Presentation to the Climate Change Advisory Council

9 March 2023

Carbon Budgeting Research Fellowship

Research Findings and Outputs

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CLIMATE CHANGE ADVISORY COUNCIL

Overview of this Carbon Budgeting Fellowship

Four work packages ⇒ ○ *Context:* ***Climate Act*** *&* *the* ***Paris Agreement goal****.*

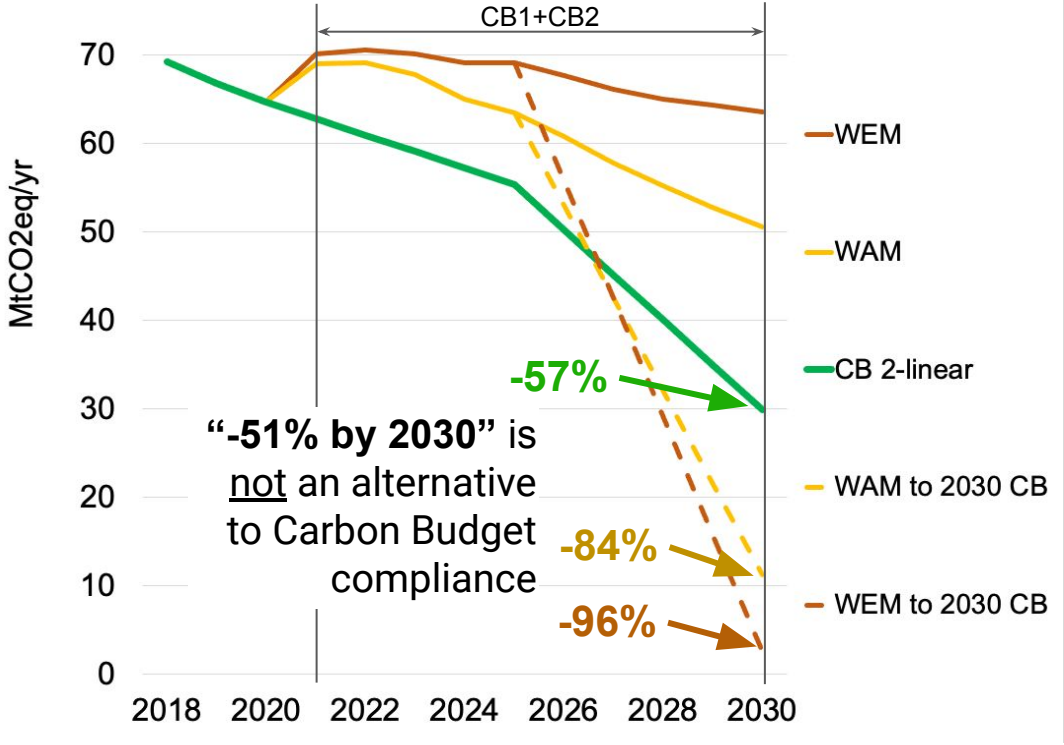
1. **Integrated carbon budget assessment of existing policy** WP3
   - Meeting CB1+2; Paris-consistent IE overshoot-and-return pathways.
2. **Assessing alternative integrated emissions scenarios** WP2
   - "Paris Test" reassessment; historic responsibility; GWP* use.
3. **Agriculture, forestry & land use in society-wide transition** WP1
   - IE land-nitrogen-emissions analysis; AFOLU & carbon budgeting.
   - *Also:* IE food system N-efficiency; Anaerobic Digestion; Rewetting.
4. **Integrating national and business-sector carbon budgeting?** WP4
   - Assessing the value of business carbon accounting and management.

1. Integrated carbon budget assessment of existing policy

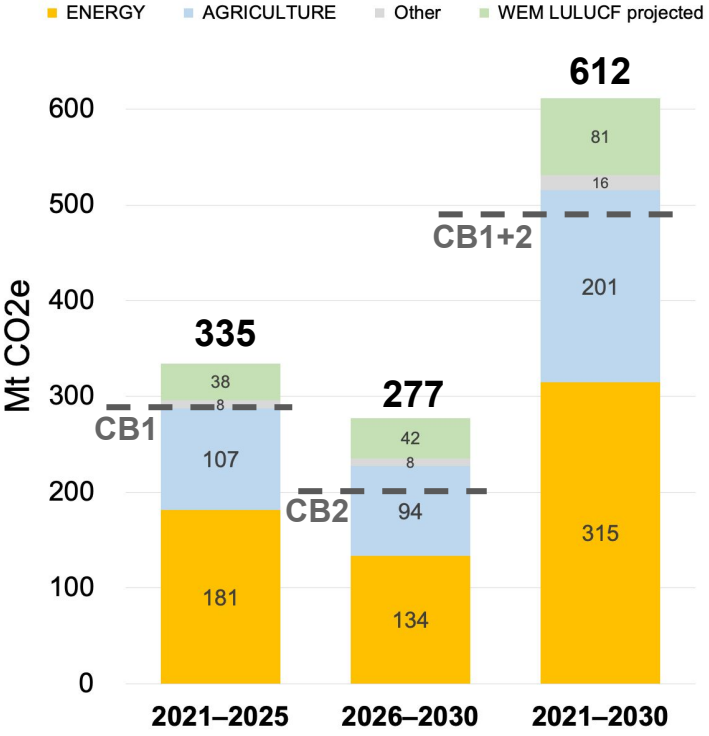
EPA projections, incl. LULUCF, relative to the 5-year carbon budgets

- CB1 and CB2 *will not* be met unless new policy effectively limits societal C & N inputs.

IE 2018–2030: WEM/WAM vs 5-yr carbon budgets



IE WAM projection 2021–2030



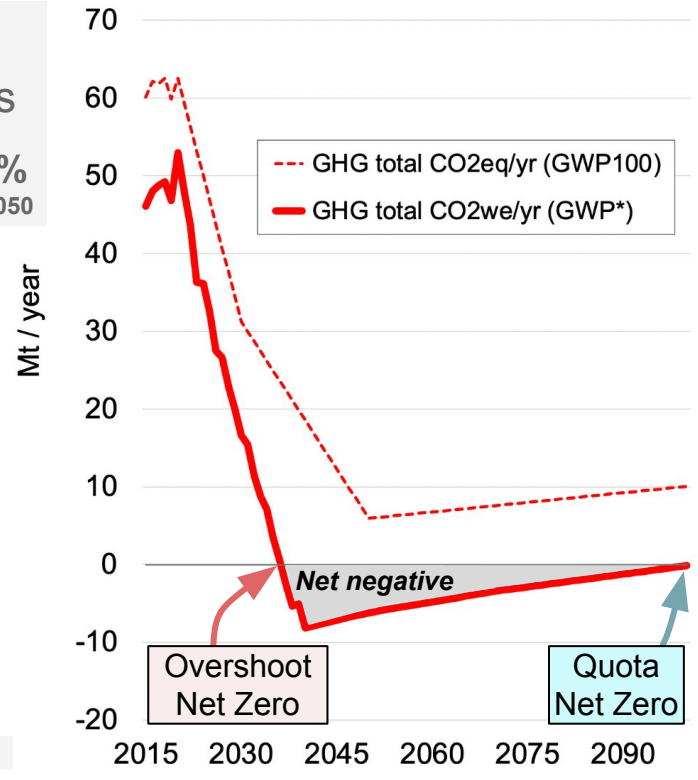
1. Integrated carbon budget assessment of existing policy

If "climate neutrality" occurs in overshoot then it is <u>not</u> 'consistent with' Paris ºC.

- **Overshoot** of Paris-consistent IE fair share quota results in <u>two</u> *different* "net zero" years.

Annual emissions

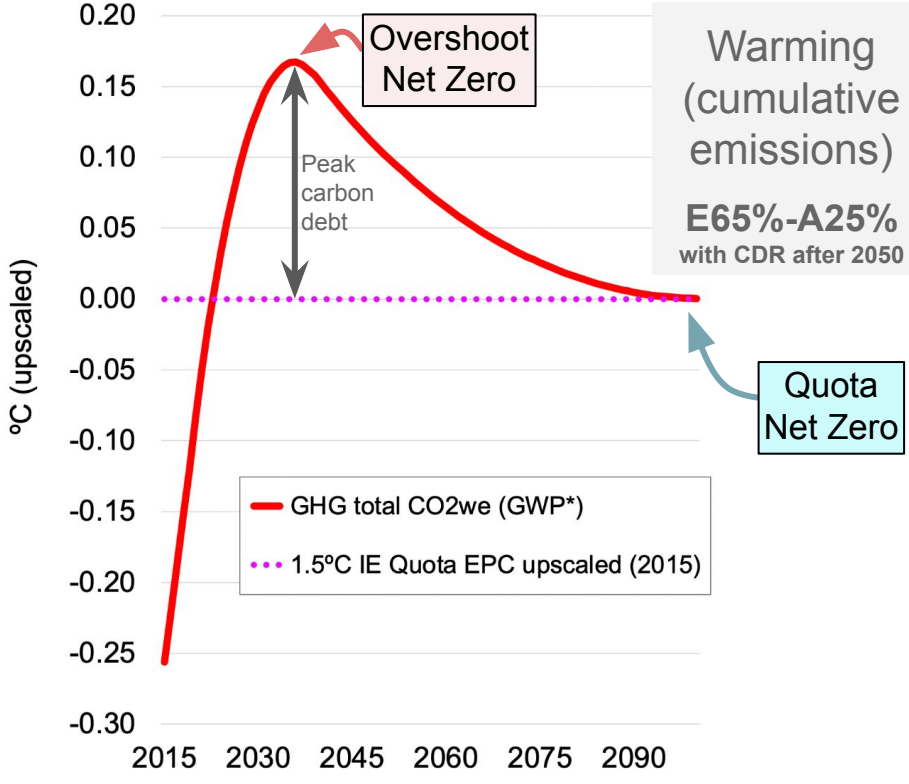
E65%-A25%
with CDR after 2050



2015 base year

Warming (cumulative emissions)

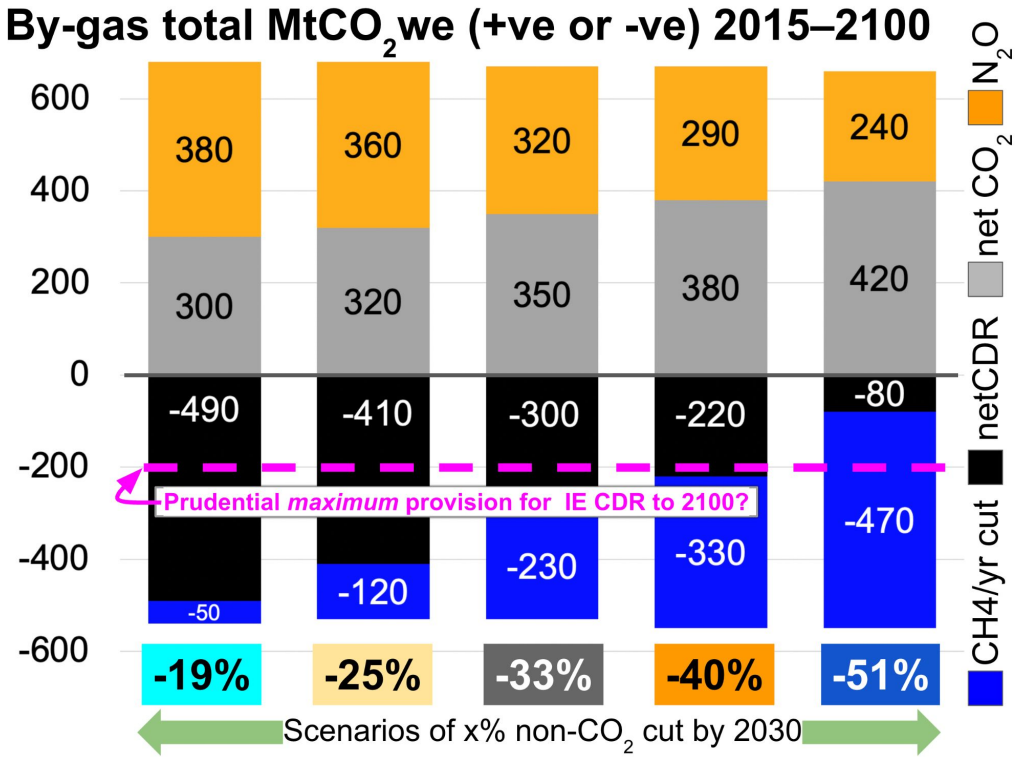
E65%-A25%
with CDR after 2050

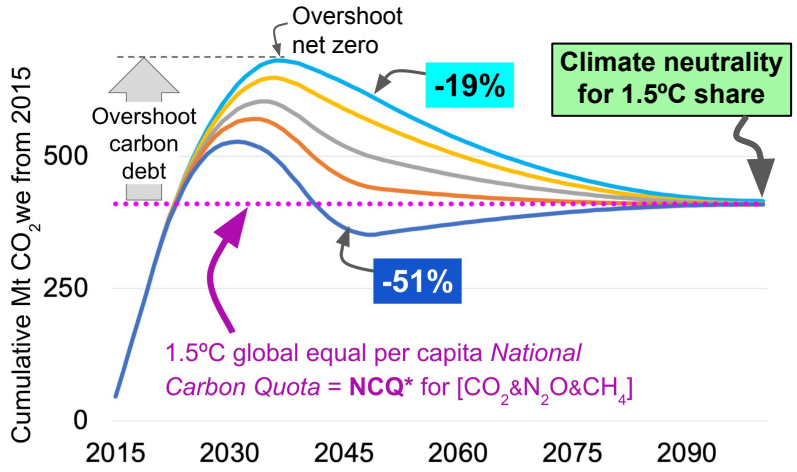


1. Integrated carbon budget assessment of existing policy

Meeting same Paris goal reveals negative emission tradeoff CH_4/yr vs CDR

- Scenarios with early+deep+sustained CH_4/yr cut: limits CDR required for IE 1.5ºC$_{\text{Equal Per Cap.}}$





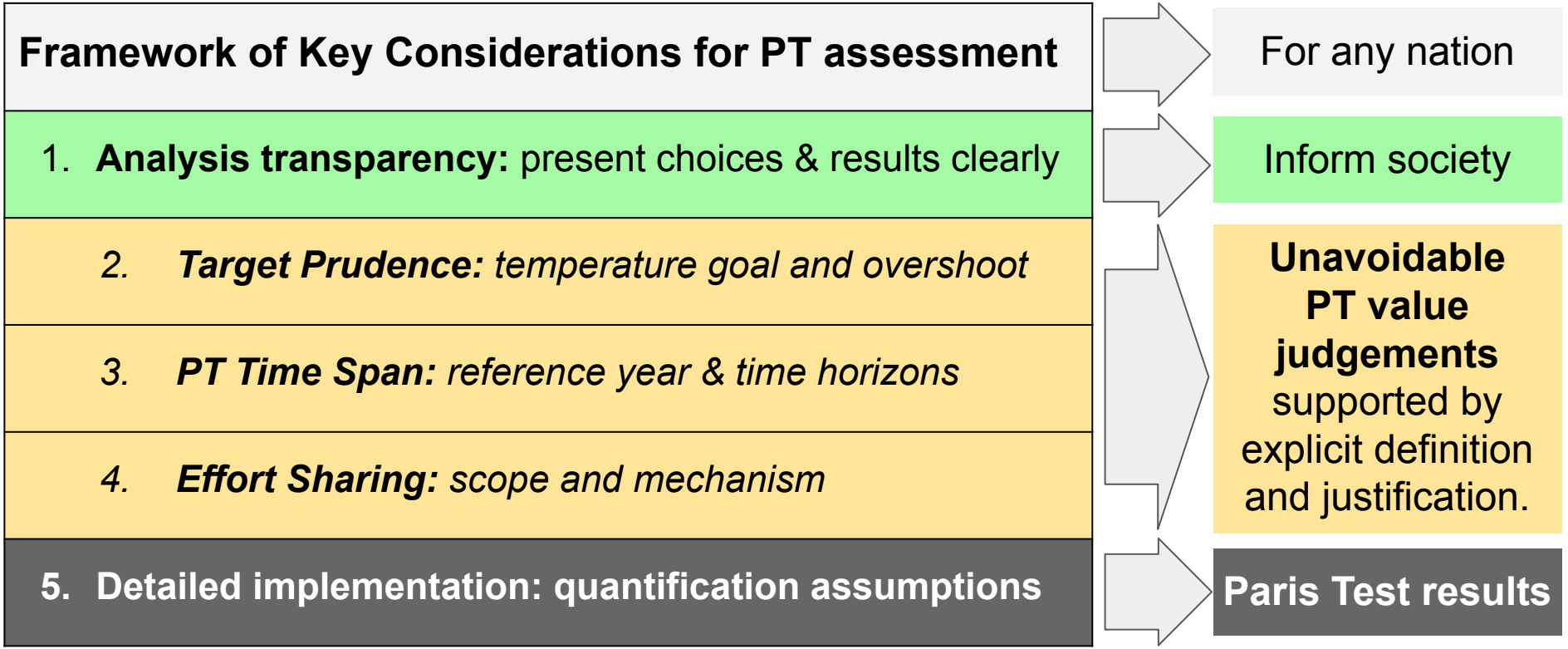
Deeper, earlier CH_4/yr reduction limits 1.5ºC overshoot *and* reduces IE CDR requirement.

CH_4/yr cut or CDR ºC reduction are useful to meet the stringent ºC limit *only if* deep CO_2 emissions reduction achieved NOW!

2. Assessing alternative integrated emissions scenarios

"Paris Test" (PT) is important to show Paris-consistency. IE is a leading example.

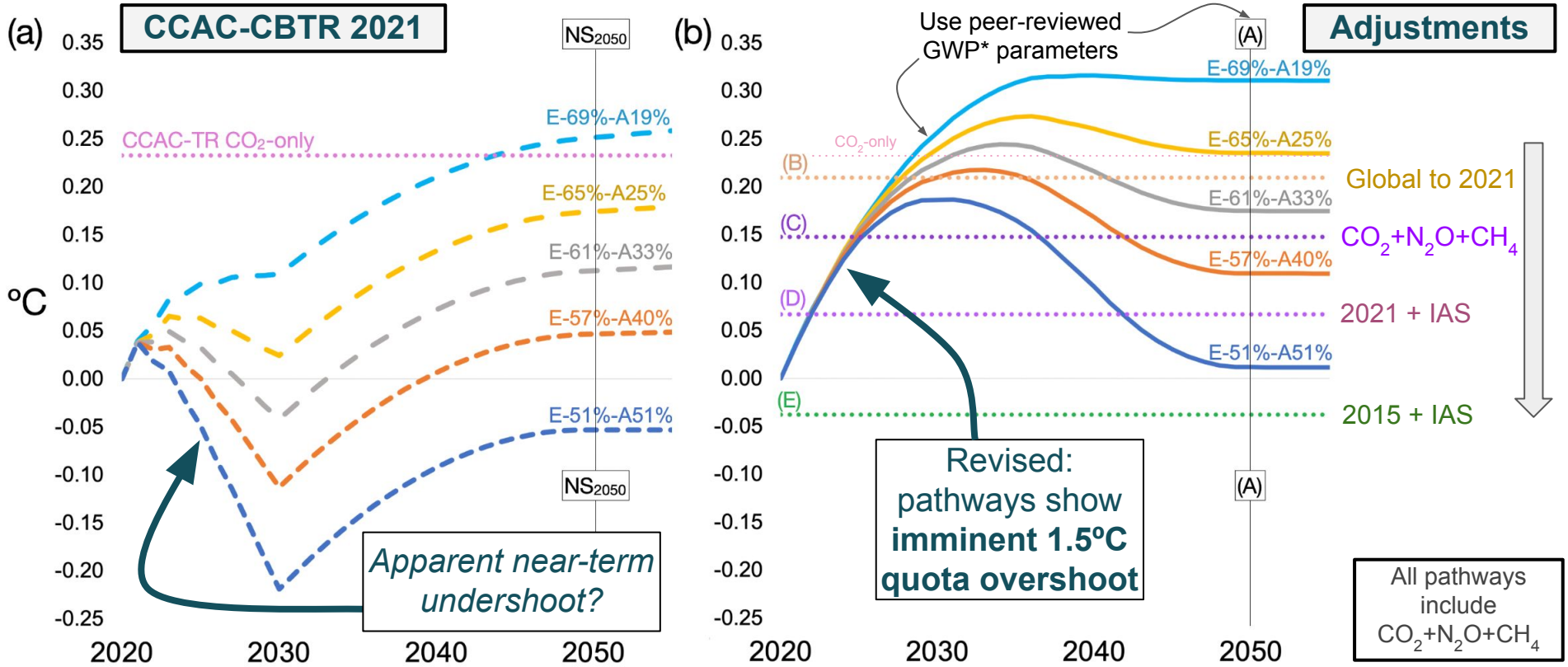
- A framework approach developed (& used to reassess 2021 CB Technical Report's PT).



2. Assessing alternative integrated emissions scenarios

"Paris Test" (PT) reassessment: overshoot, & 2050 thresholds reduced.

- Cutting CH_4/yr deeply by 2030: crucial to limit overshoot & meet the *lower* PT thresholds.



2. Assessing alternative integrated emissions scenarios

Refining the *same* Paris Test: quantitative adjustments

- ***Only one* or *none*** of the *core scenarios* pass the revised Paris Test.

Sectoral Emissions Ceilings
Sept. 2022
Agriculture -25%

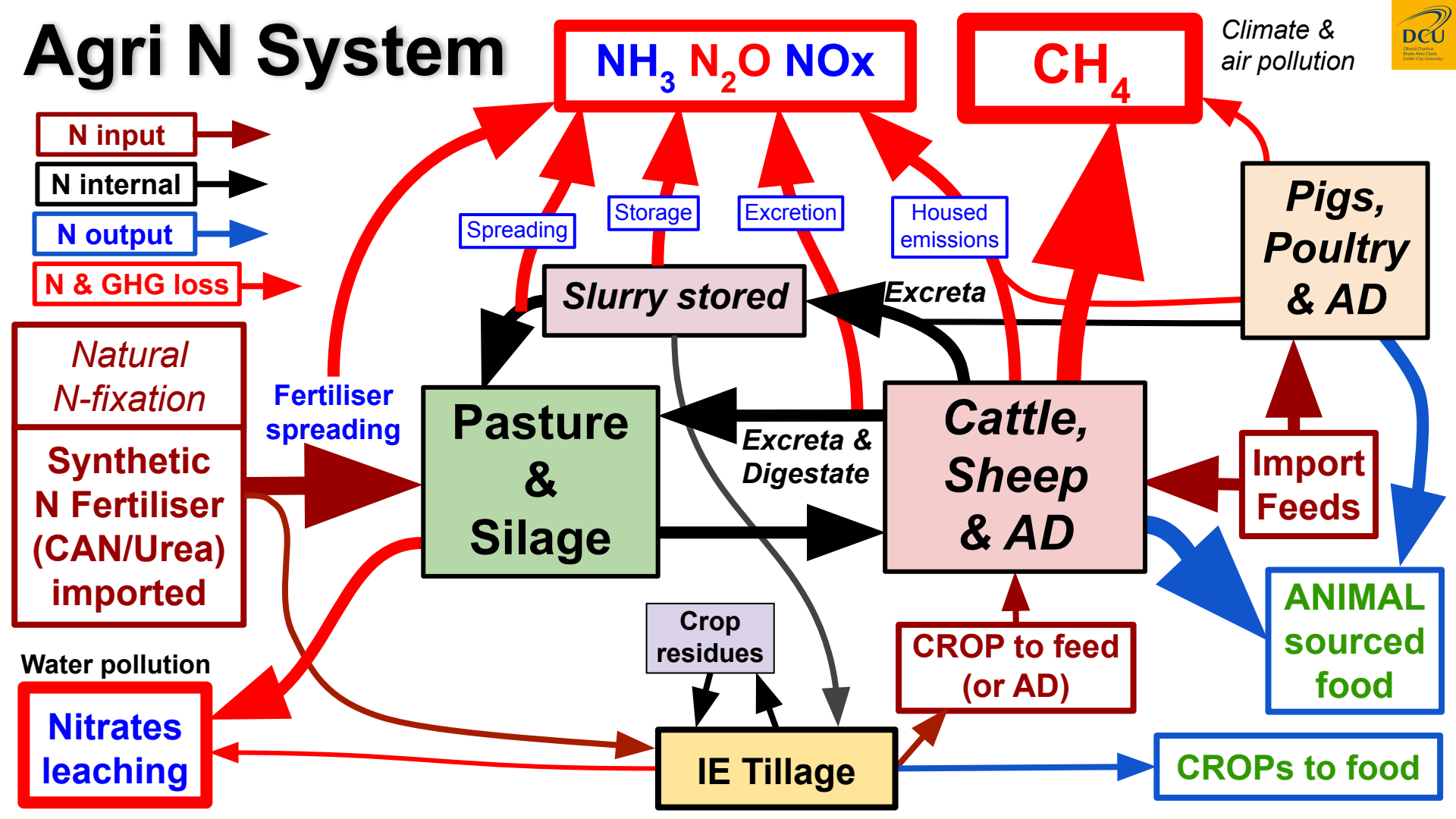
CCAC 2021 Technical Report

Upscaled **2050 Scenario ºC**			E51-A51	E57-A40	E61-A33	E65-A25	E69-A19
		Scenario warming ºC =	**-0.05**	**0.05**	**0.11**	**0.17**	**0.25**
	Paris Test threshold basis	***PT ºC***	Scenario ºC – PT ºC (negative = passes PT)				
2021 PT	***A.*** CO_2*-only (CCAC-TR PT)*	**0.23**	-0.29	-0.19	-0.12	-0.06	0.02

Adjustments added in turn:

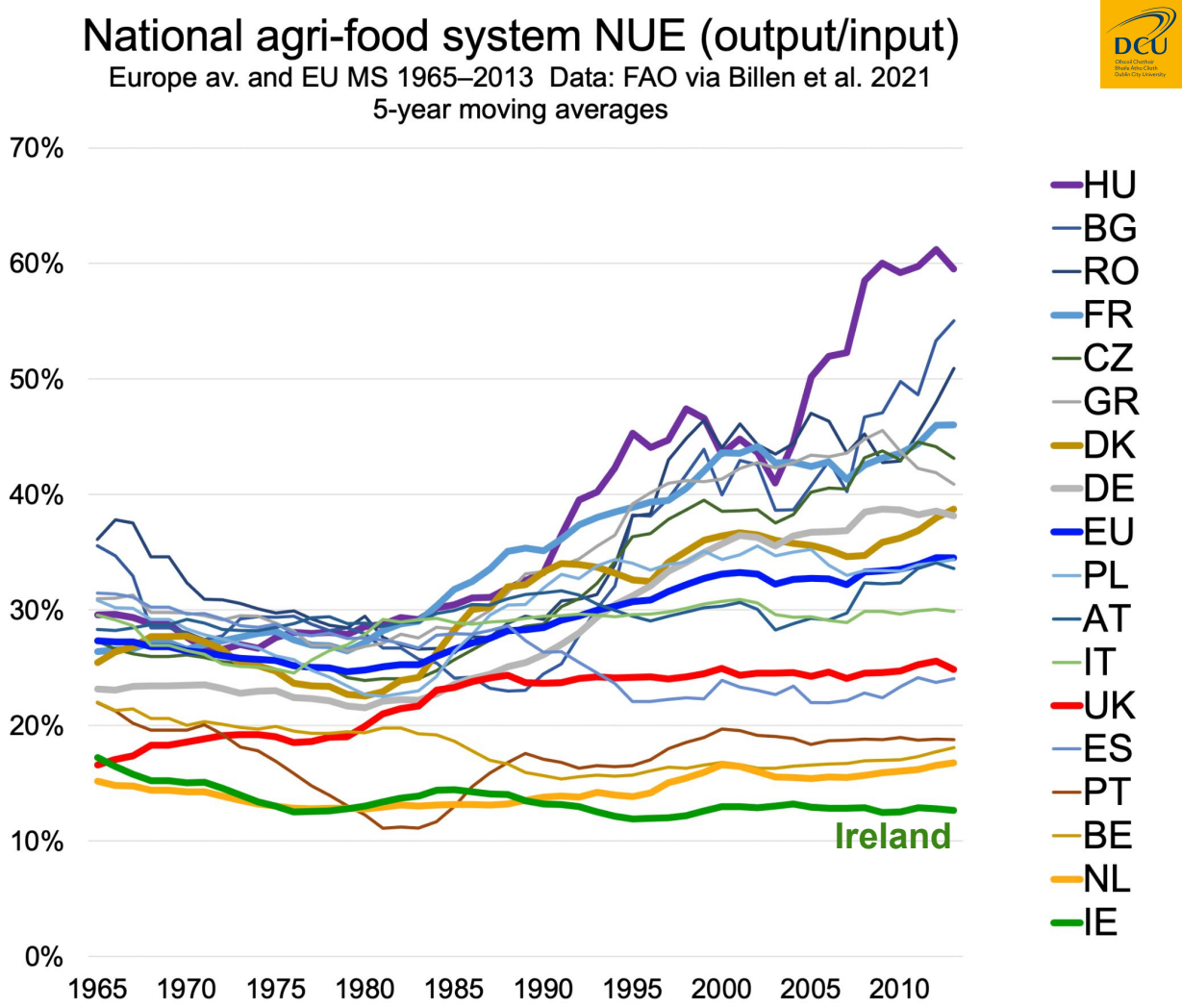
			Pass			Fail	
A. GWP* change	CO_2*-only (CCAC-TR PT)*	***0.23***	-0.22	-0.12	-0.06	0.00	0.08
B&C: 2021, CO_2&N_2O&CH_4	*rGCB*_2021*	***0.15***	-0.14	-0.04	0.03	0.09	0.16
D. 2021 minus IAS	*rGCB*_2021 minus IAS*	***0.07***	-0.06	0.04	0.11	0.17	0.24
E. 2015 minus IAS	*rGCB*_2015 minus [IAS & 2015–2020]*	***-0.04***	0.05	0.15	0.21	0.27	0.35

Earlier *Base year* or inclusion of *International Aviation and Shipping (IAS)* greatly reduces 2020–2050 budget(s).

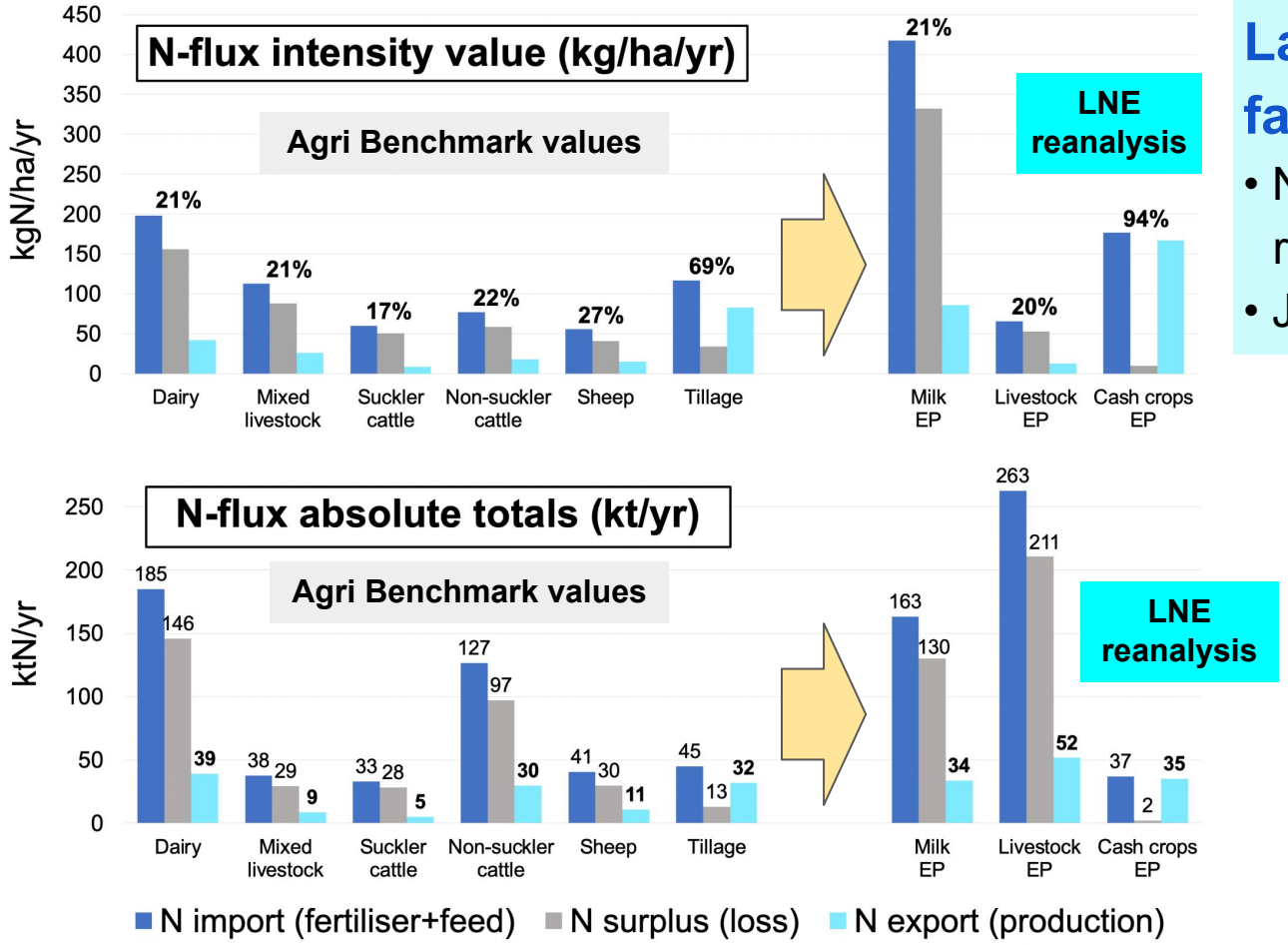

Agri N System
NH3 N2O NOx
CH4
Climate & air pollution
N input
N internal
N output
N & GHG loss
Spreading
Storage
Excretion
Housed emissions
Slurry stored
Excreta
Pigs, Poultry & AD
Natural N-fixation
Synthetic N Fertiliser (CAN/Urea) imported
Fertiliser spreading
Pasture & Silage
Excreta & Digestate
Cattle, Sheep & AD
Import Feeds
ANIMAL sourced food
Crop residues
CROP to feed (or AD)
Water pollution
Nitrates leaching
IE Tillage
CROPs to food

3. Agriculture, forestry & land use in society-wide transition

- FAO data to 2013 shows Ireland's agri-food system is the *least* nitrogen use efficient in Europe.
- Due to emphasis on grass-based ruminant meat and milk production.
- Worse since 2013 due to reduced tillage area & more net N import (fert+feed).



3. Agriculture, forestry & land use in society-wide transition



Land-nitrogen-emissions farm-gate data reanalysis

- Novel coarse grained "LNE" re-analysis by *production-type*
- Journal paper in review

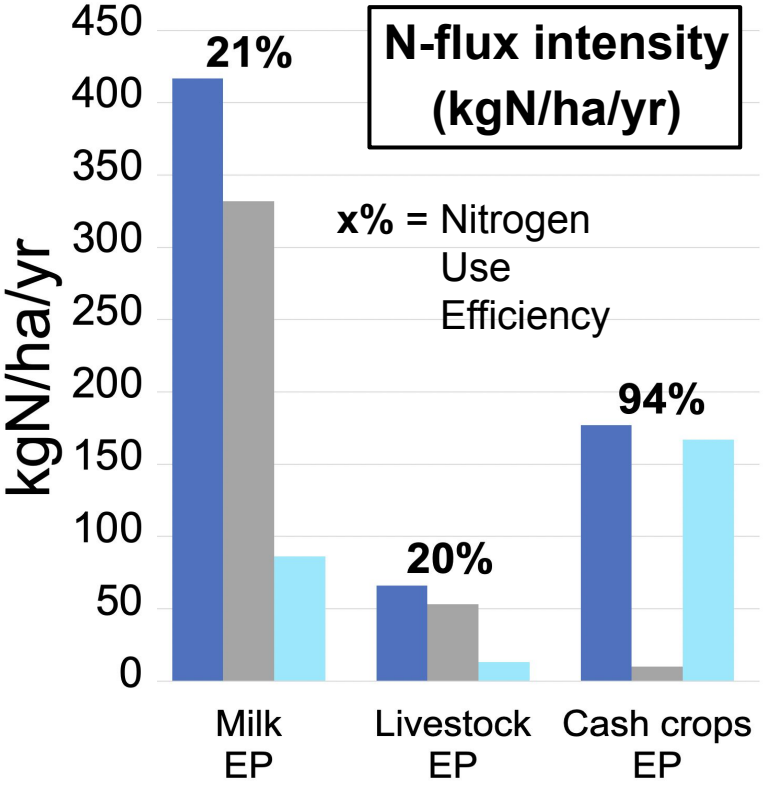
LNE reanalysis of Agri Benchmark N 2008–2015 farm-gate *farm-type* data (Murphy et al. 2021)

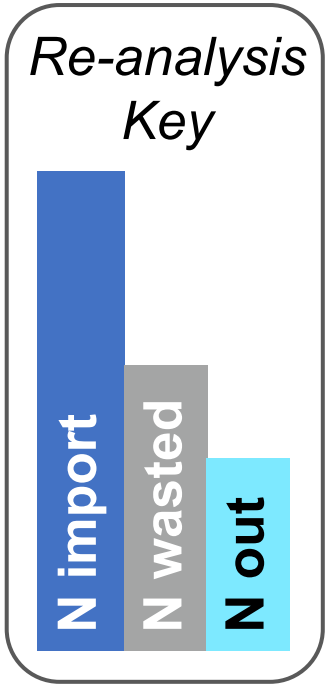
- Results in N & GHG values for intensity and IE national total *by production-type* (milk, livestock, cash crops).

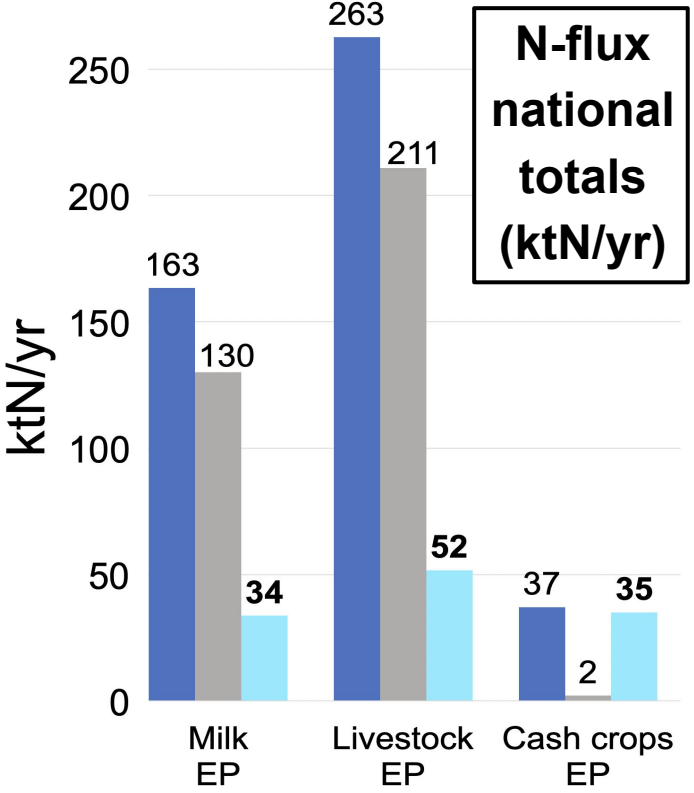
3. Agriculture, forestry & land use in society-wide transition

Land-nitrogen-emissions farm-gate data reanalysis by production type

- Novel coarse-grained reanalysis can usefully inform low-GHG AFOLU national planning.





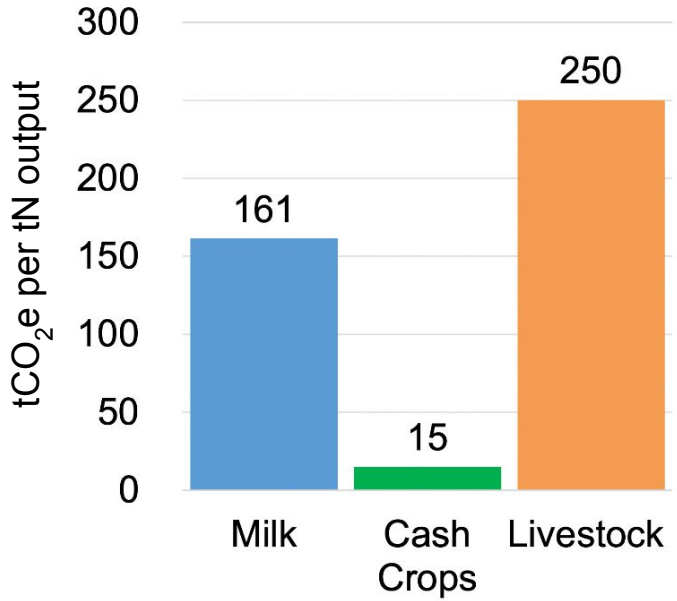


3. Agriculture, forestry & land use in society-wide transition

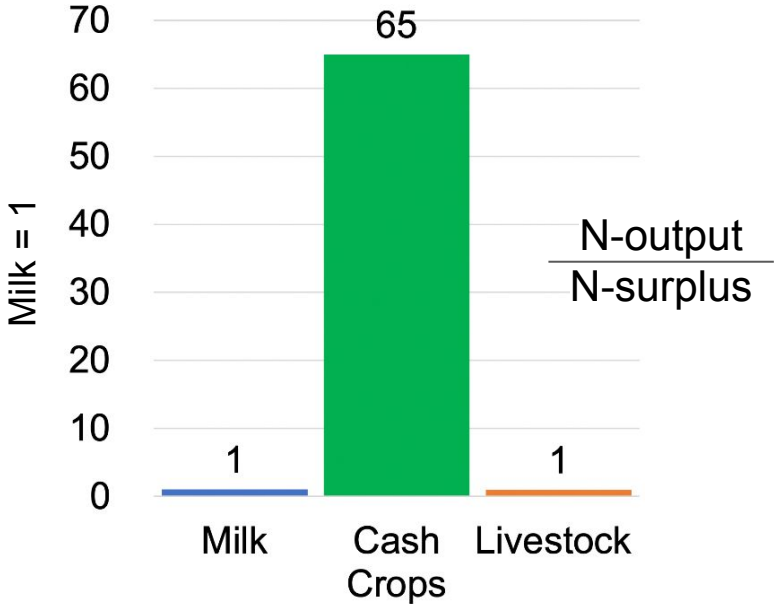
Land-nitrogen-emissions *reanalysis* of national farm-gate data & GHGs.

- Cash crop production is highly land efficient. Milk & Livestock are land, GHG- & N- inefficient.

Milk and *Livestock* have very high emissions relative to production output



Cash crop production is 65x more nitrogen efficient relative to *Milk* or *Livestock* production



3. Agriculture, forestry & land use in society-wide transition

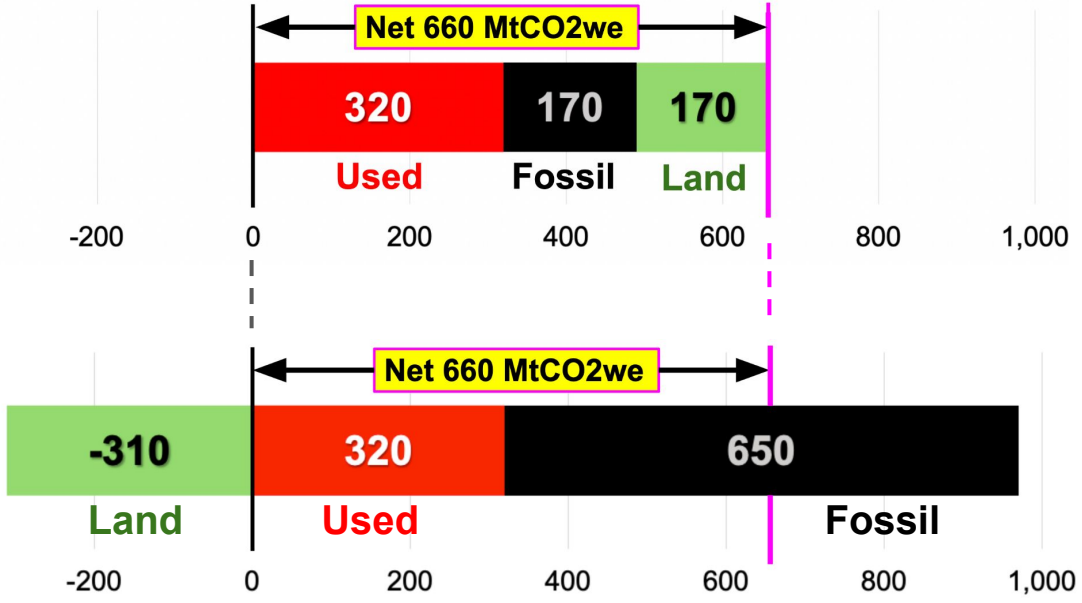
AFOLU policy is now crucial to Paris-consistent achievement

- Transition is eased if methane is cut deeply & existing land carbon is protected.

Two indicative national scenarios with the *same* net warming:

Weak AFOLU policy:
Future land CO_2we budget is ***net positive*** ⇒ decreasing feasibility of Energy transition within 1.5ºC limit.

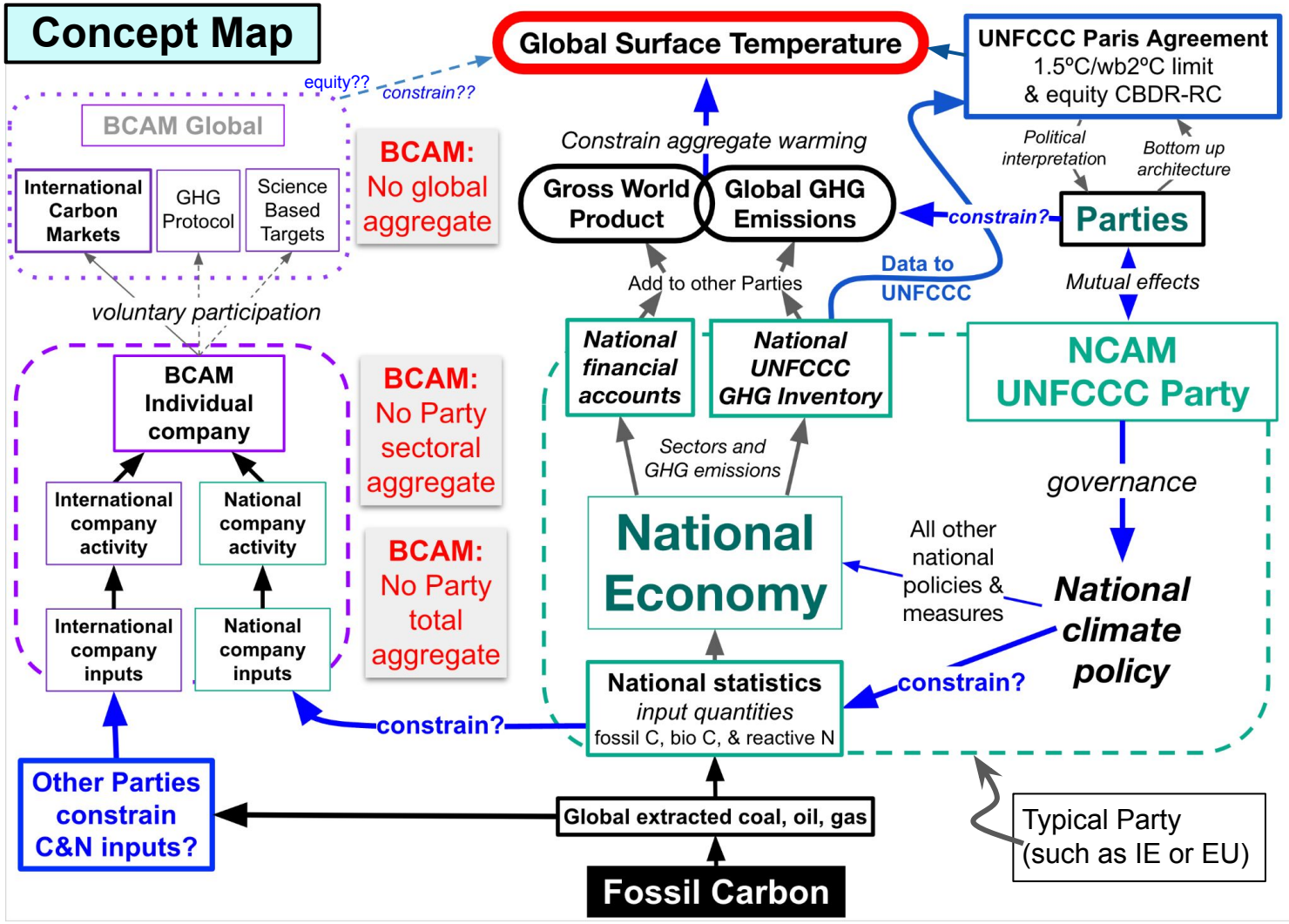
Strong AFOLU policy:
future land CO_2we budget can be ***net negative*** ⇒ increasing Energy transition, feasibility but *land carbon (standing forest and peatland) must be protected*.



4. Integration of business carbon accounting & management (BCAM) with national carbon budgeting?

Research via lit. review, concept mapping & global $:GHG analysis.

- **BCAM does not align with NCAM.**
- BCAM is ***not*** useful in national carbon budgeting. It is misaligned, unclear and incomplete. ⇒A distraction?
- Effective *policy* enforces limits on inputs of fossil C, bio C, and reactive N.



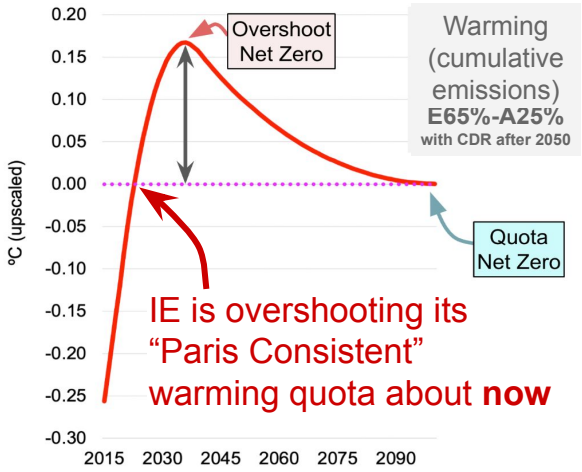
CCAC Carbon Budgeting Fellowship

Paul R Price, DCU

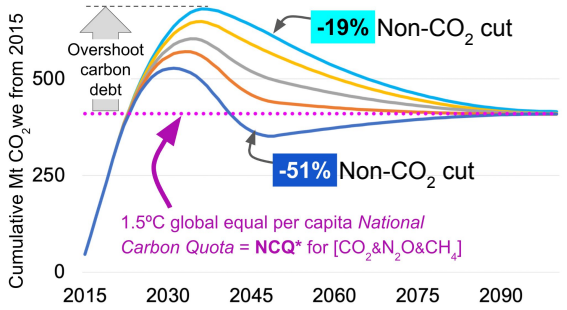
Main Finding: **Achieving 1.5ºC is *very* difficult.**

Overshoot of an equitable IE national GHG quota is *imminent* or has occurred *already*.

- **Paris Agreement consistency is arguably far more demanding** than the 2021 CCAC *Carbon Budget Technical Report* indicated. If so, current IE carbon budgets are too high.
- **Meeting CB1+2 already requires urgent policy and regulation** to effectively constrain carbon & reactive nitrogen usage through robust societal supply & demand control.
- *Assuming* good faith 1.5ºC CO_2 policy, **early, deep, sustained cut in CH_4/yr limits overshoot & future CDR dependence**.



2021 CCAC scenario warming



Supplementary Slides

Journal papers from this Carbon Budgeting Fellowship

Four work packages ⇒ 2 journal papers already in peer review, plus 2 submitted .

1. **Integrated carbon budget assessment of existing policy** (in peer review)
   - *"Setting a "Paris Test" of national carbon budgeting: an assessment framework for equitable alignment with meeting the Paris Agreement long term temperature goal"*
2. **Assessing alternative integrated emissions scenarios** (submitted to journal)
   - *"Early methane mitigation, including agriculture, can be crucial to limit dependence on uncertain carbon dioxide removal in national climate action consistent with meeting a fair share 1.5ºC quota"*
3. **Agriculture, forestry & land use in society-wide transition** (in peer review)
   - "*Land-nitrogen-emissions reanalysis of national farm data by production type can improve assessment of pathways toward sustainable agriculture and land use*"
4. **Integrating national and business-sector carbon budgeting?** (in peer review)
   - "*Limits or bust? Business carbon accounting and management in a time of climate crisis*"

Communications: selected outputs related to this Fellowship

- **CCAC inputs:** "*Assessing Ireland's fair contribution*" Literature Review, 1-pager summary, plus AR6 addendum and presentation; scenario presentations: "Implications of Agriculture scenarios for post 2030 efforts" plus Added scenario; Daly et al. position paper 2021 (co-author); "Refining the Paris Test" at CCAC workshop video & pdf.

- **Conferences:**
  - ***Environ*** 2021 AFOLU and carbon budgeting (video and presentation); ***Environ*** 2022 business sector.
  - ***Negative CO_2 conference***, June 2022 Gothenburg, Sweden: abstract, video, presentation, twitter.
  - ***IAFA*** 2022; ***EGU 2023*** "*Towards a net negative world*" abstract and poster presentation.

- **Oireachtas Committee** contributions:
  - JC-ECA 12 Jan 2022 Carbon budgets debate: Barry McMullin, John Sweeney, Kevin Anderson and PRP
  - JC-Agriculture 24 Mar 2022 PRP solo one hour – opening stmt, video and Debate transcript incl. Q&A
  - JC-Agriculture 20 Jul 2022 opening stmt: Barry McMullin (and Paul Price).

- **Media:** RTE Brainstorm; Irish Times op-ed How to keep the Government honest on climate change; Irish Times letter Climate crisis and agriculture. 2022-07-24. TheJournal.ie article input and quotes. GreenNews.ie. SiliconRepublic. **Twitter:** from @DCU_ECRN account using the hashtag #CCAC_Fship_DCU.

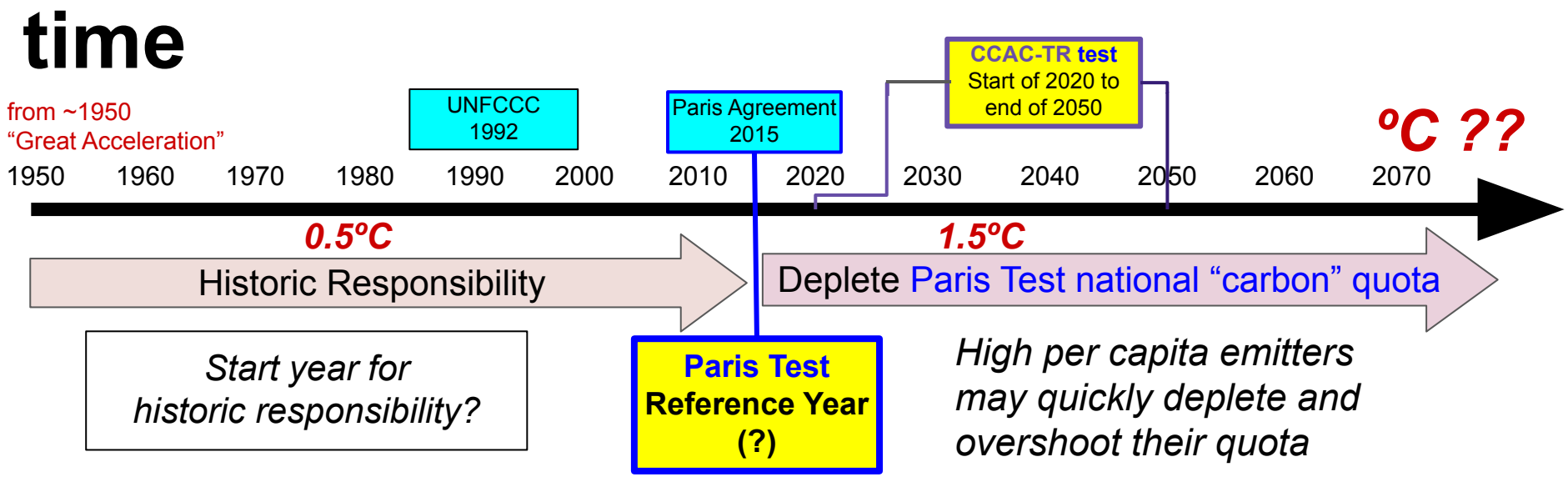
- **pdfs** of literature reviews and scenario outputs for CCAC and others made available on the DCU-ECRN website (search tag: #CCAC_Fship_DCU). Presentation to Teagasc on "*GHG metrics and agri emissions*" pdf.

- **Twitter:** from @DCU_ECRN account, hashtag #CCAC_Fship_DCU.
- **Blogposts** posted to DCU-ECRN news:
  - "Stable cattle herd"; Using GWP*; Forestry EF revision; LULUCF fraction of five-year carbon budgets.

1. Integrated carbon budget assessment of existing policy

Paris Test base year and end year definition are a value judgment.

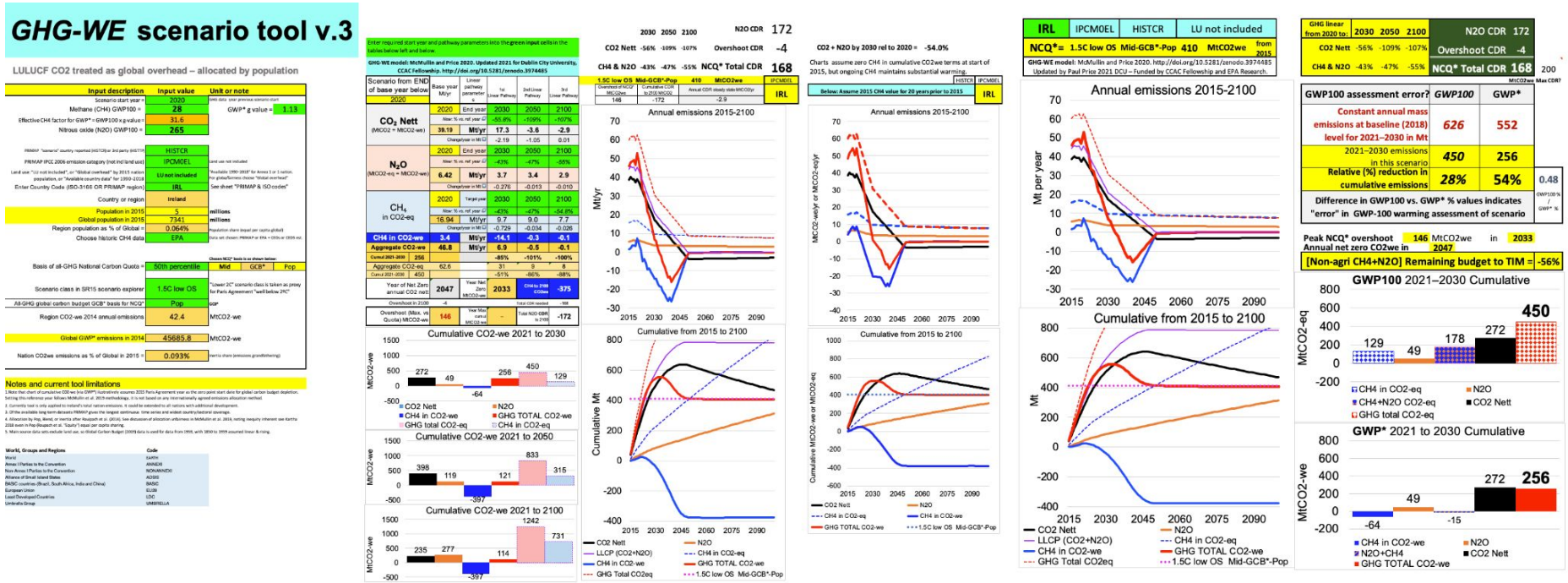
- Requires justification (CCAC 2021 Technical Report uses IPCC but IPCC not normative).
- 2015, Paris, can be justified as latest defensible choice = maximum developed nation remaining 1.5ºC budget, from which year it is depleted by national annual emissions.



1. Integrated carbon budget assessment of existing policy

GHG-WE tool upgrade: can now explore GWP* pathways for any nation

- **Input** national all-sector, multigas scenarios ⇒ **Output** ºC comparison to meet a defined "fair" IE Paris target.

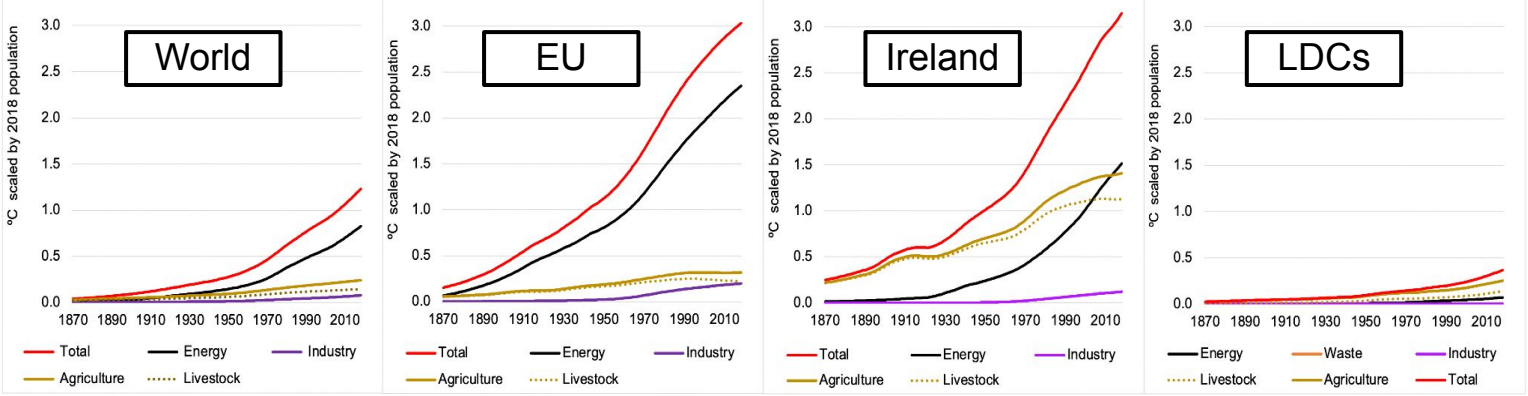


- GHG-WE tool can evaluate 1.5ºC/wb2C pathways (2015 base year) for any nation using a CBDR-RC population EPC target.
- Given EPA projections, or all GHG by-gas for all sectoral scenarios, GHG-WE indicate 2050 outcome relative to 1.5ºC EPC level.

2. Assessing alternative integrated emissions scenarios

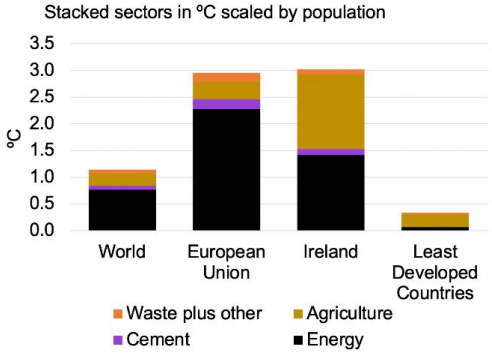
Historical Responsibility for warming up to 2018 (upscaled by population)

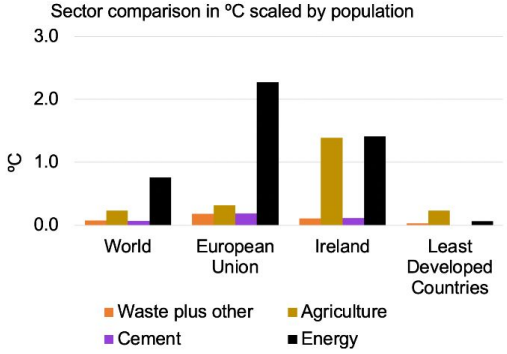
- IE warming *HR* is similar to EU (~3ºC), but much greater proportion from agriculture.

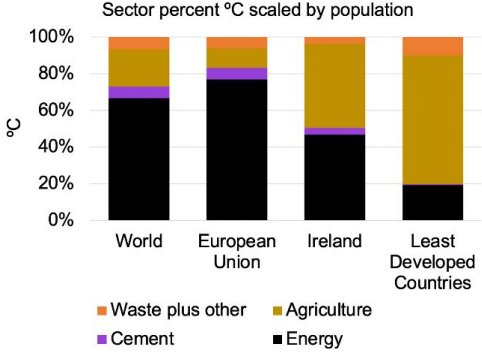


Spreadsheet tool using PRIMAP data and GWP* developed to aggregate GHG warming for CO_2+N_2O+CH4.

- Can compare Parties and blocs, for any IPCC category on ºC pop. basis.







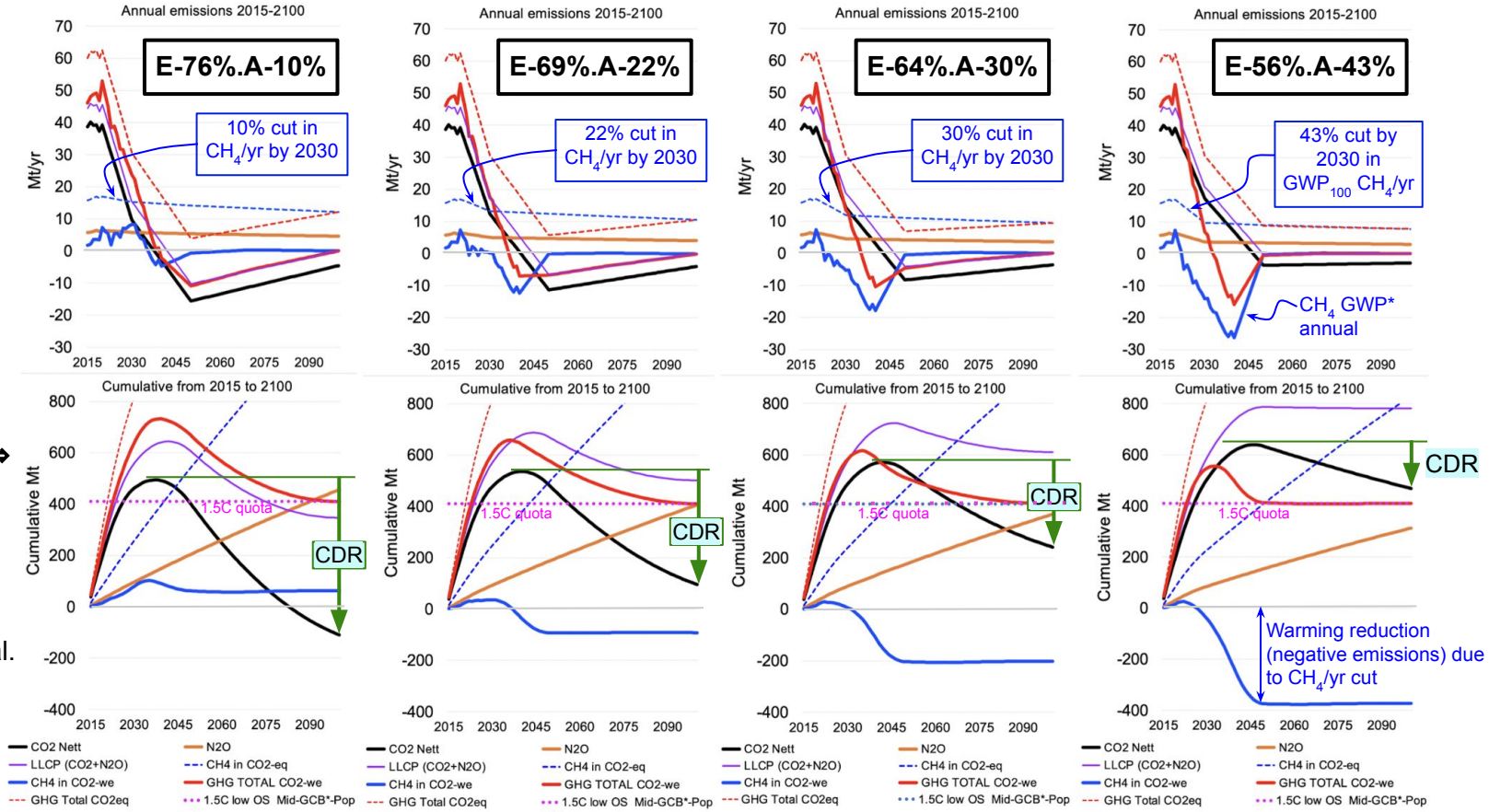
2. Assessing alternative integrated emissions scenarios

Meeting same Paris goal reveals negative emission tradeoff: deeper CH_4/yr cut, less CDR

- IE scenarios with early,deep, & sustained CH_4/yr cut limits overshoot & CDR amount required for IE 1.5ºC$_{EPC.}$

Annual charts ⇒
Depth of non-CO_2 cut by 2030 increases from left to right, -10% up to -43%.

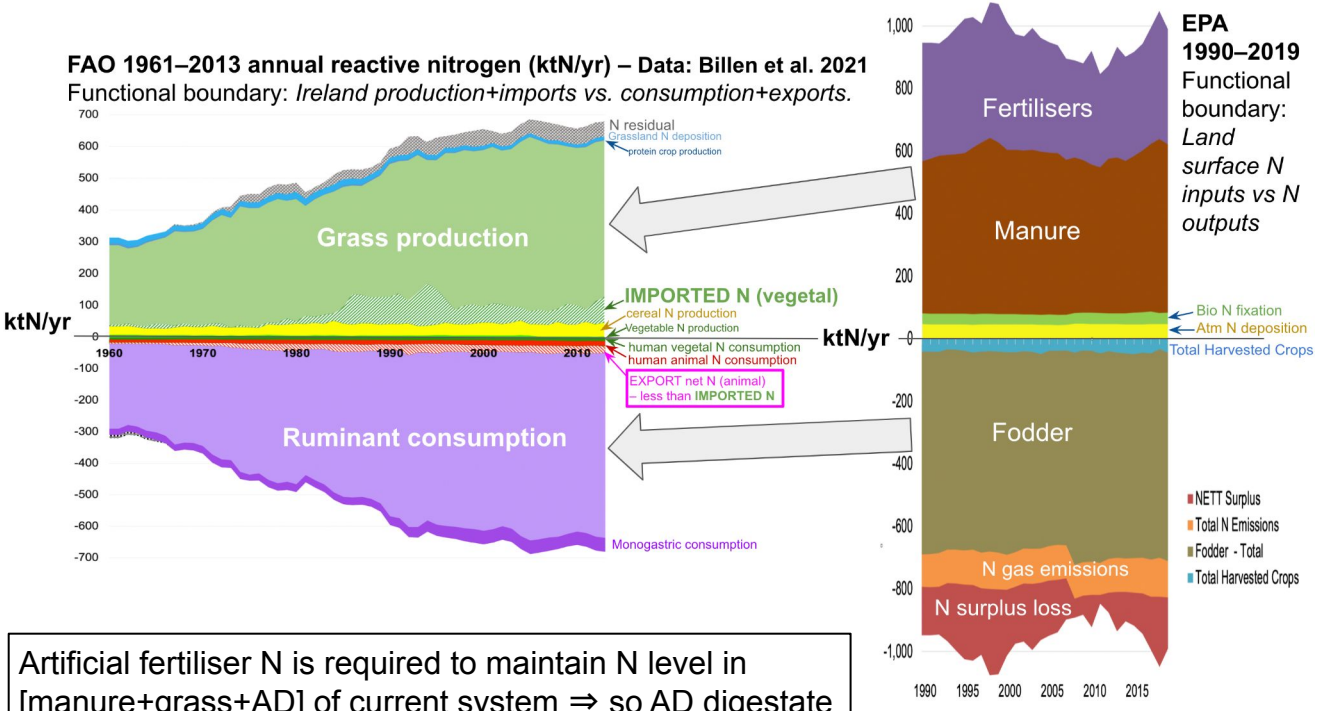
Cumulative charts ⇒
Deeper cuts in CH_4/yr have large warming reduction (negative emissions) effect, so less CDR required for Paris goal.



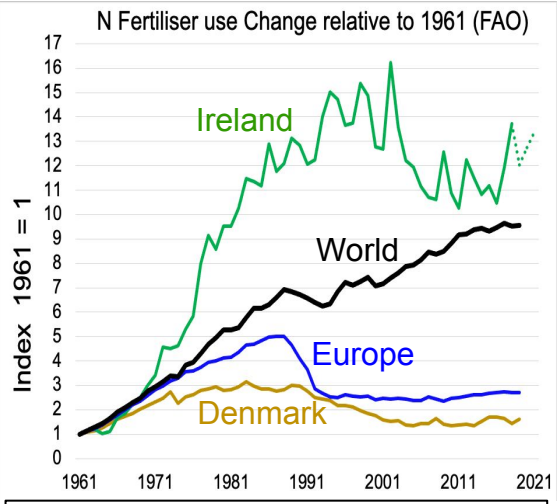
3. Agriculture, forestry & land use in society-wide transition

Ireland Nitrogen Budgets: National and land surface (scales matched)

- Time series show strong IE focus on grass-based ruminants & artificial N requirement to replace losses.



Artificial fertiliser N is required to maintain N level in [manure+grass+AD] of current system ⇒ so AD digestate is very unlikely to "replace" much if any fertiliser N.

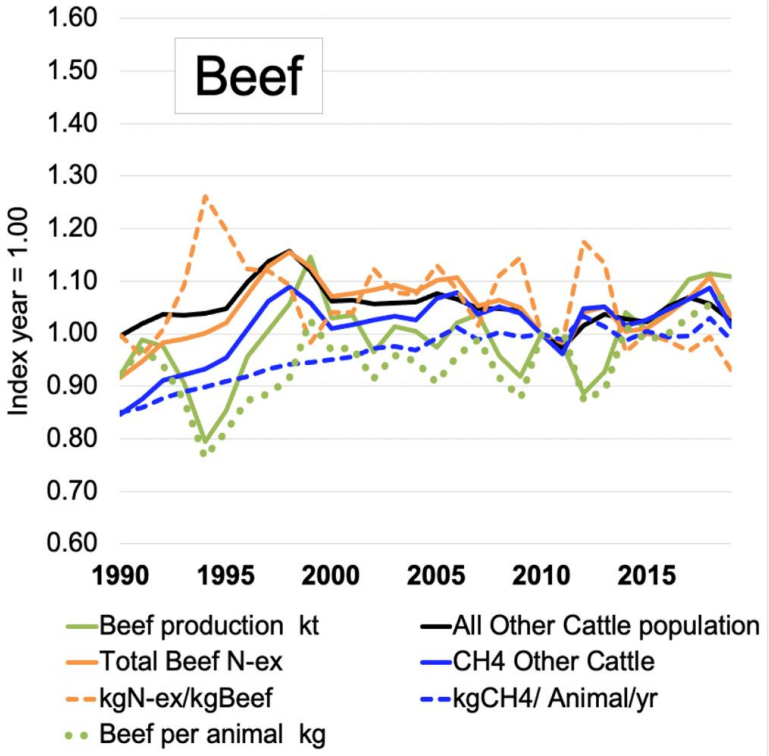


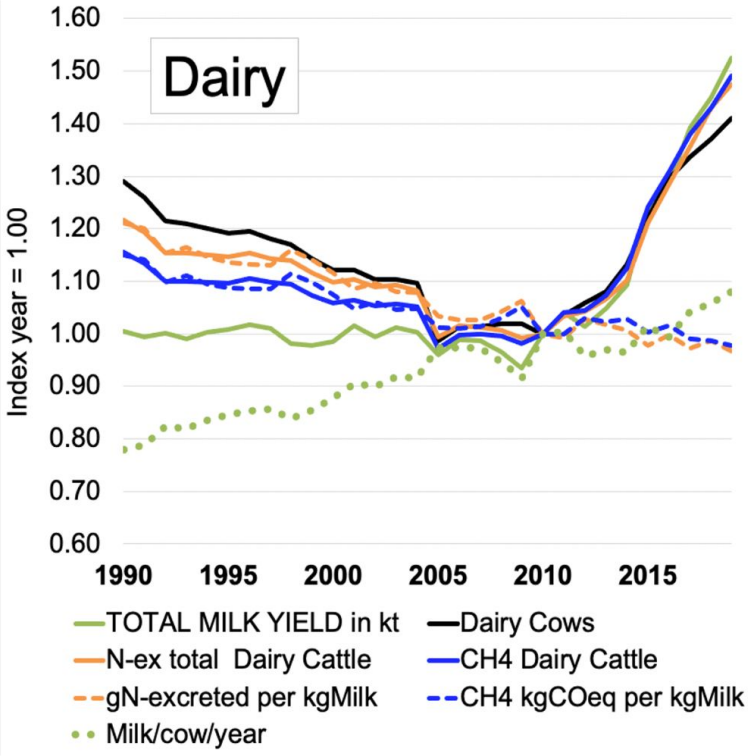
Compared to 1961: in 2013 IE produced about ~2x grass and cereal N, but relies on over ~10x fertiliser use ⇒ a major NUE drop. System now has worse NUE still, due to more N imports, less tillage.

3. Agriculture, forestry & land use in society-wide transition

Analysis of EPA 1990–2019 data for Irish beef and dairy: change relative to 2010

- IE system N-ex. & GHG relative to production: beef ~ coupled since 1998, dairy ~ coupled since 2005.



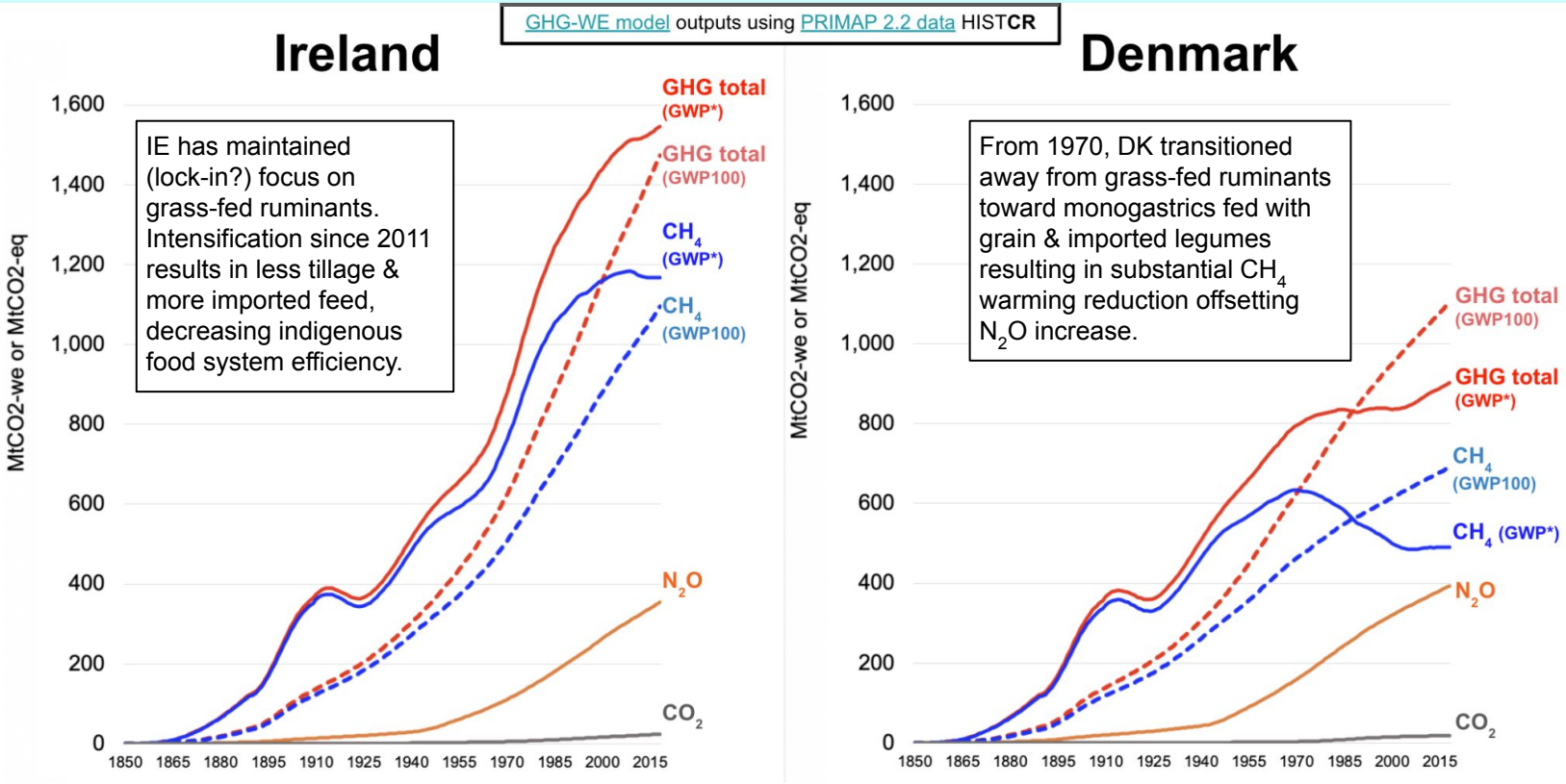


Dairy shows very little N_{ex}. or CH_4 production efficiency change since 2005

3. Agriculture, forestry & land use in society-wide transition

Ireland: warming due to agriculture 1850–2018, compare to Denmark

- DK similar animal N output to IE. IE warming continuously up, DK ~levelled off.

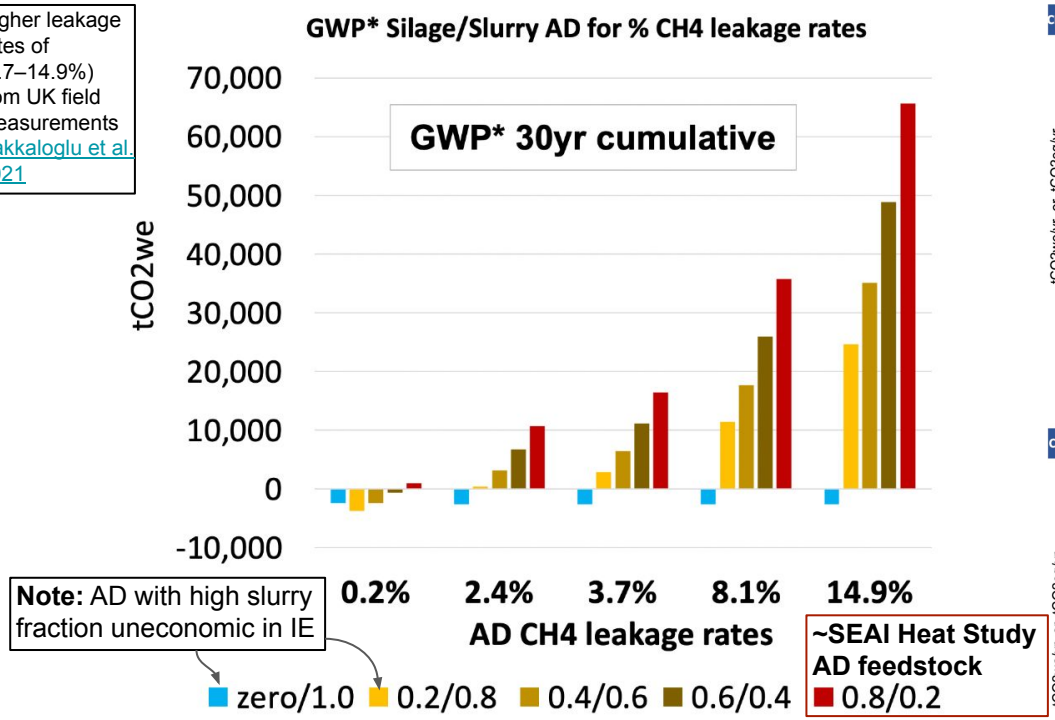


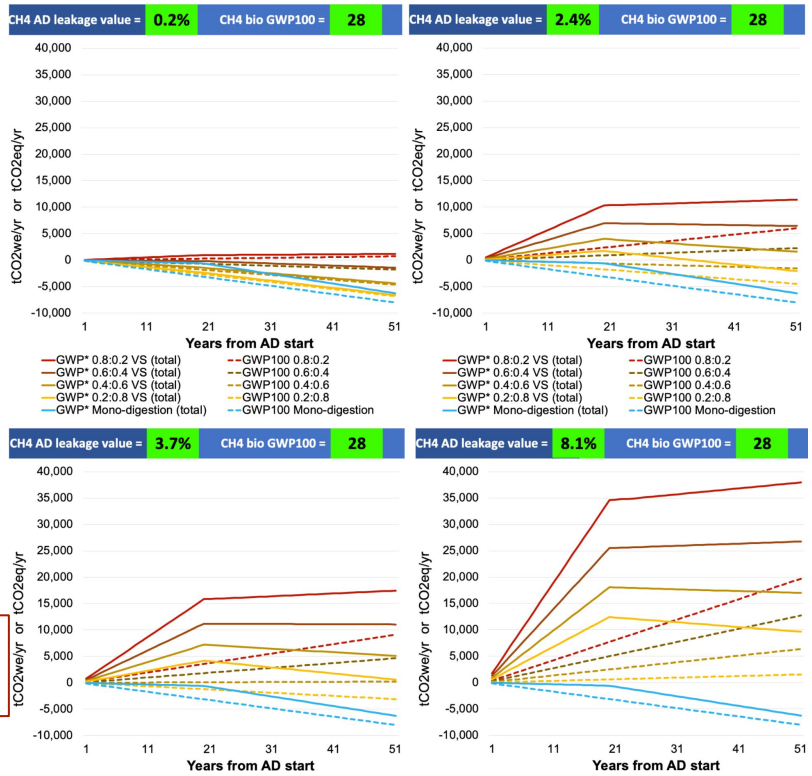
3. Agriculture, forestry & land use in society-wide transition

Anaerobic Digestion: GWP* reanalysis of GWP_{100} and CH_4 leakage data.

- SEAI Heat Study's AD *slurry:silage* feedstock mix: *fails* to deliver warming reduction to 2050.

Higher leakage rates of (3.7–14.9%) from UK field measurements Bakkaloglu et al. 2021



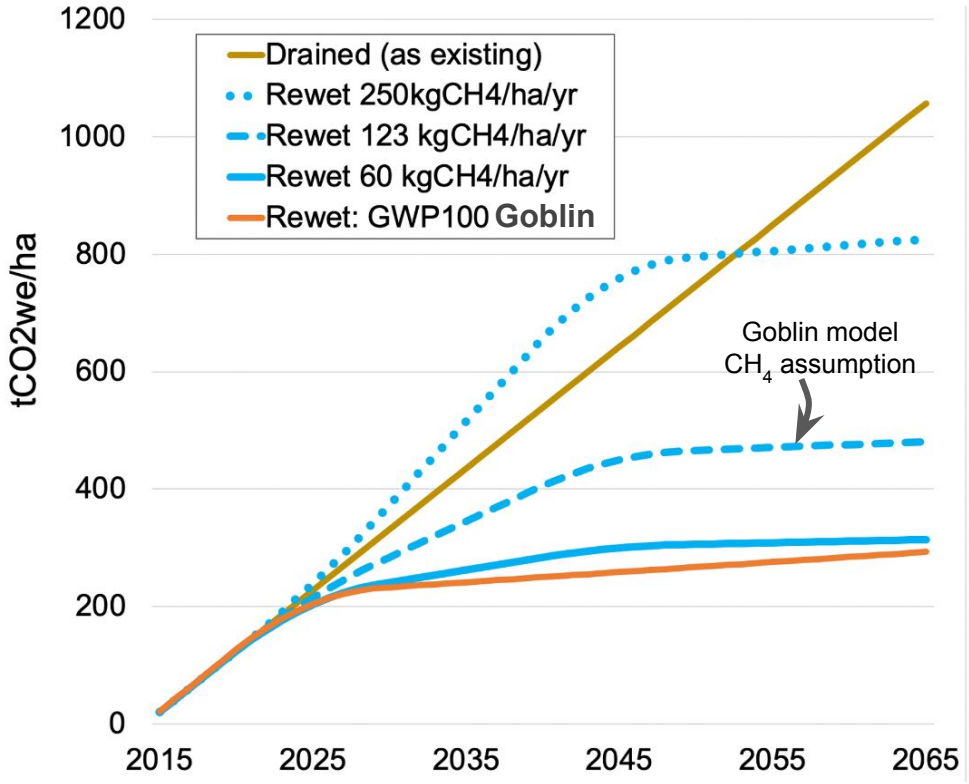


Own charts. Data from Beausang, C., McDonnell, K., Murphy, F., 2021. Assessing the environmental sustainability of grass silage and cattle slurry for biogas production. Journal of Cleaner Production 298, 126838. https://doi.org/10.1016/j.jclepro.2021.126838

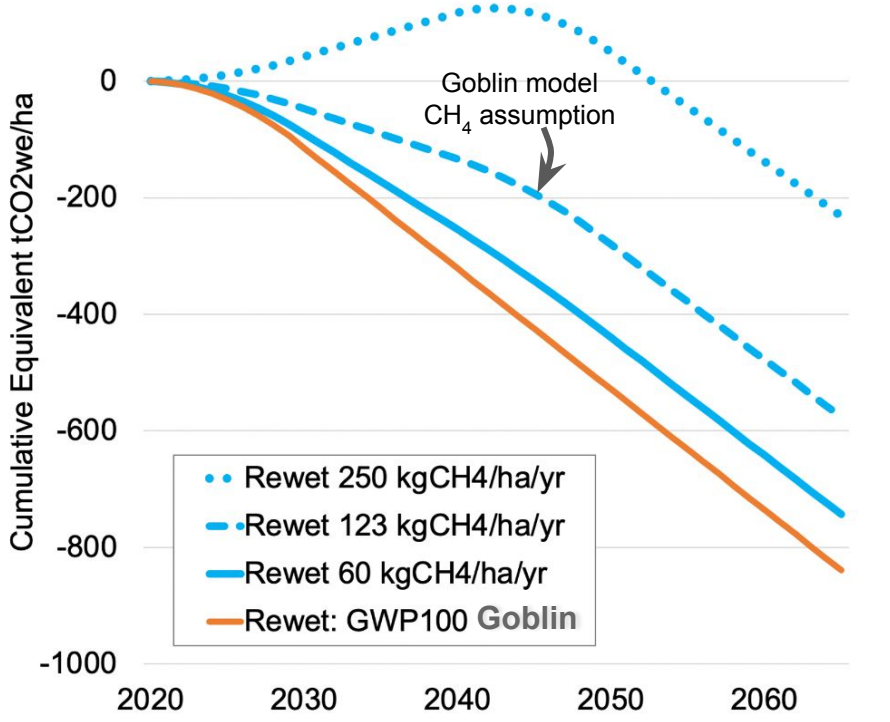
3. Agriculture, forestry & land use in society-wide transition

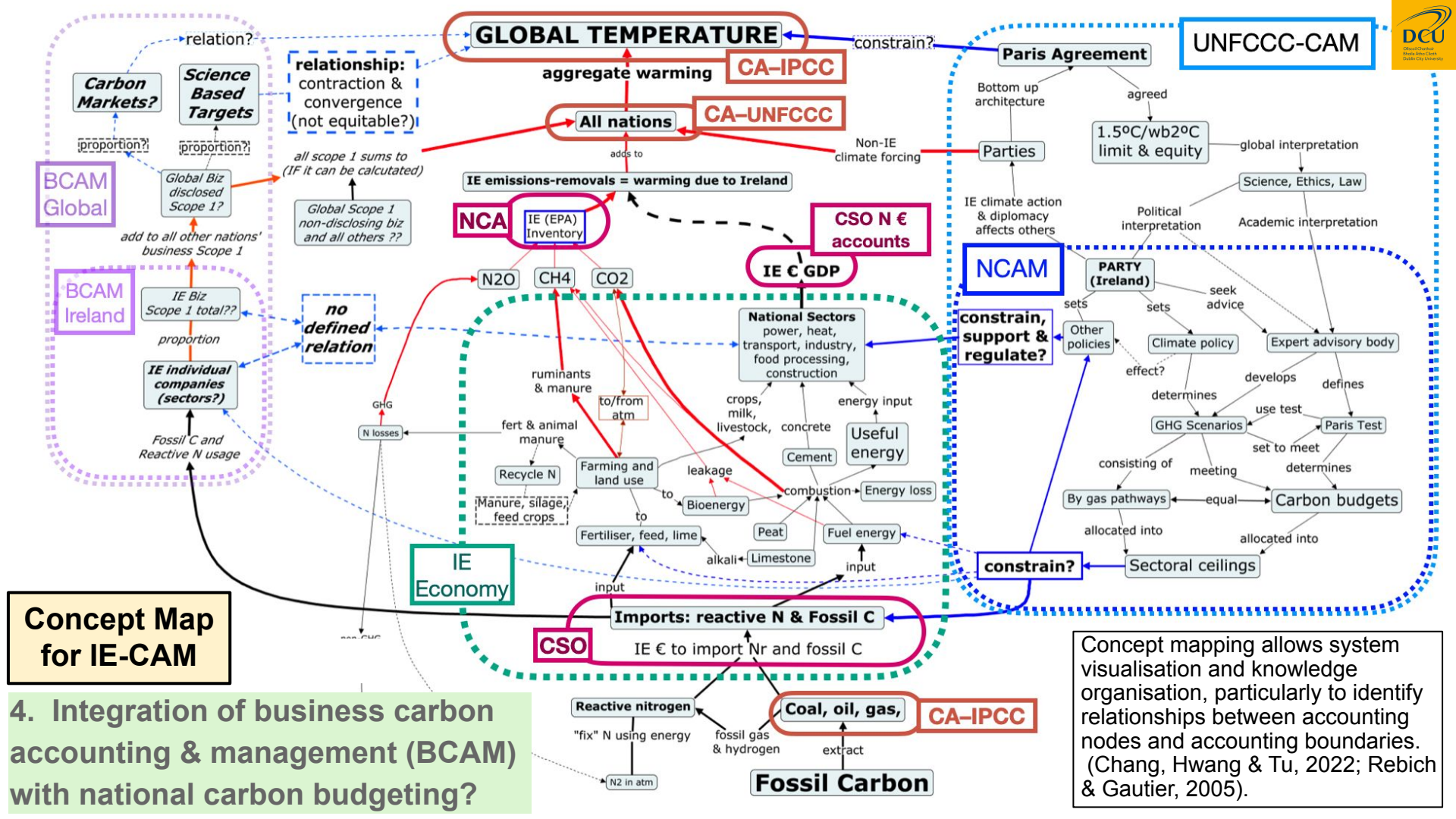
Rewetting organic soils: warming analysis of CO_2 removal vs. CH_4 emission.

- Care needed as CH_4 increase with rewetting can substantially reduce net 2050 climate benefit.



2050 warming benefit: less than GWP_{100} indicates





Concept Map for IE-CAM

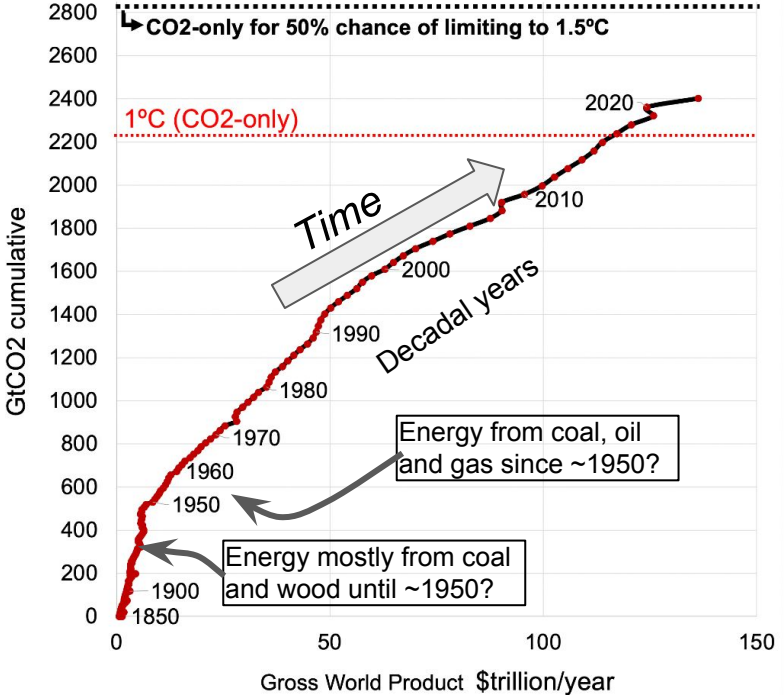
4. Integration of business carbon accounting & management (BCAM) with national carbon budgeting?

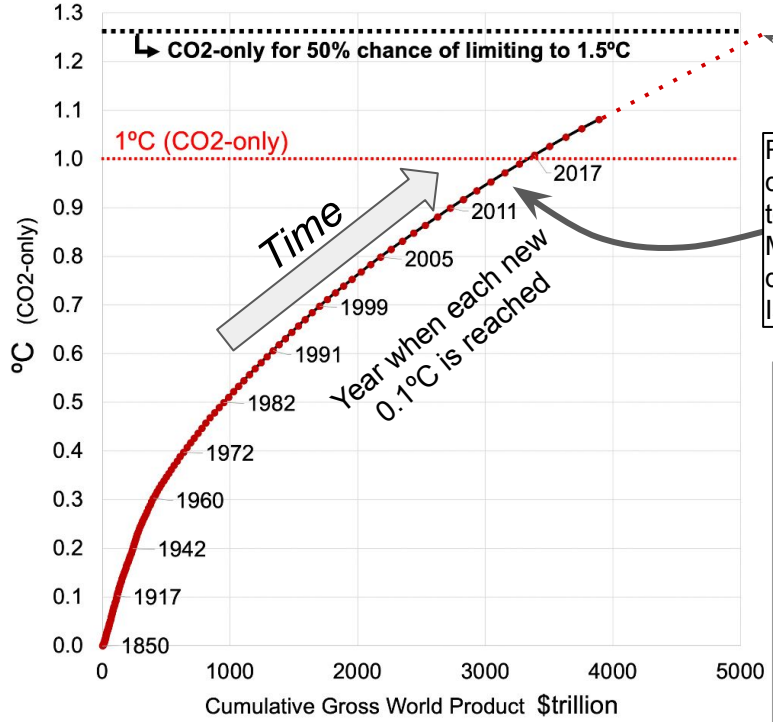
Concept mapping allows system visualisation and knowledge organisation, particularly to identify relationships between accounting nodes and accounting boundaries. (Chang, Hwang & Tu, 2022; Rebich & Gautier, 2005).

4. Integration of business sector with national carbon budgeting?

Global climate & business context: global warming vs. global $ output

- Business-as-usual continues: warming continues to accelerate, highly coupled to global economic output.
- 1.5ºC overshoot imminent. Impact risks are escalating. Managed global transition or unmanaged failure?





Jarvis et al. 2013:
This emergent coupled system is "*a manifestation of a feedback coupling between environmentally derived resources and the exploitation of these resources by society on the global scale.*"

Own charts. Data: CO2 from CDIAC (2017) and Global Carbon Project (Friedlingstein et al., 2022), GWP data derived from Bolt and van Zanden (2020)

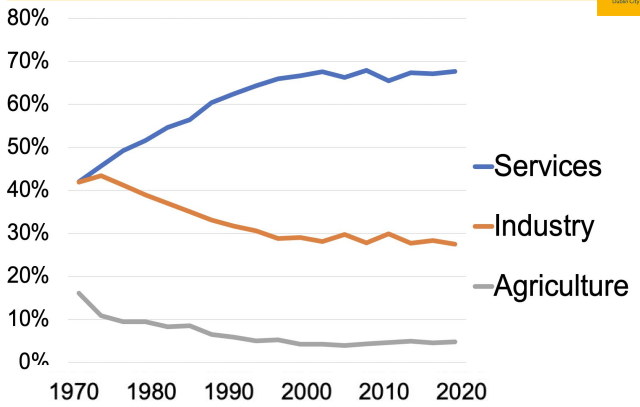
4. Aligning business vs. national carbon accounting & management (BCAM) with national carbon budgeting?

BCAM: companies align Science Based Targets with global goal

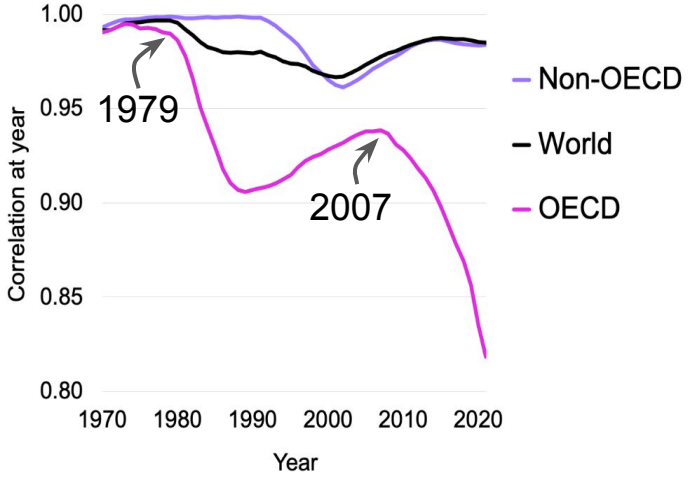
Thus, reasonable to assess BCAM (& NCAM) on *global* basis:

- Strong linear global $GDP:warming CO_2 correlation is ongoing.
  - *Services* globally & OECD "decarb" relative to Non-OECD.
  - All sectors, incl. *Services*, are similarly carbon intensive (see ref.).
- Implies strong linear relationship of ["Economic Value Added" to mass CO2] – via company EVA and national GDP – can assess BCAM to NCAM mutual alignment and relation to 1.5ºC CBDR-RC.
- Therefore, GDP may be a more meaningful assessment than territorial emissions for warming responsibility: based on an entity's share of total *gross world product* multiplied by total worldwide emissions. Explored carbon regulation or tax on this basis.
- Distributing carbon tax revenue on fair share basis among Parties provides a BCAM & NCAM benchmark.

Worldwide sectors: % of total value adde



OECD vs Non-OECD (1970–2020)



4. Integration of business sector with national carbon budgeting?

Work Package analysis relating total global CO_2 emissions to gross world product (GWP): ⇒ questionable to use only GNI* or similar as a proxy in assessing climate change action responsibility.

If a nation's GDP is inflated due to foreign direct investment (FDI) flows, as for IE and other financial centres (Lane & Milesi-Ferretti, 2018) then can plausibly argue a nation's emissions responsibility relates to its full GDP, *including* profits made by foreign-owned MNEs or other transfers.

Implies the use of GDP <u>can</u> be used by the CCAC to evaluate IE global warming responsibility. Otherwise use of GNI* (only) risks *inequitably* overlooking IE's full impact on global warming by not accounting for profits booked to IE based on emitting activities and investments elsewhere.