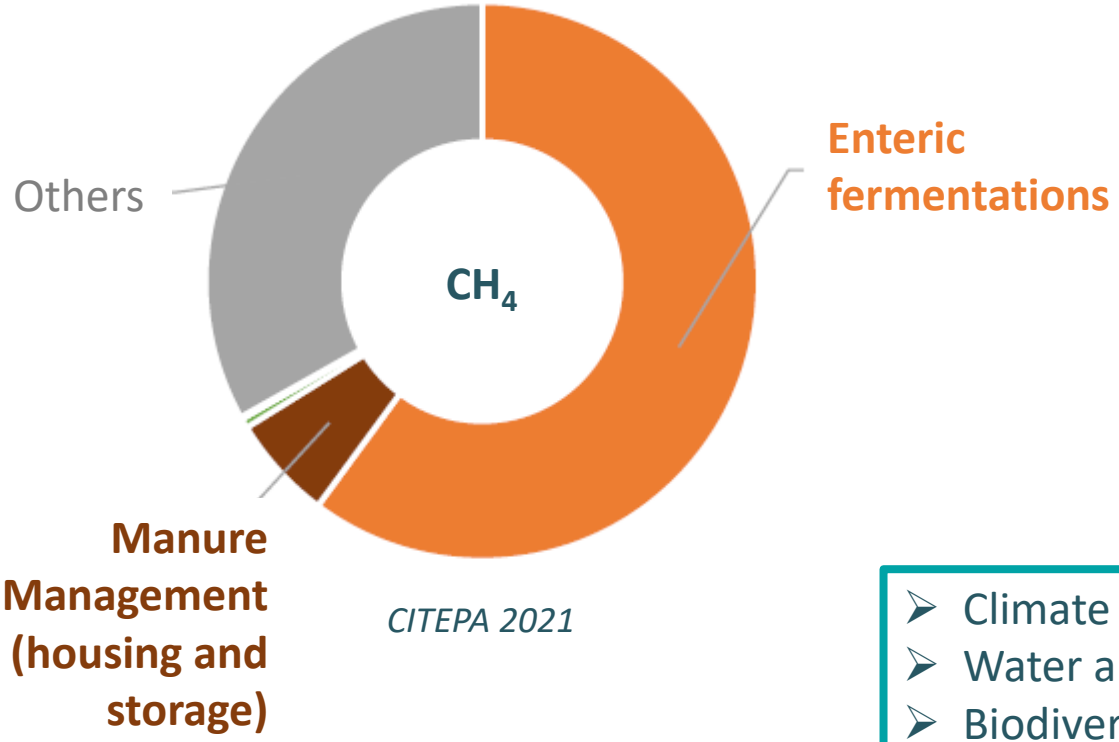
Gas emissions (building, storage, pasture) of dairy systems combining or not grazing and housing

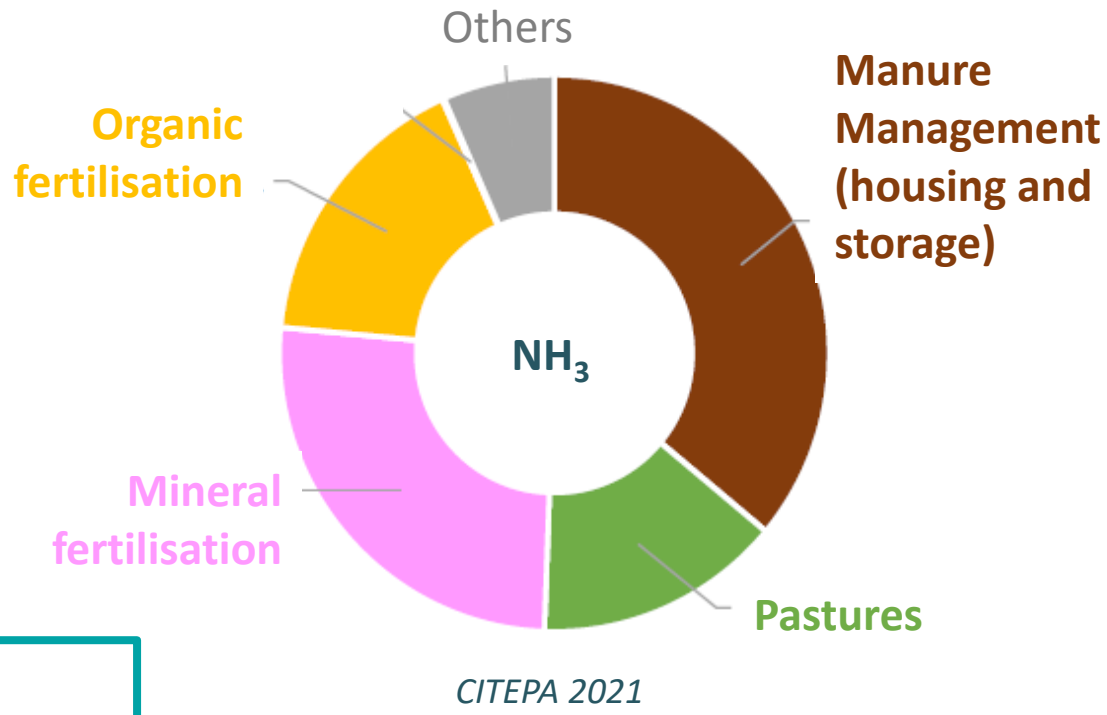
Nadege Edouard, Xavier Vergé, Christophe Flechard, Yannick Fauvel, Adrien Jacotot

Livestock contributes to environmental impacts

In France, AGRICULTURE accounts for **67% of CH_4** and **94% of NH_3** total emissions
=> mainly due to **livestock**



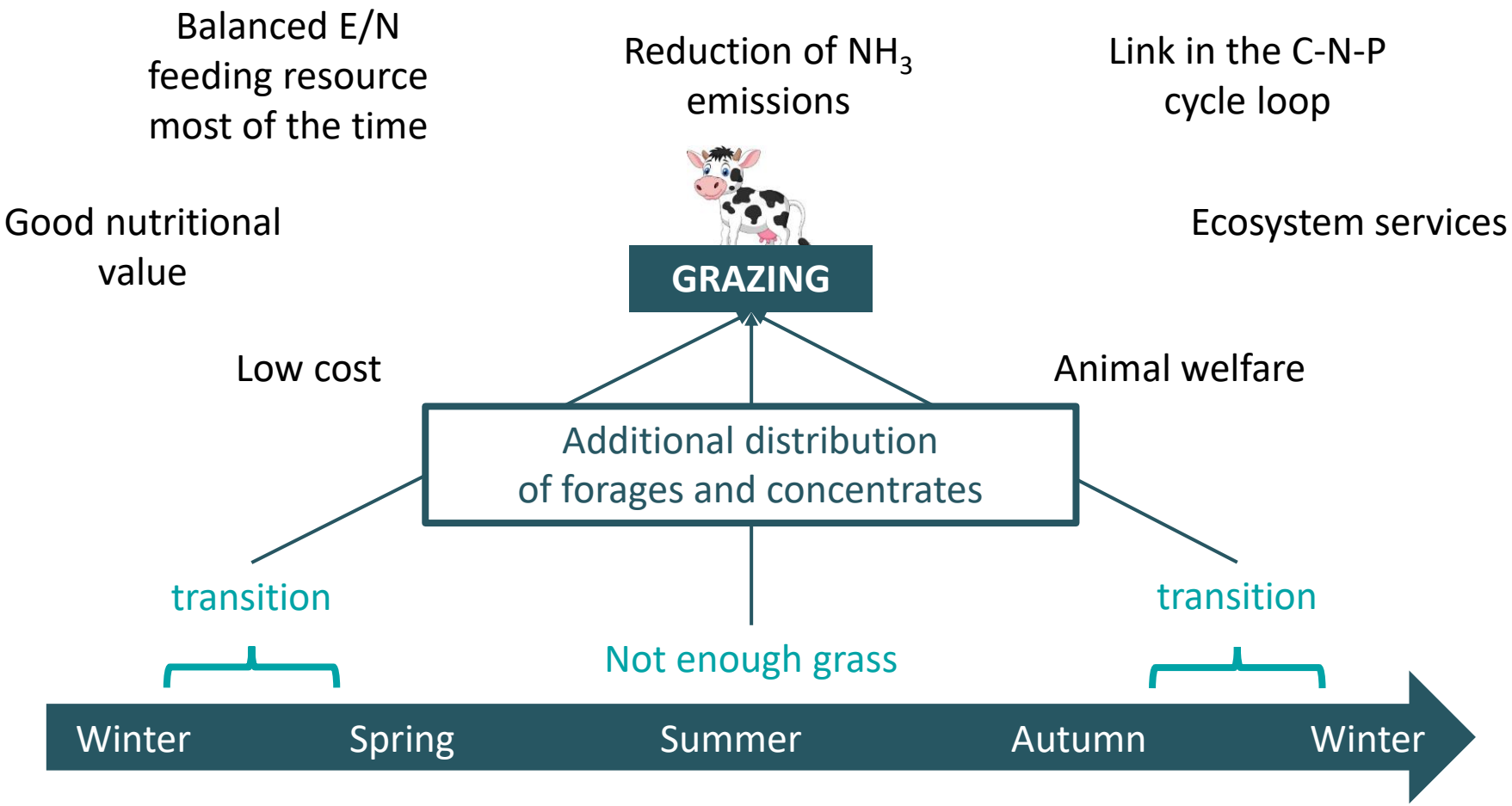
CITEPA 2021



CITEPA 2021

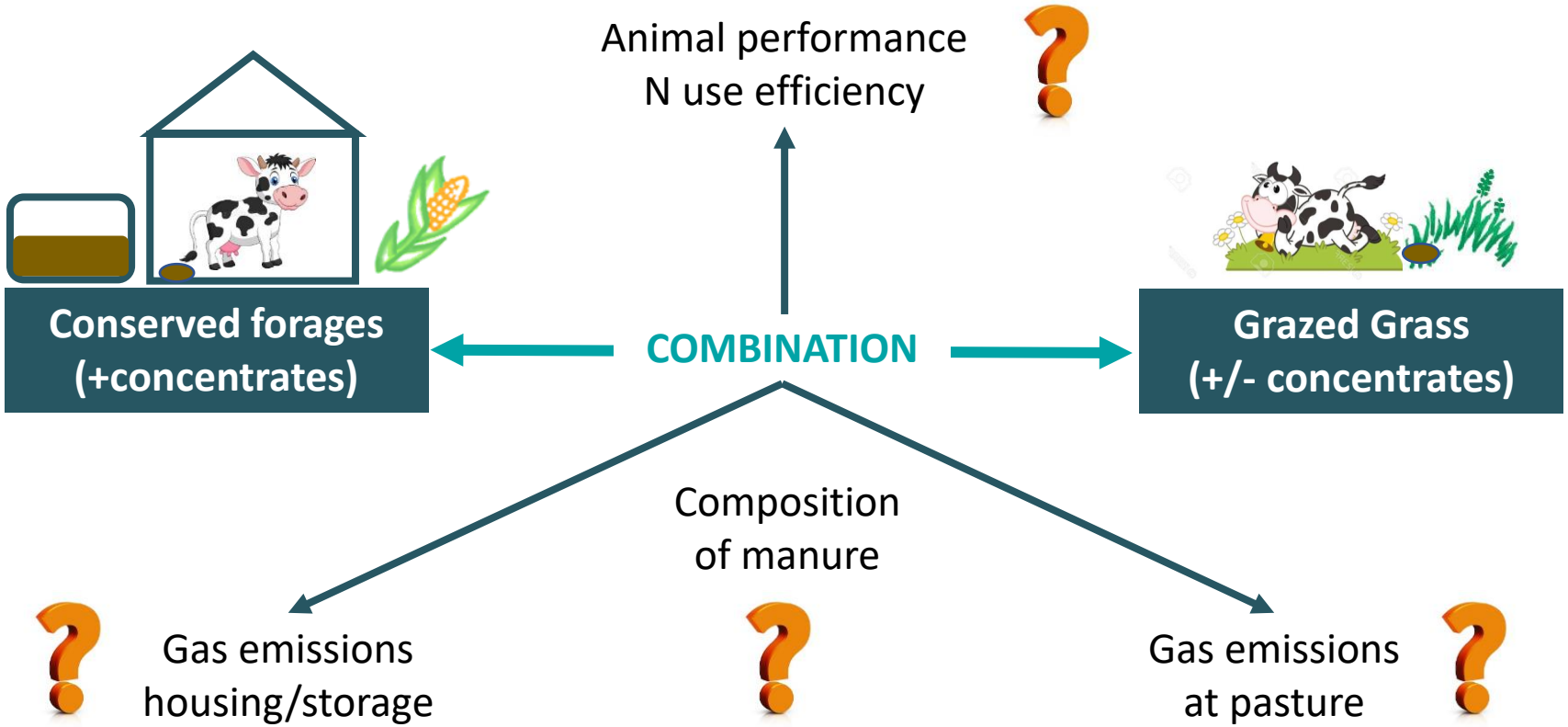
- Climate change
- Water and air pollutions
- Biodiversity losses
- …

Grazing: a lever for greater sustainability



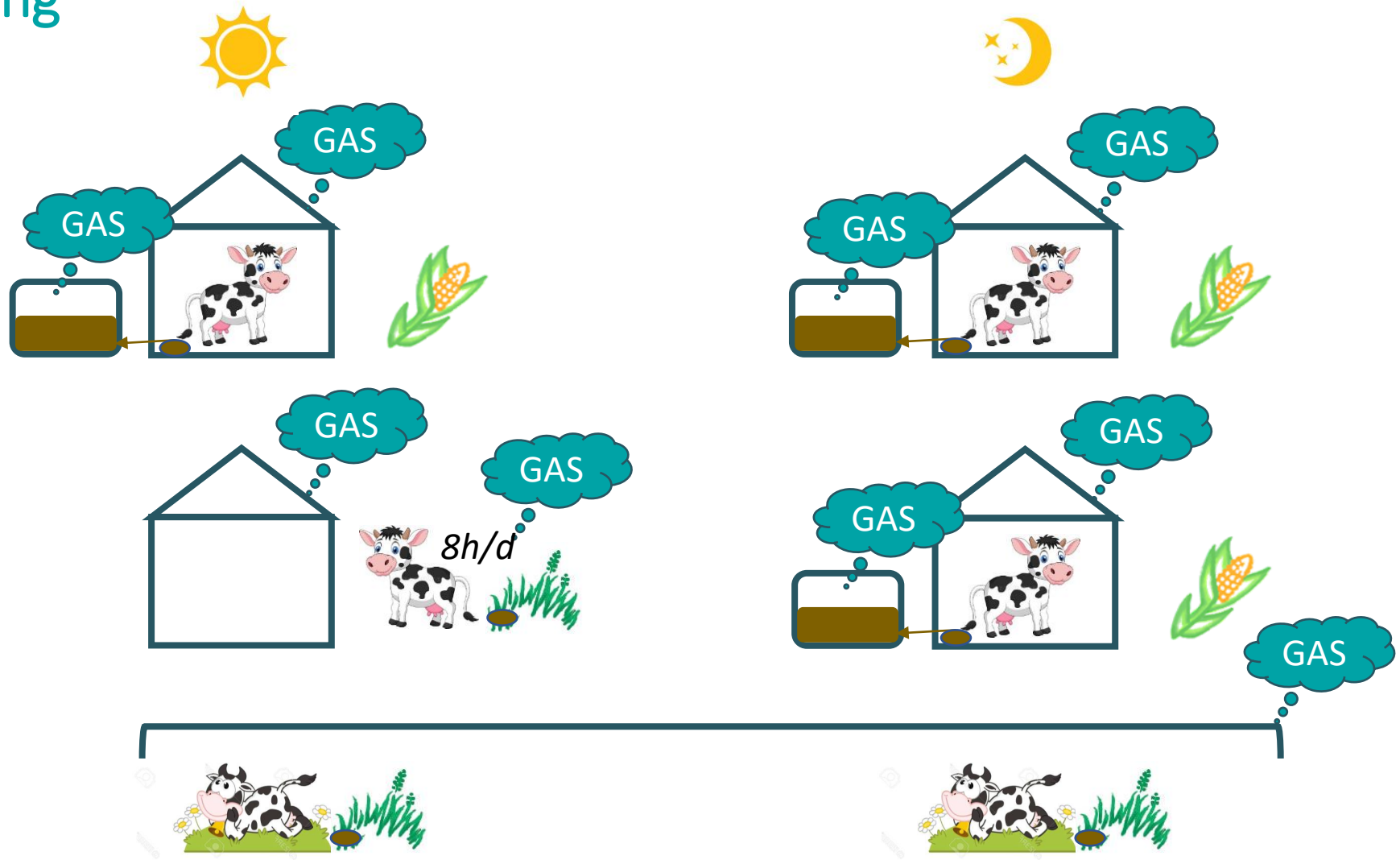
Consequences of combining grazing and forages offered at trough

On GHG and NH_3 emissions



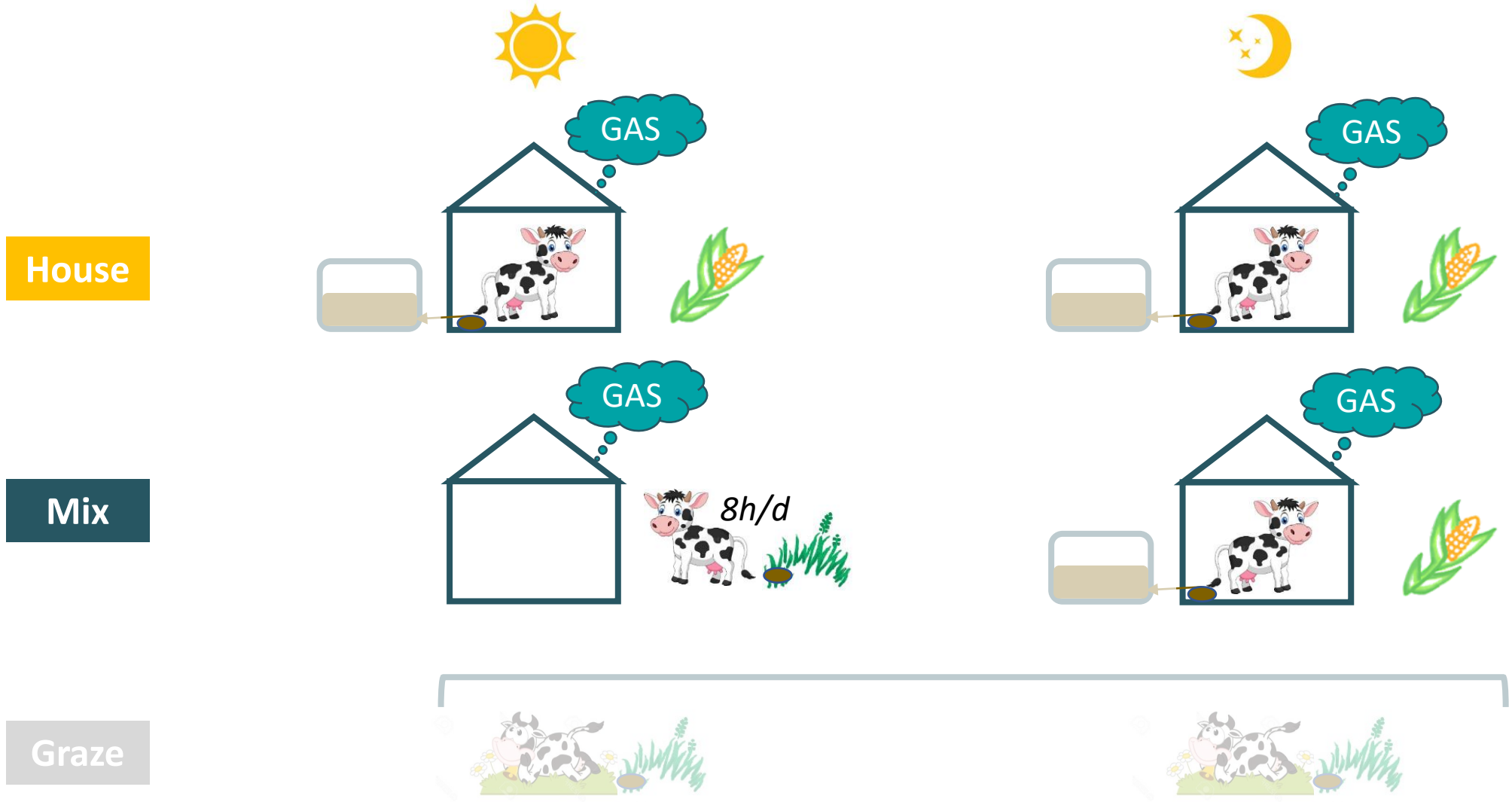
Comparing 3 strategies combining or not grazing and housing

INRAE Dairy Experimental Farm
Rennes, France
https://doi.org/10.15454/yk9q-pf68



➢ 2 seasons : Spring and Autumn

Gas emissions at the BARN level



Gas emissions at the BARN level

Experimental design

autumn **House** **Mix** **Graze**

1 group = 3 cows
Measures = 5 last d

	Period 1 3 weeks	**Period 2** 3 weeks	**Period 3** 3 weeks
Group 1	House	Mix	House
Group 2	Mix	House	Mix

24h/day **16h/day**

House :
Total Mix Ration ad lib

Mix :
8kgMS TMR in the evening

TMR:
75% maize silage
15% soya meal
10% cereals

Grazing:
Temporary pasture
0,5 à 1ha

8h/day

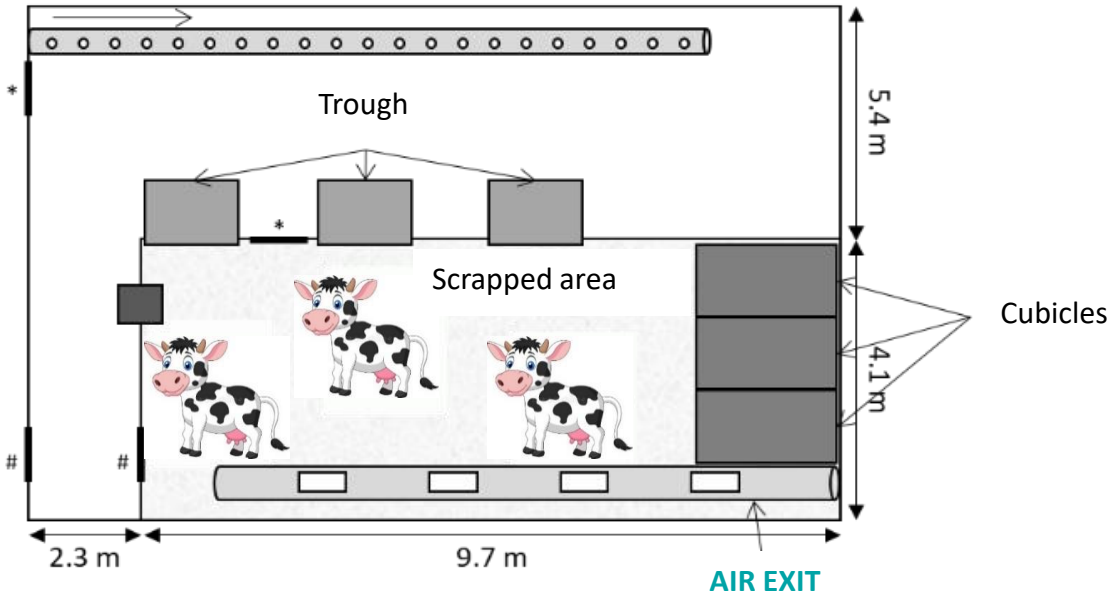
between milkings

Gas emissions at the BARN level

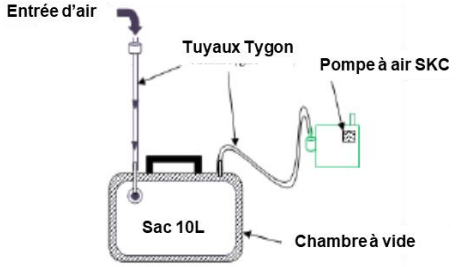
autumn **House** **Mix** Graze

Dynamic ventilation rooms – free stall barn

AIR ENTRY



Spot gas sampling in **air entry** and **air exit** at 7:00 before feeding and 18:00 after feeding



Gas concentrations

Analyser INNOVA

CH_4 - N_2O - CO_2

Colorimetric tubes

NH_3

\+

- DM Intake
- Milk Yield
- Milk composition
- Manure composition
- …

Gas emissions at the BARN level

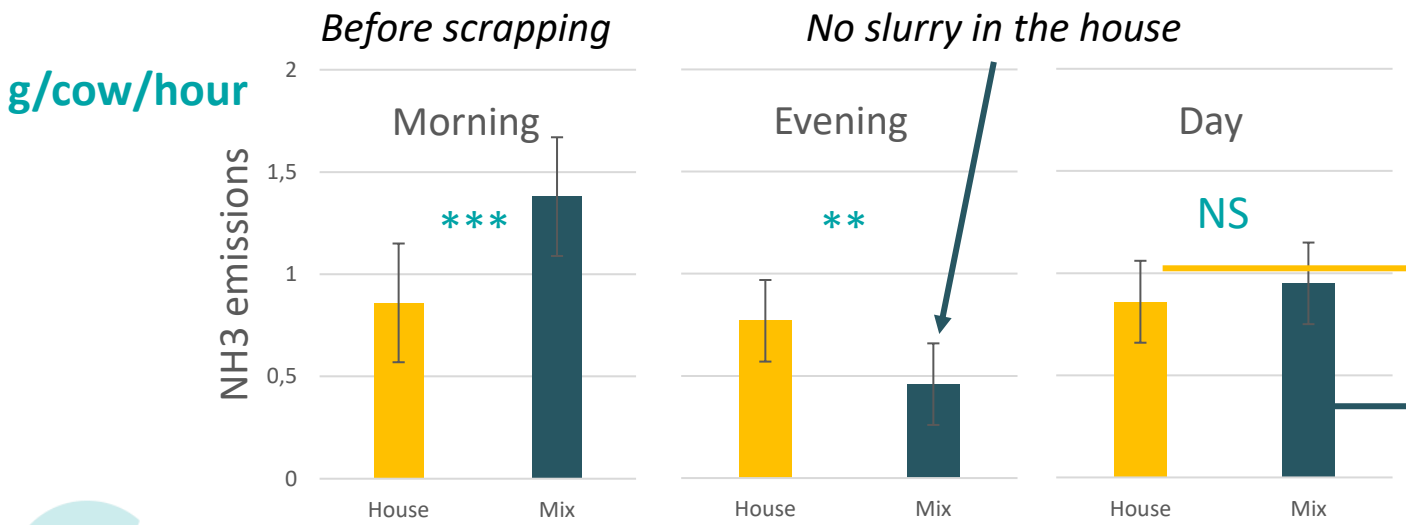
autumn **House** **Mix** **Graze**

NH_3 emissions

		House		Mix	P-value	RMSE
CP intake	kg/cow/d	**3.6**	<	**4.9**	***	0.2
Slurry N content	g/kg	**37**	<	**46**	*	0.3

Diet CP content: **14%** → **22%**

+1.3 kgCP for Mix despite lower DMI



At the BARN and DAY level

x 24h/day => 21 gNH_3/cow/day

x 16h/day => 15 gNH_3/cow/day

Gas emissions at the BARN level

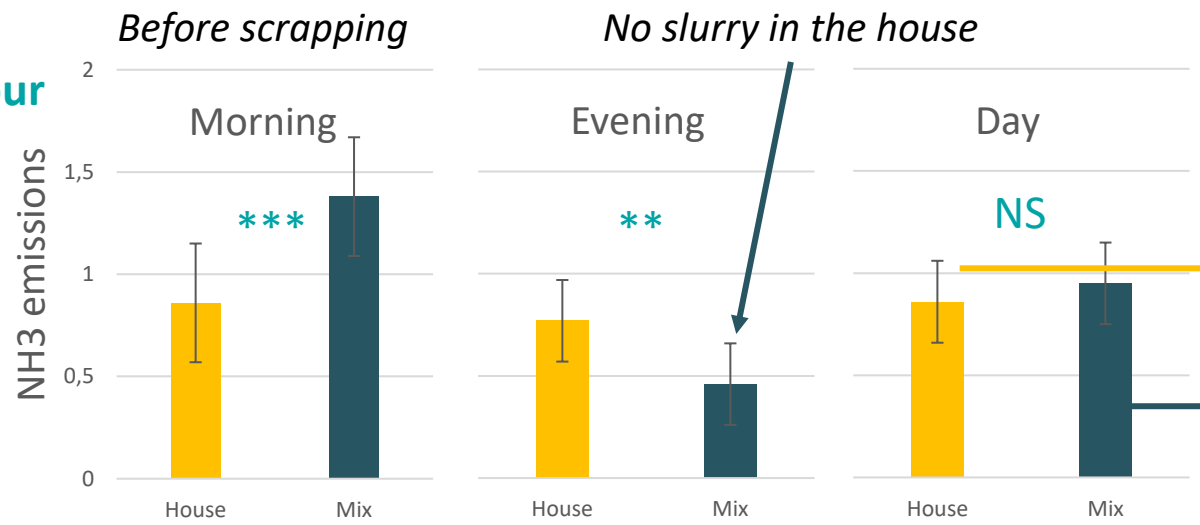
autumn **House** **Mix** **Graze**

NH_3 emissions

Ammonia emissions in g/cow/hour
are higher for cows eating grass with high CP content
when there is N-rich slurry in the house (morning)
but daily emissions are lower
due to lower amount of slurry in the house

Diet CP content:
14%
+1.3 kgCP for Mix
22%

g/cow/hour

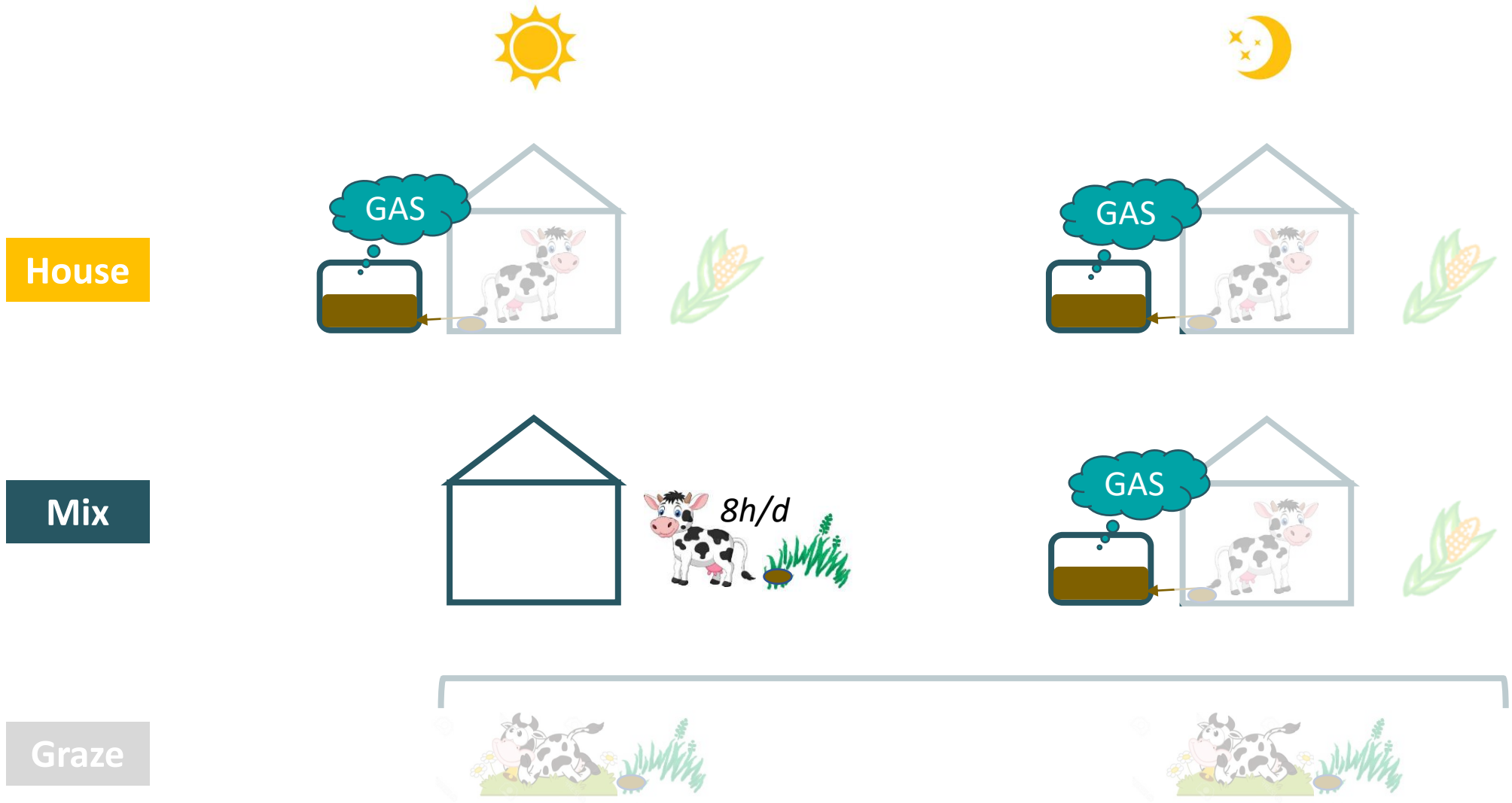


At the BARN and DAY level

x 24h/day => 21 gNH_3/cow/day

x 16h/day => 15 gNH_3/cow/day

Gas emissions at the STORAGE level



Gas emissions at the STORAGE level

autumn **House** **Mix** **Graze**

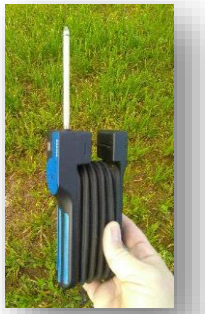
Passive flux chambers

- 100 kg slurry / treatment collected in 2 consecutive days during week 3 of the BARN phase
- Homogenized and separated in 4 containers / treatment
- Slurry regularly mixed (2 containers /treatment)
  or not (2 containers /treatment)

Spot gas sampling:
Gas concentrations

Colorimetric tubes

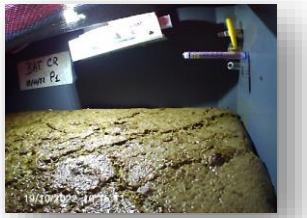
NH_3 - CO_2



Chromatography

CH_4 - N_2O - CO_2

Cameras

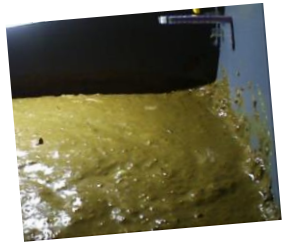


Gas emissions at the STORAGE level

Manure characteristics - composition

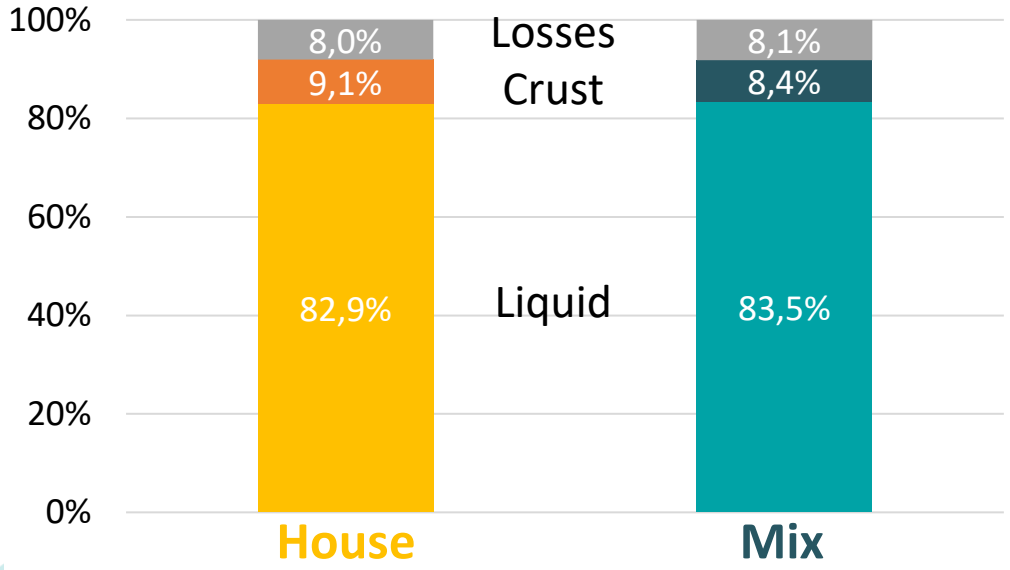
autumn **House** **Mix** **Graze**

Day 1

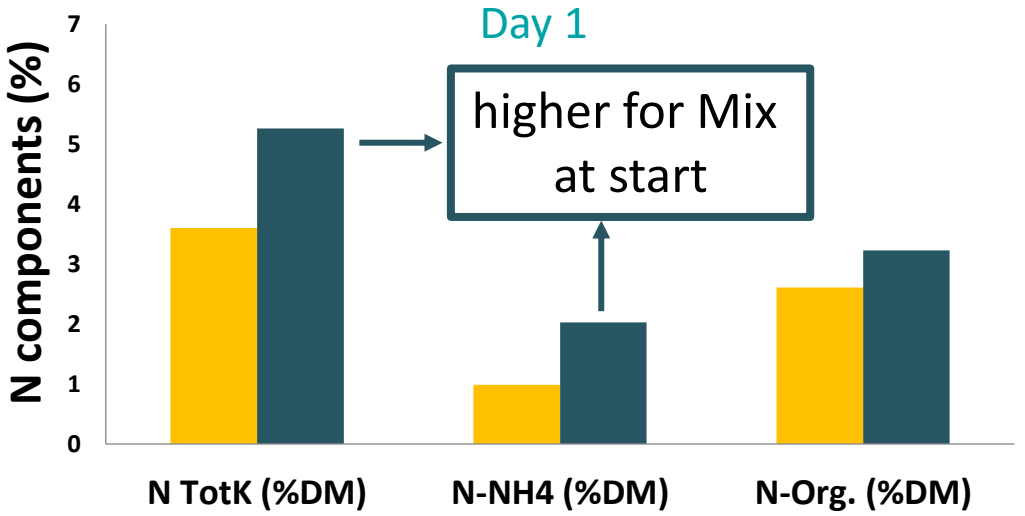


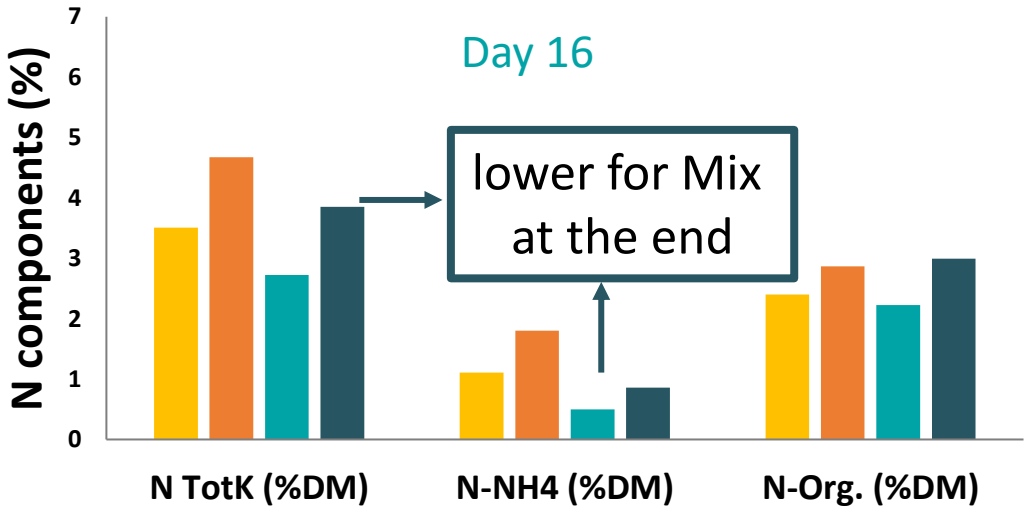
Day 16

Final manure matter distribution
(without slurry mixing)



=> Similar between feeding treatments

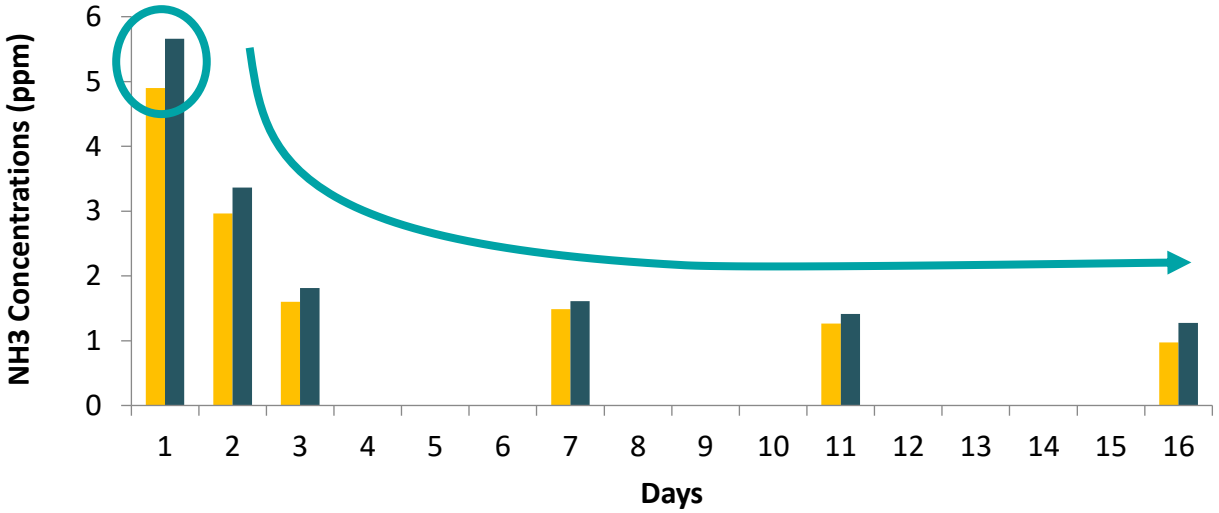




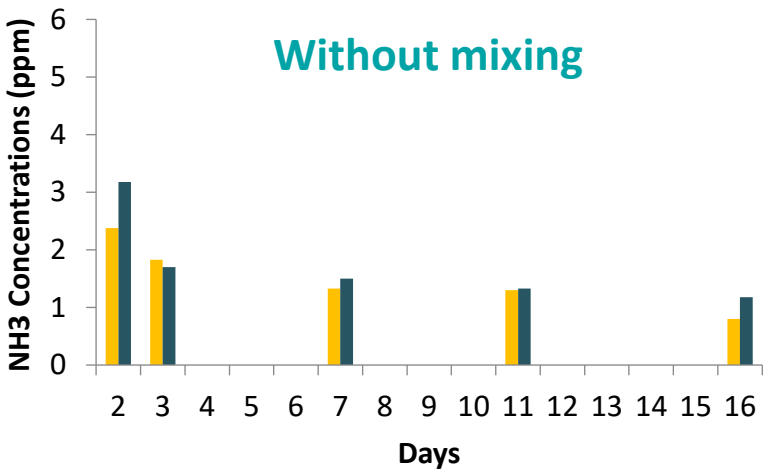
Gas emissions at the STORAGE level

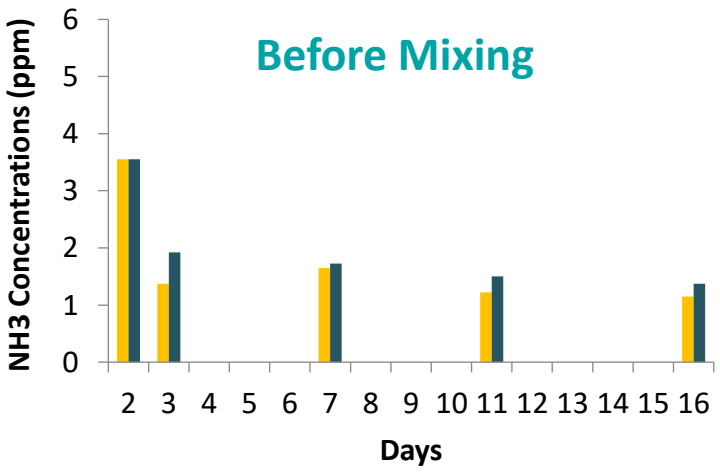
autumn **House** **Mix** **Graze**

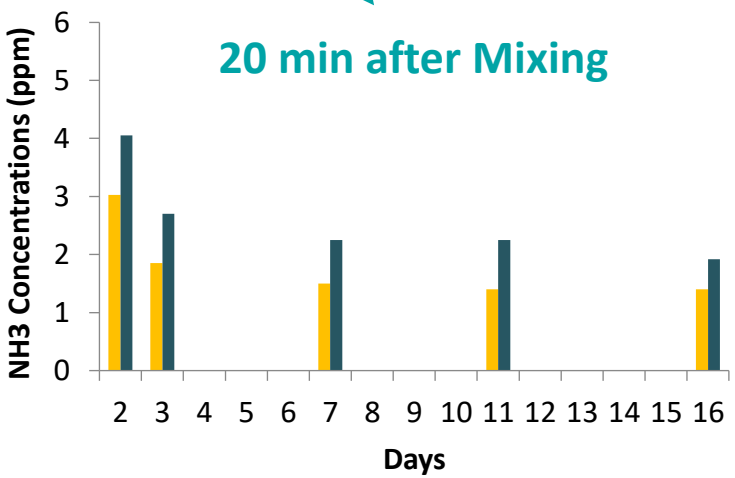
NH_3 volatilisation



- [NH_3] decreases quite rapidly
- Slightly higher [NH_3] for **Mix** vs **House** on day 1, almost similar thereafter
- Difference more visible just after mixing the manure

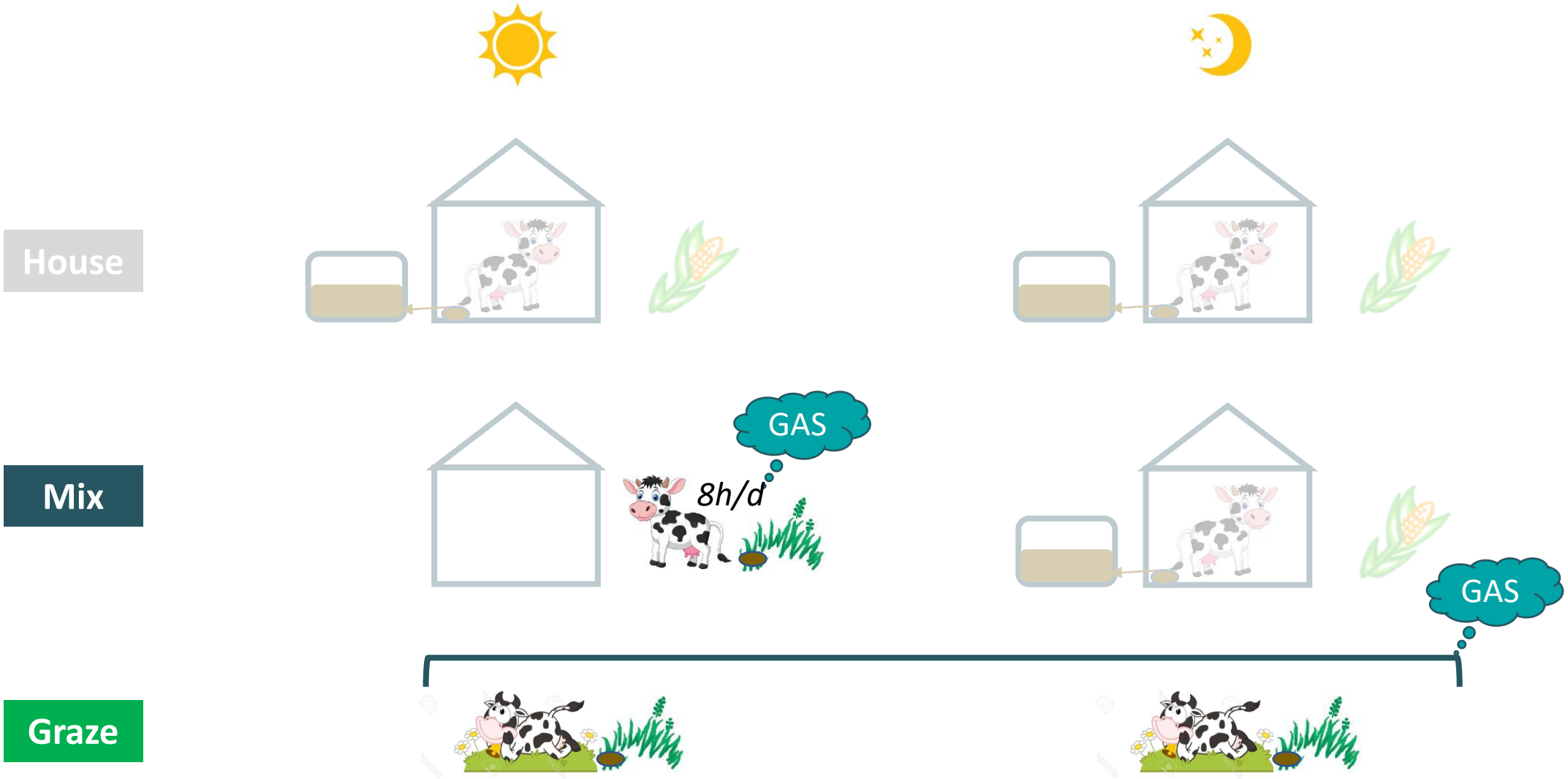






MIX: higher NH_3-N in slurry => higher NH_3 volatilisation

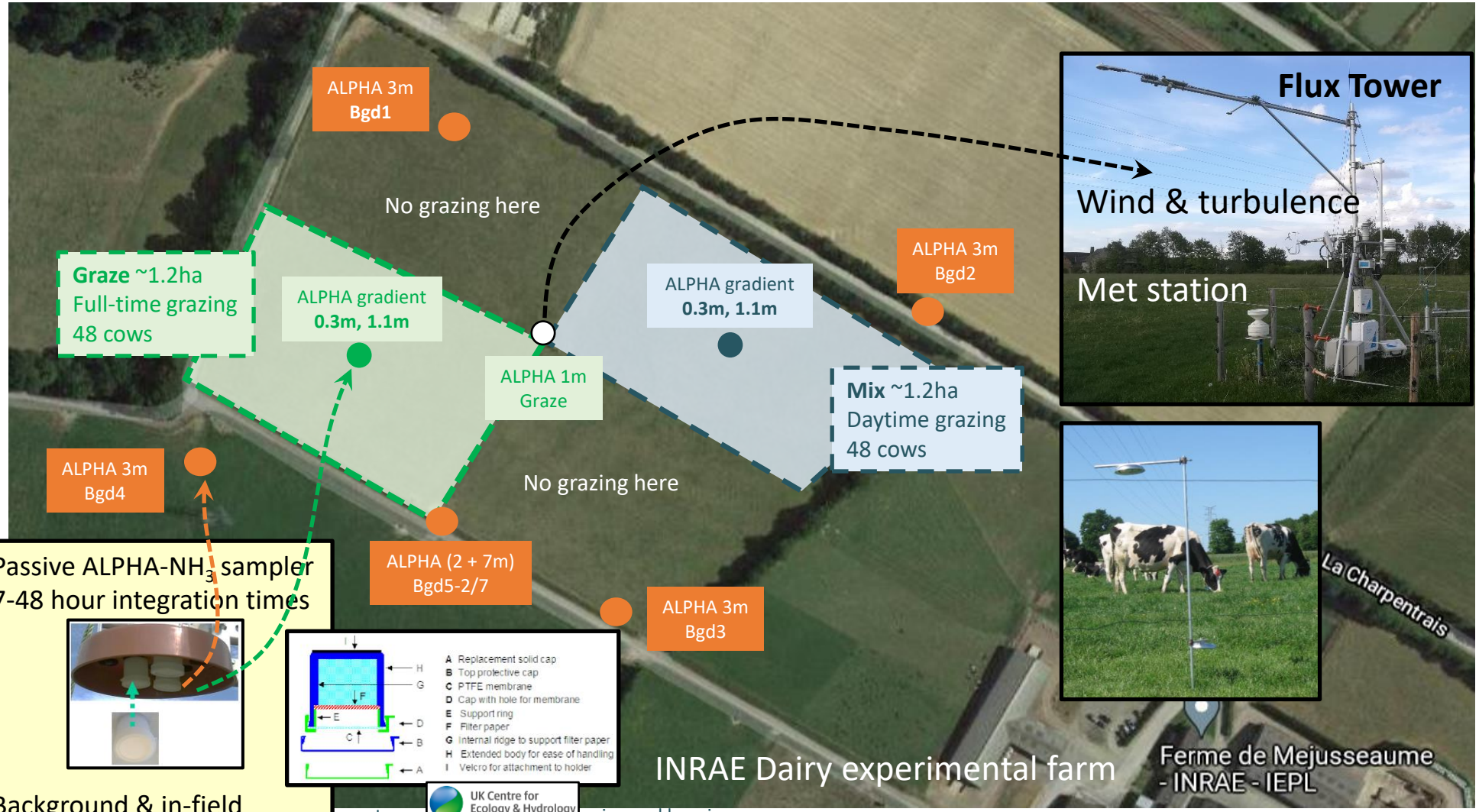
Gas emissions at the PASTURE level



Gas emissions at the PASTURE level

spring House Mix Graze

Inverse dispersion method to compare field-scale NH_3 emissions with ALPHA passive samplers



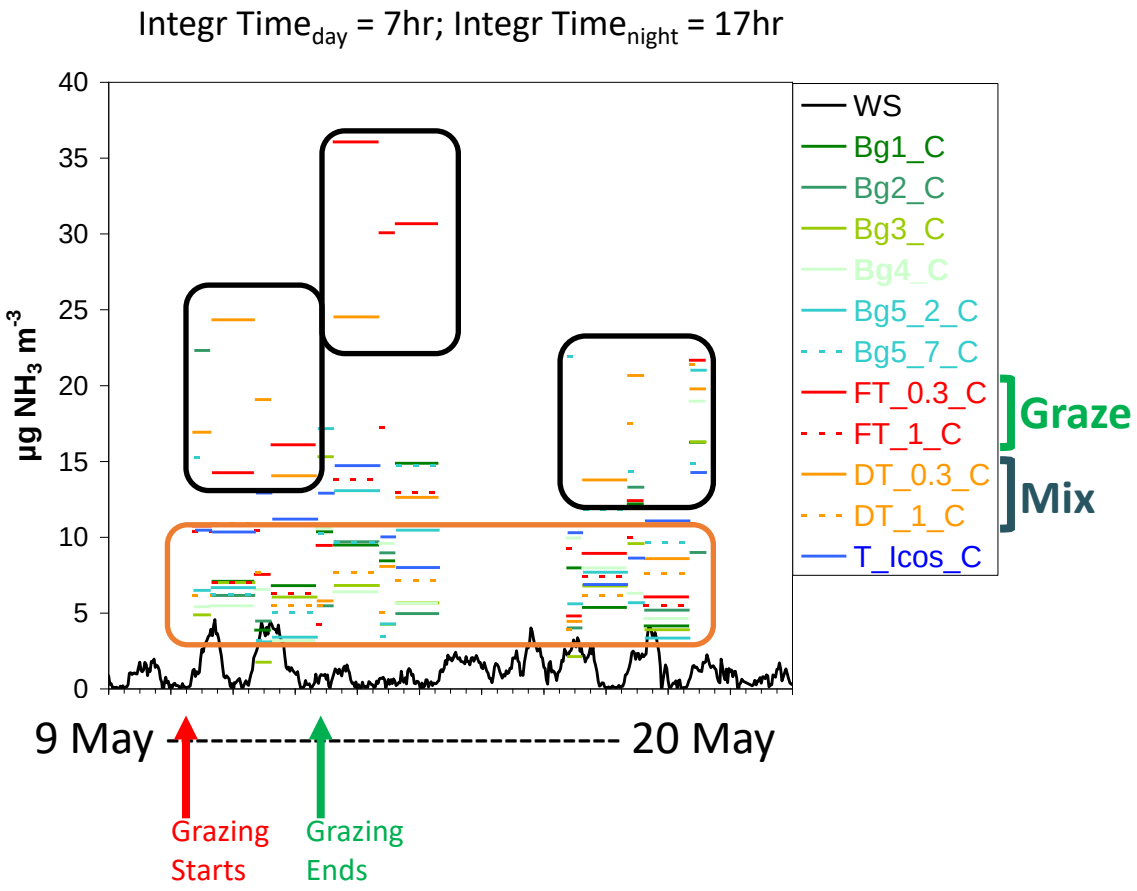
- **Horizontal and vertical NH_3 concentration gradients** above pasture and in surrounding fields
- **Atmospheric turbulence and wind** using ultrasonic anemometer
- **Short-range** (Gaussian, Loubet et al., 2010; FIDES model) **atmospheric dispersion modelling** to infer emission fluxes from concentrations and turbulence

Gas emissions at the PASTURE level

spring House Mix Graze

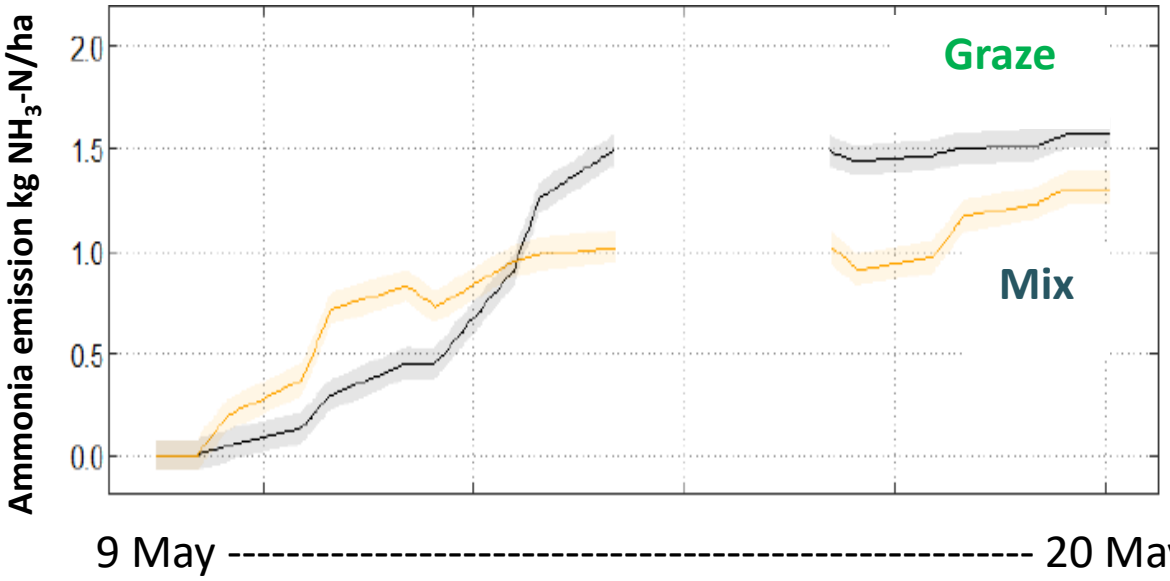
Inverse dispersion method to compare field-scale NH_3 emissions with ALPHA passive samplers

- **NH_3 concentrations** clearly larger within **Graze** and **Mix** paddocks, compared with **surrounding/background** (non-grazed) fields
- Emission gradient peaks for 2 days after end of grazing phase, then almost vanishes after ~one week



Gas emissions at the PASTURE level

Inverse dispersion method to compare field-scale NH_3 emissions with ALPHA passive samplers



1.5 kg NH_3-N/ha

- Cumulative emissions in **Graze** apparently tend to be only marginally larger than in **Mix** grazing
- But differences are **not significant** due to large uncertainties in dispersion modelling

Gas emissions at the PASTURE level

spring House Mix Graze

Tentative annual upscaling and grazing-induced emission factors

- With 48 cows/ha, 1.5 kg N cumulative emission over 10 days corresponds to
  => a **daily emission rate of ~ 3.8 g NH_3/cow/d**

- **Similar magnitude with previous NH_3 emission measurements** on the same field using high resolution mini-DOAS NH_3 concentrations and inverse dispersion modelling:
  *=> Bell et al 2017 (Atmos. Meas. Tech) = ~ **5.7-6.2 g NH_3/cow/d***

- Assuming 8 months per year of grazing (March-October), this is equivalent to
  => an **annual grazing emission rate of 1 kg NH_3/cow/year**

- The low resolution/low cost diffusion ALPHA sampler & inverse dispersion method provided **realistic estimates**, but is likely **not sensitive enough** to detect differences between **Graze**/**Mix** grazing treatments

Some conclusions and limits

NH_3 emissions

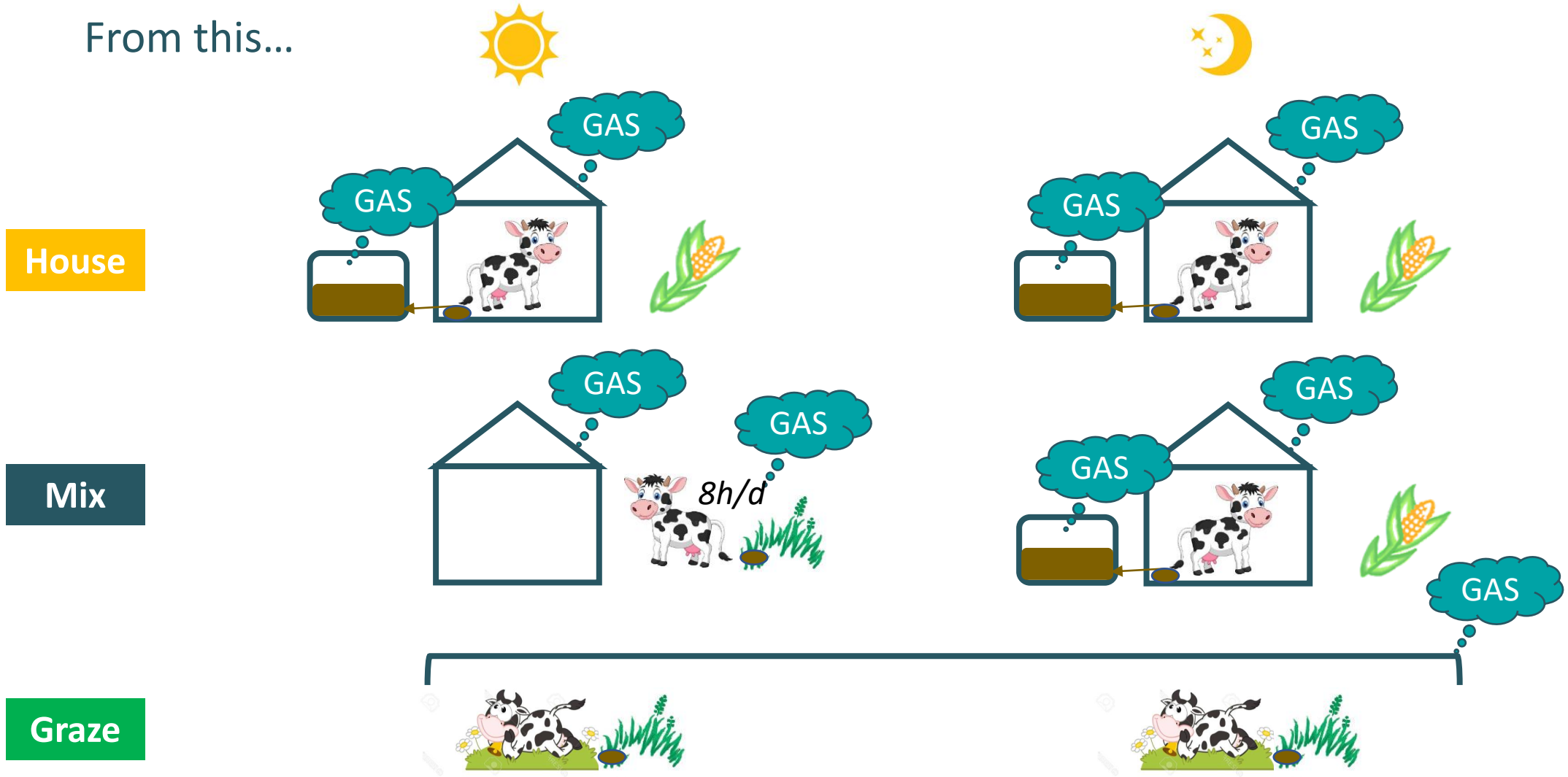
Small amount of slurry in chambers

	BARN level	STORAGE level	PASTURE level
House	*Only 3 cows /treatment…*	For the same amount of slurry: slightly higher [NH_3], + with mixing *BUT less slurry produced…* **=> probably less g NH_3/day**	*Large uncertainties in modelling*
Mix	More N in slurry => more g NH_3/hour Less slurry in the house **=> less g NH_3/day**		Almost as much **kg NH_3/ha** (NS) *BUT very low daily emissions compared with housing phase (5 times less)*
Graze			

Extrapolation?
Integration?

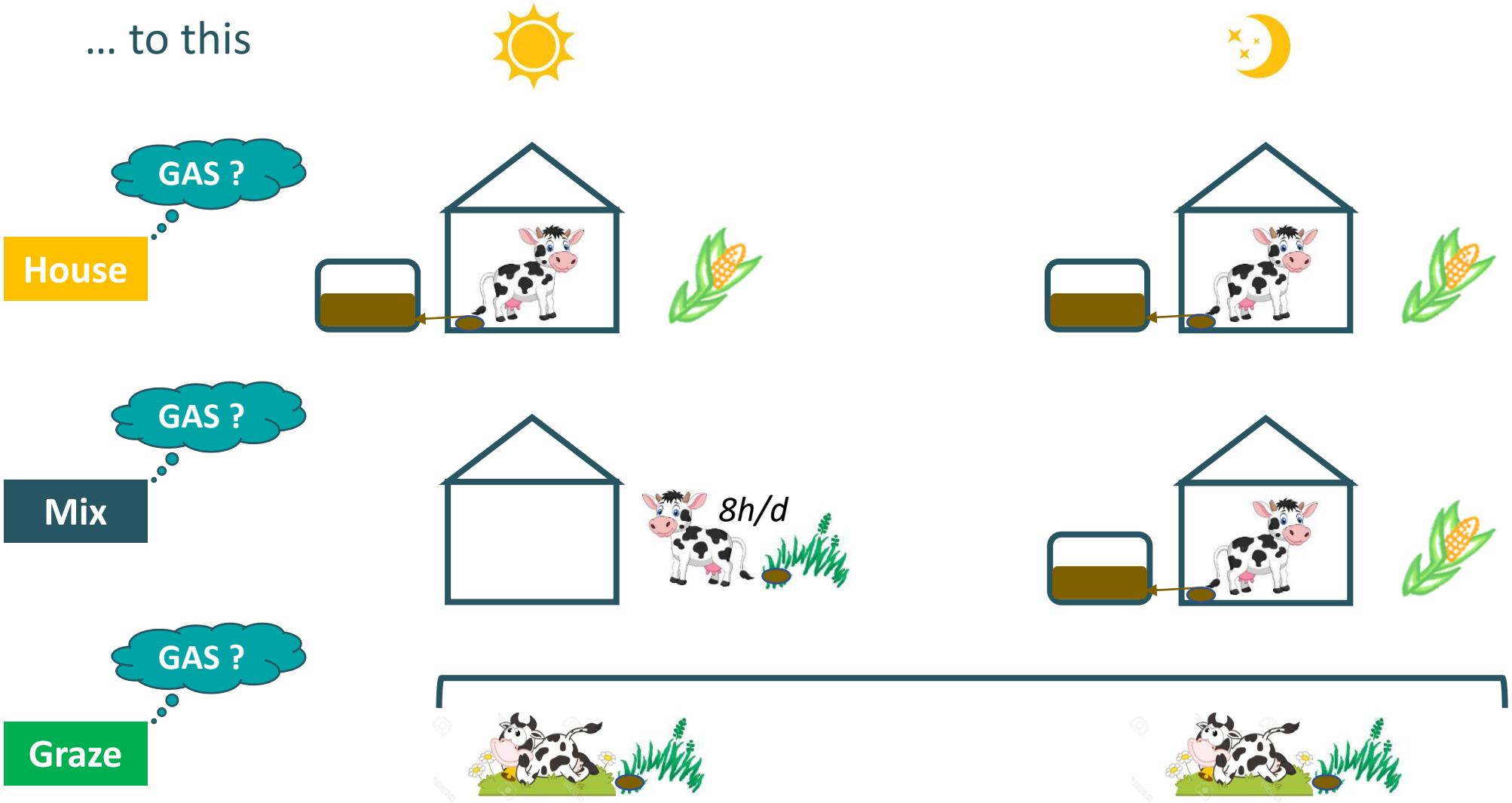
Need to integrate the whole manure management chain and all gases

From this…



Need to integrate the whole manure management chain and all gases

… to this



THANK YOU FOR YOUR ATTENTION!

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ANR: Agence Nationale de la recherche (France)
ADEME: Agence de la Transition Ecologique (France)

For more information: www.CCCfarming.eu