Simplified method developed for estimating the on-farm GHG and NH_3 emissions
Presentation and Results

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Road map…

- *I. Development of the "Simplified Method"*
- *II. Results based on an international study*
- *III. Interest and perspectives*

• I. Development of the "Simplified Method"

Objectives : *Gas emission estimates (NH_3, CO_2, CH_4, N_2O) in <u>open barns</u>, for <u>non-expert</u> people, at <u>low costs</u>*

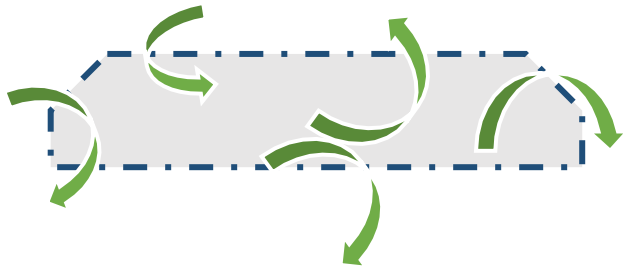
The issue : *Calculations with air fluxes and gas concentration gradients :*

$$Emissions_{Gas} = (Q_{air} \times \rho i) \times (Cgas_{in} - Cgas_{out})$$

- Q_{air} : air flow rate
- ρi : air density
- Cgas : gas concentration

Closed environment

Open environment



In open barns how to estimate the air flow rate in a simple way so that non-expert people can do it, and with acceptable costs ...?

• I. Development of the "Simplified Method"

Objective :

Gas emission estimates in open barns (NH_3, CO_2, CH_4, N_2O)

The issue :

Calculations with air fluxes and gas concentration gradients :

- Q_{air} : air flow rate
- ρi : air density
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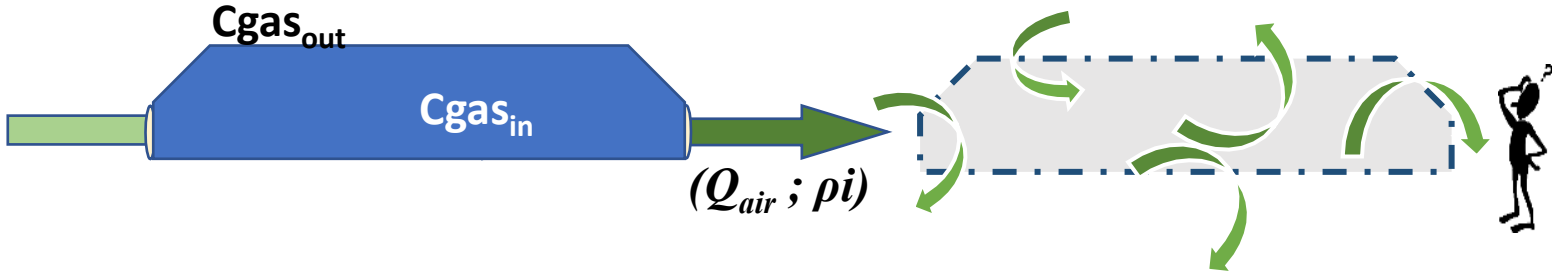
$$Emissions_{Gas} = (Q_{air} \times \rho i) \times (Cgas_{in} - Cgas_{out})$$

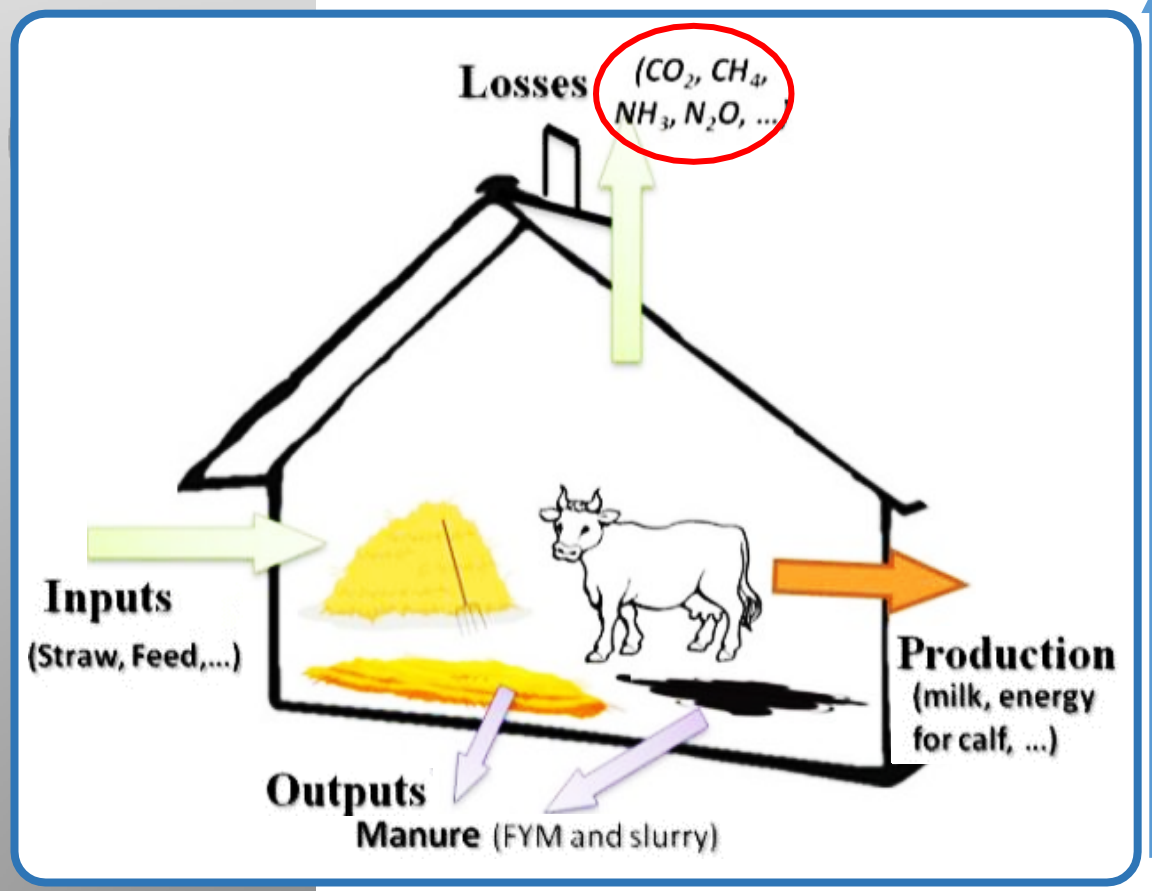


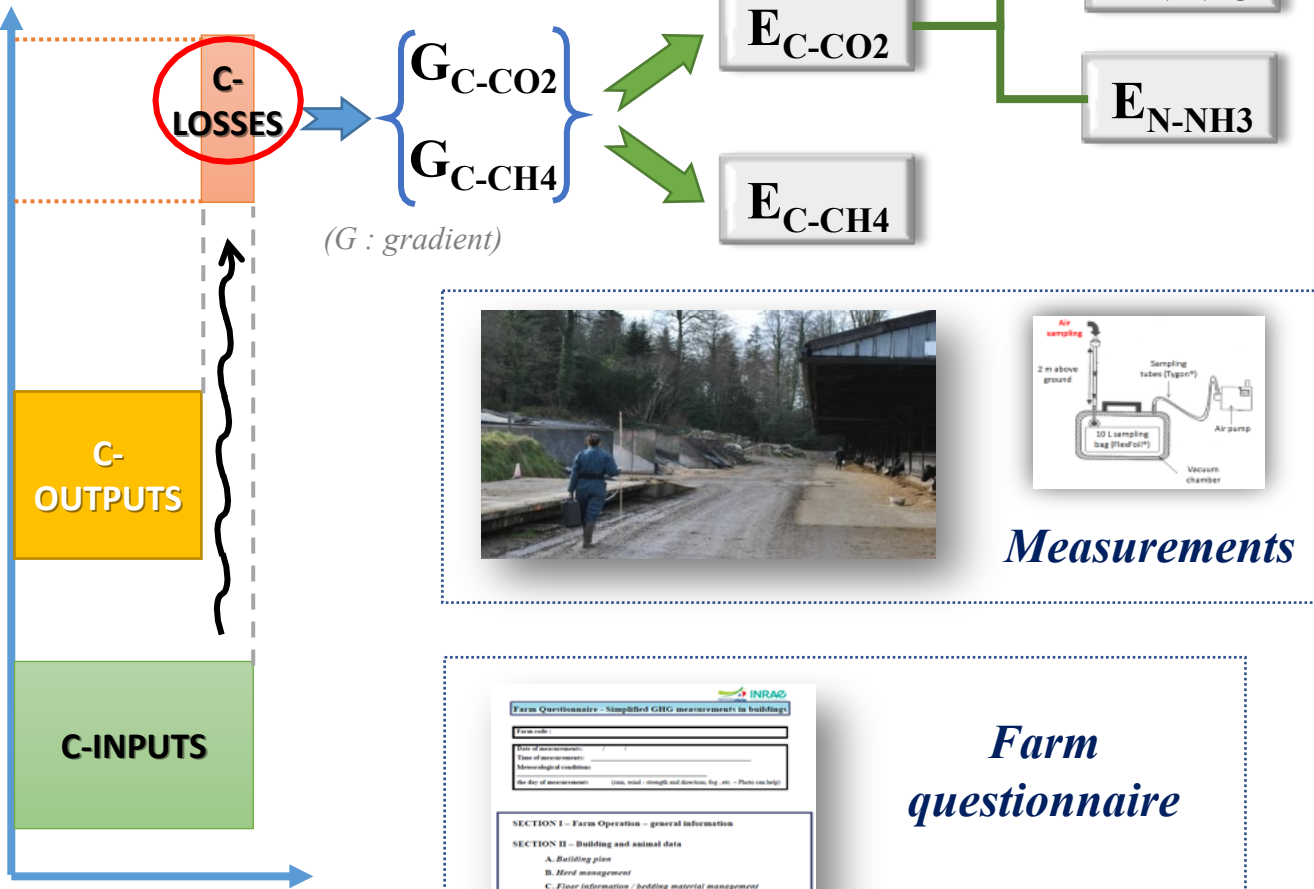
Solution :

*Replacing **air flow rate** measurements by estimating **carbon budget** in livestock buildings*

(More details available at idele.fr)

• I. Development of the "Simplified Method"





(G : gradient)

Carbon budget
Mass balance at the building scale

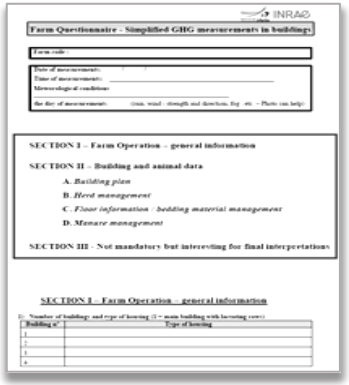
Measurements

Farm questionnaire

• *I. Development of the "Simplified Method"*

Quality Control

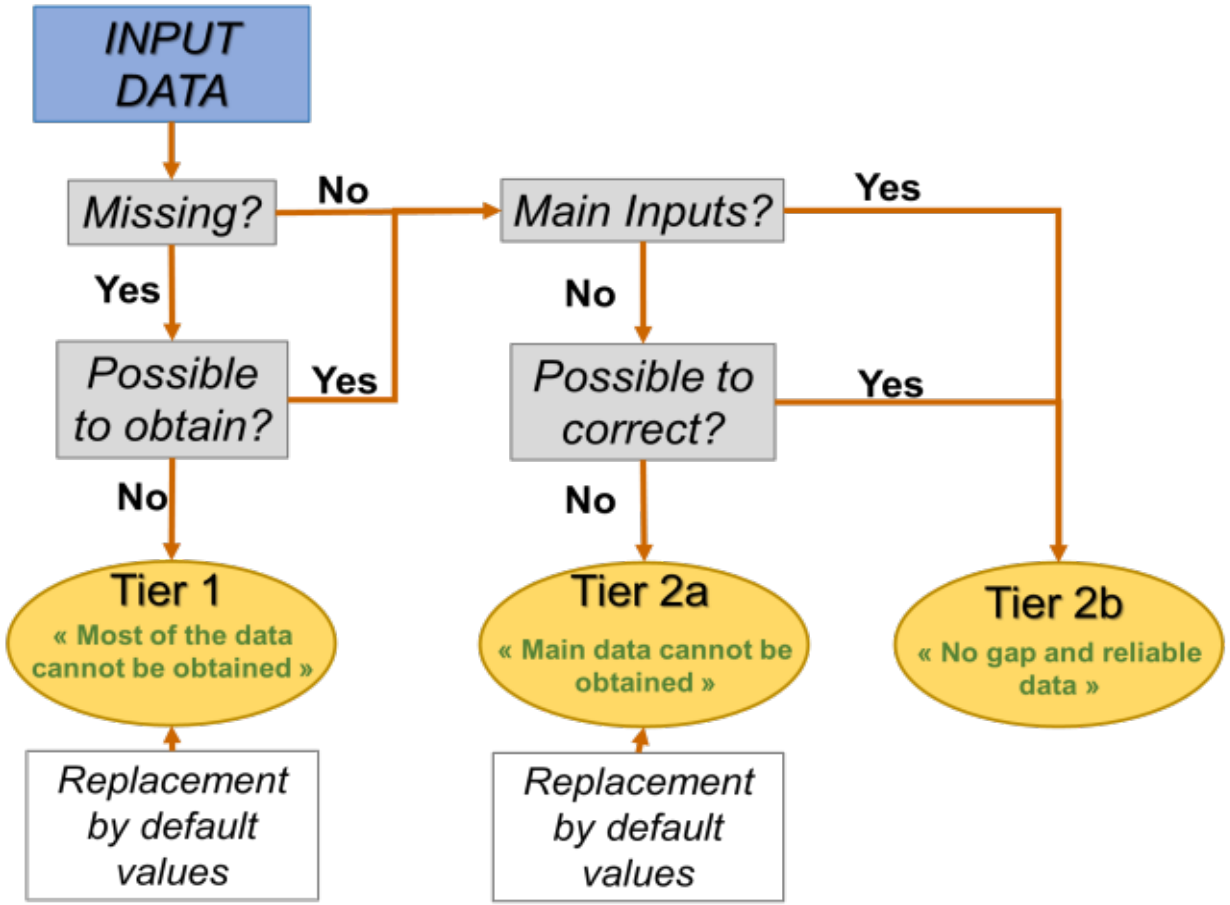
The first step of the method consist in checking all data input from the questionnaire



Depending on the level of data reliability three tiers have been defined:

Tier 1 : mainly based on default values → ***Very Low*** *farm precision*
Tier 2a : important inputs based on default values → ***Low*** *farm precision*
Tier 2b : no default value → ***Good*** *farm precision*

• *I. Development of the "Simplified Method"*



Road map…

- *I. Development of the "Simplified Method"*
- ***II. Results based on an international study***
- *III. Interest and perspectives*

• *II. Results (ClimateCareCattleFarming 2020-2023)*

CCCFarming is :

- 8 countries
- 60 dairy farms
- 264 measurements and about 1 000 EF calculations
- With a wide range of dairy production systems :

Housing

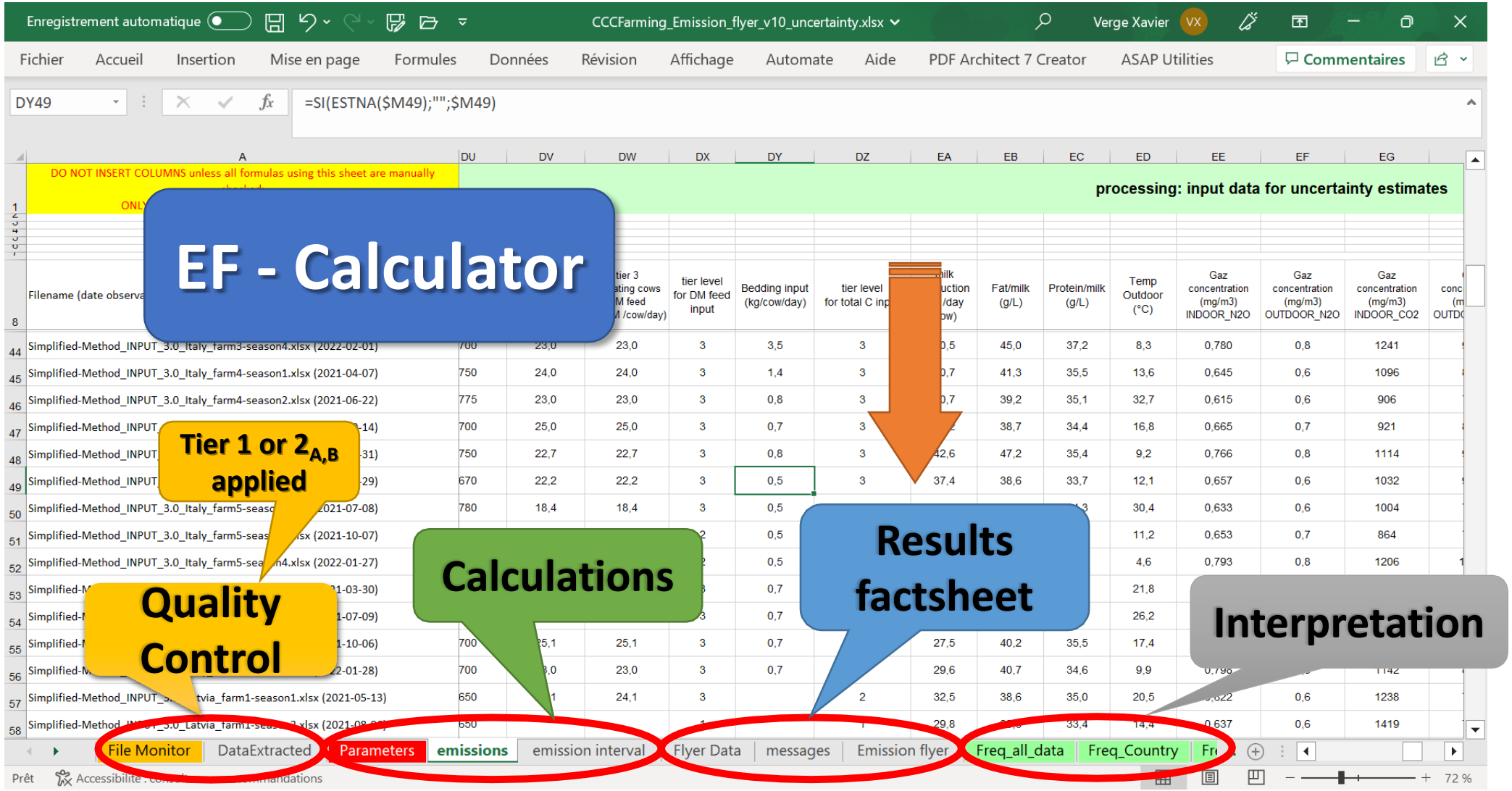
- *Cubicle, slatted floor*
- *Cubicle, sloping straw floor*
- *Cubicle, deep straw*
- *Cubicle with sand bedding and rubber floor*
- *Freewalk wood chips*
- *Compost bedded pack barn*
- *Compost barn, scraping alley*
- *Tie stall, deep straw*
- *Tie stall, scraping alley*

Climate data	Temp.$_{out}$
	(°C)
Avg ± SD	13.6 ± 8.6
[min ; max]	*[-3.2 ; 36.0]*

In-barn Sampling	CO_2	CH_4	NH_3	N_2O
	(mg.m^{-3})	(mg.m^{-3})	(mg.m^{-3})	(mg.m^{-3})
Avg ± SD	1121 ± 495	22.2 ± 39.4	0.60 ± 0.49	0.71 ± 0.44
[min ; max]	*[116 ; 5155]*	*[0.4 ; 352.4]*	*[0.01 ; 2.83]*	*[0.34 ; 4.91]*

Farm Characteristics	Area	Cows pop.	Weight	Feed	Milk	Fat	Protein
	(m^2.cow^{-1})	(anim.house^{-1})	(kg.cow^{-1})	(kg DM. cow^{-1})	(kg day^{-1})	(g.L^{-1})	(g.L^{-1})
Avg ± SD	11 ± 6	132 ± 127	678 ± 59	22 ± 3	29 ± 7	42 ± 4	34 ± 2
[min ; max]	*[2 ; 51]*	*[11 ; 1009]*	*[450 ; 825]*	*[6 ; 31]*	*[10 ; 56]*	*[32 ; 52]*	*[30 ; 40]*

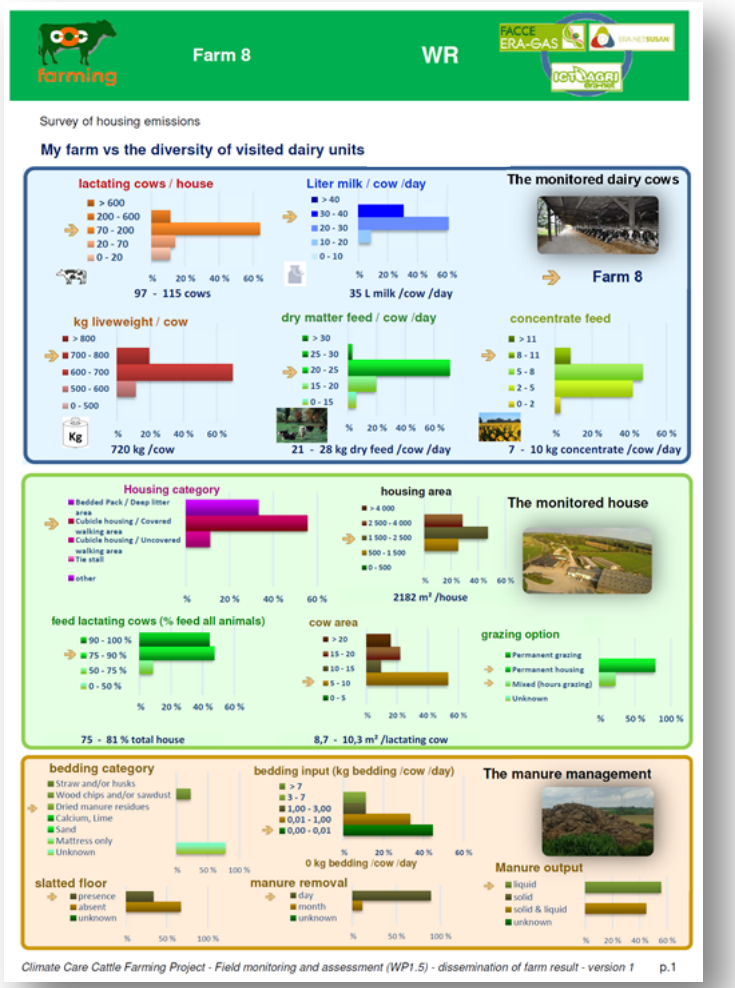
- ***II. Results*** *(ClimateCareCattleFarming 2020-2023)*



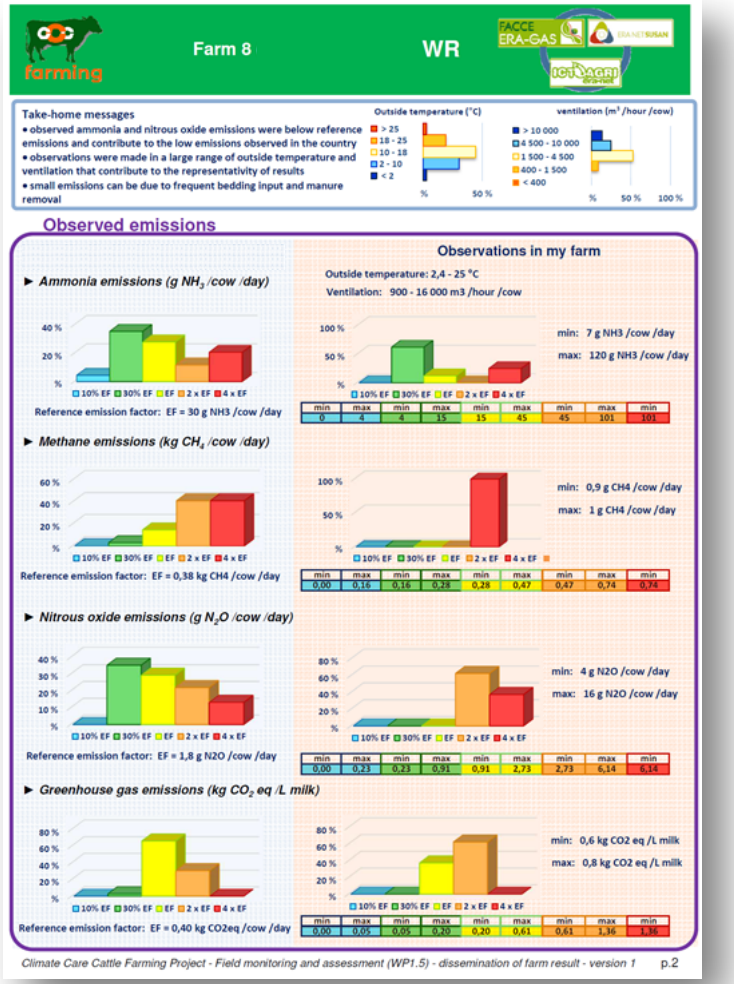
• *II. Results (CCCFarming 2020-2023)*

Overview of the results

Horizontal bars are for farm description

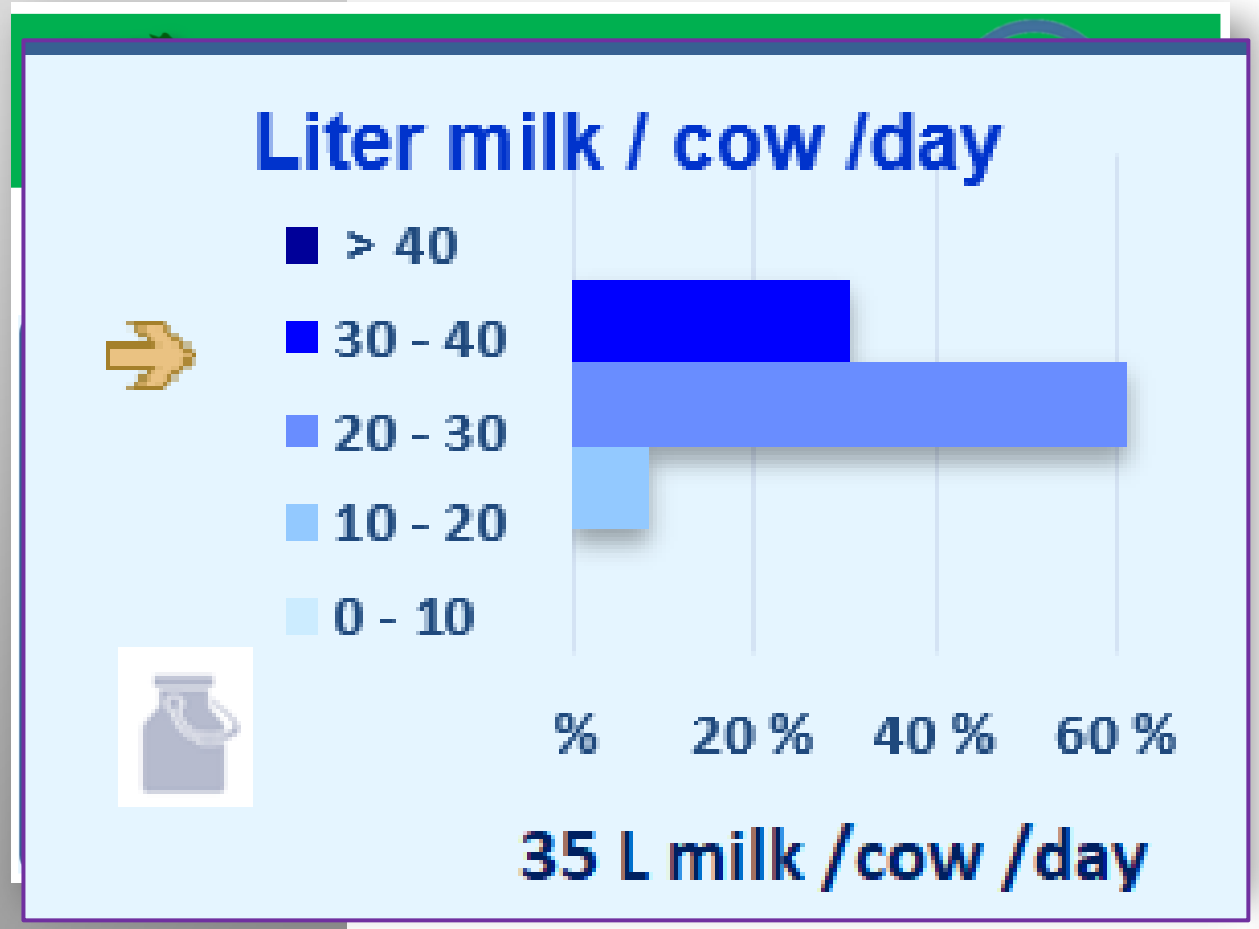


Vertical bars are for EF calculations

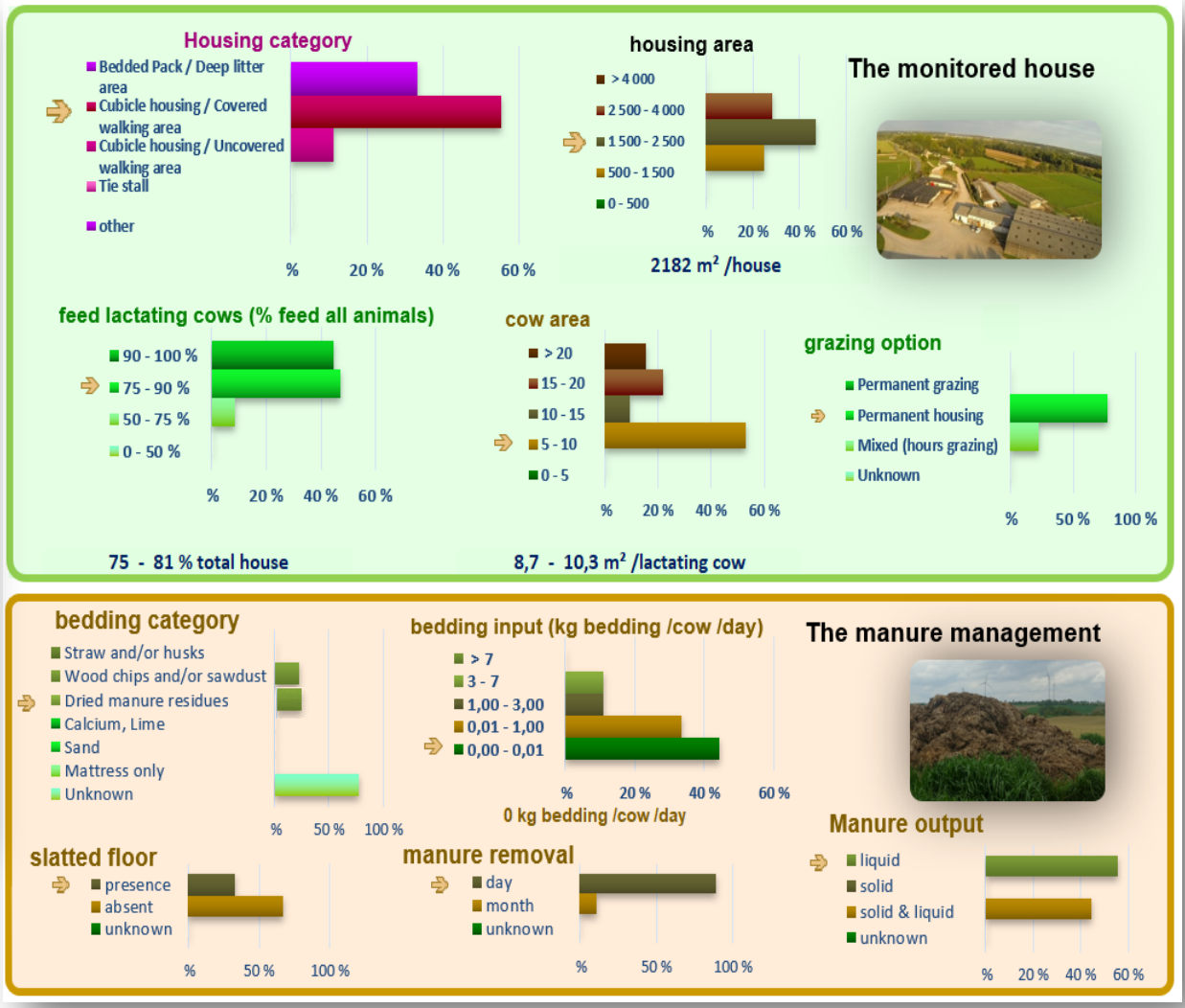


• *II. Results (CCCFarming 2020-2023)*

Graphs are for the reference situation



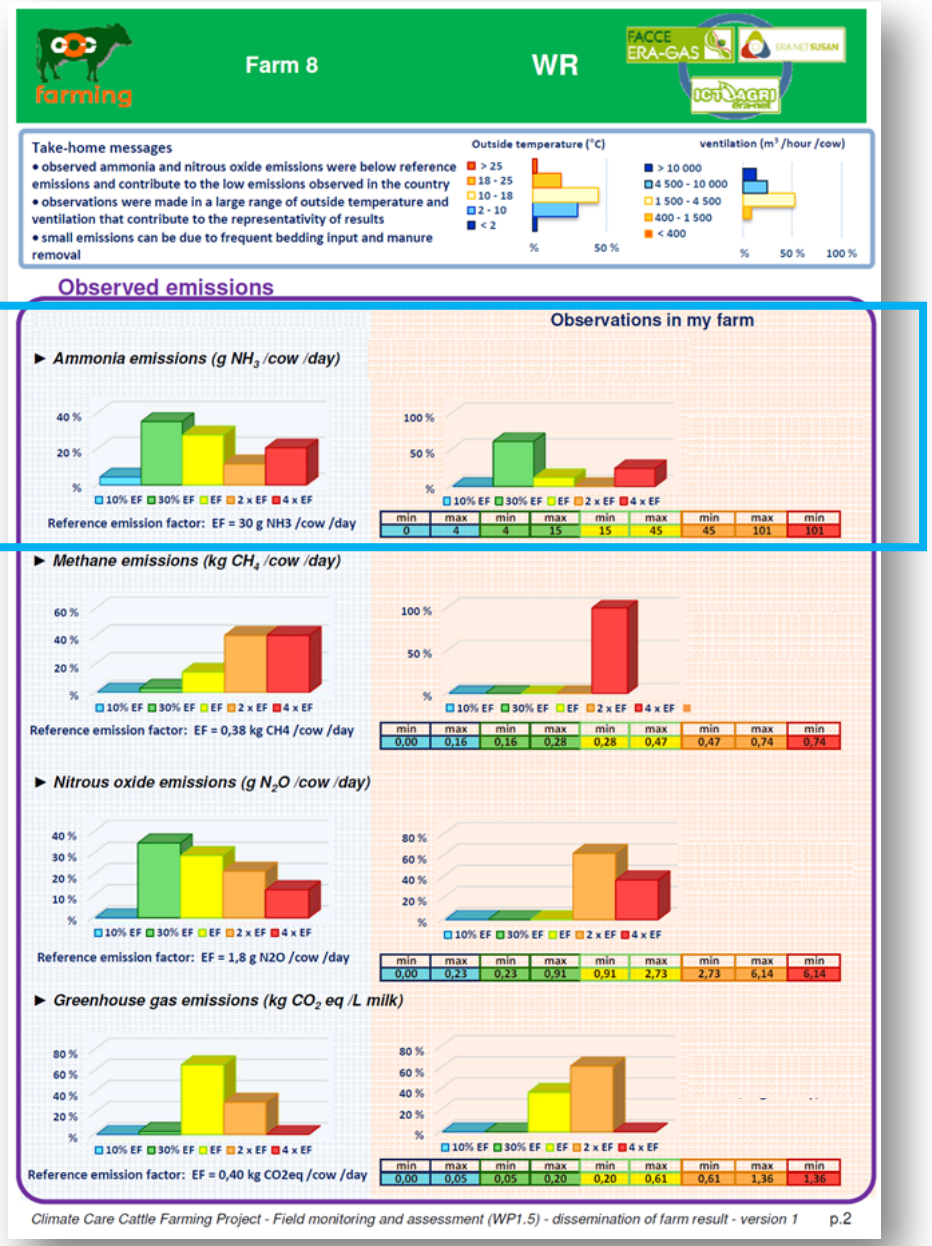
Presentation of the farm situation



• *II. Results (CCCFarming 2020-2023)*

Left graphs show the country situation

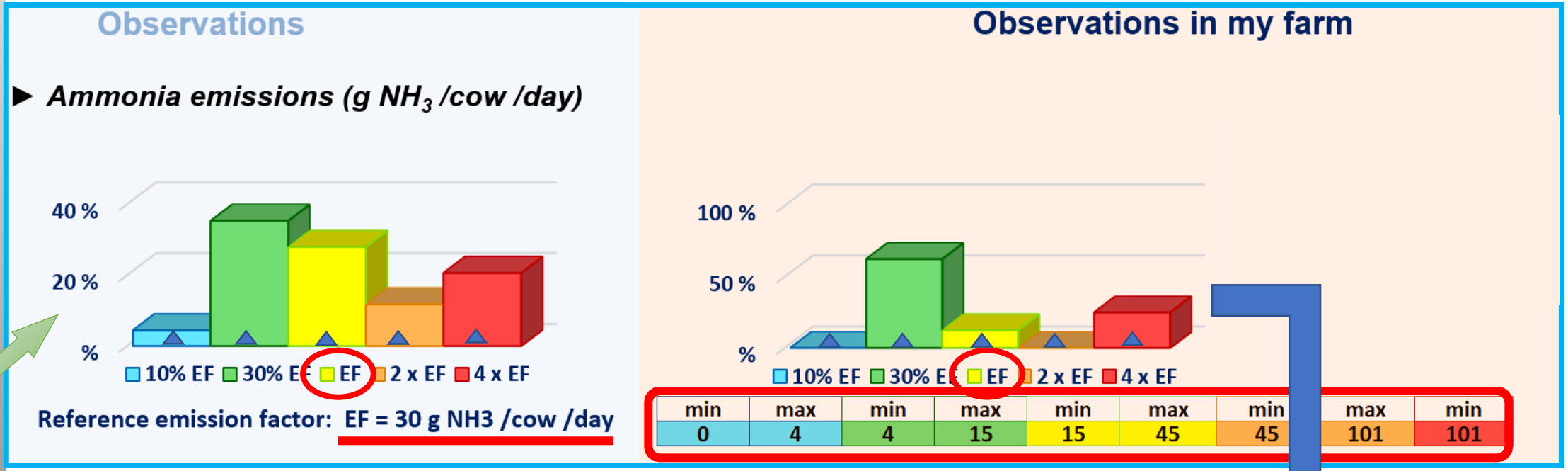
Right graphs show the farm situation



• *II. Results (CCCFarming 2020-2023)*

The farm (or country) is **NOT** characterized by only one EF for a specific year

BUT by the EF distribution over the year



Frequency

EFs distributed in 5 classes :

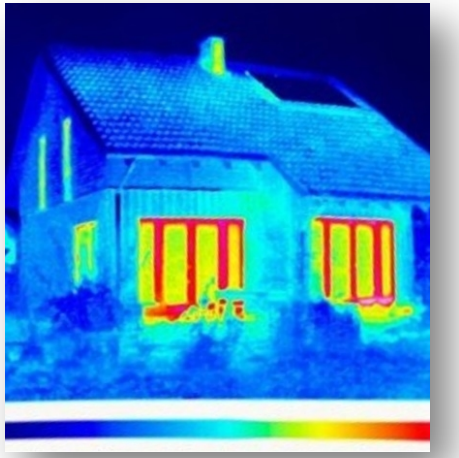
- 10% EF — Much lower
- 30% EF — Lower
- EF — Neutral
- 2x EF — Higher
- 4x EF — Much higher

It represents the « **signature** » of the farm over the year

• *II. Results (CCCFarming 2020-2023)*

OBJECTIVE

The objective of this method is to **point out « hot spots »** or **good practices**, compared to average results, to help implementing mitigation strategies



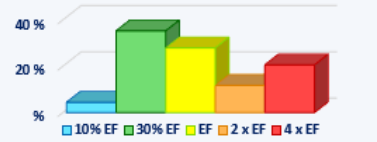
• *II. Results (CCCFarming 2020-2023)*

EXAMPLE
« HOT SPOT »

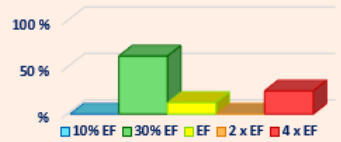
Observed emissions

Observations in my farm

► *Ammonia emissions (g NH_3 /cow /day)*

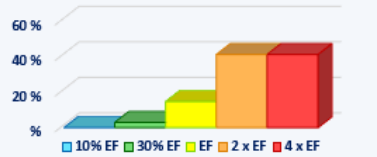


Reference emission factor: EF = 30 g NH3 /cow /day

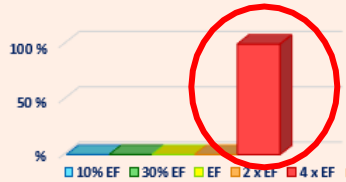


min	max	min	max	min	max	min	max	min
0	4	4	15	15	45	45	101	101

► *Methane emissions (kg CH_4 /cow /day)*

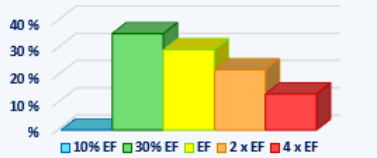


Reference emission factor: EF = 0,38 kg CH4 /cow /day

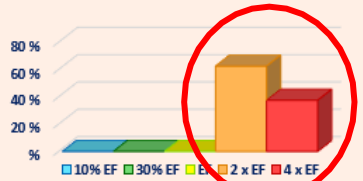


min	max	min	max	min	max	min	max	min
0,00	0,16	0,16	0,28	0,28	0,47	0,47	0,74	0,74

► *Nitrous oxide emissions (g N_2O /cow /day)*

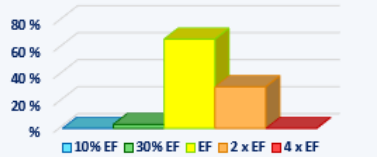


Reference emission factor: EF = 1,8 g N2O /cow /day

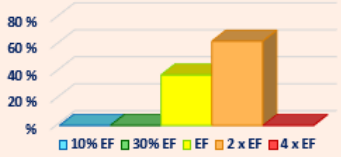


min	max	min	max	min	max	min	max	min
0,00	0,23	0,23	0,91	0,91	2,73	2,73	6,14	6,14

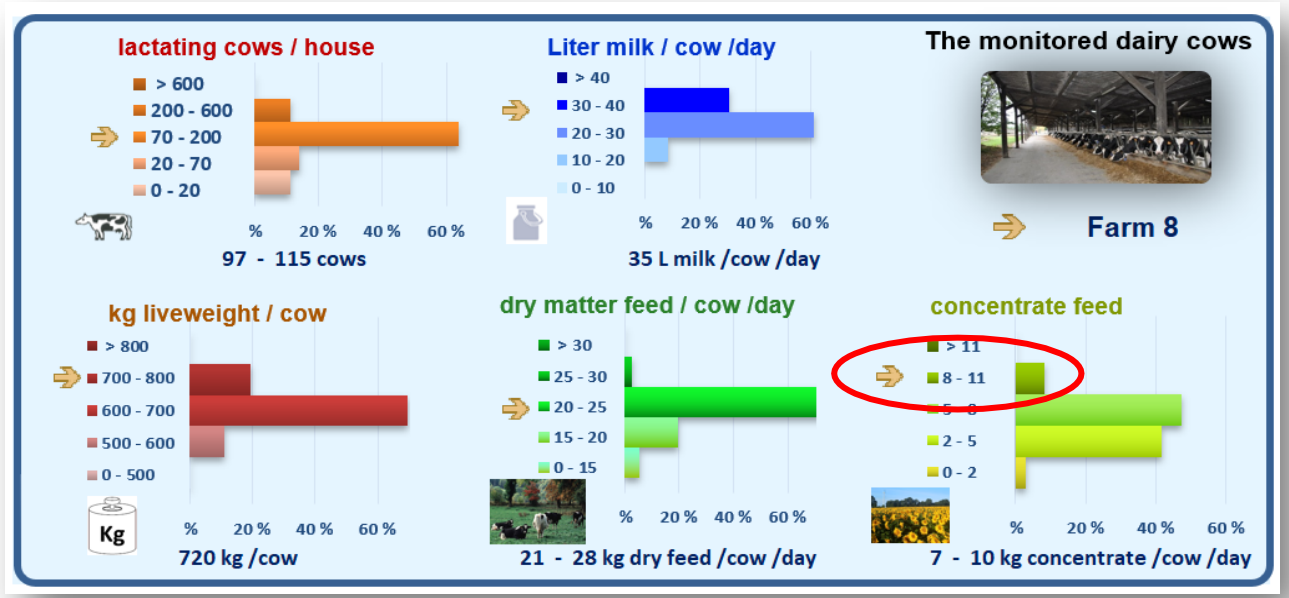
► *Greenhouse gas emissions (kg CO_2 eq /L milk)*

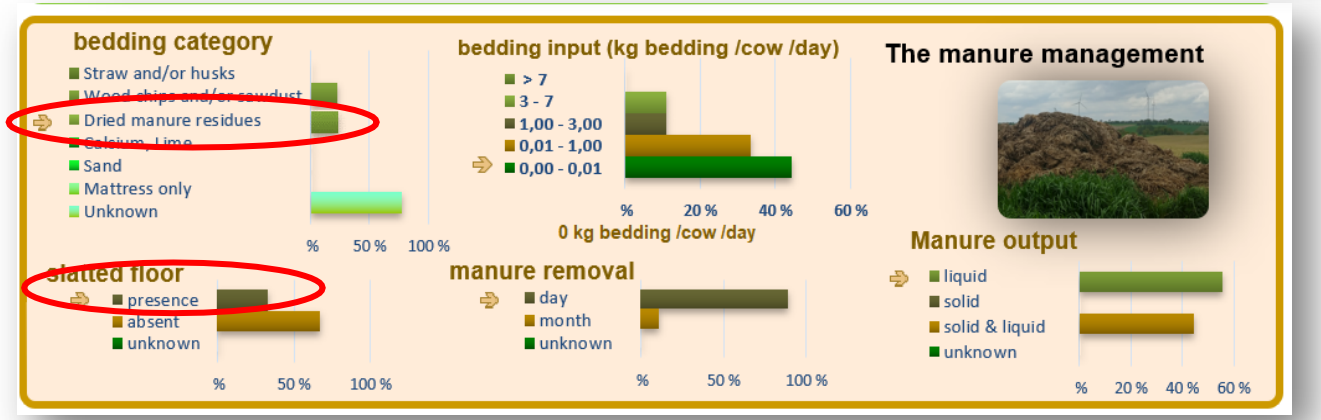


Reference emission factor: EF = 0,40 kg CO2eq /cow /day



min	max	min	max	min	max	min	max	min
0,00	0,05	0,05	0,20	0,20	0,61	0,61	1,36	1,36

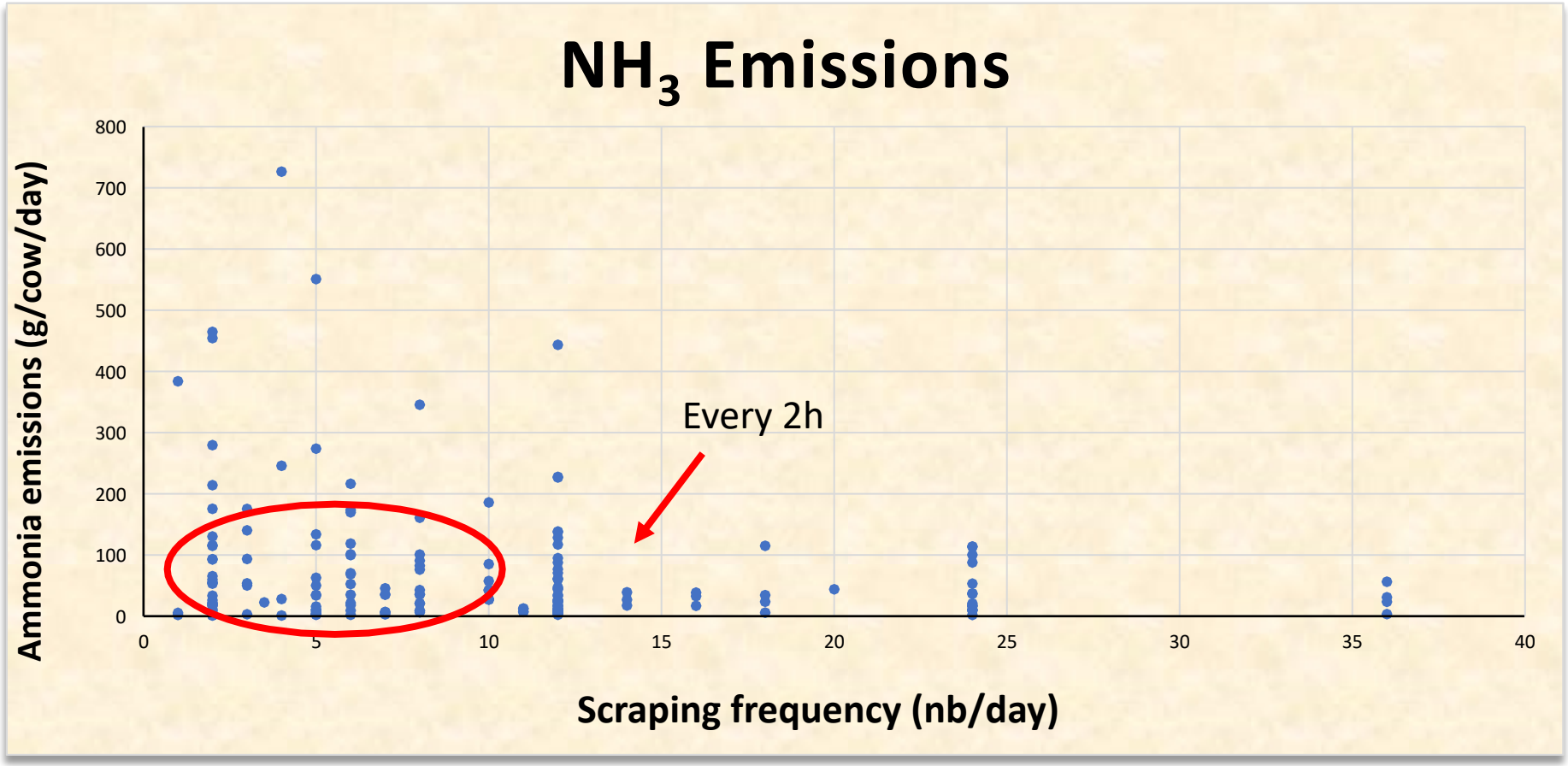




• *II. Results (CCCFarming 2020-2023)*

EXAMPLE
« GOOD PRACTICES»

*High **Scraping frequency** decrease the risk of having high NH_3 emissions*



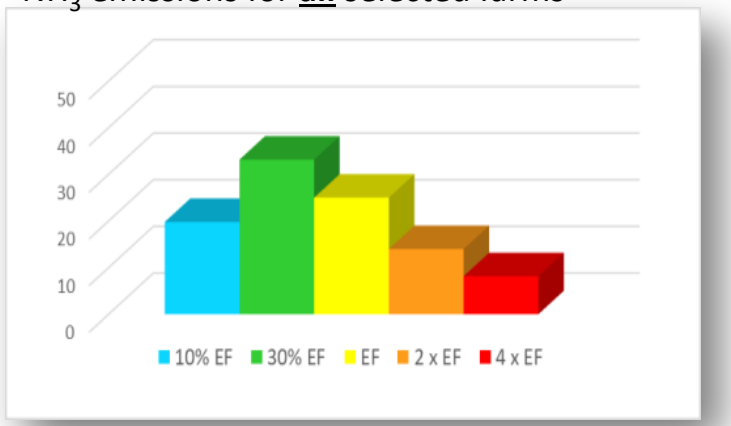
• *II. Results (CCCFarming 2020-2023)*

EXAMPLE
« GOOD PRACTICES»

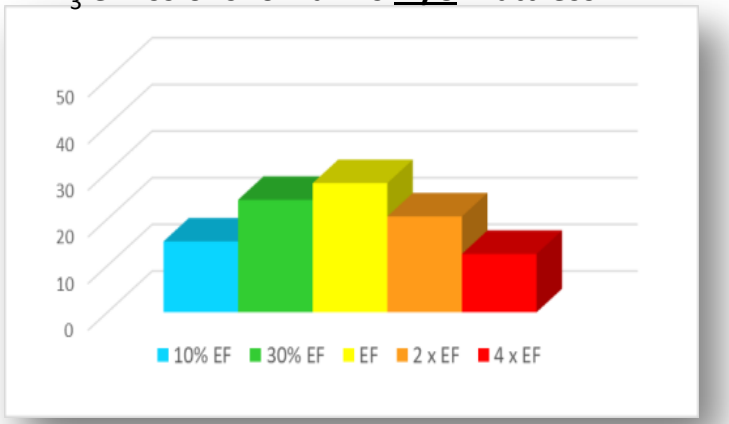
Presence of Mattress

All buildings with mattress showed low NH_3 emissions

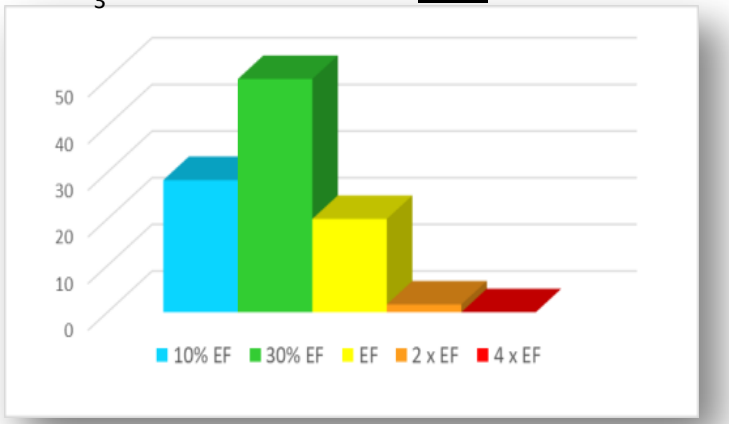
NH_3 emissions for **all** selected farms



NH_3 emissions for farms **w/o** mattress



NH_3 emissions for farms **with** mattress



Criteria for farm selection:

similar housing:
- ratio resting /walking area: 0,5 - 3 m^2 resting / m^2 walking
- slatted floor : excluded (absent or unknown)
- bedding: 0 - 5 kg litter /cow /day
- permanent housing (no grazing)

similar herd data:
- cow population: 20 - 220 dairy cow / house
- milk production: 20 - 45 L milk/day
- feed: 12 - 22 kg DMI/day

Road map…

- *I. Development of the "Simplified Method"*
- *II. Results based on an international study*
- ***III. Interest and perspectives***

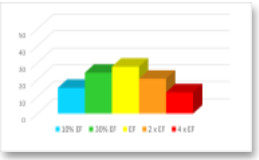
• *III. Interest and perspectives*

1. The "Simplified Method" uses **Carbon budget** instead of **air flow rate**

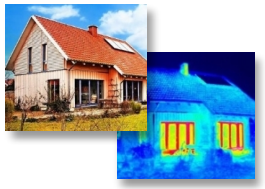
2. Designed to be used by **non-expert people** and for **acceptable costs**

3. **Robust method** applied to a **high number and diversity** of farming systems

4. The **"farm signature"** is based on the **EF occurrence** within classes of values



5. Objectives are **to bring out** « hot spots » or better management practices, ie:
   - decreasing the value and frequency of high emissions
   - increasing frequency of low emissions and disseminating to other farms



• *III. Interest and perspectives*

There is a need to do as many on-farm measurements as possible to obtain a reliable “farm signature” and to evaluate as many farm as possible at the national level to set the most reliable “country signature” (which is used as reference).

Since it has been designed to be used by non-expert people and at low cost, it is achievable.

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Paul Robin : paul.robin@inrae.fr

Thank you for your attention

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ANNEXES

Annexes – Method development

$$Emissions_{Gas} = (Q_{air} \times \rho i) \times (Cgas_{in} - Cgas_{out})$$

- Q_{air} : air flow rate
- ρi : air density
- Cgas : gas concentration

$$Emissions_{Gas} = A \times G_{gas}$$

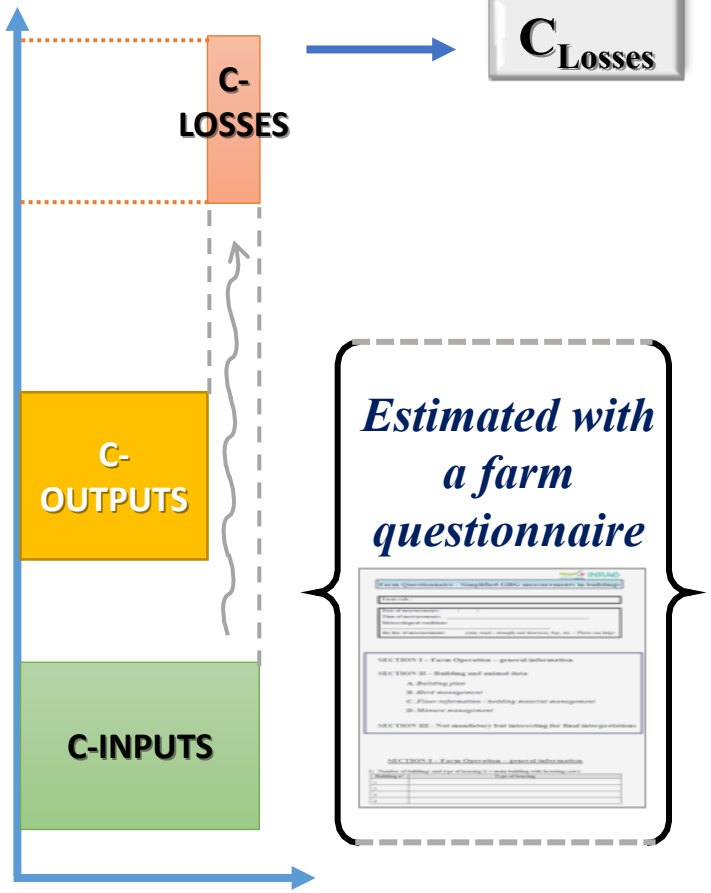
$$A = \frac{E_{C\text{-}CH4}}{G_{C\text{-}CH4}} = \frac{E_{C\text{-}CO2}}{G_{C\text{-}CO2}} = \frac{E_{N\text{-}N2O}}{G_{N\text{-}N2O}} = \frac{E_{N\text{-}NH3}}{G_{N\text{-}NH3}}$$

$$E_{C\text{-}CH4} = E_{C\text{-}CO2} \times \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}$$

$$E_{N\text{-}N2O} = E_{C\text{-}CO2} \times \frac{G_{N\text{-}N2O}}{G_{C\text{-}CO2}}$$

$$E_{N\text{-}NH3} = E_{C\text{-}CO2} \times \frac{G_{N\text{-}NH3}}{G_{C\text{-}CO2}}$$

Annexes – Method development



$$C_{Losses} = E_{C\text{-}CO2} + E_{C\text{-}CH4}$$

$$\ldots \quad E_{C\text{-}CO2} = C_{Losses} - E_{C\text{-}CH4}$$

Estimated with a farm questionnaire

$$A = \frac{E_{C\text{-}CH4}}{G_{C\text{-}CH4}} = \frac{E_{C\text{-}CO2}}{G_{C\text{-}CO2}} = \ldots \qquad E_{C\text{-}CH4} = E_{C\text{-}CO2} \times \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}$$

Annexes – Method development

Since : $E_{C\text{-}CO2} = C_{Losses} - E_{C\text{-}CH4}$

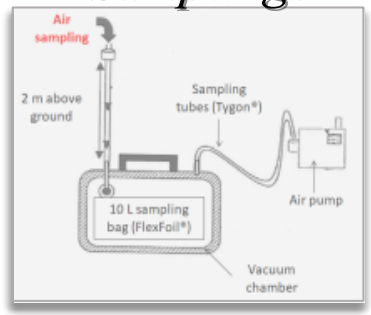
And : $E_{C\text{-}CH4} = E_{C\text{-}CO2} \times \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}$

Then …

$$E_{C\text{-}CO2} = \frac{C_{Losses}}{\left(1 + \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}\right)} = \frac{}{}$$

Questionnaire

Samplings



Annexes – Method development

$$Emissions_{Gas} = (Q_{air} \times \rho i) \times (Cgas_{in} - Cgas_{out})$$

$$Emissions_{Gas} = A \times G_{gas}$$

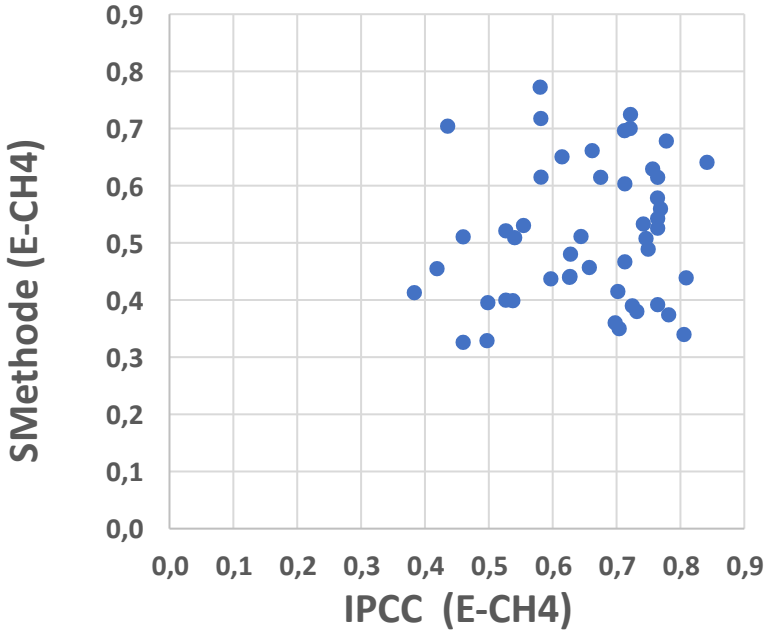
$$A = \frac{E_{C\text{-}CH4}}{G_{C\text{-}CH4}} = \frac{E_{C\text{-}CO2}}{G_{C\text{-}CO2}} = \frac{E_{N\text{-}N2O}}{G_{N\text{-}N2O}} = \frac{E_{N\text{-}NH3}}{G_{N\text{-}NH3}}$$

$$E_{C\text{-}CH4} = E_{C\text{-}CO2} \times \frac{G_{C\text{-}CH4}}{G_{C\text{-}CO2}}$$

$$E_{N\text{-}N2O} = E_{C\text{-}CO2} \times \frac{G_{N\text{-}N2O}}{G_{C\text{-}CO2}}$$

$$E_{N\text{-}NH3} = E_{C\text{-}CO2} \times \frac{G_{N\text{-}NH3}}{G_{C\text{-}CO2}}$$

CH_4 (Efmt+Mnre) emissions - SMethod/IPCC
(kg/cow/day)



Method	Max	Min	Average	Median
Simplified Method	O.77	0.33	0.51	0.51
IPCC methodology	0.84	0.38	0.65	0.70
Difference	-0,07	-0,06	-0,14	-0,19