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## **Amino acid incorporation into pig feeds reduces the environmental impacts of pig production**

Florence Garcia-Launay, Hayo van Der Werf, Thi Tuyet Hanh Nguyen, Loïc Le Tutour, Jean-Yves Dourmad

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# Amino acid incorporation into pig feeds reduces the environmental impacts of pig production



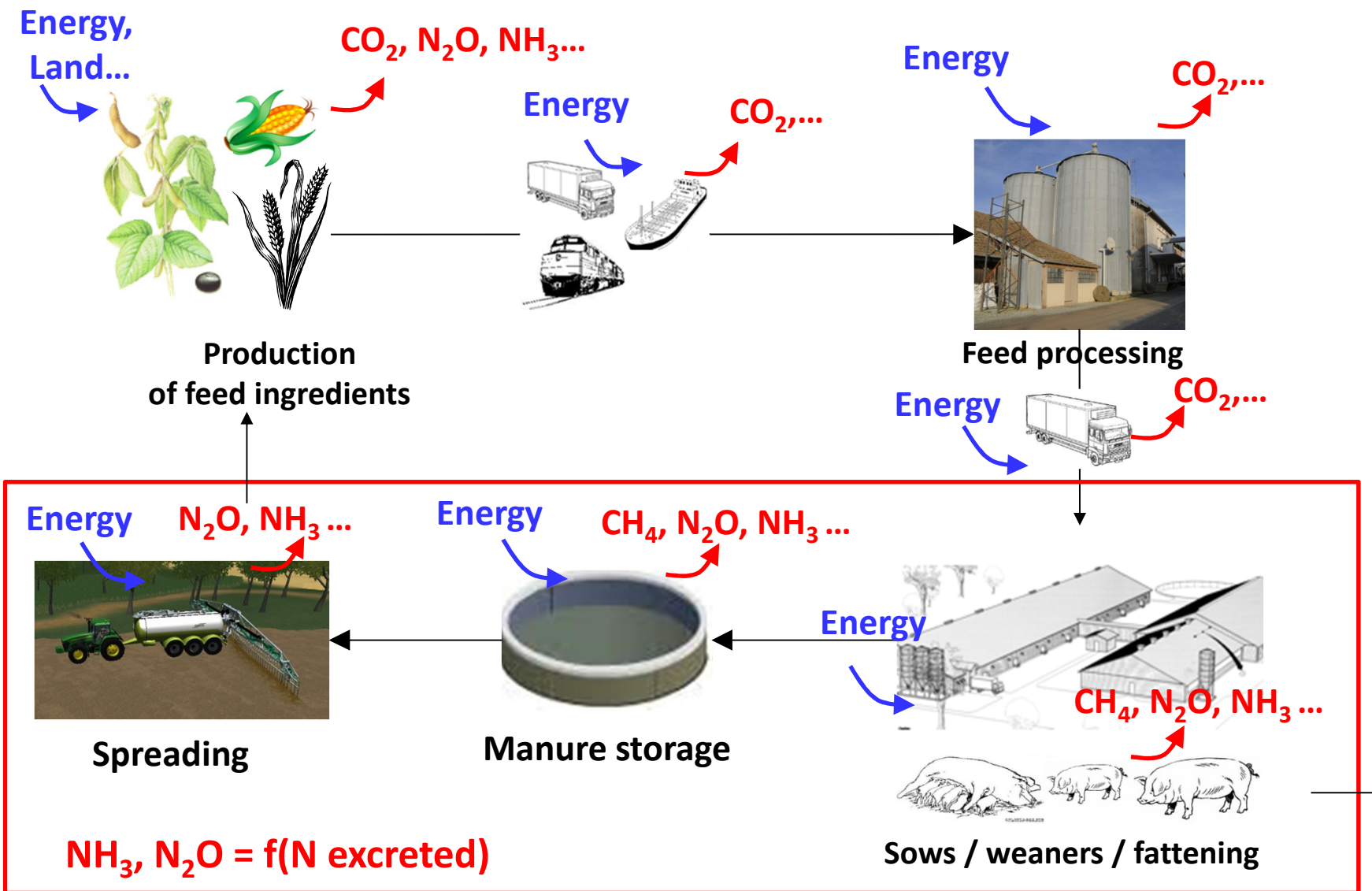
**AJINOMOTO.**

AGRO  
CAMPUS  
OUEST

AJINOMOTO ANIMAL NUTRITION  
AJINOMOTO EUROLYSINE S.A.S.

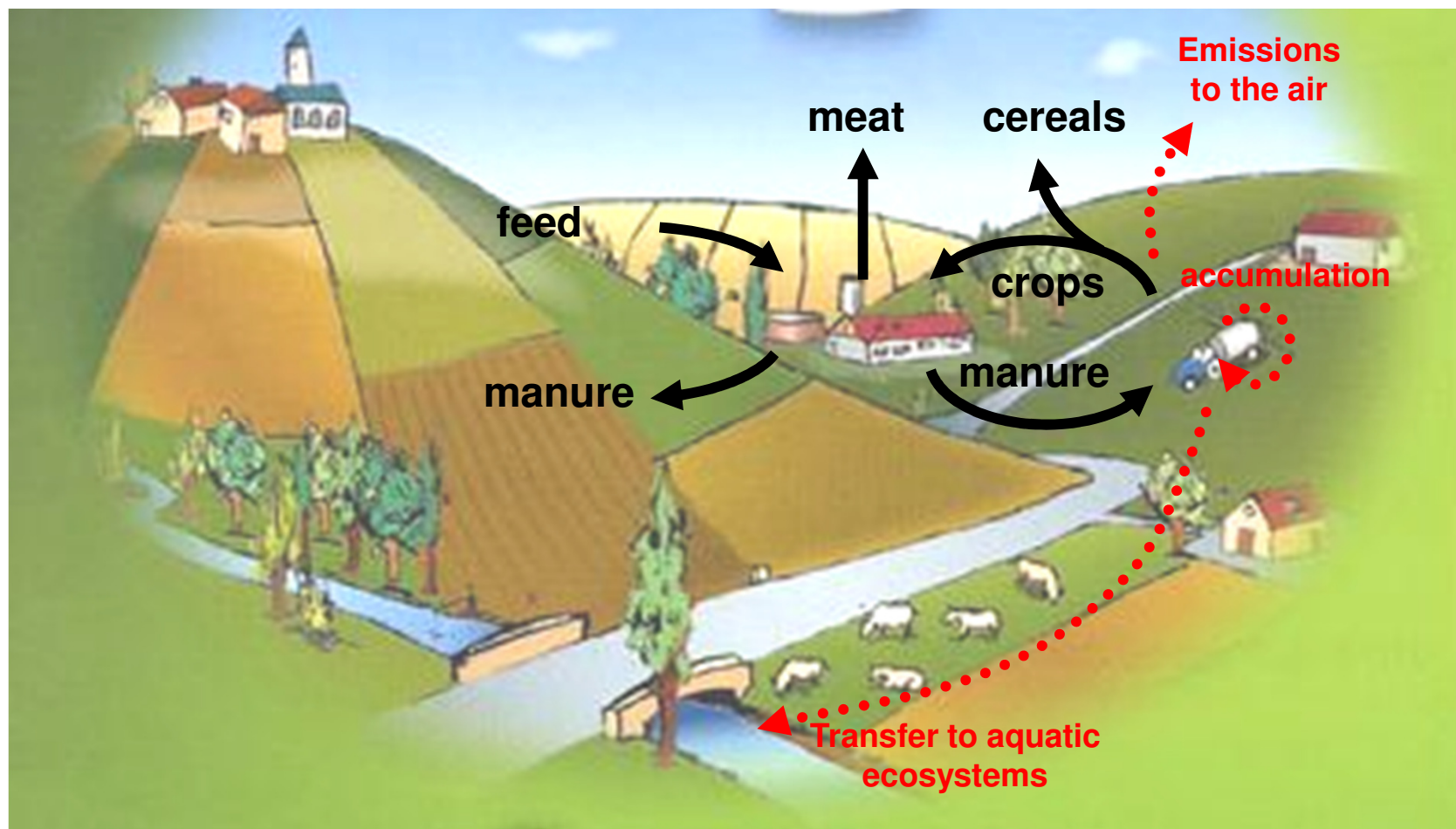
*Florence GARCIA-LAUNAY (1,2), Hayo VAN DER WERF (2,3),  
Thi Tuyet Hanh NGUYEN (2,3), Loïc LE TUTOUR (4)  
and Jean-Yves DOURMAD (1,2)*

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- (3) INRA, UMR1069 SAS, 35000 Rennes, France*
- (4) Ajinomoto Eurolysine SAS, 75817 Paris, France*





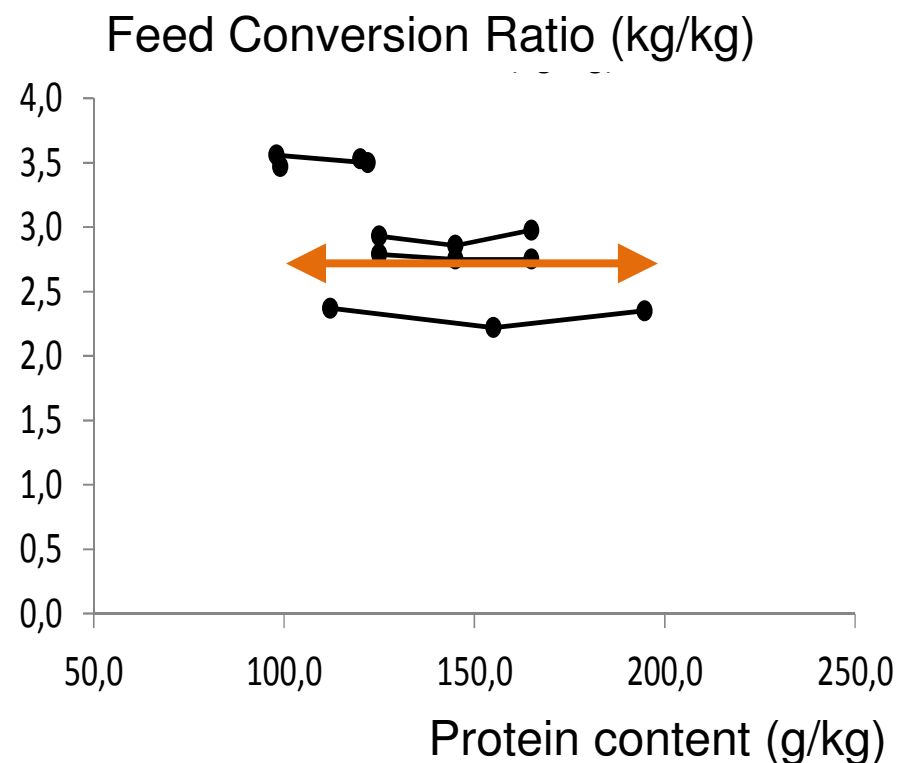
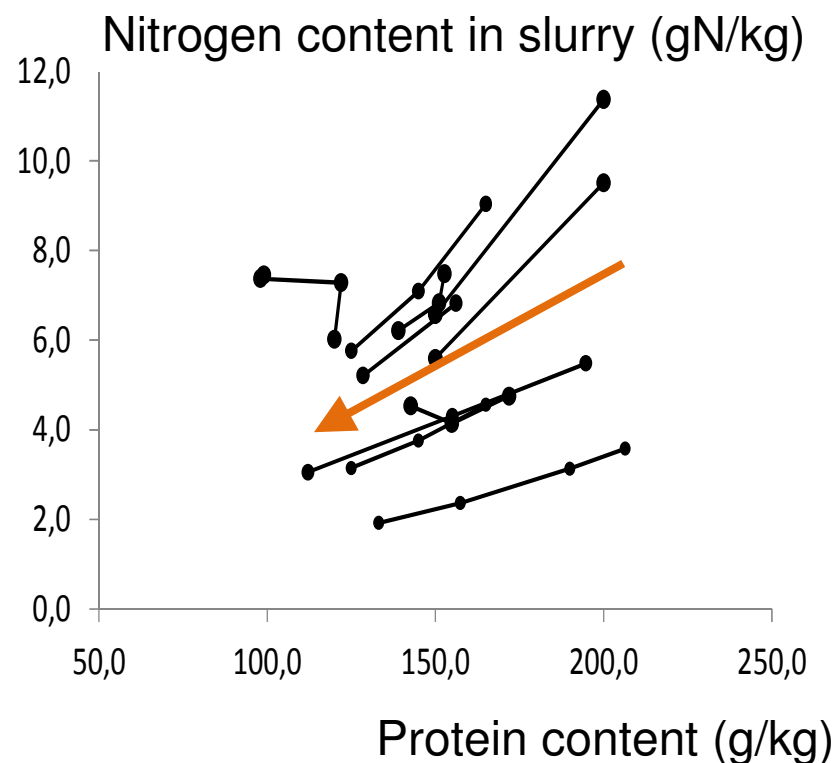
# Nutrients flows on a pig farm



# Potential environmental impacts

- Negative impacts
  - On atmosphere
    - Green House Gases ( $N_2O$ ,  $CH_4$ ) => Global warming
    - Ammonia ( $NH_3$ ) => Acidification – Fine particles
  - On water
    - Nitrates => Eutrophication
    - Phosphates => Eutrophication
  - on soil
    - Accumulation of trace elements => Terrestrial ecotoxicity
  - Utilisation of ressources => Energy, phosphates, surface...
  - ...
- Positive impacts
  - Recycling of nutrients - valorisation of co-products
  - Fertility of soils- Organic matter
  - Biodiversity – landscapes ?

↘ protein content of feeds reduces nitrogen excretion and the associated emissions ...

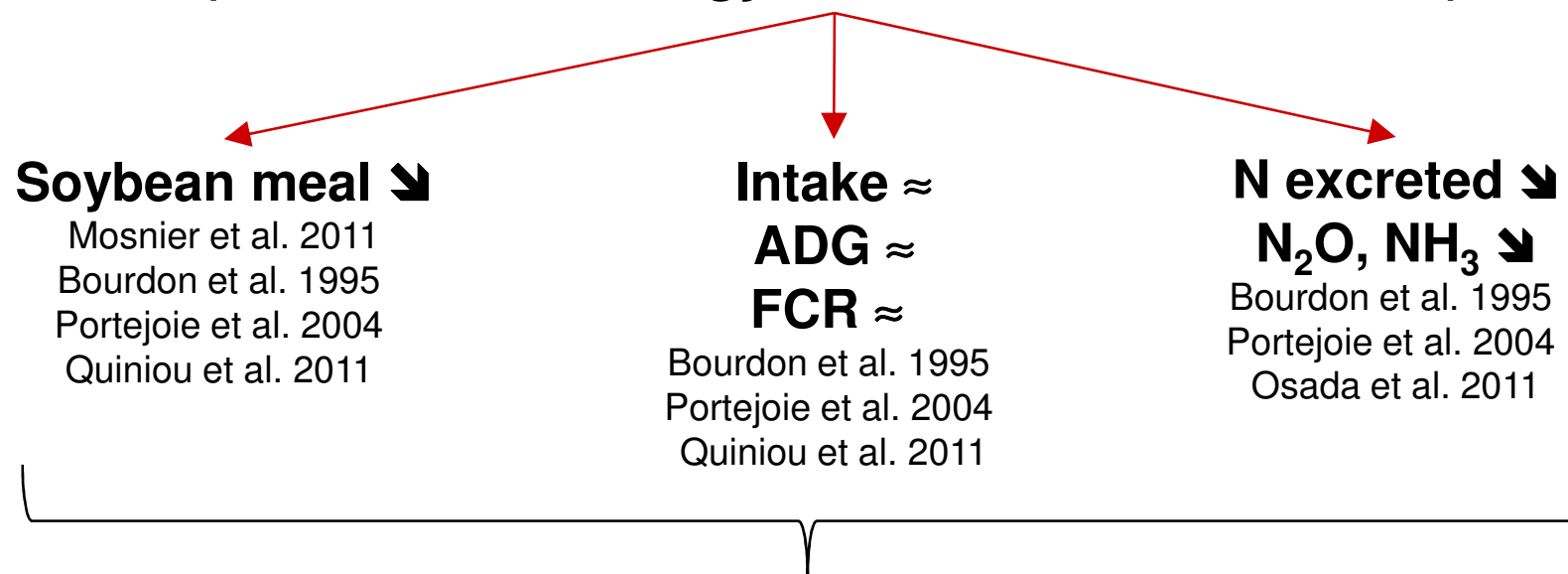


...without lowering the performances

if the contents in essential amino acids are maintained

# Reducing feed protein content

Feed with reduced protein content  
(with same Net Energy and Essential AA contents)



**Objective : evaluate the potential for mitigation of environmental impacts when incorporating feed-use amino acids into pig feeds**

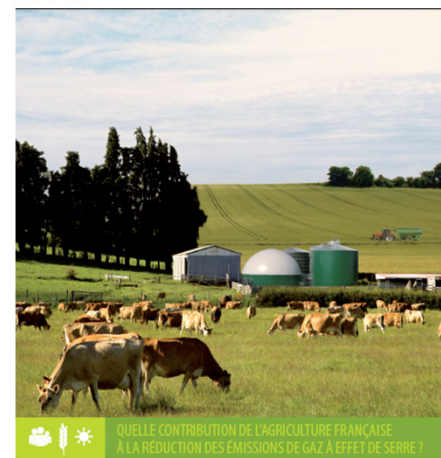
# Objectives and Layout

- Study 1:  
Evaluate the environmental impacts of the pig production for different strategies of incorporation of feed-use amino acids
- Study 2:  
Evaluate the potential for mitigation of GHG emissions from 2010 to 2030 in France for promising strategies



Evaluation of the environmental implications of the incorporation of feed-use amino acids in pig production using Life Cycle Assessment

F. Garcia-Launay<sup>a,c,\*</sup>, H.M.G. van der Werf<sup>b,c</sup>, T.T.H. Nguyen<sup>b,c</sup>,  
L. Le Tutour<sup>d</sup>, J.Y. Doumad<sup>a,c</sup>



QUELLE CONTRIBUTION DE L'AGRICULTURE FRANÇAISE À LA RÉDUCTION DES ÉMISSIONS DE GAZ À EFFET DE SERRE ?

POTENTIAL D'ATTÉNUATION ET CÔÛT DE DIX ACTIONS TECHNIQUES

Document de travail de l'état de l'agriculture française

<http://institut.inra.fr/en/Missions/Inform-public-decision-making/Advanced-Studies/All-the-news/Study-on-reduction-of-GHG-in-agriculture>



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journal homepage: [www.elsevier.com/locate/livsci](http://www.elsevier.com/locate/livsci)

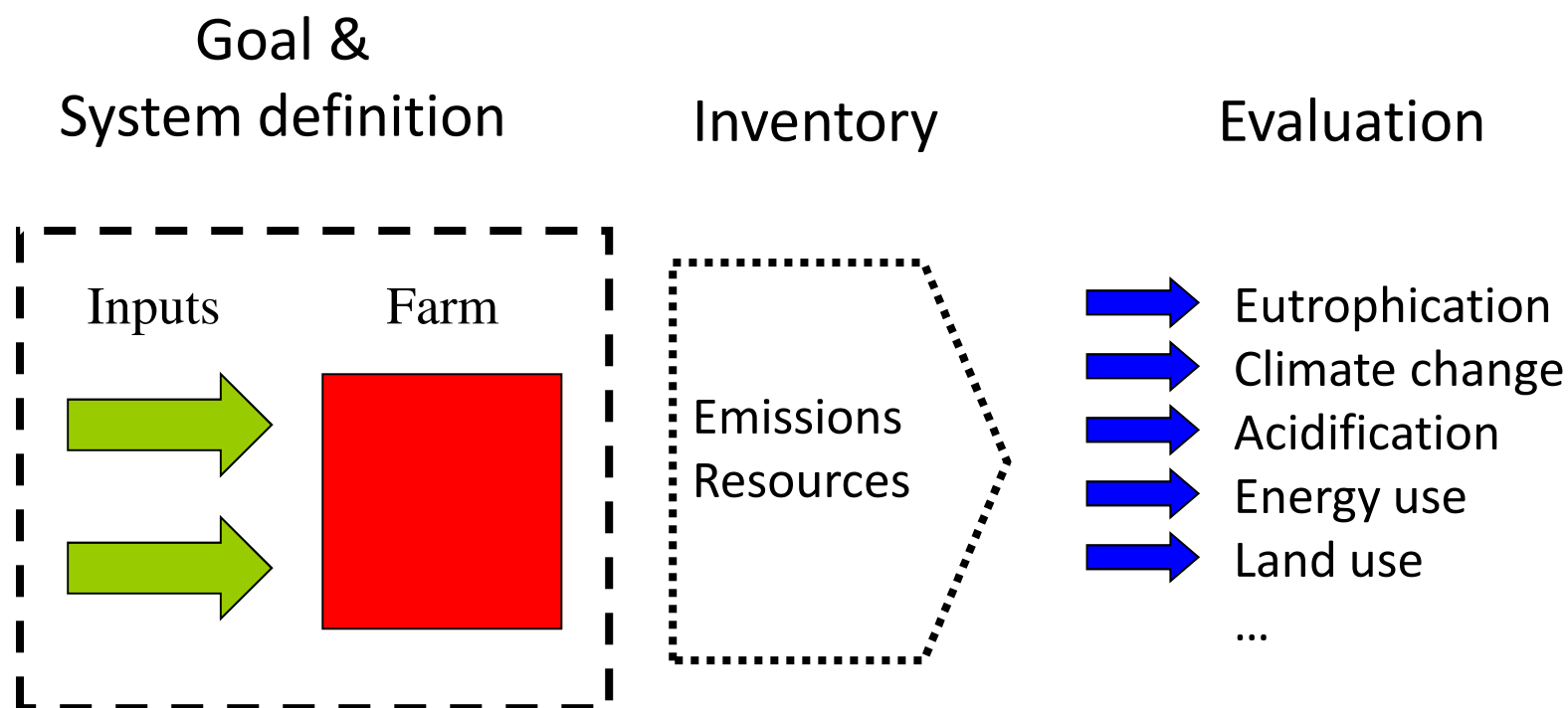


## Evaluation of the environmental implications of the incorporation of feed-use amino acids in pig production using Life Cycle Assessment



F. Garcia-Launay<sup>a,c,\*</sup>, H.M.G. van der Werf<sup>b,c</sup>, T.T.H. Nguyen<sup>b,c</sup>,  
L. Le Tutour<sup>d</sup>, J.Y. Dourmad<sup>a,c</sup>

# The stages of Life Cycle Analysis

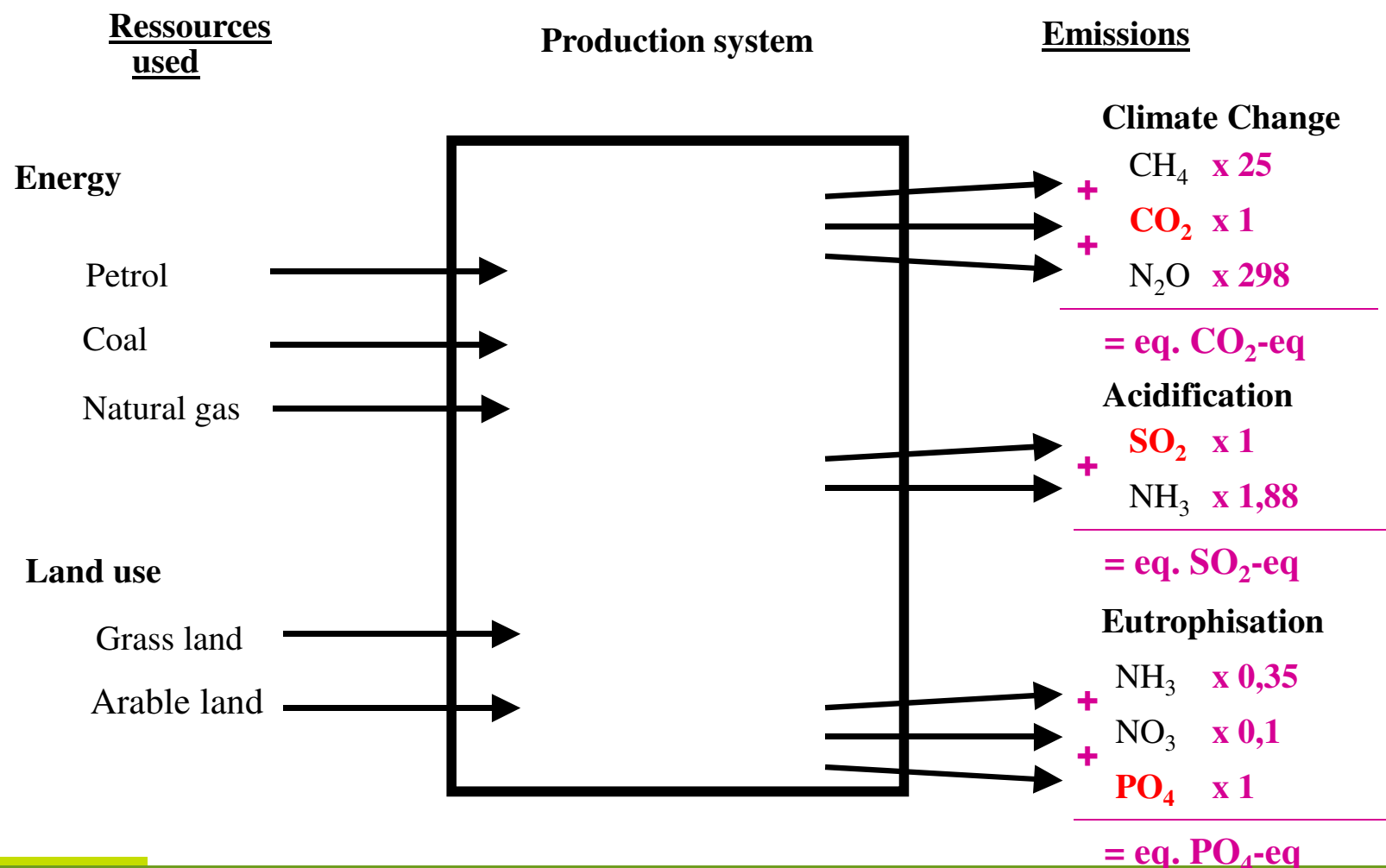


## Iso 14002 Normalization

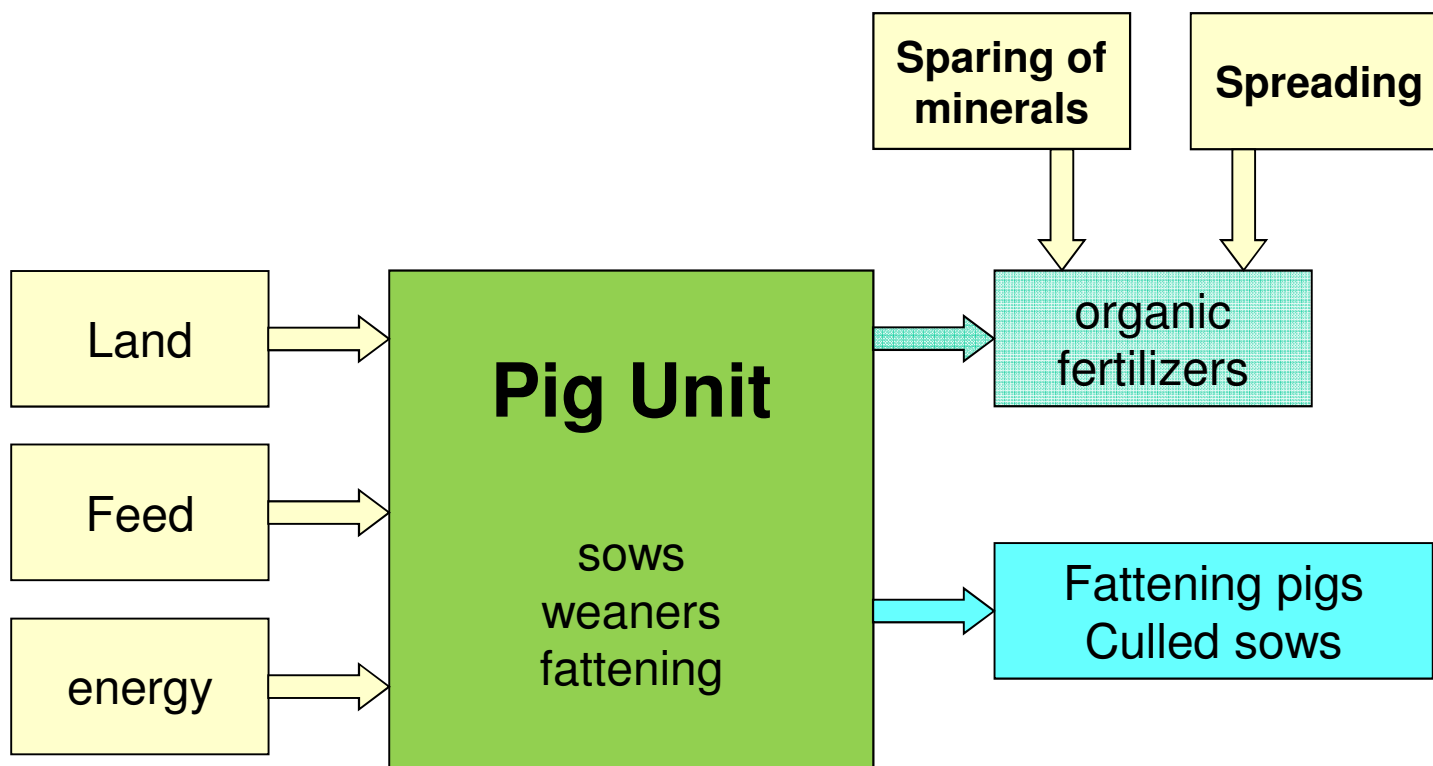
According to Geier, 1999

# Aggregation of emissions per category of impacts

(from Owens, 1999 and Guinée et al. 2002)

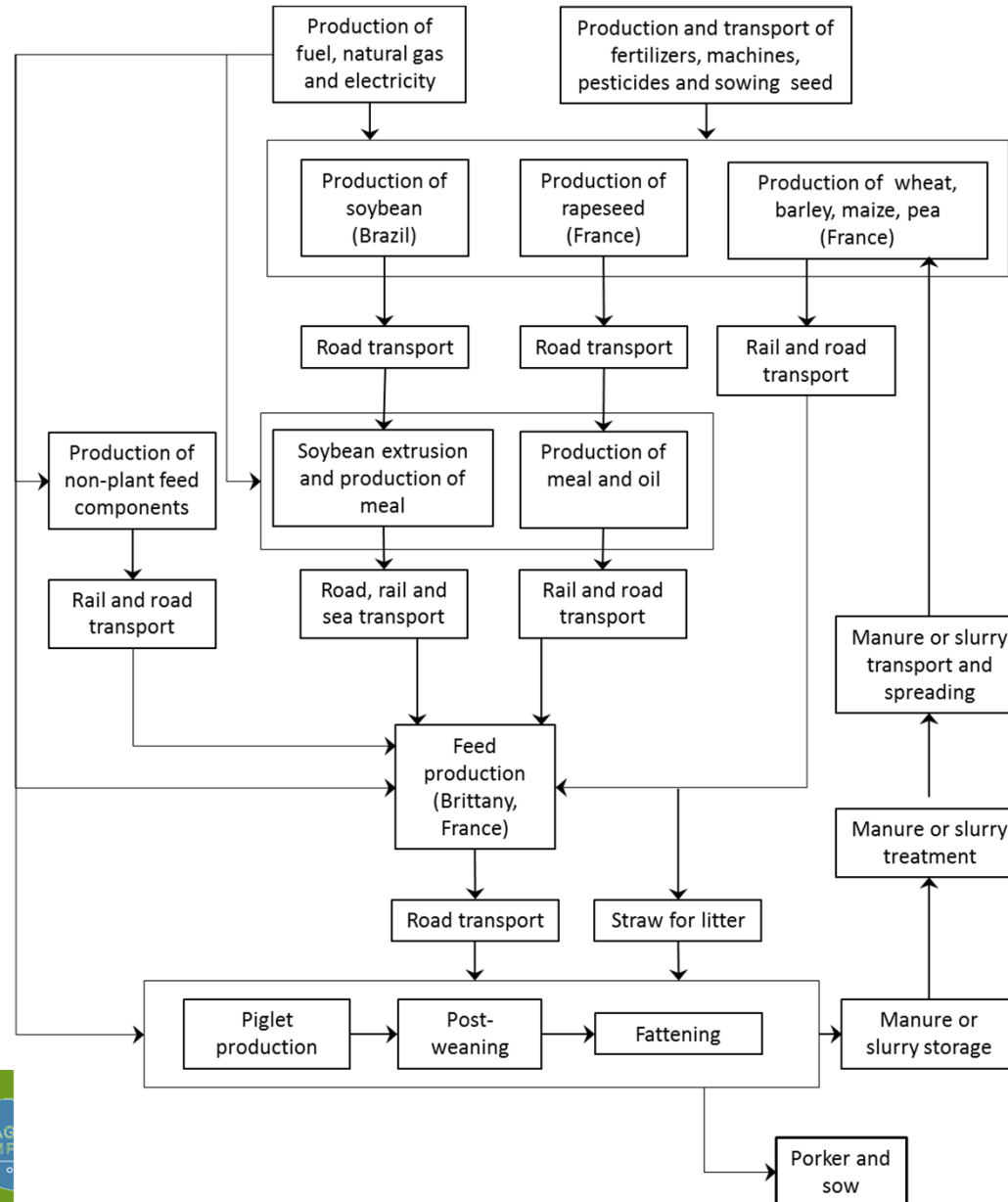


# Description of the system





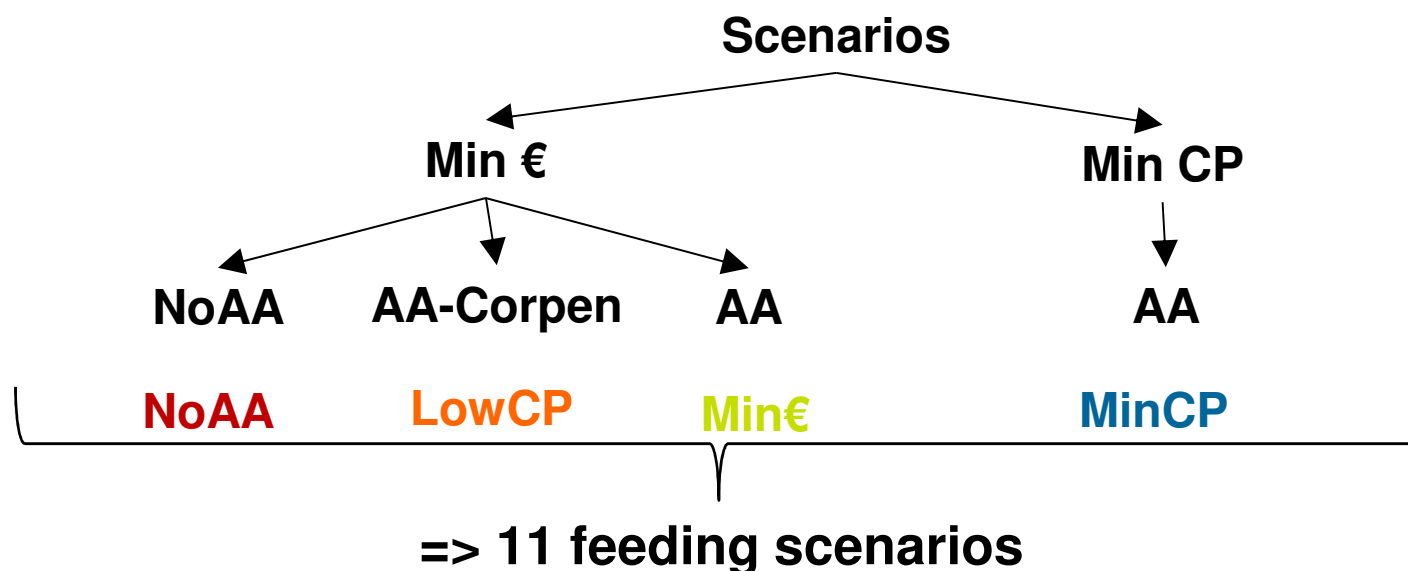
# Flow diagram for the production of pig



**Functional unit:  
Kg of live pig at the  
farm gate**

## Description of formulation scenarios

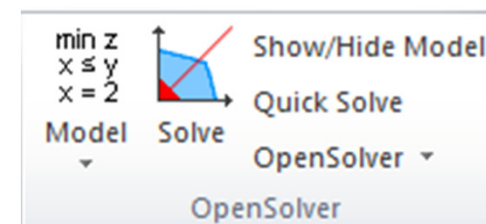
- Farrow-to-finish farm / average performance for Brittany
- Sows and weaners : two feed per stage
- Fattening : single feed (1P) vs. two-phase (2P) vs. Multiphase (MP)



Two types of manure management : slurry (SL) et straw bedding (LI)  
 Protein sources : soybean (SOJ) or soybean-rapeseed-peas (SOJRP)

## Formulation of diets

- Digestible amino-acid requirements , and others nutrients (InraPorc, 2006, Ajinomoto Eurolysine, 2011)
- Fixed Net Energy contents
- **Formulation to achieve the same performance**
- Optimisation of diets using « OpenSolver for Excel » (Mason et Dunning, 2010)



# Minimum nutritional contents for feed formulation

	Sow		Weaned Piglet		Fattening pig				
	Gestating	Lactating	Pre-starter	Starter	1P	Growing 2P	Finishing 2P	Growing MP	Finishing MP
Dry matter (g/kg)	860	860	860	860	860	860	860	860	860
Energy (MJ/kg)	9.0	9.5	10.0	10.0	9.6	9.6	9.6	9.6	9.6
SID AA									
Lysine (g/kg)	4.95	8.30	11.90	10.00	8.65	8.65	7.21	8.80	5.60
Threonine (% Lys)	72%	66%	65%	65%	67%	67%	68%	67%	68%
Methionine (% Lys)	28%	30%	30%	30%	30%	30%	30%	30%	30%
Met + Cystine (% Lys)	65%	60%	60%	60%	60%	60%	60%	60%	60%
Tryptophan (% Lys)	20%	20%	22%	22%	20%	20%	19%	20%	19%
Isoleucine (% Lys)	65%	60%	53%	53%	53%	53%	53%	53%	53%
Valine (% Lys)	75%	85%	70%	70%	65%	65%	65%	65%	65%
Leucine (% Lys)	100%	115%	100%	100%	100%	100%	100%	100%	100%
Phenylalanine (% Lys)	60%	60%	50%	50%	50%	50%	50%	50%	50%
Phe + Tyrosine (% Lys)	100%	115%	95%	95%	95%	95%	95%	95%	95%
Histidine (% Lys)	30%	42%	32%	32%	32%	32%	32%	32%	32%
Arginine (% Lys)	-	67%	42%	42%	42%	42%	42%	41%	42%
Minerals (g/kg)									
Digestible P	2.50	3.30	5.00	3.80	2.50	2.50	2.00	2.50	2.00
Ca <sup>1</sup>	9.00	10.50	13.50	11.00	7.25	7.25	7.25	7.25	7.25



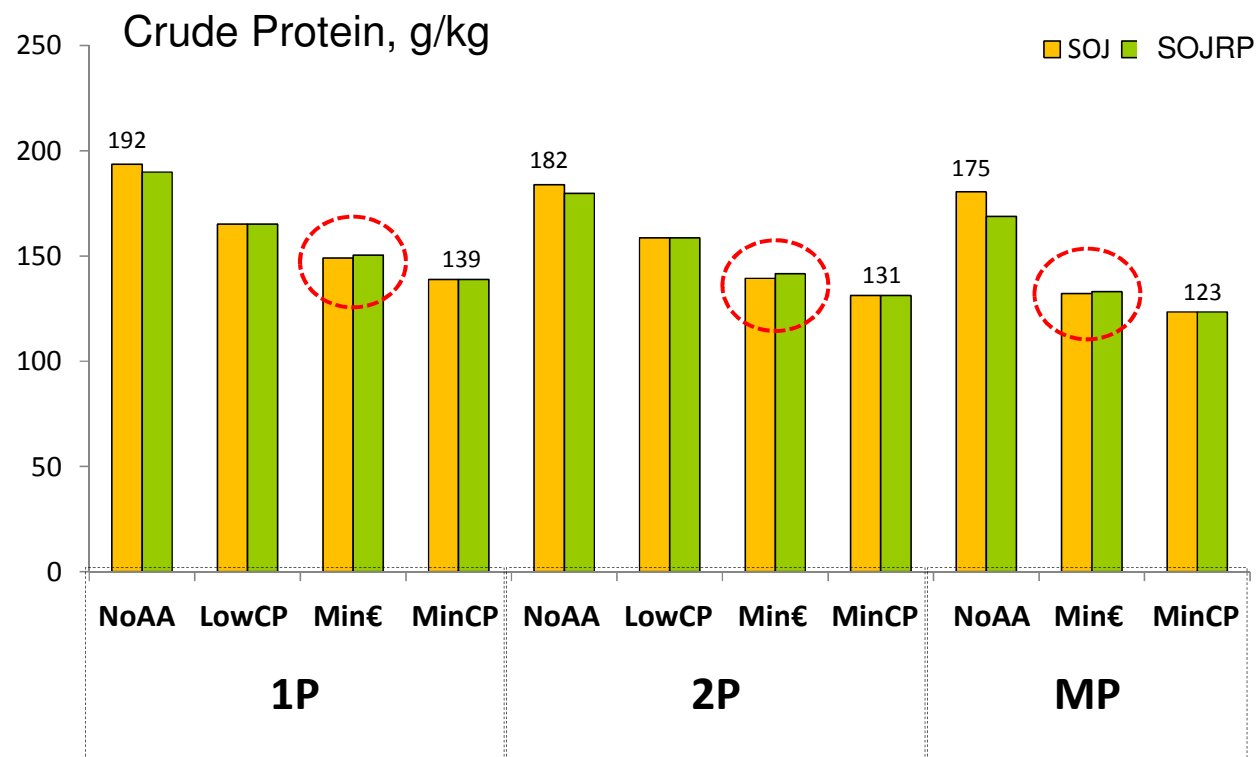
## Main inputs used, yield and nitrate-N emitted for the main crops used as feed ingredients

		Maize Brittany	Wheat France	Barley France	Pea France	Rapeseed France	Soybean Brazil C. West	Soybean Brazil South
N mineral fertiliser	kg/ha	32	165	130	0	165	9	0
N manure	kg/ha	210	10	10	0	16	0	5
P <sub>2</sub> O <sub>5</sub>	kg/ha	29	26	37	44	50	90	58
K <sub>2</sub> O	kg/ha	0	24	34	69	50	90	58
CaO	kg/ha	167	167	167	167	167	450	250
Seed	kg/ha	20	140	125	240	3	55	50
Pesticide	kg/ha	1.05	1.97	8.96	5.67	1.13	2.50	2.10
Diesel	kg/ha	85	83	84	89	92	80	67
Agricultural machinery	kg/ha	21.7	18.6	18.7	22.0	20.4	19.5	15.1
Irrigation water	m <sup>3</sup> /ha	0	0	0	88	0	0	0
Moisture at harvest	%	32	15	15	15	8	14	14
Reference moisture	%	15	15	15	15	8	13	13
Yield (dry matter)	kg/ha	6860	6010	5520	3550	3040	2400	2180
Nitrate-N emitted	kg/ha	40	40	40	70	40	16	21

# Potential environmental impacts due to the production and delivery of feed ingredients

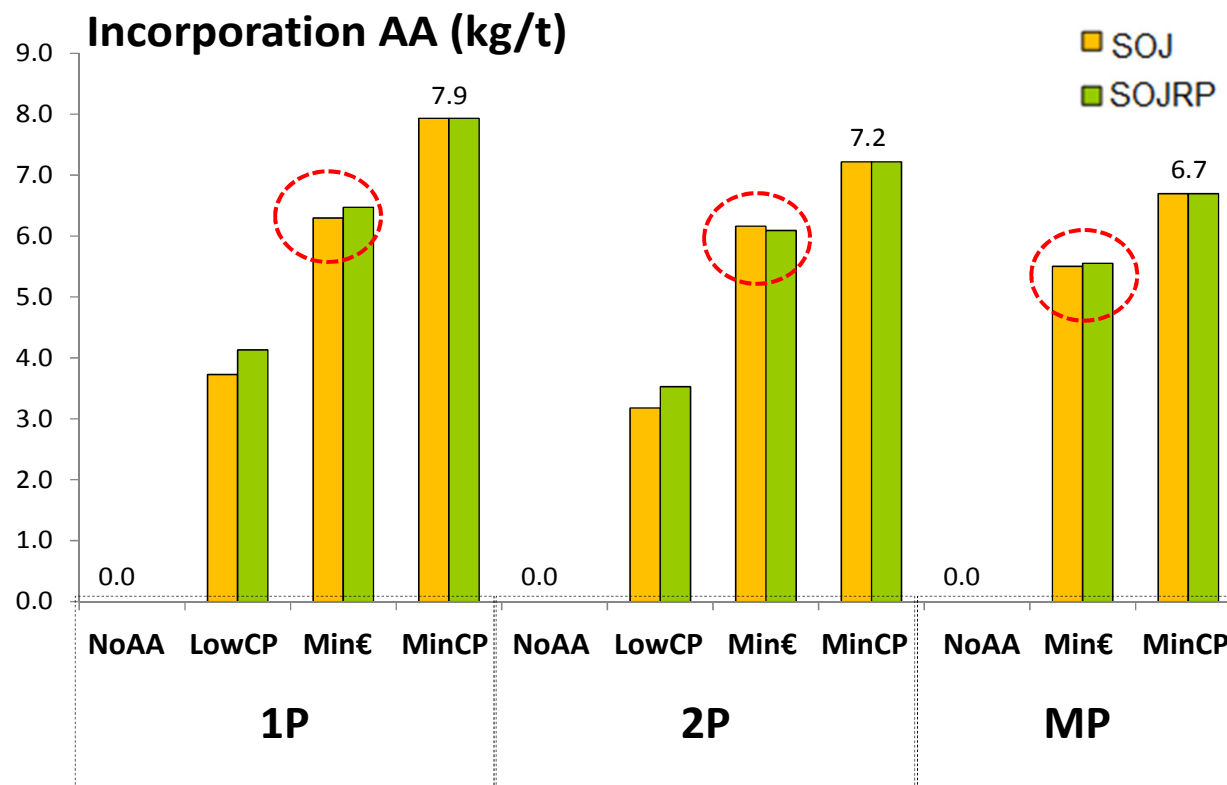
Feed ingredients	Climate change	Eutrophication	Acidification	Terrestrial ecotoxicity	Cumulative energy	Land occupation
	(kg CO <sub>2</sub> -eq.)	(g PO <sub>4</sub> -eq.)	(g SO <sub>2</sub> -eq.)	(g 1.4-DCB-eq.)	(MJ)	(m <sup>2</sup> year)
Wheat France	0.54	4.0	4.4	1.6	3.6	1.44
Maize France Brittany	0.43	4.0	5.2	7.4	3.1	1.26
Barley France	0.50	4.2	4.1	1.6	3.6	1.58
Wheat bran France	0.26	1.7	2.0	1.1	2.5	0.60
Pea France	0.37	9.0	1.7	1.7	4.0	2.56
Rapeseed meal France	0.52	4.0	4.4	2.3	4.3	1.39
Rapeseed oil France	1.95	15.7	16.9	8.8	15.4	5.57
Soybean meal Brazil						
Centre West	1.87	5.8	6.9	4.1	12.7	1.52
Average mix	1.47	5.8	6.3	3.6	11.2	1.56
Extruded soybean Brazil						
Centre West	2.15	7.0	7.7	5.2	13.7	1.85
Average mix	1.67	7.0	7.0	4.7	12.0	1.91
L-lysine.HCl / L-threonine	4.30	9.6	13.8	23.3	119.2	2.37
L-tryptophan / L-valine	8.54	19.2	27.4	46.4	237.5	4.74
DL-methionine	3.05	1.6	7.2	3.0	90.9	0.01
Whey powder France	1.32	0.3	1.2	0.6	23.1	0.00
Phytase	1.90	2.2	4.8	0.0	26.0	0.15
Monocalcium phosphate	1.17	16.1	30.7	7.6	17.7	0.31
Salt	0.19	0.7	1.0	1.3	3.5	0.02
Calcium carbonate	0.04	0.0	0.2	0.1	0.8	0.00
Premix	0.04	0.0	0.2	0.1	0.8	0.00

# Average CP content of diets according to the feeding scenarios



**Least-cost formulation without minimal CP constraints**

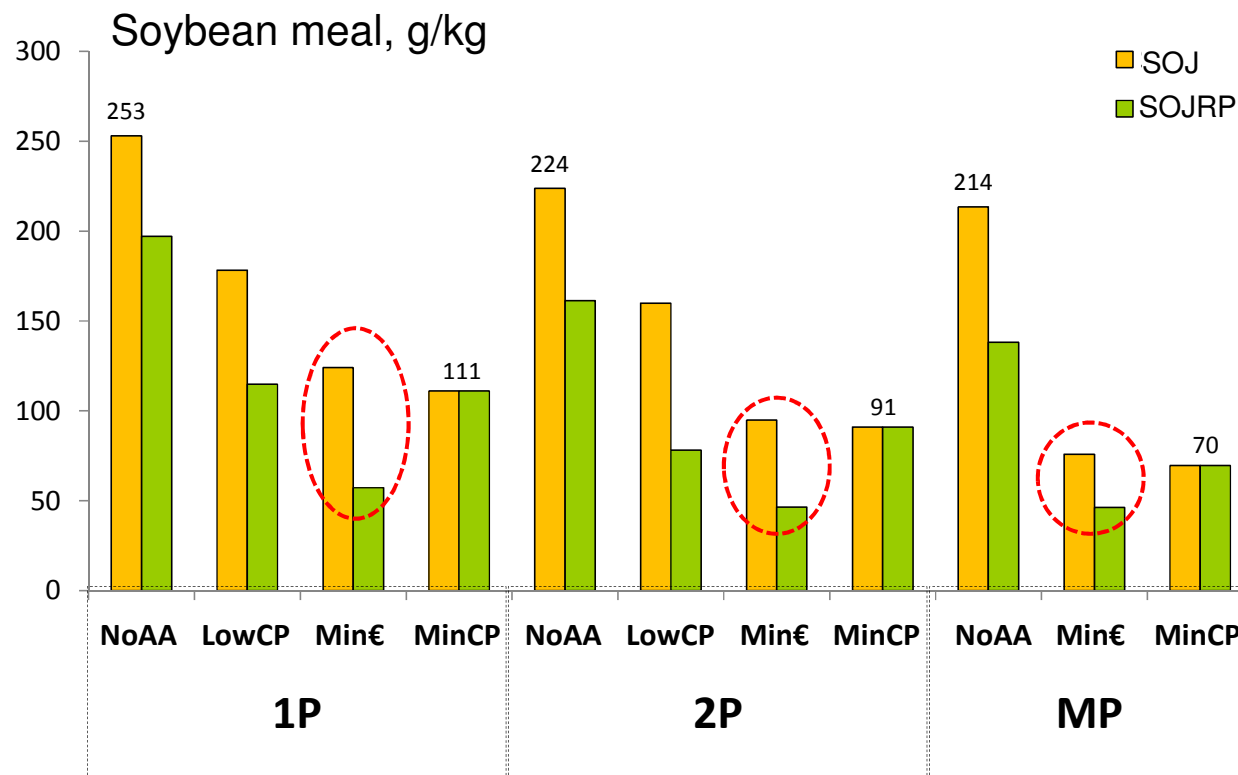
# Average incorporation of feed-use AA according to the feeding scenario



**Least-cost formulation without minimal CP constraints**

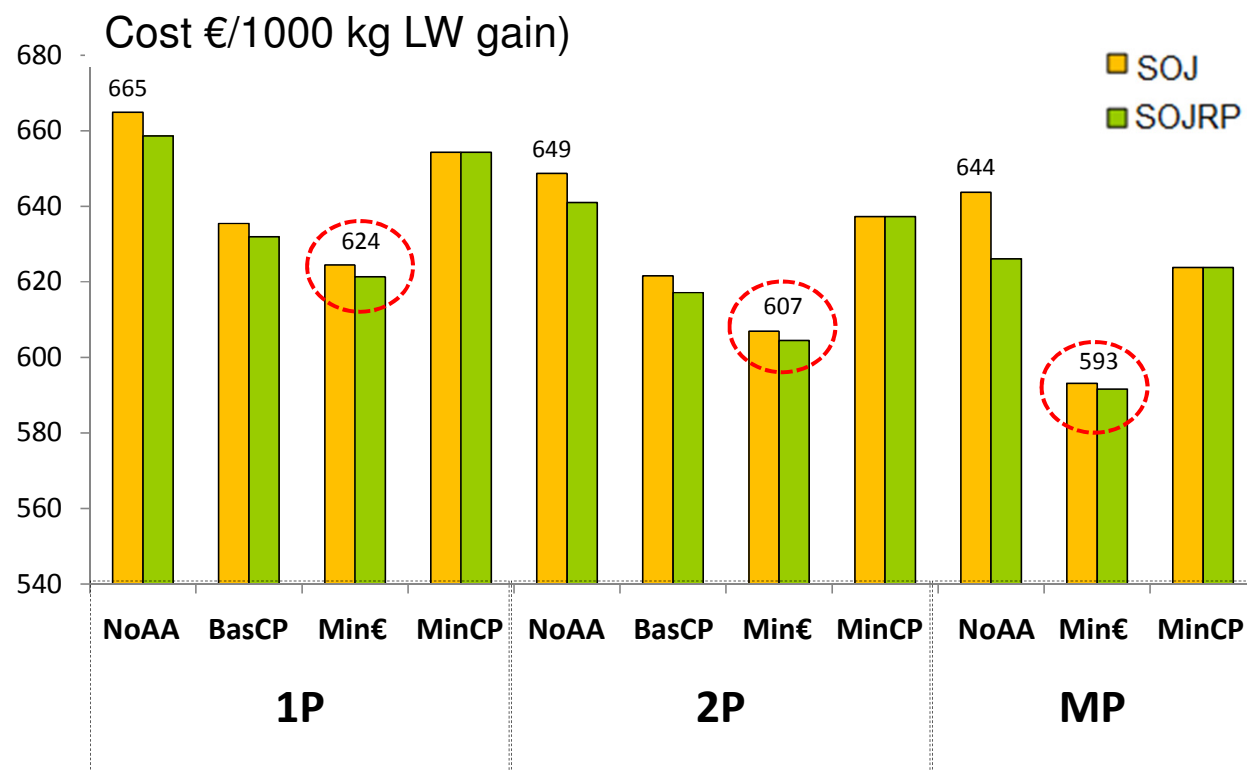


## Average incorporation of soybean meal according to the feeding scenario



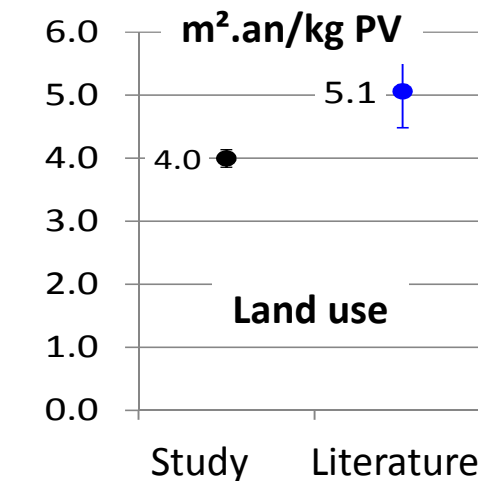
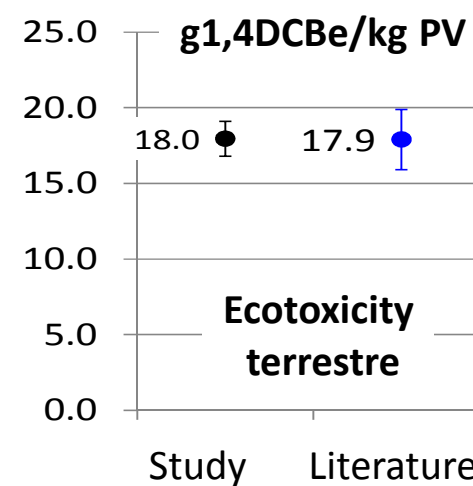
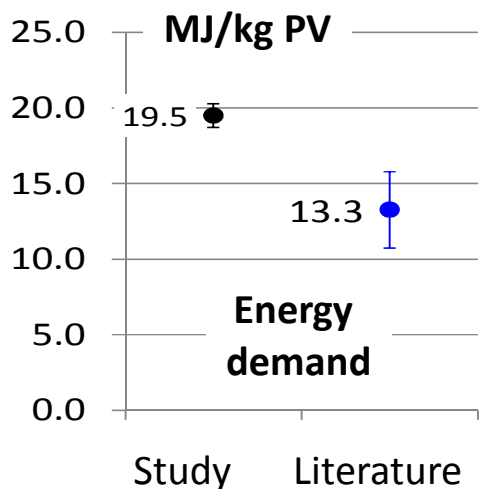
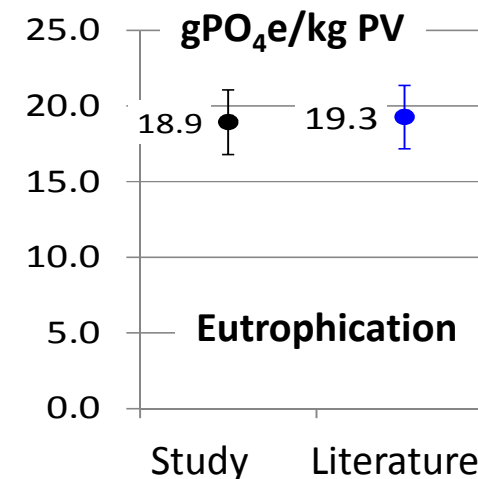
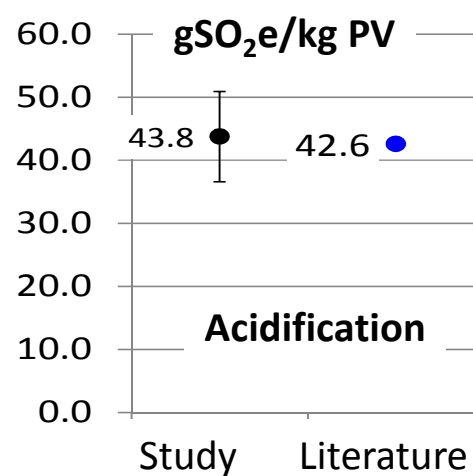
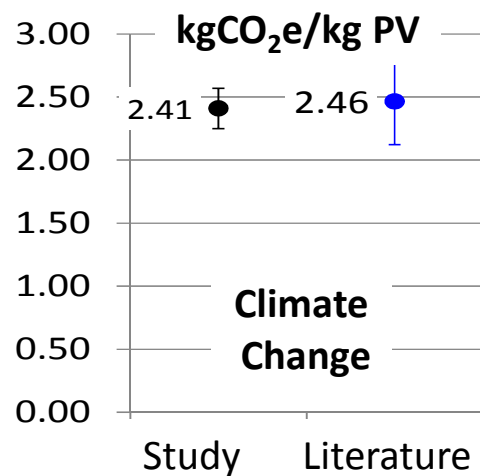
**Least-cost formulation without minimal CP constraints**

## Average feeding cost according to the feeding scenario



**Least-cost formulation without  
minimal CP constraints**

# Comparison to literature results



# Reduction of impacts per kg of live pig - for two-phase feeding using soybean/rapeseed/peas -

## slurry

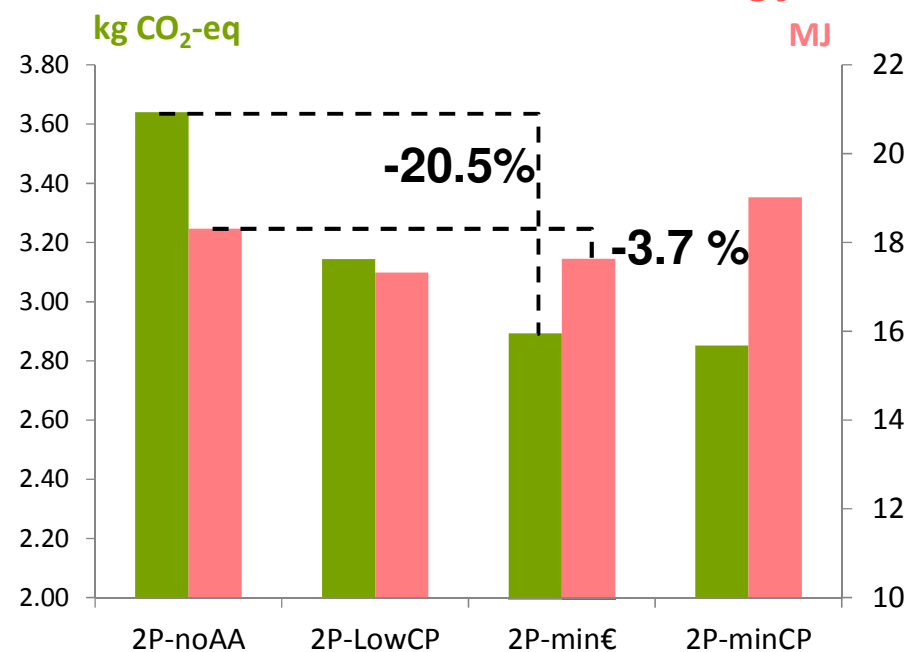
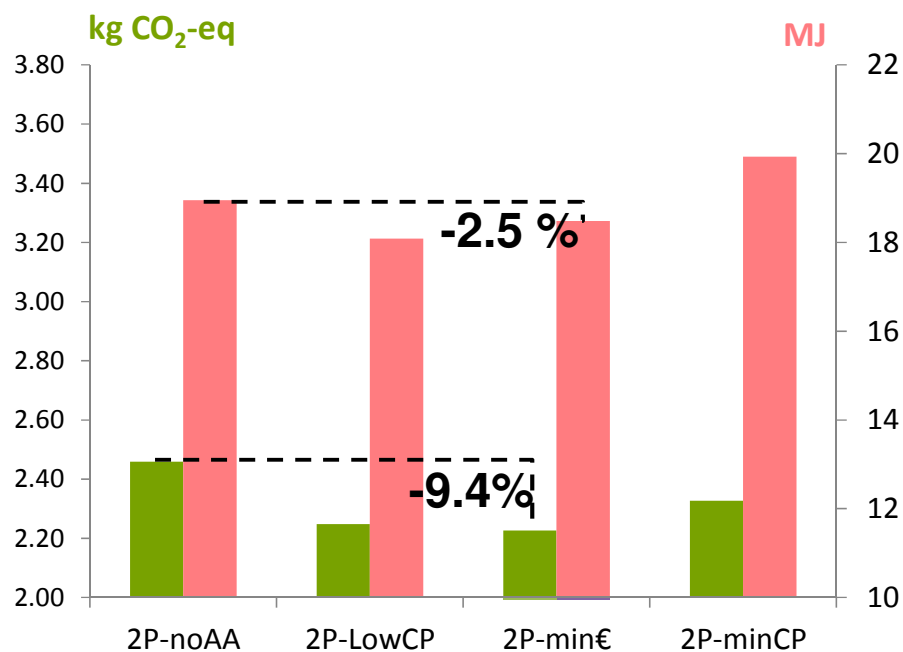
## Straw bedding

### Climate Change

### Energy

### Climate Change

### Energy



# Reduction of impacts per kg of live pig - for two-phase feeding using soybean/rapeseed/peas -

## slurry

## Straw bedding

### Acidification

### Eutrophication

### Acidification

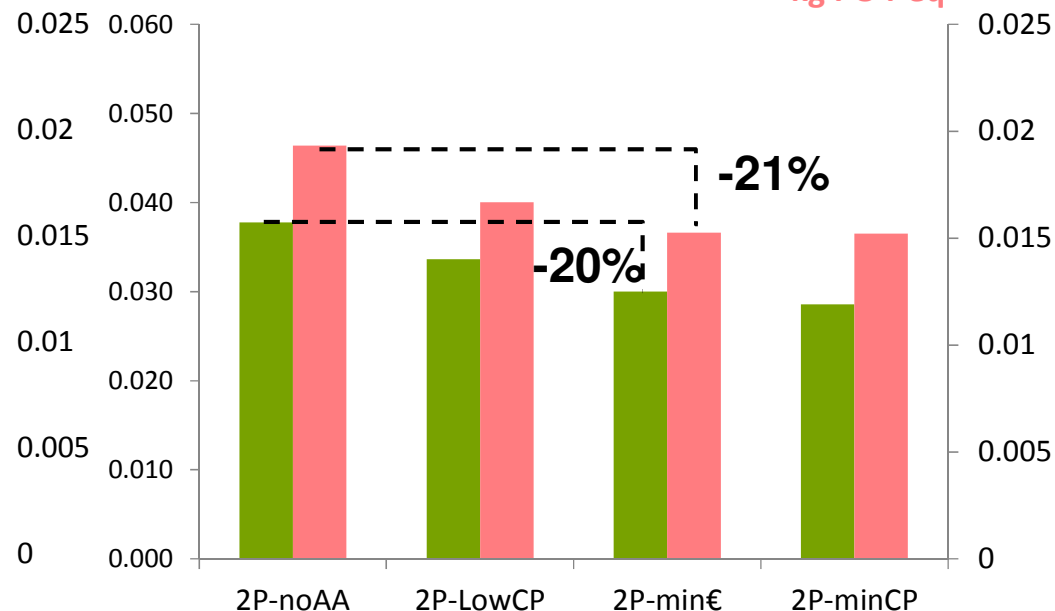
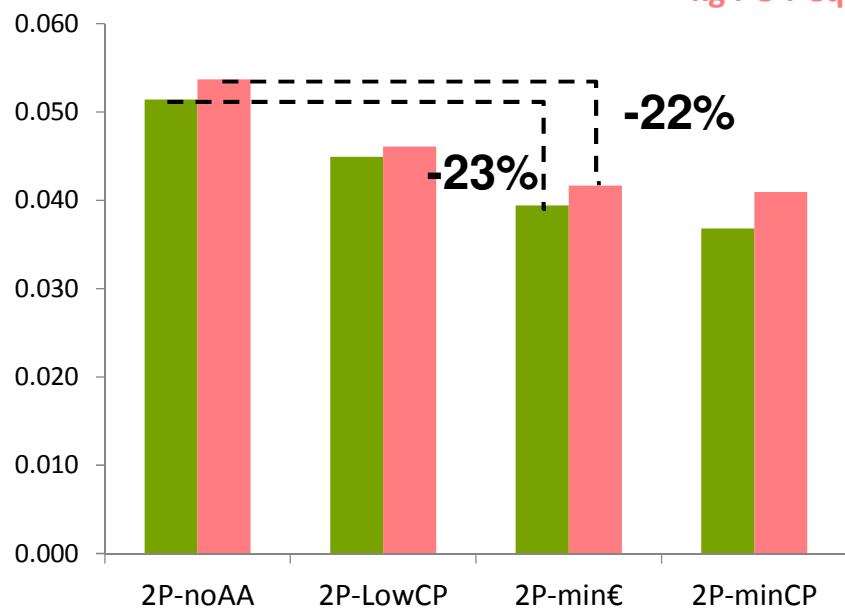
### Eutrophication

kg SO<sub>2</sub>-eq

kg PO<sub>4</sub>-eq

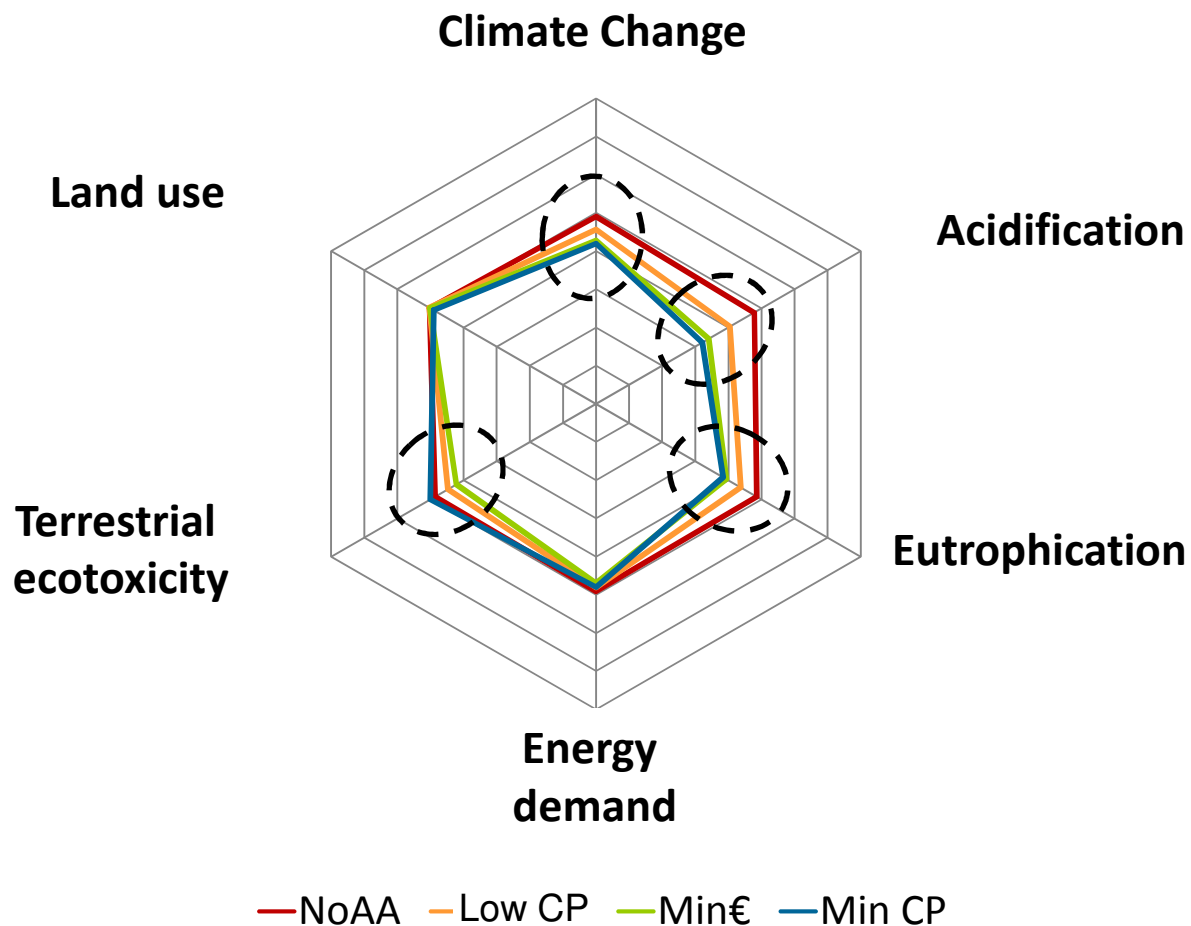
kg SO<sub>2</sub>-eq

kg PO<sub>4</sub>-eq

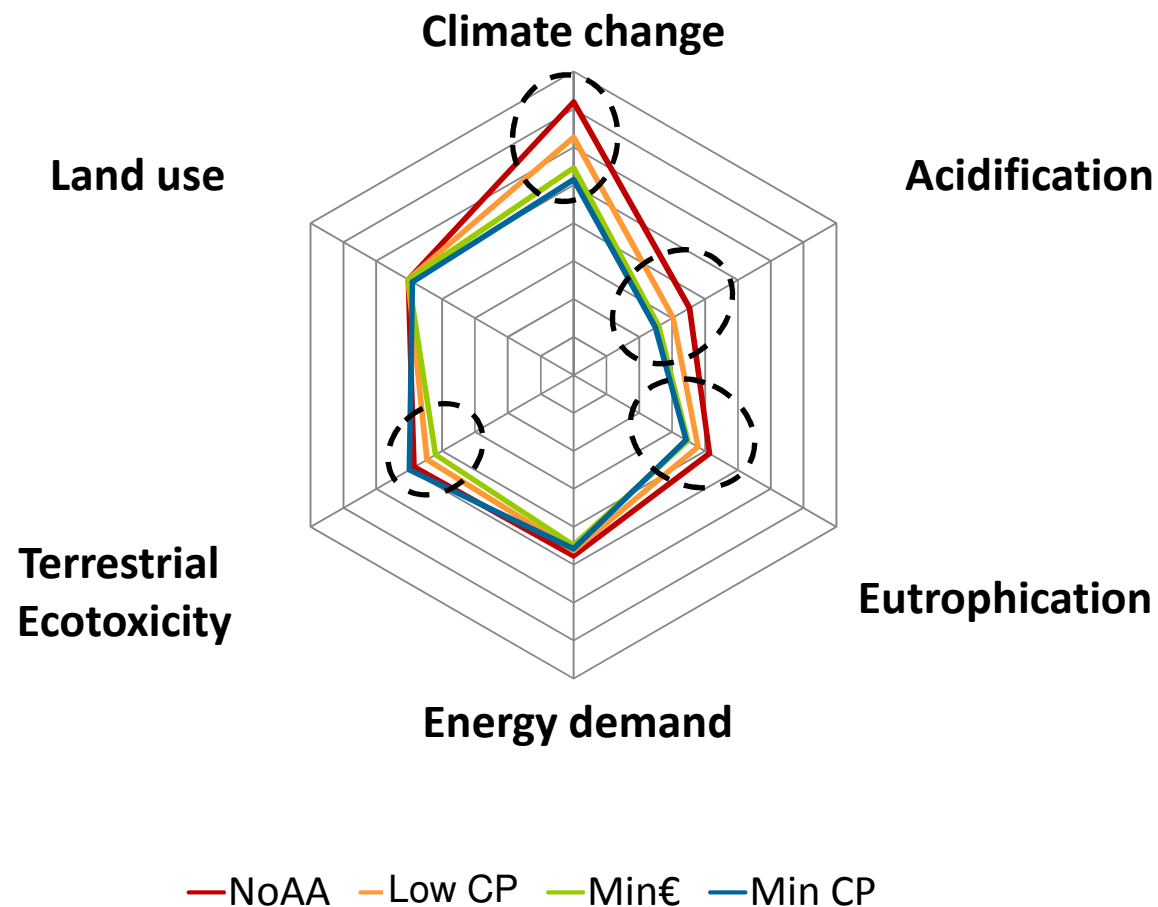


# Impacts for the different scenarios

## - Slurry -

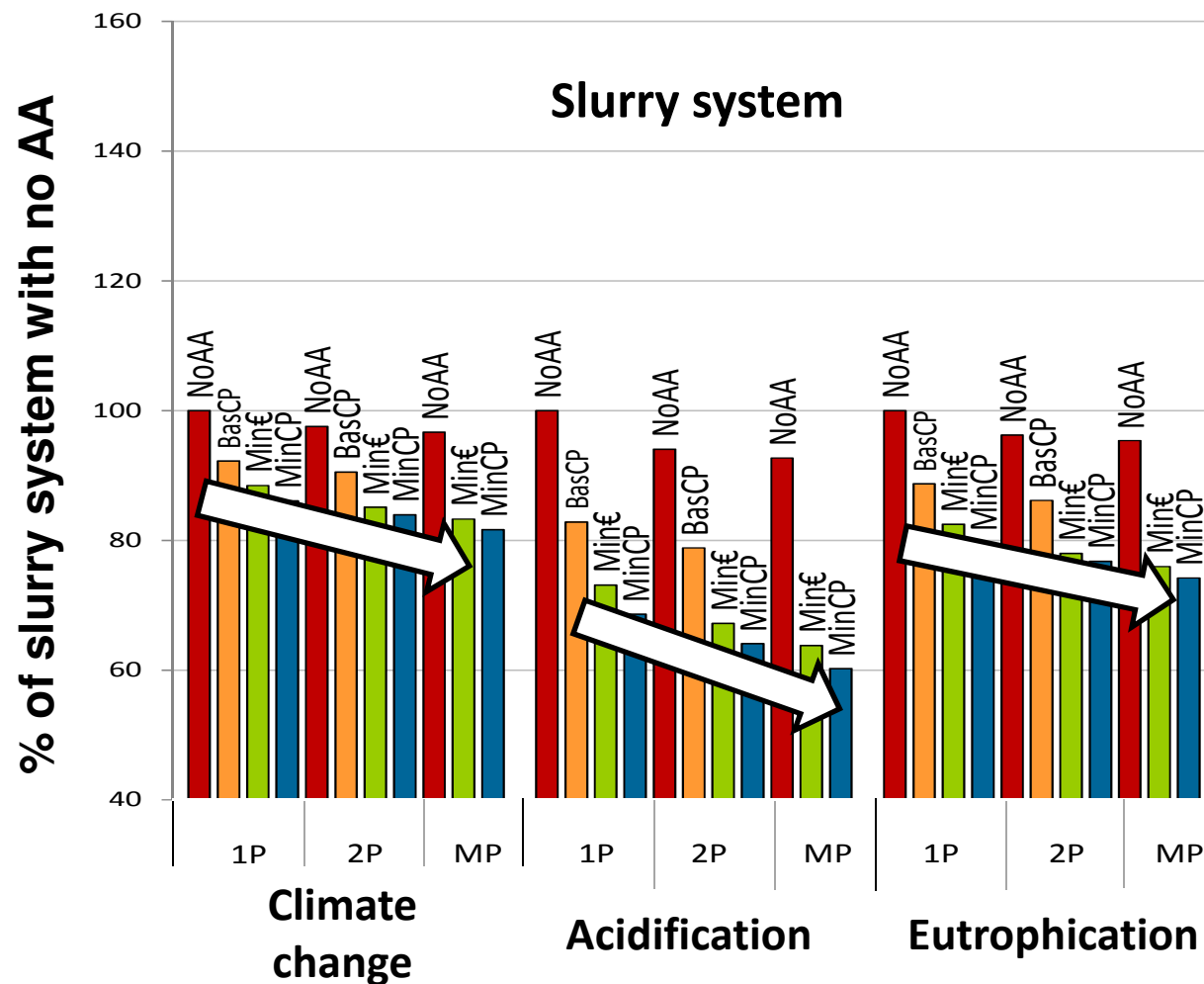


# Impacts of the different scenarios - straw bedding -

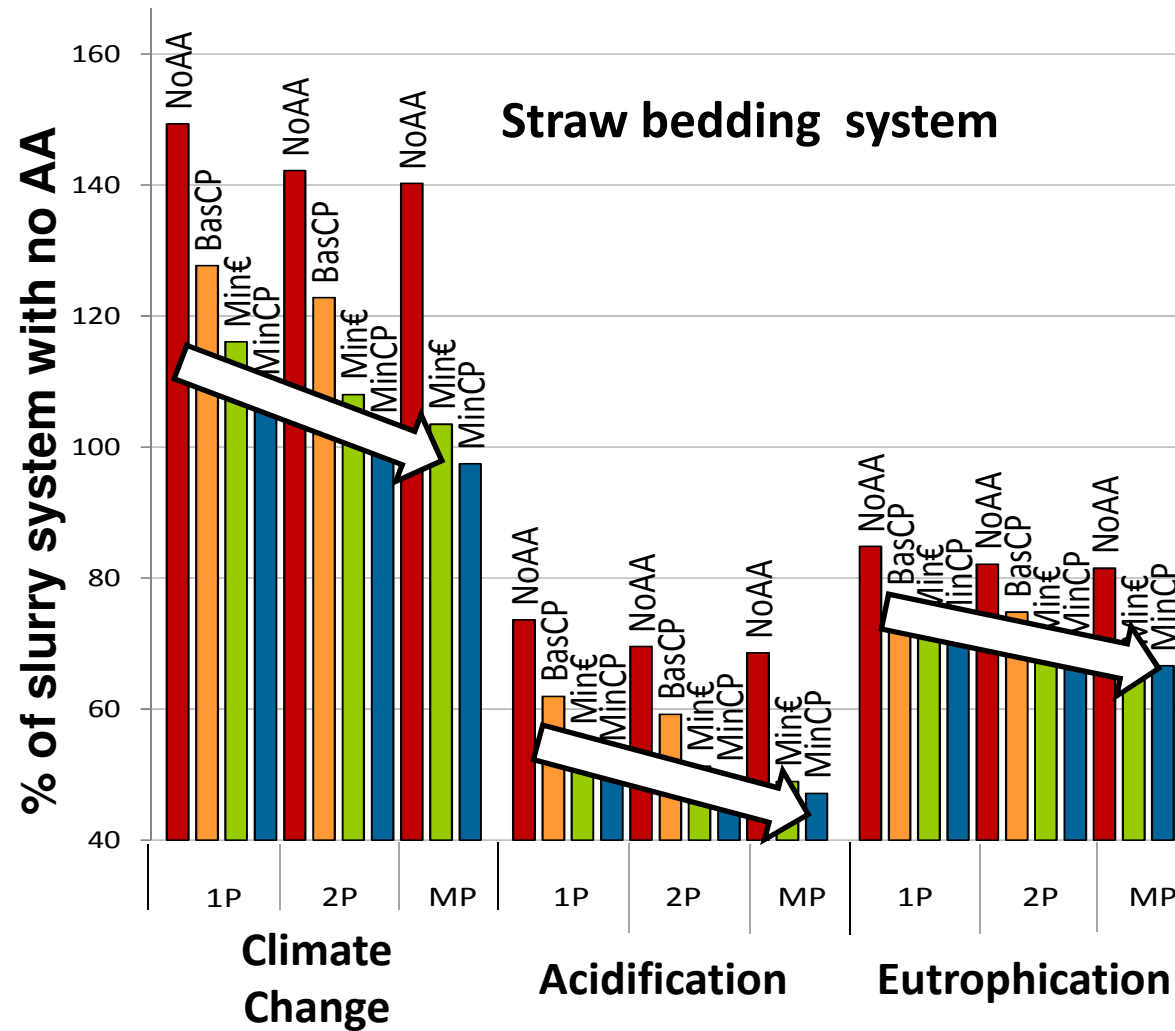




## Synergy between AA supp. & phase feeding



# Synergy between AA supp. & phase feeding



## Intermediate Conclusion

- Substitution of soybean meal by cereals and feed-use AA reduces the environmental impacts per kg pig produced especially for acidification, eutrophication and climate change
- Least cost formulation with incorporation of feed-use AA reduces both environmental impacts and feed cost whilst maintaining performance
  - **interest of suppressing minimal protein constraints**
- Synergy between «incorporation of feed-use AA» and «multiphase feeding»
  - **Maximal reduction of impacts**
  - **Potential of precision feeding to be evaluated**



# Mitigating GHG emissions of pig farms by reducing the protein content of feeds: strategies and perspectives

F. Garcia-Launay, J-Y. Dourmad, P. Faverdin, S. Espagnol

INRA UMR1348 PEGASE, Saint-Gilles  
IFIP, Le Rheu



QUELLE CONTRIBUTION DE L'AGRICULTURE FRANÇAISE  
À LA RÉDUCTION DES ÉMISSIONS DE GAZ À EFFET DE SERRE ?

POTENTIEL D'ATTÉNUATION ET COÛT DE DIX ACTIONSTÉCHNIQUES

Résumé du rapport de l'étude réalisée par l'INRA  
pour le compte de l'ADEME, du MAAF et du MEDDE - Juillet 2013



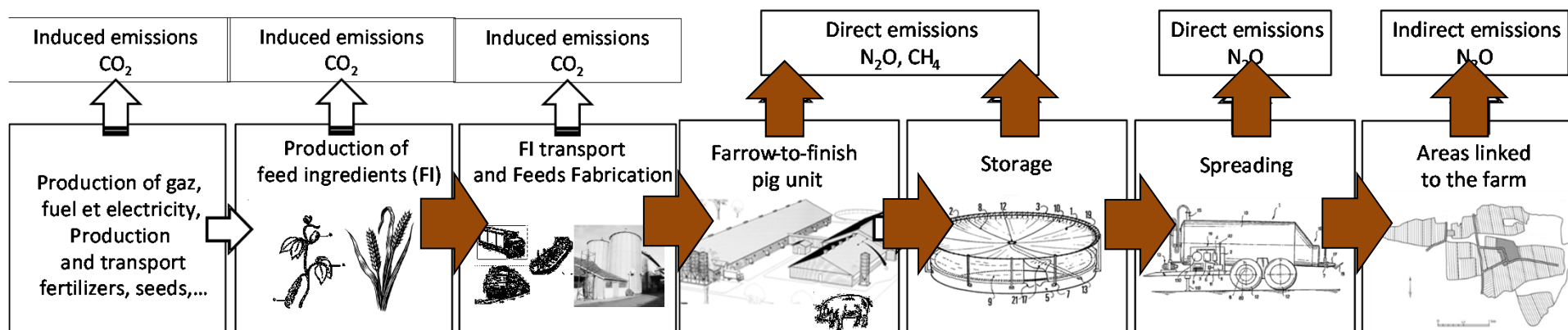


## Strategies investigated | France

Reference 2010	2PMin€	MPMin€
<p>Protein content of pig feeds in accordance with recommendations Corpen 2003 (LowCP)</p> <p>80% of pig farms with two-phase feeding for growing-finishing</p>	<p>Increased utilization of feed-use amino-acids and 100% of farms with two-phase feeding for growing-finishing</p>	<p>Increased utilization of feed-use amino-acids and 100% of farms with multiphase feeding for growing-finishing</p>
<p>Least-cost formulation with minimum amino-acids contents to cover the requirements</p>		



# Inventory of emissions



## Impacts of feed ingredients :

*Nguyen et al.*  
*Mosnier et al.*  
*Garcia-Launay et al.*  
 Dia'Terre



## N intake

N excreted

## Inventory of direct and indirect emissions

EMEP/EEA air pollutant emission inventory  
 guidebook 2009

European Environment Agency



# Functional unit and Hypothesis of strategy adoption

**Least-cost formulation**  
**Free protein content**



**/sow and production / year**

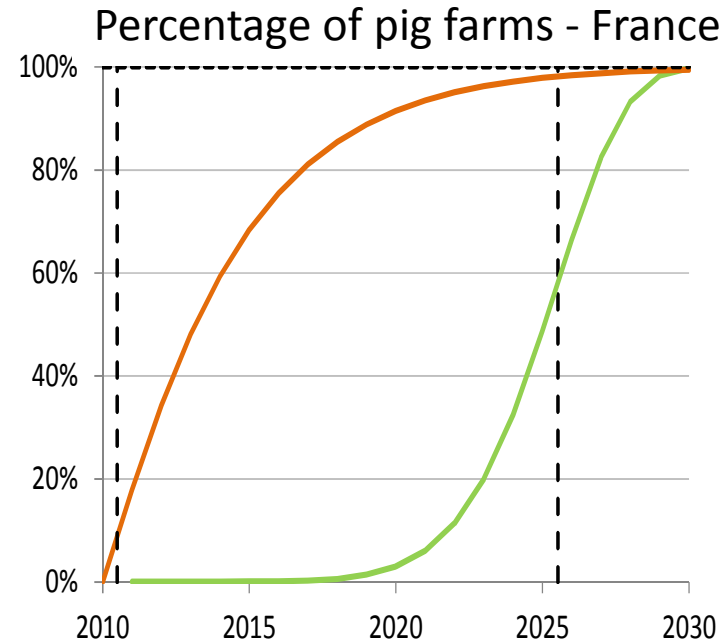
**28.2 weaned piglets /sow / year**  
**26.6 pigs/sow/year**



**Calculation of the mitigation potential  
per sow and per year**

**X**

**Sows in France 2010**



— MPMIn€

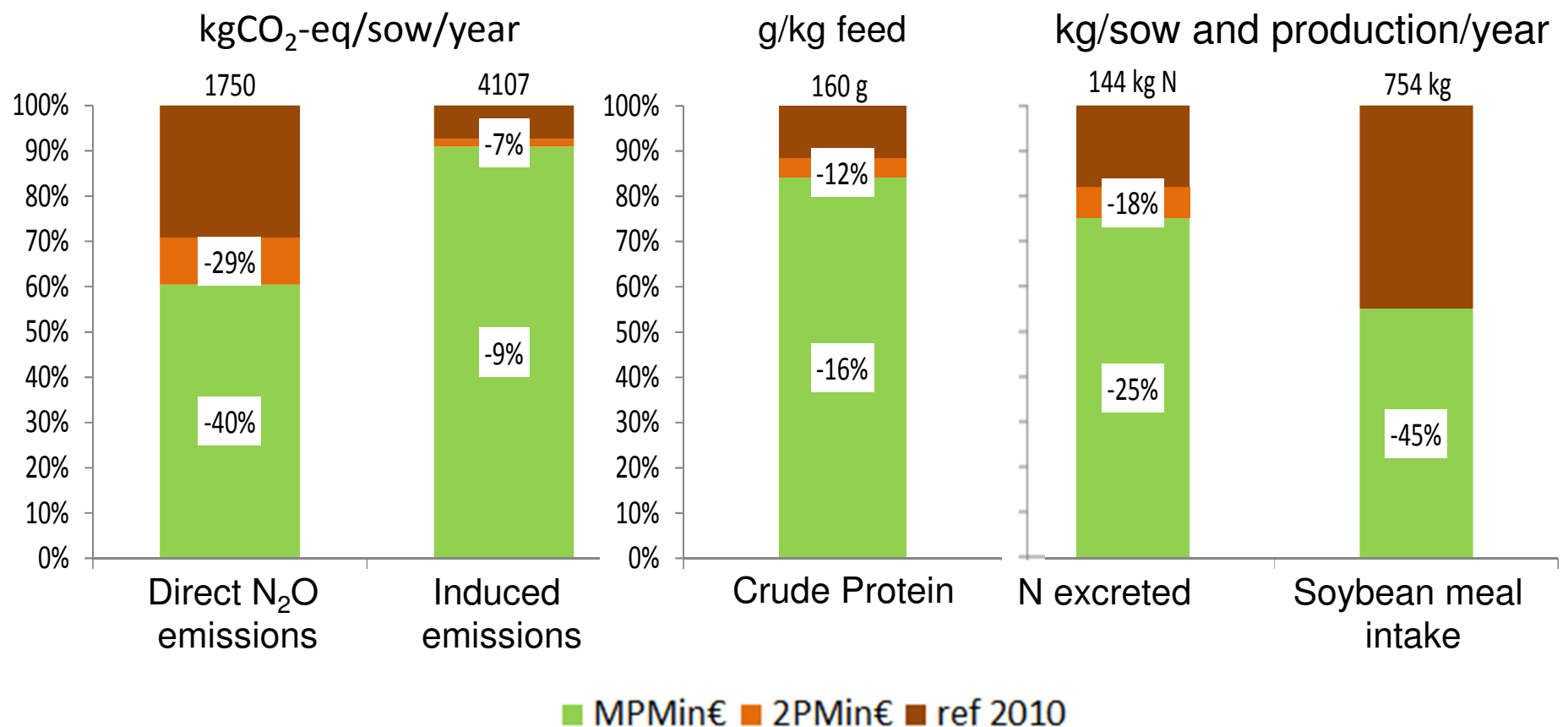
— 2PMin €



**Mitigation France 2030**  
**Cumulated mitigation France 2010-2030**



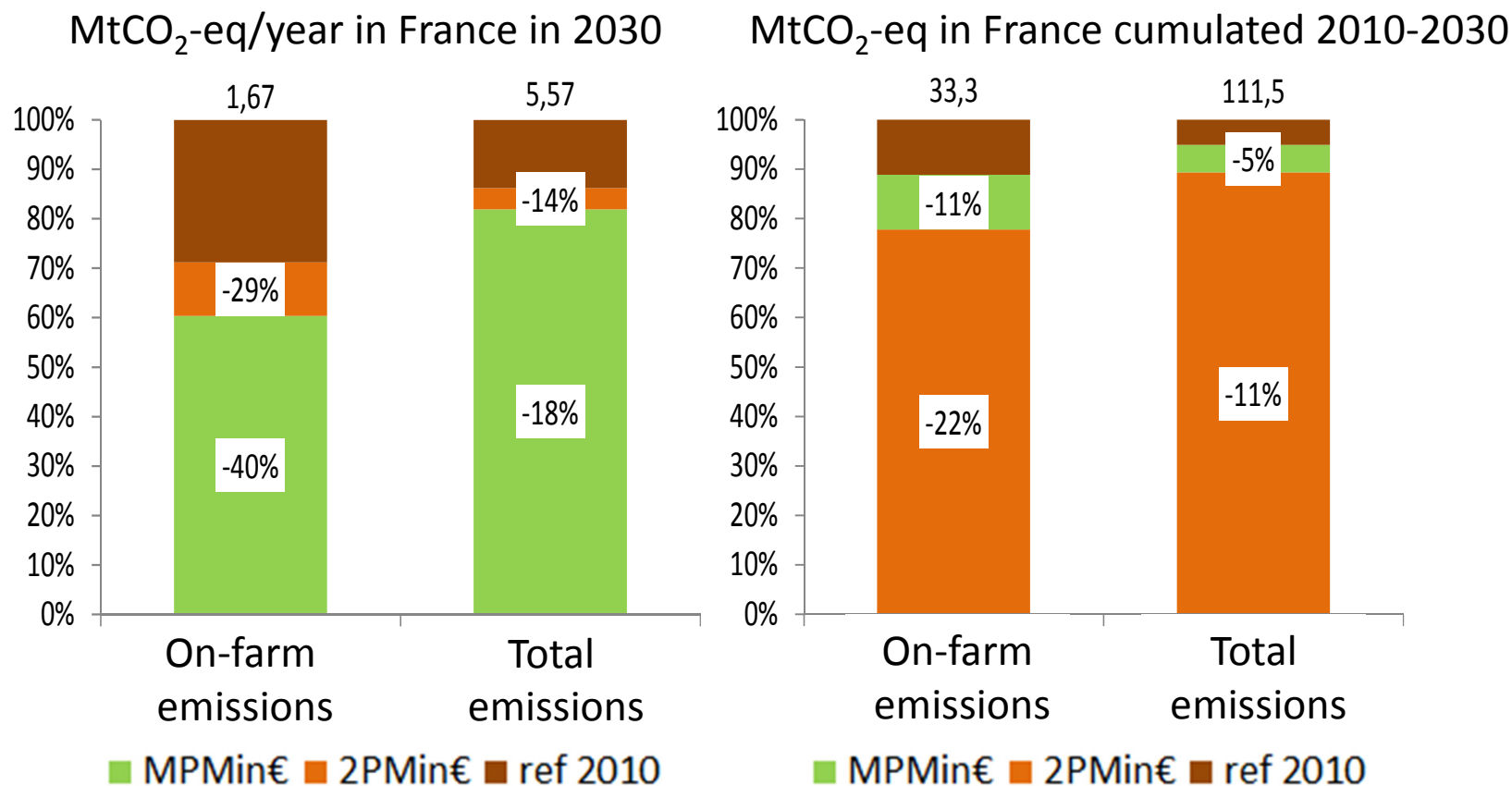
## Mitigation of GHG emissions



**MPMin€ → Improved reduction of emissions through the reduction of protein supply**



# Abatement potential until 2030



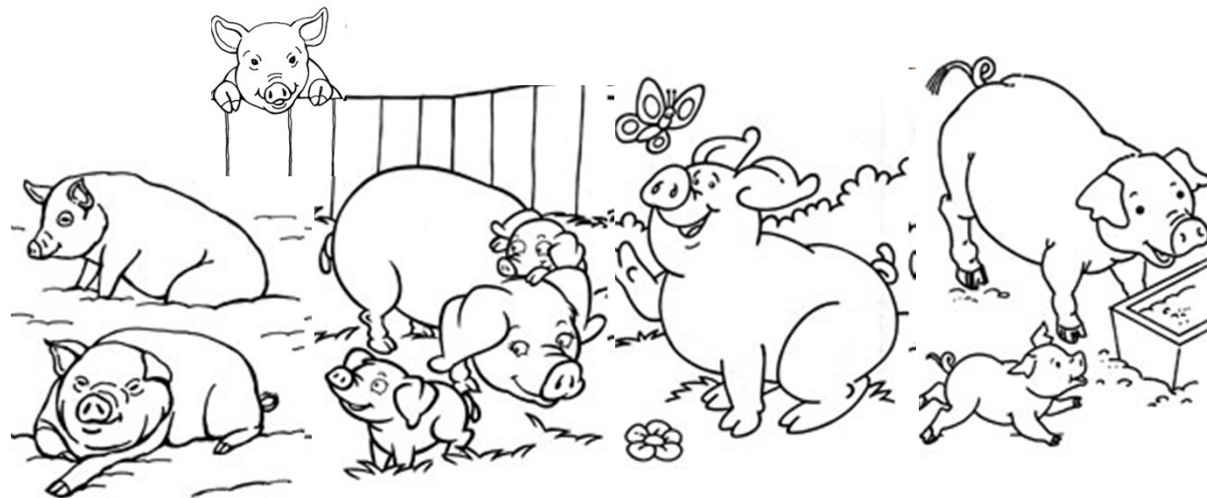
**Cumulated mitigation 2PMin€ > MPMIn€ because of the adoption hypothesis for MPMIn€**



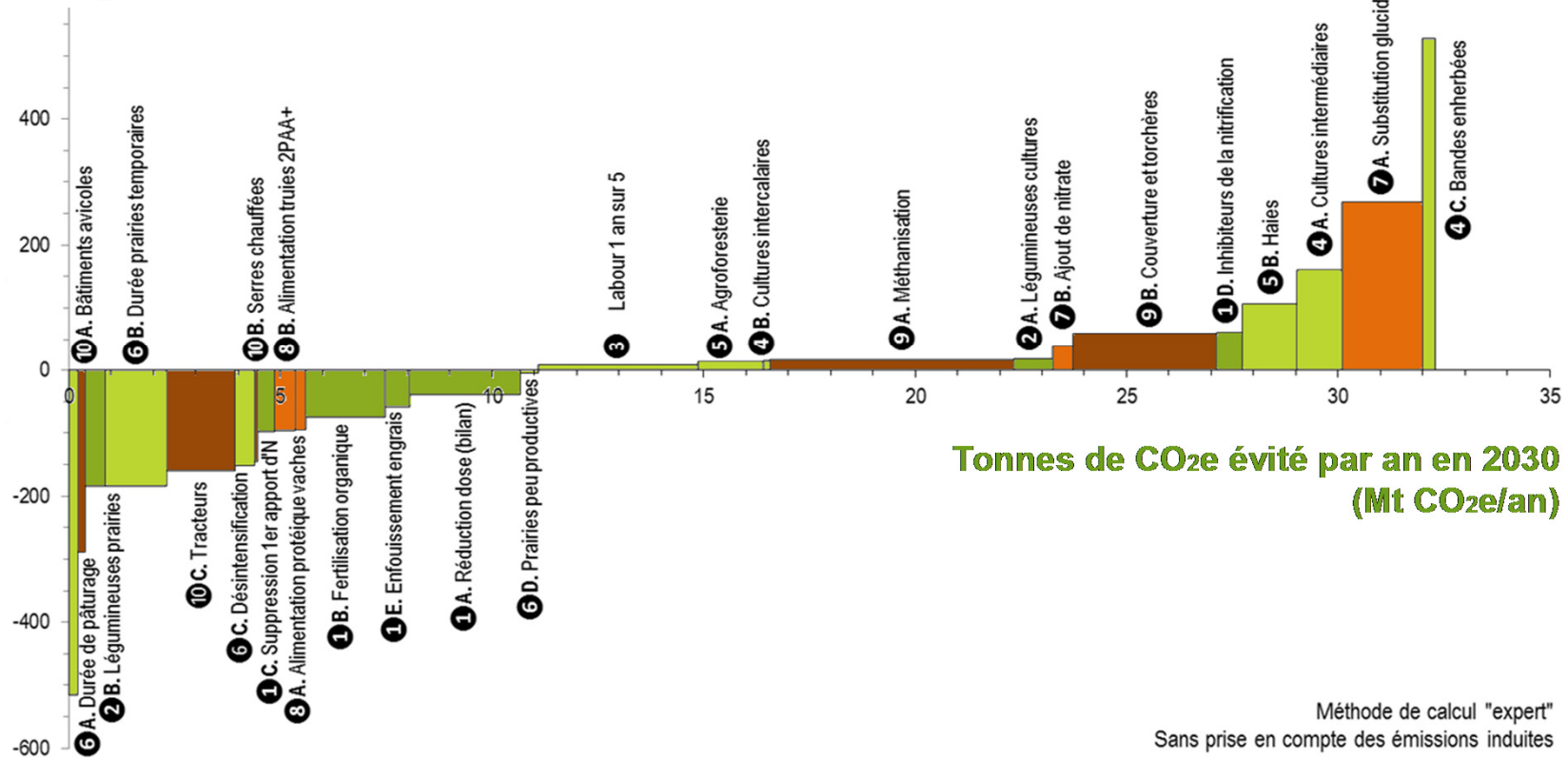
- Least cost formulation with incorporation of feed-use AA  
 → **win-win strategies** :
  - ↘ **various impacts**
  - ↘ **both induced and on-farm emissions (at least for GHG)**
  - ↘ **Feed cost**
- Abatement of GHG emissions at negative cost :
  - 2PMin€: -96€/tCO<sub>2</sub>-eq**
  - MPPMin €: -72€/tCO<sub>2</sub>-eq**
- Decision support tools and training | and to demonstrate the improvements



# Thank you for your attention



## Coût annuel de la tonne de CO<sub>2</sub>e évité (€/tCO<sub>2</sub>e)



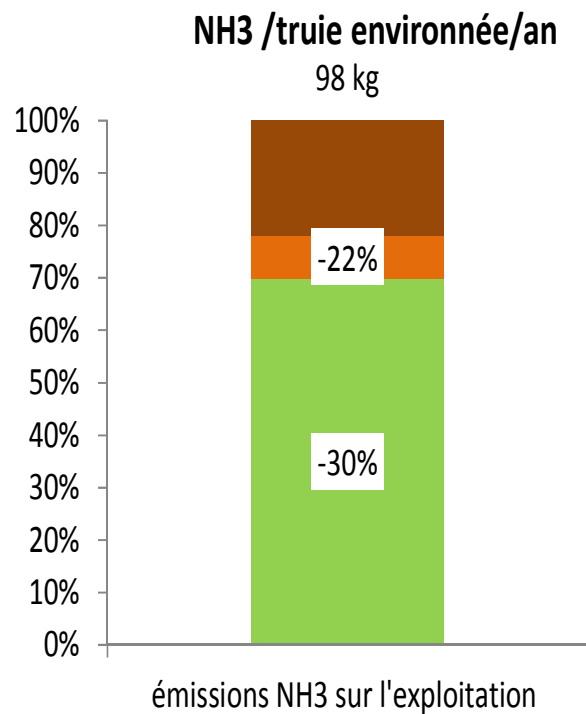






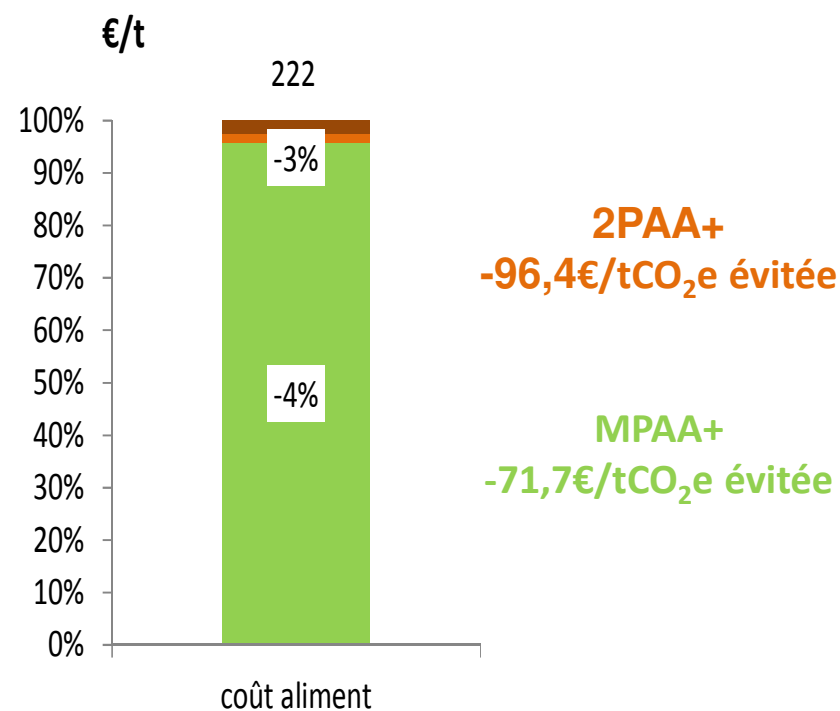


# Win-win strategies



■ MPAA+ ■ 2PAA+

↘ **eutrophication, acidification...**  
*Garcia-Launay et al. 2014*



■ MPAA+ ■ 2PAA+ ■ 2010

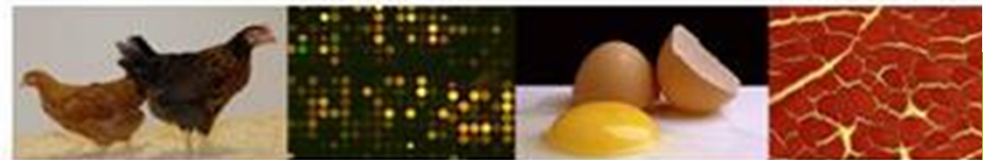
↘ **coûts d'alimentation**  
*Garcia-Launay et al. 2014*

Some results on broilers feed  
*Evaluation of the environmental implications of the  
incorporation of feed-use amino acids in the  
manufacturing of pig and broiler feeds using LCA*

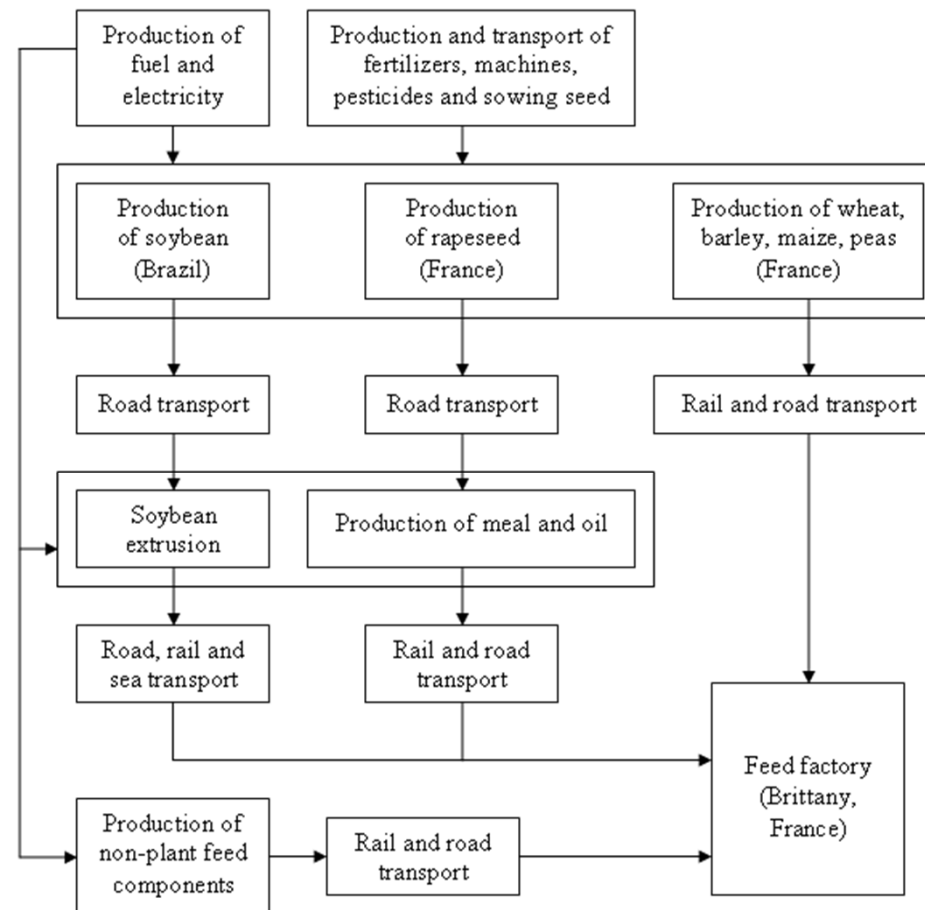
***E. Mosnier, H. van der Werf, J. Boissy,  
Jean-Yves Dourmad***

INRA Agrocampus Ouest  
UMR Pegase, UMR SAS  
35590 Saint-Gilles, France

Ref : Animal (2011), 5:12, pp 1972–1983



# Description of the system



# Simulation of broilers feeds

## Six feeding strategies

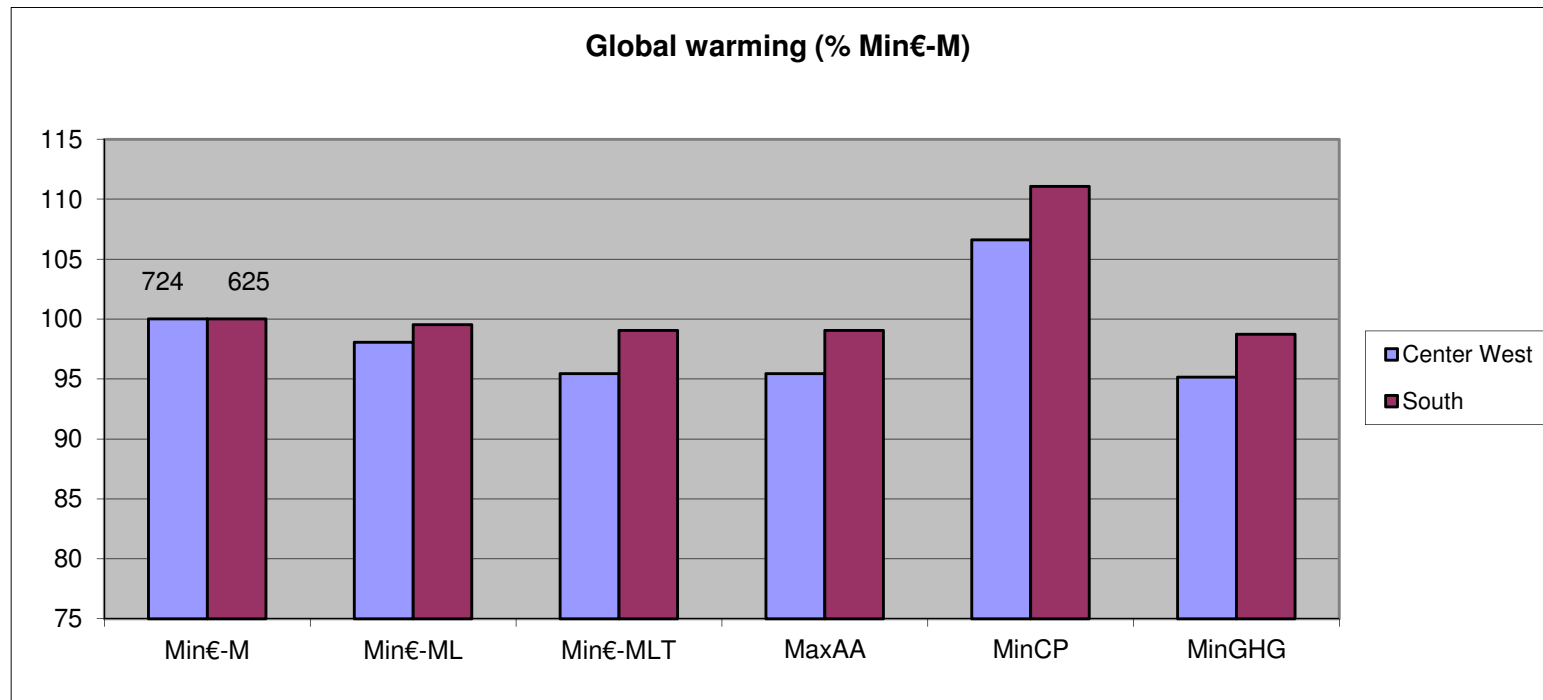
1. a starter feed with 3 AA, a growing and a finishing feed with incorporation of FU-Methionine (Min€-M),
2. a starter feed with the 3 AA, a growing and a finishing feed with incorporation of FU-Methionine and L-Lysine.HCl (Min€-ML)
3. a starter, a growing, and a finishing feed with incorporation of the 3 AA (Min€-MLT).
4. maximize the AA incorporation (MaxAA)
5. minimize the CP content (MinCP) with AA incorporation
6. minimize the emission of greenhouse gas (1F-noAA),

## Four contexts for feed ingredients

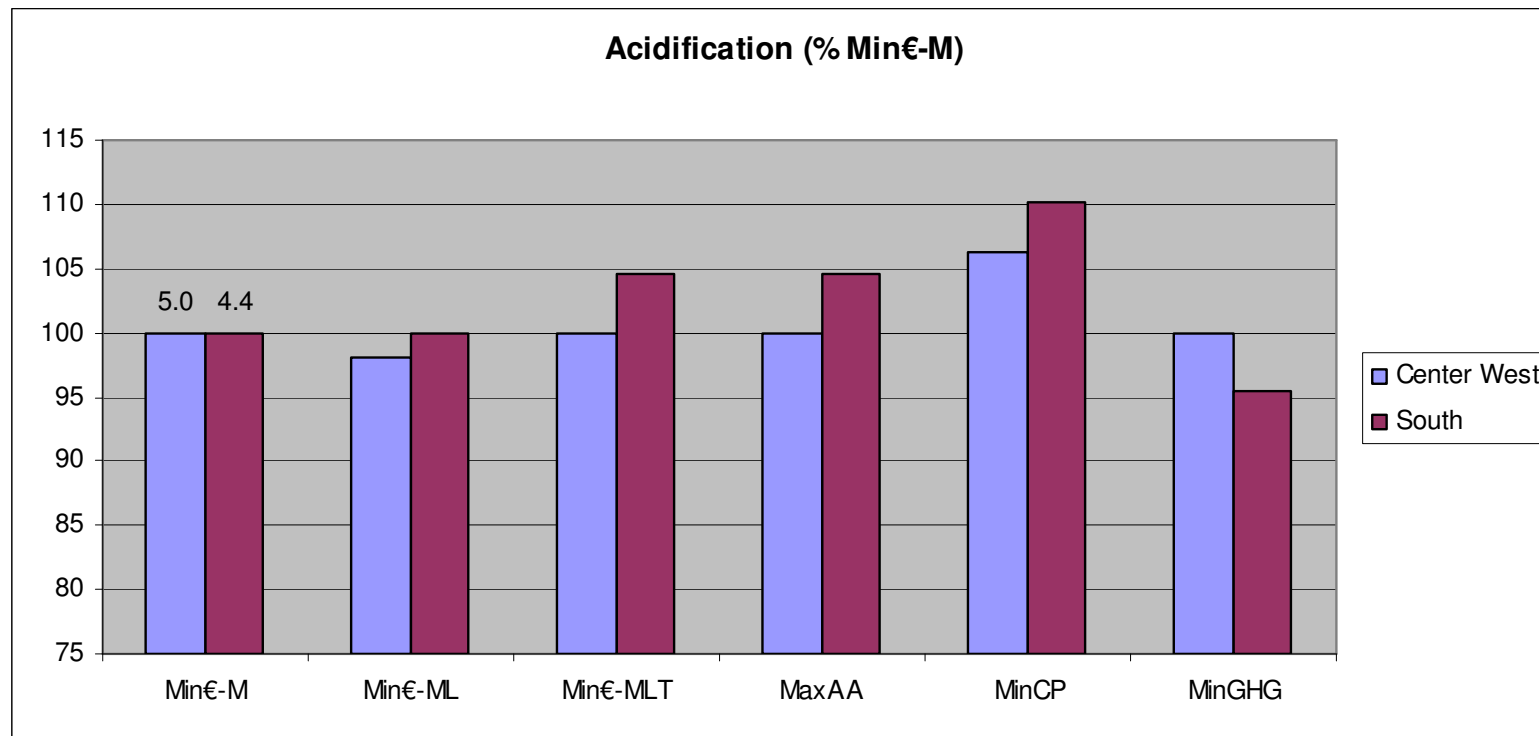
- 2 types of soybean meal (associated or not with deforestation)
- 2 origins for Maize (west or south of France)
- 2 protein sources (SBM only or SBM + RSM + Peas)

=> 48 diets formulated (6 x 2 x 2 x 2)

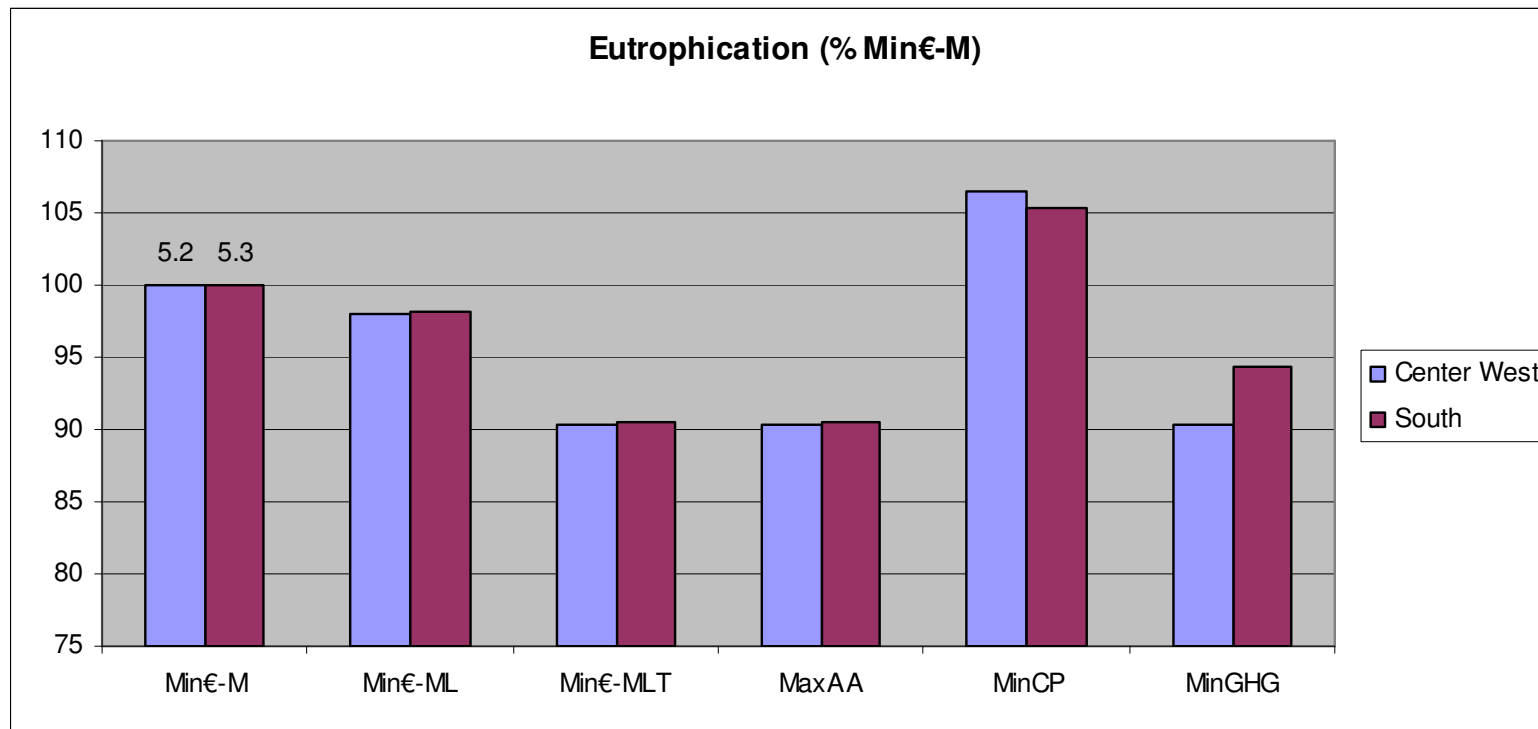
Global warming impact of different broilers feeding strategies based on cereals and soybean meal.  
- for 1 kg feed -



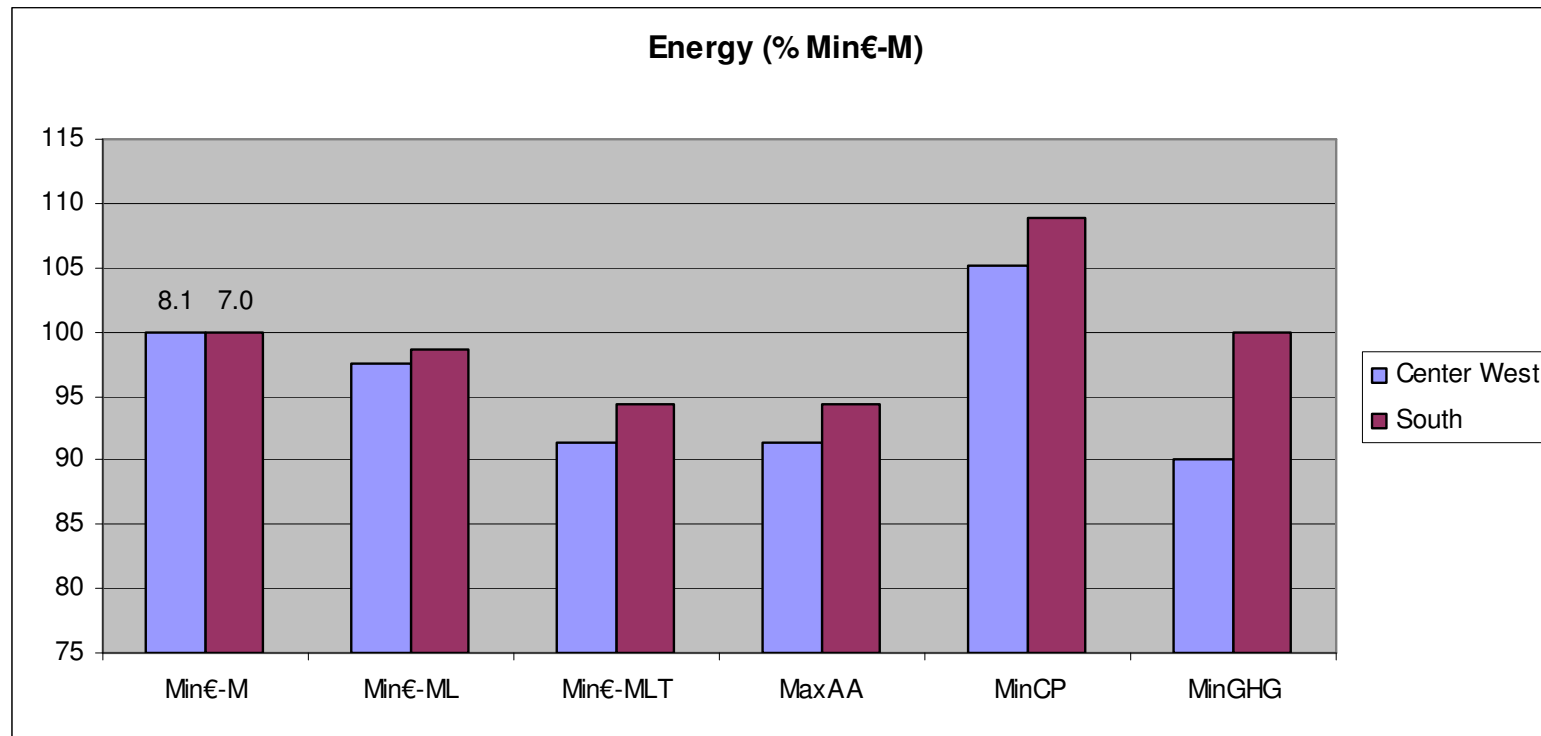
# Acidification impact of different broilers feeding strategies based on cereals and soybean meal - for 1 kg feed -



# Eutrophication impact of different broilers feeding strategies based on cereals and soybean meal - for 1 kg feed -



# Energy use impact of different broilers feeding strategies based on cereals and soybean meal - for 1 kg feed -





# Conclusion

- Similar results as in pigs but effects are generally less pronounced
  - not possible to formulate diets without FU-AA
  - constraints on minimal protein content
- More research needed to explain the effect of protein content on performance
- The effect on the whole system of production remains to be evaluated