Edificações para a redução do impacto ambiental na produção animal

Animal facilities that reduce the environmental impact of animal production

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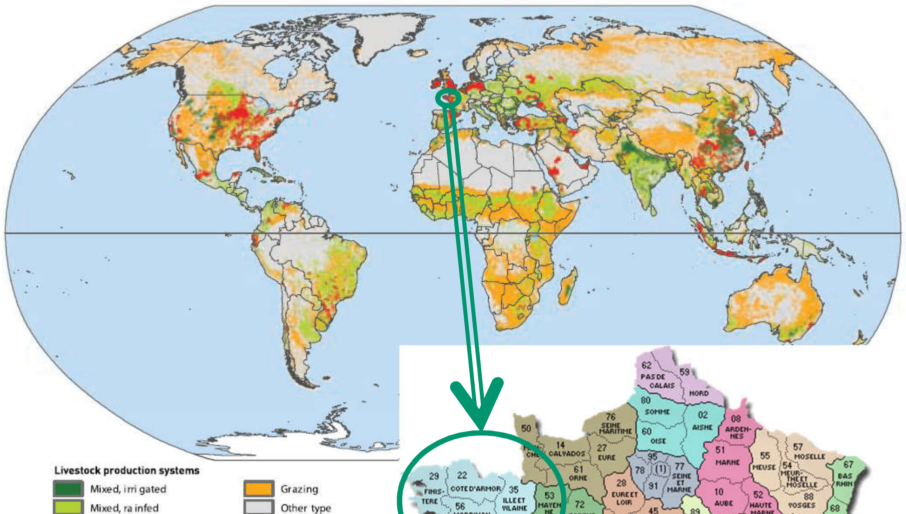
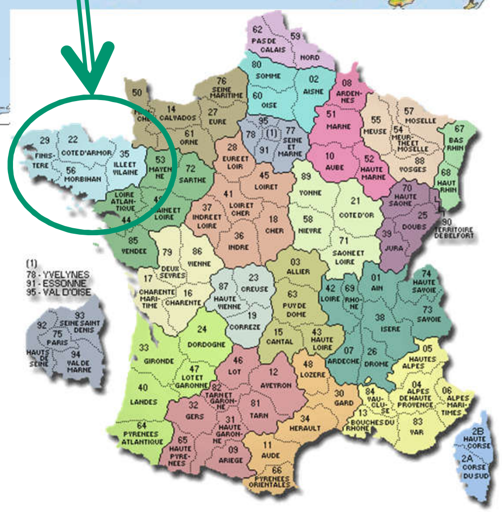
Where?



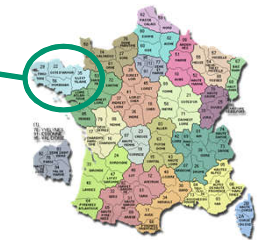


Brittany

What?

INRA research centre, Rennes

Brittany - Lower Normandy



260 researchers within 23 units

880 ha for crop and animal research (mainly cow, swine, fish)

Promotes sustainable agriculture in 4 subject areas:

- **Quality of dairy produce and food industry innovation**
- **Water quality and quality of aquatic ecosystems**
- **Overall assessment of animal industries**
- **Plant resistance to bioaggressors and environment**

(and also animal housing…)

Outlines

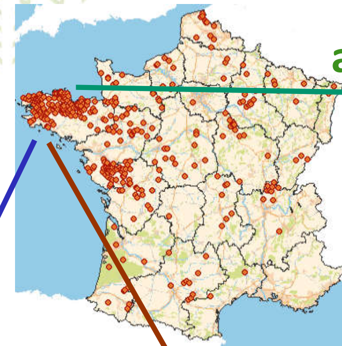
- **Introduction**: definitions, problem statement
- **Material & methods**: factors, interactions
- **Results**: techniques, systems
- **Discussion**: efficiency, strategy, trajectories of change
- **Conclusion**: plan-do-check-act = tool development

Définitions

- environmental impact?
- animal facility?
- problem statement

❖ Definitions: "environmental impact" of animal facilities

- ❑ Pollution of air, water, soils
- ❑ Resource depletion (energy, phosphorus, forests, erosion)
- ❑ Loss of biodiversity (continental, oceans)



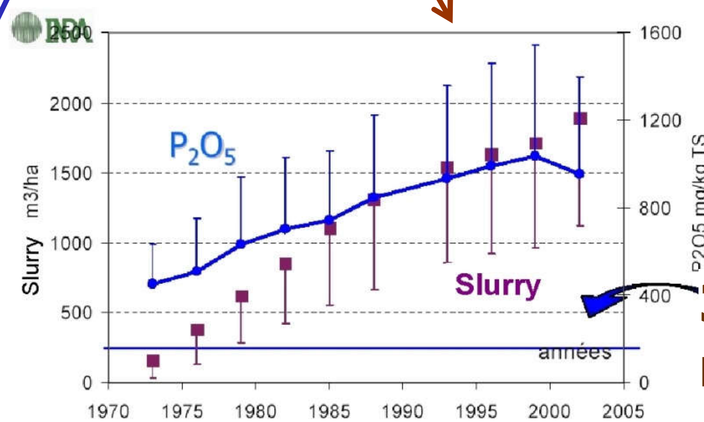
$$\frac{kg}{year}$$

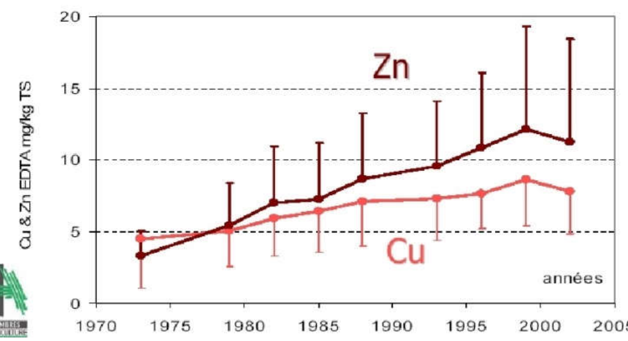
Green tides

water

1971 - 2004

soils



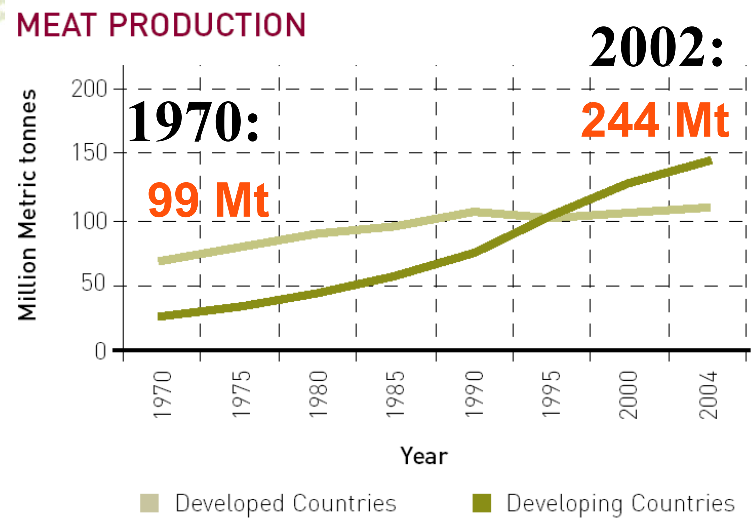


30 years monitoring on 180 plots with pig slurry inputs

❖ Definitions: “impact” = services of animal facilities

- ❑ Production of meat, eggs, leather
- ❑ Recycling of byproducts of agroindustry
- ❑ Employment, traditional dishes & activities, farm tourism
- ❑ Production of renewable energy, fertilizers

$$\frac{kg \times alloc \ (< 1)}{year}$$



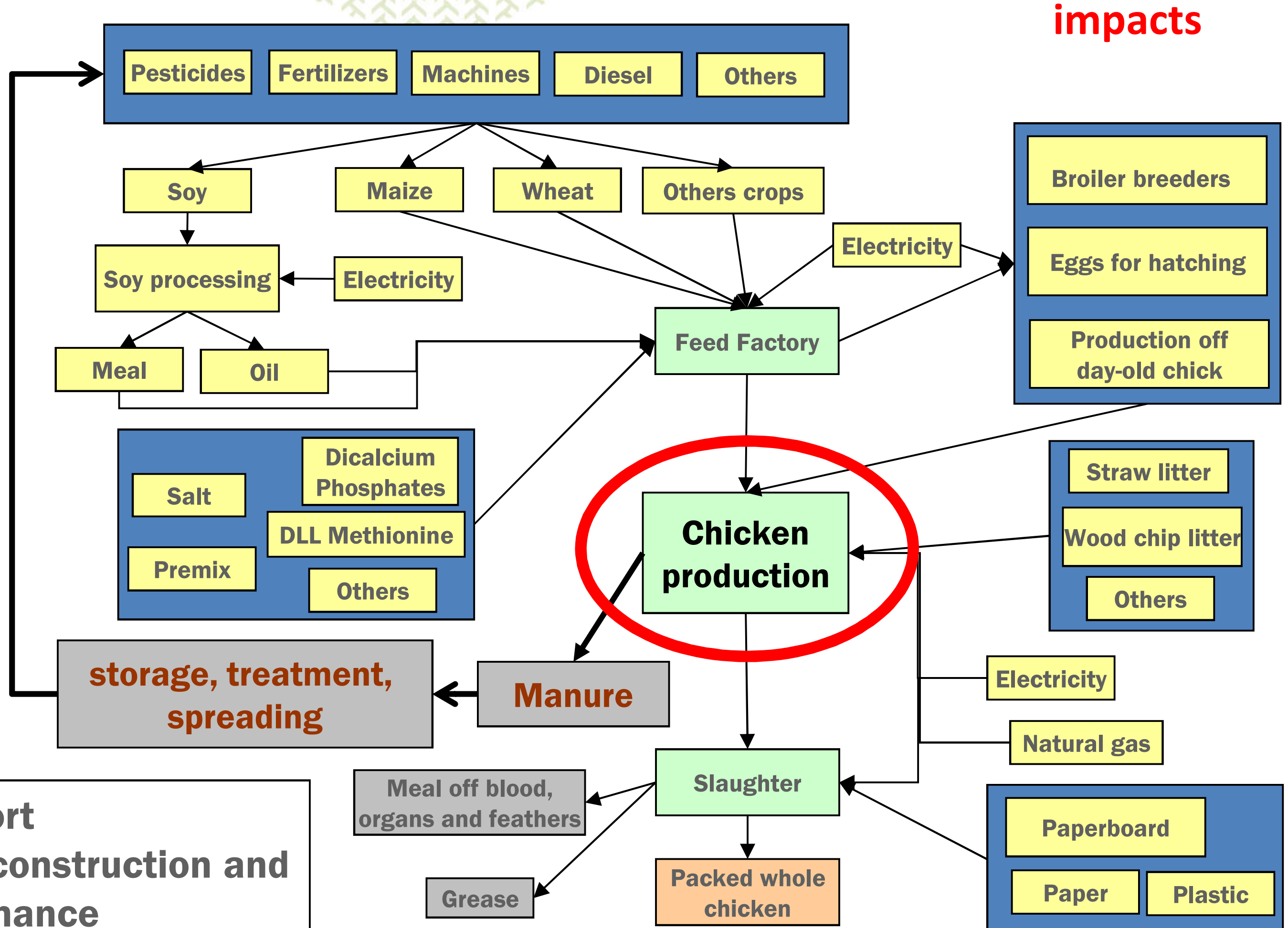
Source: FAO (2005)

❖ Definitions: "animal facilities"

from house to system

animal production chain

direct & indirect impacts

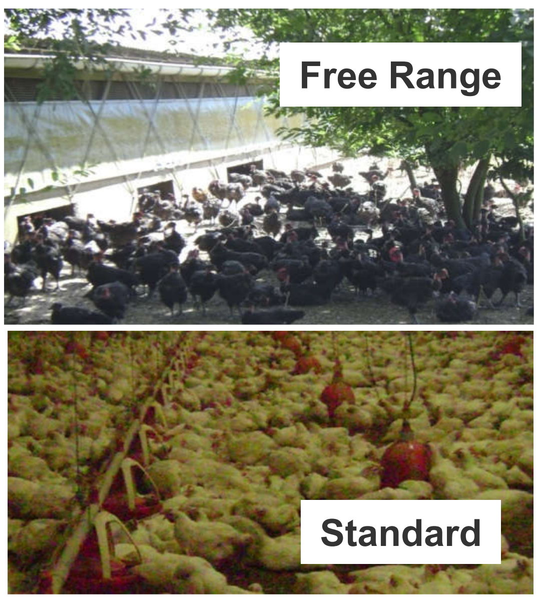


- Transport
- House construction and maintenance

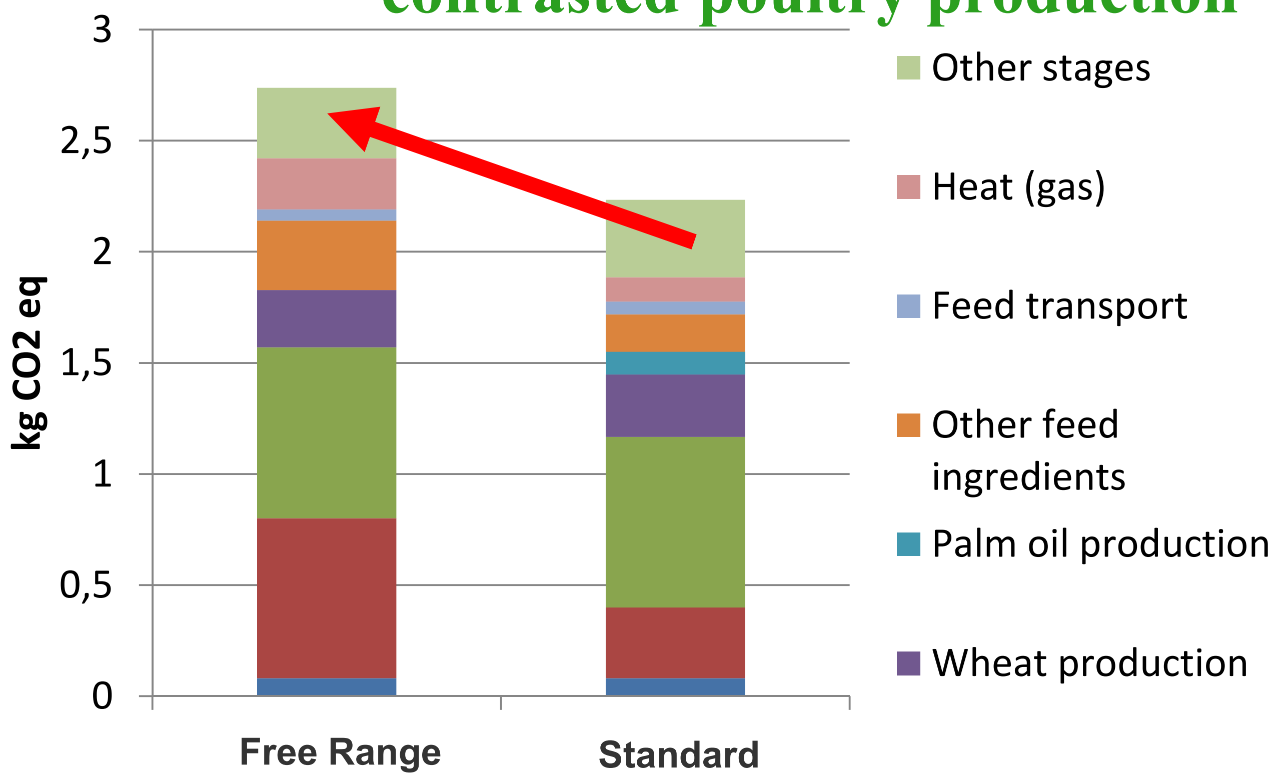
Definitions: expression of impact with the choice of a "functional unit"

$$\frac{kg \times alloc \ (< 1)}{year \times UF}$$

Impact on **climate change** of **1** **kg** **of chicken live weight**



contrasted poultry production

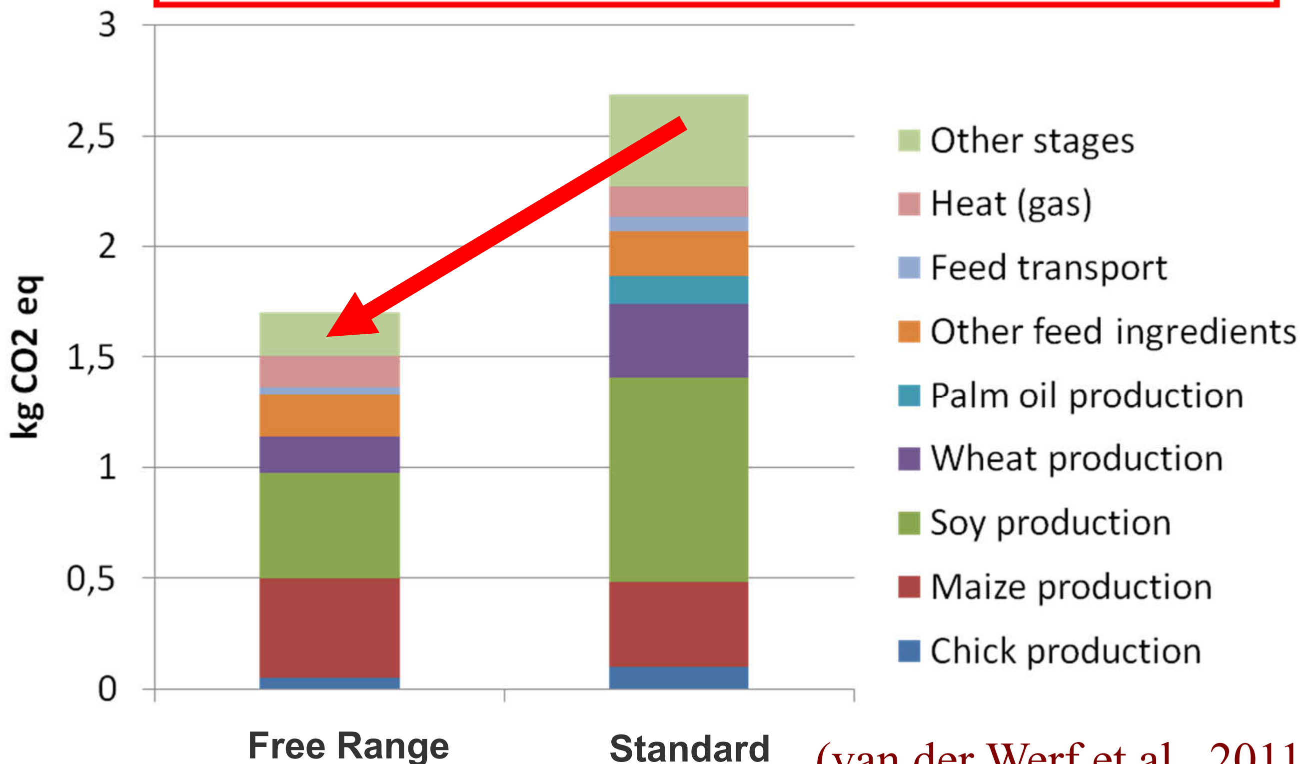


(van der Werf et al., 2011)

Definitions: expression of impact with the choice of a "functional unit"

Free range production produces less impact at constant meat budget (1 euro meat)

Impact on **climate change** of
1 **euro** **of chicken live weight**



(van der Werf et al., 2011)

❖ Definitions: “animal facilities”

animal production chain

$$\left(\frac{kg \times alloc(<1)}{year \times UF}\right) \times risk$$

- Various productions ═ allocation of impacts
  (decrease of impacts/kg meat or /ha or /€)
- Recycling of byproducts, energy production ═ decrease in resource use
- Variability of production chains (typologies of production systems: soil & climate, size, changing socio-economical environment, various local/global society's expectations)

Definitions: problem statement

animal production chain

territory

$$\left(\frac{kg \times alloc(<1)}{year \times UF}\right) \times risk$$

- How to take advantage of farm plasticity and territory opportunities to
  - improve recycling (risk),
  - decrease pollutant emissions (kg),
  - increase multifunctionality (alloc, UF)

influencing factors

levers for action

strategies

technical solutions

animal production chain

territory

Material & methods

- identifying factors that decrease the impacts
- analyze the interactions that can affect the result

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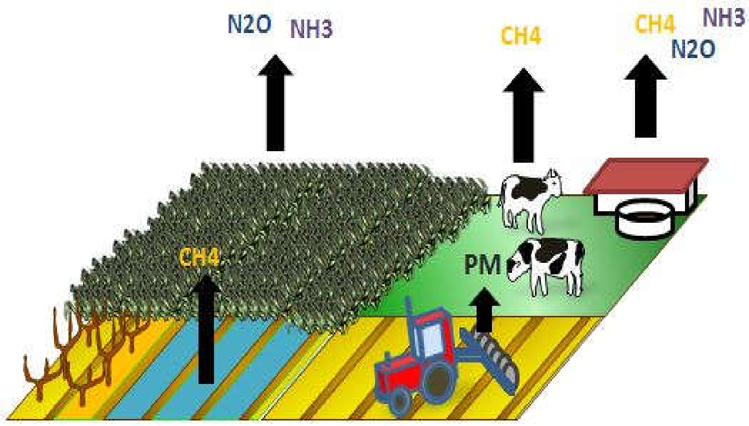
❖ M&M: factors that decrease the impacts

1. Knowledge development: process understanding

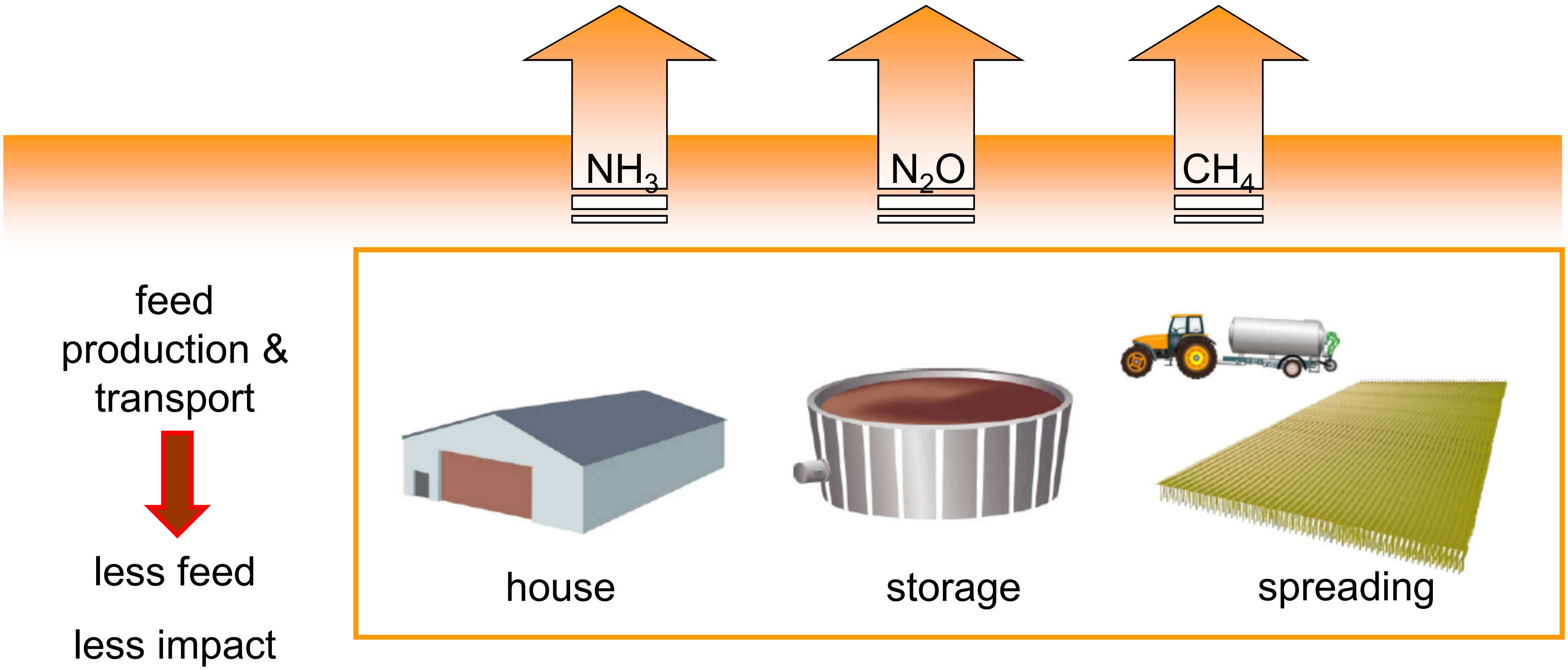
- ❖ Scientific research: understanding the emitting processes, kinetics, influencing parameters
- ❖ Validate models with observations in commercial farms



interactions

❖ M&M: factors that decrease the impacts

1. Knowledge development: characterize existing farms



manure management => increase in fertilizers, less in emissions

❖ M&M: factors that decrease the impacts

1. Knowledge development: process understanding

factors influencing the

feed efficiency

- ✓ feed fitted to animal requirements (e.g. -17% NH_3/pig)
- ✓ feed digestibility (energy, proteins, phosphorus, etc.)

- ➢ feed additives
- ➢ feed designed to improve manure processing (e.g. fiber for biogas production)
- ➢ optimal climate control

❖ M&M: factors that decrease the impacts

1. Knowledge development: process understanding

factors influencing the conservation & transformation of excreted molecules

- ✓ Characteristics of manure: pH, porosity, nitrogen content, oxygen availability, moisture…
- ✓ Climate variables: air temperature and humidity, air speed, area of manure,

  - ➢ Farming practices: manure additives, frequency of manure removal, emitting area
  - ➢ Hazards (e.g. health, climate, costs)

❖ M&M: factors that decrease the impacts

1. Knowledge development: process understanding

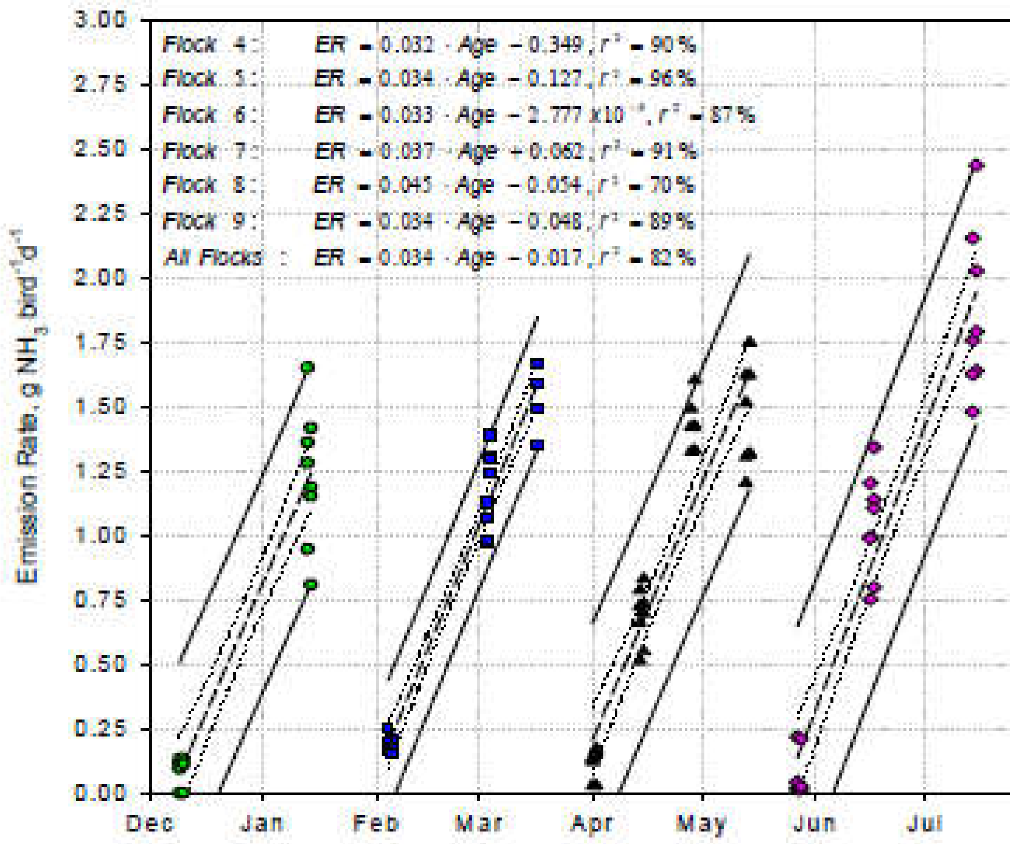
factors influencing the

exhaust air

- ✓ air circulation
- ✓ air treatment
  - ➢ heat recovery (energy saving)

❖ M&M: modeling equations

Ammonia emission: function of age, excretion, moisture



Casey et al., 2005 Broiler houses

+litter temperature
+heat production
+animal species

Check the representativeness of literature values with direct observations or farmer data!

❖ M&M: interactions

1. Gaseous losses at various scales

- ❖ Animal: CO_2, H_2O, CH_4 are released (50% C, H_2O intake)
- ❖ House: CO_2, H_2O, NH_3, N_2O, N_2, CH_4 are released from manure, sometimes after air treatment (20-60% of excreted nitrogen)
- ❖ Farm: gases are also released but fields also collect rainfall and dry deposition => net emissions can be negative (e.g. C storage in forests increased by N_{gas} deposition; CH_4 sink by agricultural soils)
- ❖ Region: farm interacts with other activities; recycling or organic byproducts/biomass production can contribute to emission decrease

M&M: interactions

1. C-N-H_2O-O_2 are necessary but not sufficient to explain emission variability (to manage emission reductions)

- Climate influence=> temperature, rainfall
- Biological activity=> toxicities, synergies explain limiting or accelerating factors
- Non linearity of biology: feedbacks can be positive then negative around a threshold
- Scale effects=> analysis of biological & social functions (e.g. food chain)

M&M: interactions

2.example: pH control in manure (CO_2 and NH_3 are both emitted from manure)

$$NH_4^+ + H_2O \underset{}{\overset{K_{AN}}{\rightleftharpoons}} NH_3aq + H_3O^+ \quad \text{pH decrease}$$

$$H\text{-}CO_3^- + H_3O^+ \overset{K_{AC1}}{\rightleftharpoons} CO_2 + 2\,H_2O$$

$$CO_3^{2-} + H_3O^+ \overset{K_{AC2}}{\rightleftharpoons} H\text{-}CO_3^- + H_2O \quad \text{pH increase}$$

- pH influences emissions and biological processes and is affected by C-N emission ratio

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❖ M&M: interactions

2. Example at house scale: consequences on composition of manure and emissions of NH_3, GHG, H_2O

prediction not possible

farm observations

Factors influencing the manure composition

- ventilation
- animal density
- soil (concrete, earth), the litter
- drinking equipment
- health of the livestock
- feed
- animal species
- storage
- treatment or spreading equipments

Results

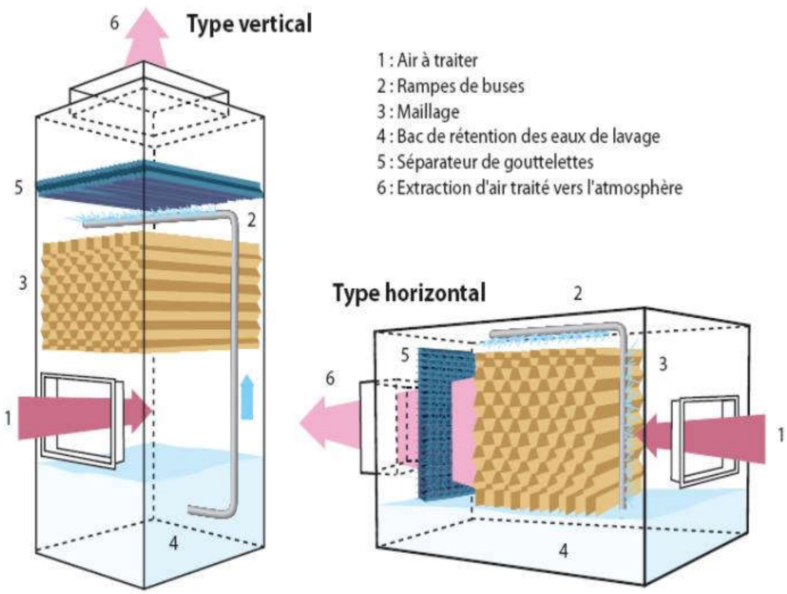
- example of techniques
- example of systems

From process understanding to technology development

(Guingand, 2011)

From process understanding to technology development

1.1. Air treatment



Decrease ammonia
Decrease particles
Decrease odors

pros

ammonia: 50 - 90 % with acid
odors: 40 - 70%
particles: 70 - 90%

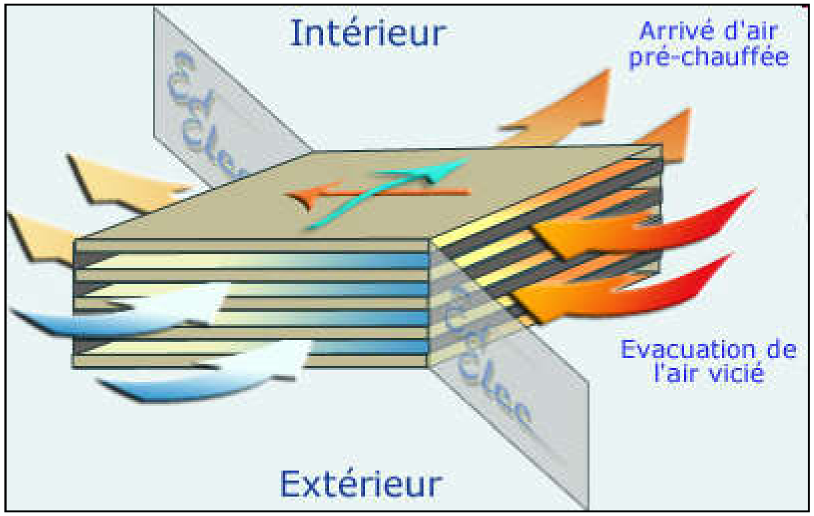
cons

Centralized air extraction
Water consumption and spreading
Cost

From process understanding to technology development

1.2. Air treatment: heat recovery

- optimizing recover of heat
  - 2 managements of the heat exchanger of heat (heat deficit or heat excess)
    - **Cyclic proportioning (walk/stop)**
    - **Variator of frequency (progressive increase in air flows during time)**



(Aubert, 2011)

From process understanding to technology development

2.1. increase in feed efficiency in Brasil

YEAR	PV* (g)	ADG** (g)	Slaughter Age (Days)	Feed Conversion	Mortality (%)
1930	1500	13,9	108	3,55	20,0
1940	1550	15,4	101	3,04	17,2
1950	1580	22,0	72	2,58	15,2
1960	1600	27,9	57	2,25	13,1
1970	1700	33,9	50	2,15	11,2
1980	1800	36,0	50	2,10	9,5
1985	1890	38,7	49	2,08	8,8
1990	2061	45,1	46	2,06	5,9
1995	2187	47,9	46	2,02	5,5
2000	2426	53,1	46	1,94	4,5
2005	2481	54,7	45	1,86	4,3
2010	2643	58,6	45	1,80	3,9
2015#	2788	64,8	43	1,70	3,7

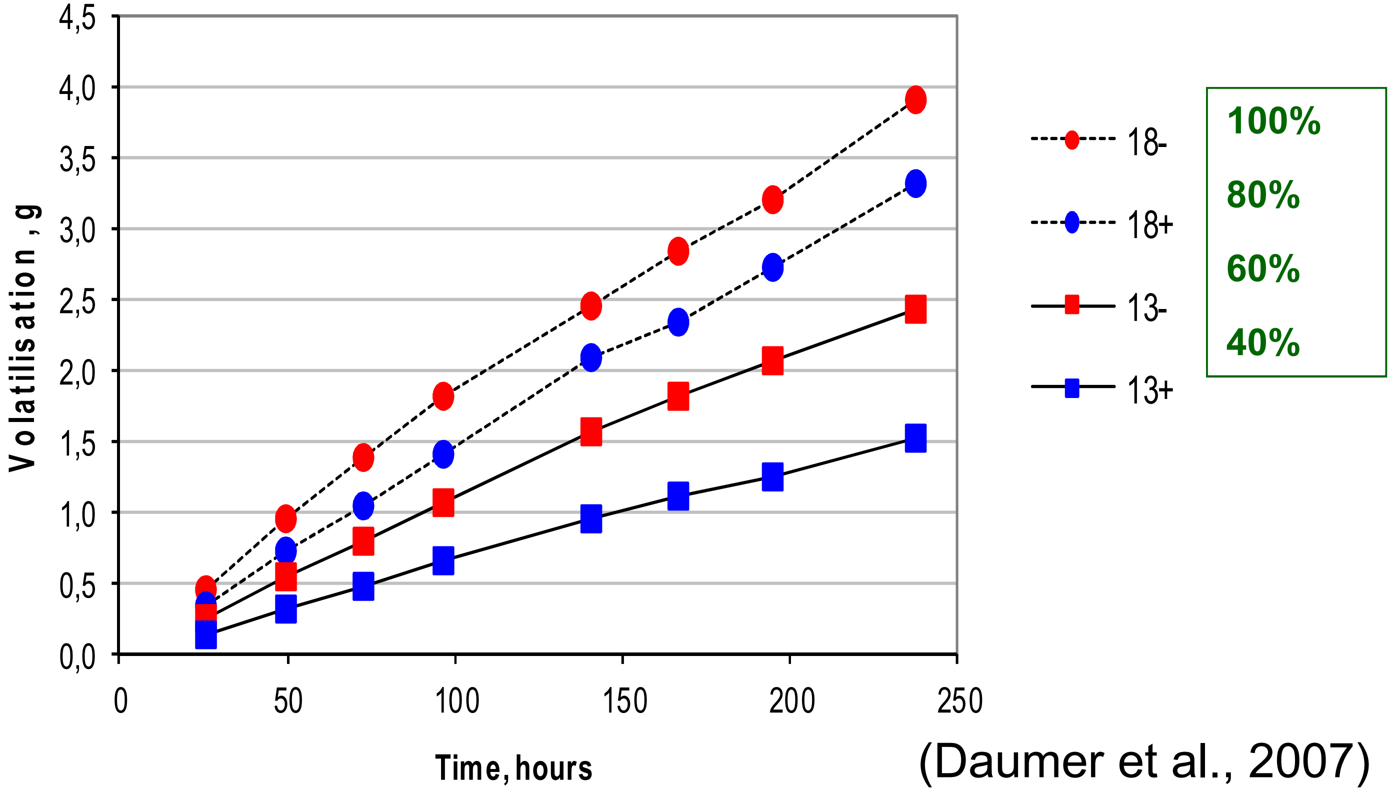
* PV-Weight Live. ** ADG-Average daily gain. # Estimate.

(Oliveira et al., 2015)

From process understanding to technology development

2.2. decrease source with feed

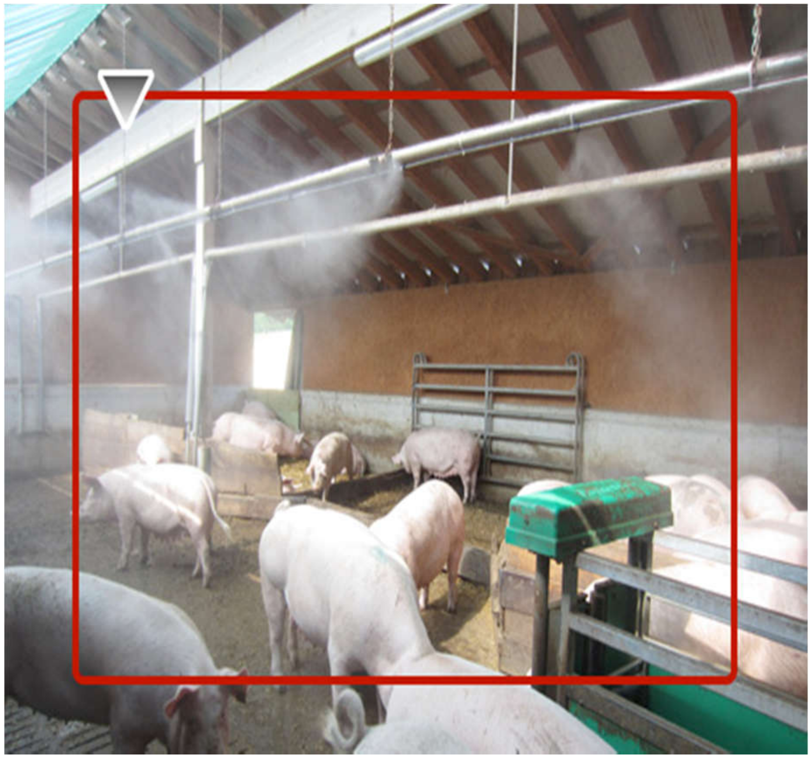
Decrease protein content and add benzoic acid in feed to reduce ammonia emission



(Daumer et al., 2007)

From process understanding to technology development

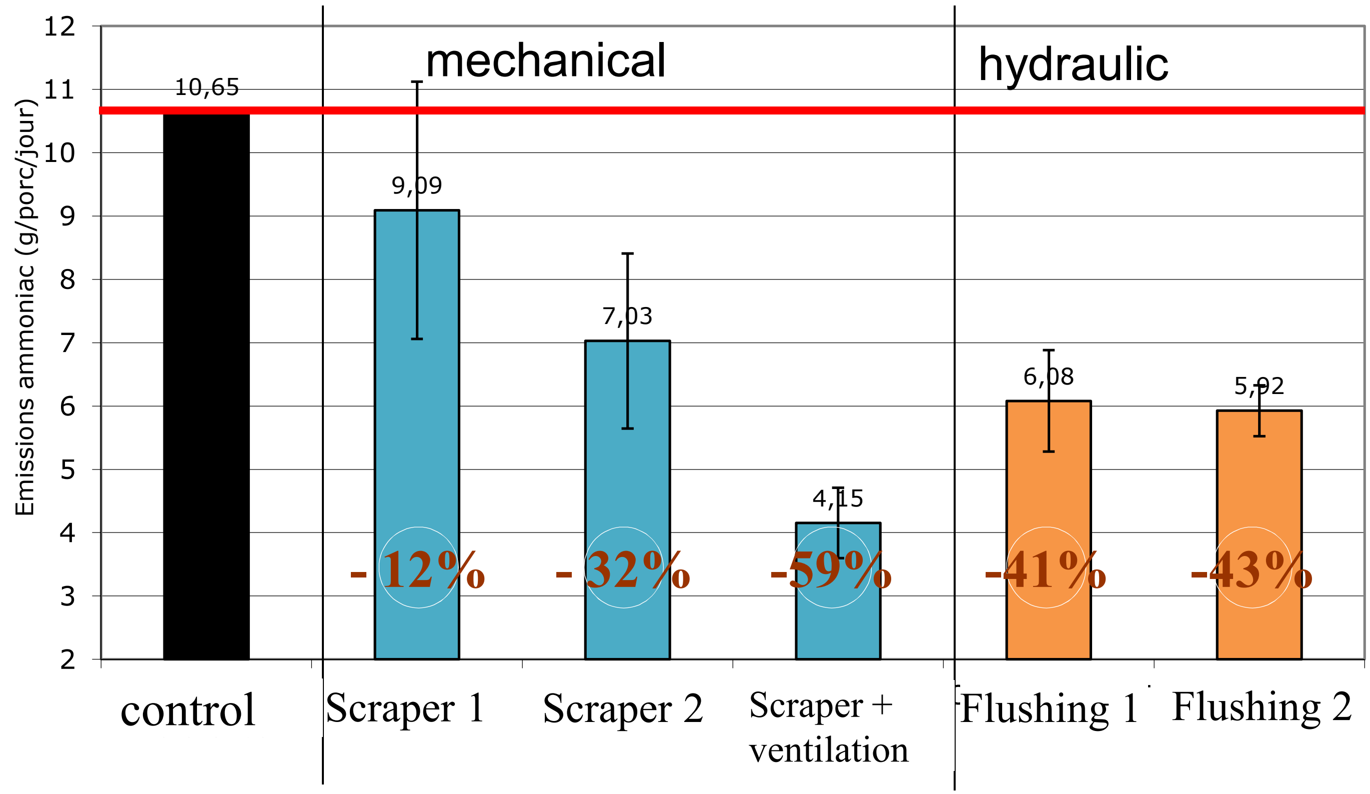
2.3. increase feed efficiency with fogging systems



Fogging also decrease NH_3 by 20-30% in growing-finishing pigs

From process understanding to technology development

3.1. Technology development: frequency of manure removal



AGRICULTURES & TERRITOIRES
CHAMBRES D'AGRICULTURE BRETAGNE

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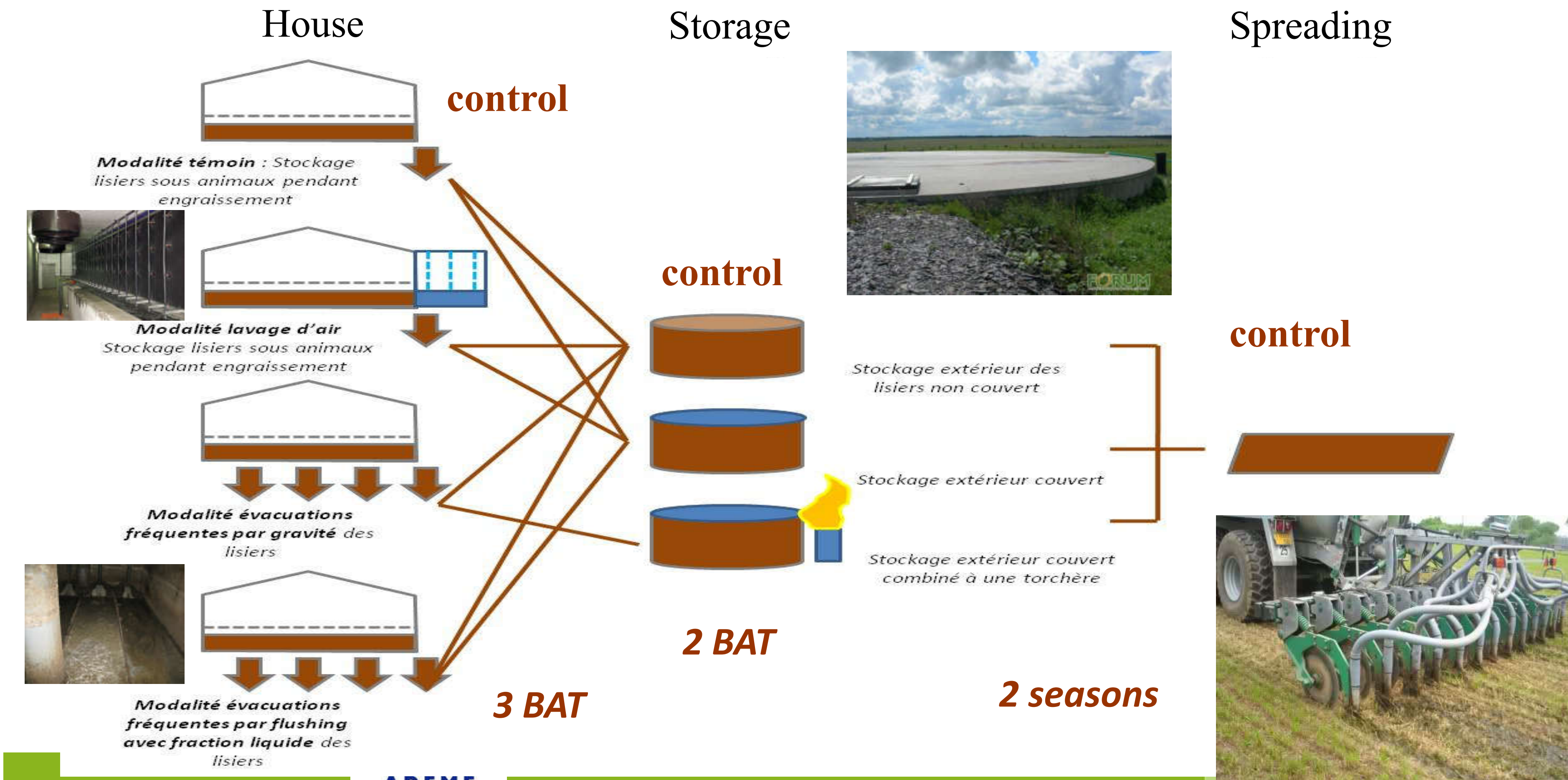
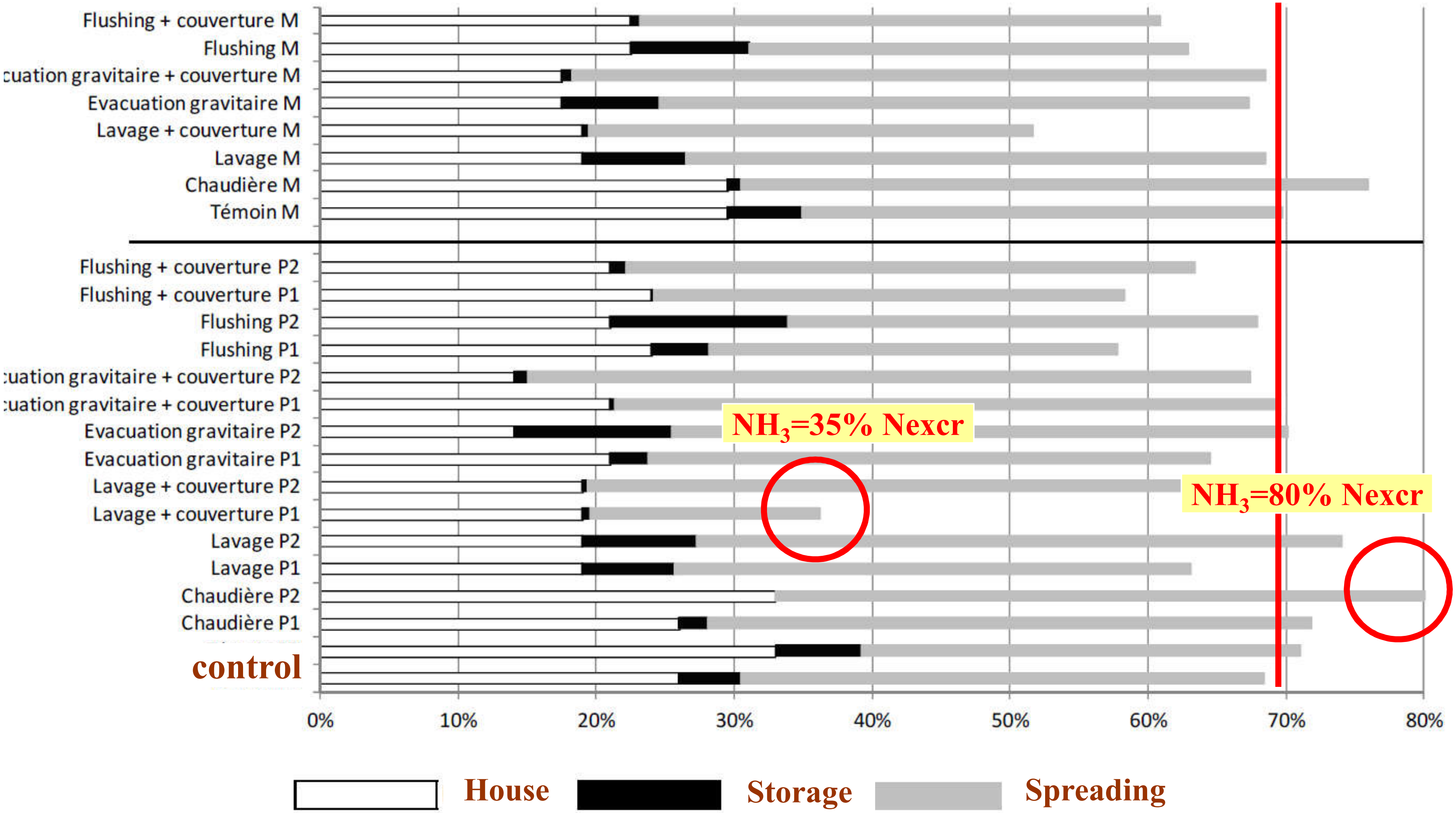
Integrating processes: 1.check pollution transfer

EMITEC project: evaluate the effect of various combinations of BAT (best available technique) applied at house, storage, spreading



Integrating processes: 1.check pollution transfer



(Espagnol et al., 2015)

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Integrating processes: 1.check pollution transfer

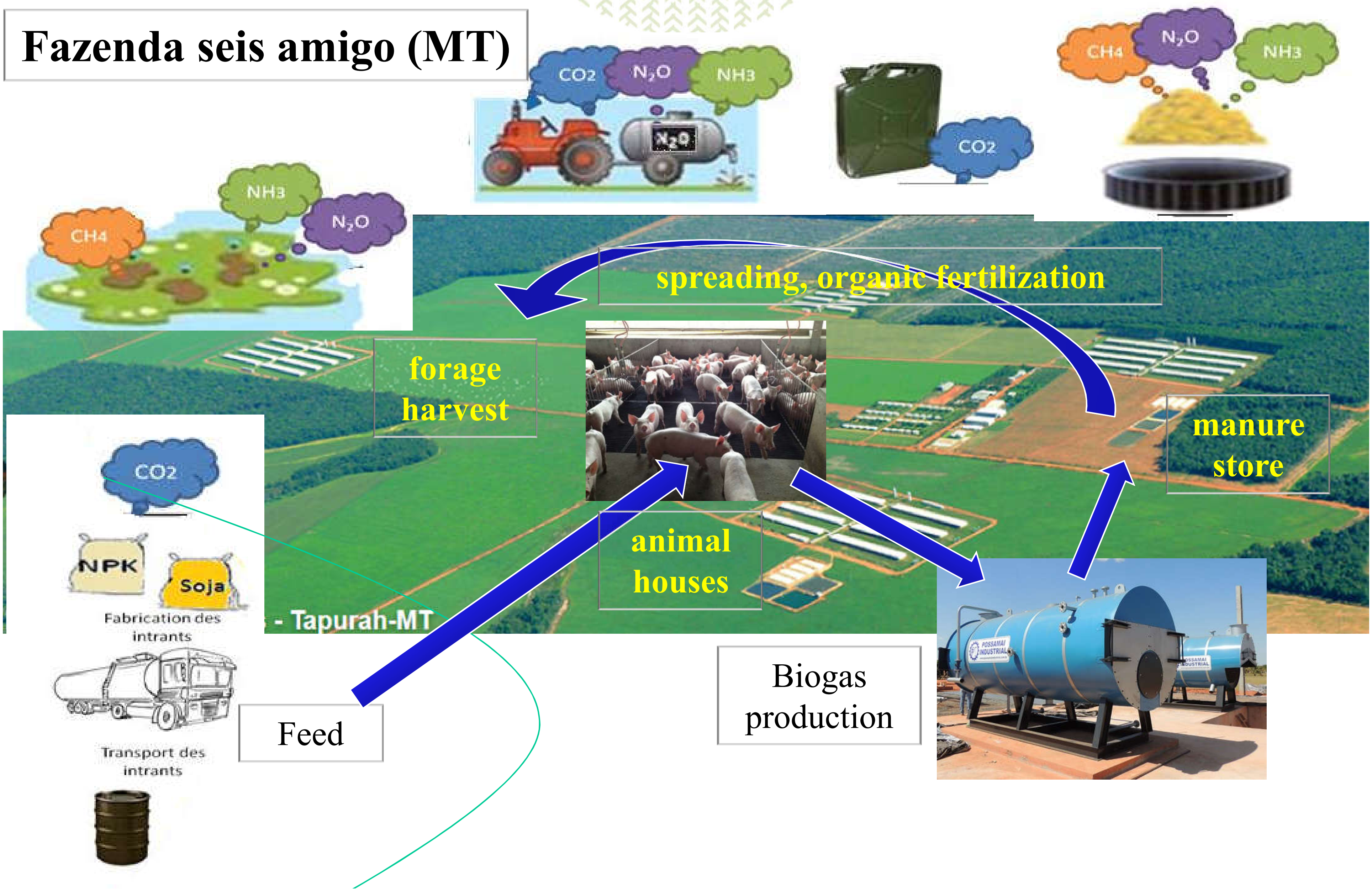
- Effect of BAT implemented in building or during the storage can be reduced by the lack of BAT on the following stages (storage, spreading) => BAT should be used at each stages
- Conservation favorable to recycling

  N conservation (% N excreted) :

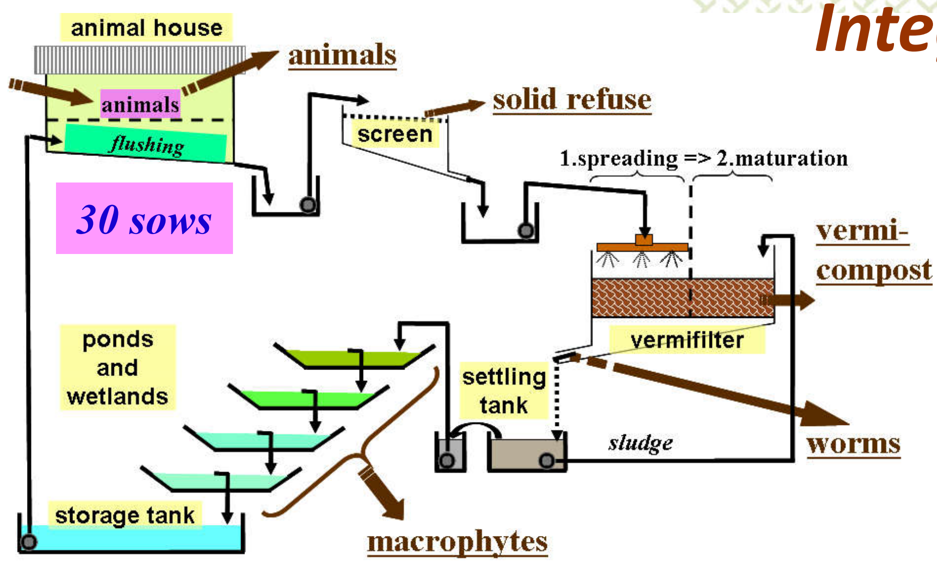
  - At the end of the storage: 61 - 85%
  - At the end of the spreading : 20 - 64%.
- Cost of observations => models!

(Espagnol et al., 2015)

Integrating processes: 2.reduce both inputs and losses



Integrating processes: 3.recycling experiment (since 2007)



➔**Principles:**

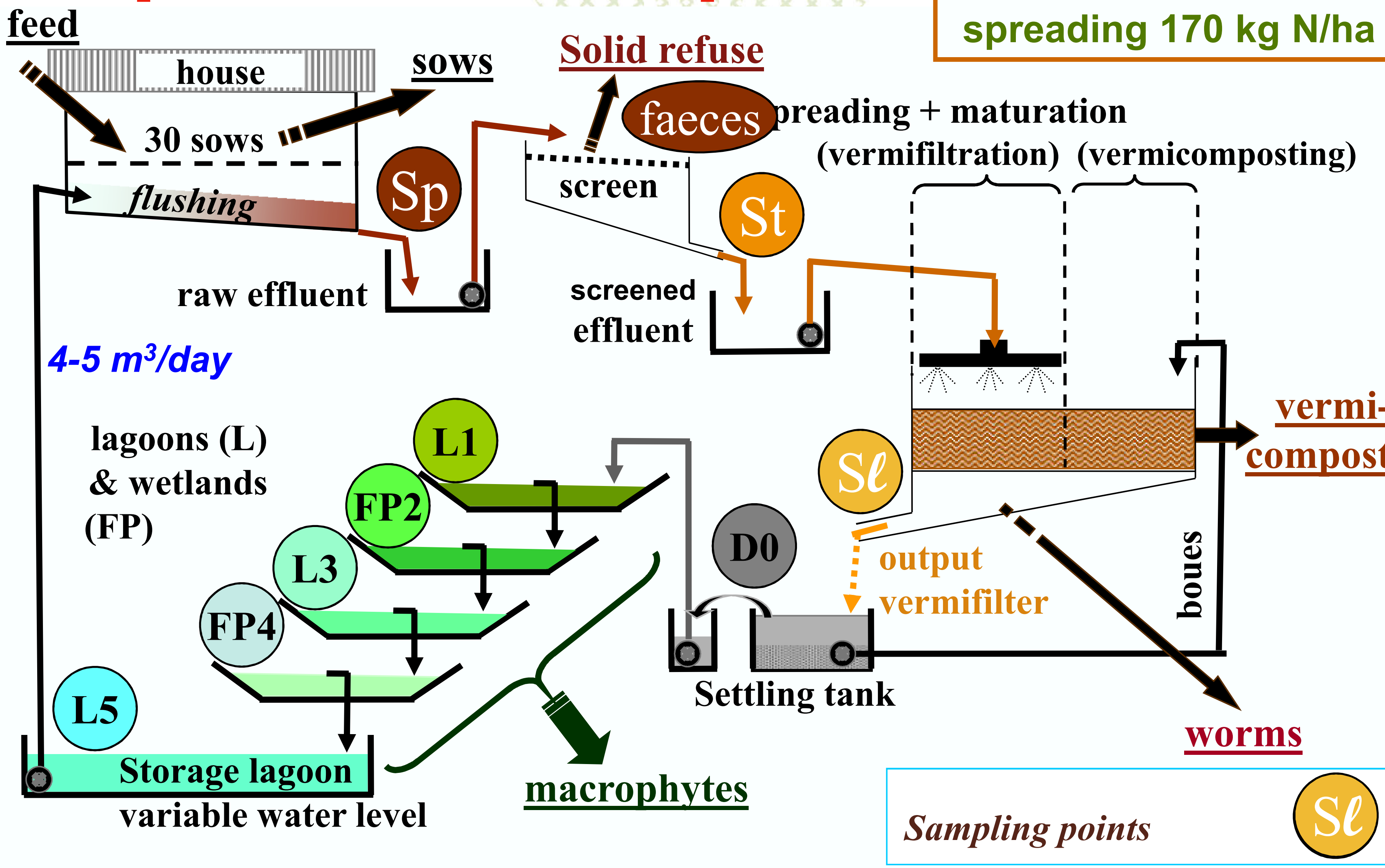
- For liquid manure, combination of agricultural productions to recycle the hygienized water for flushing
- *(For solid manure, increased storage of elements and water evaporation through carbon and porosity management)*

➔**Features:**

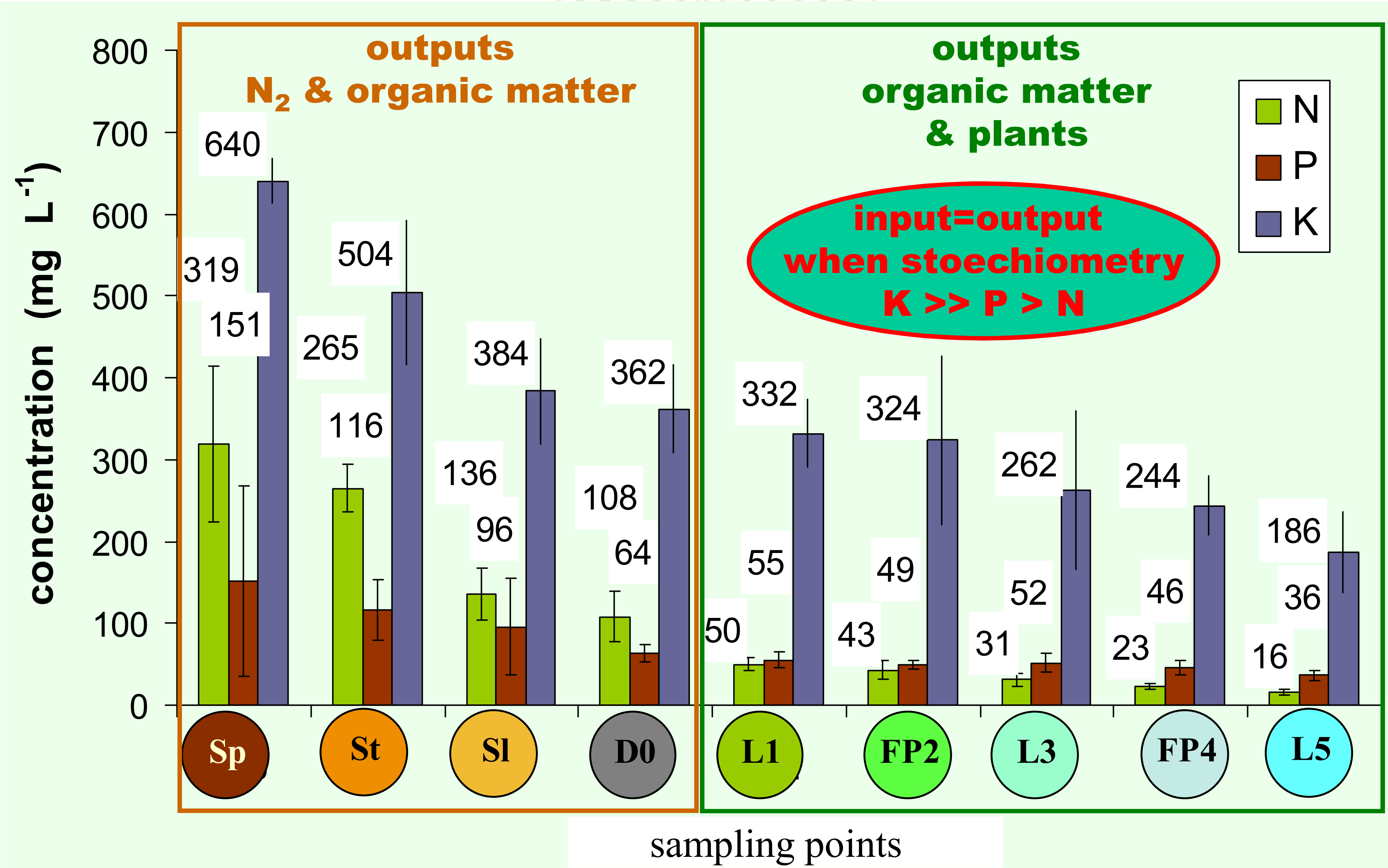
- Workers on animal farms can use the saprophytes or macrophytes as bio-monitors to adapt the management
- The solid products can be either reused to reduce inputs of the farm (fertilization, feed), or exported to balance the inputs; crop yields are increased
- Efficiency is 50 higher than spreading (600=>12 m²/pig)

Experimental setup

50 times less area than spreading 170 kg N/ha

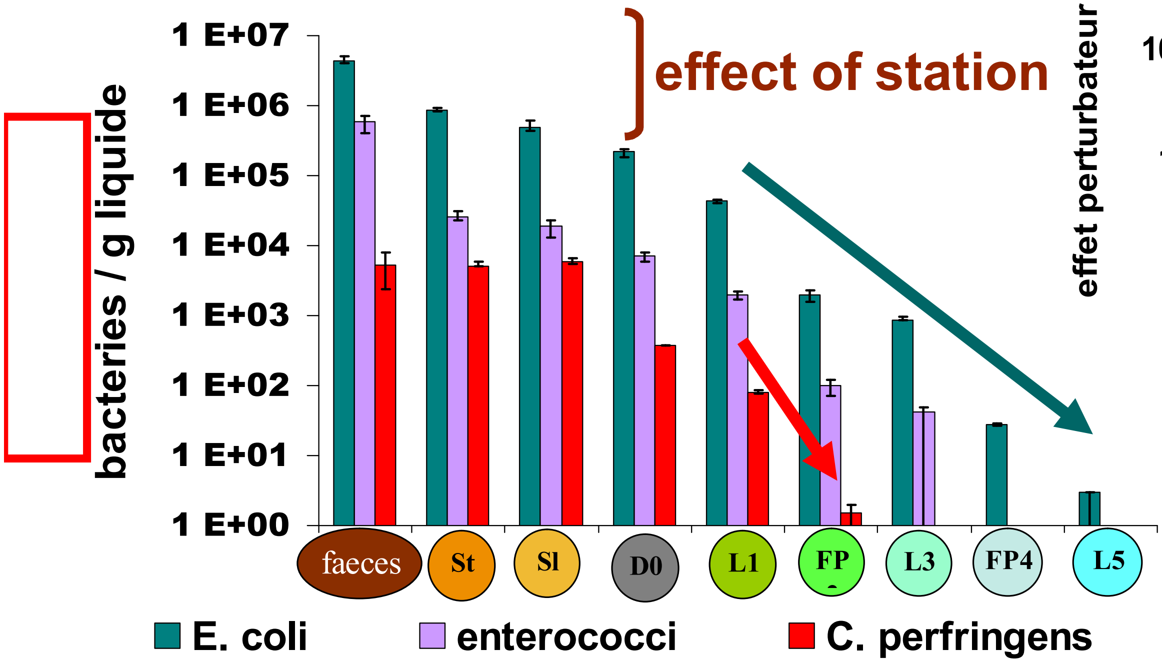


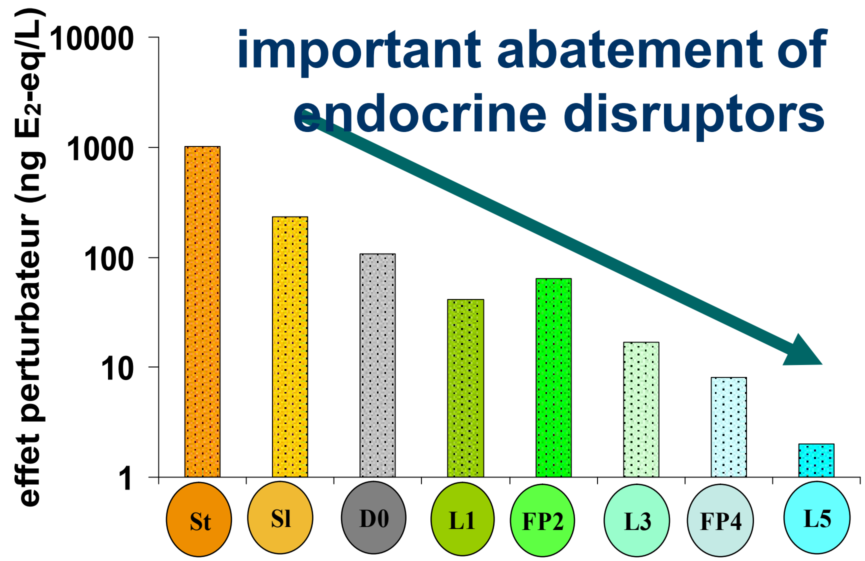
Recycling elements



Pathogenes and micropolluants

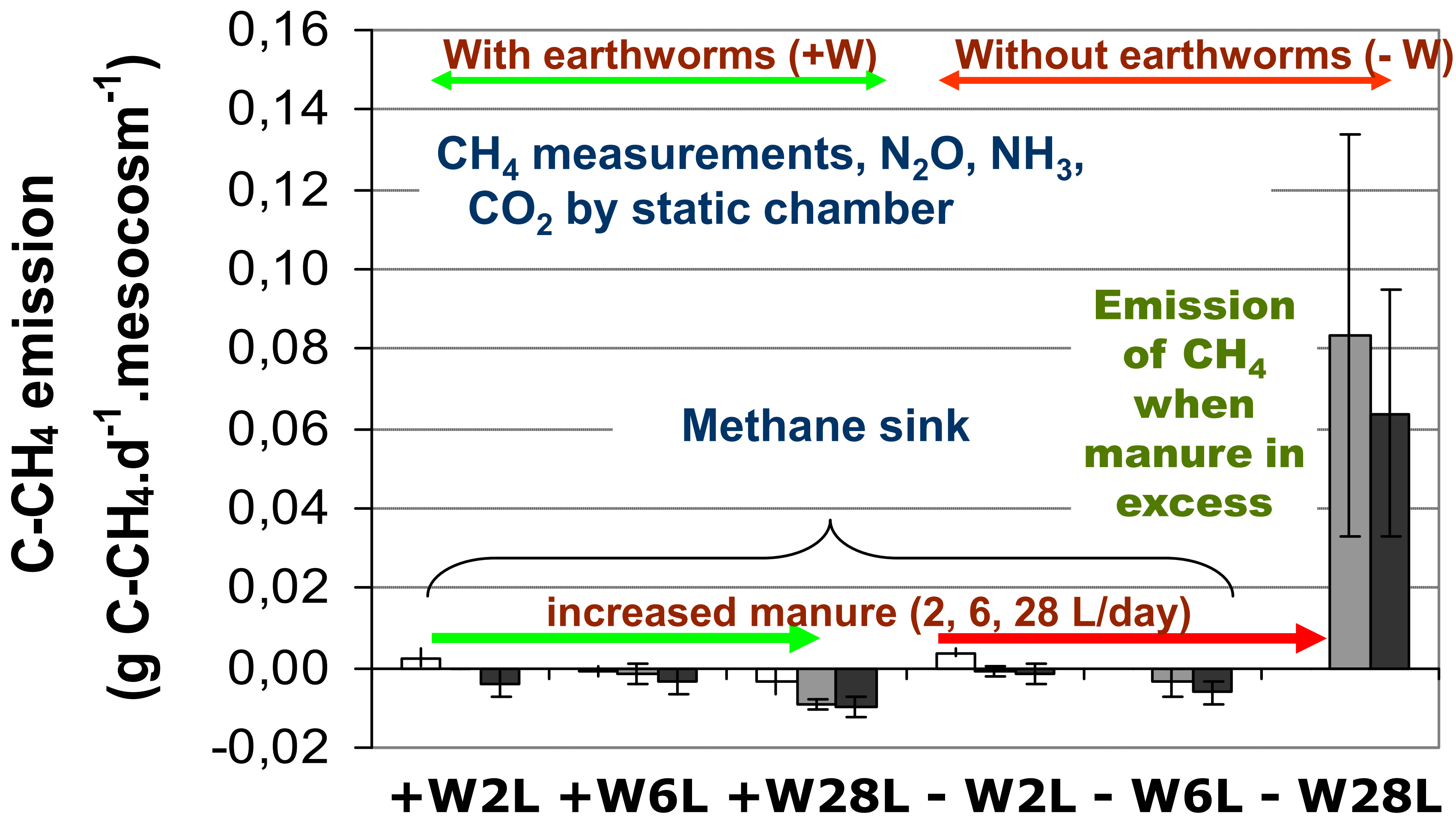
- thorough hygienisation
- essential vigilance (recycling)





- important abatement of lagooning
- effect different from lagoons and of the wetlands depending on indicators considered

CH_4 emission of the vermifiltre



The methane sink is explained by the porosity of the vermifilter and the wormcasts *(Moon et al., 2010)*;
An emission of CH_4 was observed only with an excess of manure and the absence of worms

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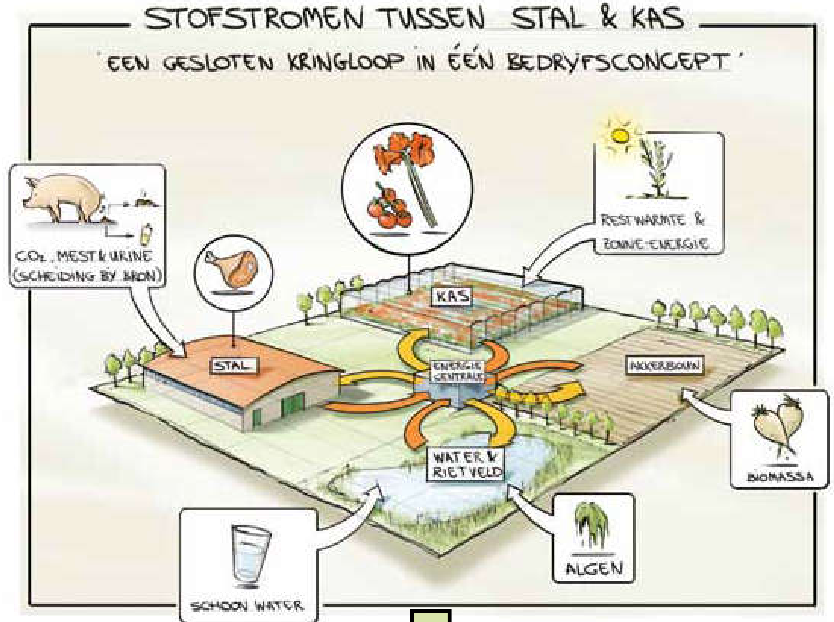
Integrating processes: 3.increase multifunctionality

New designs to produce energy, fiber, food, feed

Explore new technologies into new farming concepts:

- Which scale is optimal?
- Which part of byproducts that can be reused on farm?
- Synchronism between productions?
- Coupling heating/drying to reduce transport costs?
- Health issues associated to increased reuse of byproducts?
- Specific knowledge needed?

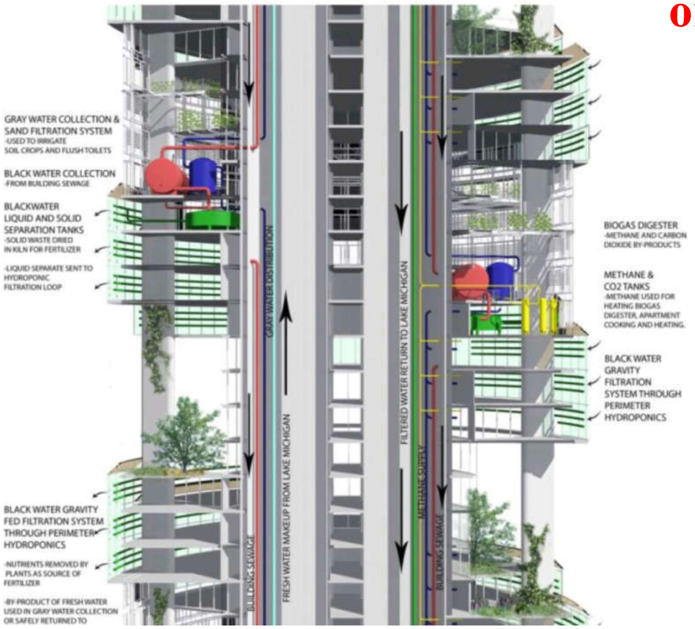


www.innovatievarkensvleesketen.nl

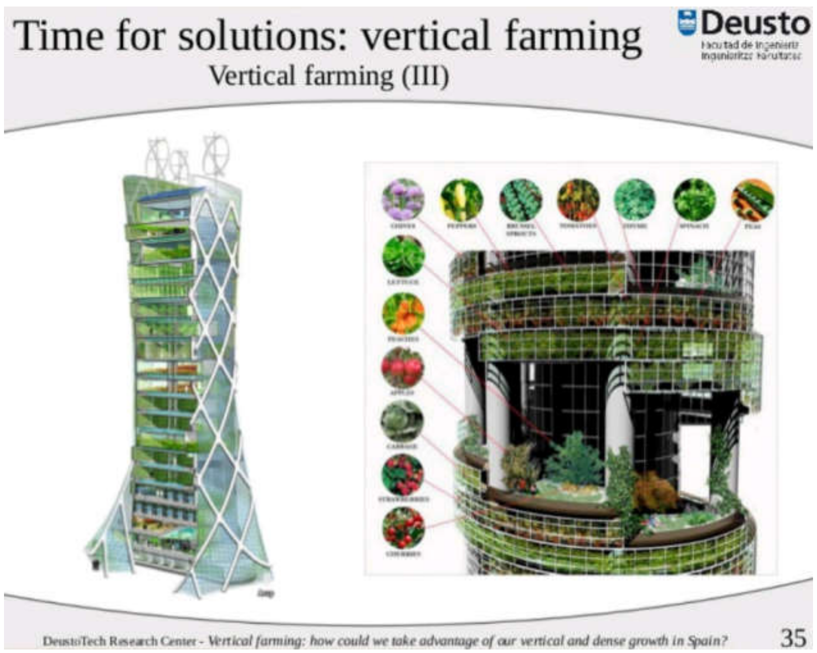
Integrating processes: 3.increase multifunctionality

New designs to produce energy, fiber, food, feed (increase in cost & services)

horizontal or vertical?



Vertical farm / vertical farming concept



Discussion:

- efficiency at national scale
- modeling: cost/benefit analysis
- trajectories of change

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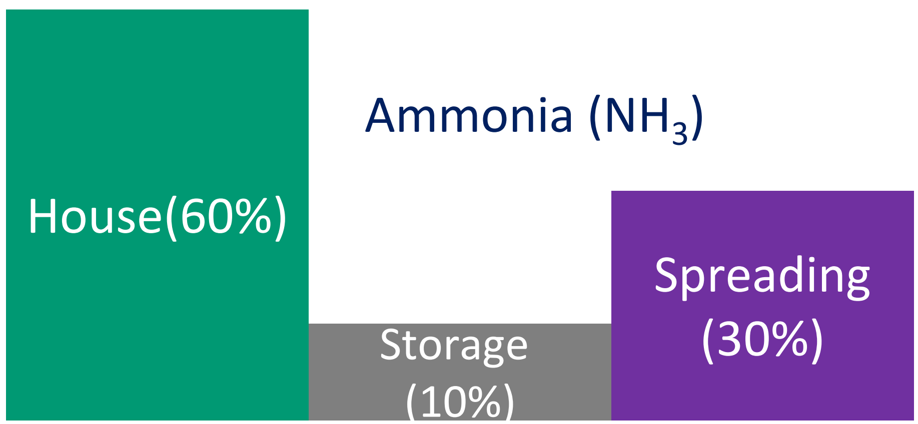
❖ efficiency of BAT at national scale?

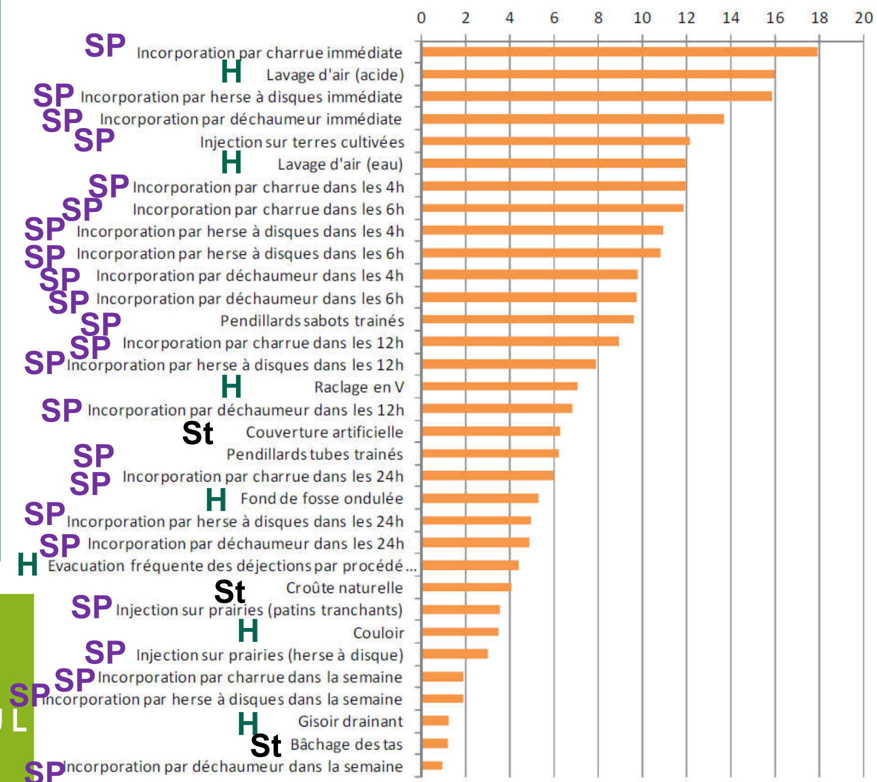
Assessment of different technical solutions to reduce emissions:

- **Social acceptability of techniques**
- **Maturity of techniques**
- **Efficacy of techniques**
- **Number of farms/animals or volume of manure concerned**

Pig farm scale: mostly house



national scale: mostly spreading



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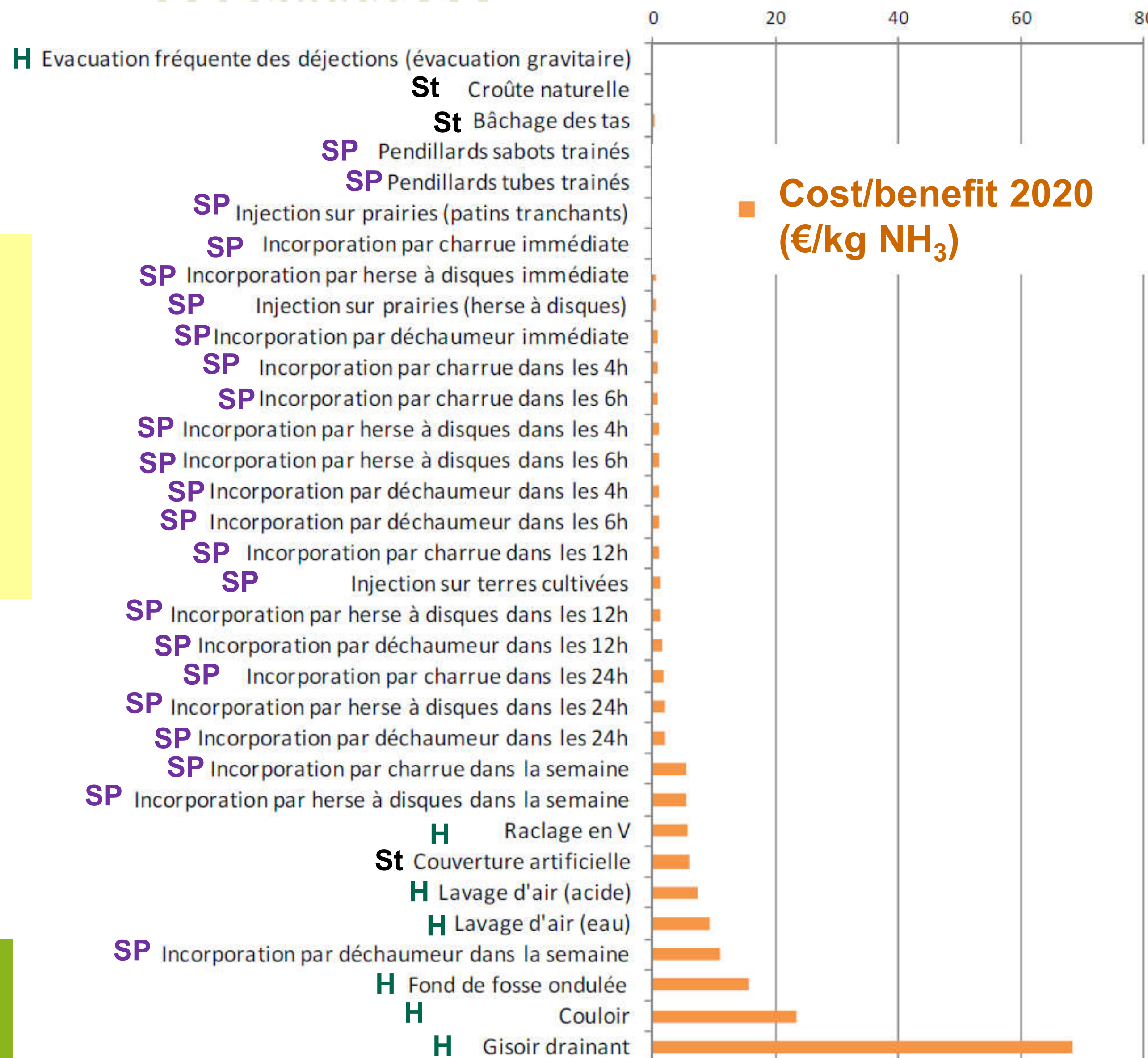
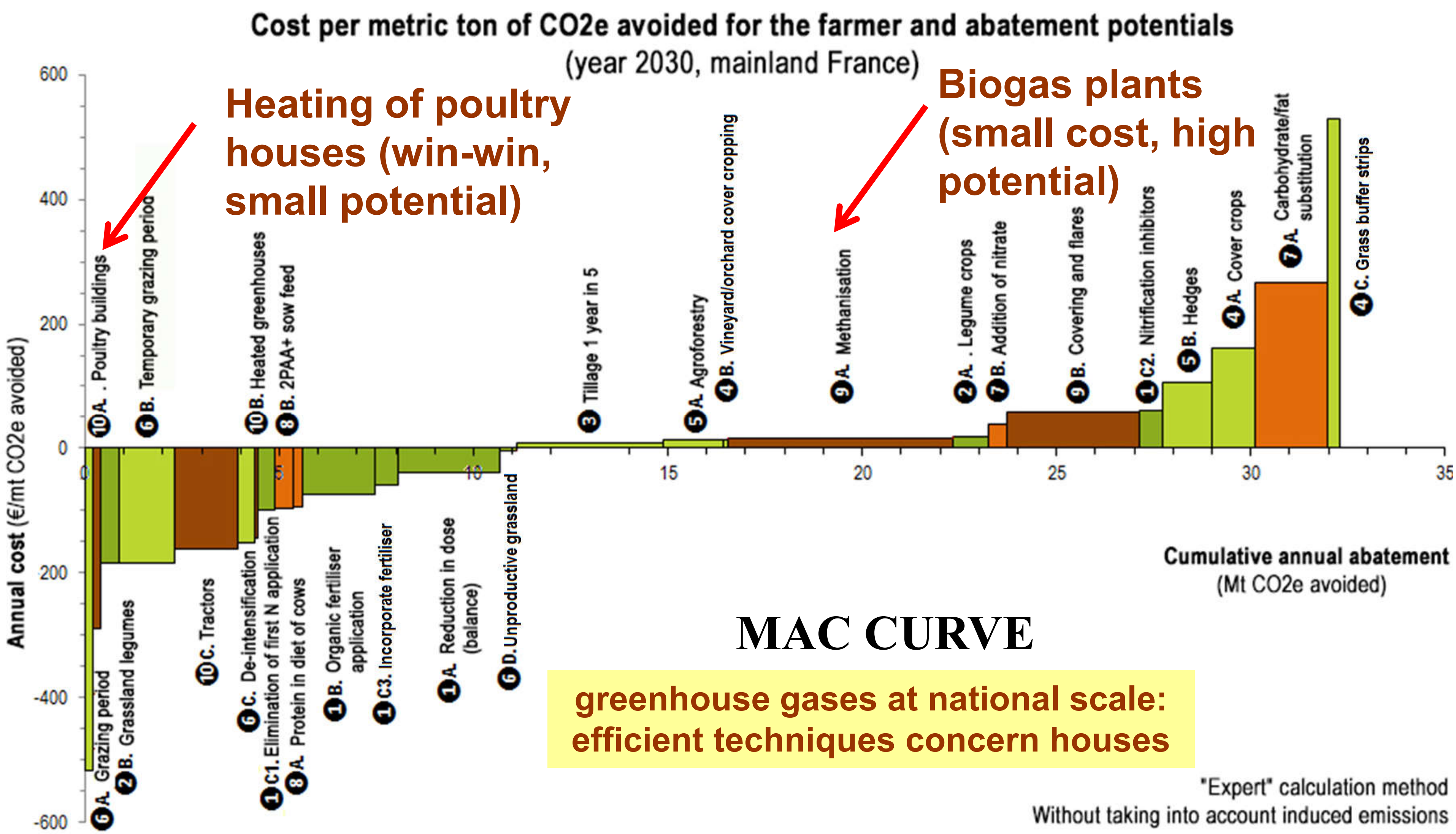
❖ efficiency of BAT at national scale?

NH_3 reduction at national scale: efficient techniques of NH_3 reduction do not concern houses (high costs)



❖ efficiency of BAT at national scale?

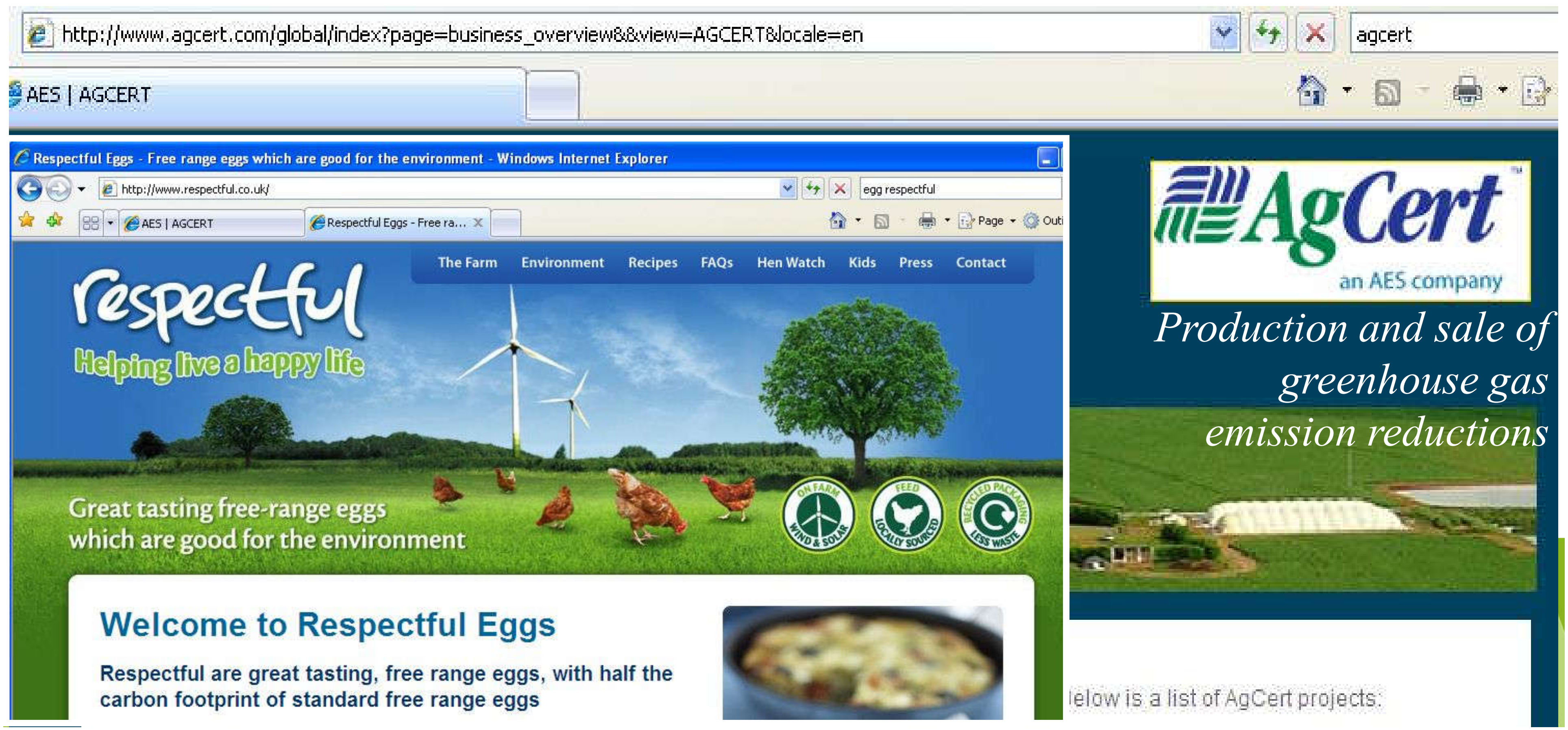


greenhouse gases at national scale: efficient techniques concern houses

❖ Trajectories of change

1. Market driven => rapid changes

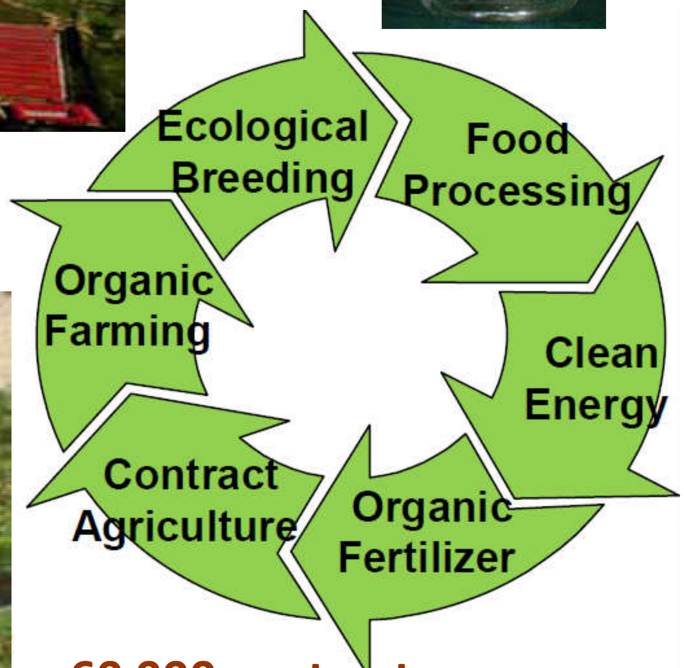
- Context : « carbon credits (approved methodologies)», « green » products, brands,…
- Limit : « green washing »



❖ Trajectories of change

1. Market driven: DQY ecological farm (10^6 eggs per day)

DQY ECOLOGICAL 德青源

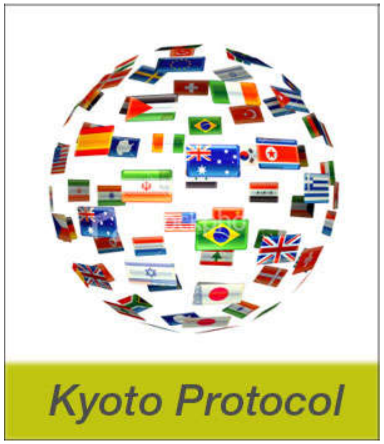


60 000 contracts with farmers

(Wenzhi Pan, 2010)

❖ Trajectories of change

2. Regulation driven



- Pollution abatement : development of mitigation techniques, certification of the efficiency
- Policy-making : national inventories
- Certification of BAT (best available technique)

Costs or risks => oppositions, slow adaptation

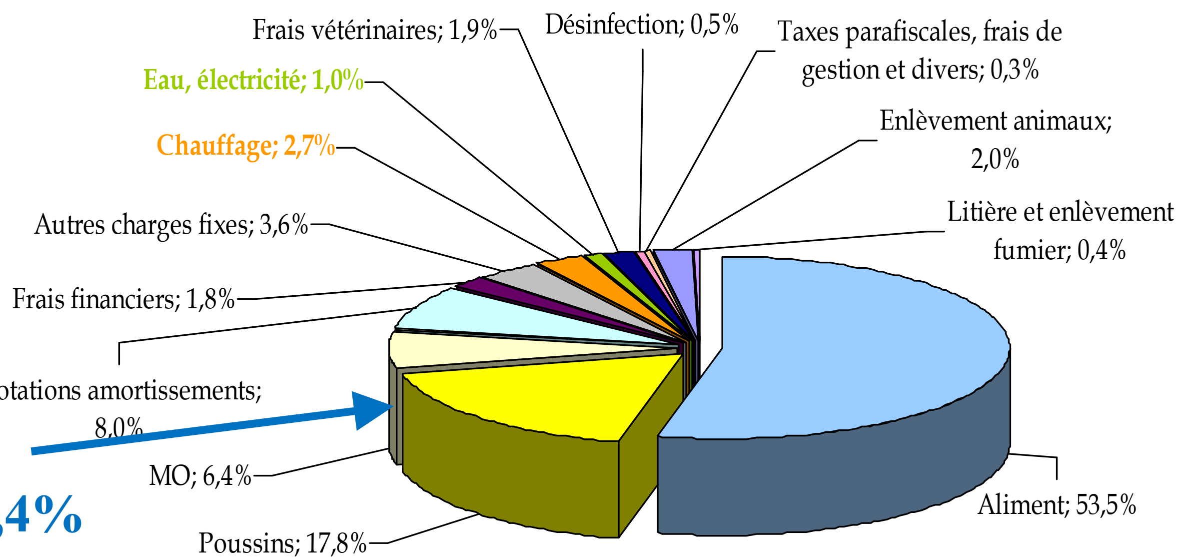
❖ Trajectories of change

3. Reducers (actors)

- Farm: what do they **win**? Who **controls** (scale? farm or farm group)?

A small increase paid by the consumer can have a huge impact on the farmer salary

economical motivation => accelerated evolution



Salary of farmer: 6,4%

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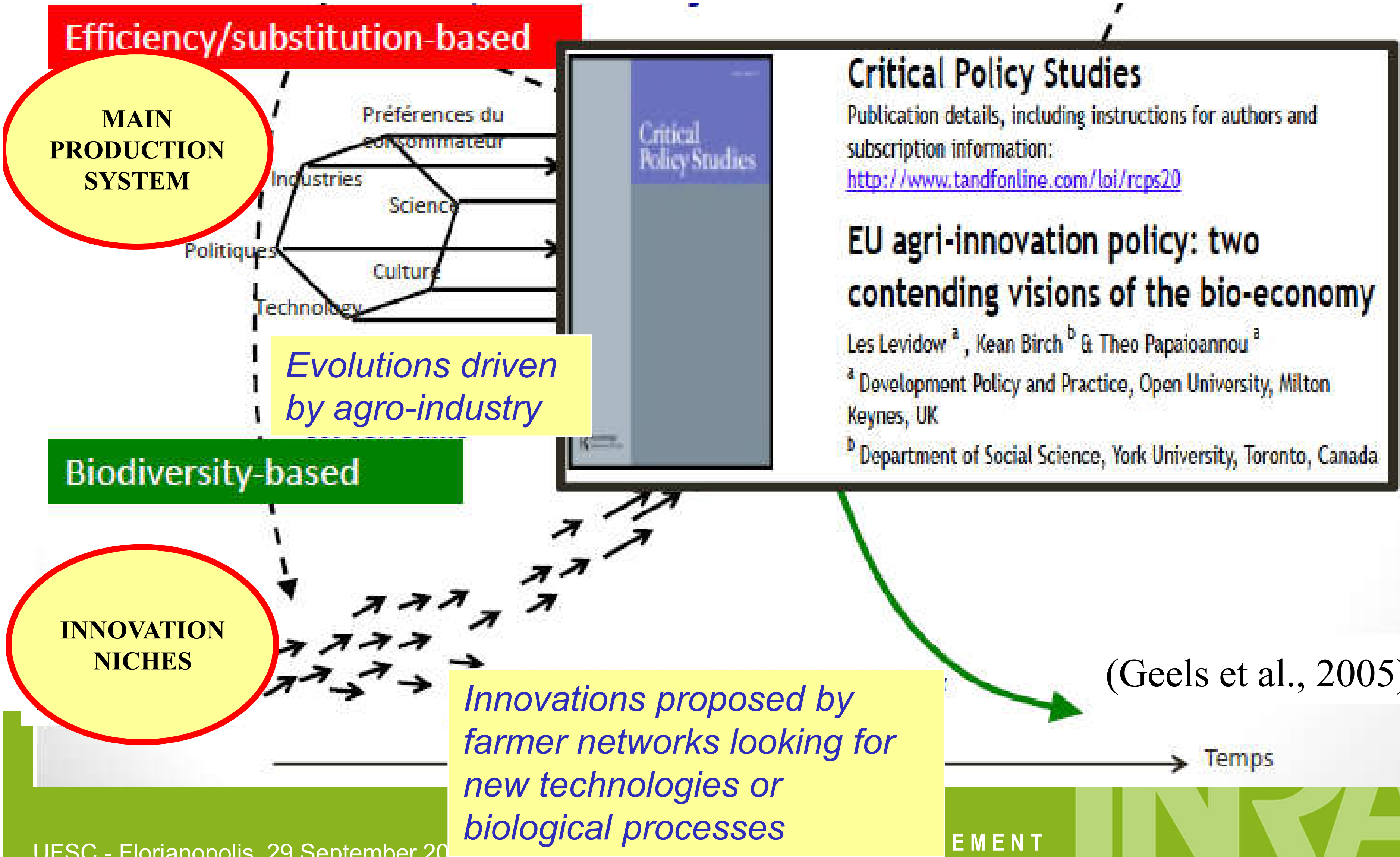
❖ Trajectories of change

Changes in the prices or regulations induce changes in production pratices



Conclusion

- plan – do – check – act – plan – do …

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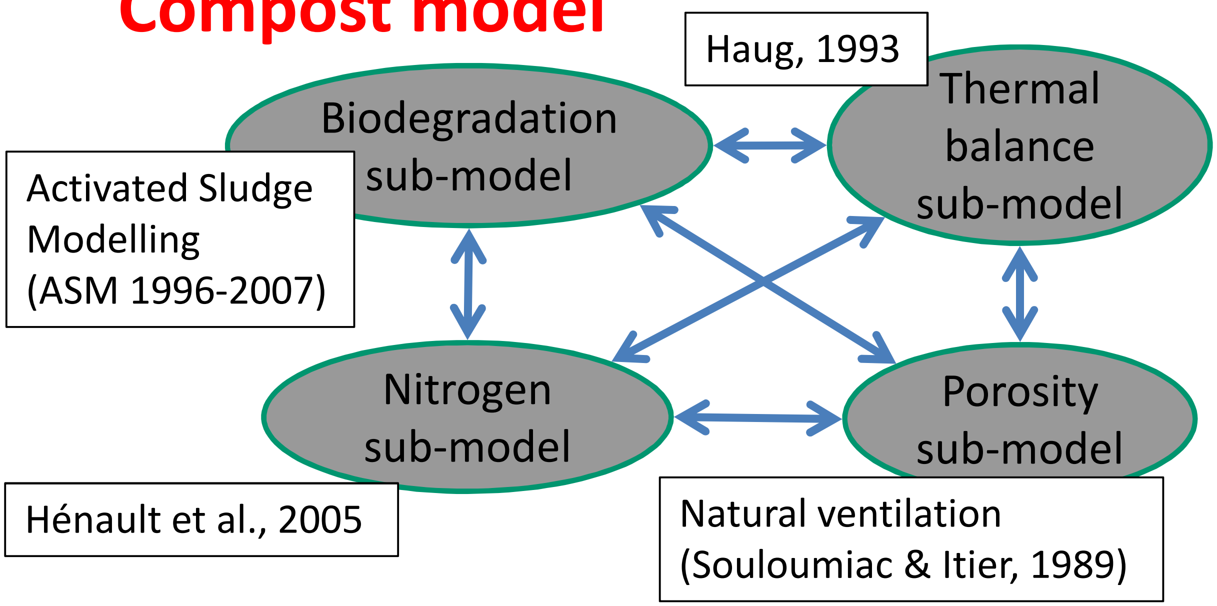
❖ Plan = Do

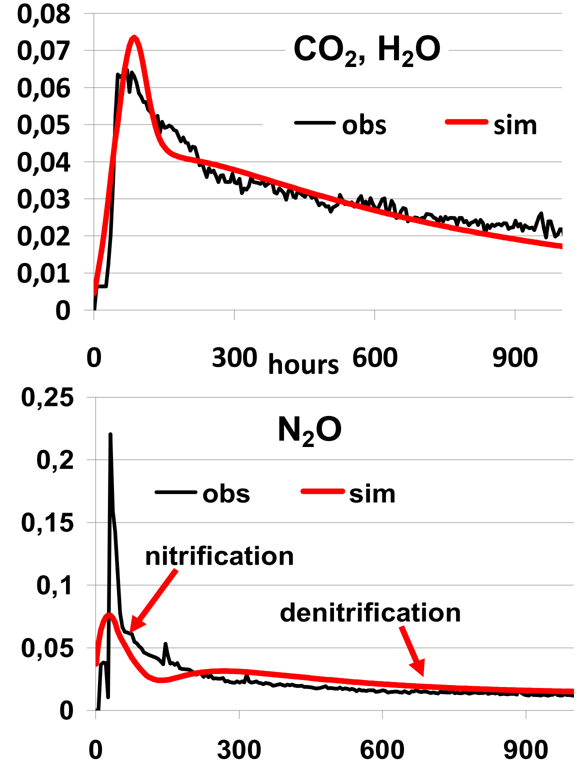
- ❖ Depend on farm categories => objectives, opportunities of change
- ❖ PLAN => evaluate with models the consequences of changes
- ❖ Choose (companies, farmers, administrations)
- ❖ DO…

➡ 4 types of modelling approaches are usefull

Coupling physical and biological processes with small input parameters

Compost model

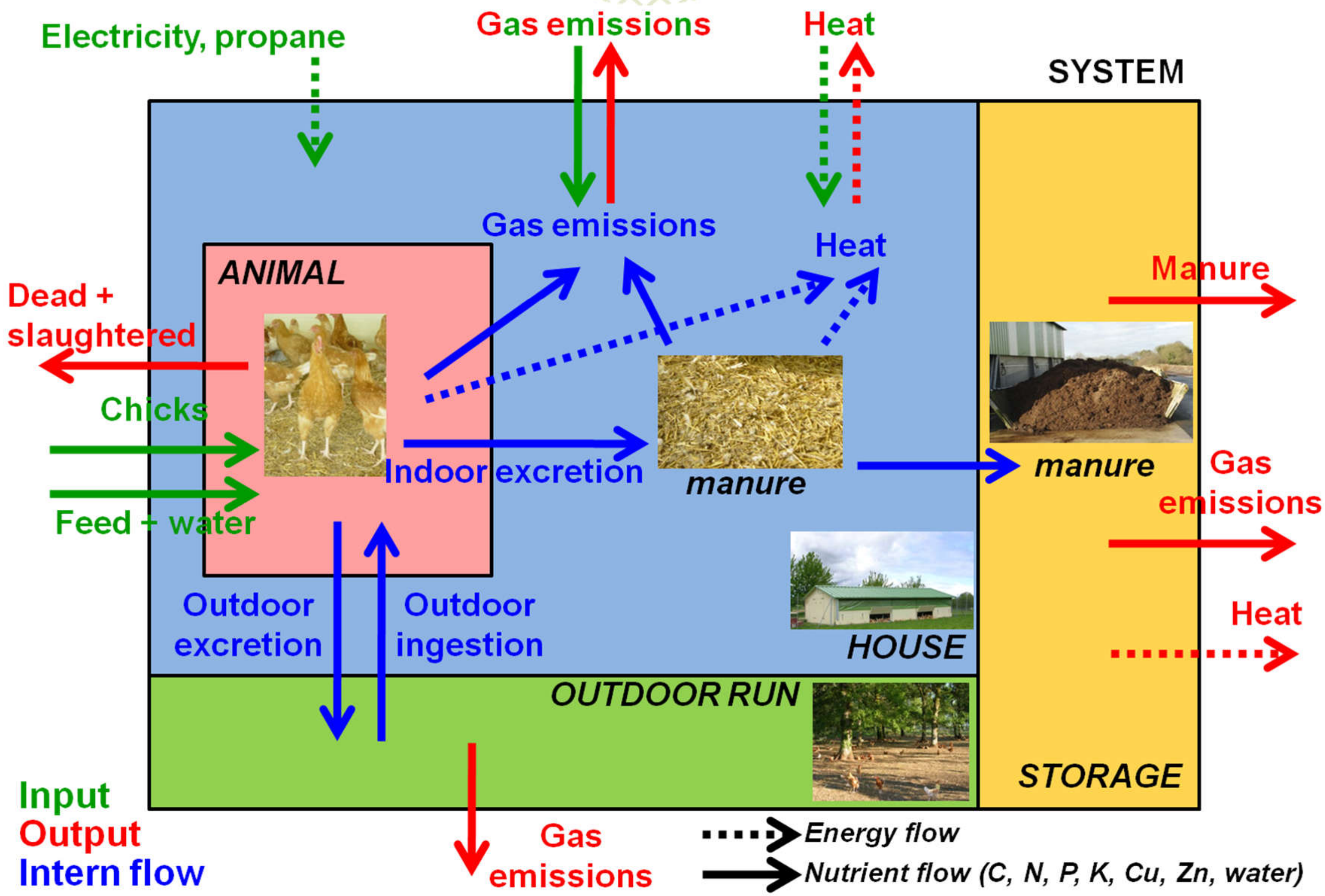




- ➔ climate input at hourly time step
- ➔ 5 parameters specific of manure + 25 based on literature and experiments
- ➔ influence of C & N biodegradability, porosity and humidity

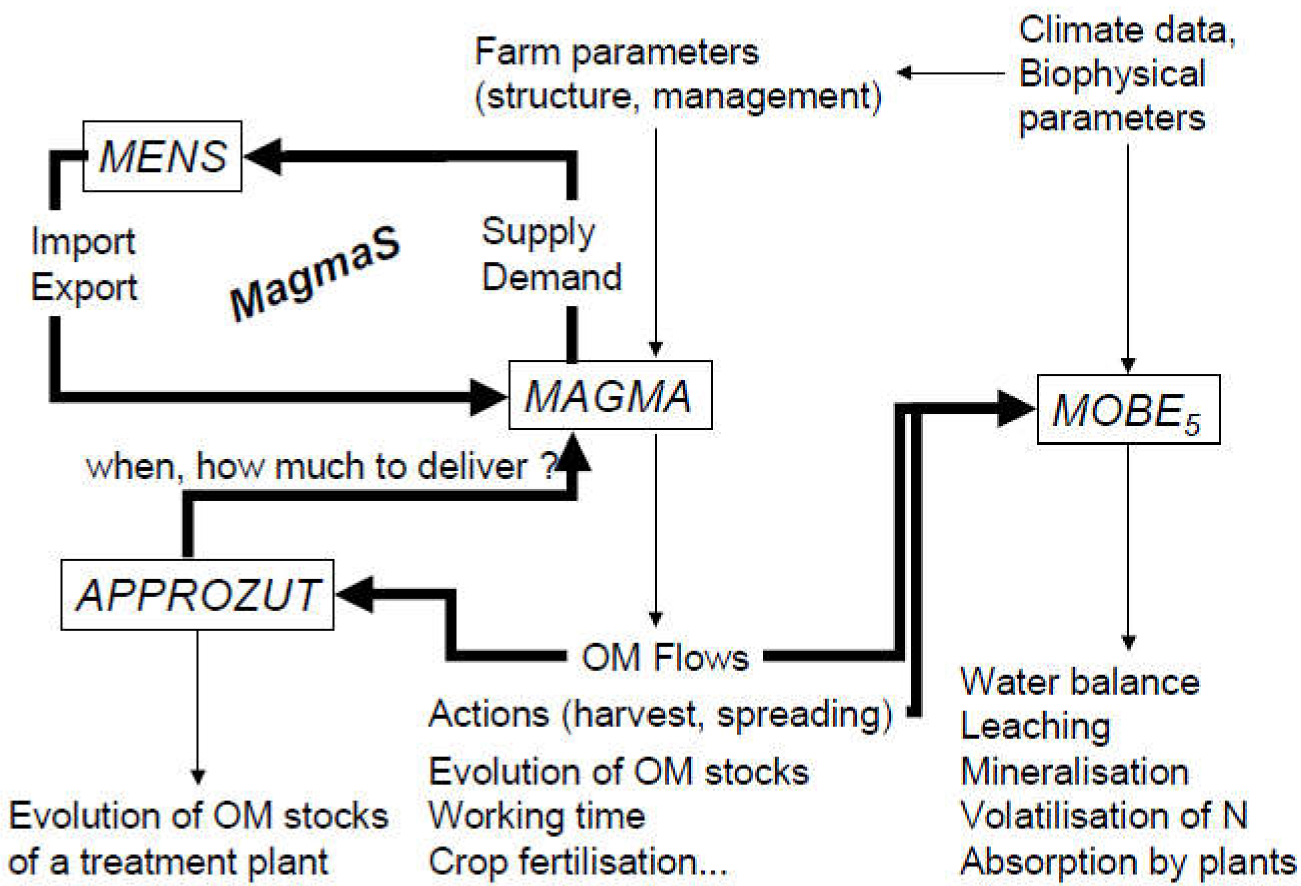
D. Oudart, 2012. Ph.D. thesis, Crête d'Or Entreprise, CIRAD, INSA Toulouse, INRA

❖ Modeling animal production systems to check dynamical coherence of mass and energy fluxes



Méda, B., 2011. Ph.D. thesis, Agrocampus Ouest, Rennes. Retrieved from http://tel.archives-ouvertes.fr/tel-00662627

❖ Modeling actor behavior for biomass recycling to choose collective equipment



Multi-agent software

Outputs:

- emissions
- energy
- limiting equipment

Guérrin & Paillat, 2003

ENGELE: serious game for pig farm management & design to learn innovative systems

- environmental balance sheet and life cycle analysis allows users to measure their progress throughout the game

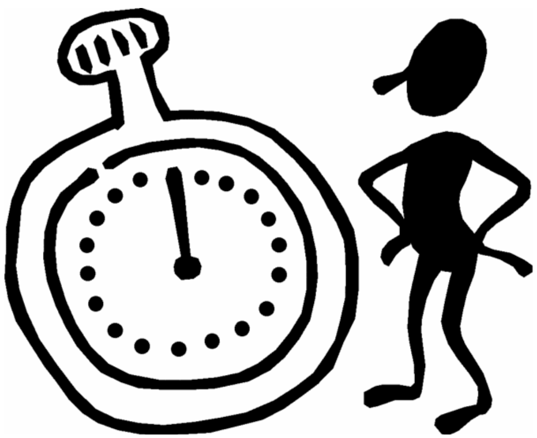
- Pig farm simulator for students & engineers to visualize the consequences of changing practices on performances & emissions

http://www.rmtelevagesenvironnement.org/pdf/ficheoutils/14-ENGELE.pdf

❖ Check = Act

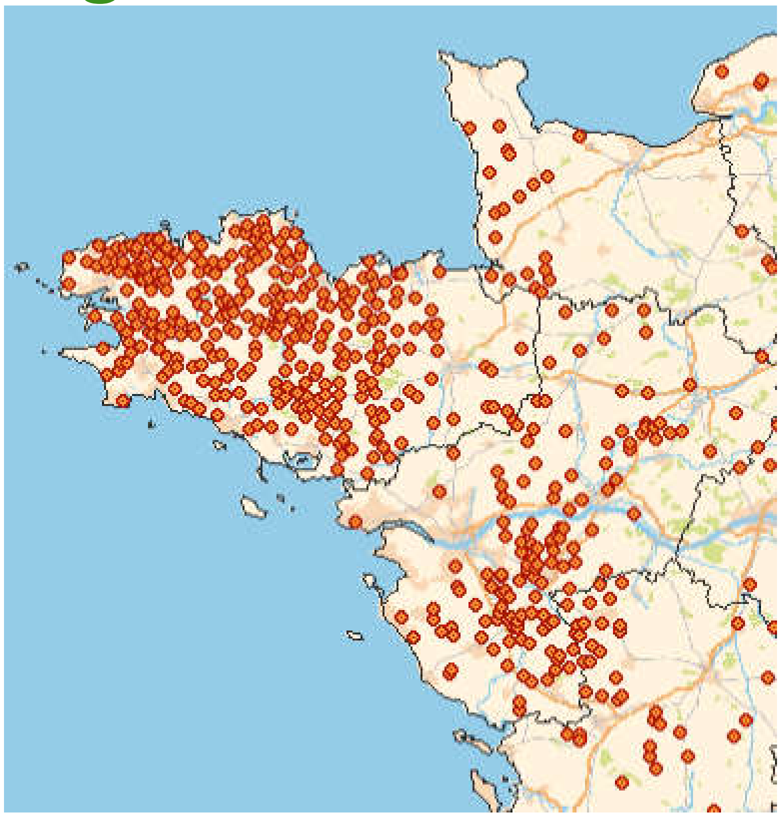
correct models, take changes into account

Surveys & network monitoring



A few data on lots of systems

Feedback on lots of BAT



IREP: public reporting on theoretical pollutant releases by animal farms

❖ Check ═ Act

correct models, take changes into account

Experiments on key-processes:

- ***choose scale***
- ***choose lab/field***
- ***define system where results will be extrapolated (definition variables & ranges)***

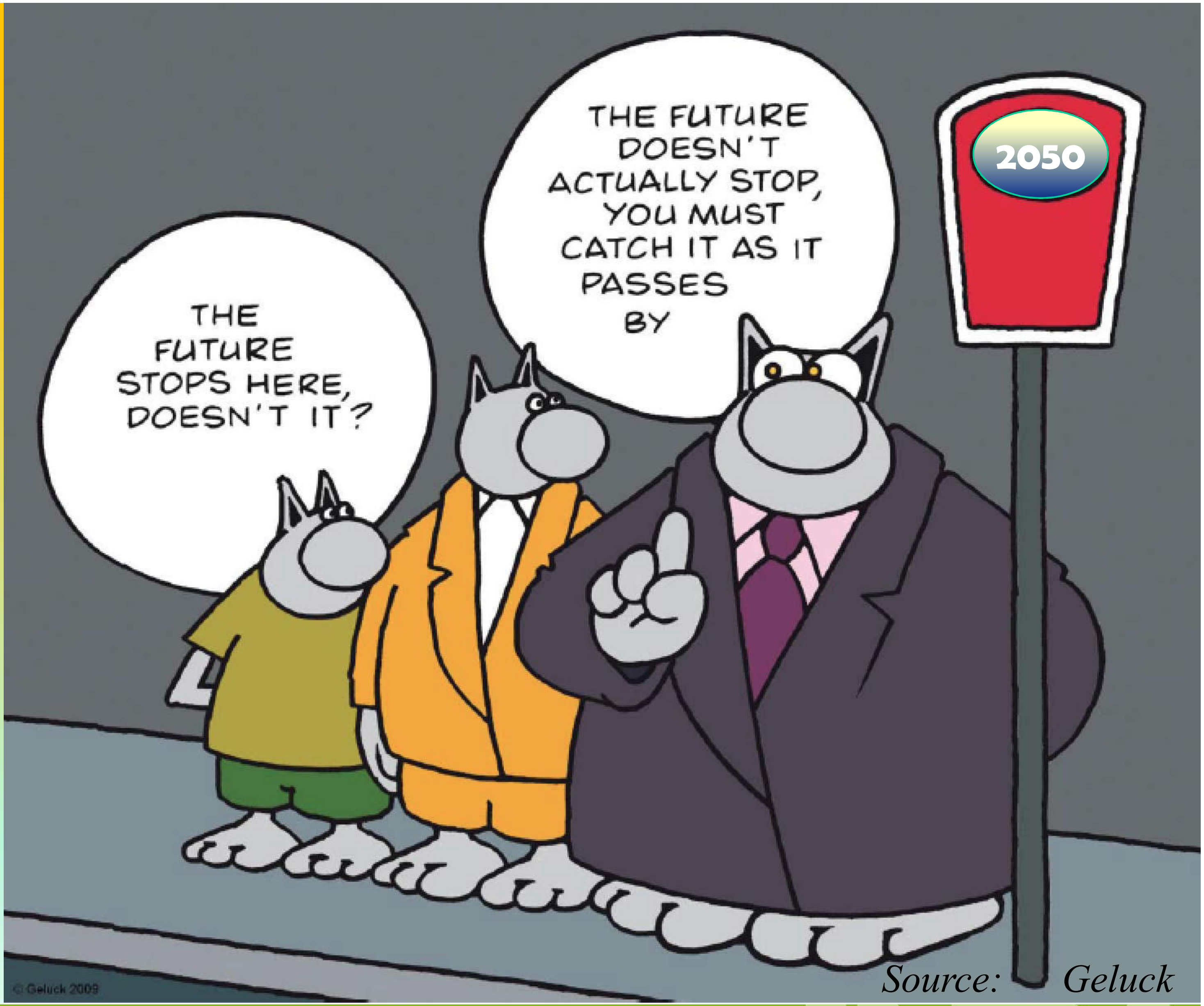
Take home messages

the challenge = rapid & global change

- Impact depends on system definition and evaluation basis (functional unit, allocation)
- Impact of a given facility depends on environment (climate, feed, animals) and farmer practices
- A lot of "best available techniques (BAT)" have been defined, their efficiency depends on the farm and the territory
- Magnitude and speed of changes depend on socio-economic issues (trajectories)
- Models and monitoring are key issues to set up efficient R&D programs

Thanks for your attention!

Any question?



Source: Geluck

Think global, act local…

Appendices

ALIMENTATION
AGRICULTURE
ENVIRONNEMENT

Welcome to next EmiLi symposium!

EmiLi 2017

THE FRENCH PARTNERSHIP NETWORK ON LIVESTOCK & ENVIRONMENT PRESENTS:

THE 3rd International Symposium on

Emission of Gas and Dust from Livestock

MAY 21-24, 2017

SAINT-MALO, FRANCE

contact emili2017@ifip.asso.fr

https://colloque.inra.fr/emili2017

ALIMENTATION
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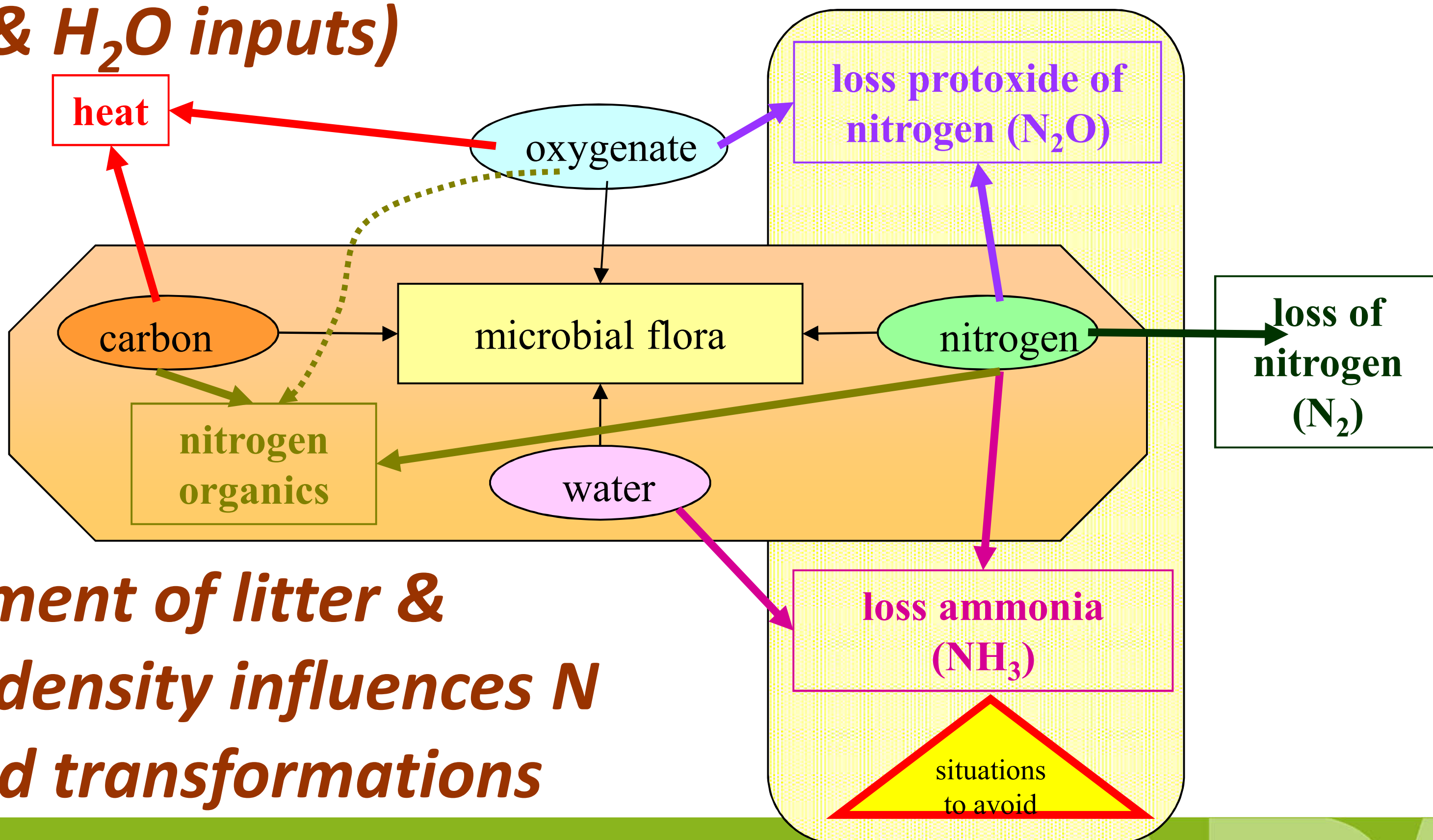
ENVIRONNEMENT

INRA

M&M: interactions

2. example: animal-manure interactions (animal behaviour determines place and amount of excretion: high N & H_2O inputs)



Management of litter & stocking density influences N losses and transformations

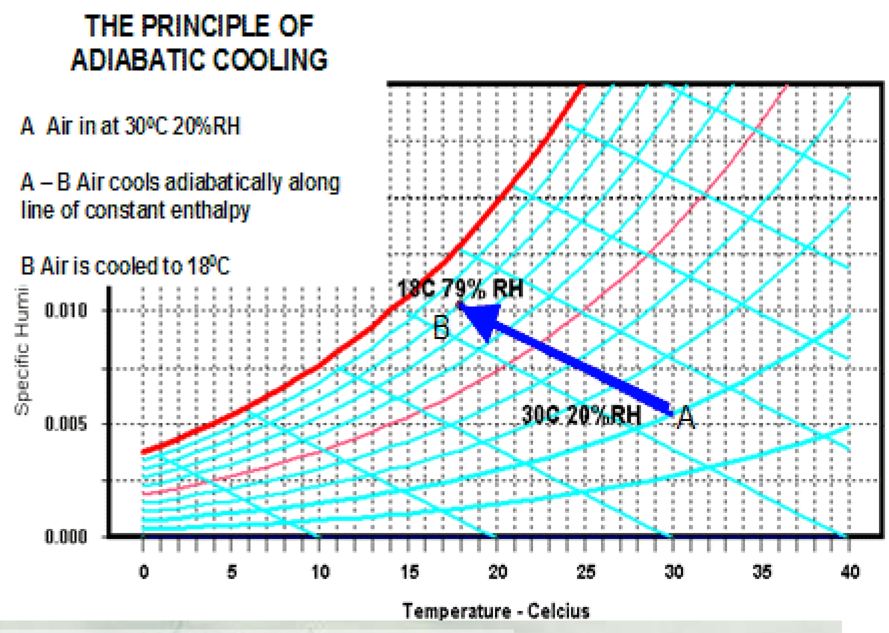
❖ M&M: interactions

4. Interactions at territory scale: urban-agricultural recycling can improve nutrient efficiency at region scale

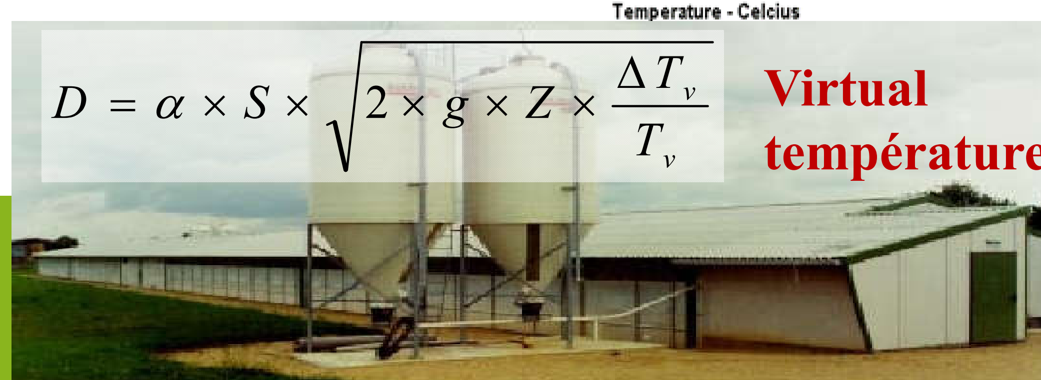
- ❖ Agricultural reuse of organic by-products
- ❖ Non-food/feed crops for contaminated OM
- ❖ Food/non food needs of urban populations and industries
- ❖ Heat & water availability for crop productions can increase productivity when they are limiting factors
- ❖ Wild animals & functions for non food requirements (recycling, hygienisation, recreation, etc.)

❖ M&M: Design of cooling/heating systems

In hot climate cooling & air speed are used to reduce animal heat stress: optimize water flow rate & natural ventilation to improve feed efficiency?



Conversion of sensible heat into latent heat



$$D = \alpha \times S \times \sqrt{2 \times g \times Z \times \frac{\Delta T_v}{T_v}}$$

Virtual température

3.2. Technology development: slurry treatment

- Separation of phases
- Biological treatment
- Treatment on filter basins
- Aerobic treatment
- Methanisation
- Treatment by mycelium
- Lagooning

Sustainability of nitrogen conservation or loss?

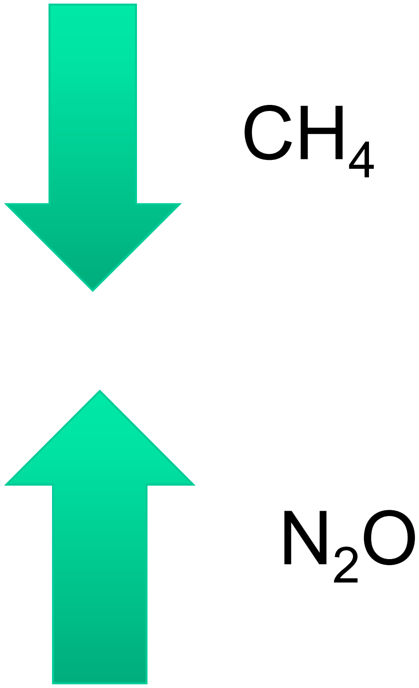
From process understanding to technology development

3.3. Solid manure management: controlled forced ventilation modifies moisture and oxygen availability

System VALLEY' ID

From process understanding to technology development

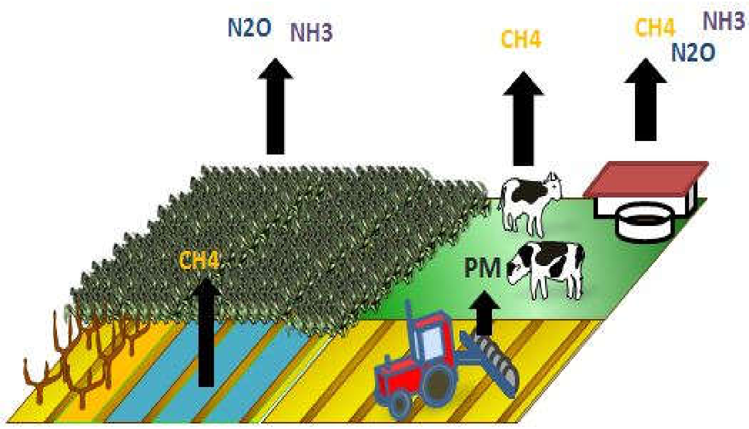
3.3. Avoid pollution transfer: compost aeration can decrease CH_4 but increase N_2O



❖ Trajectories of change

3. Reducers (actors)

- ❖ Group of farmers
- ❖ Company: impact of activity => LCA
- ❖ Region: emission reduction + landscape monitoring + urban areas



❖ Modelling challenges

- ❖ Models for understanding, discussing, management
- ❖ Models for data interpolation and data mining
- ❖ Management of model quality, model uses, knowledge integration: long term strategy for model and experimental data development is necessary to integrate various disciplines & scales