Mitigation of climate gas emissions from Danish Crop production

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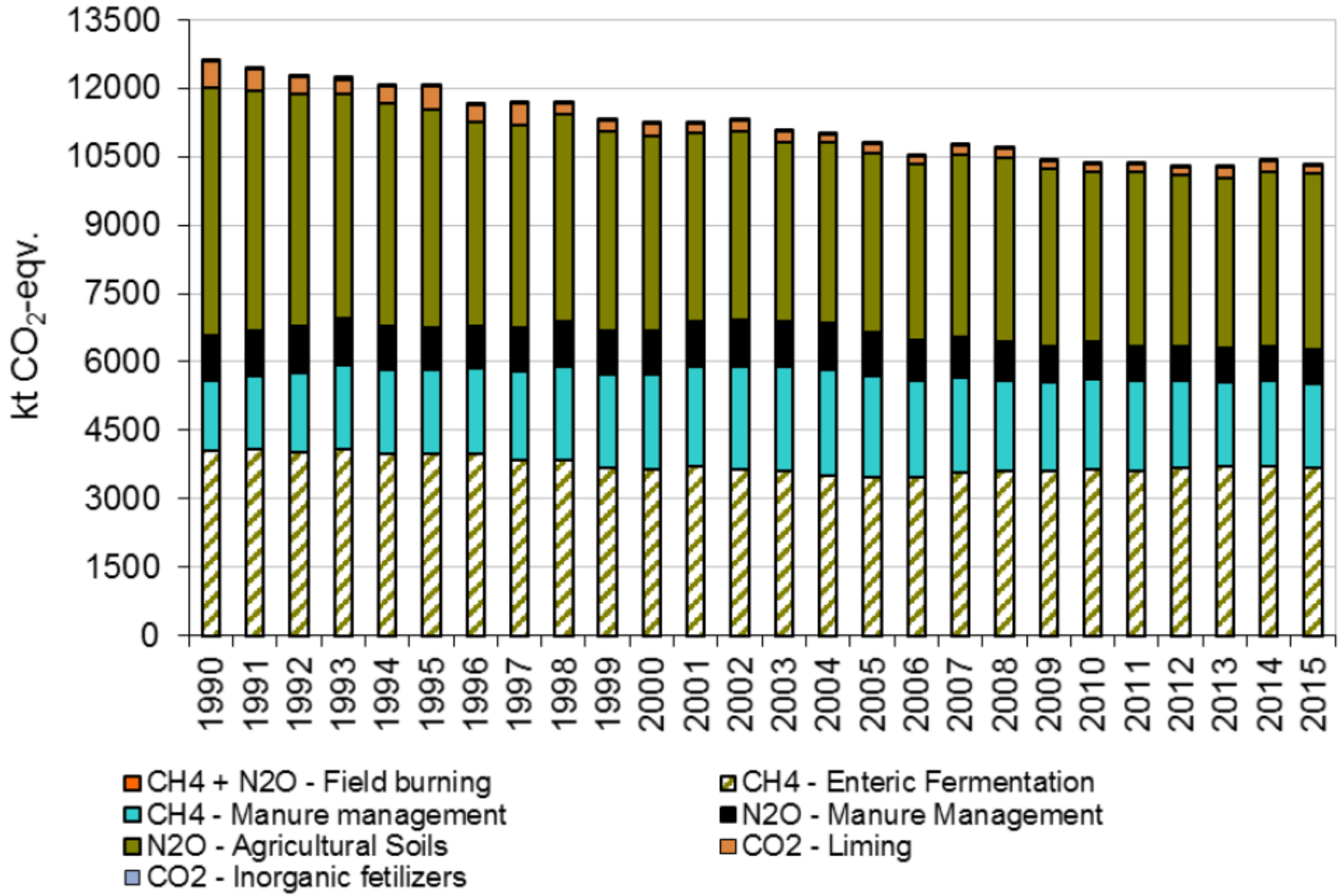
Noget at leve af. Noget at leve for.

Targets for non ETS climate gas emissions in Denmark

- Reduction target expected to be 39% compared to 2005 levels, but this is still being negotiated
- 20 – 26% points of this will be achieved without new policy measures
- 4% points of the reduction can be accomplished by LULUCF credits
- Further need for non ETS reductions are expected to be ~13,4 mio. ton CO_2 eq.

Greenhouse gas emissions from Danish farming



Time	Plan	Significant elements in legislation:
1985	NPO-plan	-regulation of allowed animal unit per ha. - min. storage capacity for animal manure
1987	Water Environm. Plan I	-50 pct reduction in N-leaching from agr. -65 pct ”autumngreen fields” -Slurry in autumn only to wintercov. fields
1992	Action plan for sustainable agriculture	-Slurry only to grass or oilseed rape in autumn -Max. N-standards for crops (N-quata per farm) -Min. utilisation of nitrogen in animal manure -Fertilizer plans and -accounts.
1998	Water Environm. Plan II	-10 pct decrease of N-standards (The N-quota) - 6 percent ”super” green fields in autumn -15 pct higher utilization of N in animal manure
2003	Water Environm. Plan III	-Target for decrease of P surplus -More wetlands - 10/14 pct. covercrops (10 at <80kg manure-N pr ha., 14 at >80 kg manure N pr. ha)
2011-2013	WFD	-More cover crops -Establishment of wetlands
2016	Agricultural package WFD 2. gen plans	- Area specific regulation based on need to obtain ”Good Ecological Quality” - N-standards back to financially optimal levels (gain of ~160$ pr. ha) - Raised N-standards compensated by 140.000 ha of cover crops - Max. 170 kg N pr. ha (previously 140) for pig production

Measures that limit climate footprint from Danish agriculture

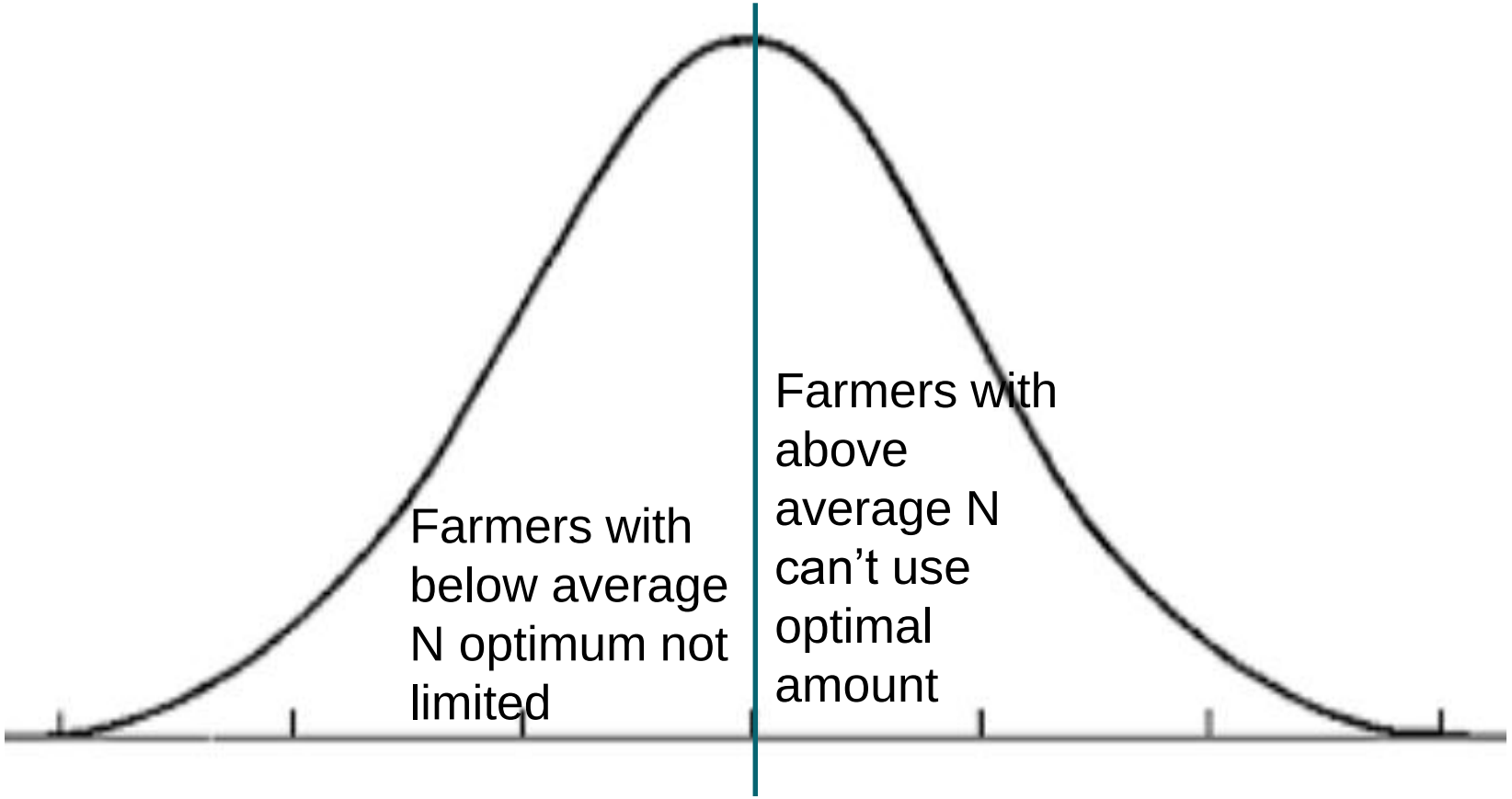
- In agriculture, many measures that limit GHG emissions have been implemented prior to 2005, so many of the low hanging fruits have been picked already
  - High utilisation of animal feed
  - Mandatory crust or lid on slurry tanks
  - Mandatory catch crops on ~14% of arable land
  - Anaerobic digestion of manure
  - Low ammonia emissions
  - Statutory quotas for nitrogen application to each crop, including fixed utilization demands for organic fertilizer
  - These

N quota system

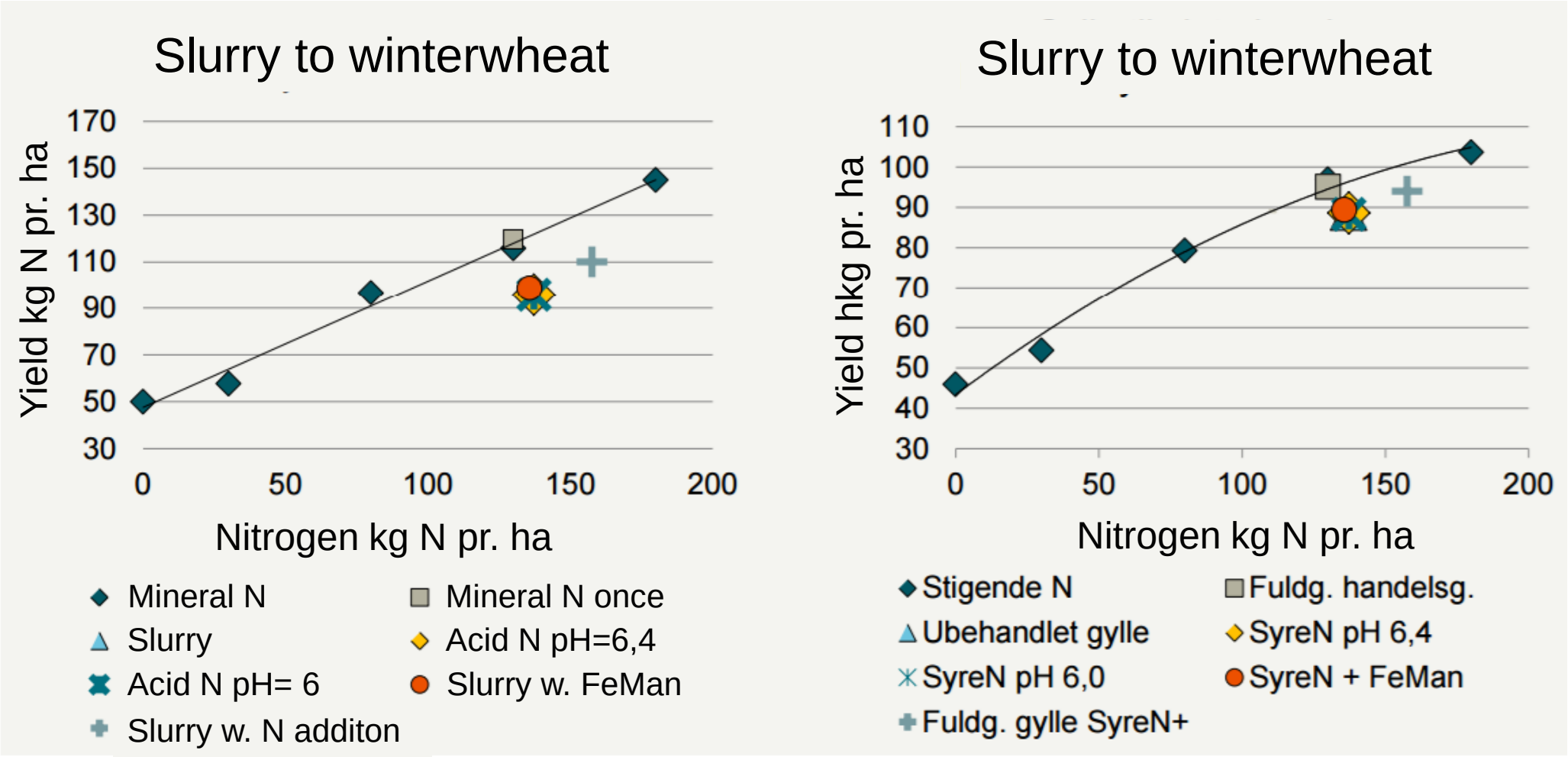
Quotas are set at the financially optimal N fertilization rate

From 1998 to 2015 quotas were set 10 – 20 % below the optimal yield

Due to high financial farmer, quotas have been increased to optimal rates since harvest 2017.

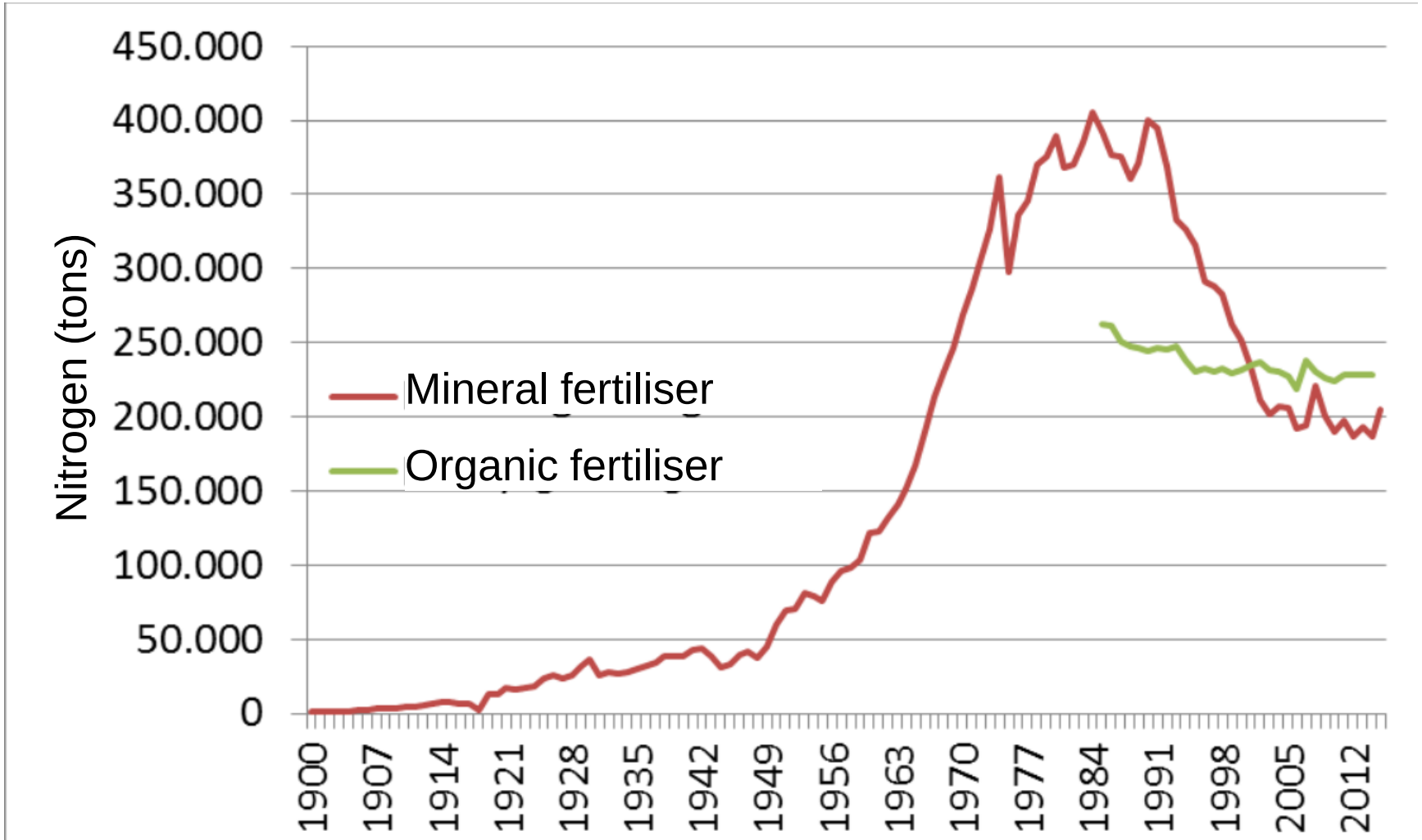


Utilisation of slurry– field trials

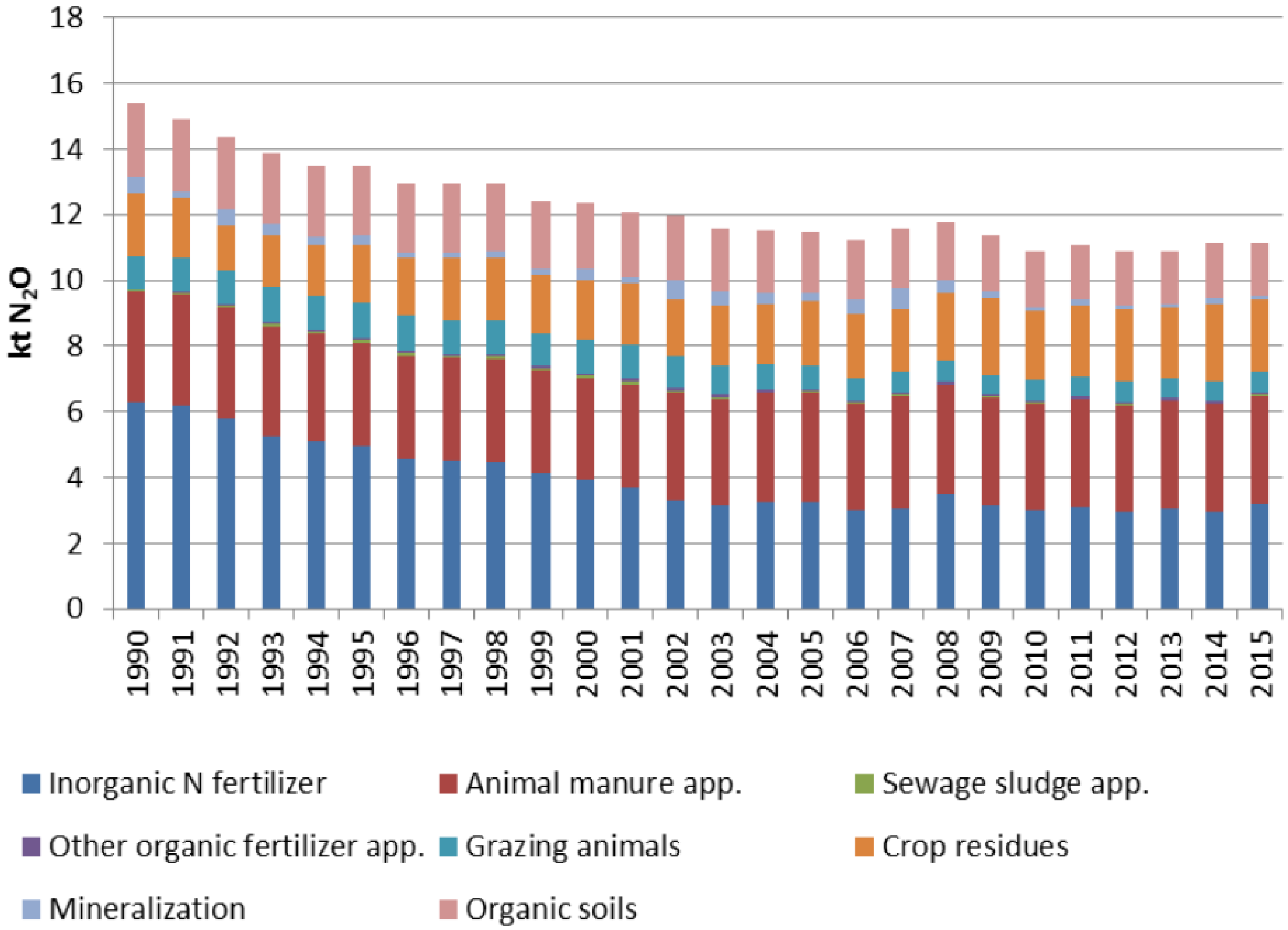


Pig or mink slurry, 8 field trials 2013-2015

Nitrogen use in Danish agriculture



Decreasing emissions agricultural fields



Proposed new measures

- Suggested by the Danish climate council
  - Acidification of slurry in tanks or housing (non field measure)
  - Energy crops (willow) on further 230.000 ha of farmland (~9% of the total Danish farmland)

- Other proposed or likely measures
  - Mandatory use of nitrification inhibitors to organic and mineral fertiliser
  - Reduction of Nitrogen quota
  - Increased use of anaerobic digestion of manure

Proposed new measures – status

- Energy crops
  - Fundamentally not financially viable – payment scheme needed
- Nitrification inhibitors
  - Few Danish studies, limited evidence. If the cost is on the farmer it will affect the optimal N fertilisation rates
- Reduced N qoutas
  - The farmers dislikes them, we just got back to optimal quotas so it is not likely that we will move back
- Acidification
  - Expensive and takes long time to implement, since it can only be implemente in new stables

Quota reduction

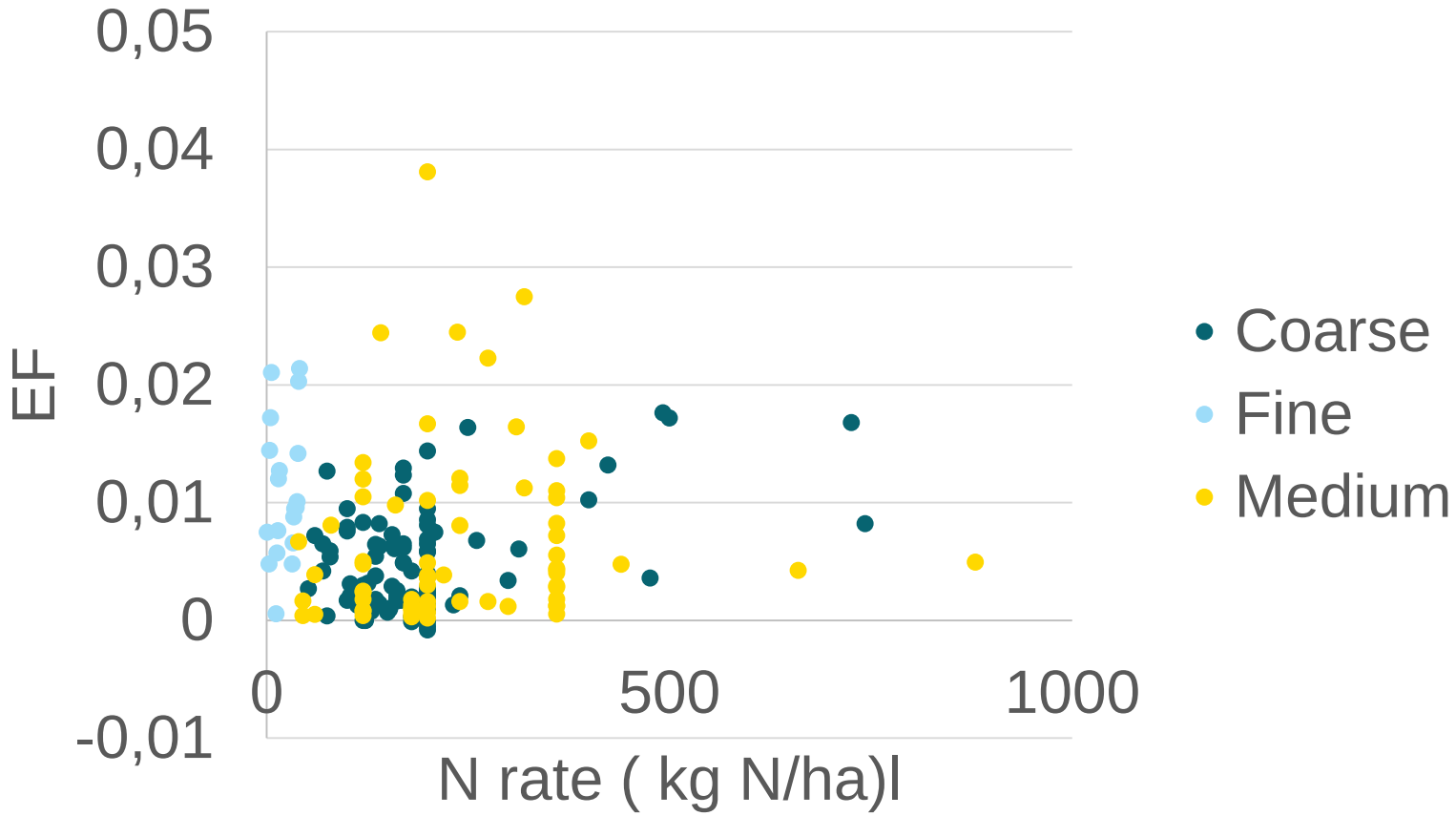
- Danish inventory made with tier 1 methodology
  - 1% of applied N is assumed to be transformed into nitrous oxide
- Danish soils are sandy, which should could reduce denitrification and thus less N_2O emissions than average
- Potential in getting a Tier II or Tier II methodology established

Review of literature

	No. observations	Emission factor (%)
Stehfest & Bouwman 2006	106	0,95
SEGES	96	0,52
Total	202	0,75

- Only studies from Temperate regions with oceanic climate and in agricultural on minreral soil
- Includes 25 observations where nitrification inhibitor has been used
- Studies in SEGES' review are newer than in Stehfest & Bouwman's review

Emission factors and soiltype



Emissions at an emission factor of 0,5

	1990	2005	2015
Emission factor	0,01	0,01	0,01
Inorganic N fertiliser, kt CO_2 eq	6,29	3,24	3,19
Manure applied on soil, kt CO_2 eq	3,36	3,33	3,28
Sewage sludge, kt CO_2 eq	0,05	0,03	0,04
Industrial waste, kt CO_2 eq	0,02	0,09	0,07
Total, kt CO_2 eq	9,72	6,69	6,59
Emission factor	0,01	0,01	0,01
Inorganic N fertiliser, kt CO_2 eq	3,14	1,62	1,60
Manure applied on soil, kt CO_2 eq	1,68	1,67	1,64
Sewage sludge, kt CO_2 eq	0,02	0,02	0,02
Industrial waste, kt CO_2 eq	0,01	0,04	0,04
Total, kt CO_2 eq	4,86	3,34	3,29

Consequences for implementation of measures

Quota reduction	Yield loss (hkg pr. ha)	Financial loss (£/ha)	Reduction in direct emissions pr. ha from fertiliser use at EF = 1% (kg CO_2 eq./ ha)	Reduction in direct emissions pr. ha from fertiliser use at EF = 1% (kg CO_2 eq./ ha)	Financial reduction efficency at EF =1% (£/kg CO_2 eq.)	Financial reduction efficency at EF =0.5% (£/kg CO_2 eq.)
0 pct.	0	0	0	0	-	-
5 pct.	1,0	13	35	17,5	0,37	0,74
10 pct.	2,3	29	70	35	0,41	0,83
15 pct.	3,8	49	105	52,5	0,47	0,93

N.B. Price does not include protein loss

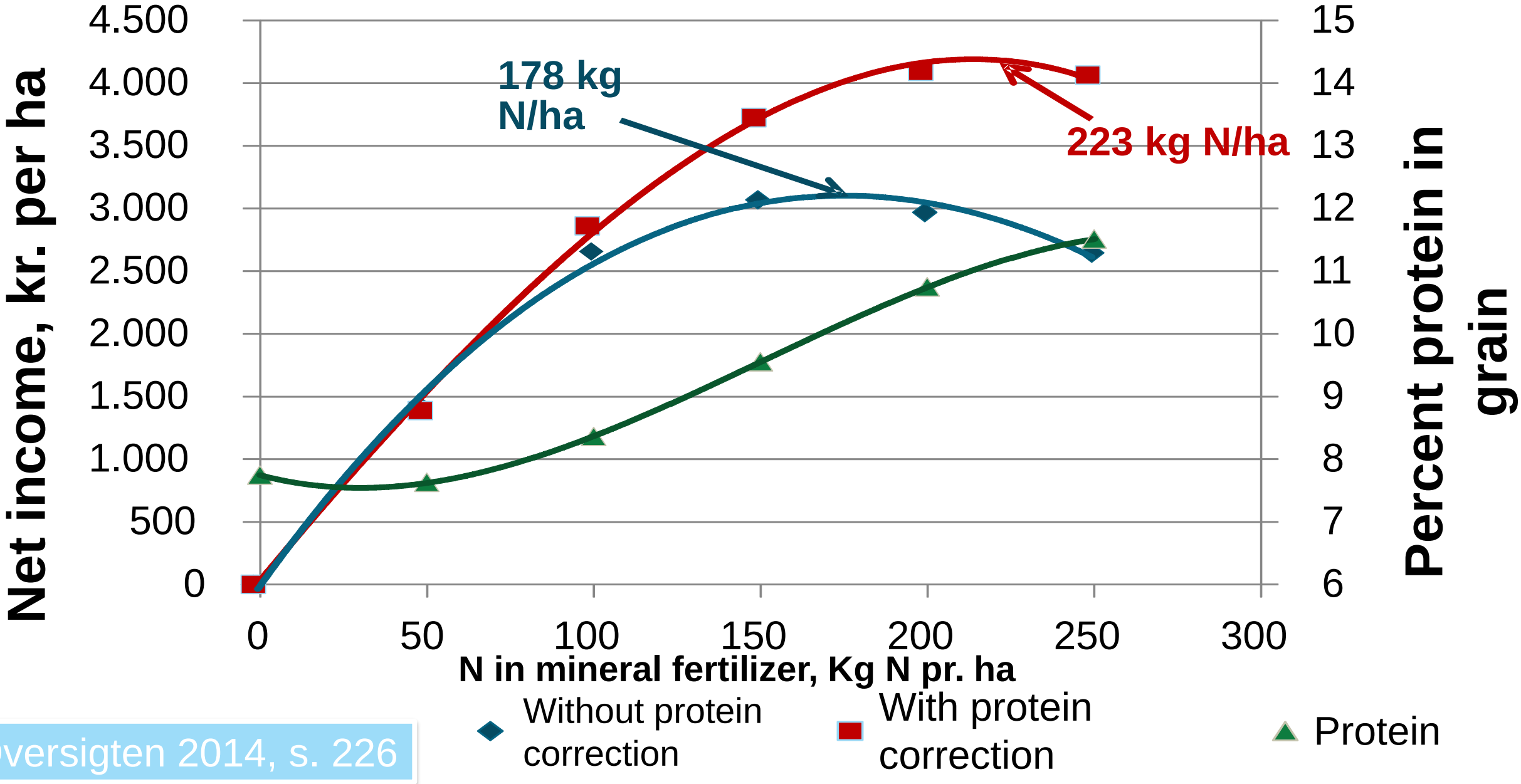
Consequences for implementation of measures

Quota reduction	Financial efficency at EF =1% (£/kg CO_2 eq.)	Financial efficency at EF =0.5% (£/kg CO_2 eq.)	Financial effiency, nitrification inhibitors for organic manure
0 pct.	-	-	0,23
5 pct.	0,37	0,74	
10 pct.	0,41	0,83	
15 pct.	0,47	0,93	

The correct emission factor is essential for determining which mitigation measure to use

230.000 tons N in organic manure
Cost: 0,28£ pr. kg N
Effect: 1,19 kg CO2 eq pr. kg N

N to winter wheat, 19 fs. 2014



Oversigten 2014, s. 226

Additional effects should be added to the price and benefit of the measures

Not included in the above analysis:

- Value of protein in cereals
- Less nitrogen leaching
- Effect of reduced ammonia volatilisation
- Yield effects of nitrification inhibitors

Additional effects can alter the competition status between the measures

Carbon storage and LULUCF

- Likely that Denmark will use the LULUCF cap without additional measures
- This is achieved through agricultural land being converted to urban areas, fallow and forestry
- Conversion of drained organic soils to undrained fallow or grazeland is a potentially strong tool to reduce greenhouse gas emissions permanently. The faster this conversion is done, the more powerful a measure. However, the incentive for additional support schemes for this is small as is cannot count towards our EU obligation.

Conclusion

- We need to be better at estimating emissions from the field (Tier II and Tier III)
- A lot of proposed measures to achieve our reductions, but none that are financially viable for the farmer without financial support
- There is a limited focus on what we can do in the field, but in the next reduction periode we will probably need to contribute

Danish fertiliser accounts and nutrient management plans – a closed mass balance based on register data