Emissions, grassland and biodiversity and role of carbon footprint tool

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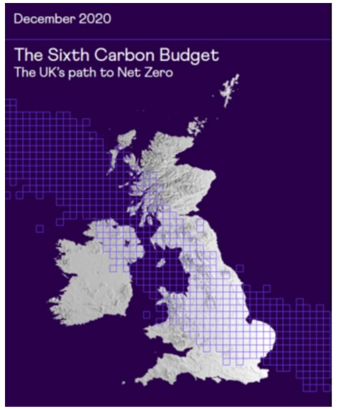
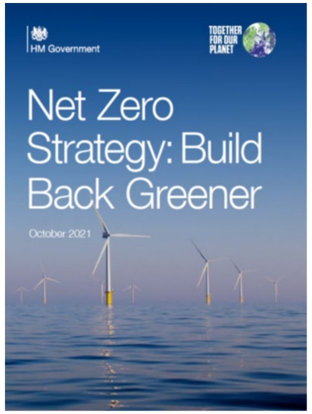
Move towards net zero

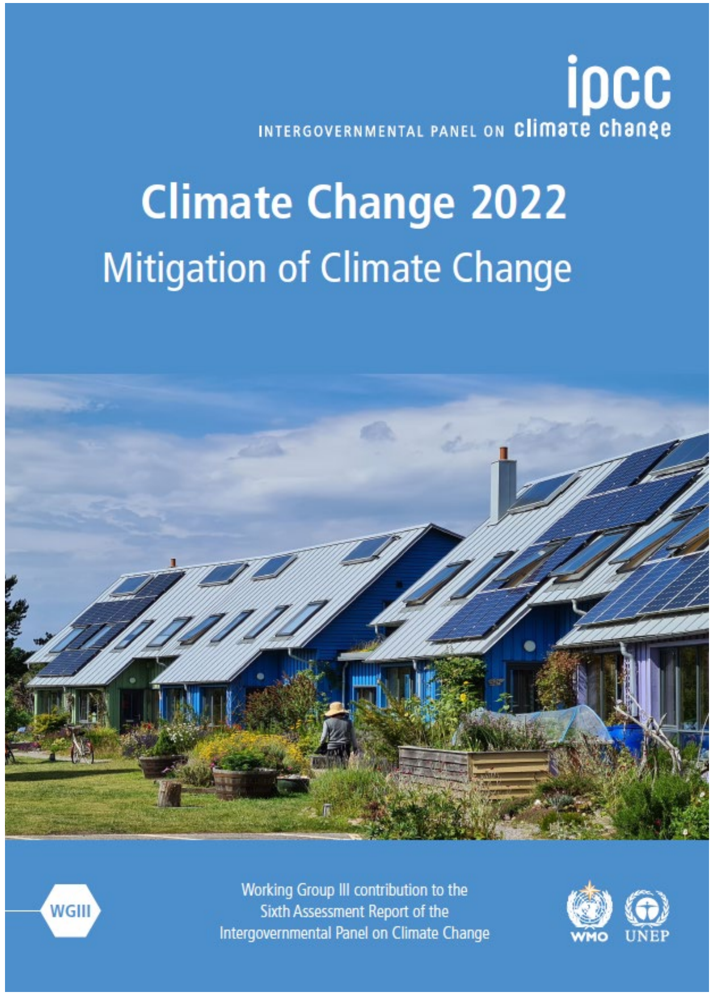
- The EU aims to be climate-neutral by 2050 –
  an economy with net-zero greenhouse gas emissions.
- Heart of the European Green Deal
- The UK has set an ambitious target to reduce greenhouse gas emissions to 'net-zero' by 2050
- Agriculture and land use will be critical





Climate policy
"Now or never"

- Halt the rise in emissions by 2025
- Halve emissions by 2030
- Net zero by 2050
- Limiting temperature rise to < 1.5^{o}C now highly unlikely

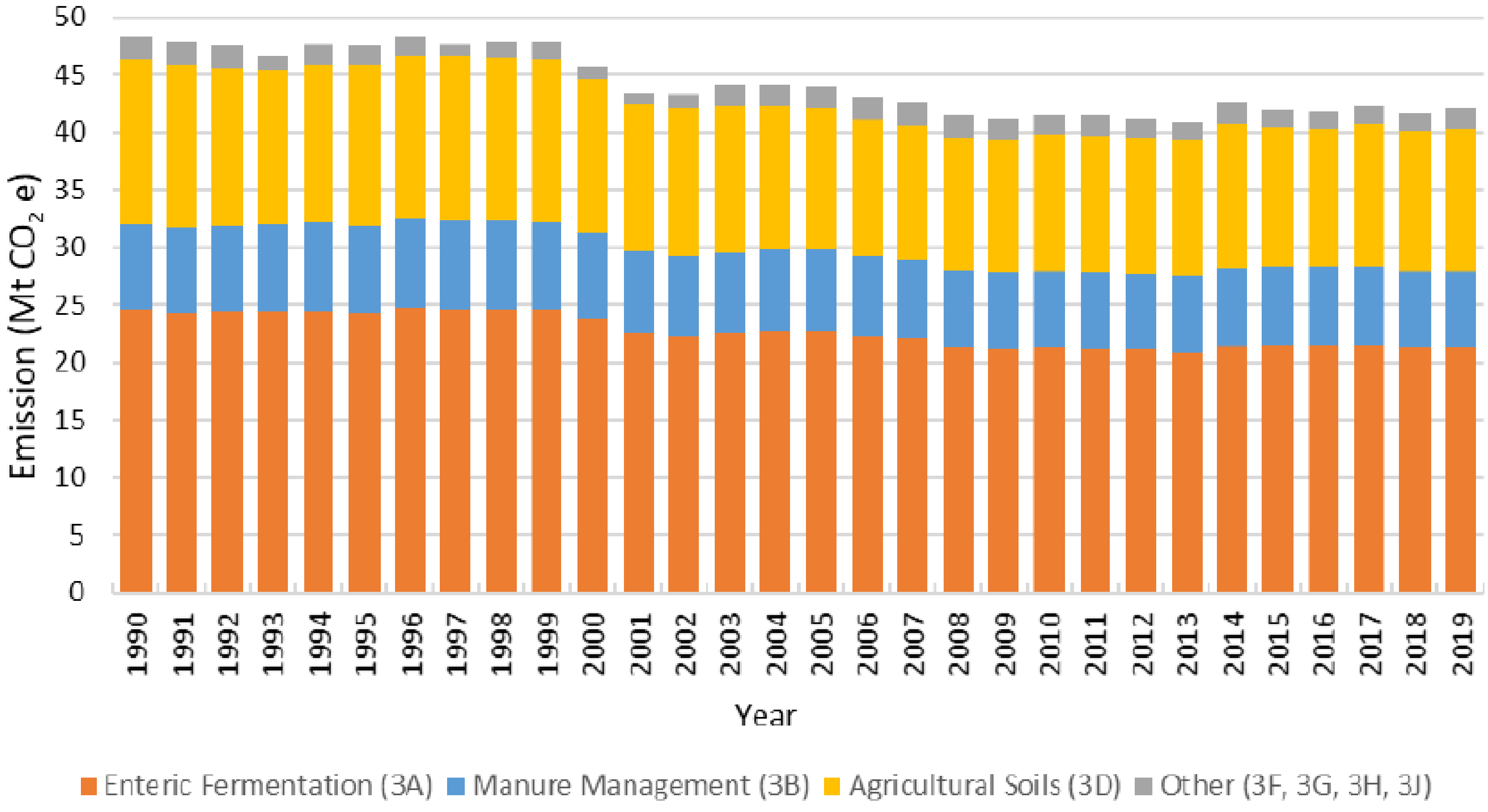


Agriculture and land-use are different

- Biological emissions
- Non-CO_2 greenhouse gases
- Emissions and uptake
- Food production is a basic human need
- Wider socio-economic implications
- Inertia

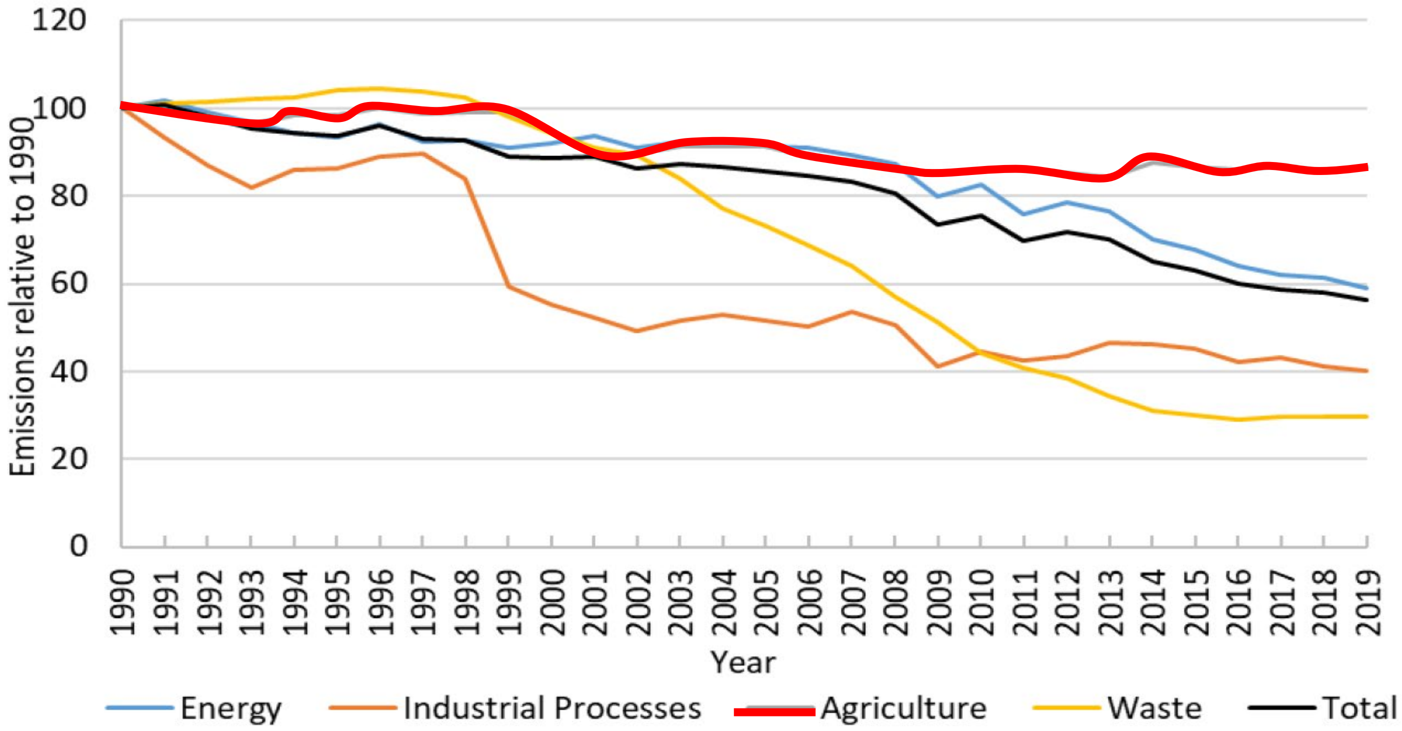
Agricultural greenhouse gas emissions

*"Progress in **agriculture and land use** has repeatedly failed to meet the indicators outlined in the Committee's progress reports in recent years."*

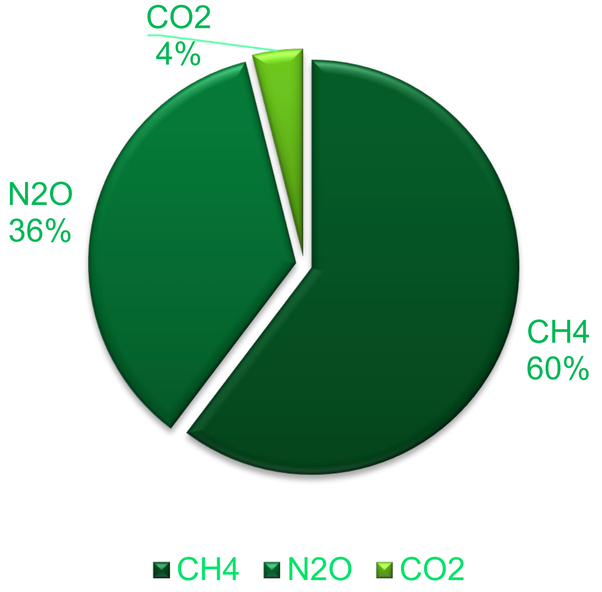


CCC 2022
UK National inventory report 2021

UK greenhouse gas emissions



Trends in emissions by sector relative to 1990



Agricultural emissions

UK National Inventory Report 2021

What has been happening?

Methane (CH_4) emissions generally contribute the greatest proportion of GHG's

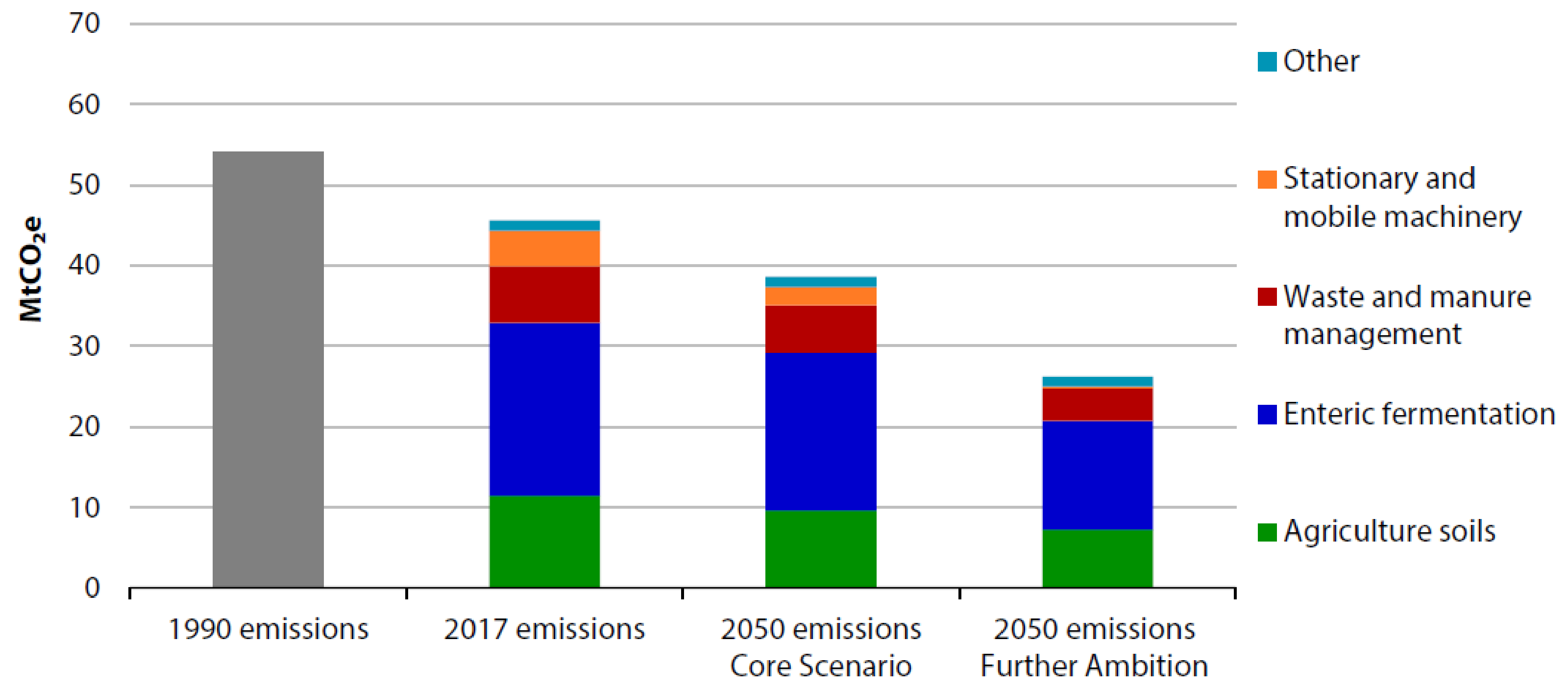
- CH_4 contributing 60% of agricultural greenhouse gases in the UK
- Emissions of nitrous oxide (N_2O), an important greenhouse gas (third most persistent), contributes 36% of the UK emissions

Some successes

- Milk production and efficiency in the UK dairy industry has resulted in GHG reductions, with total emissions falling by 16.1% (1.12 Mt CO_2-eq) between 1990 and 2020

The carbon challenge – UK agriculture to cut carbon emissions 42% by 2050 (46mt C to 26mt C)

Figure 7.3. Scenarios for very deep emissions reductions from the agriculture sector



Source: BEIS (2019) *Final UK greenhouse gas emissions national statistics 1990-2017*; SRUC, ADAS and Edinburgh University (2019) *Non-CO_2 abatement in the UK agriculture sector by 2050*; and CCC calculations.

How to measure and meet carbon reduction targets?

- **Establish a baseline - measure**
- **Then monitor, manage, verify improvements**
- Verified industry standards
- Map production chain by stage
- Life cycle assessment
  - Greenhouse Gases
  - Key Performance Indicators – feed conversion ratio, mortality, energy use.
- Identify measures that will deliver environmental and financial wins for farm and whole supply chain
- Individual and group working

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What is Agrecalc?

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- Agricultural Environmental / Efficiency Calculator

  - Web-based calculator (www.agrecalc.com)

  - Estimates the type, source and extent of GHG emissions produced from:

    - whole farm
    - individual farm enterprises
    - products

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Greenhouse Gases assessed by AgreCalc

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- The three main GHGs assessed by Agrecalc© and their sources include:
  - Nitrous oxide (N_2O) - released during the application of synthetic and organic fertilisers to the soil, from urine deposition by grazing animals and from crop residues
  - Methane (CH_4) - produced as a natural by-product of enteric fermentation during ruminant digestion and from management of organic manure
  - Carbon dioxide (CO_2) - produced through burning fossil fuels to produce energy, embedded in purchased inputs and disposal of waste
- Calculates emissions from the above sources up to the farm gate, including emissions associated with purchased inputs

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Agrecalc methodology

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- The carbon emissions methodology employed is consistent with international and national standards including:
  - Intergovernmental Panel on Climate Change (IPCC)
  - BSI standard for life cycle analysis (PAS 2050:2011)
  - Feed Print 2015-08
- SRUC use a Tier 2 methodology when calculating GHG emissions from ruminants, pigs and poultry (Tier I is normally used in UK for pigs and poultry).
- Tier 2 allows changes in performance and diet to be fully captured

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Carbon calculations – Land and crops & Energy

Activity	GHG	Data
Land use	Nitrous oxide	Cropping
Machinery use	Carbon dioxide	Fuel use
Energy use	Carbon dioxide	Fuel and electricity
Fertiliser - manufacture	Carbon dioxide	Fertiliser use
Fertiliser - application	Nitrous oxide	Fertiliser use
Manure & Slurry - application	Nitrous oxide	Manures applied

Carbon calculations – Livestock

Activity	GHG	Data
Livestock metabolism	Nitrous oxide Methane	- Average numbers - Weights - Growth rate - Age at slaughter - Milk production
Feed - production	Carbon dioxide	Quantities and types of feed used

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SRUC Agrecalc - results

- Emissions are typically displayed in terms of CO_2e (CO_2 equivalents) as an emissions intensity (i.e. CO_2e per unit of output), commonly known as a carbon footprint

- Allows comparisons to be made with other farms or enterprises and allows farm production to be taken into account

- Farms with a low carbon footprint are generally the most efficient.

- AgreCalc© benchmarks carbon footprint results against similar enterprises, highlighting areas where improvements can potentially be made, improving efficiency

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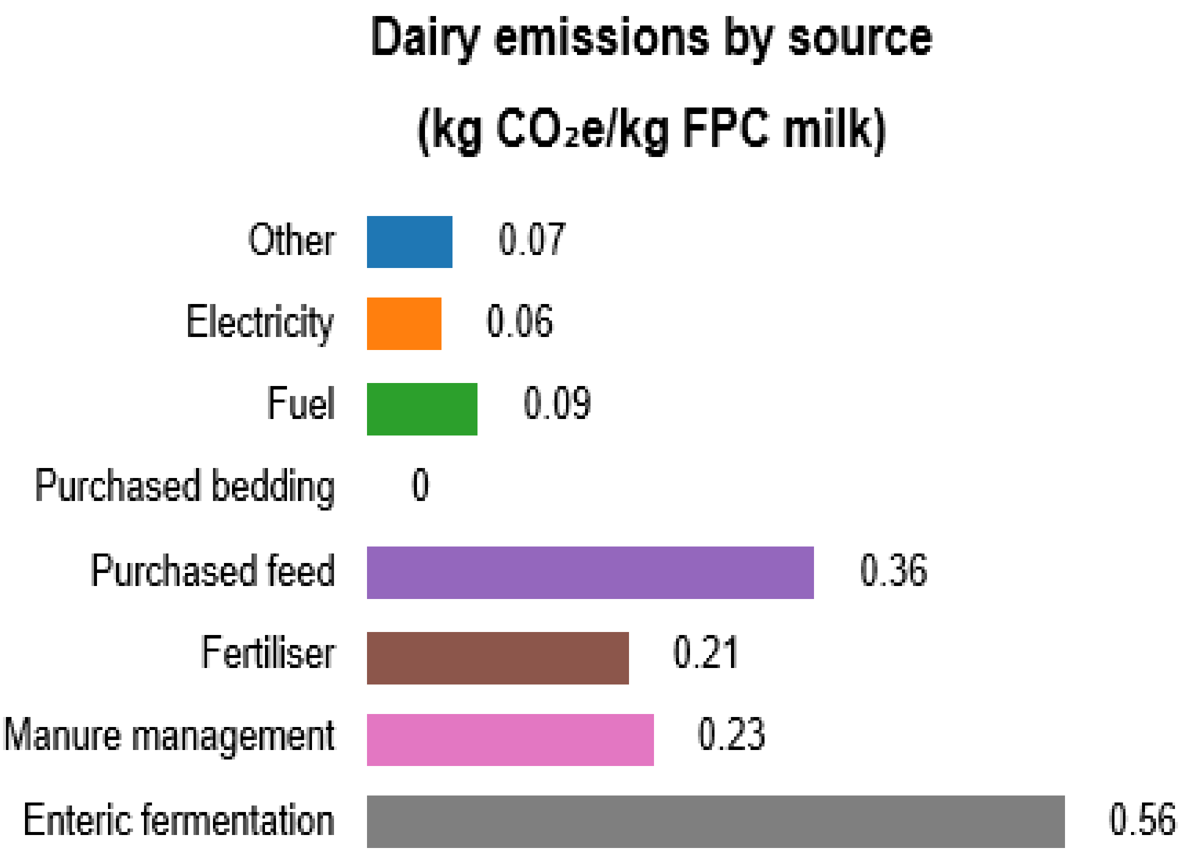
SRUC Agrecalc results – Dairy



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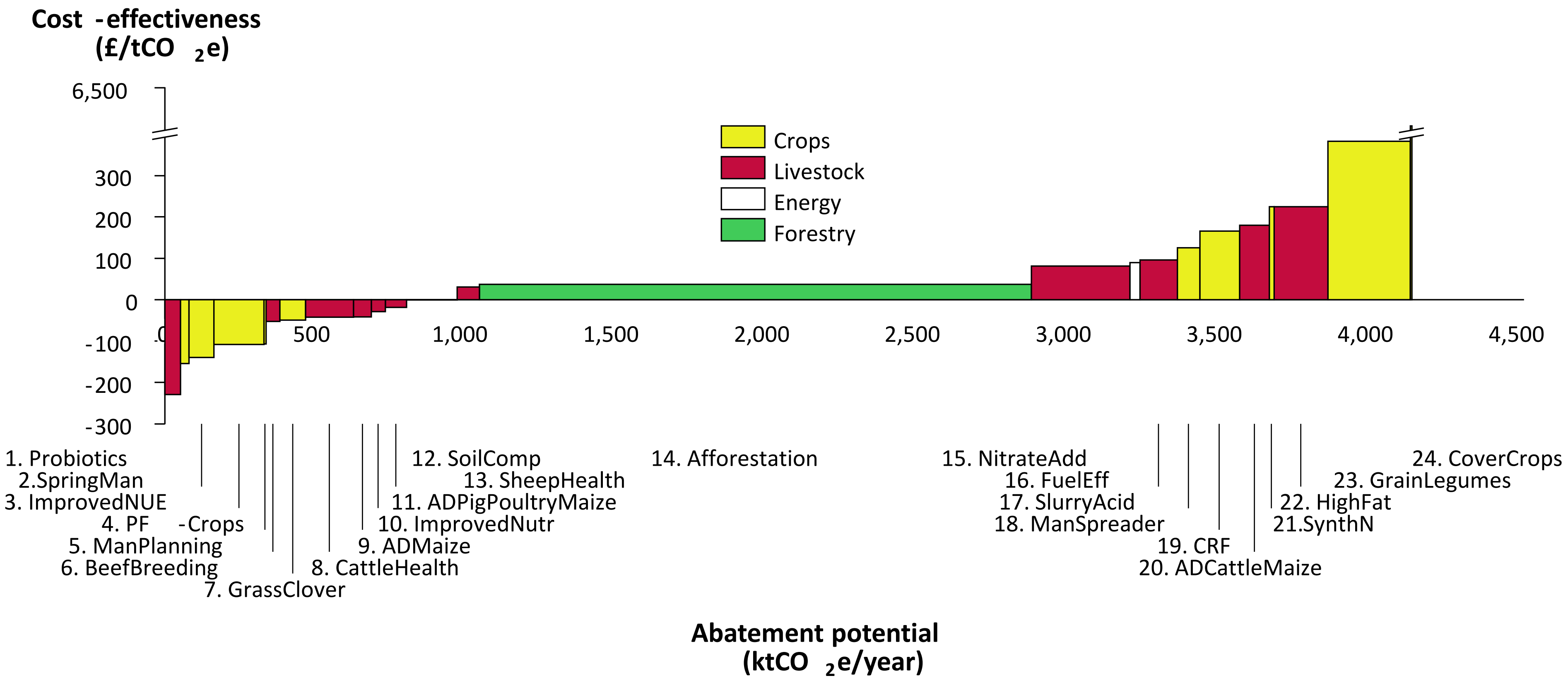
Carbon mitigation – where to start? Efficiency gains.

SRUC MACC work



Eory et al. 2015

Dairy farm mitigation – recent SRUC agrecalc examples

agrecalc

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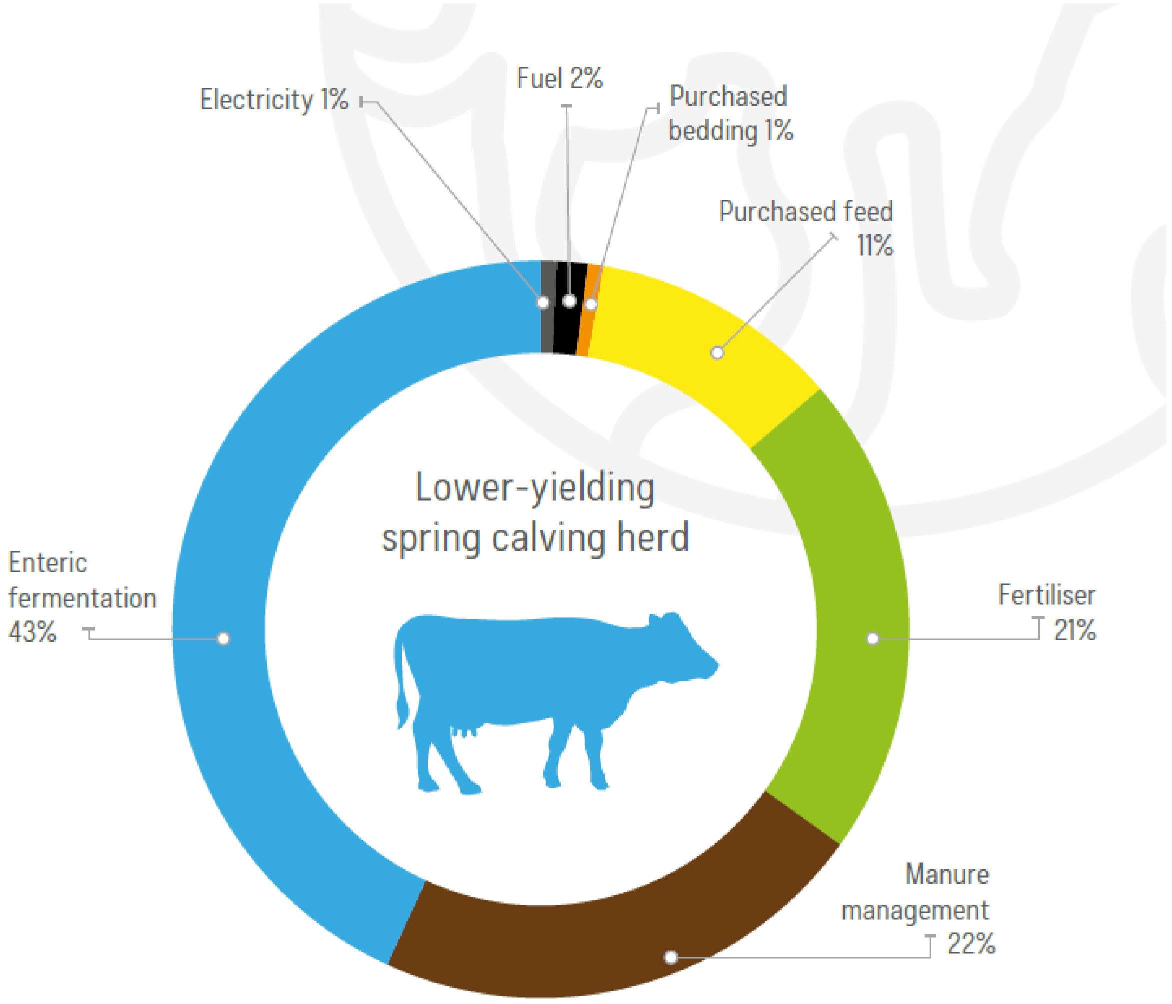
Table 1 – Mitigation measures

Mitigation action	Description	Carbon savings from	Feas-ibility	Cost
M1 - Improve grass silage quality and yield	Re-seed arable land with new grass/legume leys, raise silage quality from average to top third. (Energy 11.5-12.3ME, CP 13.2-14.2%, silage yield per ha +10%). Reduce purchased feed (rapemeal) & home grown barley use.	Reduced embedded carbon from lower feed purchases and home grown grain use, lower enteric methane from higher digestibility of diet.	High	Low/ positive
M2 - Home grown protein	Replace oilseed rape with spring beans in arable rotation to displace purchased rapemeal. Replace rapestraw with wheat straw.	Net reduction as home grown pulses are lower carbon than purchased rapemeal.	High	Med/low
M3 - Trailed shoe slurry application	Apply all liquid manures with a trailed shoe replacing existing splash plate system. Leading to reduced need for artificial nitrogen - 10kg N per ha across 1,164 ha forage = 11,654kg N saved.	Reduced embedded carbon from lower fertiliser purchases. Volatilisation losses of ammonia and consequent nitrous oxide are reduced by half from slurry application and lower due to reduced fertiliser use	High	Low

Dairy Case Study Farm 1 - Spring calving, grazed grass focused farm

- 394 Crossbred cows
- 203.5 ha platform
- 5267 litres/cow; 4.5%BF & 3.67%P
- 24 month age at 1st calving

- **Total emissions**
  - **3374 t CO2-eq**
  - **1.46 kg CO2-eq/kg milk**



Dairy Case Study Farm 1 - Spring calving, grazed grass focused farm

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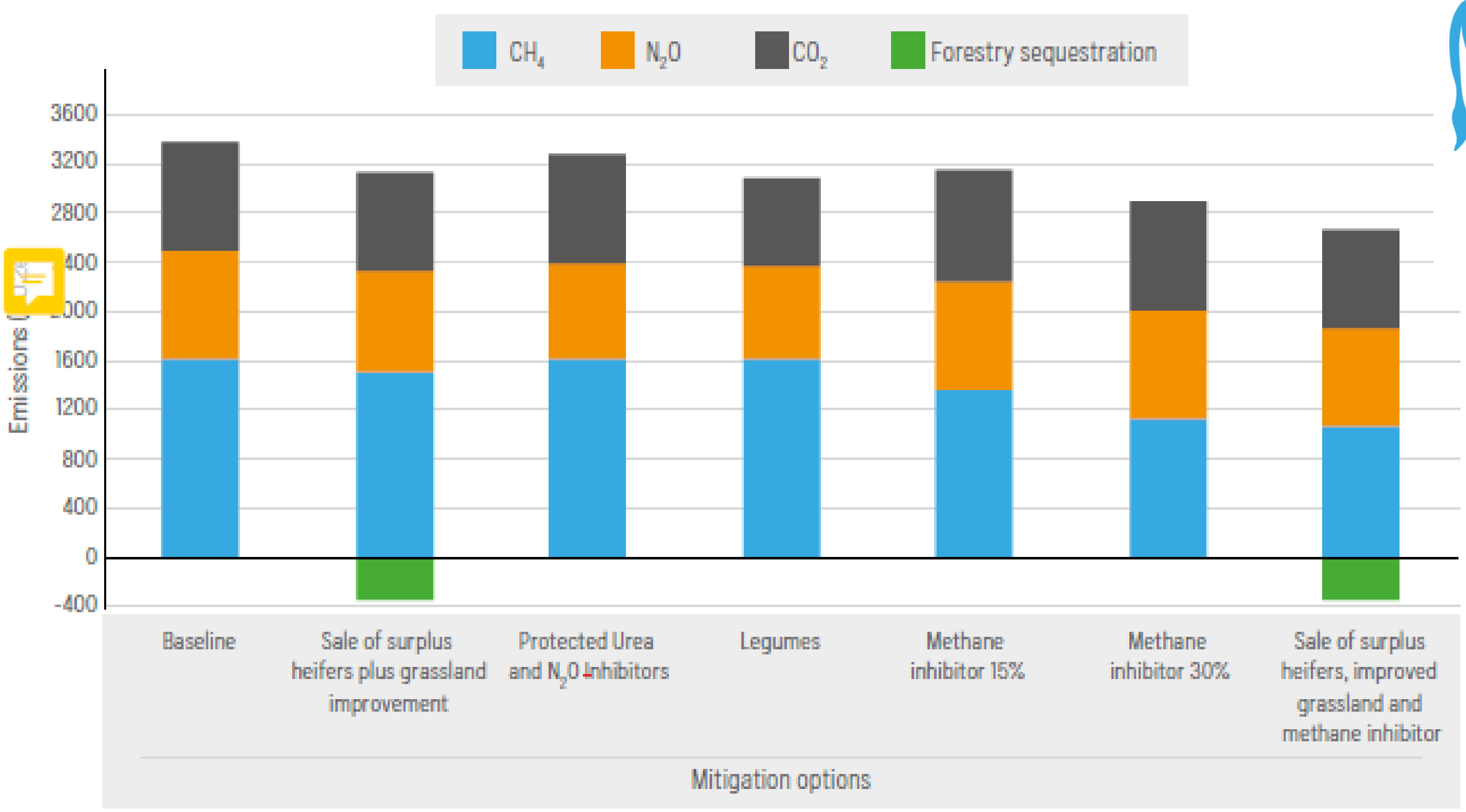
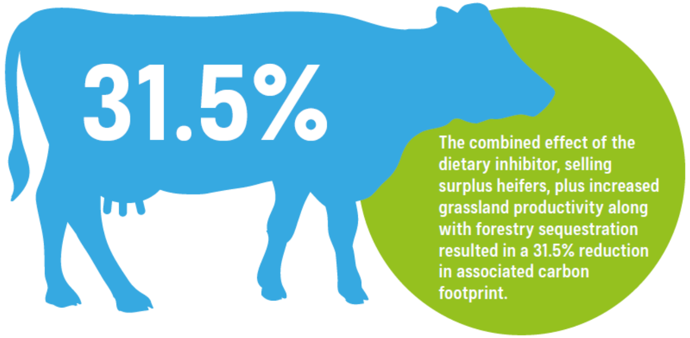
Mitigation options Lower-yielding, spring calving herd	Total emissions ($t\ CO_2$-eq) and % change from baseline		Carbon footprint ($kg\ CO_2$-eq/kg milk) and % change from baseline	
Baseline	**3374**		**1.46**	
1. Sale of surplus followers and improved grassland	3116	-7.6%	1.35	-7.5%
If released land used for forestry	2762	-18.1%	1.20	-17.8%
2. Application of fertiliser amendments protected urea and N_2O inhibitors	3280	-2.8%	1.42	-2.7%
3. Inclusion of legumes in grassland	3092	-8.4%	1.34	-8.2%
4. Employing methane inhibitor:				
at 15% effectiveness	3134	-7.1%	1.36	-6.8%
at 30% effectiveness	2893	-14.3%	1.25	-14.4%
5. Combined effect:				
Sale of surplus followers, plus improved grassland plus dietary methane inhibitor (30% effective)	2662	-21.1%	1.15	-21.2%
If released land used for forestry	2308	-31.6%	1.00	-31.5%

Dairy Case Study Farm 1 - Spring calving, grazed grass focused farm

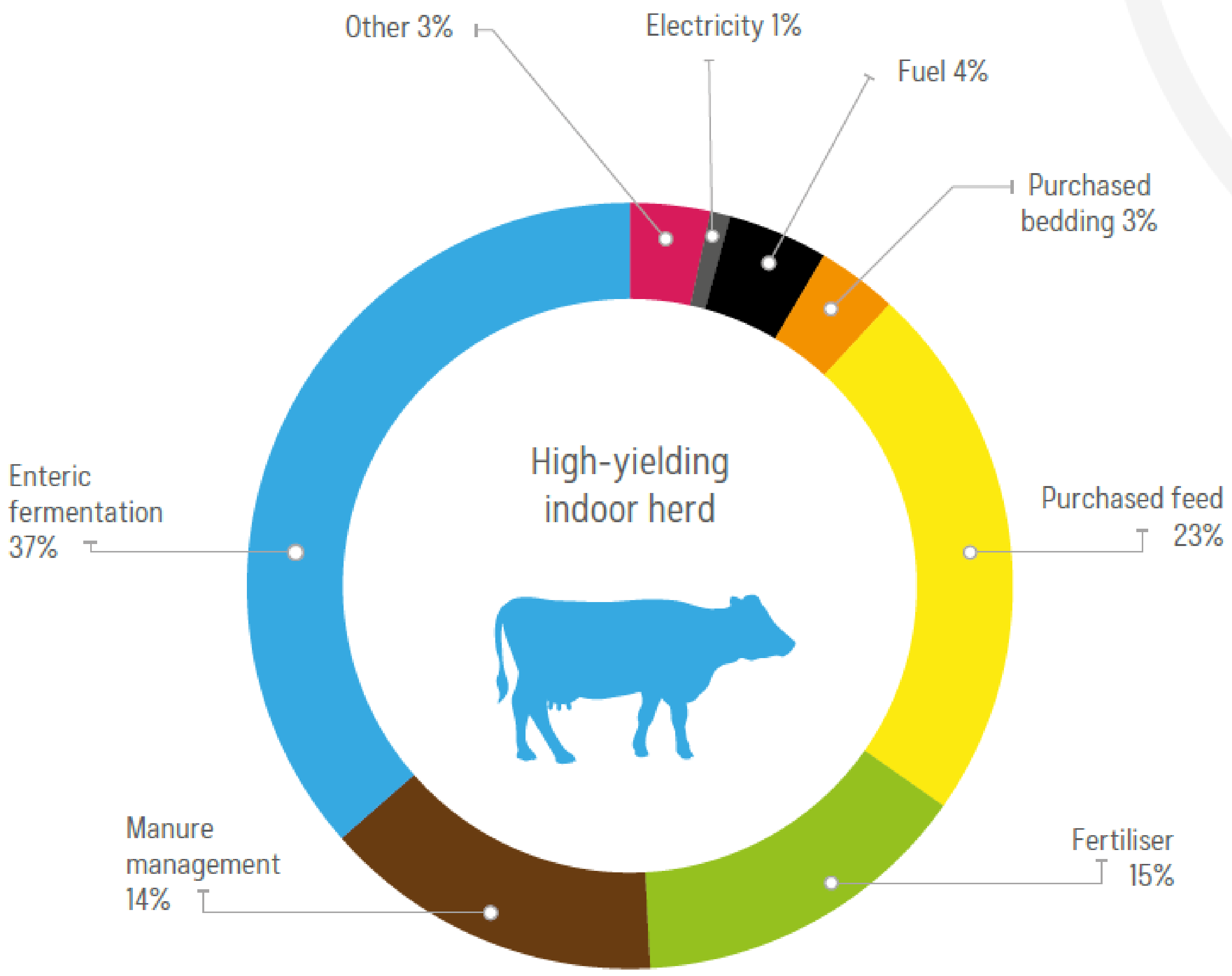




Dairy Case Study Farm 2 - Higher-yielding indoor dairy herd

- 410 Holstein cows
- 252 ha platform
- 10,377 litres/cow,
  3.49 %BF & 3.24 %P
- 25 month age at 1st calving

- **Total emissions**
  - **4851 t CO2-eq**
  - **1.18 kg CO2-eq/kg milk**



Dairy Case Study Farm 2 - Higher-yielding indoor dairy herd

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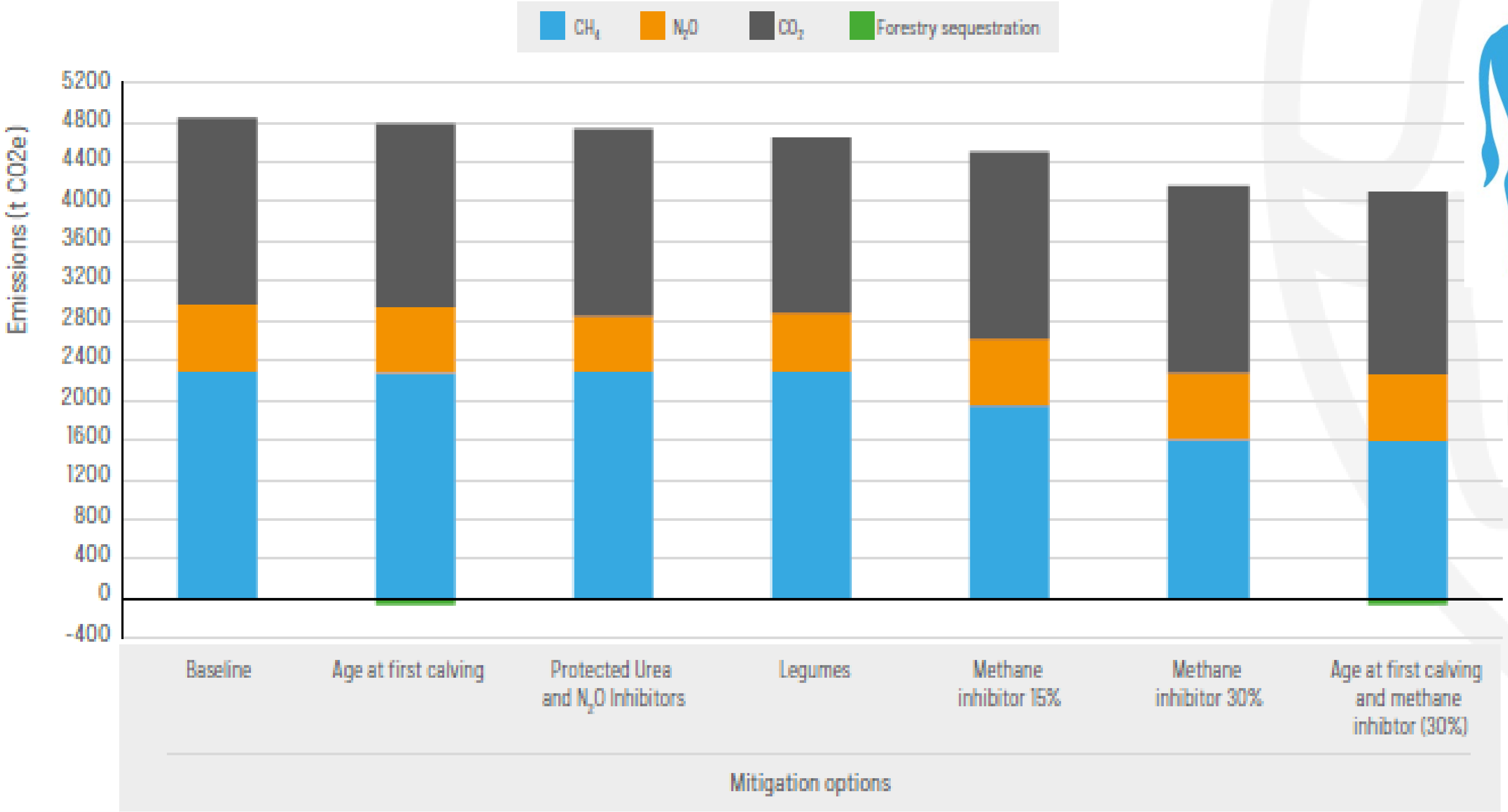
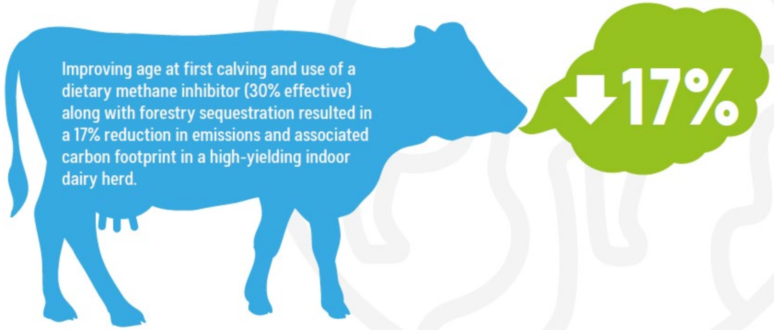
Mitigation options– higher-yielding, indoor herd	Total emissions (t CO_2-eq) and % change from baseline		Carbon footprint (kg CO_2-eq/kg milk) and % change from baseline	
Baseline	**4851**		**1.18**	
1. Reducing age at first calving from 25 to 24 months	4784	-1.4%	1.17	-0.8%
If released land used for forestry	4721	-2.7%	1.12	-5.1%
2. Application of fertiliser amendments protected urea and N_2O inhibitors	4733	-2.4%	1.15	-2.5%
3. Inclusion of legumes in grassland	4659	-4.0%	1.14	-3.4%
4. Employing methane inhibitor:				
at 15% effectiveness	4508	-7.1%	1.10	-6.8%
at 30% effectiveness	4164	-14.2%	1.01	-14.4%
5. Combined effect:				
Reducing age cows first calf plus dietary methane inhibitor (30% effective)	4103	-15.4%	1.00	-15.3%
If released land used for forestry	4040	-16.7%	0.98	-16.9%

Dairy Case Study Farm 2 - Higher-yielding indoor dairy herd





Application of mitigations to National Inventory

- Scaled down National Inventory model (200 cow herd) explored impact of improved productivity

- Land released, and utilised for forestry, delivered 15% reduction in net GHG emissions

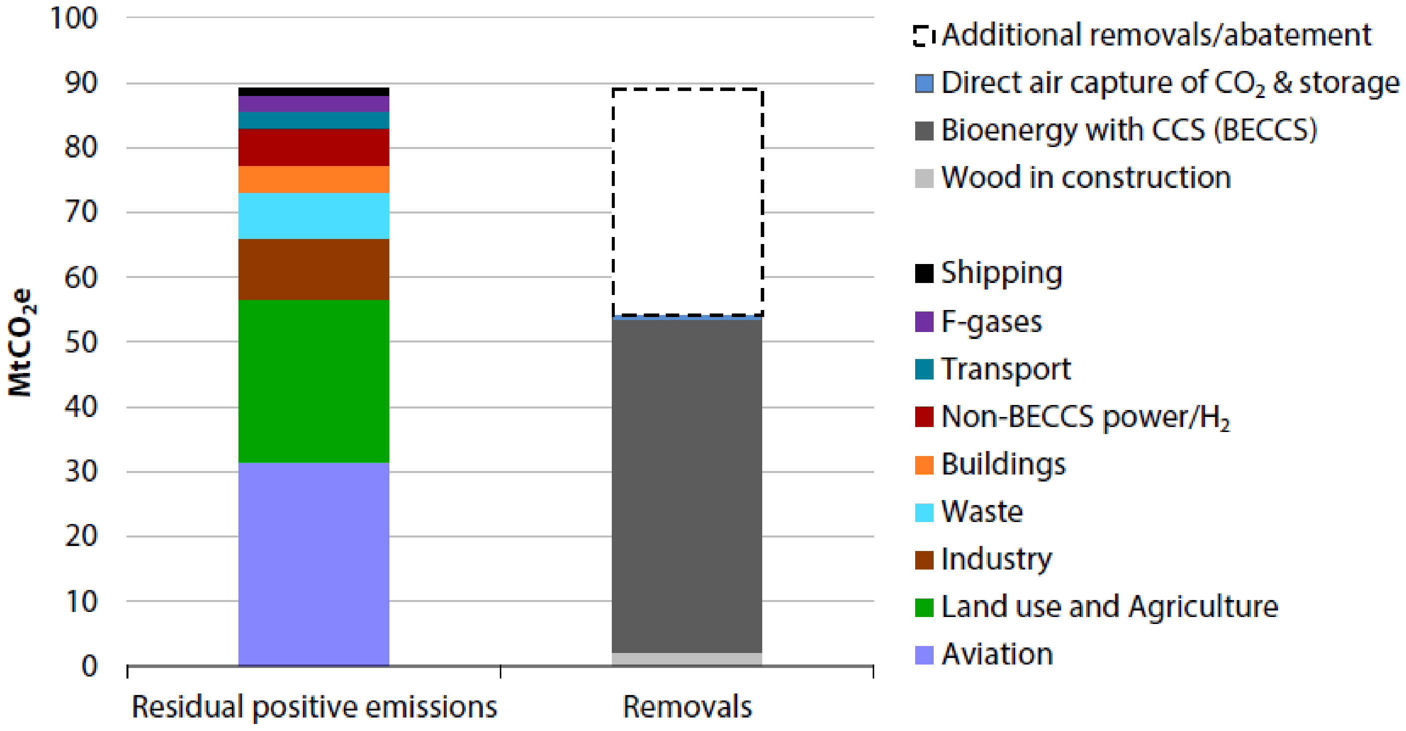
Table 5 Impact of key mitigations on GHG emissions from the whole UK dairy sector and on the overall Agricultural Inventory.

	Impact on		
	GHG reduction for UK dairy sector		GHG reduction for whole of UK agriculture
Mitigation options	**kt CO_2-eq**	**%**	**%**
Methane inhibitor used in all dairy animals	2268	20.3	5.6
Methane inhibitor used only in cows	1764	15.8	4.4
Increased productivity	1006	8.7	2.5
Reduce age at first calving from 29 to 24 months	467	4.0	1.2
Use of nitrification inhibitor with dairy slurry application	178	1.6	0.4
Dairy slurry processed by AD	1343	12.0	3.3
Use of nitrification inhibitor with all N fertiliser applied to all UK grassland	246	9.7	0.6
Combined effect of mitigations 1,3,4,5,6	5030	45.0	12.5

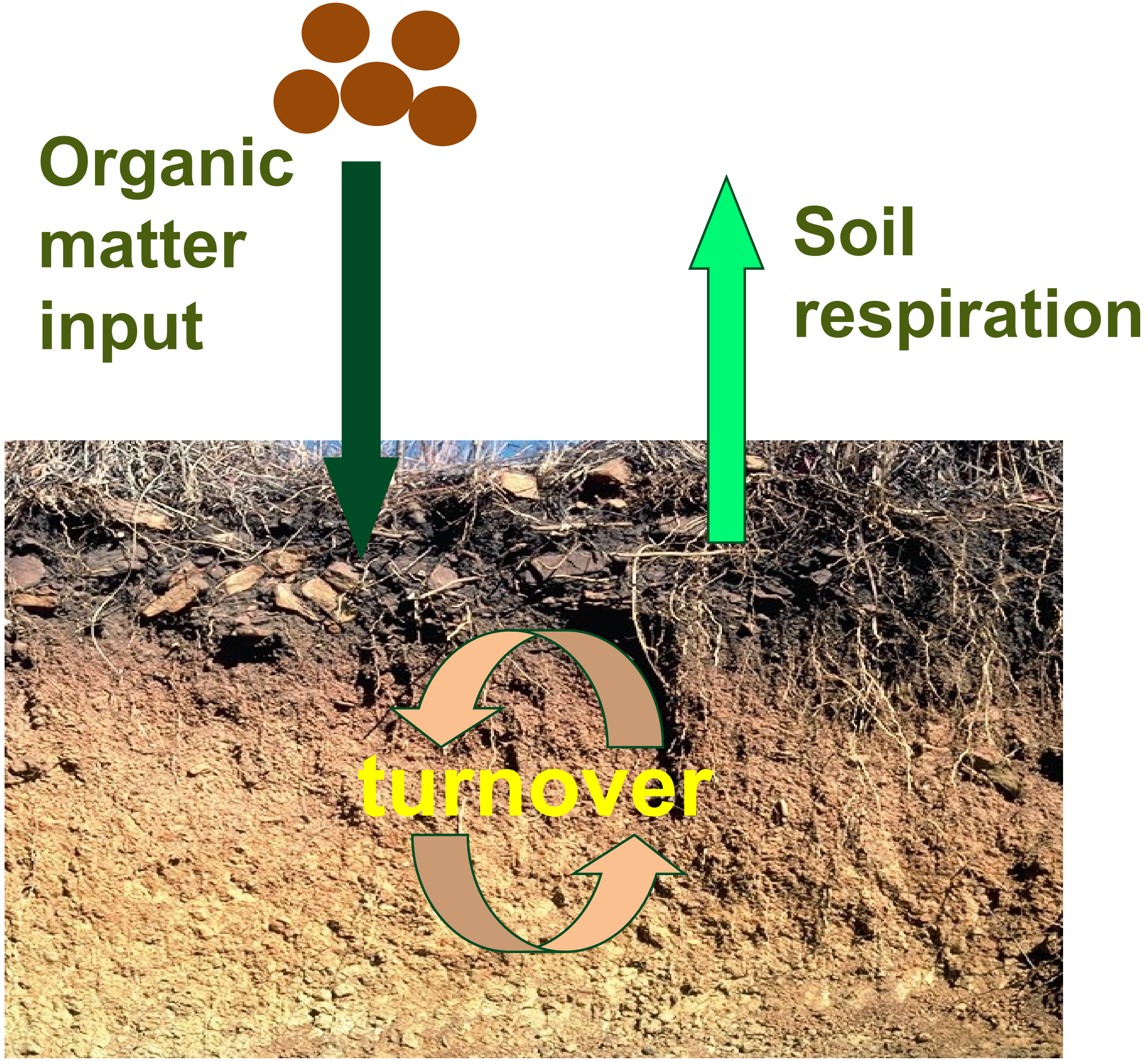
Carbon sequestration

Balancing emissions & removals by 2050

- Mitigation is not enough
- Carbon removals needed for residual emissions to reach net zero targets



What is carbon sequestration?



At equilibrium
Input = Output

Carbon sequestration - opportunities & challenges

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Opportunities

- Low cost GHG mitigation
- Co-benefits in terms of soil fertility, resilience & crop production
- Widespread opportunity

Challenges

- Reversibility of carbon storage & carbon saturation
- Non-CO_2 emissions
- Measurement Reporting and Verification

Still large uncertainties!

Interaction of climate & management

Specific management interventions

- Hedgerows
- Agroforestry
- Biochar
- Rock weathering

Accounting & verification

Conclusions

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- A need for action on reduction of GHG emissions to achieve net zero
- An understanding of what is on farm at the moment is very important
- Carbon footprinting can do this but methods must be robust
- Mitigation measures are need and extremely important
- Not one solution but a range of different approaches combined
- Soil carbon removal can contribute to the solution – the science still has large uncertainties

Thank you
Any Questions?

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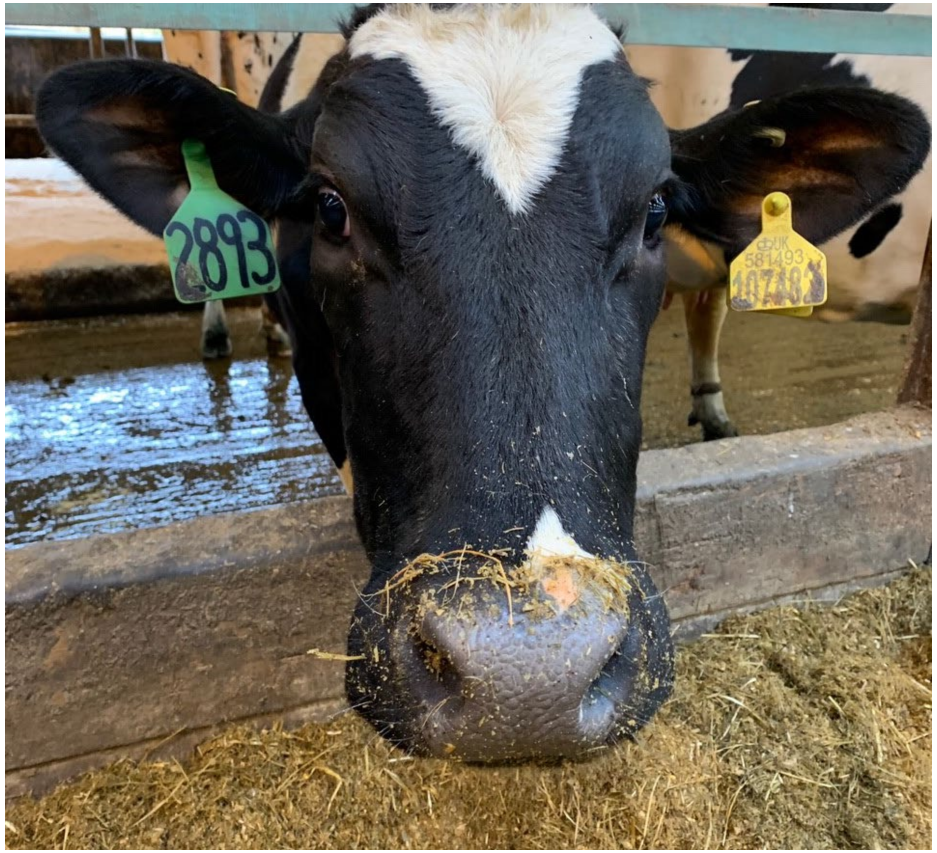

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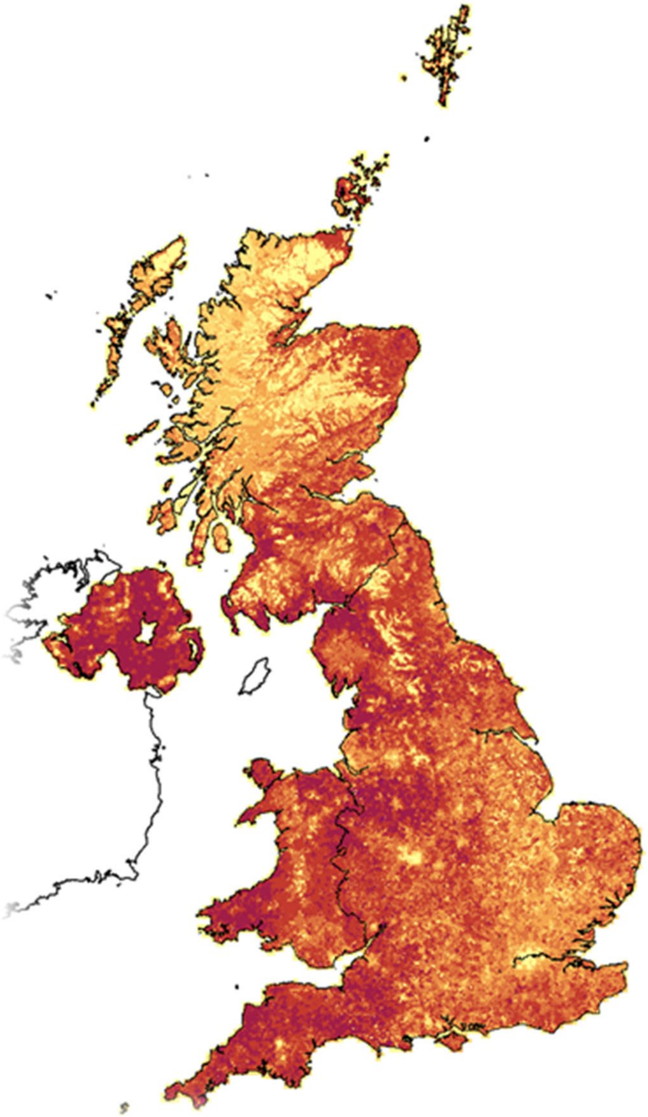
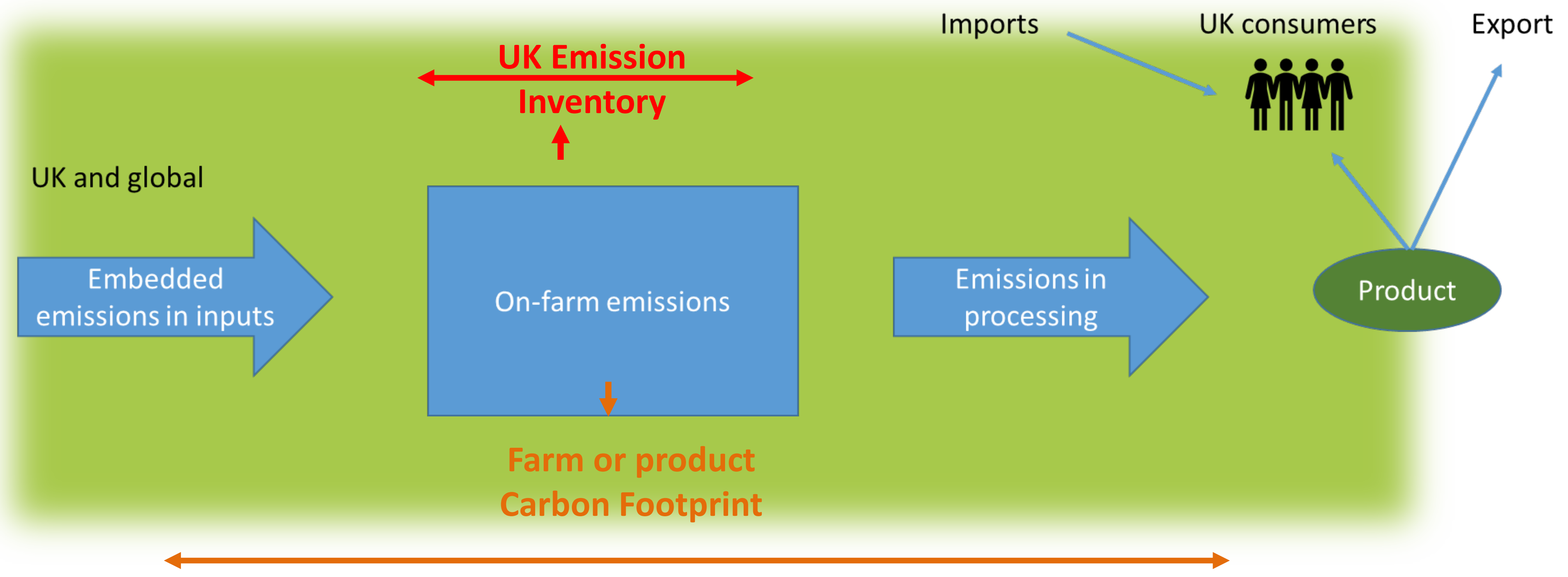
UK GHG Emission Inventory

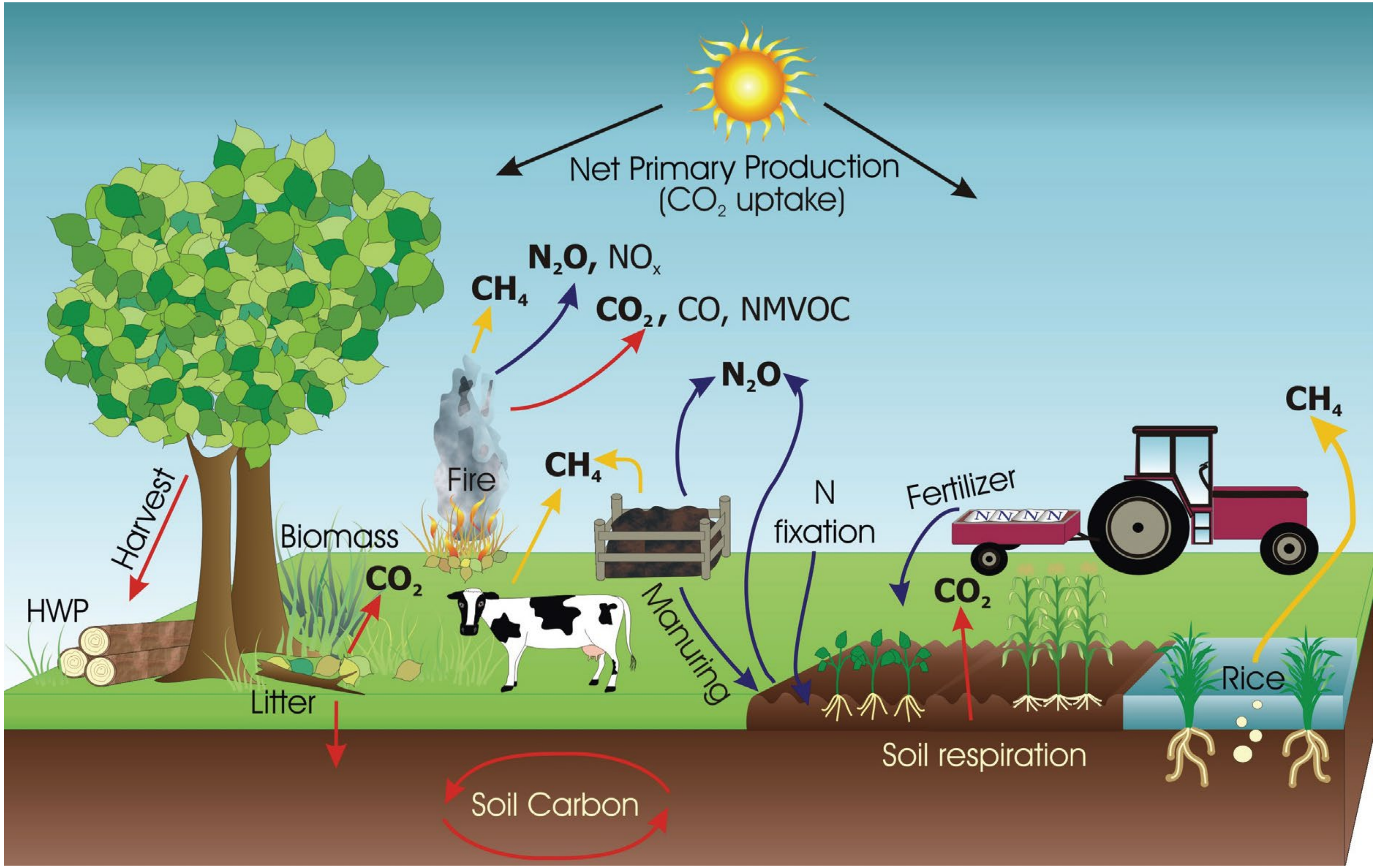


- For national level reporting under UNFCCC according to IPCC protocols
- Is the metric against which UK compliance with emission reduction targets will be assessed
- Comprises 5 reporting categories:
    - Energy
    - Industrial Processes
    - Agriculture
    - LULUCF
    - Waste

System boundaries very important



Agricultural emissions



IPCC 2006

How can we achieve carbon sequestration?

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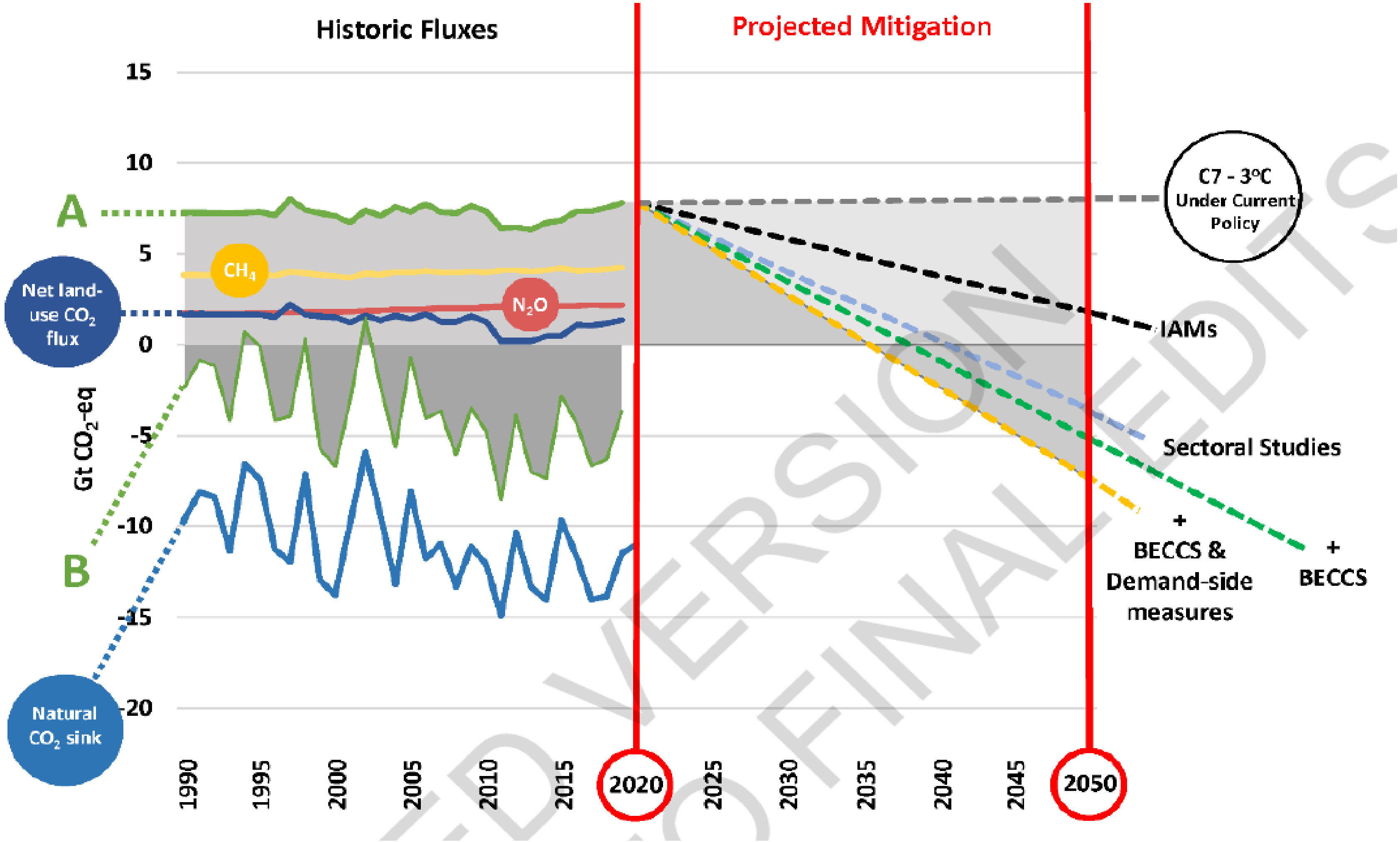
Land use, land use change, forestry and management type	Change in soil C stock
Grassland to plantation forest	-10%
Native forest to plantation forest	-13%
Native forest to cropland	-42%
Grassland to cropland	-59%
Native forest to grassland	+8%
Cropland to grassland	+19%
Fallow to grassland	+150 to 236%
Cropland to plantation	+18%
Cropland to forestry	+50%
Multi-species pasture rotations	+66%
Cover cropping	+6%
Liming	+30%

Effects of land use change (LUC) on soil carbon that are captured in current reporting approaches

IPCCs projections for the agriculture and land use sector



IPCC Working group III, 2022