

# Compared energy efficiency of dairy cow and meat sheep farms, in organic and in conventional farming

I. Boisdon and M. Benoit

**Abstract** – The compared energy analysis of various farming systems makes it possible to carry out an approach of their sustainability through their faculty to produce energy in the form of livestock or vegetable products, while limiting the resort to non renewable energies. This study was carried out from the results of 38 farms in meat sheep and dairy cow production including 13 in organic farming. It focuses on livestock production, being acquired that the presence of cash crops raises considerably the energy efficiency. The main energy expenditure are the bought food, fertilisers and mechanization. The average energy efficiency of the dairy cow farms is 0.59 and there is no difference between organic and conventional farming. In sheep production, the average is lower (0.41) but the organic farms have a higher level (0.47) thanks to a better food self sufficiency and no use of chemical fertilisers.<sup>1</sup>

## INTRODUCTION

The assessment criteria of the farming systems have largely evolved over the last decades. The technical and economic indicators are now completed with agro-ecological criteria for the valuation of the environmental impact (Bockstaller et al., 1997). In the present context of climate changes and exhaustion of fossil energy resources, the energy analysis is one of the methods which can contribute to an approach of the sustainability of farming systems (Pervanchon et al., 2002). This approach was born with the energy crisis context during the 70's (Pimentel et al., 1973). The aim of this study is to focus on the key items of the energy balance for meat sheep and dairy cow farms, managed in conventional (CONV) and organic (ORG) farming, some of them including cash crops.

## MATERIALS AND METHODS

This study is based on 38 farms (see table 1) located in the north central massif of France and its periphery: 24 meat sheep farms (10 of whom located in mountain area) and 14 dairy cow farms (all in mountain area). Only the CONV dairy cow farms did not cultivate cash crops.

I. Boisdon, Enita Clermont, UR DASEAB, Site de Marmilhat, BP35, 63370 Lempdes, France (boisdon@enitac.fr).

M. Benoit, INRA, Laboratoire d'Economie de l'Elevage, Theix, 63122 Saint-Genès-Champanelle, France (marc.benoit@clermont.inra.fr).

**Table 1.** Mean characteristics of the farms

|  | Meat  | Meat  | Dairy | Dairy |
|--|-------|-------|-------|-------|
|  | sheep | sheep | cow   | cow   |
|  | CONV  | ORG   | CONV  | ORG   |
| Number of farms                                      | 18    | 6     | 7     | 7     |
| Useable Farm area (ha)                               | 126   | 76    | 66    | 56    |
| Number of ewes or cows                               | 571   | 299   | 39    | 27    |
| Fodder area/UFarea (%)                               | 87    | 82    | 95    | 88    |
| Stocking rate (LU ha <sup>-1</sup> )                 | 1.02  | 0.82  | 1.16  | 0.85  |
| Milk yield (L cow <sup>-1</sup> year <sup>-1</sup> ) |       |       | 5 800 | 5 000 |
| Numerical productivity (%)                           | 132   | 119   |       |       |
| Work productivity                                    | 78    | 46    | 38    | 24    |

The ORG farms use less area than the CONV ones, in meat sheep (76 ha vs 126) as in dairy cow production (56 ha vs 66). The work productivity<sup>2</sup> is also lower in ORG for both systems. The stocking rates are lower in ORG (from -20 to -27%) and the animal productivity is also weaker.

We used the PLANETE<sup>3</sup> method (Risoud and Chopinet, 1999) to calculate the energy balance. The energy inputs are the non renewable energies used for the farm inputs build up and transport, and for the buildings and machinery. The outcome is the gross energy of the products (animals and plants). We also calculate the energy efficiency [EE=  $\Sigma$  products gross energy /  $\Sigma$  non renewable energies used]. Since the part of cash crops in the farm area has a great influence on the gross energy produced per ha (Risoud, 1999), we decided to separate the animal unit from the crops unit on the farms.

## RESULTS AND DISCUSSION

On meat sheep farms the **energy consumption** per hectare is less than 45% in ORG than in CONV and on dairy cow farms the difference reaches 41% (table 2). This has to be linked with the lower stocking rates in ORG. Furthermore, the inputs like fertilisation and livestock feeds are also lower in ORG. Great differences can also be highlighted between meat sheep and dairy cow farms, especially for the mechanization (machinery + fuel) which is greater on dairy cow farms due to silage process and milking. The electricity consumption is also specific to the dairy cow farms, for milking.

<sup>2</sup> work productivity=(LU+ha crops/2)/labour unit

<sup>3</sup> PLANETE: working party composed among others of Enesad, Solagro and Ceipal.

**Table 2.** Main items and energy balance in FLE<sup>4</sup>/ha

|                          | Meat  |       | Dairy |      |
|--------------------------|-------|-------|-------|------|
|                          | sheep | sheep | cow   | cow  |
|                          | CONV  | ORG   | CONV  | ORG  |
| Total energy consumption | 307   | 169   | 702   | 414  |
| Bought fertilisation     | 70    | 8     | 119   | 5    |
| Bought livestock feeds   | 93    | 45    | 211   | 48   |
| Crop energy production   | 1474  | 512   | -     | 1465 |
| Animal energy production | 116   | 77    | 401   | 242  |
| Energy balance           | -65   | -62   | -301  | -104 |
| Global energy efficiency | 0.81  | 0.67  | 0.58  | 0.88 |
| EE Animal units (EE/A)   | 0.40  | 0.47  | 0.58  | 0.59 |
| EE Cash crops (EE/C)     | 4.0   | 4.6   | -     | 5.3  |

On these farms, the **energy production** of cash crops reaches 1470 fuel litre equivalents (FLE), with no difference between CONV and ORG. For the animal units, the difference between CONV and ORG is linked with the stocking rate and the level of animal productivity. With the same stocking rate, the dairy cow farms have a greater energy production level than the meat sheep farms: 3.5 times in CONV and 3 times in ORG (table 2).

The **energy efficiency** are below 1.0 on all the farms. On meat sheep farms, the cash crops and the lower intensification level lead to a lower energy deficit than on dairy cow farms (-65 in CONV and -62 in ORG vs -301 and -104) (table 2). The energy efficiency of the animal units (EE/A) is lower on meat sheep than on dairy cow farms by 30%. The meat sheep ORG farms obtain a better EE/A than the CONV with a lesser use of fertilisers and bought livestock feed.

The energy efficiency of the cash crops (EE/C) is around 10 times better than the EE/A, for meat sheep as for dairy cow farms. This factor corresponds to the energetic losses through animal feeding.

We did not observe a difference between EE/A on ORG and CONV dairy cow farms. This is certainly due to the situation of all the farms in mountain area which induces a similar functioning for the ORG and CONV systems.

The energy efficiency we obtained are at the same level as reported by Ferrière et al. (1997) (0.62) and Risoud and Chopinet (1999) (0.60) but they are lower than Risoud (2002) described for 86 dairy cow farms: 1.01 in dairy ORG and 0.86 in CONV. These farms were situated in various conditions in France, with certainly better food self-sufficiency.

In CONV, Chayrigues (2002) announces energy efficiencies from 0.53 to 1.08 in dairy cow systems and 0.27 to 0.44 in dairy sheep.

The relation between **economic performances and energy efficiency** of the farms can be analysed with the ratio: [Farm product without subsidies (€) / Energy incomes (FLE)] (Risoud, 1999). This ratio varies from 1.5 to 5.0 €/FLE and is increasing with the food self-sufficiency. The ORG systems have a better ratio thanks to a higher price of the products.

The **food self-sufficiency** (SS) of the animal units has a great influence on the potential EE/A. For a SS at 60%, the maximum EE/A observed is at 0.40; for 95% it can reach 0.80. The bought concentrates inputs have an important weight on the EE/A. On meat sheep farms, we observed that autumn lambing farms in mountain areas have a lower EE/A (0.35) than in grass systems with spring lambing (0.60). This is linked with the amounts of concentrates bought for fattening lambs.

#### CONCLUSIONS

Even if the dairy cow systems seem to have a better energy efficiency than the meat sheep systems, this EE is rarely better than 1.0. They are both far from the levels reached by plant productions, and can be considered as a "luxury" (Risoud, 1999). However we should not forget their part in the maintenance of rural areas in many French regions.

Moreover, the cash crop farms have increased their energy efficiency with the technical progress (Bonny, 1986). The animal productions have at the same time increased their food dependence. To progress in terms of energy efficiency, these systems will have to work on their self sufficiency for animal feeding. Another way could be to organize exchanges between breeders and crop farmers in mixed areas.

The organic farms can obtain a better energy efficiency, thanks to the absence of chemical fertilisers and a better food sufficiency and in spite of a sometimes greater energy consumption for the machinery.

#### ACKNOWLEDGEMENT

This study was carried out with the methodology of the PLANETE group, with the financial support of ADEME Auvergne and the collaboration of the Réseaux d'élevage Auvergne-Lozère for the dairy farms.

#### REFERENCES

- Bockstaller, C., Girardin, P., Van der Werf, H.M.G. (1997). *European Journal of Agronomy* **7**:261-270.
- Bonny, S. (1986). "L'énergie et sa crise de 1974 à 1984 dans l'agriculture française", Etudes et Recherches, vol 4, tome 1. (INRA-ESR:Grignon, France)
- Ferrière, J.M., Fauveau, C., Chabanet, G., Stoll, J., Hoffmann, M., Risoud, B., Farruggia, A., Fortin, G. (1997). *Fourrages* **151**:331-350.
- Pervanchon, F., Bockstaller, C., Girardin, P. (2002). *Agricultural Systems* **72**:149-172.
- Pimentel, D., Hurt, L.E., Bellotti, A.C., Forster, M.J., Oka, I.N., Sholes, O.D., Whitman, R.J. (1973). *Science* **182**:443-449.
- Risoud, B. (1999). *Economie Rurale* **252**:16-26.
- Risoud, B., Chopinet, B. (1999). *Ingénieries EAT* **20**:17-25.
- Risoud, B. (2002). Rapport d'étude pour l'ADEME.

<sup>4</sup> 1 FLE (Fuel Litre Equivalent) = 35.8 MJ