CAP'2ER®- A TOOL TO EVALUATE AND REDUCE ENVIRONNMENTAL IMPACT FROM FARMS: METHODOLOGY

CAP'2ER® is an environmental assessment tool available for all sectors:

DAIRY CATTLE · BEEF CATTLE · DAIRY SHEEP · MEAT SHEEP · GOATS · PIGS* · POULTRY* · FIELD CROPS

* In development

CAP'2ER® GENERAL PRESENTATION

The objective of the CAP'2ER® tool is to provide advisors and farmers with a multi-criteria environmental assessment tool at the farm, unit and product levels.
There are two levels of evaluation:

- **Level 1**, at the unit level with a simplified methodology to allow for rapid data collection with the aim of raising farmers' awareness.
- **Level 2**, at the farm level with the different units that make up the farm. This is a detailed evaluation that allows the construction of an action plan and advising. Level 2 is used in the context of the Low Carbon Label and the CARBON AGRI methodology.

GENERAL DESCRIPTION

LAUNCHED IN 2014

PUBLISHER: Institut de l'Elevage idele

https://cap2er.eu

CAP'2ER® Level 1 «web»: free access, allows results to be published

CAP'2ER® Levels 1&2: access to advisors, allows results to be edited and data saved

Organisation: **365 organisations**

Farm advisor: **1,650 users**

LANGUAGES: F, G, I, EN, S, RO

COUNTRY SETTINGS: France, Italy, Romania, Switzerland and Spain. It is possible to adapt environmental (emission factors, etc.) and technical (animal weight, etc.) parameters

DIAGNOSTICS AND DATABASE

Number of audit carried out: 29,500
Production of references by anonymous processing of the database

AVAILABLE DOCUMENTS

Data collection guides: French and English
User manual: French and English
Methodology: French and English
Reference sheets by production system: French

PRODUCTION SYSTEM AND SCOPE

A diagnosis is carried out on an accounting year/crop year at the farm level. The farm currently covers the following units: dairy and beef cattle, dairy and meat sheep, goats and cash crops. The pig and poultry units will be added in 2023.

FORMATION

CAP'2ER® Level 1: 2 x 2 h remote + 1 day

CAP'2ER® Level 2: 2 h remote + 2 days

DELIVERABLES

For each diagnosis carried out, a PDF file of results is generated:

CAP'2ER® Level 1: 2 or 3 pages with results at the unit level and comparison with an equivalent production system

CAP'2ER® Level 2: 10 to 24 pages with results at farm and units level (technical indicators and comparison with an equivalent production system)

SUPPORT

HOTLINE service open 50/52 weeks
Number of requests per year: 4,000

MANAGEMENT OF DIAGNOSIS

The advisor can carry out a simulation of an action plan based on the diagnosis. This simulation is saved in the database.
It is possible to share a diagnosis with another organisation with the farmer's consent.

DATA MANAGEMENT

Data input feature: pre-fill data in the diagnostics
Batch processing feature: updating diagnostics and generating result PDF
Export feature: exporting the results of finalised and validated diagnostics in Excel in order to produce collective summaries

MAINTENANCE AND DEVELOPMENT

Updating of the methodology, evolution according to users' requests to improve the tool's features.

ENVIRONMENTAL INDICATORS ASSESSED BY CAP'2ER®

	MAIN INDICATOR	SCOPE	STANDARD
Climate change	GHG emissions (CO_2,CH_4 and N_2O)	Farm, units, products and emissions sources	GES'TIM+ IPCC
Energy	Fossil energy consumption Renewable energy production	Farm, units, products and emissions sources	GES'TIM+
Nitrogen	Nitrogen balance Nitrogen efficiency	Farm, units	GES'TIM+
Air/water quality	Ammonia emissions Leaching Eutrophication and acidification	Farm, units, products	EMEP/AEE 2019
Plant protection products	Treatment Frequency Index (TFI) Untreated areas	Farm and crops	MAA
Water	Water consumption for irrigation	Farm and crops	/
Carbon storage	Storage in the soil of grasslands, crops, intercrops and hedges	Farm, units and products	IDELE
Biodiversity	Areas of Ecological Interest Crop diversity	Farm, units and products	MAA
Soil	% Soil cover Tillage intensity % Legumes		/
Nutritional performance	Number of people fed	Farm and units	CEREOPA
Autonomy	Protein autonomy Dependence on mineral nitrogen	Units	IDELE
Economic	EBITDA/GP Income/manpower Units production cost	Farm and units	IDELE
Working conditions	Satisfaction level	Farmer	IDELE

Compatibility with existing guidelines

The design of the CAP'2ER® tool is based on the methodological rules and references from the most common reference systems and guidelines for environmental assessment applied to agricultural systems.

In particular, the following sources were considered:

- The **international standards ISO 14040 and ISO 14044 (ISO, 2006)** define the principles, methodological framework and communication related to Life Cycle Assessment (LCA).
- The **international standard ISO 14067** (ISO, 2018) setting out requirements and guidelines for quantifying the carbon footprint of products.
- The **FAO LEAP Guidelines** (2015a and b, 2016, 2017a and b, 2019) are guidelines for conducting LCA in the livestock sector (feed, large ruminants, small ruminants, pigs, poultry).
- The **AGRIBALYSE 3.1 methodological report** (Koch and Salou, 2017), which is a reference at national level for conducting LCAs of agricultural products, according to a methodological framework shared with the other agricultural productions studied (choice of models for calculating emissions, allocation, etc.).
- The **GIEC 2021 guidelines** for quantifying greenhouse gas emissions.
- The **EMEP/AEE guidelines** for the nitrogen gas emissions.

Certification of the methodology by Ecocert which will be renewed with Bureau VERITAS in 2022 following the addition of goat and sheep units and the updating of environmental parameters.

SCOPE OF CAP'2ER®

SCOPE OF AGRICULTURAL ACTIVITIES COVERED BY CAP'2ER®

Agricultural activity refers to all the processes necessary to produce foodstuffs on the farm, upstream of the farm, and until products leave the farm (figure 1). Activities downstream of the farm are not considered.

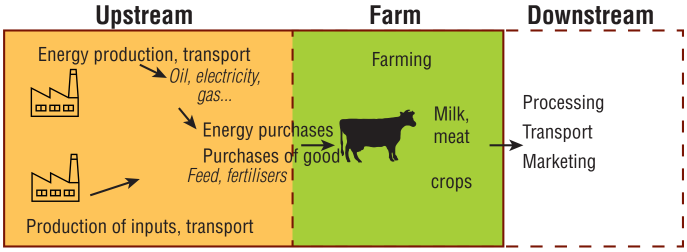


FIGURE 1: Scope of the environmental assessment of foodstuffs

Details of the scope covered by CAP'2ER® :

▶ **For crop production:**

- production and transport of plant protection products,
- mechanisation (fuel consumption) related to the cultivation of crops,
- the production, transport and supply of mineral and organic fertilisers,
- the irrigation of surfaces,
- farm work firm,
- drying of grain maize,
- the soil and its biological interactions.

▶ **For livestock production:**

- manufacture and transport of feed, bedding and fertiliser,
- animal biological activity (enteric fermentation and manure),
- soil activity during grazing,
- farm work firm,
- electricity and fuel consumption (milking parlour, lighting and ventilation, handling equipment, building, etc.)..

EMISSIONS TAKEN INTO CONSIDERATION

CAP'2ER® accounts for the direct and indirect impacts linked to agricultural activity.

▶ **Direct impacts: linked to emissions that physically take place during and/or at the site of agricultural production.**

- For livestock: enteric emissions, emissions from manure at the building, storage (and treatment), spreading and grazing.
- For crops and grasslands: the effect of fertilisation and the delayed effects of redepositing volatile and leached nitrogen, carbon storage/destorage in soil and biomass.
- For all activities: emissions induced by the combustion of energy resources.

▶ **Indirect impacts: related to emissions occurring during the production and transport of inputs.**

Figure 2 shows the scope of the study of the impacts of livestock activities on the greenhouse effect.

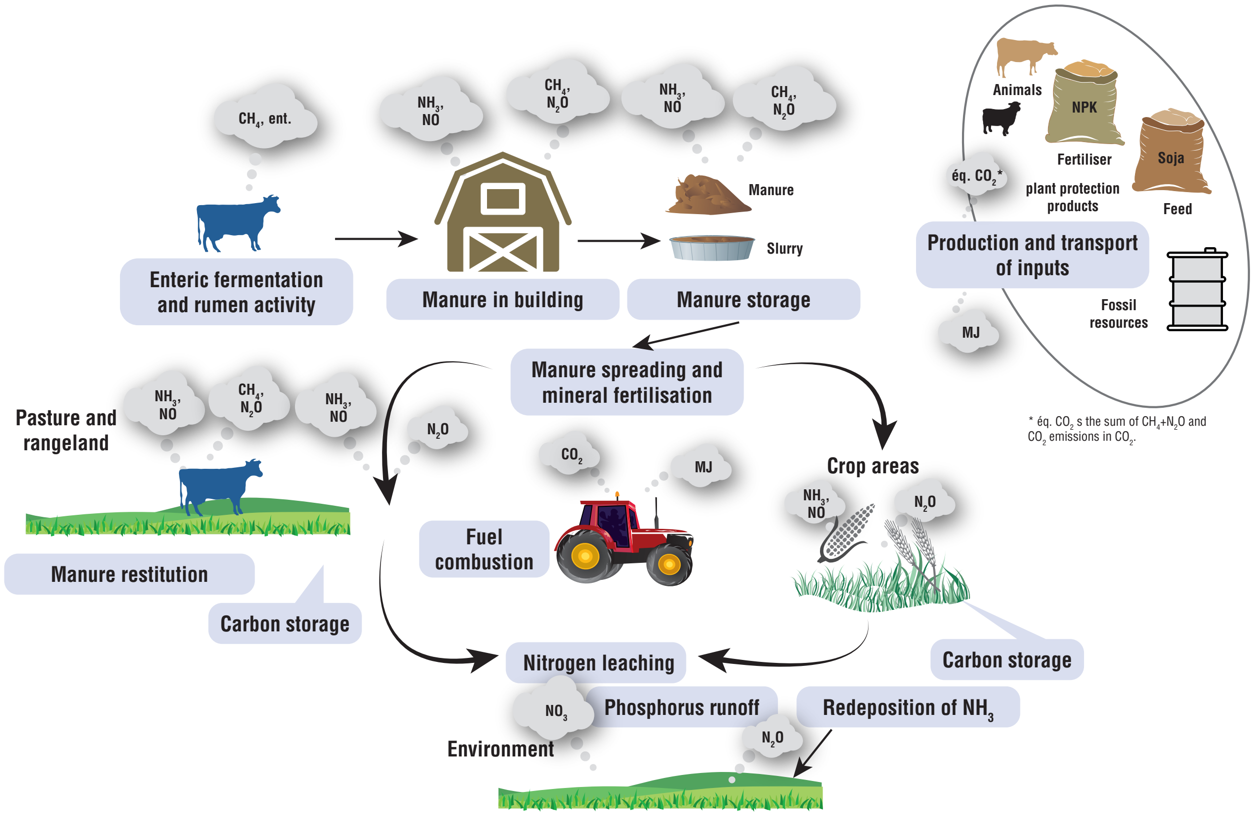


FIGURE 2: THE DIFFERENT SOURCES OF EMISSIONS OF ENVIRONMENTAL IMPACTS ON A FARM

ALLOCATION RULES

An agricultural production system, whether it is a farm or a unit, often contributes to the simultaneous production of several products. In environmental assessments, it is a question of allocating the inputs and environmental impacts of the system between the various products and co-products generated by this multifunctional system.

ALLOCATION OF INPUTS AND SURFACES BETWEEN UNITS

A CAP'2ER® Level 2 diagnosis is carried out at the farm level.

Different allocation keys are defined in order to distribute the surfaces and inputs between the farm's units.

The allocation of surfaces (self-consumed cereals and fodder) and feed purchases to the different animal units can be done by:

- a simplified method where the share of crops/fodder and purchased feed used for feeding the different units (dairy cattle, beef cattle, goats, dairy sheep, meat sheep and sales crops) is allocated during data collection. This allocation is made according to the farmer's opinion, based on the annual production of fodder, stock variations and sales of plant products or,
- a detailed method by filling in the rations of all animal categories of the different herds. A consistency check between the production/purchase of each input/forage/sales crop and the total consumption calculated from the rations helps to control and limit the uncertainties of this data collection step.

As soon as the surface areas are allocated to each unit, it is possible to distribute between the units the inputs that have been allocated upstream to each crop on the farm during data collection (mineral and organic fertilisers applied, import of livestock effluents, plant protection products).

For electricity and fuel purchases, in the absence of separate meters, a breakdown based on theoretical consumption by unit is used:

- **Electricity purchases** at the farm level are distributed among the units on the basis of benchmark values for beef cattle and meat sheep (benchmarks per LU), dairy cattle, dairy sheep and goats (benchmarks per litre of milk) and crops (benchmarks per ha).
- **Fuel purchases** at farm level, including work by third parties, are distributed between units by determining the theoretical fuel consumption for each unit (dairy cattle, beef cattle, sheep, goats and sales crops) using benchmark values per LU and ha of surface area consumed.
- **Animal purchases** (cattle, sheep and goats) are allocated to each unit during data collection.

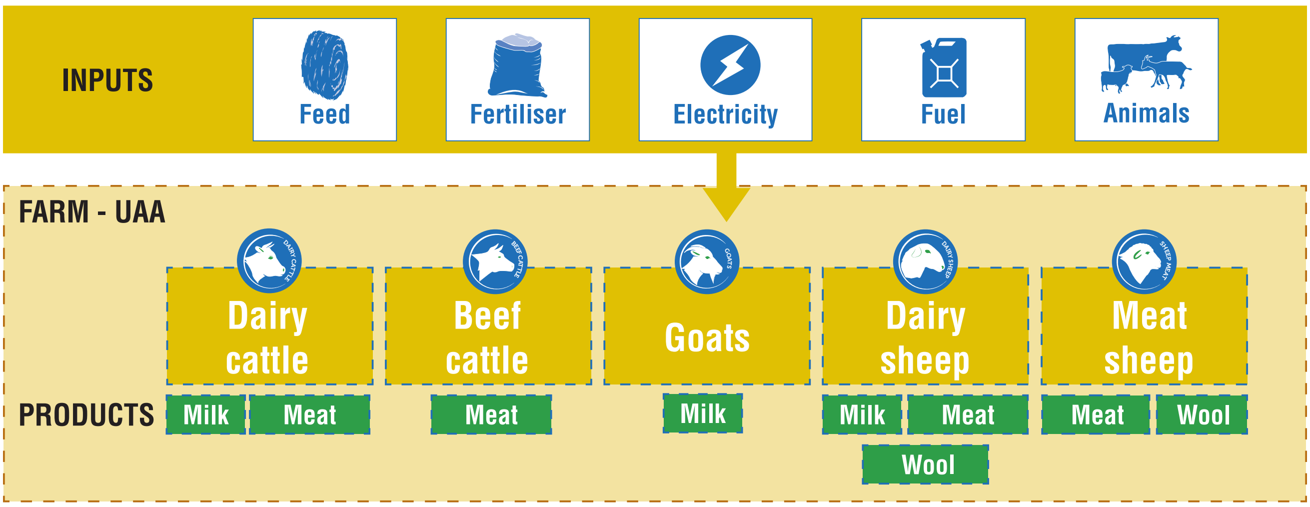


Figure 3 : The different levels of allocation of inputs and surfaces

AT THE UNIT LEVEL, DISTRIBUTION OF ENVIRONMENTAL IMPACTS BETWEEN PRODUCTS

The allocation method applied in CAP'2ER® is the allocation by production phase and is based on the energy required for the different phases of an animal's life. The energy required for survival, activity, growth, lactation, gestation and wool production is accounted for.

FUNCTIONAL UNITS

In order to express the results of the environmental impact indicator, it is necessary to use one or more «functional units», abbreviated as FU.

FUNCTIONAL UNITS

CAP'2ER® allows both a product/sector approach and an operational approach by proposing two types of FU.

For **the farm approach**, the FU selected is the UAA in hectares.

For the **product approach**, the choice of the FU for presenting the results was adapted according to the units and the technical and economic indicators used by the advisors in order to maintain technical consistency in the advice given.

TABLE 1: FUNCTIONAL UNITS ACCORDING TO PRODUCT

Cattle milk	Goat milk	Sheep milk	Milk cattle and goat meat	Sheep meat	Beef meat
Fat and protein corrected milk					
TB 40 g/kg TP 33 g/kg	TB 35 g/kg TP 31 g/kg	TB 75 g/kg TP 55 g/kg	kg live weight	kg eq. Carcass lambs	kg live meat

For meat, the unit «kg live weight» is used to express the environmental impacts of an animal leaving the farm (including the environmental impacts during the period it was raised if it was not born on the farm), according to the LCA.

However, when one wishes to study the action levers of a beef farm, it is more relevant not to take into account the environmental impacts of the animals purchased and to focus on the environmental impacts of the meat produced on the farm.

The unit to be used is therefor «kg of live meat» for beef cattle and kg eq. carcass lambs for meat sheep.

ACTIVITY DATA

A CAP'2ER® diagnosis is carried out over an accounting year.

CAP'2ER® COLLECTION QUESTIONNAIRE: MAIN ACTIVITY DATA

Herd

- Number of animals and inventory change by animal category
- Weight of animals
- Milk sold: litres, TB and TP
- Purchases and sales of animals by animal category
- First calving

Housing

- Type of housing by animal category
- Time repartition in barn/pasture
- Type of manure storage and treatment
- Type of manure burial and spreader
- Manure import/export

Crops

- Surface area by type of crop,
- Mineral and organic fertiliser input by type of crop
- Rotation PT/crops
- Irrigation by type of crop
- Treatment of plant products
- Description of Ecologically significant areas

Feed

- Nature and quantities of feed and fodder purchased
- Quantities of fodder and cereals produced on the farm and self-consumed
- Ration by animal category

Energy

- Fuel and electricity consumption
- Work by and for third parties
- Energy for drying grain maize
- Energy for irrigation
- Renewable energy production

CLIMATE CHANGE - GREENHOUSE GASES

To quantify the impact on climate change of the different greenhouse gases (GHG) emitted (for agriculture mainly N_2O, CH_4 and CO_2), coefficients specific to each gas are used. CAP'2ER® uses the 100-year Global Warming Potential published by the GIEC in 2021.

Table 2: global warming potential of greenhouse gases

Greenhouse gas		100-year Global Warming Potential coefficient
compound	symbol	IPCC, 2021
Carbon dioxide	CO_2	1
Methane	CH_4	27,2
Nitrous oxide	N_2O	273

table 3: overall presentation of GHG emissions

	Emission items	Technical data	Accuracy level	Source-reference
Methane (CH_4)	Enteric fermentation	• Intake level • Share of concentrates in the ration • Digestibility of the ration • Addition of fat to the ration for dairy cows or milk fatty acids for dairy cows	Tier 3*	Sauvant, 2013 INRA 2018 Ecosens
	Effluent management (building, storage and pasture)	• Non-digestible organic matter in the ration - Type of manure (manure/liquide manure/slurry) • Temperature • Type of building • Type of manure storage • Time on pasture/in barn • Manure treatment (composting, methanisation)	Tier 2	Mondférent I, 2013 GIEC 2021
Nitrous oxide (N_2O)	Manure management (building, storage and grazing)	• Nitrogen excreted on the basis of the nitrogen intake of the ration by animal category • Type of building • Type of manure storage • Temperature • Time on pasture/in barn • Manure treatment (composting, methanisation)	Tier 2	GIEC 2021 EMEP 2019 OMINEA 2019
	Application of organic and mineral nitrogen	• Amount of mineral nitrogen applied • Use of nitrification inhibitor • Amount of organic nitrogen applied	Tier 2	GIEC 2021
	Soil related emissions	• Ammonia redeposition calculated from NH_3 emissions from organic and mineral fertilisation and grazing • Nitrogen leaching calculated from apparent nitrogen balance • Burial of crop residues • Soil carbon removal	Tier 1	GIEC 2021
Carbon dioxide (CO_2)	Direct energy consumption	• Fuel consumption and third party work • Electricity consumption • Gas consumption	Tier 3	Agribalyse Ecoalim Ecoinvent
	Inputs (manufacture and transport of inputs)	• Nature and quantity of feed purchased (fodder, concentrates and supplements) • Nature and quantity of mineral fertilisers purchased • Electricity, fuel and gas • Phytosanitary products • Animals purchased	Tier 2 and Tier 3	Agribalyse Ecoalim Ecoinvent

** To account for emissions, the IPCC defines three «Tiers», i.e. three levels of methodological complexity. Tier 1 is the simplest estimation method, based on the multiplication of national activity data and a default emission factor provided by the GIEC. Tier 2 involves the search for a territory-specific emission factor, while Tier 3 often involves complex models and/or data sources.*

QUANTIFICATION OF ENTERIC METHANE (CH_4)

Enteric methane emissions from ruminants are evaluated using an equation developed by INRAE. This equation, which allows specific calculation of enteric methane emissions as a function of feed, corresponds to a quantification whose precision is level 3 (Tier 3). Enteric methane emissions are derived from the amount of digestible organic matter (DOM) ingested (Sauvant & Nozière, 2013). The proposed approach combines the effects of dry matter intake level and the proportion of concentrates.
The DOM variables and intake level are zootechnical parameters estimated using the Systali method.

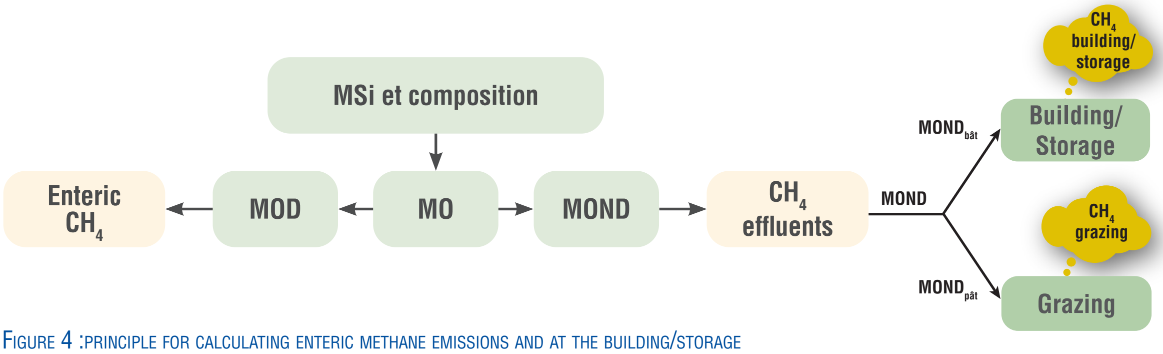


FIGURE 4 :PRINCIPLE FOR CALCULATING ENTERIC METHANE EMISSIONS AND AT THE BUILDING/STORAGE

EQUATION NO. 1: enteric methane (Sauvant & Nozière, 2013)

Enteric CH_4 (kg/head/year) = CH_4 (g/kg OMD) * $OMD_{corrected}$ (kg/head/year) / 1000

Key:

$OMD_{corrected}$: Organic Matter Digested by the animal category considered

CH_4 (in g/kg OMD) = $45,42 - 6,66*NI + 0,75*NI^2 + 19,65*PCO - 35*PCO^2 - 2,69*NI*PCO$

NI (without unit) = Ingestion Level = amount of dry matter ingested per 100 kg live weight

And:

Total enteric CH_4 (kg/year) = $\sum_{\text{animal category i}}$ enteric $CH_{4\ \text{animal category i}}$ (kg/head/year) * Head $\text{count}_{\text{animal category i}}$ (no. heads/year)

SPECIFIC EQUATION FOR FAT SUPPLEMENTATION OF DAIRY COW RATION

For dairy farms where fat supplementation (pre-defined list) is used to reduce enteric methane emissions, a specific methodology is applied for enteric methane emissions.
Indeed, for dairy cows, the quantity of enteric methane emitted can be calculated from two distinct equations depending on the technical data available on the farm and the type of supplementation:

- ▶ **Equation INRA 18** which predicts methane emissions and can integrate the effect of a supplementation of fat in the ration.
  For each kg of MS ingested, 1 g of supplemented fat reduces methane emissions by 0.075 g (Ruminant Feeding, INRA 2018, Equation 14.5 page 246).

- ▶ **Bleu-Blanc-Cœur (BBC) equation** in the case of omega-3 type fat supplementation (non-deoiled flaxseed, non-deoiled and extruded flaxseed, flaxseed meal (oil>5%) and alfalfa protein concentrate) according to the equation:

$$CH_4\ produced = \frac{FA \leq C16}{Total\ FA}\ (a \times milk\ production^{b})$$

With « $\frac{FA \leq C16}{Total\ FA}$ » expressed as a percentage (%) and representing the ratio between the amount of fatty acids with 16 carbon atoms or less to the total amount of fatty acids;
With «*milk production*» expressed in kg per cow per year and representing the total amount of milk produced per animal per year;
With «CH_4 *produced*» expressed in g per litre of milk and representing the amount of CH_4 produced;
With «a» and «b» as numerical parameters, are 11.368 and -0.4274 respectively.

QUANTIFICATION OF GHG EMISSIONS FROM LIVESTOCK MANURE

QUANTIFICATION OF GHG EMISSIONS FROM LIVESTOCK MANURE

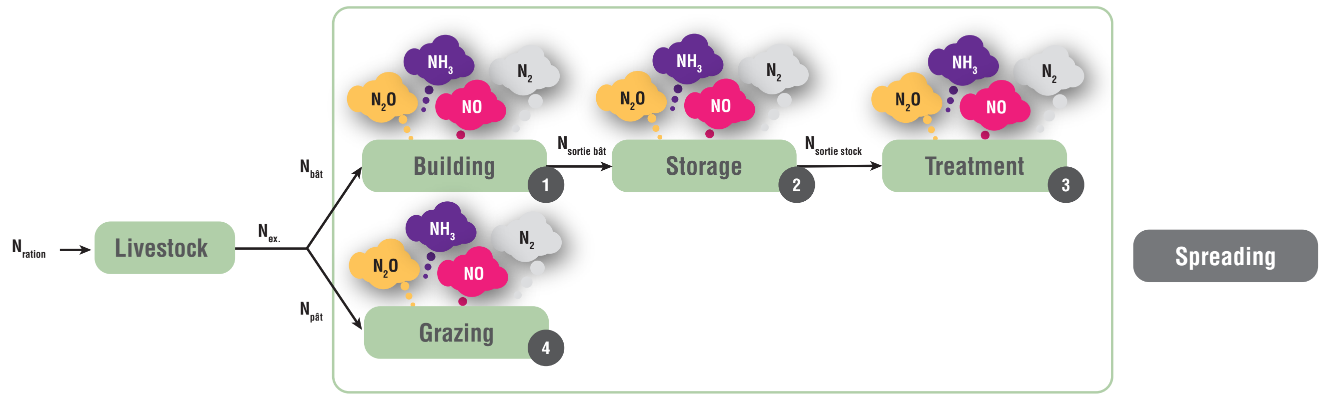
Livestock animals excrete volatile elements such as nitrogen and organic matter (OM) in their manure. For each stage of a farm (building, pasture/range, storage, treatment, spreading), nitrogen and OM are volatilized according to the characteristics of the farm.

The calculation of emissions for the whole farm is obtained by calculating the flows from a mass balance for each farm stage (figure 4). Thus, from a value of nitrogen or OM ingested, a quantity of element is excreted in the building or on pasture. Emission factors are associated with this excretion during this period. The amount of remaining (non-volatilized) elements output at the barn stage will become the input amount for the next stage (here: manure storage) and will be associated with specific emission factors for this stage. This «cascading» calculation of incoming and outgoing flows at each stage of manure management in the livestock unit makes it possible to differentiate emission factors according to practices and ensures that emission calculations are accurate.

METHANE (CH_4) EMISSIONS FROM LIVESTOCK MANURE

From the OM ingested and the OMD, the NDOM (Non Digestible OM) is deduced (figure 5), which then allows CH4 emissions to be calculated (replacing volatile solids (VS)) (MONDFERENT, 2013) by using a coefficient (B0) that characterises the methanogenic potential of the product and a Methane Conversion Factor (MCF) as described in the **IPCC Tier 2 method** guide (GIEC 2021). In the IPCC guide, these MCFs are very general, and there are eight of them: grazing, solid outdoor storage, slurry with or without land bark, storage in buildings of less than or more than one month, and litter of less than or more than one month. Each MCF is modulated by the average annual temperature. In France, the building stock is very diversified. These MCFs are therefore adapted to take this diversity into account in the calculation of emissions. **The assessment of methane emissions concerns one animal category**. For each animal category, a type of building is defined.

Figure 5 :nitrogenous gas emission stage in the effluent management chain (up to treatment)



EQUATION NO. 2 : CH_4 of livestock manure, per capita and per year, for the animal category considered (GIEC 2021)

CH_4 manure (kg/head/year) $= \sum_i NDOM_i$ (kg NDOM/year) $* 0{,}67$ (kg/m^3) $* B0,_i * FCM_i * GF_i$

CH_4 manure total (kg/year) $= \sum_{animal\ category\ i} CH_4\ effluent_{animal\ category\ i}$ (kg/head/year) $*$ No. head$^{animal\ category\ i}$ (no. head/year)

where:

NDOM : Non Digestible Organic Matter excreted and managed in the manure management system i, in kg per head i

0,67 = conversion factor from m^3 CH_4 to kg CH_4

$B0_i$: methanogenic potential of the effluent produced by the manure management system i, in m^3 / kg NDOM (table 1)

MCF_i: Methane conversion factor for manure management system i, in %. i

GF_i: Fraction of manure of the animal category under consideration, managed in the manure management system i, in %.

QUANTIFICATION OF GHG EMISSIONS FROM LIVESTOCK MANURE

NITROUS OXIDE (N_2O) EMISSIONS FROM LIVESTOCK MANURE

The nature and level of emissions depend on the amount of nitrogen excreted by the animals, the temperature and the type of manure management system. The method for assessing nitrogen gas emissions is based on the **GIEC 2021 methodological guidelines (Tier 2)** for nitrous oxide. The assessment of N_2O emissions concerns one animal category. For each animal category, a building type is defined.

For each type of manure (slurry manure or solid manure), a type of storage (4 modes for slurry and 3 for manure), a storage duration and treatment methods (composting, methanisation) are defined.

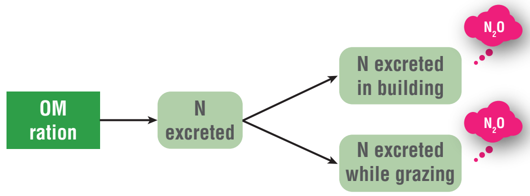


FIGURE 6: PRINCIPLE FOR CALCULATING NITROUS OXIDE EMISSIONS FROM LIVESTOCK MANURE

N_2O EMISSIONS IN BUILDINGS

In buildings, the first potential source of emissions is the dispersion of manure on the living areas frequented by the animals. This phase, prior to storage, results in emissions.
Emissions in buildings depend on the type of building, the method of manure management and the temperature, which we have translated into an effect of the season in which manure is managed.

N_2O EMISSIONS AT STORAGE

In storage, the guide (EMEP, 2019) distinguishes only two types of manure: solid (manure) and liquid (slurry). To be more consistent with the diversity of French systems, we wanted to maintain a diversity of solid and liquid products. The emission processes of these products are different in relation to their nature (porosity, DM rate, etc.) and their management mode (mixing, turning, etc.). This distinction will facilitate the updating of the methodology in line with scientific advances on these products.

EQUATION NO.3: Emissions of kg N-N_2O at the building according to manure management method

$$E_{N\text{-}N2O\_building}\ \textbf{(kg N)} = N_{build}\ (kg\ N) * FE_{N\text{-}N2O\_build}\ (\%)$$

The management modes considered are manure scraped area, slurry scraped area, accumulated litter, slatted floor and methanisation.

Nbuild: Quantity of nitrogen at the entrance to the building

$FE_{N\text{-}N2O\_build}$: N_2O emission factor depending on the management mode considered

EQUATION NO. 4: Emissions of kg N-N_2O at storage

$$E_{N\text{-}N2O\_storage}\ \textbf{(kg N)} = N_{exit\_build}\ (kg\ N) * FE_{N\text{-}N2O\_storage}\ (\%)$$

Where manure = solid manure or slurry.

Manure storage mode: Uncovered slurry pit, slurry pit with natural crust, slurry pit with artificial cover, slatted pit, manure methanisation.

Manure storage method: manure storage, field storage, composted manure with turning, manure methanisation.

Nexit_build : Quantity of nitrogen leaving the building

$FE_{N\text{-}N2O\text{-}storage}$: N_2O emission factor according to the type of storage

QUANTIFICATION OF GHG EMISSIONS FROM SOILS

N_2O EMISSIONS FROM SOILS

So-called «direct» N_2O emissions are associated with mineral and organic fertiliser inputs (including grazing), the burial of crop residues and the quantity of nitrogen released as a result of carbon de-stocking during nitrification and denitrification processes by microorganisms in soils.
In addition to so-called «direct» emissions, there are also so-called «indirect» N_2O production pathways: these are N_2O emissions from:

- nitrate or nitrite dissolved in water and carried to groundwater or surface water by runoff (leaching),
- deposition of ammonia or NOx which, when dissolved in water, is transformed into NH_4+ and thus feeds the nitrification and denitrification processes again; it can also be transformed into nitrate, leached, and contribute to indirect N2O emissions (redeposition).

All these emission are assessed in CAP'2ER® (GIEC Tier 1, 2021).

EQUATION NO. 5: N_2O emissions related to nitrogen denitrification in soils, GIEC Tier 1, 2021

	Calculations
Mineral fertilisation	= amount of mineral N applied (kg N)*FE(m)
Organic fertilisation (grazing and land application)	= amount of organic nitrogen applied (kg N)*FE(o)
Mineralization and burial of crop residues	= amount of N supplied by crop residues (kgN/ha)*FE(o)
Ammonia redeposition	= [Amount of N in mineral fertilisers * rate [volatilisation and redeposition] in mineral fertilisers + Amount of organic fertiliser N * rate [volatilisation and redeposition] organic fertiliser] * EF(v)
Leaching	=N water losses (from nitrogen balance) x FE(l)

QUANTIFICATION OF GHG EMISSIONS FROM INPUTS

INPUTS CONSIDERED

CAP'2ER® takes into account the main inputs that can enter farms, namely: feed, animals, litter, fertilisers and plant protection products. Although they are located upstream of the farm, they should be included in the assessment of the impacts of agricultural activities because they are associated with indirect impacts, with gaseous emissions, energy consumption and other environmental flows during their production and transport stages. Other inputs such as veterinary or hygiene products, animal semen, buildings, machinery, etc. are not considered and quantified, because they represent much smaller volumes and also due to lack of information.

FEED AND STRAW INPUTS

The ECOALIM v7 data (Wilfart et al., 2016) integrated with the Agribalyse database 3.1 provide life cycle inventories associated with the production of the main feed inputs used in compound feeds and concentrates for livestock.
These data integrate several stages (figure 1):

- production of cereals, protein crops and forages
- storage of harvested crops
- the possible processing of crops
- all transport stages between the field, storage units, processing plants and the port of arrival in France for imported raw materials.

Transport from the feed factory to the farm has been added to the ECOALIM data (GESTIM+, 2020).

ANIMAL INPUTS

In cattle farming, animal inputs can be of different types: calves from dairy farms, for the production of veal calves in fattening units, renewal dairy heifers, dairy cows in production, renewal suckler heifers, male and female grazers, for the production of young cattle in fattening units...
The inventory data shown below are from Agribalyse 3.1.

FERTILISERS

The production phases of mineral fertilisers require the extraction of ores and sedimentary rocks (sedimentary phosphate rocks, apatites, potash, sulphur), the use of fossil energy resources during several factory processing phases and international transport. For mineral nitrogen fertilisers, the manufacturing processes have a particular impact due to:

- the use of natural gas as a raw material during the manufacture of ammonia,
- N_2O emissions during the production of nitric acid.

CAP'2ER® uses average references that are representative of French supply. They were obtained from the WFLDB 3.3 references on transformation processes and assumptions on supplies and distances travelled from UNIFA statistics for 2018.

PLANT PROTECTION PRODUCTS

The assessment of the impacts of plant protection products is carried out in a simplified way from the Treatment Frequency Index (IFT) and a generic value per kg of active ingredient corresponding to an average value of all the plant protection products substances at from the ecoinvent 3 database. Indeed, on the impacts of climate change, energy consumption and emissions considered in this guide, the contribution of plant protection products is marginal.

ASSESSMENT OF CARBON STORAGE IN SOILS

Organic carbon storage corresponds to the retention of carbon biomass in the soil in organic form, while removal corresponds to the release of these stocks by mineralisation into the atmosphere in the form of CO_2.

The evaluation of the variation of the carbon stock in soils is currently based on an empirical model that relies on factors established on the basis of bibliographical references. See table 4.

Three types of cropping systems are considered in CAP'2ER® to evaluate the additional annual carbon storage in soils:

- the permanent grassland system, which includes areas always under grass
- the crop/crop system where the rotation never includes grassland
- the crop/grassland system where the rotation includes at least one year of grassland.

For the latter cropping system, carbon storage is assessed by considering that grassland areas store 570 kgC/ha/year and crop areas release 950 kgC/ha/year

TABLE 4: PRACTICES ASSOCIATED WITH CARBON STORAGE AND ASSOCIATED REFERENCES

	Technical data used	Calculation formulas	Average storage levels used
Permanent grassland	• Permanent grassland area	**PP storage (kg C/year)** = $Area_{permanent\ grassland}$ (ha) x $Coefficient_{permanent\ grassland}$	***According to Dollé et al., 2013 :*** $Coeff_{permanent\ grasslands}$ = 570 kg C/ha/year
Pastoral areas...	• Pastoral areas	**Pasture storage (kg C/year)** = $Area_{pasture}$ (ha) x $Coefficient_{pasture}$	***According to Dollé et al., 2013 :*** $Coeff_{pasture}$ = 250 kg C/ha/year
Hedgerows	• Linear metres of hedges	**Hedge storage (kg C/year)** = ($Metres_{hedges}$ /100) x $Coefficient_{hedgerow}$	***According to Dollé et al., 2013 :*** $Coeff_{hedges}$ = 125 kg C/100 ml/year
Crops (not in rotation with grassland)	• Crop area	**Crop storage (kg C/year)** = $Area_{crops}$ (ha) x $Coefficient_{crops}$	***According to Dollé et al., 2013 :*** $Coeff_{crops}$ = -160 kg C/ha/year
Grassland and crops in rotation	• Grassland and crop area • Duration of TG establishment • Duration of rotations	See box below	***According to Dollé et al., 2013 :*** $Coeff_{tempory\ grassland}$ = 570 kg C/ha/year $Coeff_{crops}$ = -950 kg C/ha/year
Intercrops	• Areas under intercrop	**Intercrop storage (kg C/year)** = $area_{intercrop}$ (ha) x $coeff._{interC}$	***According to Pellerin et al., 2019 :*** $Coeff_{interC}$ = 126 kg C/ha/year

FOCUS ON CARBON STORAGE IN ROTATIONAL AREAS (TEMPORARY GRASSLANDS AND CROPS)

Temporary grasslands (TG) in rotation with crops are also carbon sinks. The duration of establishment of temporary grasslands is the major factor concerning the impact on carbon storage. Using the average storage levels for temporary grassland and crops and the rotation length, the calculation is made at the rotation scale (example below).

	PG	PG	PG	PG	Crop	Crop	TOTAL
kgC/ha/year	570	570	570	570	-950	-950	380

Positive balance ➔ 380 kg C/ha stored over 6 years, i.e. +63 kg C/ha/year

Evolution 2022: the CHN-AMG model will be implemented in CAP'2ER® for annual crops. This new model will be based on pedoclimatic data, initial carbon content, practices and biomass inputs. This development will allow a tier 2 assessment.

NITROGEN BALANCE ASSESSMENT AND EMISSION INDICATORS

THE APPARENT BALANCE, OR MINERAL BALANCE

This is used (Simon and Le Corre, 1992) to assess the main mineral flows and surpluses at farm level. It allows the production potential of a farm to be evaluated with the quantities of elements available and the products produced. By knowing all the flows produced by the system, one can establish the unvalued surplus. This surplus is potentially lost from the system to water, air or soil. It is then necessary to optimise this balance to reduce nitrogen losses and thus the pollution of a farm on its environment. The farm is considered as a «black box» (systemic approach) and mineral flows within the farm are not taken into account. The balance is thus determined by calculating the difference between nitrogen inputs to the farm (purchase or import of feed, fodder, fertiliser, etc.) and nitrogen outputs (milk, meat, crops, etc.). Figure 7 shows schematically the apparent nitrogen balance on a farm.

The data needed to establish this balance are based on the farm's accounting data for the analysis period. The apparent nitrogen balance is expressed in kg of nitrogen per ha of UAA. It is calculated as follows:

$$\text{Apparent nitrogen balance} = \frac{N_{inputs} - N_{outputs}}{UAA}$$

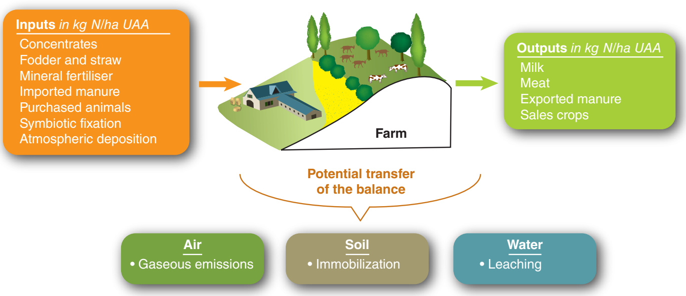


FIGURE 7: APPARENT NITROGEN BALANCE ON A FARM

THE POTENTIAL TRANSFER OF THIS APPARENT BALANCE

It is explained using 3 emission indicators expressed in kg N/ha of UAA:

Emission indicators provide an estimate of nitrogen losses in a system. They help to explain the transfer of the nitrogen surplus and to define the leaching potential of the farm.

- **Nitrogen losses to air** including losses in the form of ammonia.

  The evaluation of nitrogen gas losses is based on emission factors from the literature (Table 5), and is modelled on the basis of the practices and characteristics of the farms, at each stage in the manure management chain (building/storage/spreading/pasture). This approach makes it possible to characterise the quantities of nitrogen «entering» each stage by taking into account the losses made in the previous stage. These gaseous losses are calculated from information such as the type of building, type of storage, type of manure treatment (composting, methanisation), type of spreading equipment, and the time taken to plough in slurry and manure and the time the animals spend grazing (figure 8).

TABLE 5: SOURCES OF NITROGEN GAS EMISSION FACTORS

Emission factors nitrogen gases	Source of references
kg N-NH_3/ha UAA	EMEP 2019
kg N-NO/ha UAA	Skiba and al. 1997 Misselbrook et al., 2015
kg N-N_2O/ha UAA	GIEC 2021
kg N-N_2/ha UAA	Misselbrook et al., 2015

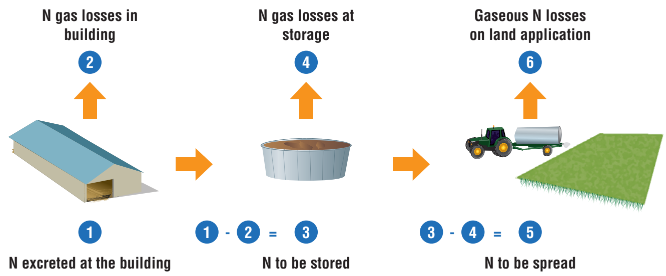


FIGURE 8: GASEOUS NITROGEN LOSSES IN THE MANURE MANAGEMENT CHAIN

- **Nitrogen storage in soils:** Nitrogen storage is estimated from carbon storage by applying a factor of 10.

$$\Delta N_{soil} = \frac{1}{10}\,\Delta C_{soil}$$

- **Nitrogen losses to water:** This indicator expressing the leaching potential of farms is based on the balance of the apparent nitrogen balance, nitrogen losses in gaseous form and nitrogen storage in the soil. It thus expresses the amount of surplus nitrogen at the overall system level that can be lost through leaching.

  Leaching potential = Apparent N balance - air N losses - N storage

NITROGEN EFFICIENCY

It expresses the ratio between N outputs and inputs on the farm.

$$\text{Nitrogen efficiency} = \frac{N_{outputs}}{N_{input}}$$

ASSESSMENT OF FOSSIL FUEL CONSUMPTION

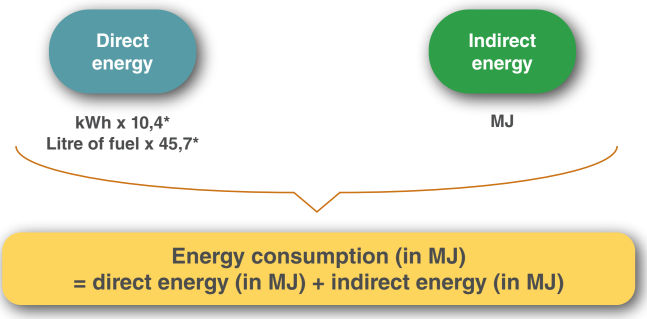
Fossil fuel consumption is assessed using the CED 1.8 method. This indicator takes into account the direct energy used on the farm (fuel oil, electricity, gas) and the indirect energy used in the manufacture and transport of inputs (fertilisers, feed, fodder, straw) and plant protection products.

ITEMISED ENERGY CONSUMPTION

TABLE 6: ITEMISED ENERGY CONSUMPTION

	Breakdown of emissions	Technical data used	Calculation formulas
Direct energy	Direct energy	• Electricity consumption	kwh consumed
		• Fuel consumption	Litres of fuel oil consumed
Indirect energy MJ	Energy related to inputs (manufacturing and transport)	• Nature and quantities of inputs purchased	Indirect energy (MJ) $\sum$(quantity of inputs x CF $_{MJ}$) CF = Caracterization factor

TOTAL ENERGY CONSUMPTION



* MJ conversion factor (Dia'Terre 2014), AGB3 based on ecoinvent 3 1989-2018

FIGURE 9: CALCULATION OF ENERGY CONSUMPTION

ASSESSMENT OF RENEWABLE ENERGY PRODUCTION

Agriculture has a significant potential for renewable energy production (RE) with biomass (biomass heat, methanisation, biofuels, etc.) and the management of large surfaces, on the roof of buildings and on the ground, that could accommodate renewable electricity production systems (wind, photovoltaic, solar thermal). An indicator of RE production on the farm is proposed in CAP'2ER®. It is independent of the CAP'2ER® environmental balance sheet (energy consumption, GHGs, etc.). This production does not replace the farm's energy consumption.

The CAP'2ER® environmental balance sheet will show reductions in fossil fuel consumption only in situations where the energy produced replaces the energy purchased (solar water heater, self-consumption of energy from solar panels in the case of a milking robot, etc.).

ASSESSING THE MAINTENANCE OF BIODIVERSITY

The contribution to the maintenance of biodiversity is an indicator that is rarely evaluated in environmental analyses. There is currently no recognised national or international method on this subject. To evaluate this indicator, the various significant ecological area (table below) present on the farm and contributing to the maintenance of biodiversity are counted. These elements are translated into equivalent hectares of biodiversity using the equivalence coefficients defined in the BCAE/PHAE (Good Agricultural and Environmental Conditions) rules.

AGRO-ECOLOGICAL ELEMENTS

Table 7: coefficient of equivalence of significant ecological area

	Ecological significant area (SEA)	Coefficient of equivalence ($Coeff_{EAE}$)
MAAF (2012)	1 ha of Natura 2000 grassland	2
	1 ha other grassland	1
	1 ha buffer strips	2
	1 ha fallow land	1
	1 ha of field edges, embankments	1
	1 linear metre of agroforestry alignment	0,001
	1 m² of groves	0,01
	1 isolated tree	0,005
	1 linear metre of aligned trees	0,001
	1 linear metre of hedges	0,01
	1 linear metre of ditches	0,001
	1 linear metre of pond perimeter	0,01
	1 linear metre of low walls	0,05

INDICATOR FOR MAINTAINING BIODIVERSITY

Biodiversity (in ha biodiversity eq)
$= \sum_i$ Significant ecological area$_i$ x Coefficient of equivalence$_{\text{Significant ecological area}}$

ASSESSMENT OF NUTRITIONAL PERFORMANCE

Nutritional performance is the number of people fed by the net annual quantities (quantities sold - quantities purchased) of Agricultural Raw Materials (ARM) produced by a farm. This indicator is evaluated using the PerfAlim© method of CEREOPA.

CALCULATION PRINCIPLES

Each type of raw material is characterised by a nutritional value, estimated according to three possible indicators:

- energy (in calories),
- total proteins (in grams),
- animal protein (in grams).

The total nutritional value of the net quantities of agricultural raw materials (ARM) is divided by the average nutritional requirement of an individual (in energy, total protein or animal protein). This requirement expresses the recommended amounts of energy, protein and animal protein for a 70 kg man with moderate physical activity.

Nutritional requirements		
CEREOPA (2013)	Average energy requirement	2,700 kcal/day/person
	Average total (assimilated) protein requirement	52.5 grams/day/person
	Average animal protein requirement	22.5 grams/day/person

Only agricultural raw materials that can be used for human consumption are taken into account in the calculation (cereal-based feed, meat and milk). Straw and fodder are not considered.

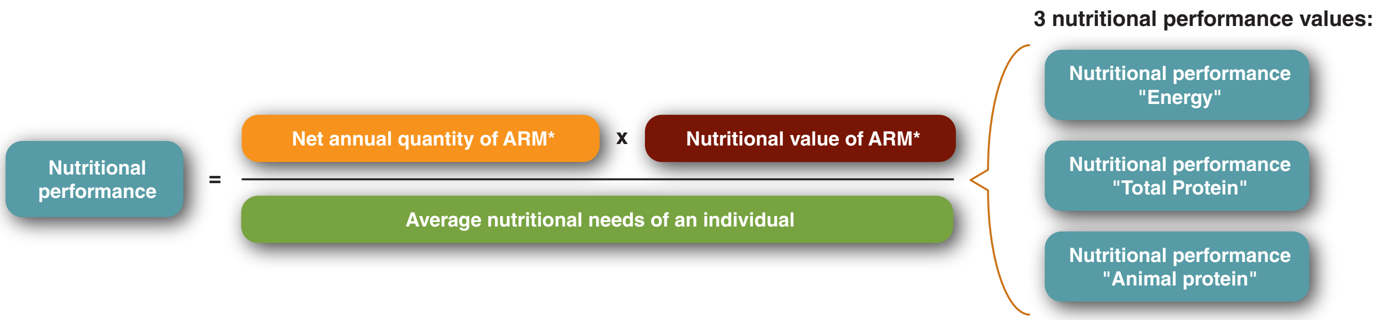


FIGURE 10: CALCULATION OF NUTRITIONAL PERFORMANCE

Among these three indicators, the best score is chosen to define the nutritional performance.

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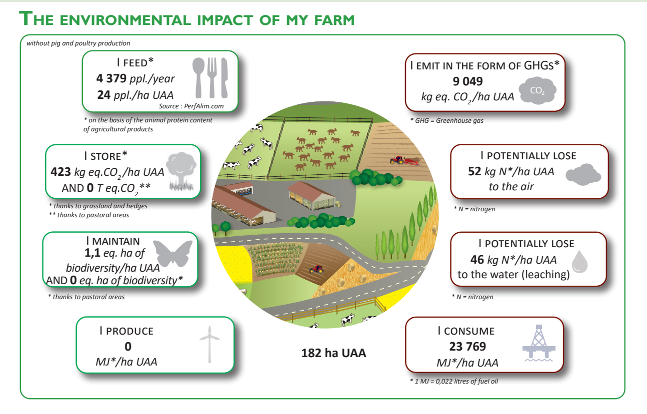
THE RESULTS AVAILABLE TO THE FARMER

CAP'2ER® LEVEL 2 : SUMMARY AND TECHNICAL PERFORMANCE INDICATORS TO BUILD AN ACTION PLAN ADAPTED TO THE FARM

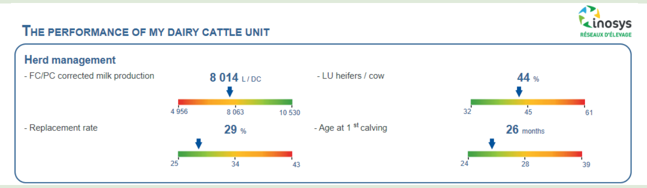
RESULTS AT FARM LEVEL

An overall assessment of environmental impacts and positive contributions at farm level to provide the farmer with elements for synthesis and communication.



TECHNICAL PERFORMANCE INDICATORS FOR EACH UNIT

Technical indicators, compared to an equivalent production system reference. This makes it possible to explain the results of the unit and thus to identify practices that are a source of improvement and to set technical objectives to improve the environmental balance.

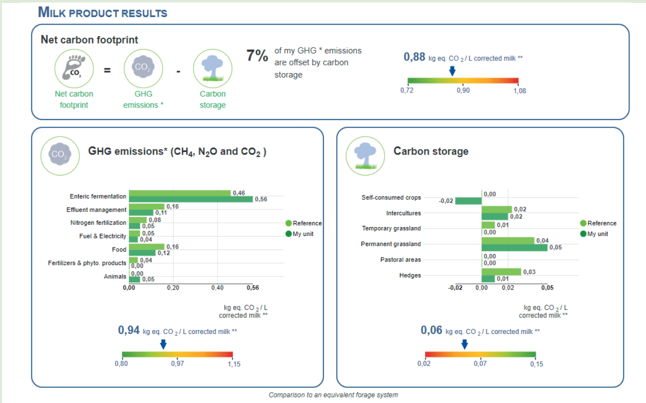


A «SIMULATION» FUNCTION FOR NEW PRACTICES

Once the action plan has been drawn up, the advisor and the farmer can evaluate the potential carbon gain and the evolution of the co-benefits using the so-called «expert» simulation, which makes it possible to generate a copy of the initial diagnosis and to modify the activity data. The farmer and advisor will thus have access to the environmental results obtained by the implementation of the action plan. This feature allows the farmer to see the impact of his new practices in concrete terms.

RESULTS AT THE UNIT AND PRODUCT LEVEL

Results by unit are available for the dairy, beef, goat, dairy sheep, meat sheep and cash crop units.
The detailed results per item explain the origin of the impacts and are compared to an equivalent production system reference.
This comparison makes it possible to identify potential areas for improvement.



CAP'2ER® THE REFERENCE TOOL FOR THE «CARBON AGRI» METHODOLOGY REFERENCED IN THE LOW CARBON LABEL

The results of the CAP'2ER® diagnosis can be used to submit a project to reduce GHG emissions or increase carbon storage using the CARBONE AGRI (LBC) methodology. These emission reductions are then certified and can be valued on the voluntary carbon credit market.
At the end of 2022, a request for certification as a tool that can be used in the «Cash Crops» (LBC) methodology will be launched.

VALUATION OF RESULTS BY COMPANIES

SYNTHESIS AND MONITORING OF THE EVOLUTION OF ENVIRONMENTAL IMPACTS AND CO-BENEFITS ON A TERRITORY

A function for exporting the diagnostics carried out by the organisation enables summaries to be made, the evolution of results and the impact of actions undertaken with farmers to be monitored, CSR reporting, etc.

COLLABORATION BETWEEN ORGANISATIONS

With the farmer's consent, it is possible to share data and the results of a CAP'2ER® diagnosis between organisations.

CAP'2ER® LEVEL 1

THE OBJECTIVES

CAP'2ER® level 1 is a simplified tool which, with approximately 35 activity data, enables the main environmental impacts and co-benefits to be assessed at the unit level. The tool is available for dairy, beef, goat, dairy sheep and meat sheep farms. It is a very effective tool for mapping a territory (level 1 and 2 concordance rate of over 80% for GHG emissions).

ENVIRONMENTAL INDICATORS AT THE UNIT AND PRODUCT LEVEL

CAP'2ER® level 1 enables the following indicators to be assessed:

- GHG emissions and net carbon footprint,
- carbon storage,
- nitrogen balance and ammonia emissions,
- consumption of fossil fuels,
- maintenance of biodiversity,
- nutritional performance,
- A benchmark comparison is available for the indicators «climate change», ammonia and fossil energy consumption.

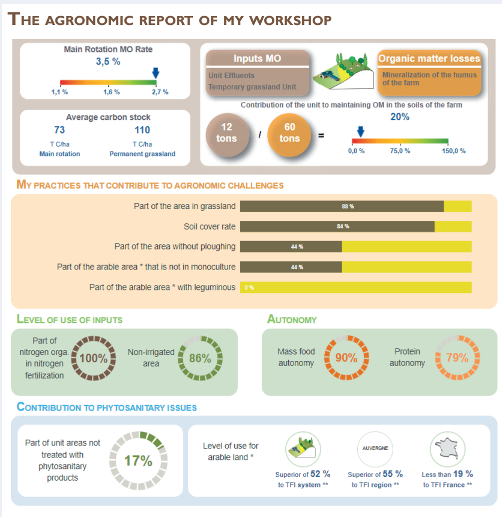
THE MAIN SIMPLIFICATIONS OF CAP'2ER® LEVEL 1

- Purchased fodder is not considered.
- An average concentrate is used per type of production system.
- An average fertiliser is used for mineral nitrogenous fertiliser inputs to crops.
- P and K fertiliser inputs are not considered.
- A fixed rate of nitrogen fixation by legumes of 15%
- The nitrogen excreted is fixed by animal category according to the references of the nitrate directive.
- Manure management methods are defined by default:
  - ⇨ manure = an uncovered pit with regular mixing,
  - ⇨ the burial period for manure and slurry is set at «more than one week»,
  - ⇨ the type of slurry spreader application = 80% broadcast spreader and 20% trailing shoe spreader,
  - ⇨ the building for heifers and goats is an integral straw-bedded area and 180 days of building time for heifers and 365 days for goats. For dairy sheep there are 3 modalities for ewe lamb (0%/50%/100%) and the ram is considered to be 100% in barn.
- The carbon storage of temporary grassland is set at 80 kg C/ha/year.
- Only linear metres of hedges and permanent grassland are counted for the biodiversity indicator.

AGRONOMY MODULE FOR REGENERATIVE AGRICULTURE

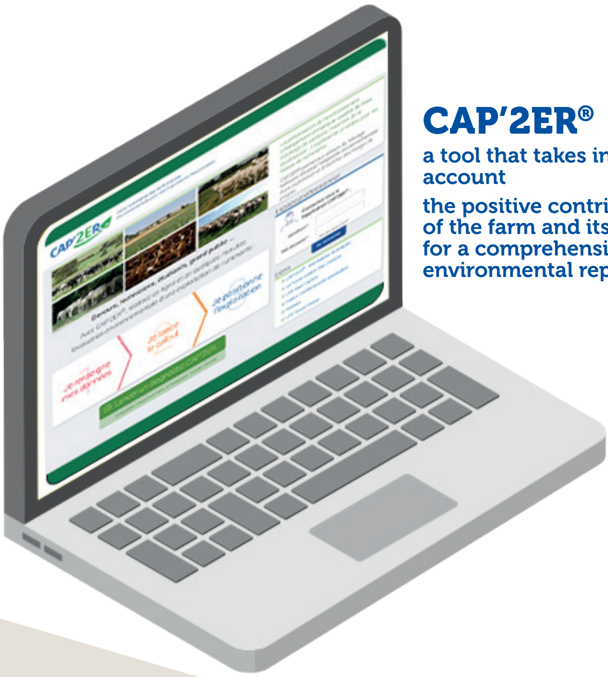
An optional agronomy module has been developed in CAP'2ER® level 1 for dairy and beef cattle in order to raise farmers' awareness of agro-ecological practices. This module enables an inventory to be made of:

- organic matter in the soils of the unit in rotation,
- the participation of the unit in maintaining the fertility of the farm's soils (manure and temporary grassland from the unit),
- practices favourable to soil preservation:
  - ⇨ covering the soil (share of grassland and soil cover rate)
  - ⇨ reducing tillage (share of no-till)
  - ⇨ rotation (share of monoculture)
  - ⇨ legumes (share of temporary grassland with legumes)
- the level of input use,
- the level of mass and protein autonomy,
- the situation of the unit with regard to the objectives of reducing the use of plant protection products.



Tool box

CAP'2ER®



CAP'2ER®
a tool that takes into account
the positive contributions of the farm and its impacts for a comprehensive environmental report.

POSITIVE CONTRIBUTIONS

- Carbon storage
- Maintaining of biodiversity
- Production of renewable energy
- Nutritional performance

ENVIRONMENTAL IMPACTS

- GHG emissions
- Air quality (ammonia)
- Fossil fuel consumption
- Water quality (nitrogen, plant protection product)
- Water consumption

CAP'2ER®

Automated calculation of Environmental Performance for Responsible Farms

PERFORMANCES ASSESSMENT AND MONITORING ACCORDING 2 LEVELS CONDUCTED BY AN ADVISER

RÉSULTATS CERTIFIÉS – BUREAU VERITAS 1828

	CAP'2ER® Level 1	CAP'2ER® Level 2
	To carry out an overview of environmental performance and see how one farm compares to others	To carry out a detailed assessment of the environmental performance, make a link with the farm's practices and build an action plan
ANALYSIS SCALE	Production unit, products	Farm, production unit, products
NUMBER OF DATA	Between 35 and 45	Between 150 to 200
COMPLETION TIME	1 to 1h30	From half a day to 1 day

DISCOVER CAP'2ER®

https://cap2er.eu

Find all the information on CAP'2ER® and a free demonstration version of CAP'2ER® Level 1.

Advisor training

1.5 days (level 1) or 2.5 days (level 2)

To become familiar with the tool, learn to interpret the results and build an action plan based on concrete case studies.
For more information: **https://idele.fr/formation**

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