New York dairy greenhouse gas mitigation: progress made and future potential

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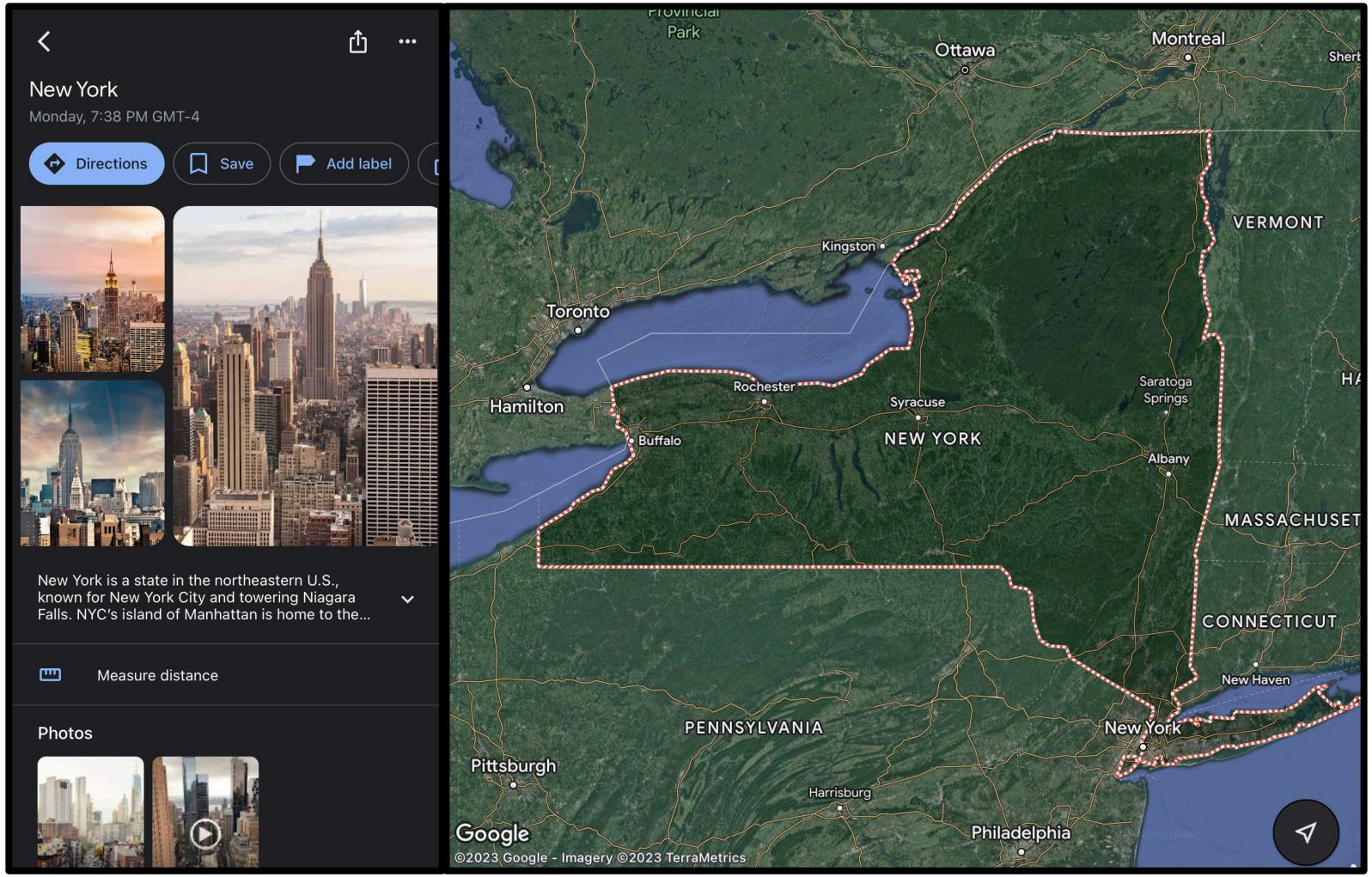
Introduction: New York agriculture



2.8 million hectares of agricultural land

Integrated crop-livestock system

Introduction: New York dairy

New York dairy industry in 2022

- 5th for milk production in the US
- 3 600 dairy farms
- 630 000 milk cows (6.7% of US total)
- 7.3 million Mg milk (7.1% of US total)
- > $3.5 billion

Comparison to 1997

↓ **70%**

↓ **10%**

↑ **>50%**

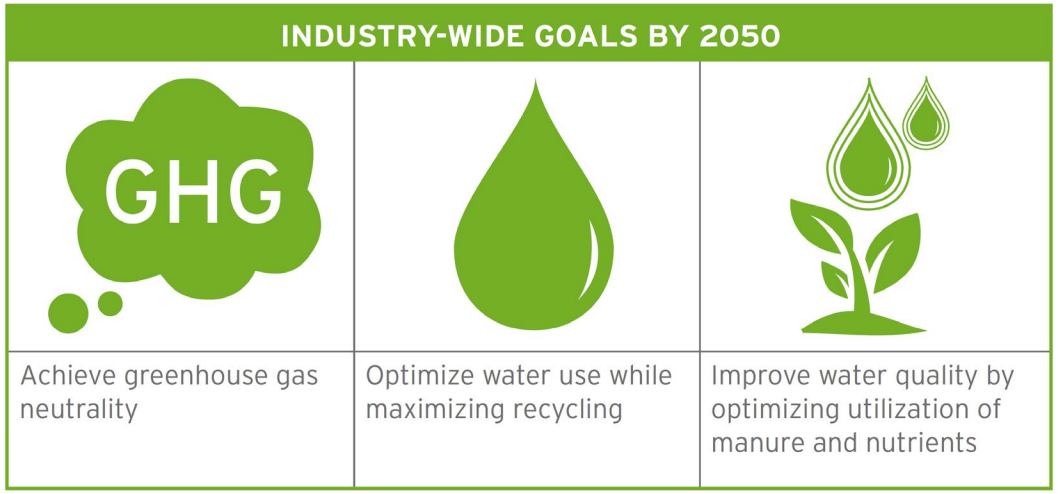
Consolidation of smaller, less productive farms to **improve efficiency**:

- More milk from fewer cows and resources
- **But** concern over the environmental impact

Source: USDA National Agricultural Statistics Service

Introduction

U.S. Dairy STEWARDSHIP COMMITMENT
Innovation Center for U.S. Dairy



Expected 20% ↑ milk demand in New York

No New York or US studies on greenhouse gas emissions of large, commercial dairy farms using **actual farm data**

?

How do farms currently perform?

What progress have they already made?

How achievable are these goals?

How can farms make progress towards them?

Source: US Dairy

Objectives

1. Estimate total farm-gate greenhouse gas emission intensity (GHG_{ei})
2. Quantification of progress made in reducing GHG_{ei}
3. Identification of potential opportunities for further mitigation

Materials and methods

Total milk production = 870 000 Mg

12% of total NY milk production in 2022

- 36 large (> 300 mature cows) **commercial** dairy farms
- Located in **all regions** of New York selling to four different co-ops
- Predominantly **Holstein** cows in all herds
- Average herd size = **2 100 milk cows** (range = 345 – 6 350)
- Average animal density = **3.16 AU ha^{-1}** (range = 1.76 – 4.85)

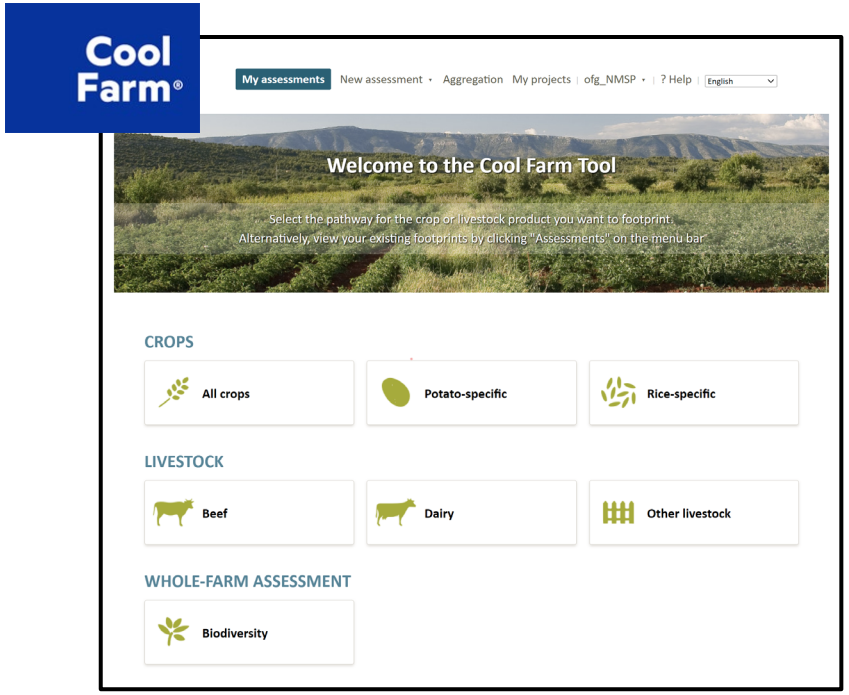
1 animal unit = 455kg live animal weight

- Average annual milk yield = **12 700 kg FPCM cow^{-1}** (range = 11 400 – 13 900)
- Average homegrown feed = **64%** of total feed DM (range = 49-84%)
- Average crude protein content of feed = **15.6%** (range = 12.8 – 17.2)
- Average phosphorus content of feed = **0.36%** (range = 0.29 – 0.71)
- Average herd feed consumption intensity = **0.67 kg DM kg FPCM^{-1}** (range = 0.55 – 0.80)

Materials and methods

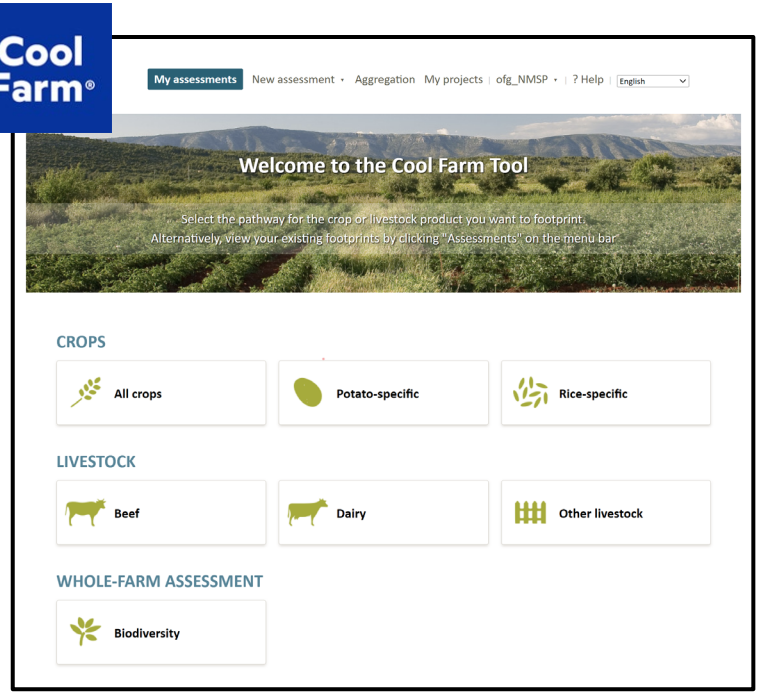
- Predominant manure systems:
  - Open liquid storage = **25 farms, 51%** of milk
  - Anaerobic digesters = **8 farms, 41%** of milk
  - Solid liquid separation (SLS) with cover and flare = **3 farms, 8%** of milk produced
- Crop rotation
  - Typically **4 – 5 year maize and lucerne/grass** rotation
  - Double cropping of rye or triticale: **7 farms**
  - Cover cropping: **32 farms, 47%** of corn acres (range = 0 – 100%)
  - Acres in continuous reduced till = **21 farms, 52%** of total acres

Materials and methods



Materials and methods

- Whole-farm assessment
- Comprehensive results from relatively easy to obtain data
- IPCC 2019 methodology, AR6 100-year GWPs
- Crop, animal and whole-farm emissions by GHG and source:
  - Feed production: fertilizer, soils, tillage, cover crops
  - Grazing management
  - Enteric emissions
  - Manure management
  - Fuel, energy use and transport
- Ability to track progress made
- Can identify potential for further improvement



Allows assessment of integrated crop-livestock systems

Continuous development

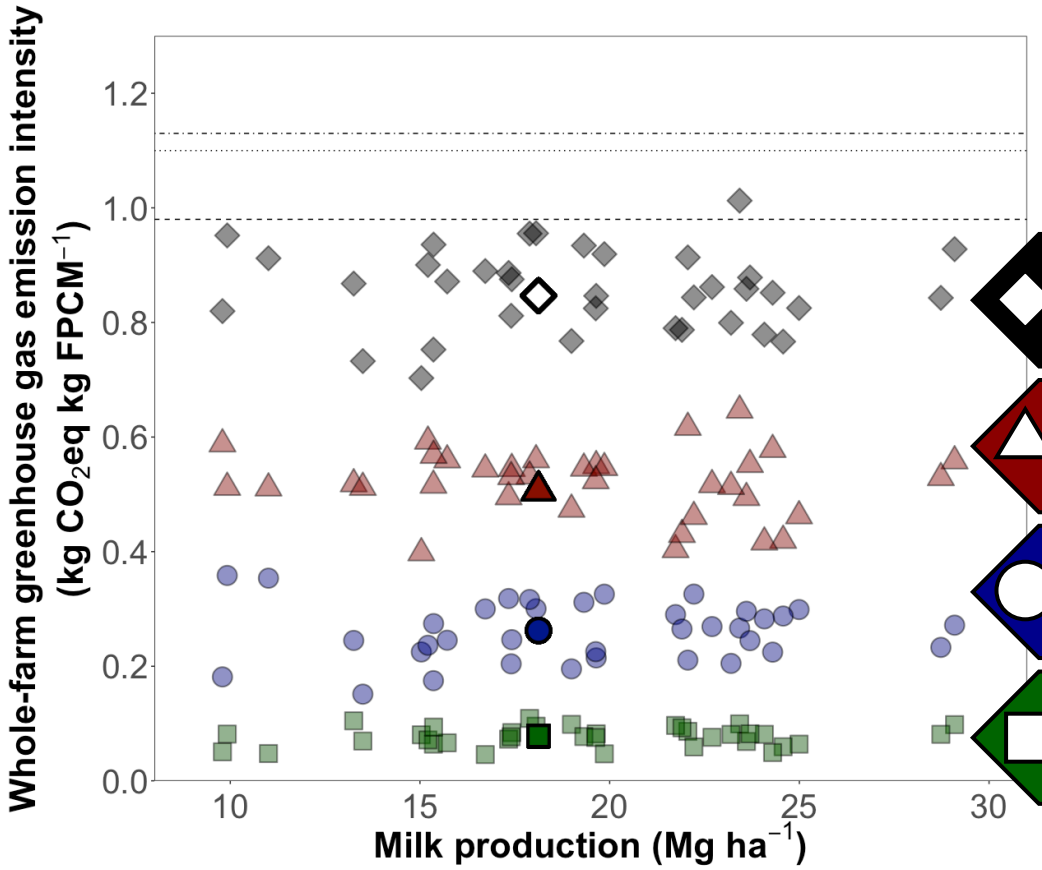
Materials and methods

BMP	Current uptake (2022)		Potential uptake
Homegrown feed	36 / 36 farms	63% of feed	-
Cover cropping	31 / 36 farms	46 % of cropland	100% of cropland
Reduced till	20 / 36 farms	37% of cropland	100% of cropland
No till	3 / 36 farms	9% of cropland	100% of cropland
SLS + cover and flare	3 / 36 farms	8% of FPCM	19 farms, 29% of FPCM
Anaerobic digester	6 / 36 farms	41% of FPCM	-
Anaerobic digester with RNG technology*	0 / 36 farms	0% of FPCM	Upgrade existing system: 8 farms 41% of FPCM Install new system: 6 farms 22% of FPCM
Feed additive			
Monensin	36 / 36 farms	100% of FPCM	*Cannot be modelled in Cool Farm Tool*
Agolin	*Confidential*	*Confidential*	*Cannot be modelled in Cool Farm Tool*
3-NOP / Bovaer	0 / 36 farms	0% of FPCM	36 farms 100% of FPCM

BMP: beneficial management practice
SLS: solid liquid separator
FPCM: fat and protein corrected milk
RNG: renewable natural gas
**RNG technology requires ≥ 4000 animal units*
1 animal unit = 455kg live animal weight

Results: Current GHG_{ei} breakdown by gas

Greenhouse gas emissions by gas



Potential carbon removal estimate (sequestration):
Average = **-0.02** kg CO_2eq kg $FPCM^{-1}$, range = -0.07- 0.00

1.13 kg CO_2eq kg $FPCM^{-1}$ – North American average – FAO, 2022
1.10 kg CO_2eq kg $FPCM^{-1}$ – NY organic – Olivo et al., 2024
0.98 kg CO_2eq kg $FPCM^{-1}$ – Northeast USA – Rotz et al., 2021

Total emissions:
Average = **0.86** kg CO_2eq kg $FPCM^{-1}$, range = 0.70 – 1.01

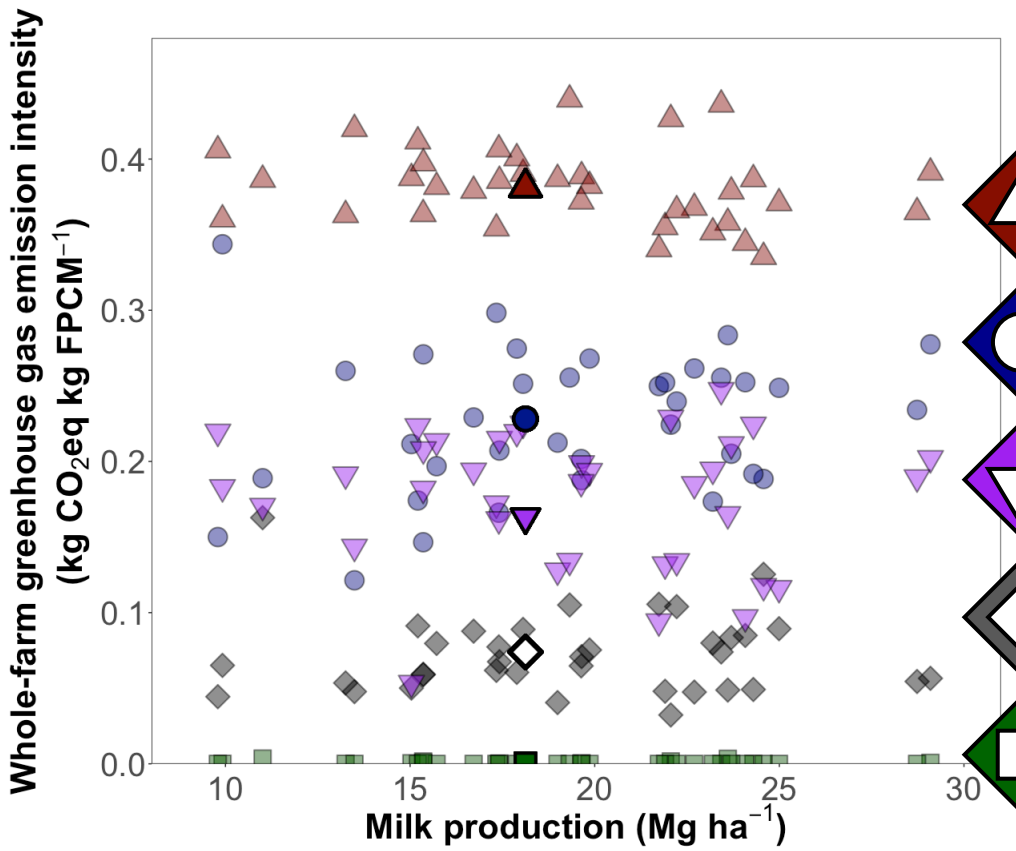
Methane (CH_4) emissions = **61%** of total emissions
Average = **0.52** kg CO_2eq kg $FPCM^{-1}$, range = 0.40 – 0.65

Carbon dioxide (CO_2) emissions = **30%** of total emissions
Average = **0.26** kg CO_2eq kg $FPCM^{-1}$, range = 0.15 – 0.36

Nitrous oxide (N_2O) emissions = **9%** of total emissions
Average = **0.08** kg CO_2eq kg $FPCM^{-1}$, range = 0.05 – 0.11

Results: Current GHG_{ei} breakdown by source

Greenhouse gas emissions by source



Potential carbon removal estimate (sequestration):
Average = **-0.02** kg CO_2eq, range = -0.07- 0.00

Enteric emissions = **45%** of total emissions
Average = **0.38** kg CO_2eq kg $FPCM^{-1}$, range = 0.34 – 0.44

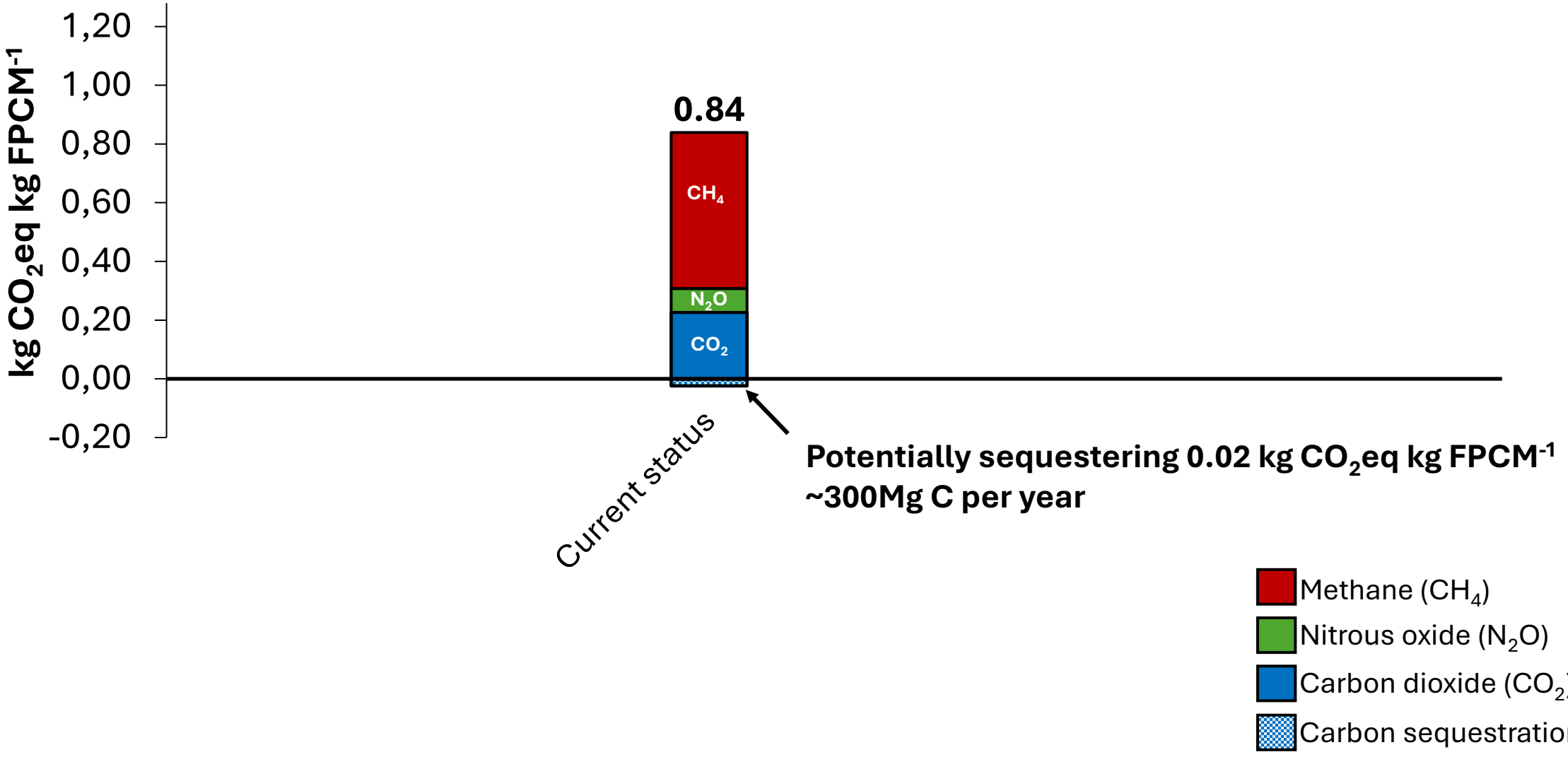
Feed production emissions = **26%** of total emissions
Average = **0.23** kg CO_2eq kg $FPCM^{-1}$, range = 0.08 – 0.42

Manure management emissions = **20%** of total emissions
Average = **0.18** kg CO_2eq kg $FPCM^{-1}$, range = 0.05 – 0.25

Energy, fuel and transport emissions = **8%** of total emissions
Average = **0.07** kg CO_2eq kg $FPCM^{-1}$, range = 0.03 – 0.16

Grazing emissions = **<0.01%** of total emissions
Average = **<0.01** kg CO_2eq kg $FPCM^{-1}$, range = 0.00 – <0.01

Results: progress made and opportunities



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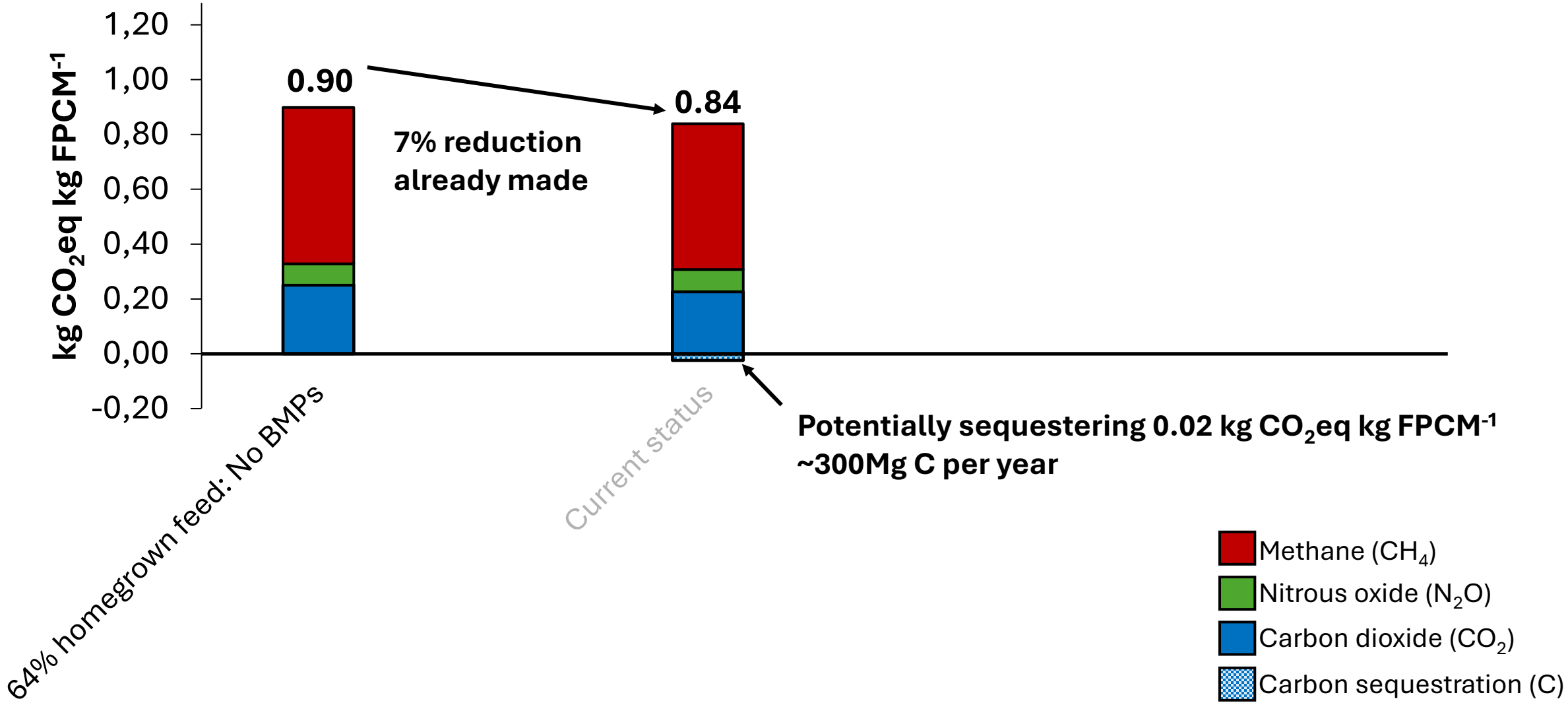

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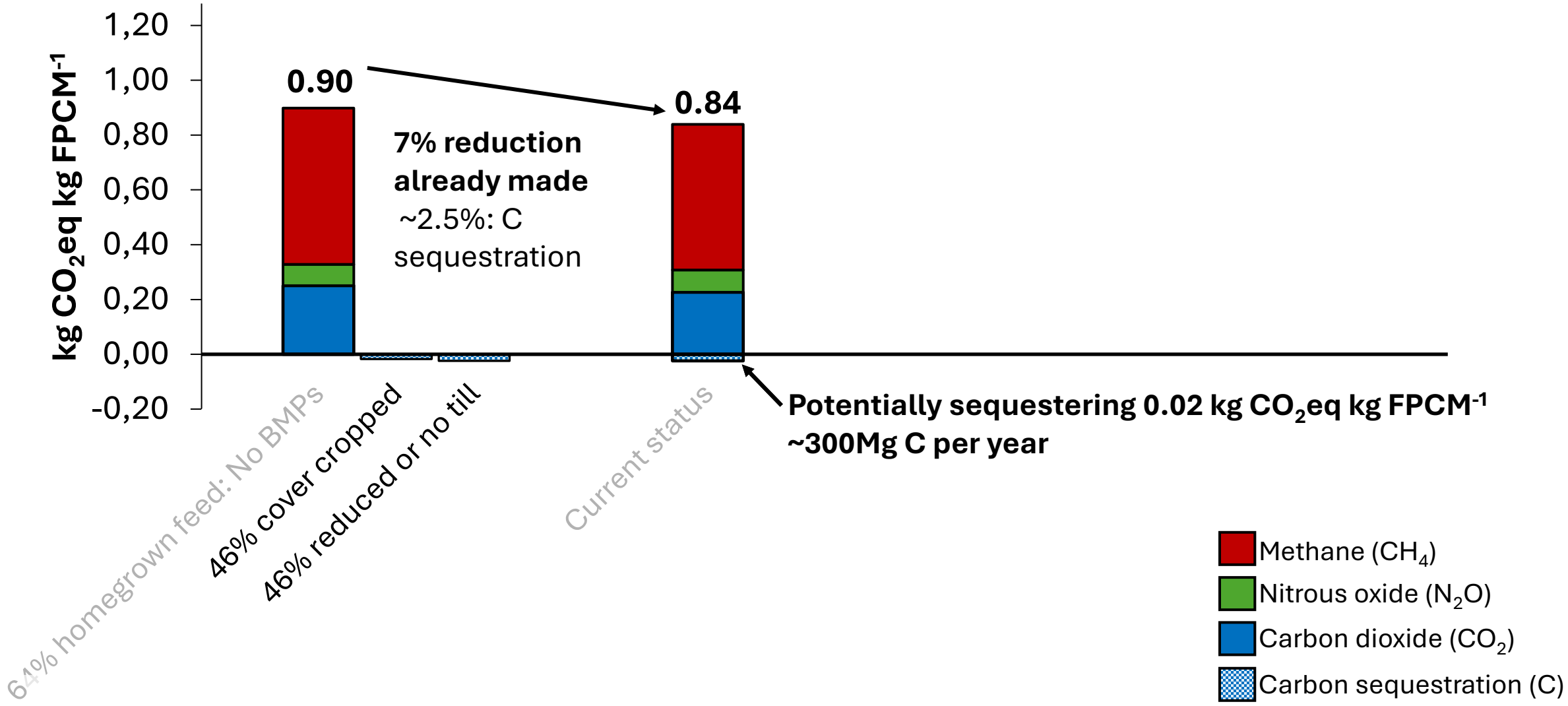

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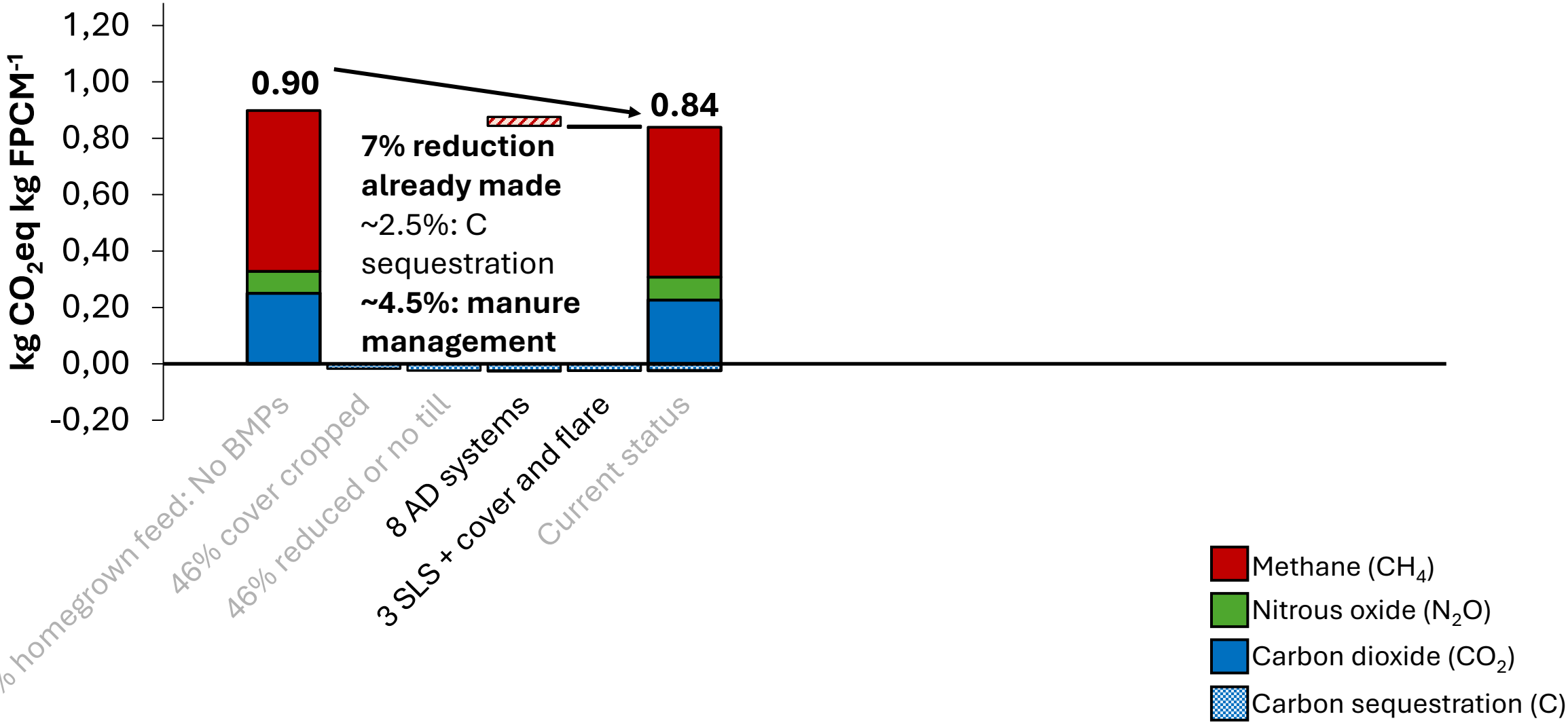

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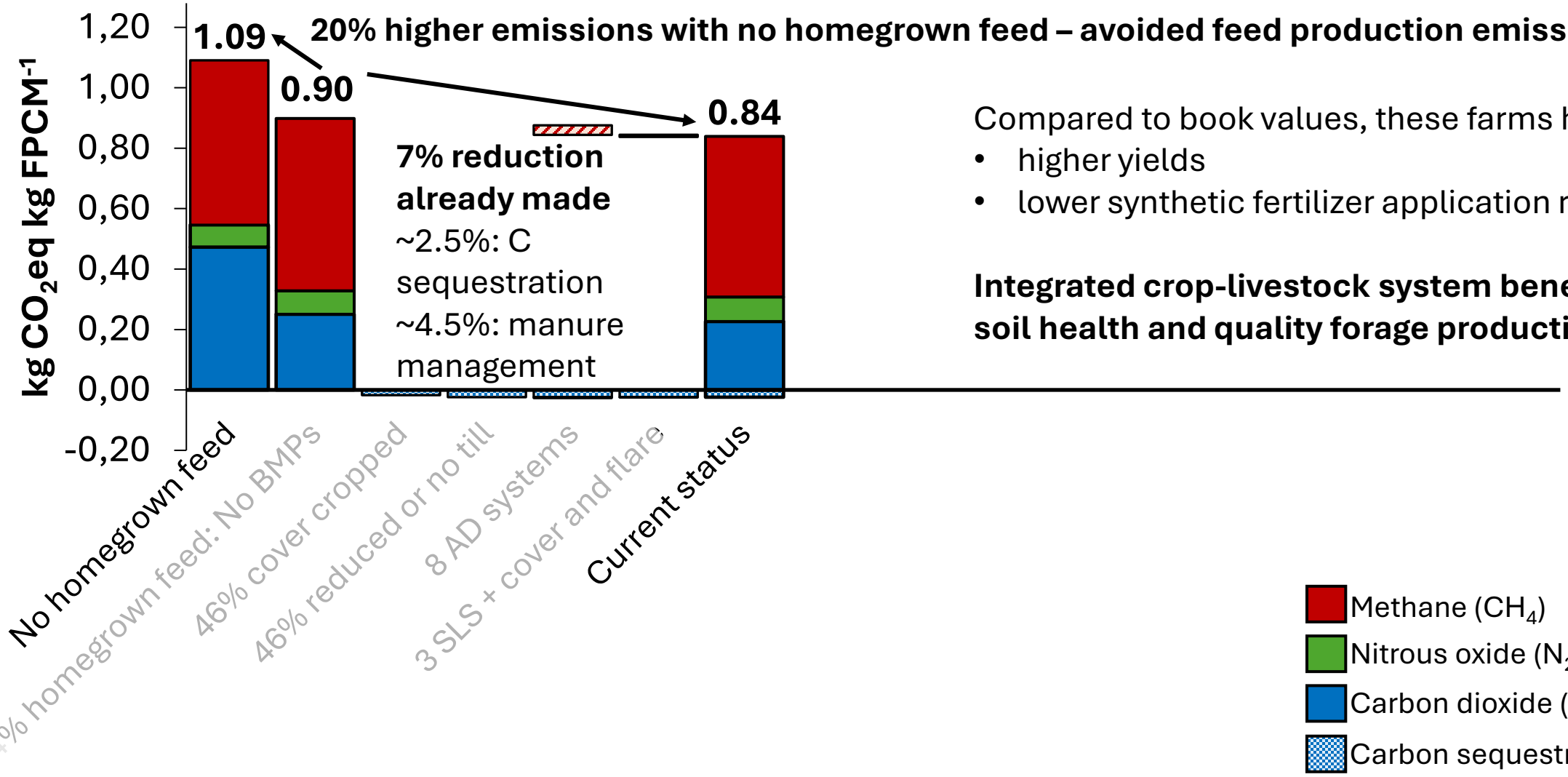
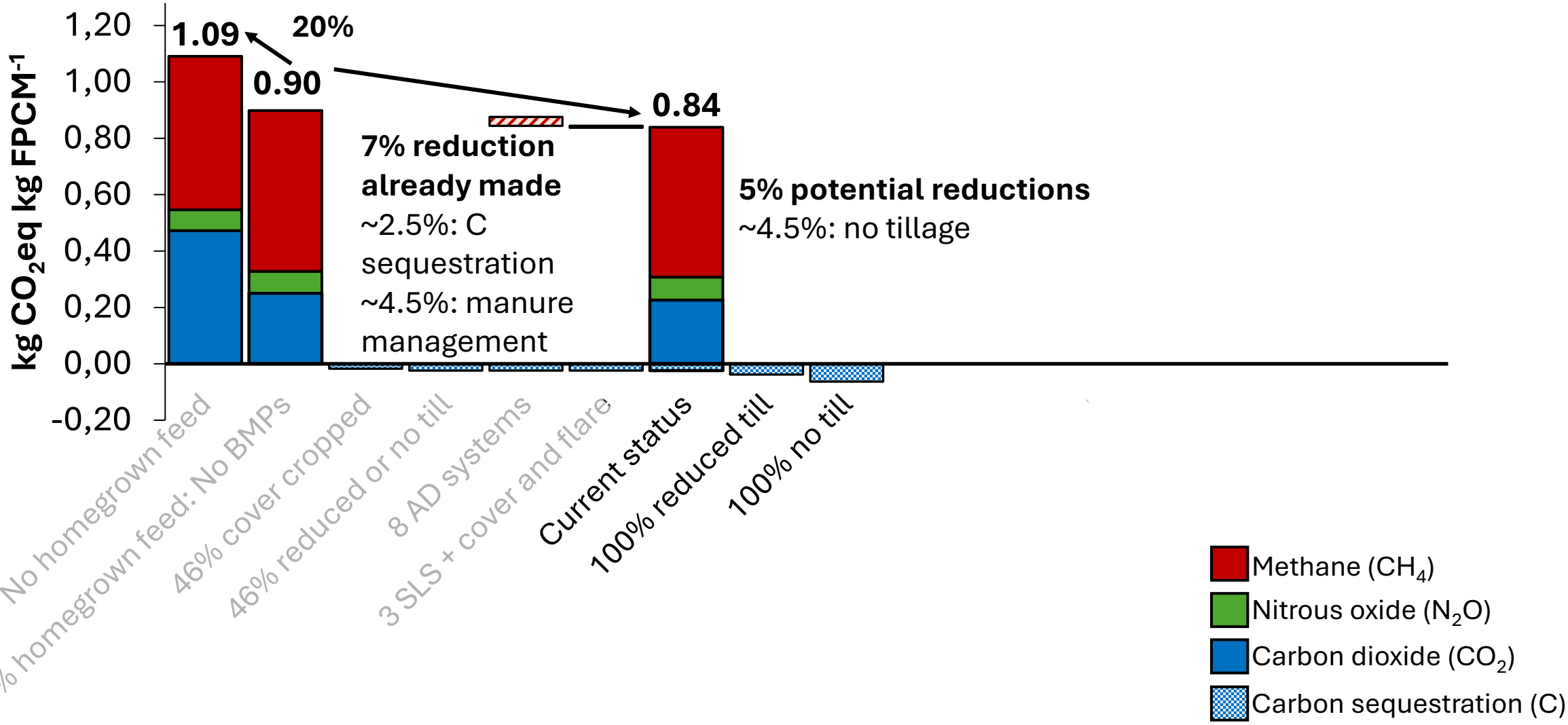


Compared to book values, these farms have:

- higher yields
- lower synthetic fertilizer application rates

Integrated crop-livestock system benefits soil health and quality forage production

Results: progress made and opportunities



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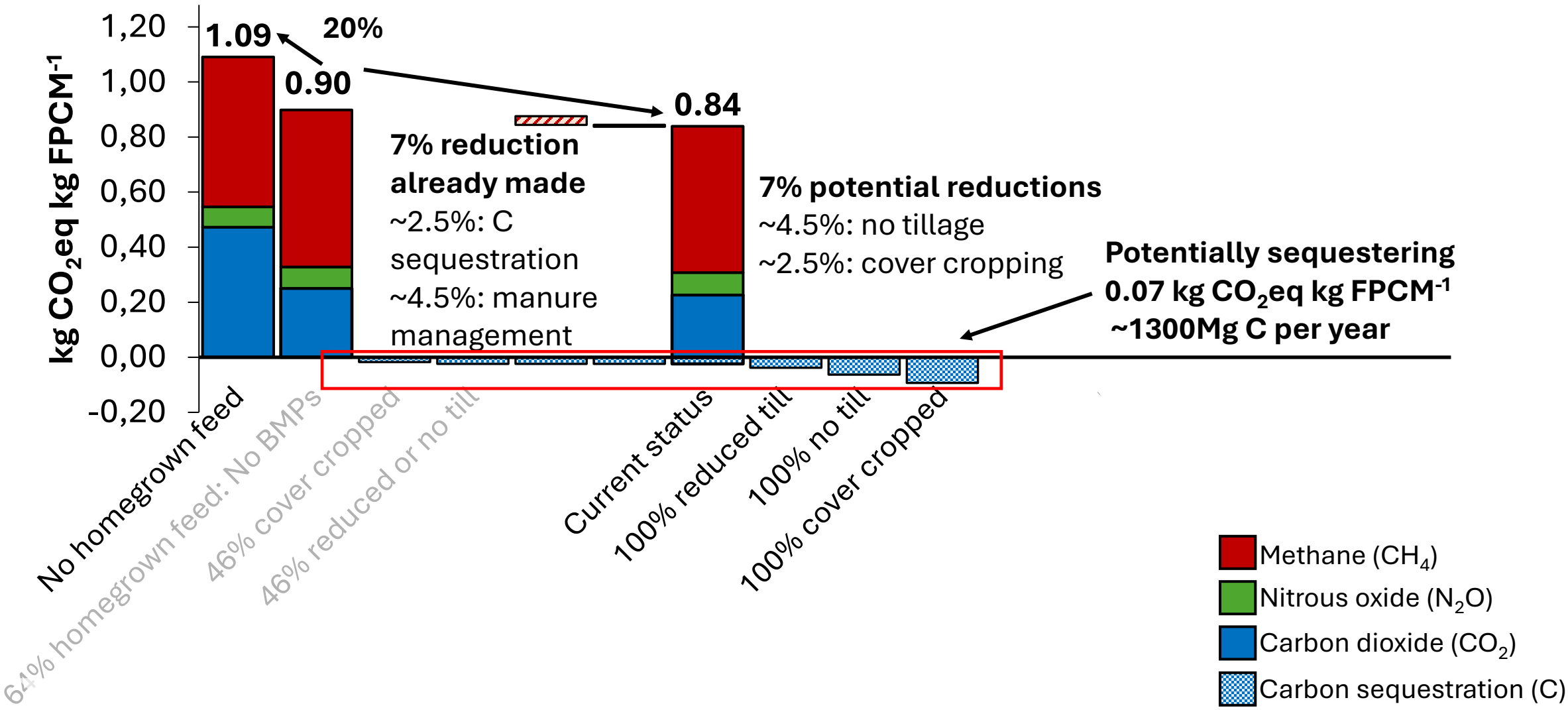

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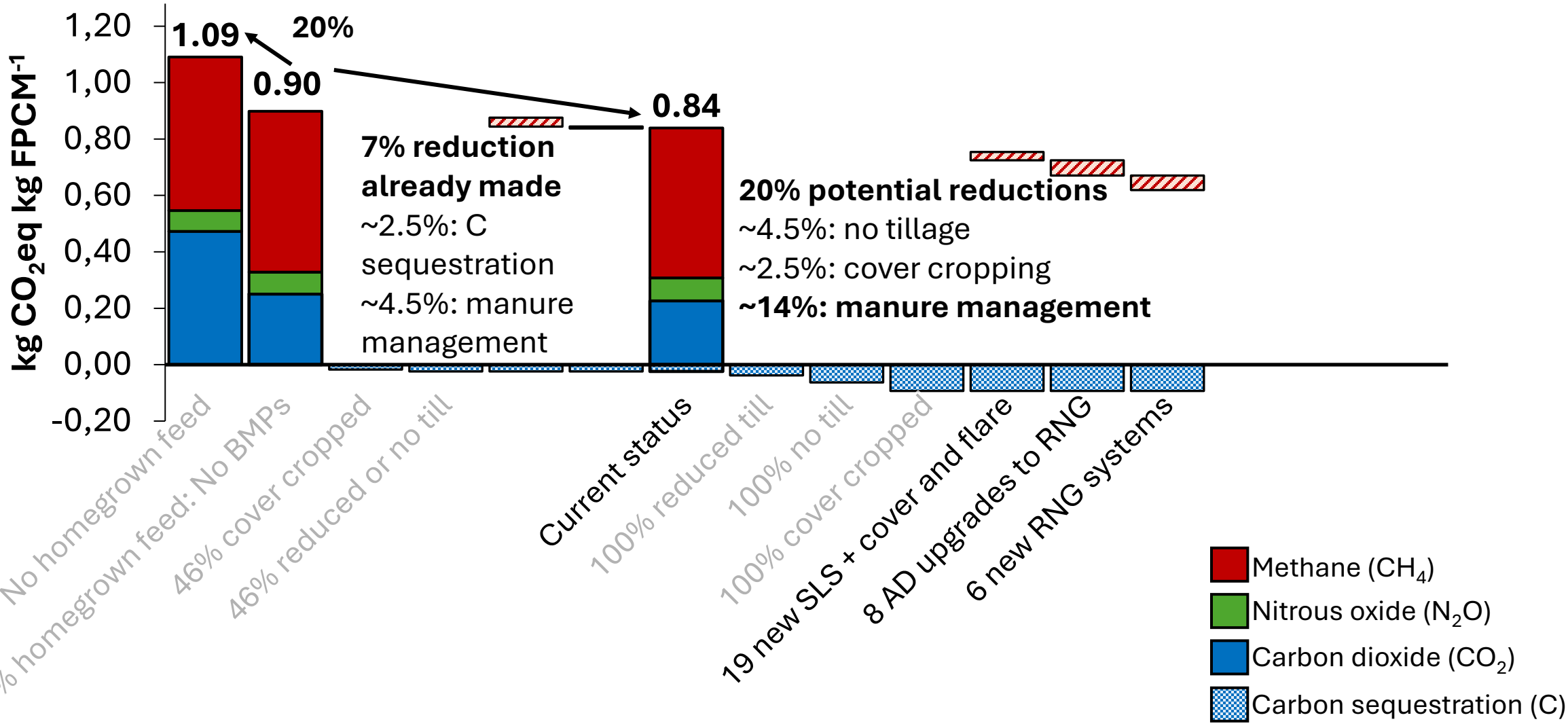

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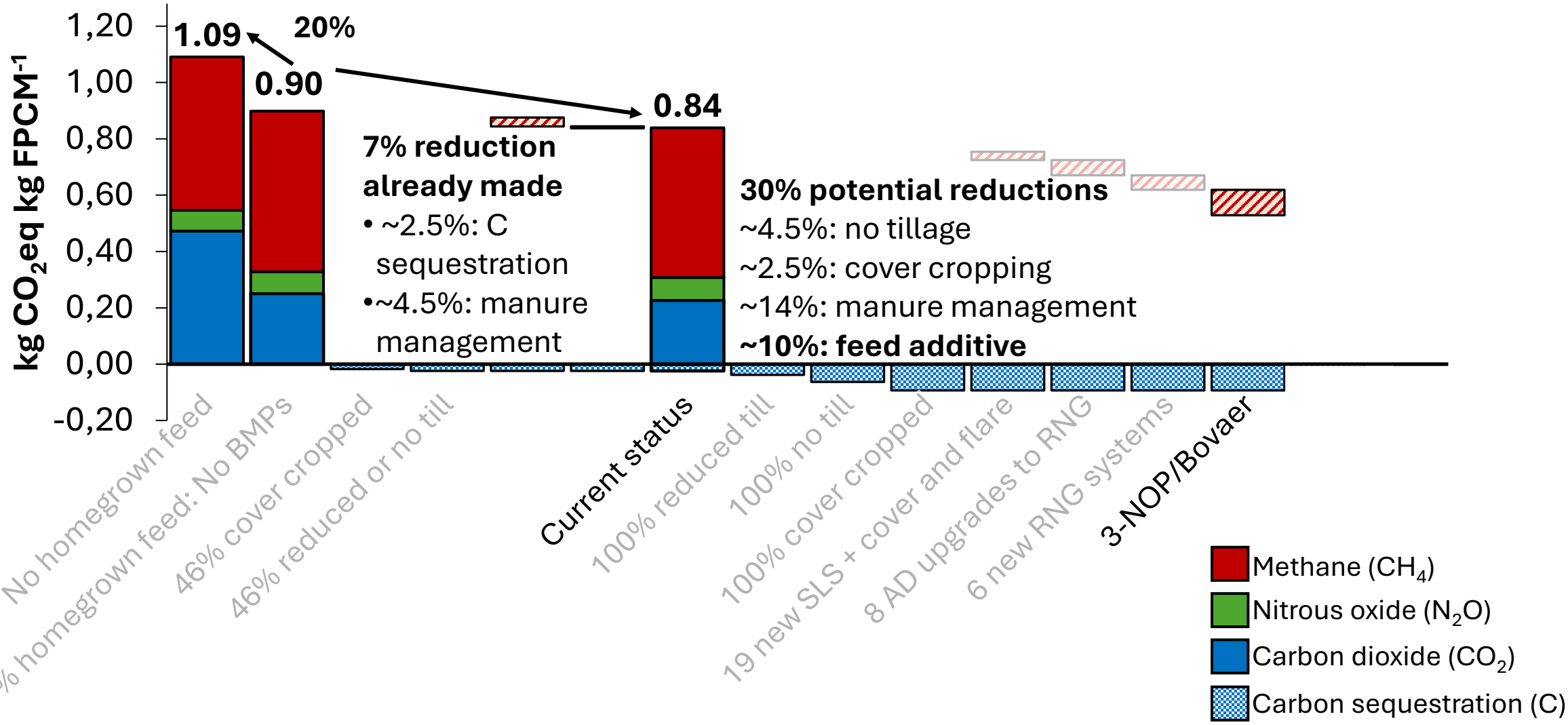

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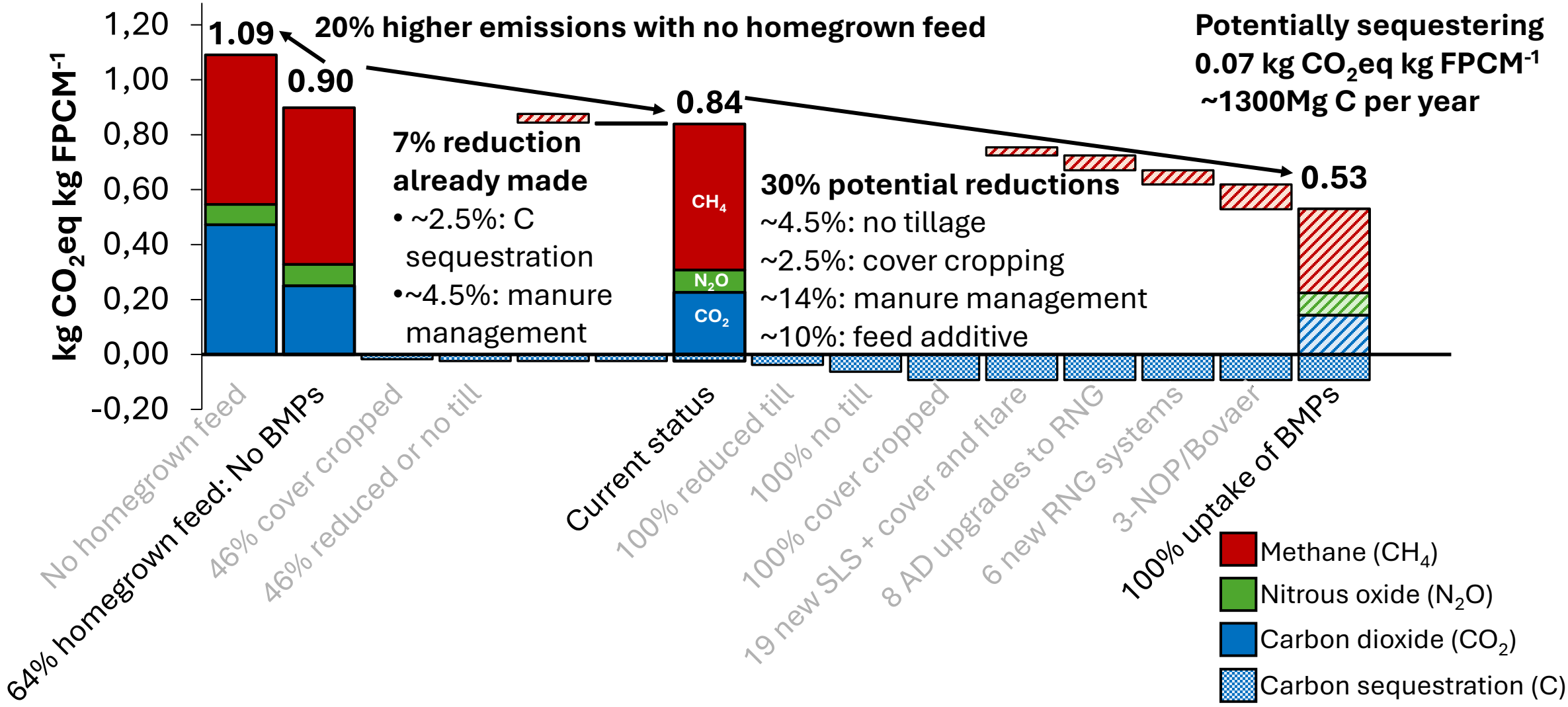

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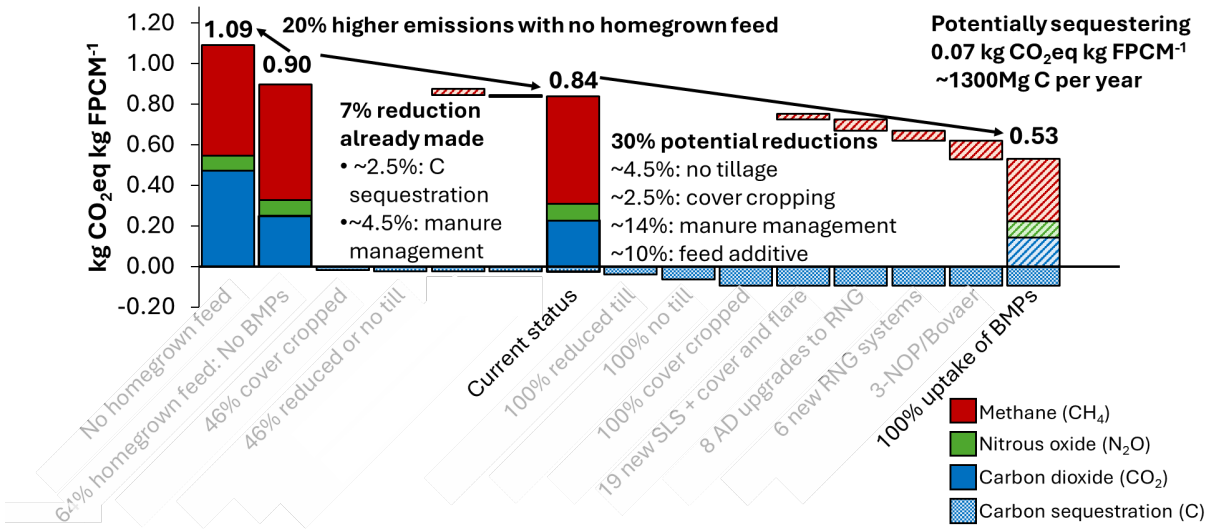

Key messages

- Progress has already been made
  - Learn from these success stories
- Homegrown feed is a key advantage to New York dairy farms
- Future opportunities exist, but not without challenges
  - Economics
  - Labor and infrastructure needs
  - Potential trade-offs
- Will it get us to GHG neutrality?

Biggest opportunity: farmer engagement, participation and assistance

Future work

- Optimum animal density
  - Heifer to cow ratio, herd replacement rates
- Optimum crop rotation to reduce crude protein imports
- Double cropping to increase homegrown feed
- Amino acid balancing of feed
  - Increase milk components, improve nitrogen use efficiency
- Balance of homegrown feed/forage production versus methane emissions
- Improved purchased feed footprints for New York
- Impact of meeting 20% increase in milk demand: consider total emissions too
- How do other dairy farm systems compare in New York?
- What can be achieved in Cool Farm Tool®?
  - Continue to feedback on future development needs
  - Will process based models be required for some evaluations?

Continue to work **directly** with farmers to understand their needs and grow **voluntary** participation

How can we help the farmers to achieve **their** goals, alongside industry goals? **Win-wins**

Thank you!

This work is not possible without the invaluable data and feedback provided by NY dairy farms and the support of their nutrient management planners, nutritionists and advisors.

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