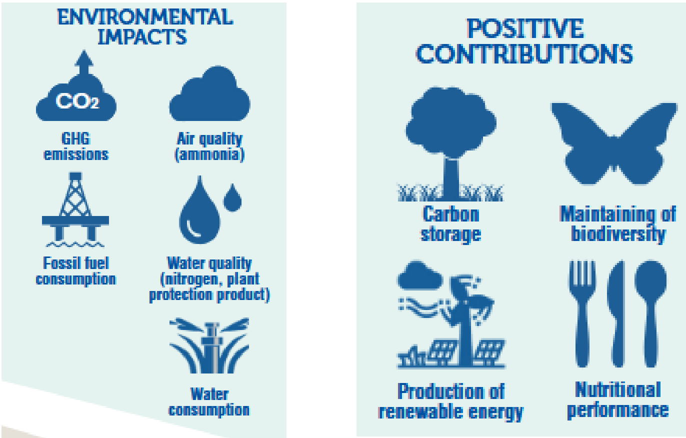
The ecological footprint of milk production: examples from Switzerland, France and Germany

As part of the **ResKuh** project, environmental assessments are being carried out at a total of 80 dairy farms using the **CAP'2ER** tool**, level 2**.
A consultant carries out the analysis at farm level, taking into account all aspects of the farm's operations. The tool's multifaceted approach makes it possible to capture both the environmental impact of a farm and its positive contributions to climate protection, as shown in the figure below.



Source: CAP'2ER, simplified guide to environmental assessment of an agricultural business, IDELE, 2022, link https://idele.fr/detail-article/cap2er-guide-simplifie-de-la-methodologie-devaluation-environnementale-dune-exploitation-agricole

Once the in-depth analysis is complete, the environmental impact, including GHG emissions, is quantified. The results of the ecological footprint are converted into CO2 equivalents per product unit (milk, meat), and the total emissions of the farm are converted into CO2 equivalents per unit of agricultural land (ha).

The main advantage of these assessments is that the results of one's own farm can be compared with those of other farms or with reference values of comparable production systems. The results make it possible to:

- quickly identify the strengths and weaknesses of your own environmental performance,
- establish the link between emissions and the farm's practices that influence the various emission items
- and thus select the practices and techniques to be improved in an individual action plan to reduce the system's emissions.

Once the diagnosis has been completed and the levers for action identified, the consultant works with the farmer to develop an action plan to implement several measures to reduce environmental impact.

This approach offers valuable insights, particularly in **the Upper Rhine region**, which stretches across **Switzerland**, the **Black Forest** and **Alsace**. Despite different structural conditions, the farms face similar challenges. The following case studies from the three countries illustrate how farms can assess their environmental performance, identify opportunities for optimisation and thus contribute to a more sustainable dairy industry in the region.

The following appendices present the results of several businesses evaluated as part of the project.

- In the Swiss example (**Appendix 1**), two companies, A and B, with very different strategies are compared. Both companies have the same production system, but there is a clear difference in their net greenhouse gas emissions due to their different operating strategies.

In the case of the German and French farms, the results are compared with a reference system and with a simulation of the production system after technical optimisation.

- **French** farm C (**Appendix 2**) is a mixed dairy farm in the Alsace plain. This farm keeps 130 dairy cows on 255 hectares of agricultural land.
- The **German** farm D (**Appendix 3**) is a dairy farm in the Black Forest with 51 dairy cows and 140 hectares of agricultural land, 124 hectares of which is permanent grassland.

Regardless of the region, the results clearly show that milk producers face similar challenges despite different situations. Across national borders, it is evident that the ecological footprint of milk production depends not only on regional conditions, but also significantly on the management strategies chosen.

By jointly applying a uniform methodology using the **CAP'2ER** advisory tool, farms can compare their results not only nationally but also across borders. This opens up valuable opportunities to learn from each other, exchange good practices and jointly develop concrete measures to reduce GHG emissions.

In this way, the **ResKuh** project is helping to make dairy farming in the Upper Rhine region more climate-friendly and resource-efficient and to strengthen cross-border cooperation.

Appendix 1
The ecological footprint of milk production: examples from two Swiss dairy farms

As part of the ResKuh project, detailed environmental assessments are being carried out on 80 dairy farms using the CAP'2ER consulting tool, level 2, in order to evaluate greenhouse gas (GHG) emissions, compare them with reference systems and derive targeted measures for reducing emissions. The table contains a summary of the environmental results and technical indicators of two farms in Switzerland.
Both farms, A and B, are located in the valley zone and produce milk for cheese, which means that silage feeding is prohibited according to the specifications.
Nevertheless, their GHG emissions differ significantly. The technical indicators show how both farms can reduce their GHG emissions.

	Farm A	Farm B	Difference
Environmental results			
Contribution of the 3 greenhouse gases (GHG)	69 % / 20 % / 11 % CH_4 = 27*CO_2 / N_2O = 273*CO_2 / CO	76 % / 5 % / 19 % CH_4 = 27*CO_2 / N_2O = 273*CO_2 / CO_2	
GHG emissions (kg CO_2 eq/ha UAA)	8,940	13,302	4,362 (49%)

- Methane (CH_4) accounts for the largest share of emissions on a ruminant farm: it accounts for 69% and 76% of emissions on the two farms respectively. Methane emissions come from two sources: enteric fermentation and farm manure management. Between ¼ and 1/3 of GHG emissions come from the other two gases: nitrous oxide (N_2 O) and CO_2 (emissions resulting from the combustion of direct energy sources and indirect emissions associated with the use of production inputs).
- The gross GHG emissions from dairy farming per unit area show a significant difference of 4,362 kg CO_2 eq/ha UAA between farms.

	Farm A	Farm B	Difference
Gross emissions (kg CO_2 eq/L milk)	**0.72**	**0.9**	**0.27 (38%)**
of which enteric fermentation	0.48	0.56	0.08
of which farmyard manure management	0.09	0.22	0.13
of which nitrogen fertilisation	0.07	0.01	-0.06
of which fuels and electricity	0.03	0.05	0.02
of which animal feed	0.04	0.14	0.1
of which fertilisers, plant protection products	0.01	0	
Carbon storage (kg CO_2 eq/L milk)	**0.20**	**0.15**	**-0.05 (25%)**
Net emissions (kg CO_2 eq/L milk)	**0.52**	**0.84**	**0.32 (62%)**

- The **gross footprint** per litre of milk of A is 38% lower than that of B.
- When carbon storage is deducted, the difference becomes even greater. The **net footprint** of A is 62% smaller than that of B.
- Three items explain the higher gross emissions from farm B: enteric fermentation, farm manure management and feed.

	Company A	Company B	Difference
Technical indicators			
Herd management			
Milk/cow/year (L corrected milk or ECM)	7,168	8,693	1,525 (21%)
Gross milk production corrected (L/ha main forage area - milk)	9,921	11,520	1,599 (16%)
Age at first calving (months)	24	25	1
Replacement rate (%)	20	56	36

- The average milk yield per cow in herd A is one-fifth lower. Nevertheless, with almost 10,000 litres per hectare of main forage area - milk, A's gross milk production reaches a level close to that of B.
- The age at first calving was almost the same on both farms.
- The replacement rate of herd B is very high compared to A, as the farmer breeds all his young stock and sells it for rearing. As a result, herd B, with a higher proportion of "unproductive" animals, will worsen the CO_2 balance.

Feeding the herd	Company A	Company B	Difference
Concentrated feed (kg/LU milk)	139	1,600	1,466 (x 11)
Excreted N (kg N/LU)	88	114	26 (30%)
Protein autonomy (%)	94	58	-

- In order to achieve the average level of almost 8,400 litres per lactation, Farm B requires a considerable amount of concentrated feed, both for the lactating cows and for the heifers. The table only shows the consumption figure per LU. The CO_2 footprint (transport and origin) of the concentrated feed is added to B's footprint. Farm B would have scope to reduce the amount of concentrated feed.
- As a result, the nitrogen excretion at B is also higher, while A, which uses concentrated feed very sparingly, achieves a protein autonomy of 94%. This lower dependence on purchased concentrated feed is reflected in an improved greenhouse gas balance.

Land management	Company A	Company B	Difference
Surplus of nitrogen balance inputs - outputs (kg N/ha LN)	180	109	-71 (-39%)
Nitrogen efficiency (output/input ratio)	44	44	
Yield (t DM/ha)	10.6	9.9	-0.7 (7%)

- Both farms aim for intensive feed production.
- The yield A of forage production is over 10 t DM per ha. The nitrogen balance surplus is 71 higher than in B. This higher nitrogen input is related to a longer grazing period (210 days).

Criteria for carbon storage	Company A	Company B	Difference
Hedge (running metres/ha UAA - milk)	83	34	-49
Permanent grassland/UAA - milk (%)	100	83	-

- The higher number of running metres of hedge per hectare of milk production area and the fact that A has only permanent grassland enables higher carbon storage.
- Farm A has only permanent grassland. Farm B has some temporary grassland.

	Farm A	Farm B	Difference
Farm manure management			
Grazing period (days)	210	93	-117 (56%)

- A maximises grazing duration to 210 days, which is twice as long as B. Fewer animals in the building means less manure to store and spread, resulting in lower methane and nitrous oxide emissions, as well as less feed harvesting and distribution.

Energy			
Fuels (L/ha UAA - milk)	108	194	86 (80%)
Electricity (kWh/1 000 L)	62	115	53 (85%)

- A consumes significantly less fuel and electricity for its dairy operations than B. This low fuel consumption is due to the maximised use of pasture grass at A. In contrast, with a herd that spends more than ¾ of its time in the barn, farm B has to use more mechanisation to feed its dairy herd and manage farm manure. The structure of the plots may also explain the higher fuel consumption.
- The lower electricity consumption of farm A is due to the fact that the milking parlour was closed for two months and the quality of the preserved feed (dry period) is less demanding for cows that are all dry in winter.

Although the production system is identical, a detailed analysis of the technical indicators reveals a significant difference in the decisions made by the farmers and, ultimately, different impacts on the environment. Farmer A uses a system of full grazing and block calving. Full grazing is maximised with economical concentrate feeding. The cow breed must be suitable for this system with calving at 24 months of age (e.g. Kiwi cross).
Farmer B spreads calving throughout the year and has a high performance target per cow. The optimum production system for B is at a level that differs significantly from that of A.

Conclusion

Farmer A achieves a very good result with a net footprint of 0.52 kg CO_2 eq. /L milk. Compared to farmer B, who has a net footprint of 0.84 kg CO_2 eq. /L milk, there is little room for improvement. Farmer B can improve his result by implementing various measures, e.g. with regard to the number of "unproductive" animals, by influencing the replacement rate and changing the feeding, e.g. by:

- Reviewing the concentrate feed supply for heifers and cows in production
- Including more protein-rich plants in feed production
- Possibility of increasing the proportion of pasture.

The feasibility and implementation of the measures must be supervised by a consultant and agreed with the farmer.

Similar farm comparisons for France and Germany were made as part of the ResKuh project. These can be found in Appendices 2 and 3 of the information sheet "**The ecological footprint of milk production: examples from Switzerland, France and Germany**".

Appendix 2
The ecological footprint of milk production: Example from a French dairy farm

As part of the ResKuh project, detailed environmental diagnoses are being carried out on 80 dairy farms using the CAP'2ER Level 2 tool to assess greenhouse gas emissions, compare them with reference systems and derive targeted measures for reducing emissions. The table summarises the environmental results and technical indicators for a French farm in Alsace.

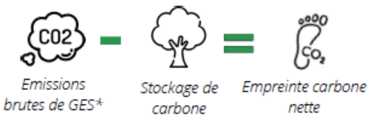
Farm C is a mixed dairy farm located on the plains. This farm has 130 dairy cows on 255 hectares of agricultural land.

The results are compared with a reference system and with a simulation of the system after technical optimisation.

The simulation was based on the farmer's wishes (the changed data is highlighted in purple):

- Discontinutation of cattle fattening: 7 LU to 0 LU
- Reduction in replacement rate: 48% to 40% replacement
- Reduction in the amount of concentrated feed for dairy cows: 328 to 306 g/l milk

	Farm C	Reference system maize, plain	Simulation
Environmental results			
Contribution of the 3 greenhouse gases (GHG)	57 % $CH_4 = 27*CO_2$; 18 % $N_2O = 273*CO_2$; 25 % CO_2		56 % $CH_4 = 27*CO_2$; 18 % $N_2O = 273*CO_2$; 26 % CO_2
GHG emissions (kg CO_2 eq/ha UAA)	8,648		7,760
Gross emissions (kg CO_2 eq/L milk)	**1.07**	**0.99**	**1.00 (-0.07)**
of which enteric fermentation	0.5	0.54	0.46
of which farmyard manure management	0.23	0.15	0.2
of which nitrogen fertilisation	0.09	0.08	0.07
of which fuels and electricity	0.05	0.06	0.05
of which animal feed	0.16	0.13	0.15
of which fertilisers, plant protection products	0.03	0.02	0.03
Carbon storage (kg CO_2 eq/L milk)	**0.07**	**0.09**	**0.07**
Net emissions (kg CO_2 eq/L milk)	**1.0**	**0.9**	**0.92 (-0.08)**



	Farm C	Reference system maize, plain	Simulation
Technical indicators			
Herd management			
Milk/cow/year (L corrected milk or ECM)	10,350	8,047	10,350
Gross milk production corrected (L/ha main forage area - milk)	12,614	10,444	13,418
Age at first calving (months)	24.6	28	24.6
Replacement rate (%)	**48**	40	**40**

As a rule, a replacement rate of around 30% is targeted. A lower number of animals for replacement has less impact on the environment and saves costs in rearing. At this farm, the aim is to extend the useful life of cows and thus reduce the replacement rate. For the simulation, we have set a replacement rate of 40% as the reference system.

Feeding the herd			
Concentrated feed (kg/LU milk)	**328**	182	**306**
Concentrated feed for cattle (kg/LU cattle)	525	709	524
Excreted N (kg N/LU)	125	105	124
Protein autonomy (%)	49	61	50

The amount of concentrated feed for dairy cows is 328 g per litre of milk. This is relatively high compared to the reference system. Barley is grown for own consumption on this farm, and feed with a protein content of 22% and 40% is purchased.
One way to reduce the amount of concentrated feed is to harvest feed with good nutritional values. In the simulation, the amount of concentrated feed was reduced by only 22 g/l, as this must be feasible while maintaining milk production.
The nitrogen excreted corresponds to the difference between the nitrogen ingested in the rations and the nitrogen utilised in milk and meat at herd level.

Land management			
Surplus nitrogen balance Inputs - Outputs (kg N/ha LN)	143		120
Nitrogen efficiency (output/input ratio)	37		44
Yield (t DM/ha)	9.7	7.1	9.7

The nitrogen balance surplus improves thanks to the simulation, as there is a reduction in the amount of concentrated feed given to dairy cows.

	Farm C	Reference system maize, plain	Simulation
Criteria for carbon storage			
Hedge (running metres/ha UAA milk)	0	104	0
Permanent grassland/UAA milk (%)	48	21	51

Permanent grassland accounts for 25% of the farm's utilised agricultural area.

Farm fertiliser management			
Grazing period (days)	0	134	0

This farm, located on flat land, does not practise grazing as it has no green areas around the buildings. By making maximum use of grazing areas, the amount of excrement produced in the buildings and the associated N_2O, CH_4 and NH_3 emissions can be reduced as far as possible!

Energy			
Fuels (L/ha UAA milk)	183	208	181
Electricity (kWh/1 000 L)	61	65	61

Fuel consumption per hectare is the most important indicator of direct energy consumption. It is interpreted in terms of load, consumption from stocks (tonnes of feed per LU) and also in terms of plot size. High fuel consumption per hectare can have structural causes, such as fragmented or distant parcels or long downtimes in the building, and thus high fuel requirements for harvesting, distribution, manure disposal, etc.

Conclusion

78% of emissions from milk processing are attributed to dairy products and 22% to meat products. The gross CO_2 footprint of milk is 1.07 kg CO_2 eq./L milk. With an estimated carbon storage of 0.07 kg CO_2 eq./L milk, the net CO_2 footprint of milk is 1 kg CO_2 eq./L milk. This means that this farm offsets 7% of the emissions for dairy products through carbon storage. Thanks to the simulation, the net CO_2 footprint of this farm fell to 0.92 kg CO_2 eq./L milk, which corresponds to a reduction of 0.08 CO_2 eq./L milk.

Similar farm comparisons for Switzerland and Germany were made as part of the ResKuh project. These can be found in Appendices 1 and 3 of the information sheet "**The ecological footprint of milk production: examples from Switzerland, France and Germany**".

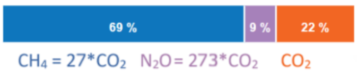
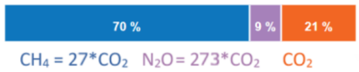
Appendix 3
The ecological footprint of milk production: Example from a German dairy farm

As part of the ResKuh project, detailed environmental assessments are being carried out on 80 dairy farms using the CAP'2ER Level 2 tool to evaluate greenhouse gas emissions, compare them with reference systems and derive targeted measures for reducing emissions. The table contains a summary of the environmental results and technical indicators of a German farm in the Black Forest.

Farm D is a dairy farm with 51 dairy cows and 140 hectares of agricultural land, 124 hectares of which is permanent grassland.

The results are compared with a reference system and with a simulation of the system after technical optimisation.

The simulation was based on reducing the age at first calving from 35 to 30 months (the changed data is highlighted in purple):

	Farm D	Reference system mountain, grass	Simulation
Environmental results			
Contribution of the 3 greenhouse gases (GHG)			
GHG emissions (kg CO_2 eq/ha UAA)	3,352		2,874
Gross emissions (kg CO_2 eq./L milk)	**1.08**	**1.09**	**1.06**
of which enteric fermentation	0.62	0.65	0.61
of which farm manure management	0.19	0.17	0.19
of which nitrogen fertilisation	0.04	0.07	0.04
of which fuels and electricity	0.09	0.08	0.11
of which animal feed	0.10	0.12	0.09
of which fertilisers, plant protection products	0.00	0.01	0
Carbon storage (kg CO_2 eq./L milk)	**0.62**	**0.38**	**0.71**
Net emissions (kg CO_2 eq./L milk)	**0.46**	**0.71**	**0.35 (-0.11)**

- The **gross emissions** of farm D are similar to those of the reference group. However, due to high carbon storage, the farm achieves significantly lower **net emissions**.
- The **gross footprint** per litre of milk after reducing the age at first calving is only slightly lower than that of farm D.
- However, when carbon storage is deducted, the difference becomes greater. The **net footprint** after reducing the age at first calving is 11% smaller than the baseline.
- Gross GHG emissions per unit area decrease by 8% (20 CO_2 eq./ha UAA) with the reduction in the age at first calving.

	Operation D	Reference system mountain, grass	Simulation
Technical indicators			
Herd management			
Milk/cow/year (L corrected milk or ECM)	6024	6254	6019
Gross milk production corrected (L/ha main forage area - milk)	2183	4401	2183
Age at first calving (months)	**35**	32	**30**
Replacement rate (%)	25	33	25

- The age at first calving was reduced to 30 months in the simulation.
- The result: the herd in the initial situation, with a higher proportion of "unproductive" animals, has a poorer CO_2 balance than the herd after the reduction in the age at first calving.

Feeding the herd			
Concentrate feed for dairy cows (g/L)	117	254	118
Concentrated feed for cattle (kg/LU cattle)	**0**	537	**286**
Excreted N (kg N/LU)	91	100	94
Protein autonomy (%)	68	71	70

- In order to achieve the average level of 6,000 litres per lactation, the farm uses less concentrated feed than the reference group.
- However, reducing the age at first calving makes it necessary to include concentrated feed in the ration for the heifers so that they are in the necessary physical condition for the subsequent pregnancy phase.
- The CO_2 weight (transport and origin) of the concentrated feed is added to the simulation's footprint. This dependence on the purchase of concentrated feed is initially reflected in a poorer environmental and carbon balance.

Land management			
Surplus of nitrogen balance inputs - outputs (kg N/ha LN)	34	79	29
Nitrogen efficiency (output/input ratio)	27		32
Yield (t DM/ha)	3	4.3	3

- The low surplus in the nitrogen balance of farm D indicates rather extensive fodder production. At the same time, protein autonomy of 68% indicates dependence on the purchase of concentrated feed.

Criteria for carbon storage			
Hedge (running metres/ha UAA milk)	0	43	0
Permanent grassland/UAA milk (%)	88	77	88

- A large proportion of permanent grassland enables higher overall carbon storage than in the reference group, even though the reference group has an additional opportunity for carbon storage via hedges.

	Operation D	Reference system mountain, grass	Simulation
Farm fertiliser management			
Grazing period (days)	90	172	90

- The farms in the reference group have almost twice as many grazing days as farm D. Fewer animals in the building means less manure to store and spread, and thus fewer methane and nitrous oxide emissions, as well as less feed harvesting and distribution. In this respect, a longer grazing period is desirable.
- In addition, the "automatic" separation of faeces and urine during grazing has a positive effect, i.e. it reduces ammonia emissions.

Energy			
Fuels (L/ha UAA milk)	76	100	76
Electricity (kWh/1 000 L)	83	87	83

- Farm D consumes less fuel and electricity for its dairy cattle operations than the reference group, even though the reference group has significantly more grazing days and the very high use of pasture grass in feeding means less effort is required to prepare feed rations. In contrast, farm D, with a herd that spends more than three-quarters of its time in the barn, would need to use more mechanisation for feeding its dairy herd and managing farm manure, but the opposite is the case. Despite fewer grazing days, farm D has lower fuel consumption than the reference group. The structure of the plots and the average distance between the farm and the fields could explain the lower fuel consumption.

Although the production system on farm D is similar to that of the reference group, a detailed analysis of the technical indicators reveals differences in the decisions made by farmers and, ultimately, different impacts on the environment. Farmer D only uses the full grazing system for a limited period of time, as it is costly to drive the cows to the pasture. However, full grazing is maximised with economical concentrate feeding.

Conclusion

With a net footprint of 0.46 kg CO_2 eq. /litre of milk, farm D already achieves a very good result, so there is little room for improvement. Nevertheless, it can improve its result by implementing various measures, e.g. with regard to the number of "unproductive" animals, by reducing the age at first calving and reviewing feeding (concentrate feed for heifers and cows, inclusion of more protein-rich plants in feed production, possibility of increasing the proportion of pasture). The feasibility and implementation of the measures must be monitored by a consultant and agreed with the farmer.

Similar farm comparisons for Switzerland and France were made as part of the ResKuh project. These can be found in Appendices 1 and 2 of the information sheet "**The ecological footprint of milk production: examples from Switzerland, France and Germany**".