Life cycle assessment of energy use on Irish dairy farms

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Introduction

Energy consumption in milk production is important because it impacts directly on profitability and environmental footprint. In order to reduce energy consumption we must first understand how, and where it is consumed. The aim of this study was to measure baseline data on the total energy inputs of Irish dairy farms.

Materials and Methods

To calculate these energy inputs data on farm production, direct farm energy inputs (i.e., fuel and electricity) and indirect inputs (i.e. fertilizers, purchased feed and chemicals) were collected from 22 commercial dairy farms for 12 months (2011). The energy use of each input was calculated using energy coefficients. The energy coefficients for chemical fertilizers, herbicides, and ingredients of purchased concentrates were based on the international Life Cycle Assessment (LCA) database Ecoinvent (2010), and used to convert all inputs to the common unit of energy, the mega-joule (MJ). Mean herd size was 118 cows (range 47-290) and mean stocking rate was 2.27 LU/ha (range 1.68-3.45). The farms in this study represent the larger than average modern dairy farm, with a higher stocking density per ha. However, milk output and hence herd size will increase in future if farmers respond to the potential for expansion in milk production identified in the *Food Harvest 2020* report. Results of this study and hence the conclusions drawn are relevant for larger and more intensive dairy farms.

Life cycle assessment and data collection

In order to identify hot spots of energy use it was necessary to perform a LCA of energy use according to ISO (2006). Results were quantified in MJ per kg of milk solids (MS). Over the calendar year of 2011 all data necessary to compile the life cycle assessment were recorded using a combination of manual recording and wireless data transfer. Each farmer completed monthly questionnaires. Data collected included; quantity and type of fertilizer used, quantity of diesel consumed, area of land worked by contractors, concentrate feed used, forage/manure/slurry imported or exported from the farm, quantity and type of farm chemicals used and a stock take of all animals. In addition to these data, milk production data were obtained from the milk processors. Electricity consumption was recorded using a wireless monitoring system. Domestic use was excluded from the measurements. The system boundary of the LCA was defined as being from cradle-to-farm-gate, which implies that energy use is quantified for all processes involved up to the moment that milk leaves the farm gate, including production and transport of concentrates, roughage, seeds, herbicides and chemical fertilizer. Such a cradle-to-farm gate LCA, therefore, resembles quantification of the direct (i.e. energy use on-farm) and indirect energy use (i.e. energy needed to produce farm inputs) of milk production (De Boer 2003). Besides milk, the production system also yields meat from culled cows and calves. In such a multiple-output situation, the energy use of the system has to be allocated to these various outputs. Economic allocation was used, implying that the energy use was allocated to the various outputs based on their relative economic value (i.e. 88.3 % to milk).

Results

Total energy use averaged 31.73 MJ/kg MS, ranging from 15.28 to 49.00 with a SD of 7.72 MJ/kg MS, (Table 1). About 57% of this energy use was accounted for by the application of chemical fertilizers. Other energy consuming processes included production and transport of purchased concentrate feed (21%), electricity (12%) and liquid fuels such as diesel, petrol and kerosene (8%). Other items such as seeds and herbicides represented 2% of total energy use.

Table 1. Total energy consumption values (mean with SD in parentheses, min and max) per energy input category, expressed in MJ/kg of milk solids (MS).

	Energy Consumption (MJ/kg MS)		
Category	Min	Mean (SD)	Max
Fertilizer	10.54	17.96 (6.25)	30.71
Concentrates	2.17	6.55 (2.57)	11.87
Electricity	2.25	3.91 (1.06)	6.75
Fuel	0.04	2.54 (1.32)	6.18
Other	0.00	0.77 (1.11)	5.08
Total	15.28	31.73 (7.72)	49.00

Conclusion

On average, a total of 31.73 MJ was required to produce one kg of milk solids, of which 20% was direct and 80% was indirect energy use. Electricity accounted for 60% of the direct energy use and appeared centred around milk harvesting operations.

References

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