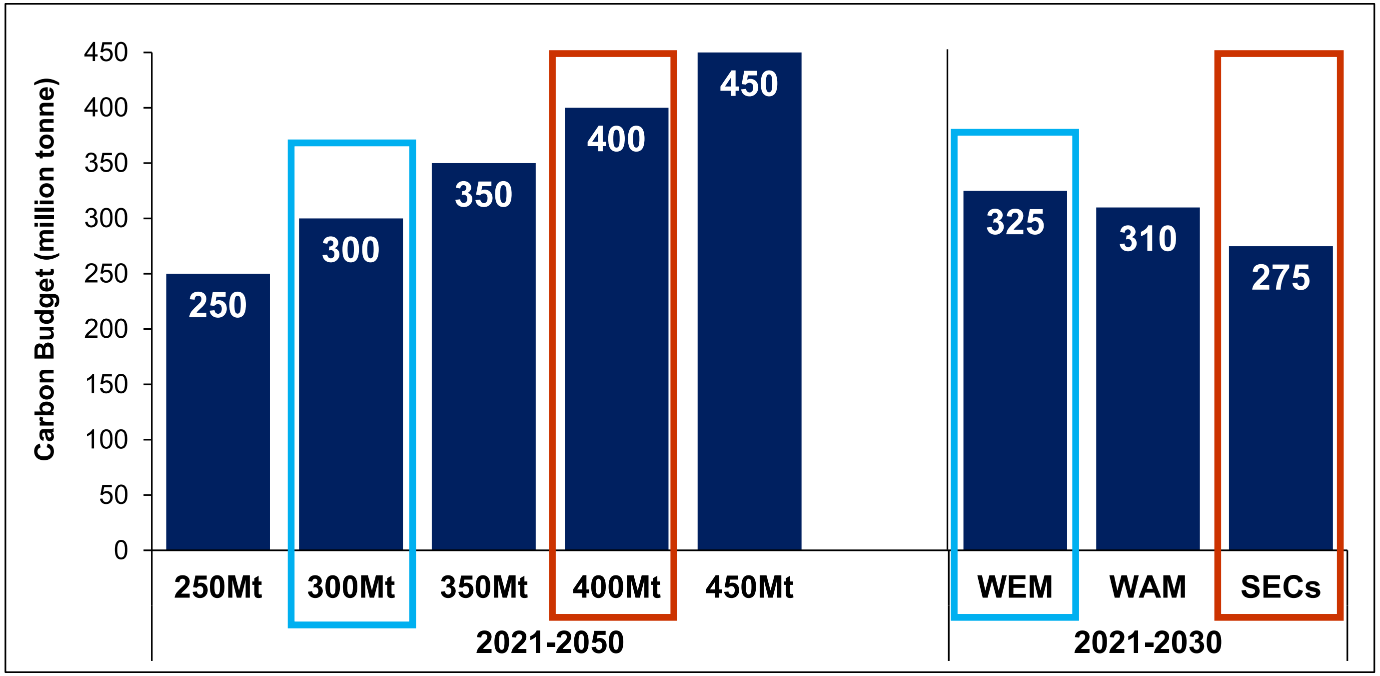
3rd iteration updates

- ***New results web portal:***
  - https://epmg.netlify.app/TIM-Carbon-Budget-2024-v2/about?scen1=mitigation_cb2024-250mt&scen2=null&diff=false
- ***Engagement***
  - Feedback from CCAC
  - Broader peer-review of interim report
  - SEAI Modelling team
  - Engagement with NTA on travel demand, with GOBLIN team on bioenergy & land use
- ***Submitted revised version for review in nature Climate Action journal***
  - Title: *Implications of Accelerated and Delayed Climate Action under Carbon Budget*

The model updates between 2nd and 3rd iteration of modelling to support CCAC CBWG:

- Major updates:
  - Major redevelopment of industry sector
    - Using SEAI National Heat Study
    - Consists of 9 subsectors/uses with 4 temperature levels of process heat
    - Different technologies for each temperature level
    - ETS and non-ETS energy use split
  - New vehicle sales for 2023-2024
  - Bioenergy import assumptions update using European studies
  - WAM/WEM scenario runs using EPA emissions projections as lower bound for emissions
- Minor updates:
  - Corrected small calibration issues
  - Bug fixes in result tables and webpage view

Scenario assumptions



*SECs for energy sectors for CB1+CB2 add to 275 Mt.
**WEM and WAM are rounded to the nearest 5.

Core scenario (400Mt)

- CB constraint for 400Mt:
  - ✓ 400Mt for 2021-50
  - ✓ SECs for 2021-2030
- BAU energy demand projection

WEM scenario (300Mt)

- CB constraint
  - ✓ 300Mt for 2021-50
  - ✓ WEM for 2021-2030
- BAU energy demand projection

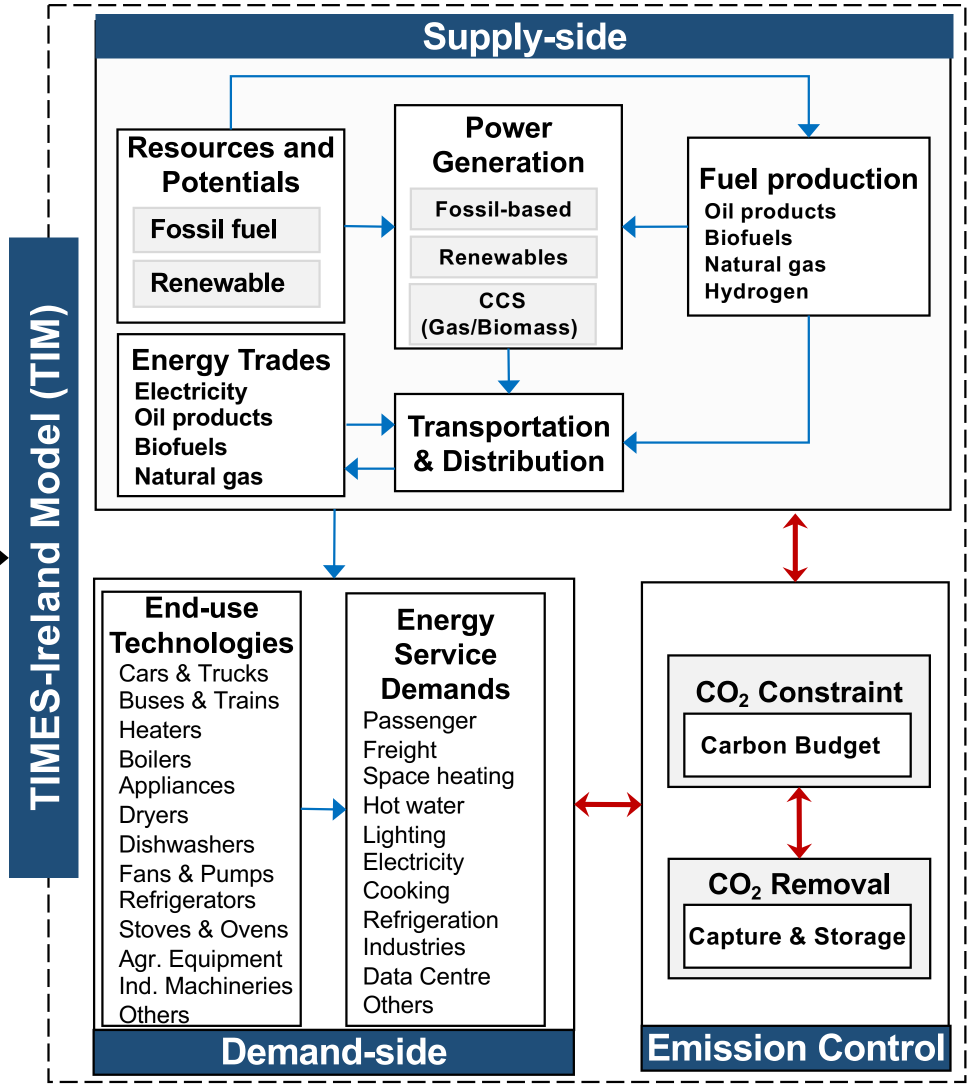
Carbon budget & scenarios

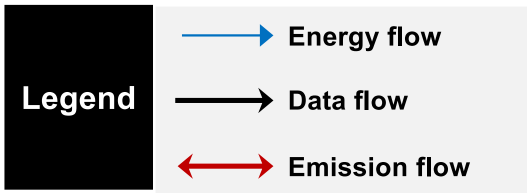
Further analysis
▪ Low Energy Demand ▪ WEM & WAM ▪ Limited Bio-Supply ▪ High Solar PV

→

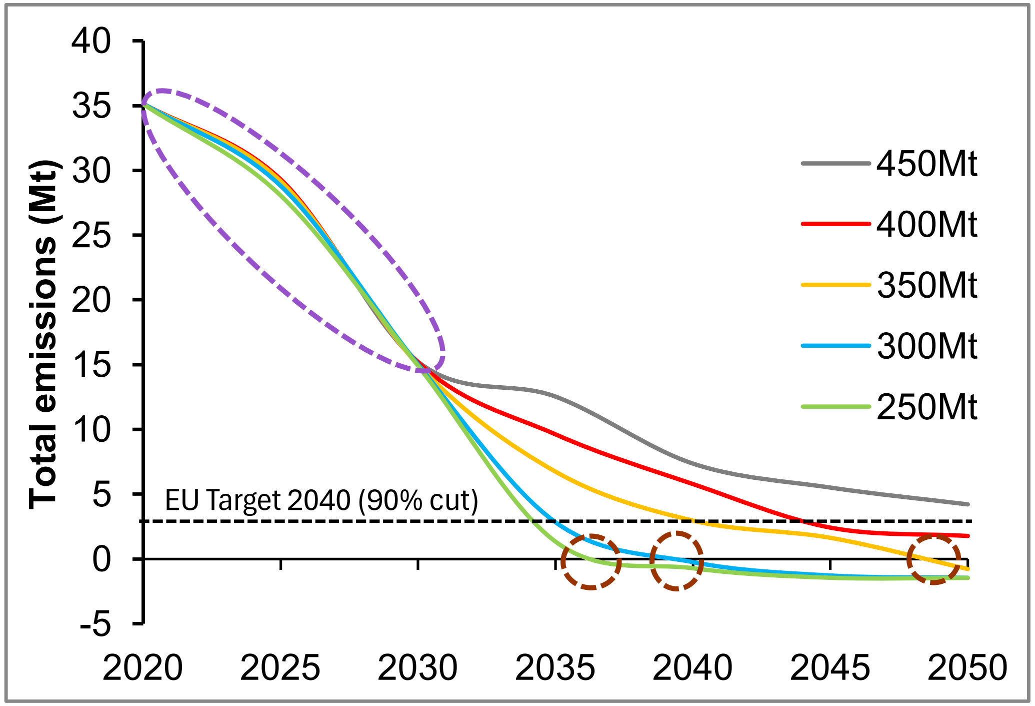
Core Scenarios (Carbon Budgets)
▪ 250Mt ▪ 300Mt ▪ 350Mt ▪ 400Mt ▪ 450Mt

→





Mitigation pathways: Core



Pre-2030

- Single pathway (no matter which CB)
- PfG target: 51% by 2030 compared to 2018
- Planning under CB suggests 60% reduction

Post-2030

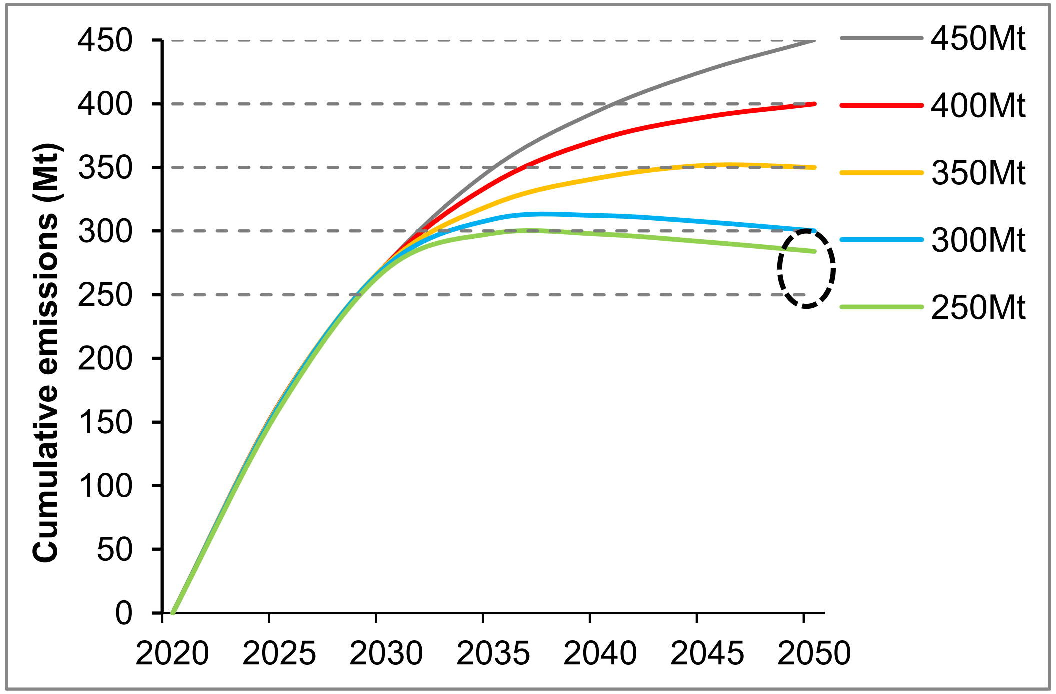
- Divergence appears
- 250Mt & 300Mt: Net-zero by 2036 & 2039
- 350Mt CB: Net-zero by 2045

Indicative EU Target 2040

- The Max. CB is 350Mt to meet the target

➢ Stronger emissions cuts before 2030 are essential to meet smaller carbon budgets

Cumulative emissions: Core



2021-30

- 270Mt: Utilisation of existing fossil-based technologies

Overshoot year

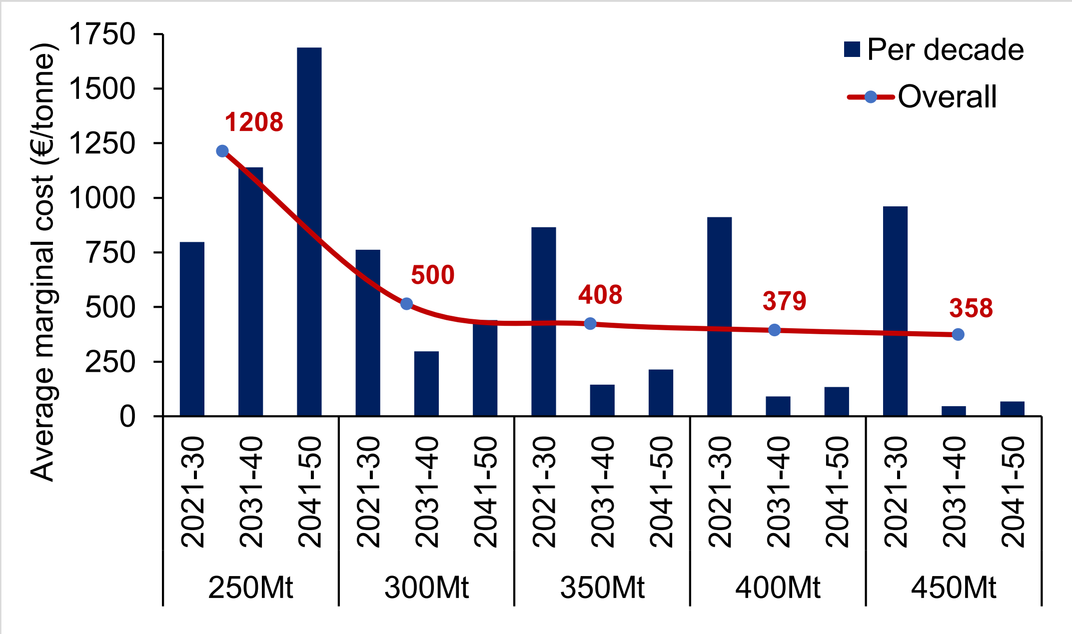
- >400Mt: No overshoot
- 350Mt: Year 2045
- 300Mt: Year 2034
- 250Mt: Year 2029

Unabated emissions

- 34Mt in 250Mt CB scenario

➢ Earlier overshoots increase the urgency for rapid cuts and reliance on CDR

Marginal abatement cost: Core



Per decade carbon price

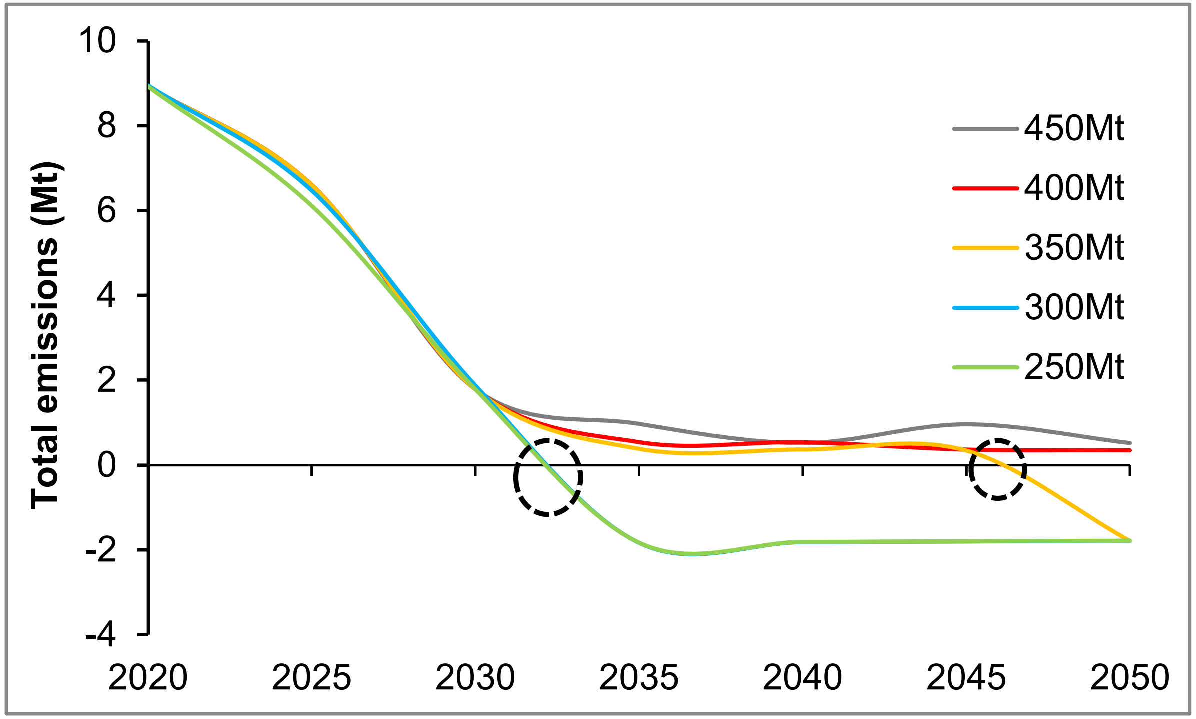
- Consistently increases in 250Mt
- Increases by 2040 and reduces in 300Mt
- Decreases in generous CBs

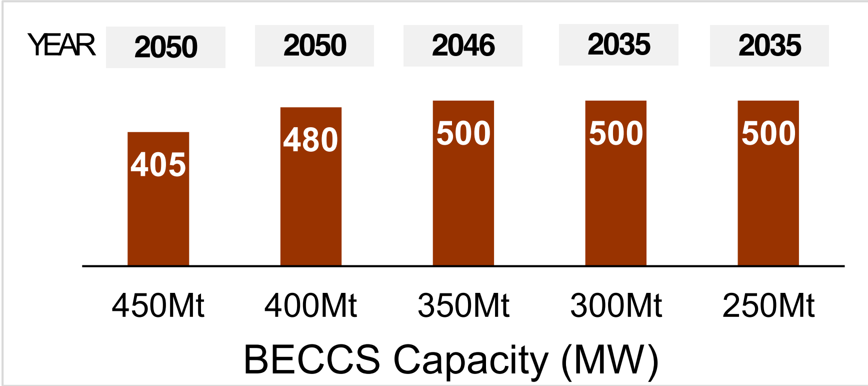
Overall carbon price

- Inverse relationship between the size of the CB and the abatement cost
- More than double from 300Mt to 250Mt
- Maintaining a CB between 300 and 350Mt results in only a modest increase in costs

➢ Higher ambition raises marginal abatement costs & requires carbon dioxide

Power sector



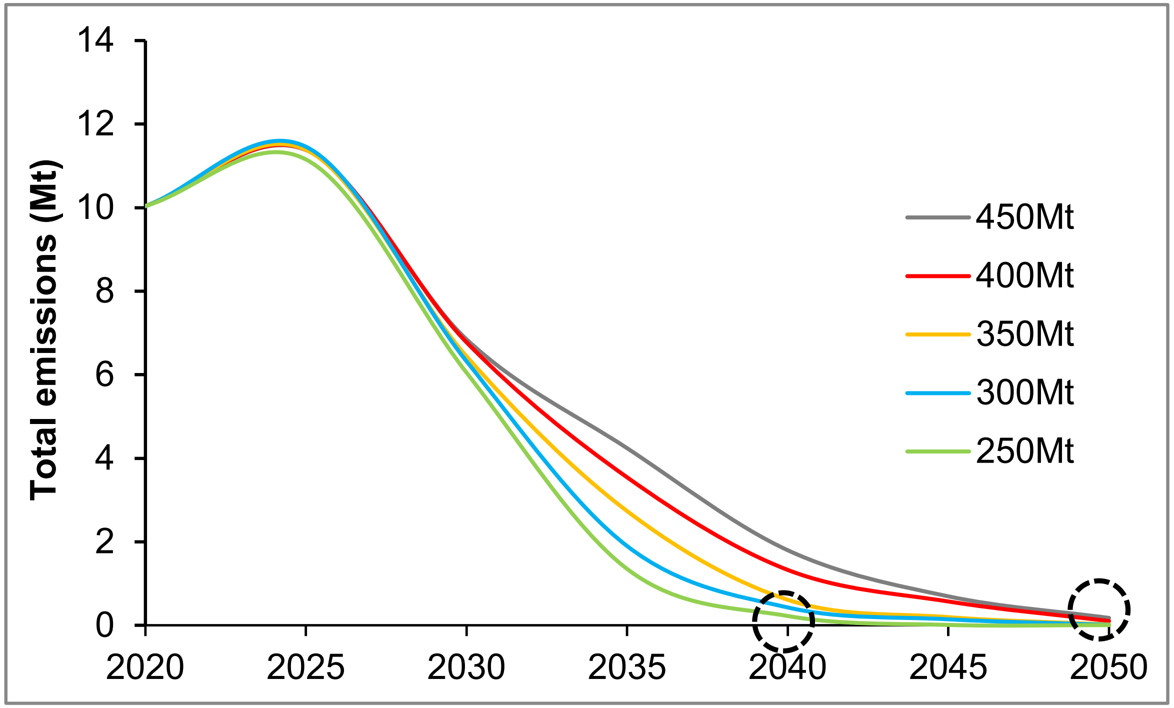


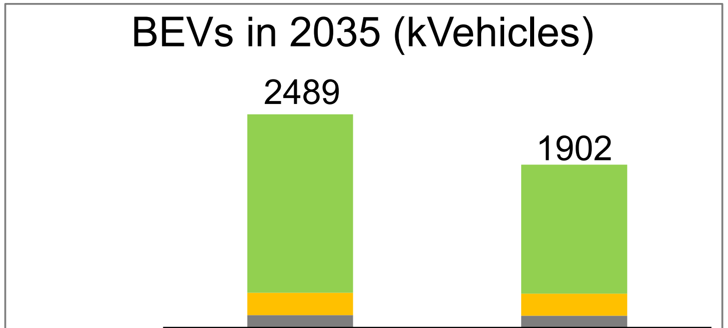
Negative emissions:

- Lower CB accelerates reliance on CDR

➢ Lower CB accelerates net-zero & advanced power generation technologies by 10 years

Transport sector



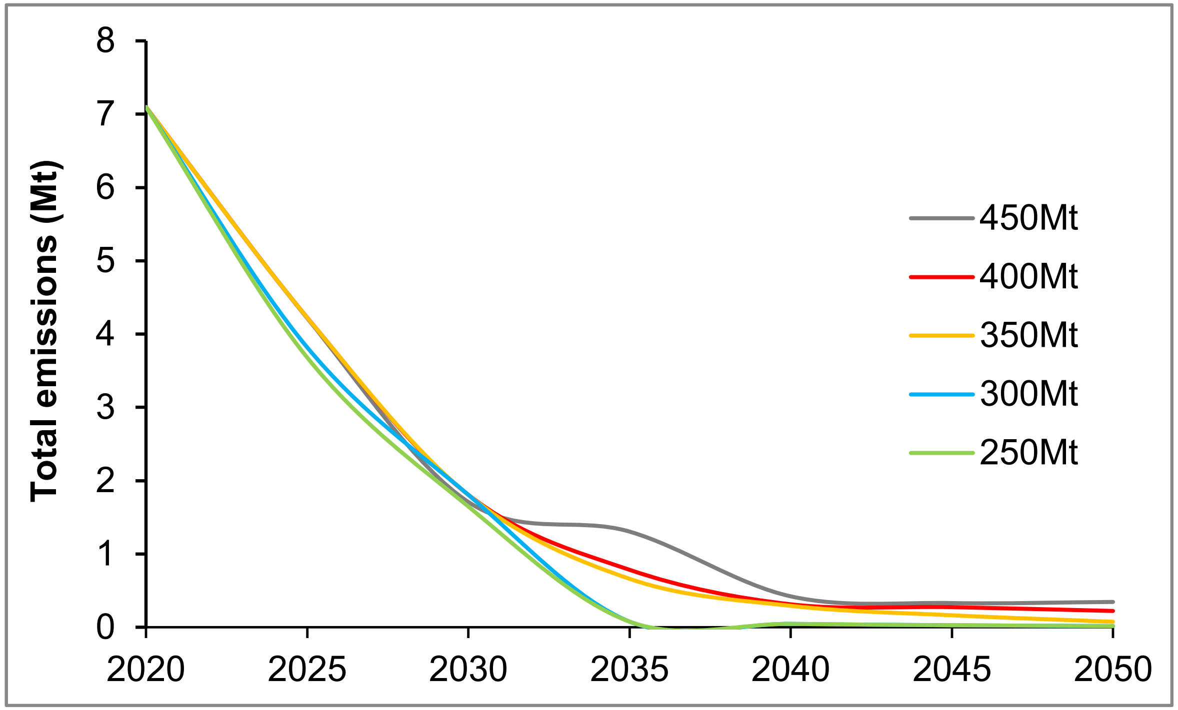


	300Mt	400Mt
Car	2080	1501
Van	258	258
Truck	151	142

- Stringent CB: Nearly zero by 2040
- Generous CB: Nearly zero by 2050
- About 600k more EVs on the Irish roads

➢ Early action can prevent stranded assets and underutilisation of existing ICEs

Residential sector



Pre-2030

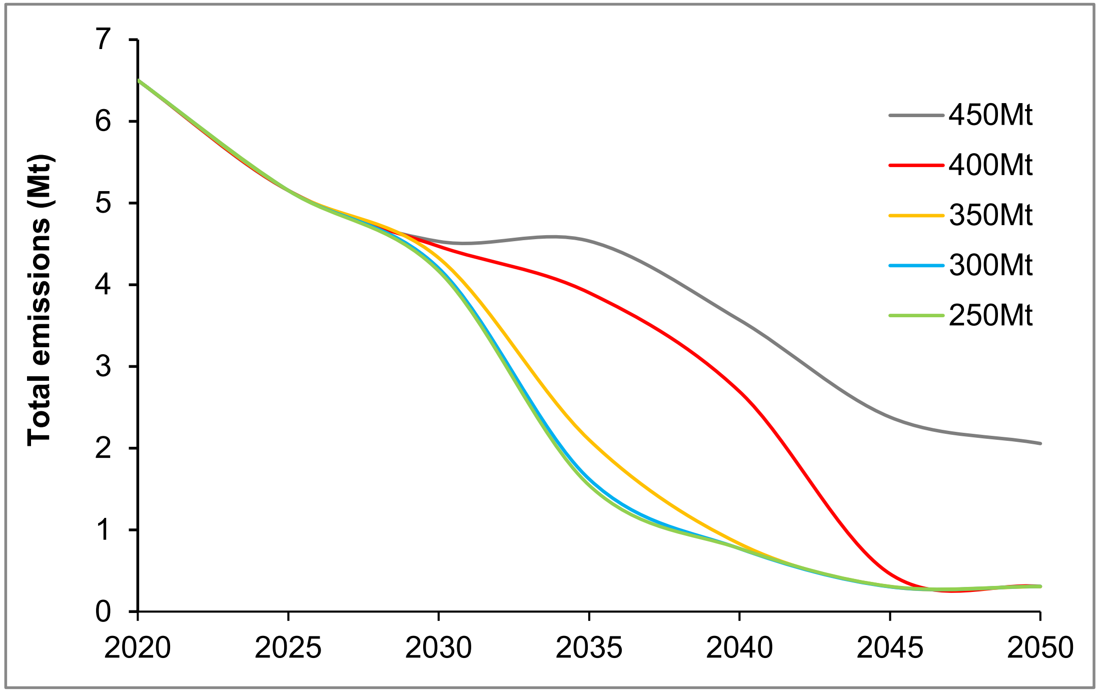
- Single pathway (no matter which CB)
- 75% reduction by 2030 compared to 2018

Stringent CB in 2035

- Nearly zero-emission
- Electricity share from 25% to over 50%

➢ 75% emission cut by 2030 and transitioning to over 50% electricity use by 2035

Industry sector



Pre-2030

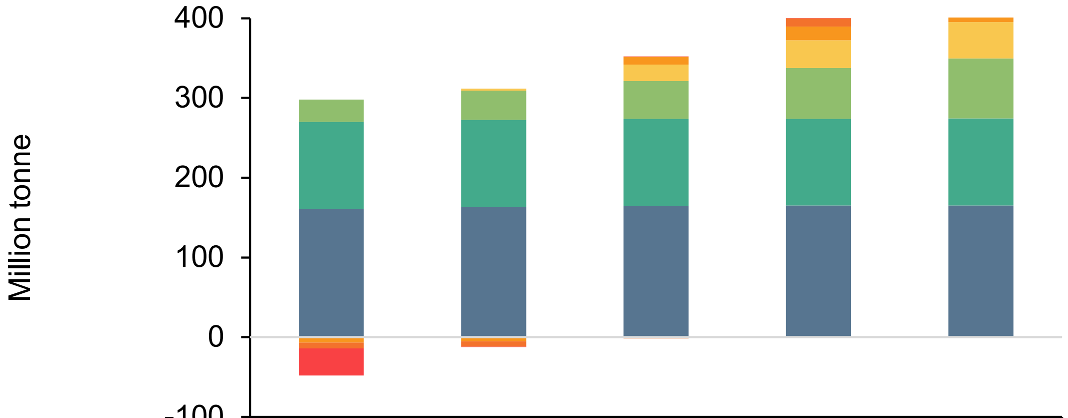
- 38% reduction by 2030 compared to 2018

Post-2030

- 250-350 Mt: Cement & CCS by 2031
- 400 Mt: Cement & CCS by 2043
- Electricity consumption doubles by 2040

➢ Accelerated adoption of CCS and a doubling of electricity consumption by 2040

Temporal Allocation of CB



	250Mt	300Mt	350Mt	400Mt	450Mt
Overshoot	-34	0	0	0	0
CB6 (2046-50)	-7	-7	-2	10	23
CB5 (2041-45)	-6	-5	10	18	31
CB4 (2036-40)	-1	3	21	34	45
CB3 (2031-35)	28	37	48	64	76
CB2 (2026-30)	109	109	109	109	109
CB1 (2021-25)	161	164	165	165	165

1st Decade

- High allowance (Min. 270Mt) shows the time needed to implement initial mitigation measures

2nd Decade

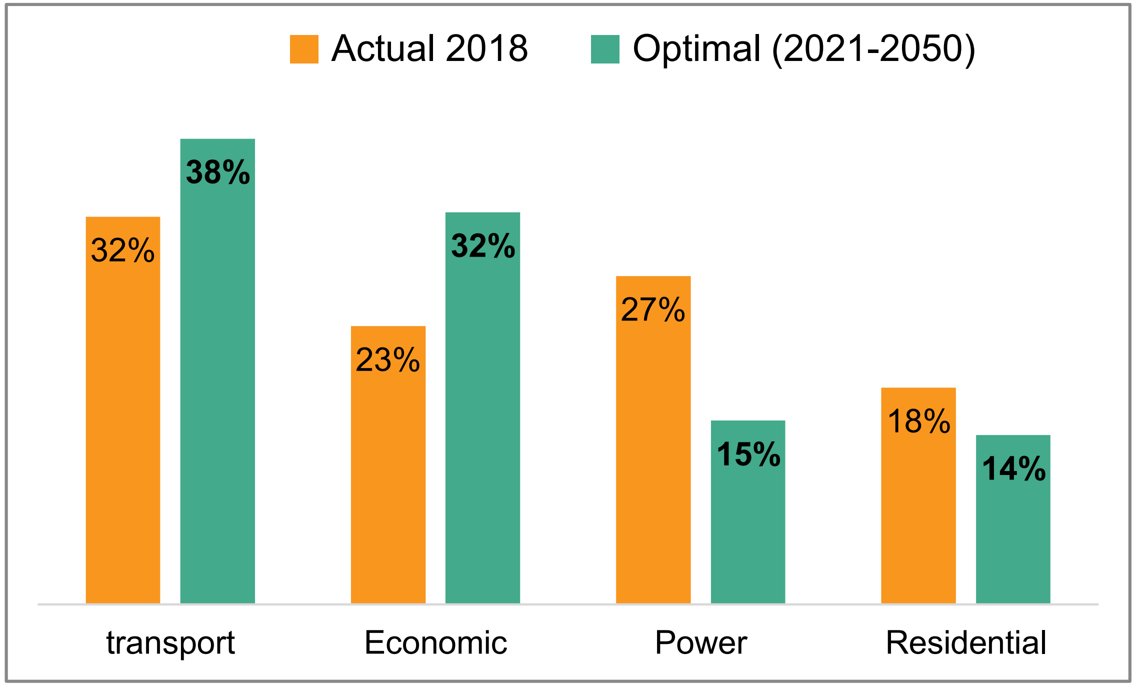
- Decrease significantly (27Mt to 76Mt) as a result of first decade action

3rd Decade

- Very strict (-7Mt to 23Mt) suggests net-zero emissions by this decade

➢ Immediate action is needed to prevent unprecedent cuts later.

Sectoral Allocation of CB



Emphasis on Transport and Economic Sectors
- Hard-to-abate sectors require more attention

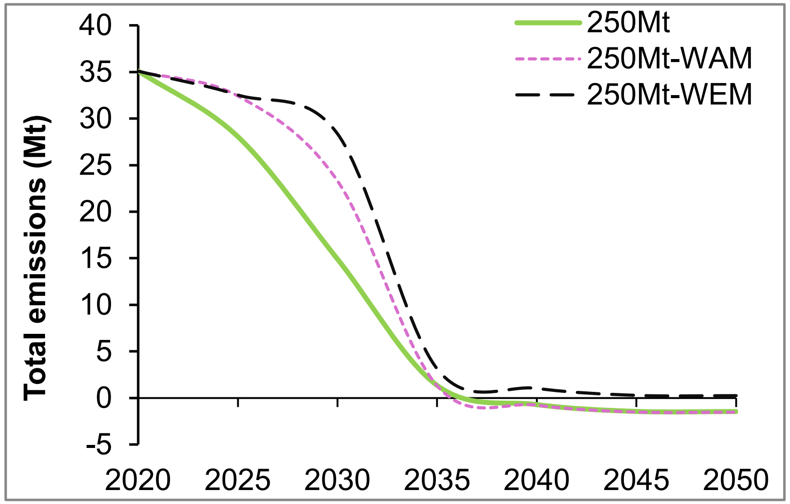
Significant Reduction in Power Sector Emissions
- Critical need for a transition to renewable-based power system

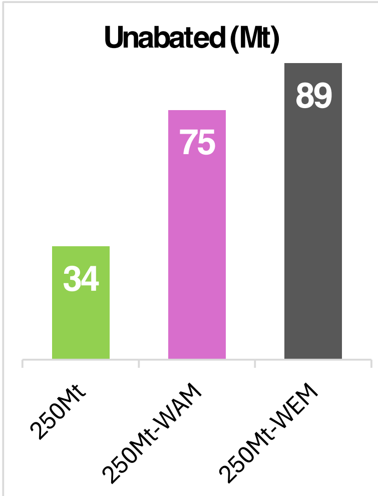
Lower Residential Emissions
- Potential for substantial reductions through energy efficiency measures & electrification

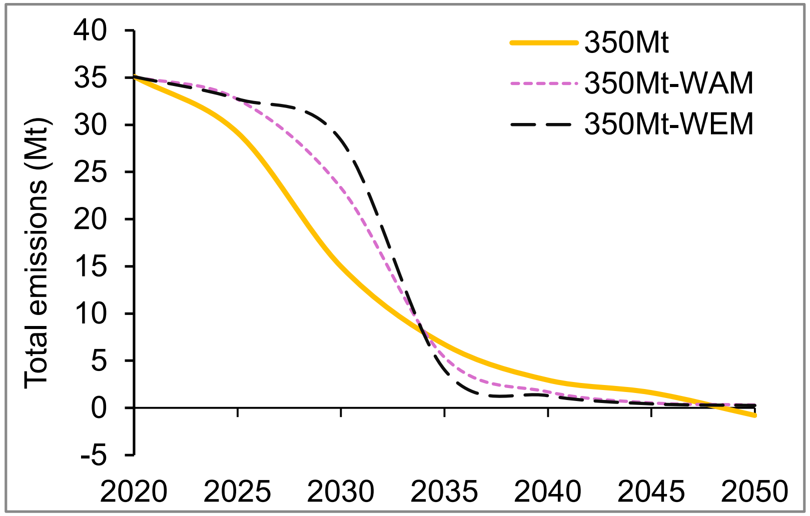
Economic: Industry, Agriculture, Public service

➢ Fundamental transformations in power sector and addressing hard-to-abate sectors

Implications of WEM & WAM







250Mt

- Near-vertical reduction post-2030
- Unabated emissions more than double

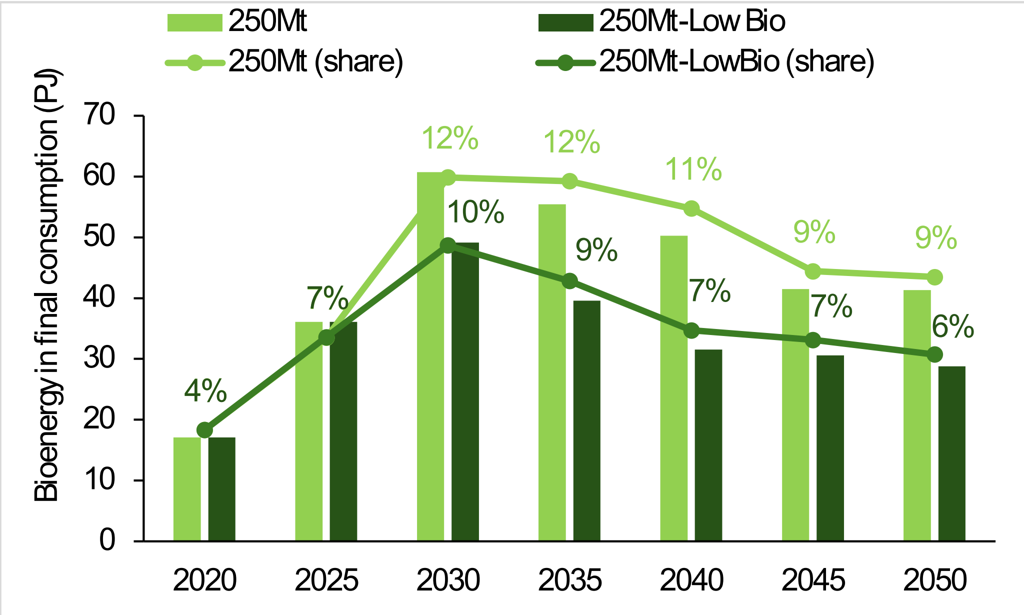
350Mt

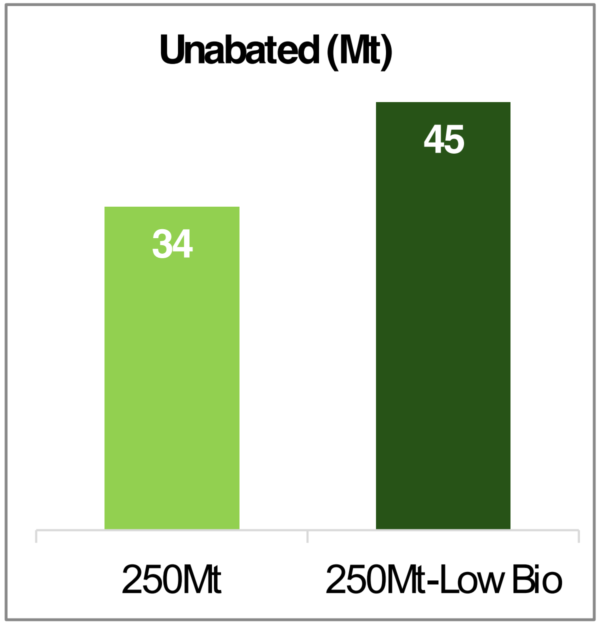
- Near-vertical reduction
- Bring forward near-zero year by 5-8 yrs

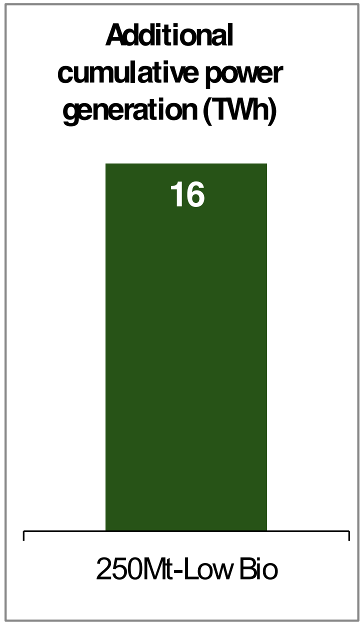
➢ Failure to accelerate emissions cuts this decade and meet (or exceed) SECs will require unprecedented reductions after 2030, accelerate net-zero timelines, and increase "unabated" emissions

HEALTH WARNING: TIM is over-estimating the feasibility of CO_2 cuts from 2030-35 here

Implications of Low Bio-Supply





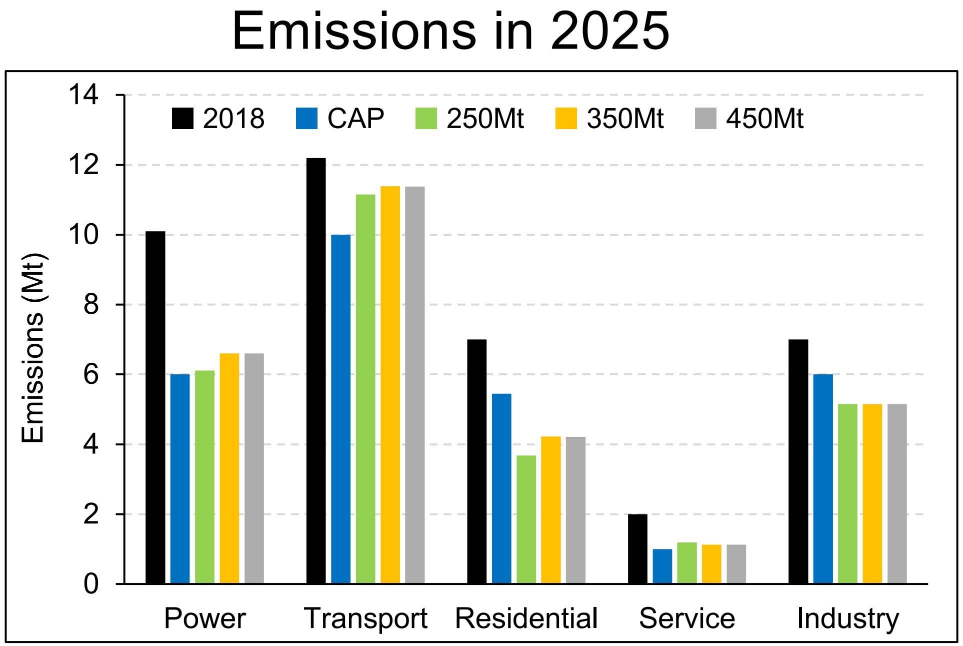


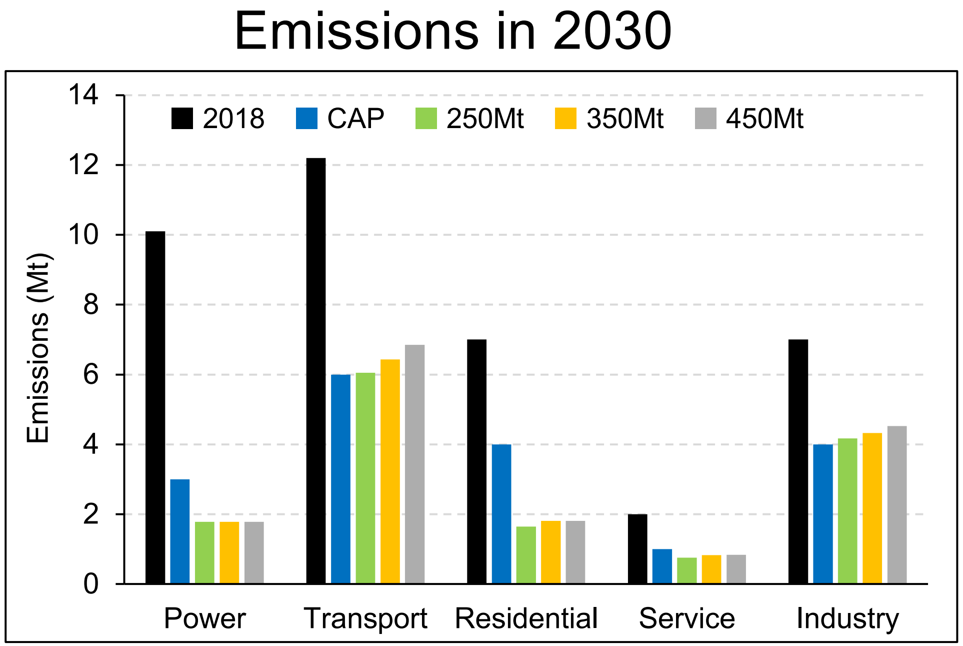
- Lower bioenergy supply increases unabated emissions and requires more electrification

Conclusions

- **From 1st iteration – still hold:**
  - Nearly complete **phase-out of all fossil fuels** required in 2040s in all scenarios.
  - Depending on temperature outcome & early overshoot, some **negative emissions technology** (NETs) required. This brings **very significant risks & trade-offs:**
  - Moderating final energy demands through structural change – is necessary to meet most carbon budget scenarios, especially to deal with overshoot
- **Existing commitments and policies to 2030 already overshoot many CB scenarios by 2030**
  - Committed SECs already overshoot 250Mt CB by 2030
  - WAM & WEM pathways both exceed 300Mt CB by 2030 & require infeasible cuts and/or reliance on CDR post-2030
  - Moreover, SECs are already too high – 16Mt "unallocated savings" yet to be allocated
- **Delayed mitigation** is locking-in carbon and stranded assets, leading to overshoot of early CBs, which increases reliance on risky carbon dioxide removal technologies, misses out on opportunities of mitigation and leads to higher long-term mitigation costs.
- Over-reliance on **bioenergy** creates risks for land use & sustainability. Energy transition mainly requires rapid solar, wind & electrification, and demand reductions.

Benchmarking against Sectoral Emissions Ceilings





Notes, assumptions & references

- **Carbon budget assumptions**
  - CB: downscaling remaining Global Carbon Budget from the beginning of 2020 on a **per-capita basis** to estimate Ireland's share
  - **Global RCB:** from IPCC AR6 Table SPM.2, beginning from 2020 the global RCBs (see here)
  - 5 energy-related CBs for Ireland, **rounded** to 250 to 450 Mt for the period of **2021-2050**
  - Recent estimates indicate that GCB is reducing – from beginning of 2023, 250 Gt for 50% probability of 1.5C (Lamboli et. al., 2023). Inadequate non-CO2 mitigation exhausts this budget already (https://doi.org/10.21203/rs.3.rs-3326772/v1)
  - This analytical framework **covers energy systems** CO_2 emissions (excluding Int. Aviation and Shipping, excluding LULUCF)
  - Acknowledgement that downscaling on a per-capita basis, and starting from 2020, are conservative assumptions from the perspective of climate justice (Mintz-Woo, *in prep*)
- **TIM**
  - Energy system calibrated to 2022 energy balances
  - Social discount rate: 2%
  - Planning horizon: 2023-50
  - "Unmitigated emissions": mitigation backstop technology €2000/tonne CO2
  - Costs include fuel imports and production, energy technology investments and partially infrastructure costs

- **TIM Documentation Paper**
  - O. Balyk *et al.*, "TIM: Modelling pathways to meet Ireland's long-term energy system challenges with the TIMES-Ireland Model (v1.0)" *Geoscientific Model Development*, vol. 15, 2022 (Link)
- **TIM Application**
  - **Trucks:** V. Aryanpur, F. Rogan, "Decarbonising road freight transport: The role of zero-emission trucks and intangible costs" *Scientific Reports*, vol. 14, 2024 (Link)
  - **District Heating:** Mc Guire *et al.*, "Is District Heating a cost-effective solution to decarbonise Irish buildings?" *Energy*, vol. 296, 2024 (Link)
  - **Private cars:** V. Aryanpur *et al.*, "Decarbonisation of passenger light-duty vehicles using spatially resolved TIMES-Ireland Model" *Applied Energy*, vol. 316, 2022 (Link)
  - **Low Energy Demand:** A. Gaur et al., "Low energy demand scenario for feasible deep decarbonisation: Whole energy systems modelling for Ireland" *Renewable Sustainable Energy Transition*, 2022 (Link)
  - **Residential Sector:** J. Mc Guire *et al.*, "Developing decarbonisation pathways in changing TIMES for Irish homes" *Energy Strategy Reviews*, vol. 47, 2022 (Link)
  - **Power Sector:** X. Yue *et al.*, "Least cost energy system pathways towards 100% renewable energy in Ireland by 2050" *Energy*, vol. 207, 2020 (Link)
- **Results Visualisation Website**
  - link
- **TIM Source Code on GitHub**
  - https://github.com/MaREI-EPMG/times-ireland-model

MaREI
Energy · Climate · Marine

Environmental
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sfi
For what's next

MACC 2050

Gary Lanigan, Kevin Hanrahan, Trevor Donnellan, Karl Richards

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Teagasc
Agriculture and Food Development Authority

Teagasc contribution to Carbon Budget Working Group

- **2020:** Teagasc analysis informed 1st Carbon Budget setting process. Based on FAPRI-Ireland projections (Donnellan et al. 2019) & 2018 Teagasc MACC (Lanigan et al. 2018)
  - Technical abatement of 17.5% under baseline by 2030
- **2022:** Carbon budget for ag. sector allocated: equivalent to 25% reduction target by 2030
- **2023:** Teagasc MACC 2023 provided revised estimates of mitigation under ambitious and very ambitious MACC measure adoption pathways to meet 2030 targets (Lanigan et al. 2023)
- **2024:** Teagasc was asked to generate a range of alternative scenarios for GHG emissions from Agriculture over period to 2050
- Simulation horizon extended to 2050, using a modified FAPRI-Ireland model and Teagasc MACC
- 9 projections to 2050 - **3 agricultural activity scenarios** x **3 MACC measure adoption rates**
  - BAU- no adoption of MACC measures => no mitigation of Agricultural GHG emissions
  - Pathway 1- Ambitious MACC measure adoption rates
  - Pathway 2 Very Ambitious MACC measure adoption rates (approach biophysical limit)
- All mitigation analysed is based on known current/emerging technologies (Lanigan et al. 2023)

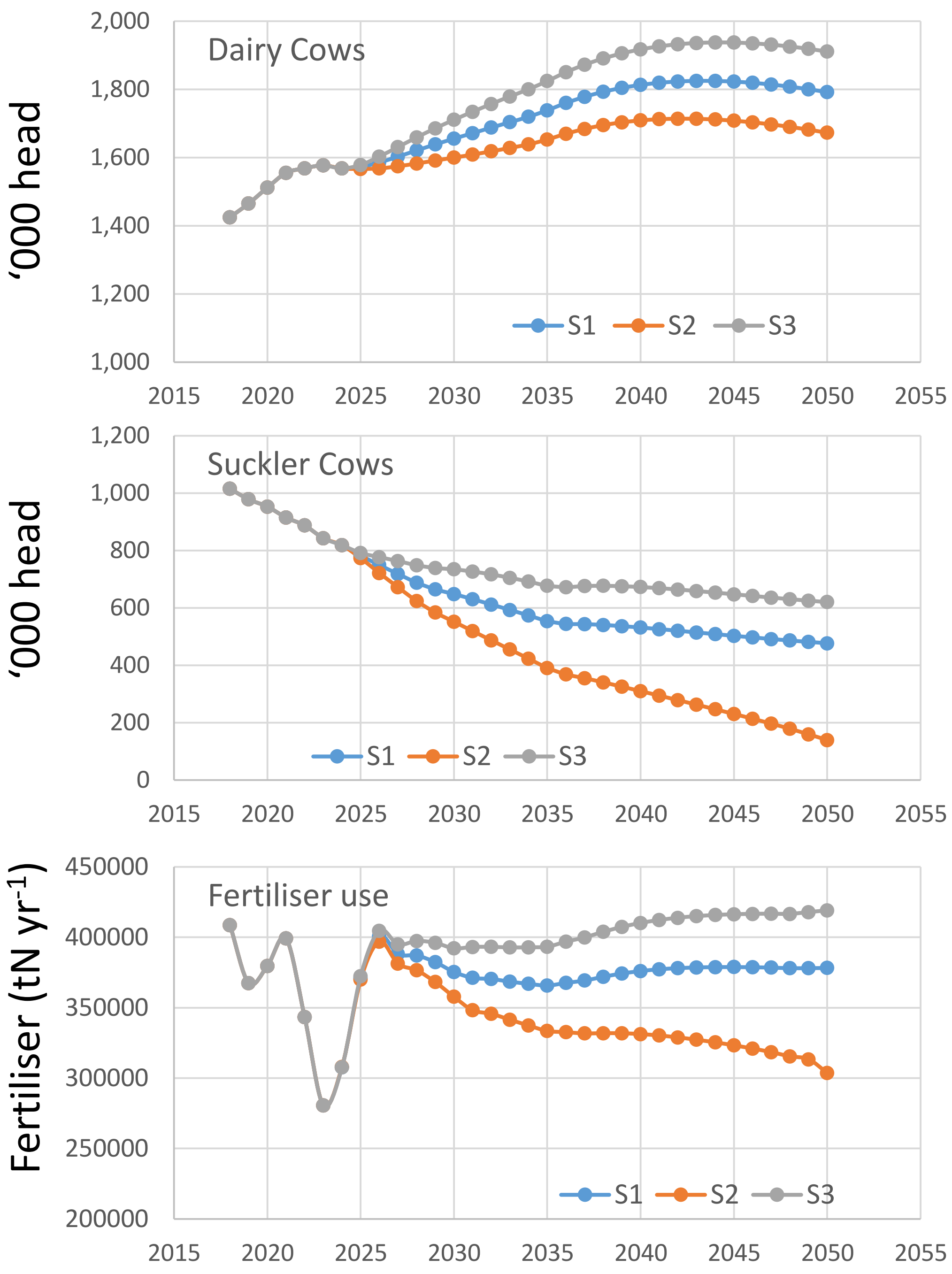
FAPRI-Ireland Scenario activity levels

S1: Baseline projection of agricultural activity
S2: Lower agricultural activity
S3: Higher agricultural activity

- S1: Dairy cows =1.8m head
- S2: Dairy cows = 1.7m head
- S3: Dairy cows = 1.9m head

- S1: Suckler cows = 0.48m head
- S2: Suckler cows = 0.14m head
- S3: Suckler cows = 0.62m head

- S1: Fertiliser use = 378 ktN
- S2: Fertiliser use = 304 ktN
- S3: Fertiliser use = 419 ktN



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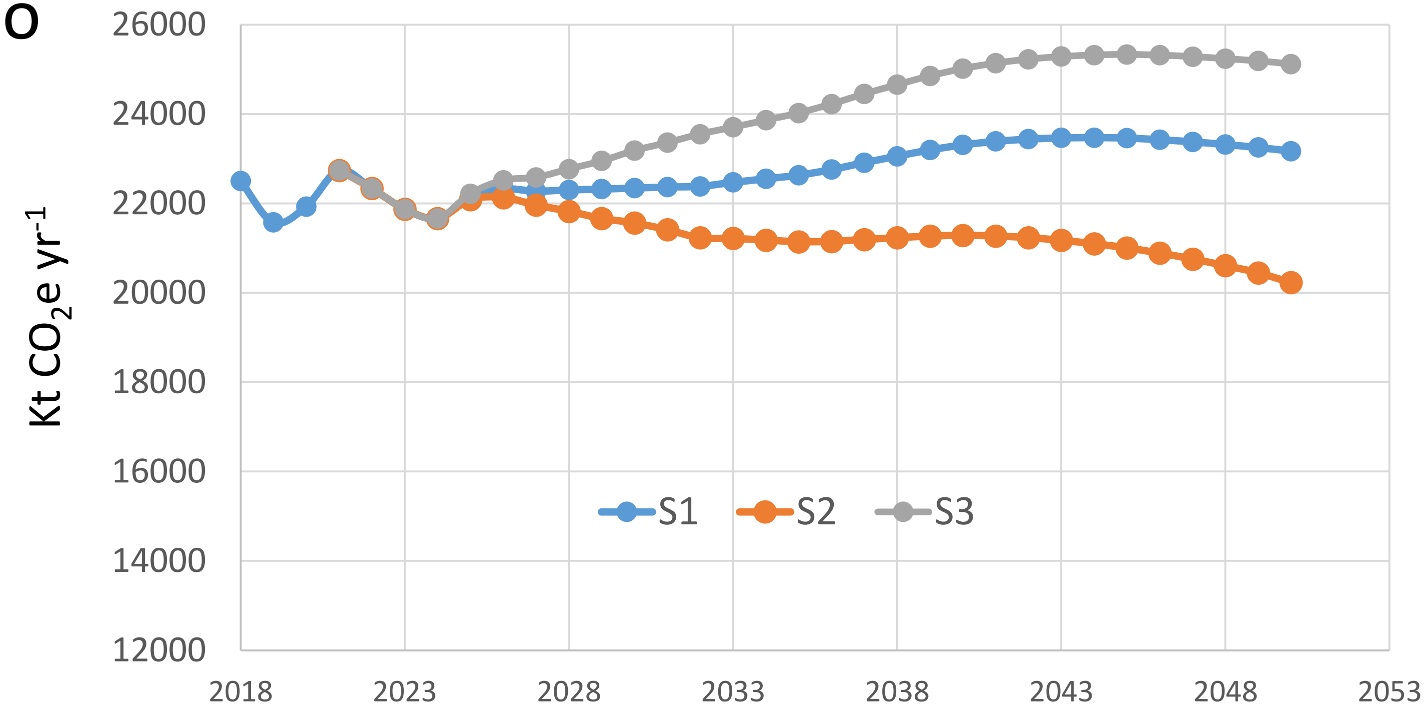
FAPRI-Ireland Scenarios GHG emissions

- BAU emissions by 2050 with no mitigation from MACC measures
  - S1 23.2 $MtCO_2e\ yr^{-1}$
  - S2 20.2 $MtCO_2e\ yr^{-1}$
  - S3 25.1 $MtCO_2e\ yr^{-1}$



(NB Emission calculations based on Irelands National Inventory Report 2024 GHG emissions 1990-2022)

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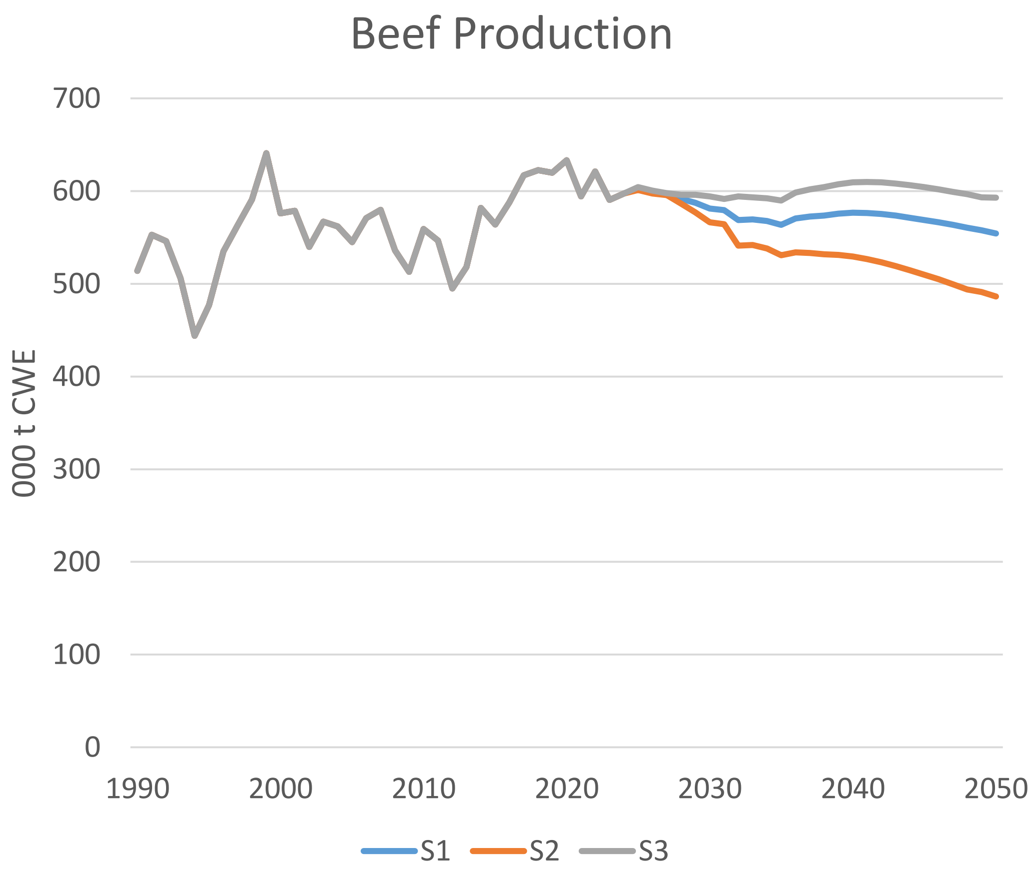
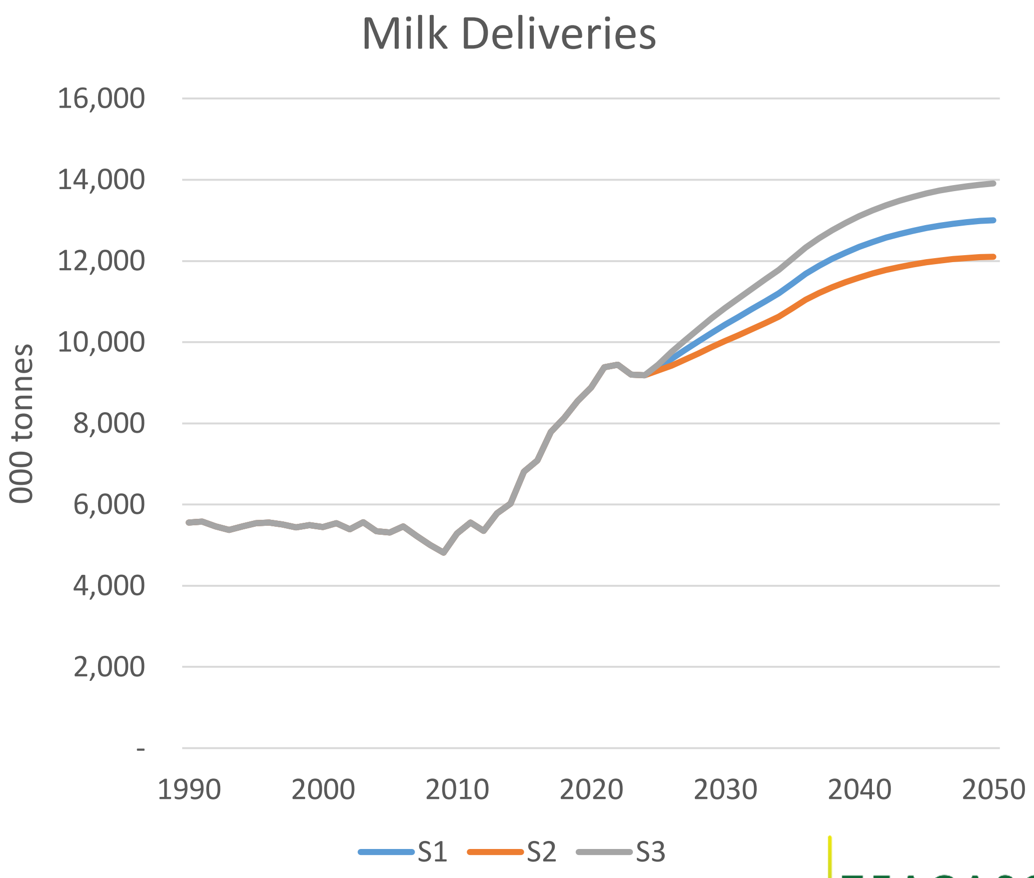
Milk and Beef production under S1, S2 and S3





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Methodology

- Run FAPRI-Ireland agricultural activity projections through GHG inventory mitigation models
- Submodels
  - Enteric methane: Bovines based on DMI and animal growth rates
  - Enteric Methane: Ovines – use static emission factors
  - Manure management: mitigation calculated using new IPCC model
  - Ammonia model
  - N_2O from soils: Tier 2 emission factors used and cross-referenced with dynamic values from two process-based models - DAYCENT/DNDC (used to calculate DSOC for LULUCF)
  - Economics: Marginal costs are quantified using NPV where appropriate or annualised costs for fertiliser, lime, etc.
  - Inflation rates: 1.8% p.a. for period to 2050

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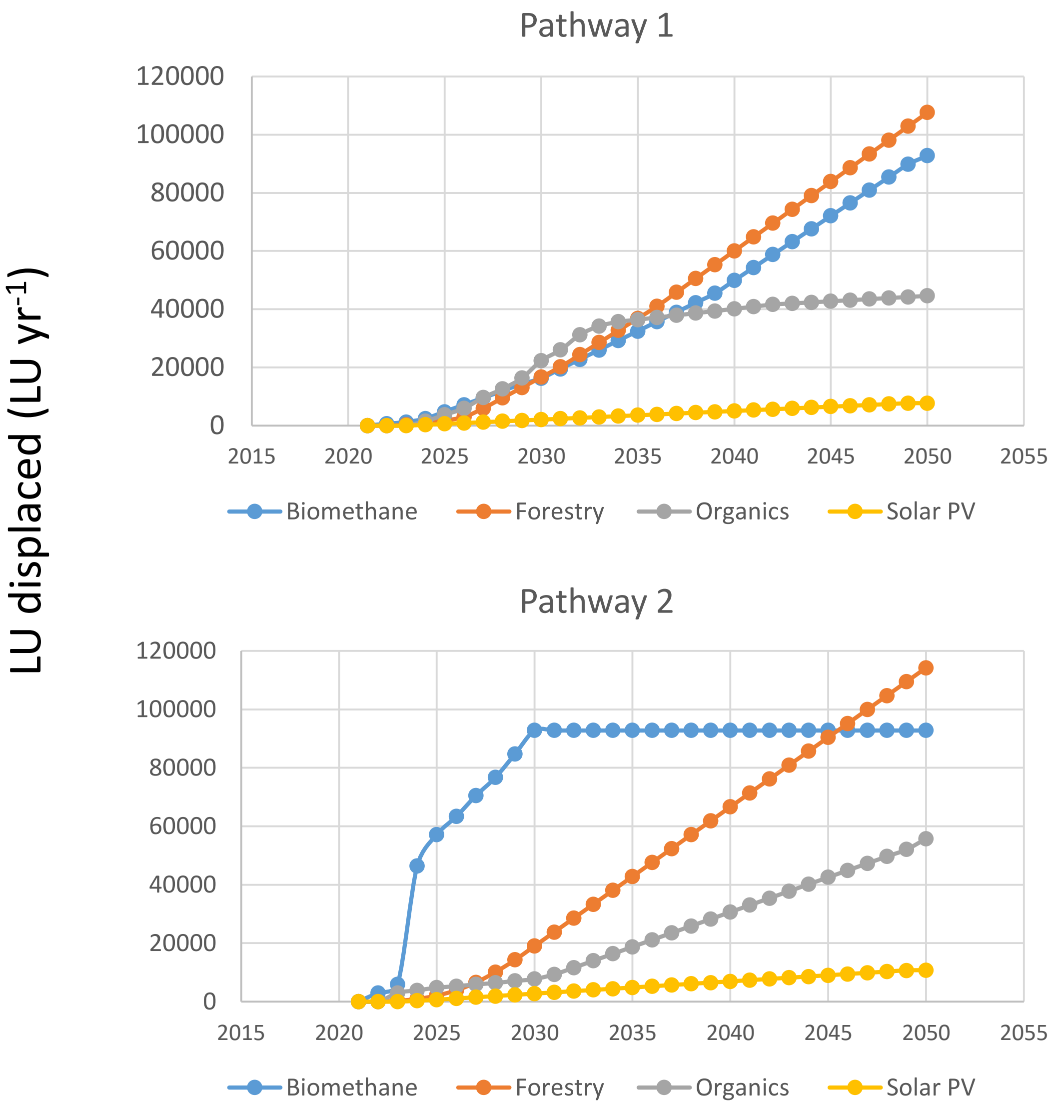
Agricultural Measure	Uptake rate response curve	2018 situation	Pathway 2 2030 Uptake	2050 - Pathway 1	2050 - Pathway 2
Dairy EBI	Linear	€190 per cow	€240 per cow	€360 per cow	€440 per cow
Reduced Age of Finishing	Linear	25.2 months	3 months earlier with sexed semen	3 months earlier with 65% sexed semen	4 months earlier with 90% sexed semen
Feed Additives	Sigmoidal	0	**Efficacy:** 7% efficacy during grazing to 2028 – 20% post 2028 as halides are fed to 50% of dairy cows **Housing**: Efficacy 15% (spring calvers) 25% (autumn calvers) 30% (beef cattle). **Uptake:** 40% spring calvers 70% autumn calvers 45% beef cattle 0% sheep	**Efficacy:** 7% efficacy during grazing – fed to 60% of dairy cows **Housing**: Efficacy 15% (spring calvers) 25% (autumn calvers) 30% (beef cattle). **Uptake:** 50% spring calvers 70% autumn calvers 55% beef cattle 0% sheep	**Efficacy:** 7% efficacy during grazing up to 2028 – 20% post 2028 –10% efficacy in sheep **Housing**: Efficacy 15% (spring calvers) 25% (autumn calvers) 30% (beef cattle). 15% sheep **Uptake:** 60% spring calvers 90% autumn calvers 70% beef cattle 20% sheep
Diversification Impact on Livestock Numbers	Sigmoidal	0	137,963 LU reduction	240,027 LU reduction	366,286 LU reduction
Protected Urea + Nitrification Inhibitor	Linear	3.5% CAN 24% Urea	85% CAN replaced with PU 100% Urea to PU	90% CAN replaced with PU 100% Urea to PU	100% CAN replaced with PU or PU+NI 100% Urea to PU
Clover & MSS	**Linear**	**17 kha**	**757 kha**	**1.14 Mha**	**1.83 Mha**

Agricultural Measure	Uptake rate response curve	2018 situation	2030 Pathway 2	2050 - Pathway 1	2050 - Pathway 2
Liming	Linear	1.04M tonnes	2.5 M tonnes	2.5 M tonnes by 2040	2.5 M tonnes by 2030
Acidification/ Amendments	Sigmoidal	0%	20% dairy/pigs 10% other	21% dairy/pigs 18% other	50% dairy/pigs 25% other
Slurry Aeration	Sigmoidal	0%	40% dairy/pigs 20% other	40% dairy/pigs 35% other	70% dairy/pigs 50% other
Phosphorus Impact on N_2O emissions	Linear		30% move to Index 3	25% move to Index 3	40% move to Index 3
Reduced Crude Protein	Linear	0% (current CP = 17%)	**Both targets held level from 2030**	2% CP reduction 40% Bovines, 3% reduction 40% Pigs	2% CP reduction 90% Bovines, 3% reduction 80% Pigs
Extended Grazing	Linear	227 days	**Both targets held level from 2030**	80 days extra grazing for 10% of bovine population	80 days extra grazing for 10% of bovine population
Low Emission Slurry Spreading	Hyperbolic	50%	80% uptake	100% uptake	100% uptake
Mineral Soil Drainage	Linear		**Both targets held level from 2030**	10% of poor-drained land	25% of poor-drained land
Digestate (biomethane)	Sigmoidal	2000 m^3	3,500,000 m^3 slurry	520,000 m^3 slurry (2030) 3,500,000 m^3 slurry by 2050	3,500,000 m^3 slurry (2030 to 2050)

Diversification measure
Potential Livestock Displacement



2050 Fertiliser Use

Scenario	Pathway	Fertiliser N-use
		tN yr^{-1}
S1	BAU	378,201
S2	BAU	303,582
S3	BAU	419,033
S1	P1	217,182
S2	P1	144,266
S3	P1	265,985
S1	P2	177,544
S2	P2	104,628
S3	P2	217,348

Diversification – Impact on agricultural emissions

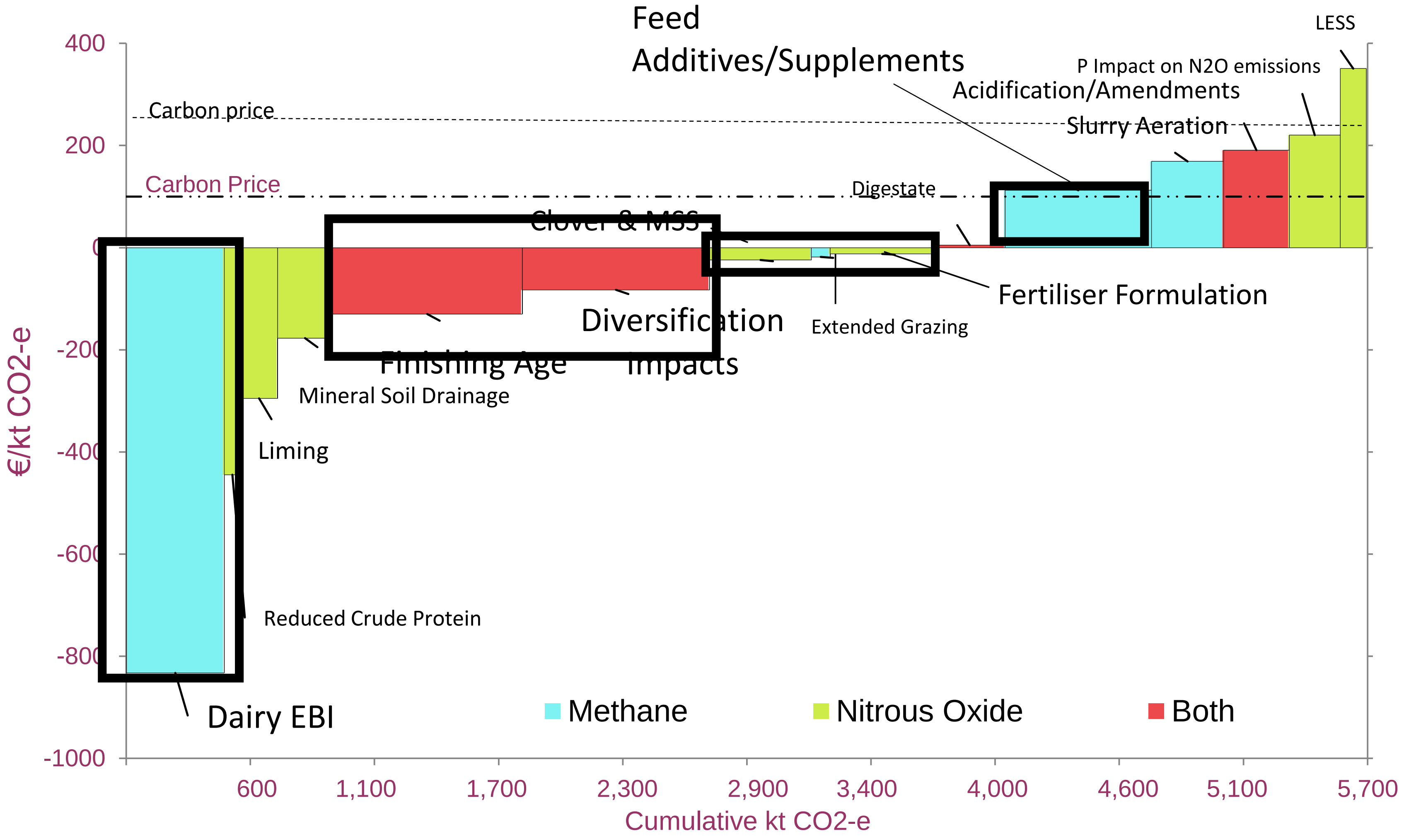
- Expanding on MACC 2030 diversification sub-measures

1. Forestry 2050 (kha yr): BAU = 2.5 kha, P1 = 8 kha p.a., P2 = 16 kha p.a.
2. Organic farming
   - P1: 150 kha by 2030 and 300 kha by 2050
   - P2: 300 kha by 2030 and 375 kha by 2050 (7.5% of UAA)
3. Anaerobic Digestion (AD)
   - P1: 1.0 TW by 2030 (27.3 kha) & 5.7 TW by 2050 (156 kha)
   - P2: 5.7TW by 2030 and held constant to 2050 (156 kha)

- Displacement assumptions
  - Forestry: 1 ha = 0.595 LU displaced
  - Organics: 1 ha = 0.149 LU displaced
  - AD: 1 ha = 0.595 LU displaced

MACC in 2050: Scenario 1 Pathway 1

Mitigation of 5,655 kt CO_2e



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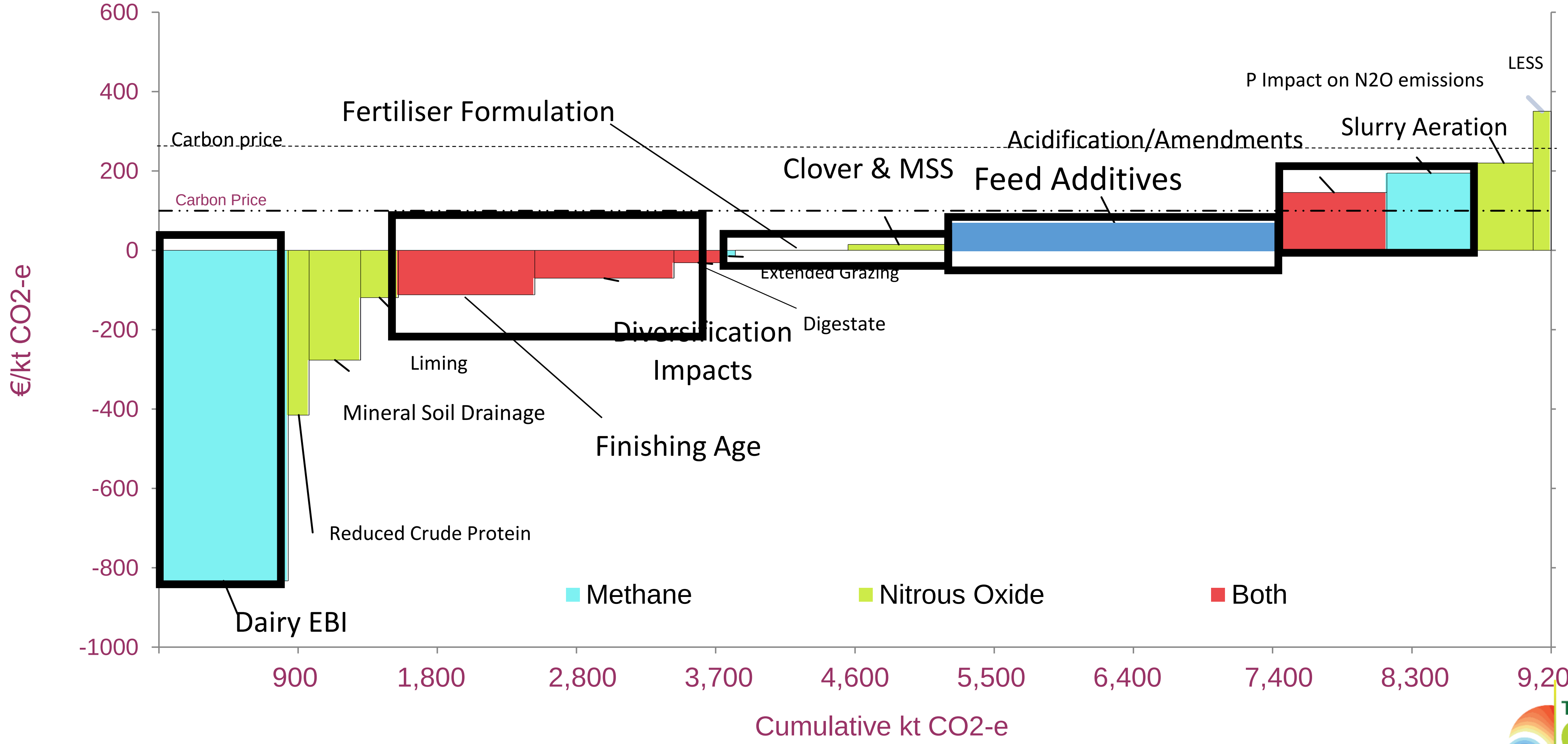
MACC in 2050: Scenario 1 Pathway 2
Mitigation of 9,209 kt CO_2e



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Agriculture GHG with MACC mitigation: Pathway 1 & Pathway 2

Scenario	Pathway	BAU Emissions in 2018	Emissions in 2030 WITH mitigation	Emissions in 2050 WITH mitigation	Mitigation in 2050*	Cumulative Emissions 2021-2030	Cumulative Emission 2031-2040	Cumulative Emission 2041-2050
		$MtCO_2e\ yr^{-1}$	$MtCO_2e\ yr^{-1}$	$MtCO_2e\ yr^{-1}$	$MtCO_2e\ yr^{-1}$	$MtCO_2e$	$MtCO_2e$	$MtCO_2e$
S1	P1	22.5	19.1	17.5	5.7	207.6	186.5	180.5
S2	P1	22.5	18.4	14.9	5.2	205.2	172.7	158.4
S3	P1	22.5	19.9	19.2	5.9	209.9	199.1	196.7
S1	P2	22.5	17.2	13.9	9.2	200.3	162.7	148.0
S2	P2	22.5	17.0	11.7	8.5	198.0	150.1	128.7
S3	P2	22.5	17.6	15.4	9.7	202.5	174.1	162.1

Emission calculations based on Irelands National Inventory Report 2024 GHG emissions 1990-2022

* Mitigation in 2050 compared to BAU 2050

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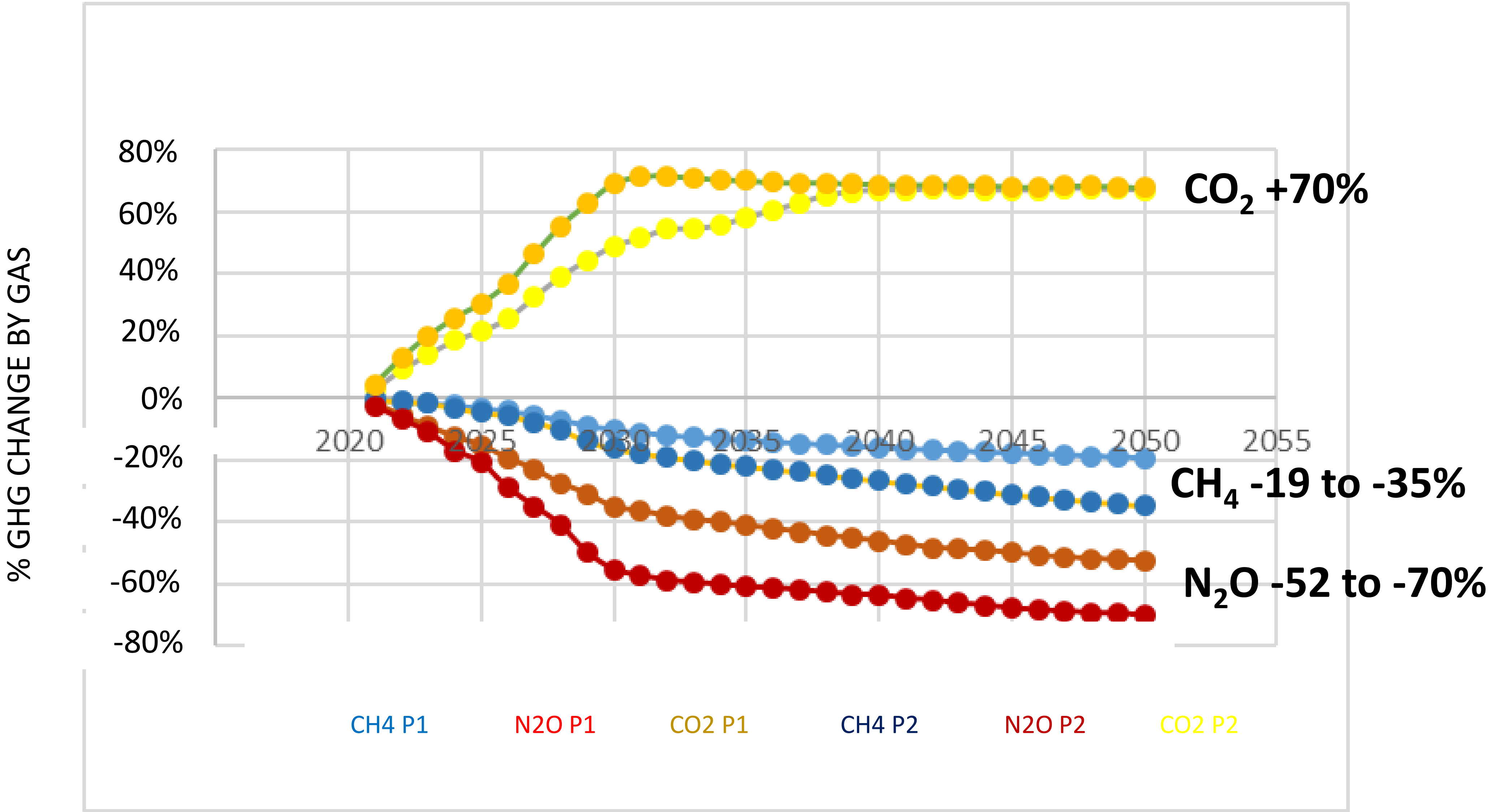
% GHG emission change by Gas: Scenario 1 - Pathway 1 & 2



Summary

- Mitigation to 2050 with **two rates** of MACC measure **adoption** P1 and P2
- **Substantial mitigation achievable** from technical measures and diversification of agricultural activities
- P1 will require **ambitious effort** by farmers and incentivisation by industry stakeholders and policy makers
- P2 will require **very ambitious/transformational effort** by farmers, and greater incentivisation by industry stakeholders and policy makers

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Conclusions

- Scenario 1 pathway 1 & 2 projected emissions 2050 17.5 & 13.9 $MTCO_2e\ yr^{-1}$
- Scenario 2 pathway 1 & 2 projected emissions 2050 14.9 & 11.7 $MTCO_2e\ yr^{-1}$
- Gas reductions inline with IPCC: N_2O -53% & -71% CH_4 -19% & -35%
- Some measures impact LULUCF inventory
- Adoption of some measures contingent on diversification (eg. bioenergy, forestry)
- Requires transformational change in terms of adoption of change technologies and management practices
- Many measures are cost negative – but accompanying policy actions are costly

Challenges to be addressed to achieve mitigation

- Strong policy mechanisms and/or economic incentives are required to drive MACC measure adoption at farm level
- To achieve large savings from diversification measure**, forestry and AD targets** must be achieved
- **Fertiliser displacement** by clover and increased NUE must be delivered
- **Nitrification inhibitors** must be adopted
- **Viable Feed Additives** that reduce grazing emissions must be made commercially available
- **Food produced using new technologies must be acceptable** to farmers, consumers and other stakeholders in the food chain

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Discussion?

Land-Use Measure	Uptake rate response curve	2018 situation	Pathway 2 2030 Uptake	2050 - Pathway 1	2050 - Pathway 2
New Hedgerows	Sigmoidal	0	40,000 km extra	30,000 km extra	46,000 km extra
Hedgerow Management	Linear	0	75,000 km	71,000 km	103,500 km
Grassland Management	Linear	0	757 kha	948 kha	1.1 Mha
Water Table Management (Peat soils)	Sigmoidal	0 kha	80 kha	72 kha	90 kha
Cover Crops	Linear	1.5 kha		76 kha	106 kha
Straw Incorporation	Linear	10 kha		75 kha	110 kha
Manure to cropland	Linear	50 kha		67 kha extra	83 kha extra
Afforestation	Hyperbolic	2kha	8 kha	8kha by 2040	8 kha by 2030
Prevent Deforestation	Straight Line (constant rate)	752 ha p.a	Both targets held level from 2030	495 ha p.a.	495 ha p.a.
Extend rotation to MMAI	Linear	0%	Both targets held level from 2030	21% of forests	31% of forests
Agroforestry	Linear	0%	2 kha	6 kha	10 kha
Birch (Raised bogs)	Linear	0 kha	Both targets held level from 2030	17.9 kha	17.9 kha