STRATEGIES TO ACHIEVE GHG-EMISSION TARGETS FOR AGRICULTURE IN NORWAY

Klaus Mittenzwei

NIBIO
NORWEGIAN INSTITUTE OF BIOECONOMY RESEARCH

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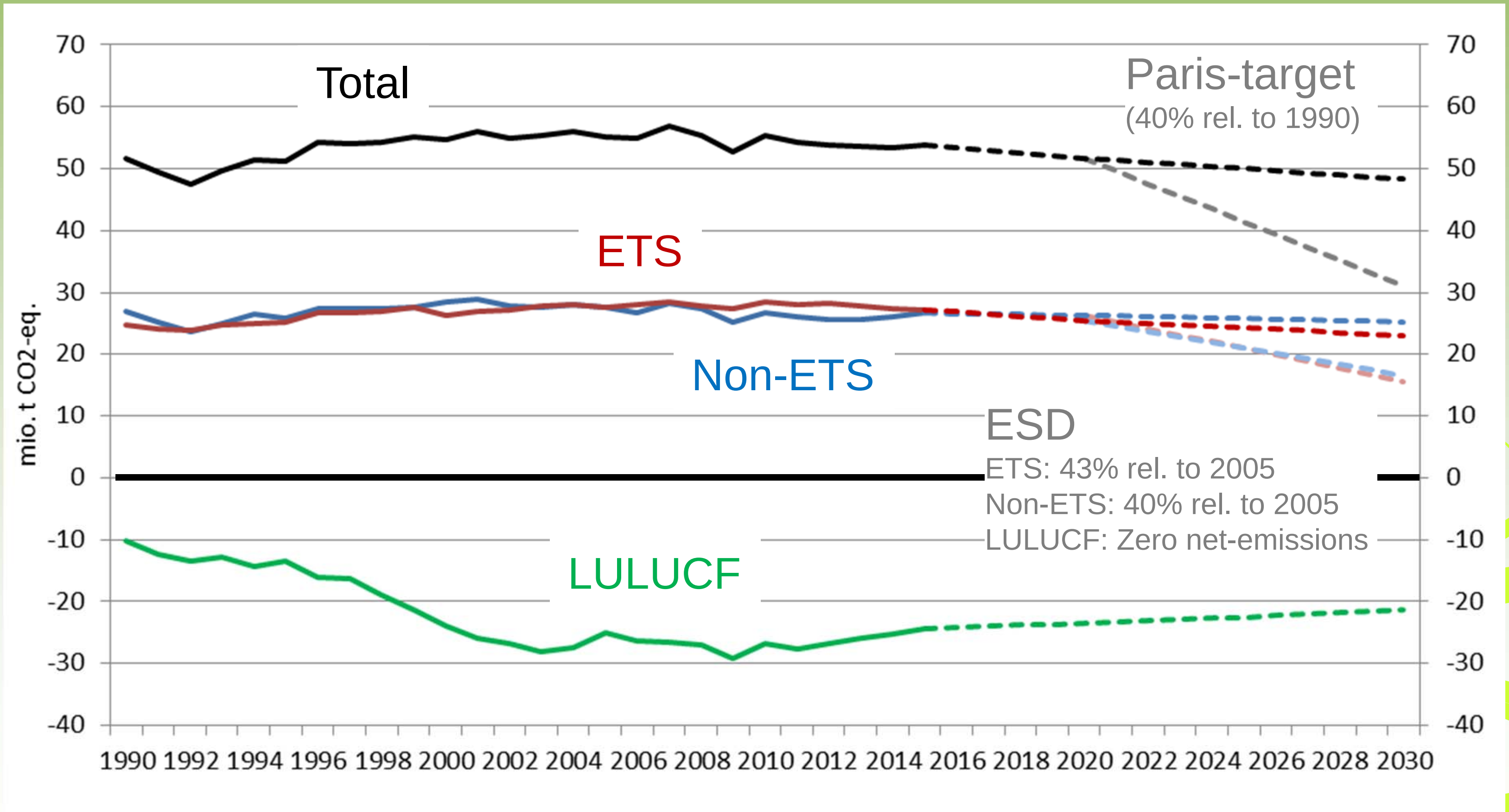
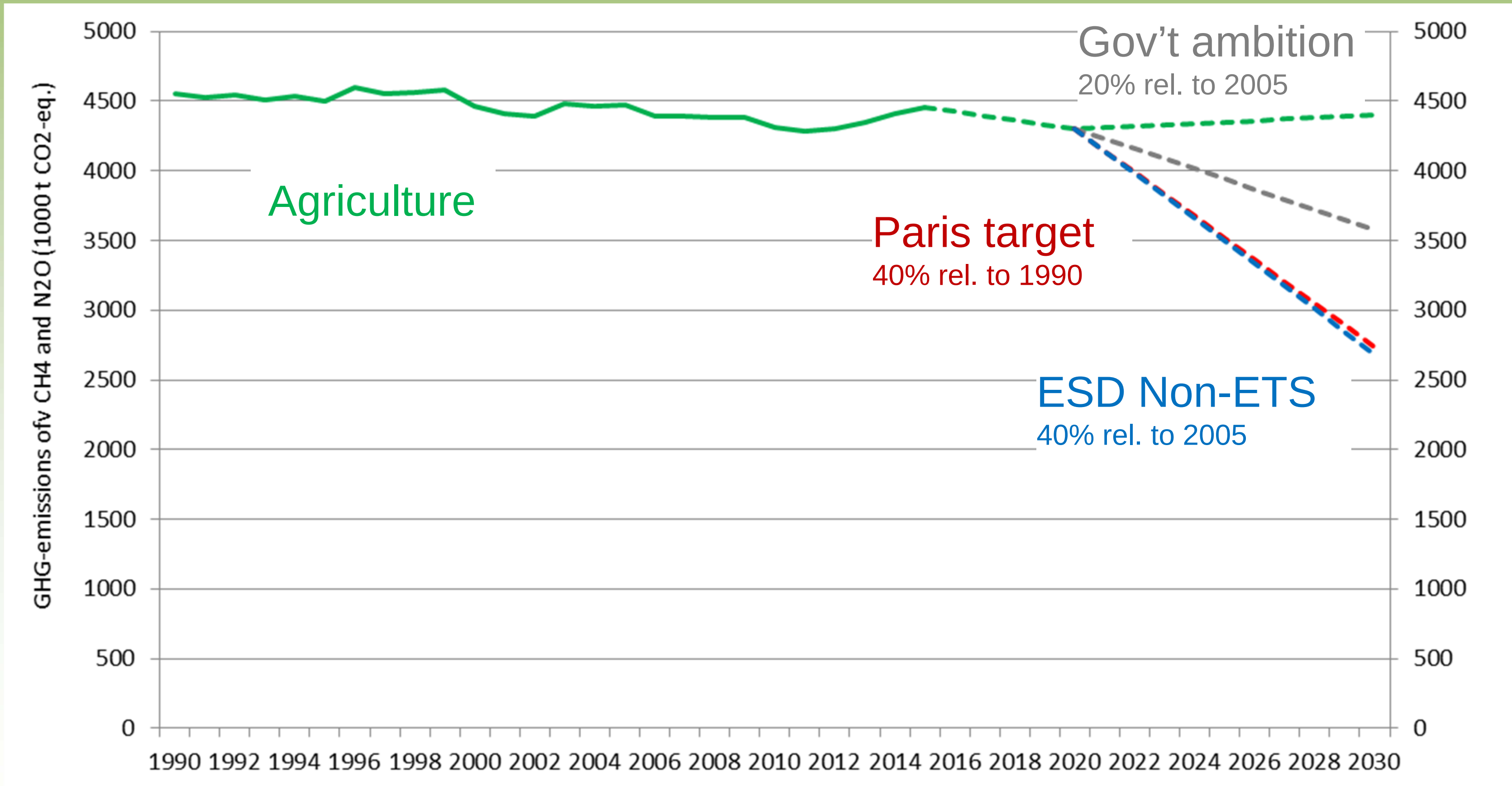
Norway's climate targets



Norway's climate targets translated to agriculture



Problem statement

- How to achieve GHG emissions from agriculture at lowest social costs considering conflicting agricultural policy objectives?

Method

- Jordmod: a partial, spatial and static equilibrium model for the Norwegian agricultural sector
- Supply:
  - Endogenous farm optimization
  - Multiple farms that differ wrt production type, location, size and climate mitigation options
    - allows for detailed modeling of size- and regionally different payment rates of many subsidies
  - Processing industry with endogenous margins
- Ordinary linear demand functions
- 32 regions + ROW, 22 primary products, 33 final demand products, 44 inputs
- Equilibrium found by maximizing social welfare in the sector which determines «optimal» weights in the farm population

GHG emission mitigation options

Name	Description of strategy
FodQ	Earlier cuts and improved quality of fodder to ruminants
FedA	Reduce methane emissions from enteric fermentation applied to dairy cow feed concentrate
ManT	Improved manure applying technology
BioG	Anaerobic digestion at farm scale

GHG emission mitigation options: FedA and FodQ

	FedA_H	FedA_L	FodQ_H	FodQ_L
Direct CH_4 from enteric fermentation (kg CO_2-eq.)	-5%	-5%	-14.2%	-6.8%
Direct CH_4 from manure storage (kg CO_2-eq.)			-21.3%	-10.6%
Indir. N_2O from manure storage (kg CO_2-eq.)			-6.7%	-3.4%
Quantity of feed concentrate for dairy cows (kg per cow)	-4.25%	-4.25%		
Price of feed concentrate for dairy cows (€ per kg)	20.3%	2.9%		
Fodder quality (MJ/kg DM)			8.7%	10.8%
Fodder quantity (kg DM/ha)			-16.9%	-18.2%
Abatement cost (€ per t CO_2-eq.)	1 195	199	408	616

GHG emission mitigation options: ManT and BioG

	ManT_H	ManT_L	BioG_H	BioG_L
Indir. N_2O from manure spread (kg CO_2-eq.)	-30% [1)]	-10% [1)]	-90%	-90%
Dir. and indr. N_2O from manure storage systems and dir. N_2O from manure spread (kg CO_2-eq.)			-90%	-90%
N uptake of crops from manure	10%	10%		
Additional cost in manure application technology (€ per ha)	71	31		
Investment in biogas facility (€ per farm)			246 914	105 820
Maintenance (€ per farm)			43.6%	17.4%
Energy (€ per farm)			-59.1%	-23.6%
Abatement cost (€ per t CO_2-eq.)	550	301	227	98

1) Double effect on 50% of farms translated to 50% effect on all farms.

Scenario assumptions

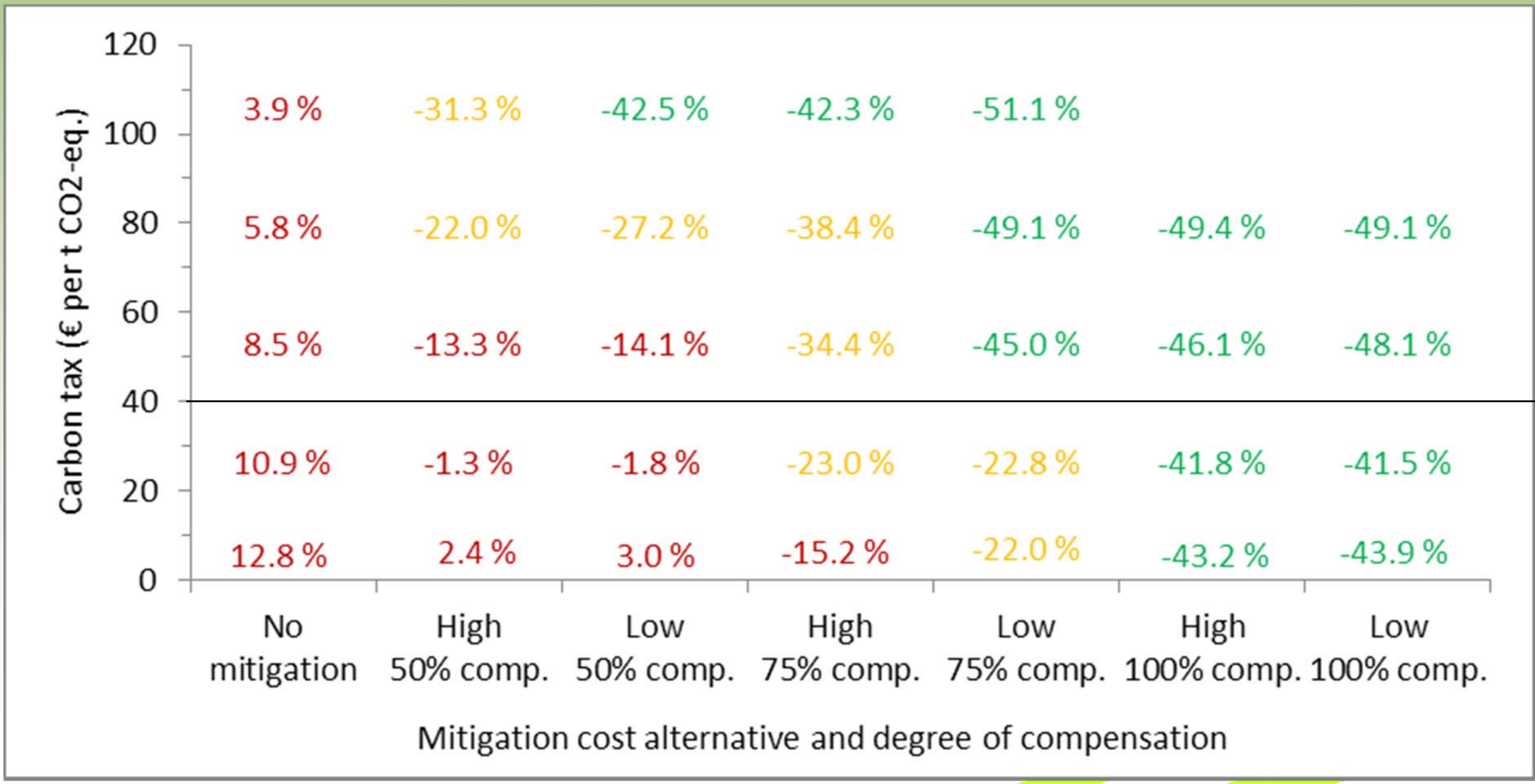
Variable	Value	Source
Simulation year	2030	
Population growth	0.92 % p.a.	SSB (2016)
Consumer price index	2 % p.a.	SSB (2016)
Interest rate	2 % p.a.	SSB (2016)
Real wage increase	0.8 % p.a.	SSB (2016)
Technical progress	0.25 % input-saving in primary agriculture and food industry	Own assumption
World market prices	-1.8 % - 3.4 % p.a.	OECD/FAO (2016)
Trade policies	No change in trade agreements	Own assumption

Scenarios

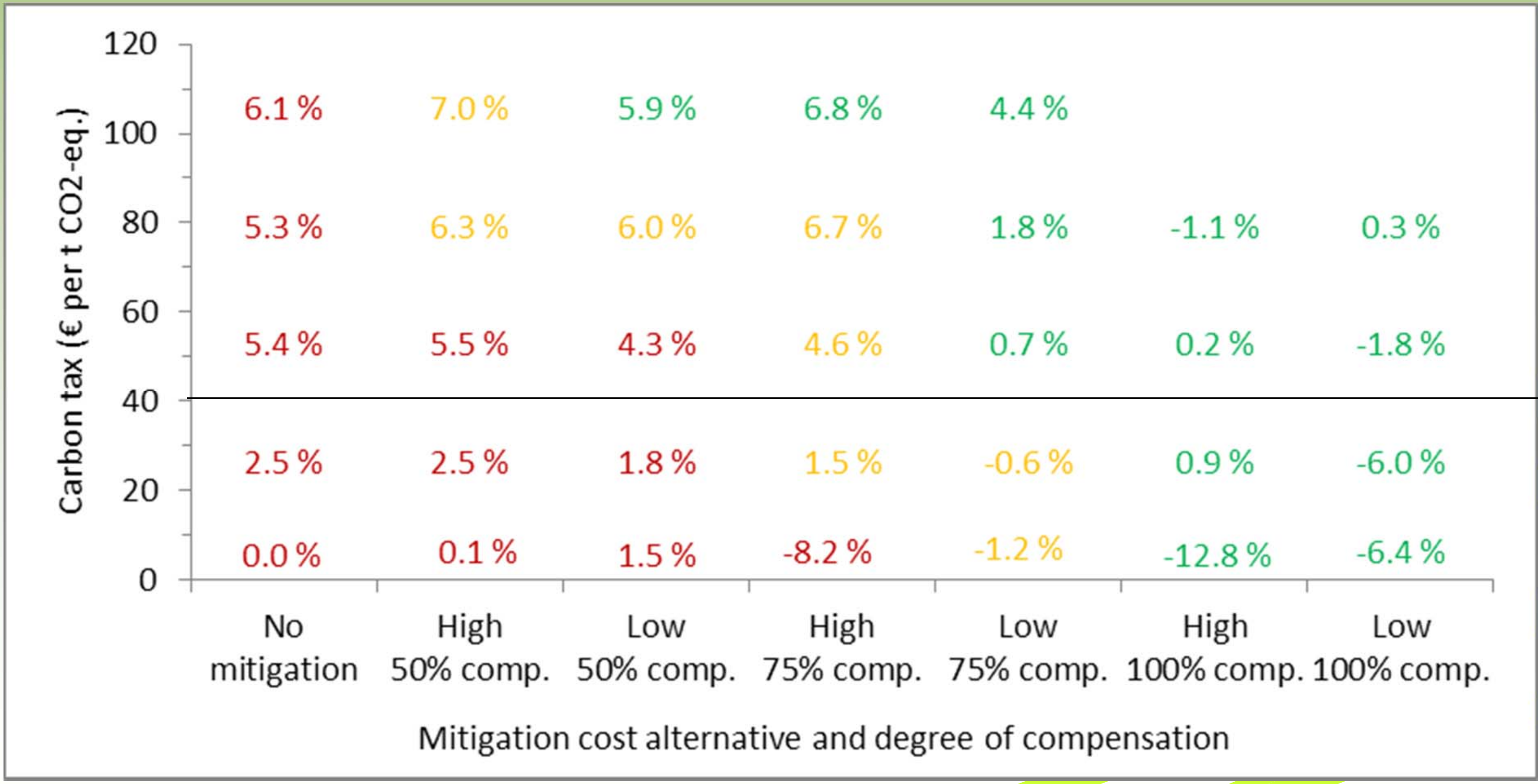
- 35 combinations of
  - 3 mitigation options
    - No mitigation
    - Mitigation at high cost
    - Mitigation at low cost
  - 3 compensation regimes
    - 50% - 75% - 100% of abatement cost
  - 5 levels for carbon tax (€ per t CO_2-eq.)
    - 0 – 26 – 52 – 79 – 105

GHG-emission reduction relative to 2005: Compensation payments required to achieve emission target

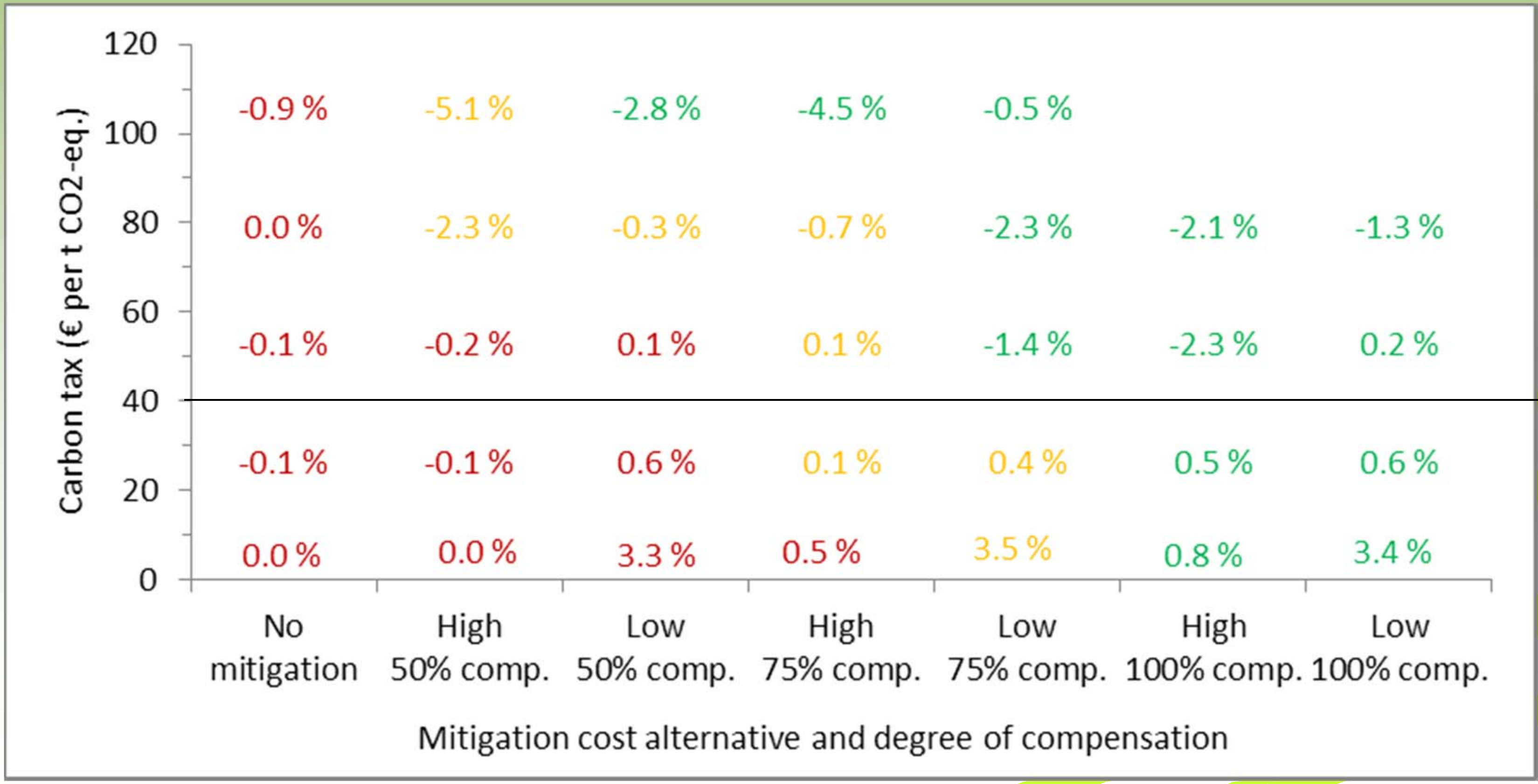
Red: <20%   Yellow: 20-40%   Green: >40%



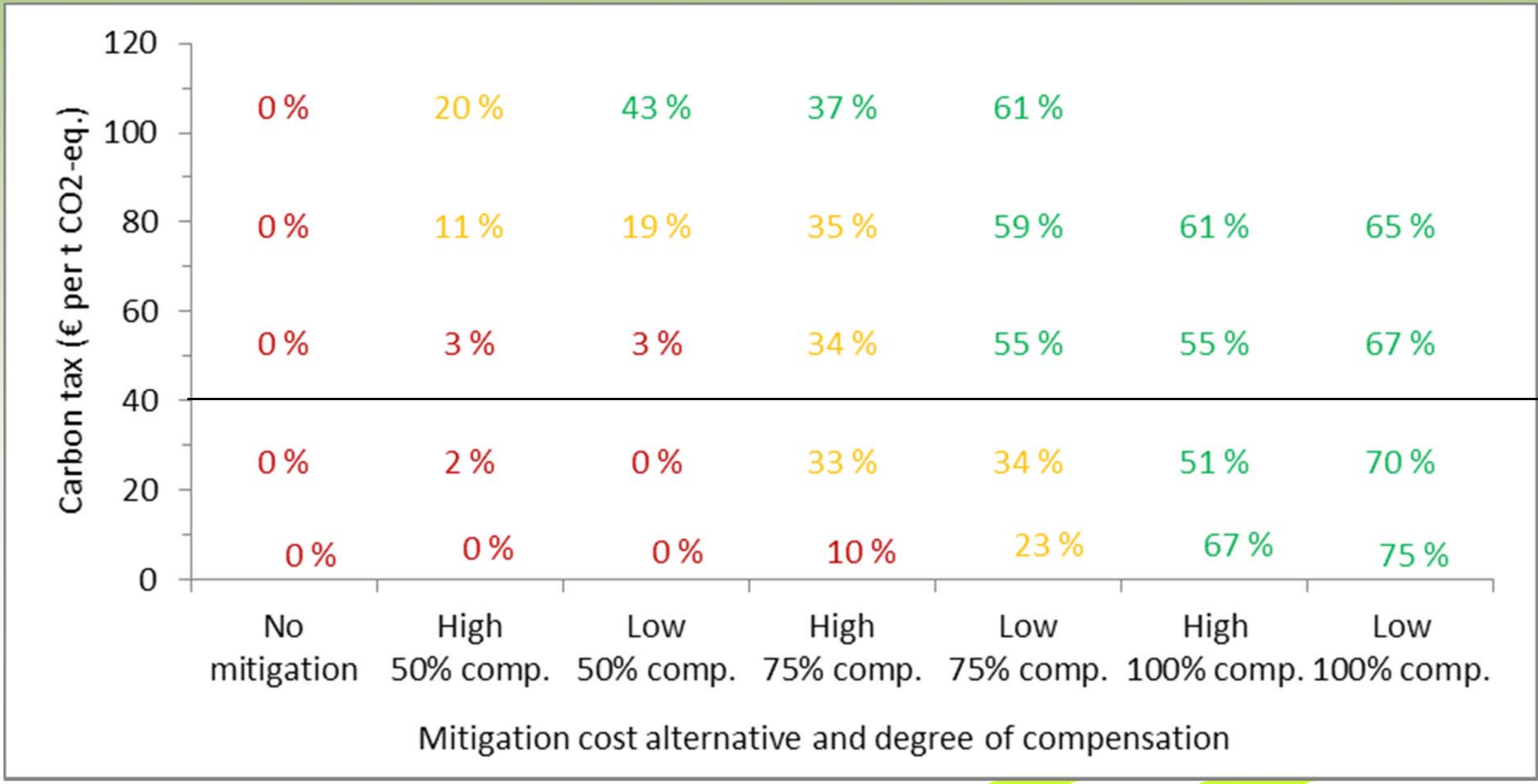
Change in food production (energy content) compared to baseline: Potential risk of lower food production



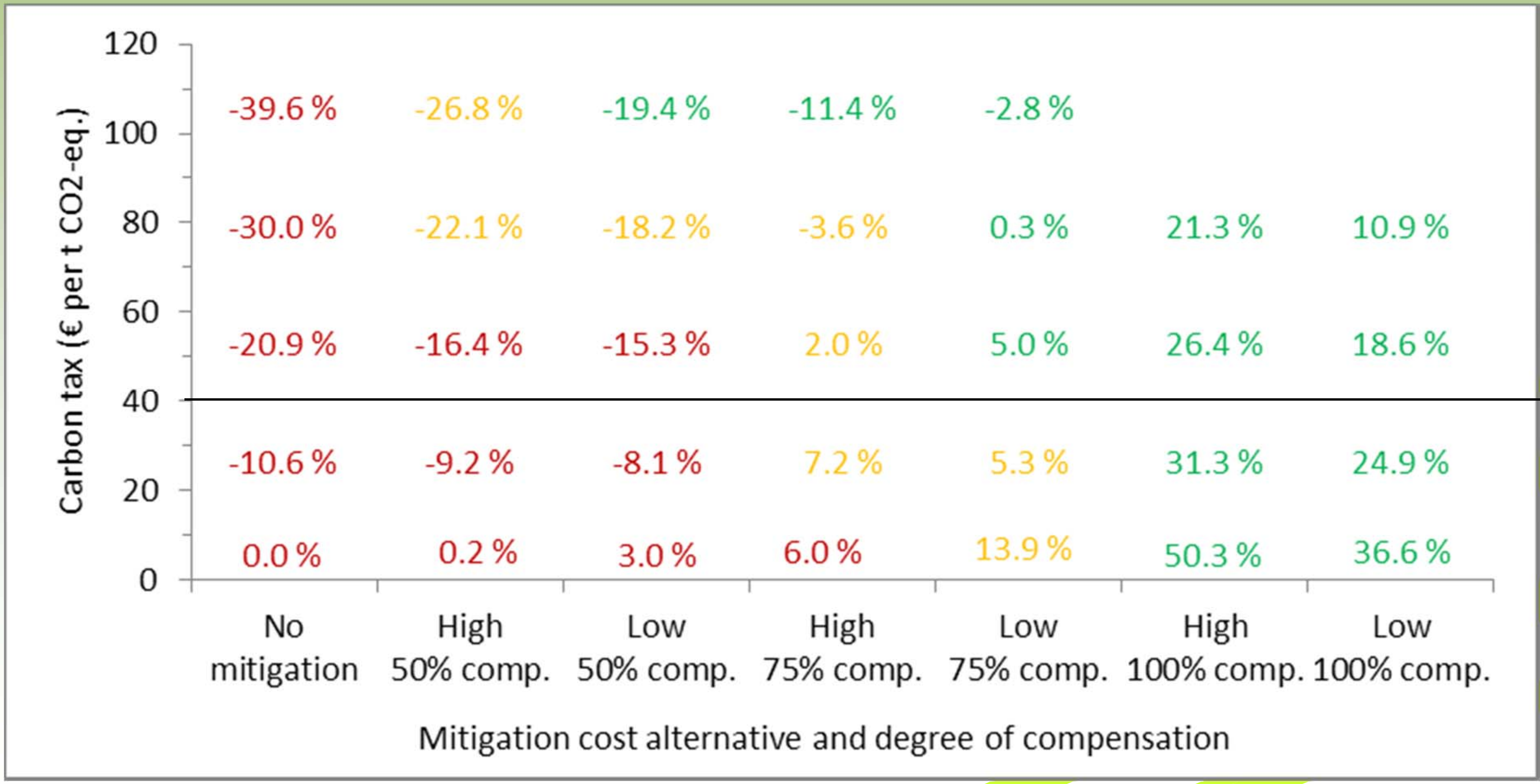
Change in agricultural area compared to baseline: Small changes



Share of agricultural area participating in mitigation strategies: Carbon tax and compensation boost participation



Budget support net of carbon tax relative to baseline: Budget spending increases



Discussion and conclusion

- GHG-emission reductions ...
  - are costly to achieve,
  - but do not necessarily conflict with other policy objectives
- Challenge of modeling complex mitigation measures at farm-scale within a rather simplifying national sector model
- Relationship between effect of mitigation measure and national inventory?

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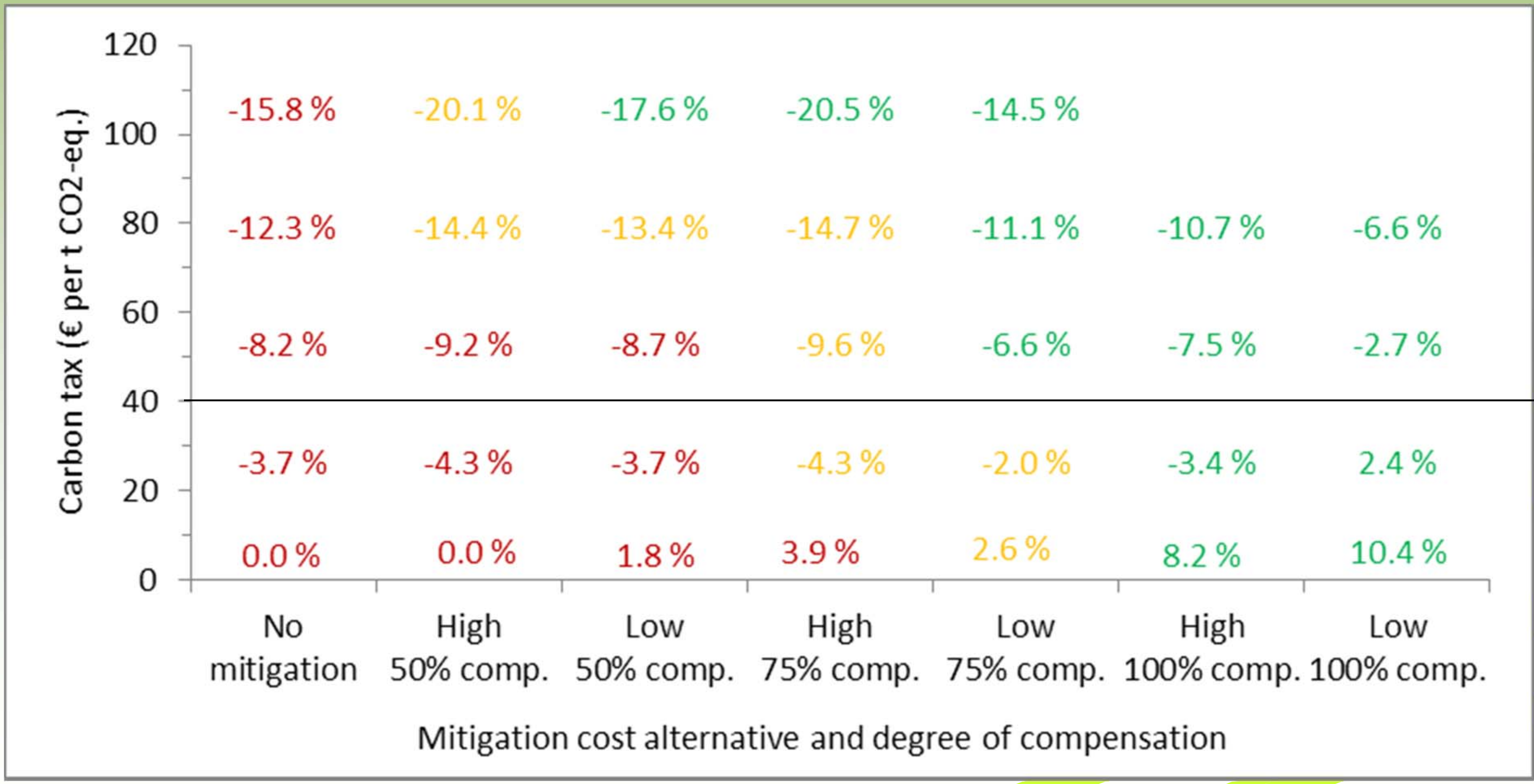
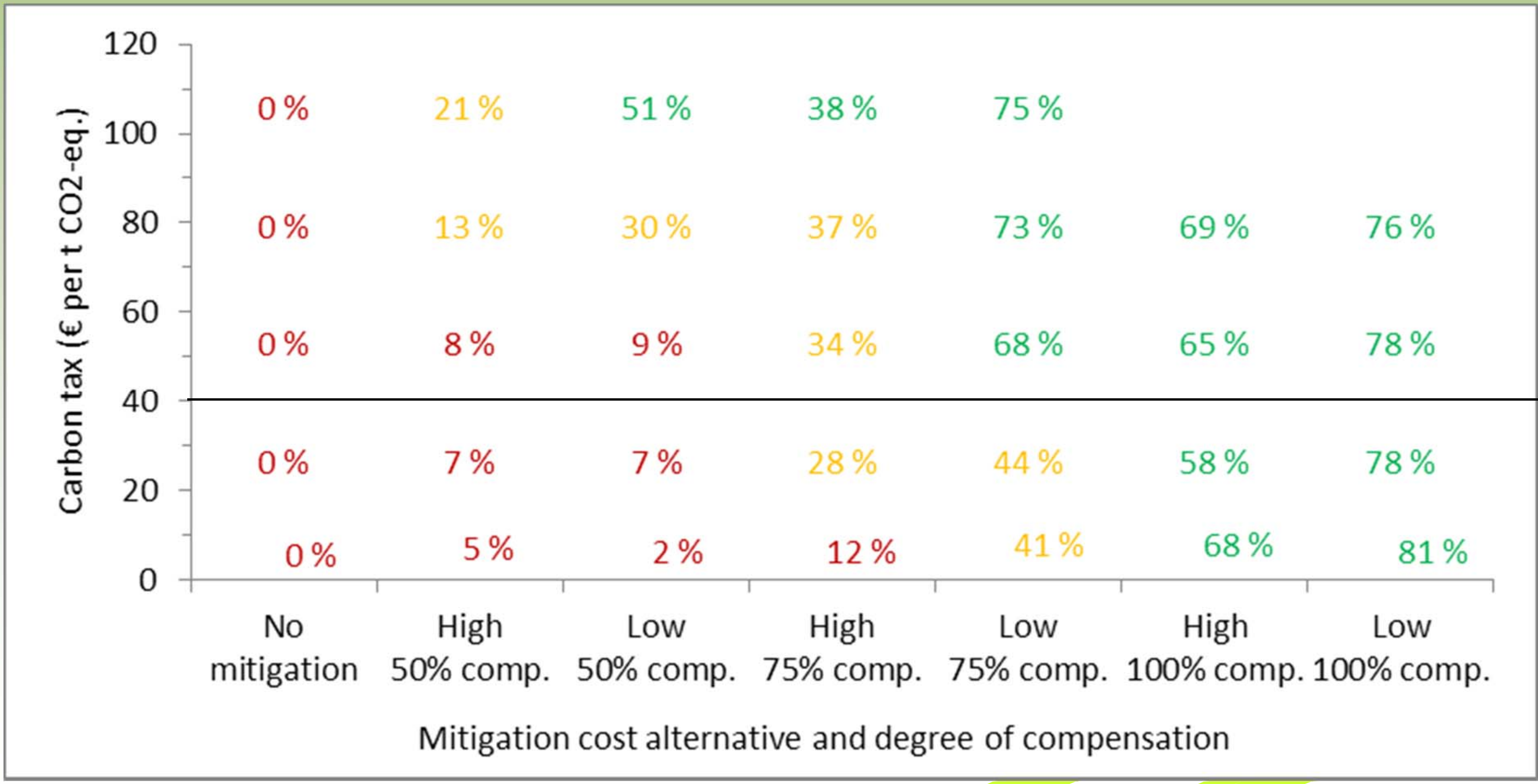
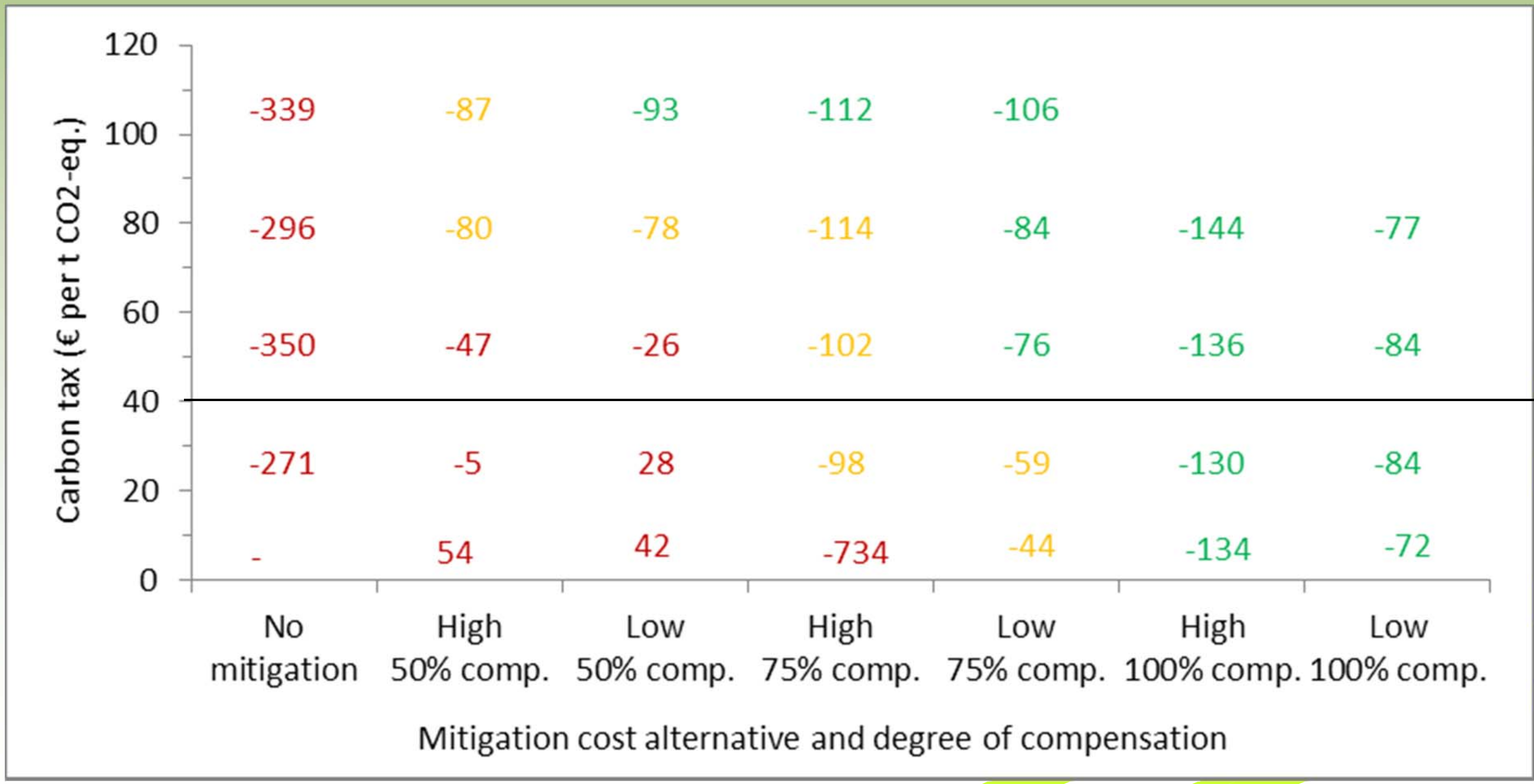
Production of red meat compared to baseline: Significant reduction under carbon tax despite compensation



Share of farms participating in mitigation strategies: Carbon tax and compensation boost participation



Gross welfare change (€ per t CO_2): Welfare loss due to comp. payments



Net welfare change (€ per t CO_2): Small welfare gains due to less agriculture