

An assessment of the energy footprint of dairy farms in Missouri and Emilia-Romagna

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ABSTRACT

The strong dependence of the livestock sector on fossil fuel could be challenged in a matter of decades or sooner, either by rising fossil fuels prices or by the commitments foreseen under carbon emission reduction protocols. In this context, it is relevant to assess the energy footprint of animal products and to identify potential strategies for the transition towards a greater reliance on renewable energy.

The present research was based on a comparative analysis of milk production systems in Missouri, USA and in Emilia-Romagna (EU NUT 2), Italy. A total of fifteen dairy farms, either grain based, forage based or organic, were investigated, using data on direct (fuel and electricity) and indirect (structures, machinery, feed, fertilizers, pesticides, seeds) energy inputs. All inputs were reported in the functional unit of 1 kg of Energy Corrected Milk (ECM). The impacts of feeding practices, fertilizer use intensity and organic methods on energy consumption levels were evaluated and discussed.

Emilian farms showed a lower energy input than Missouri farms, mainly due to their greater reliance on alfalfa as feed, and less use of fertilizers and fuel. Forage based farming was more energy efficient in Missouri, while organic farming was more efficient in Italy.

This research suggests that policy interventions could lead to lower energy input dairy systems by promoting reduced use of fertilizers, and by minimizing waste along the milk supply chain, and thereby encouraging a more sustainable industry.

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1. Introduction

Since the diffusion of the lactase persistence genetic mutation in Europe (Leonardi et al. 2012), cow milk and related products have become an important element of the daily diet, both in the old world and in the so called “new Europes” (Cosby, 2004). World production in 2013 was 770 Mt, or 90 kg per capita per year, supplying about 10% of protein and 6% of energy daily intake. Consumption levels are higher in North America (253 kg) and in Europe (240 kg), where milk and its derivatives constitute 20% of protein and 10% of energy intake (FAOSTAT, 2015).

Due to the importance of dairy products in the human diets of a large part of the world, the dependence of this sector on non-renewable fossil energy and the influence of various farming practices on the energy footprint of the dairy sector are crucial issues for the transition of food systems towards less carbon intensive practices.

Several studies assessed the energy inputs of dairy farming in New Zealand (Wells, 2001, Hartman and Sims, 2006) and Northern Europe:

Finland (Grönroos et al. 2006, Mikkola and Akolas, 2009), Estonia (Frorip et al. 2012), Denmark (Refsgaard et al. 1998), Sweden (Cederberg and Mattson, 2000), Norway (Eide, 2002), Germany (Haas et al., 2001, Kraatz, 2012), Ireland (O'Brien et al. 2012, Upton et al. 2013), Belgium (Meul et al. 2007) and the Netherlands (Thomassen et al. 2008). European studies have mainly focused on grain based systems, both conventional and organic, with substantially no consideration to forage based farming. Little attention has been paid to Southern Europe (Castanheira et al. 2010), while for North America, Pimentel and Pimentel (2008) has addressed the milk sector only marginally.

This research is aimed at analyzing, from a comparative perspective, the energy inputs necessary for the production of cow milk in one region of Southern Europe (Emilia-Romagna, Italy) and in one state of North America (Missouri, USA). These two geographical contexts share key common features, such as population size (respectively 4.4 and 6 million inhabitants) and GDP per capita, around \$42,000 to \$45,000 per year in the 2011–2013 period (Eurostat, 2013). The average herd sizes are comparable, while the Italian region is characterized by higher number of farms and cows and by greater milk productivity (+30%), (see Table 1).

Production is almost stable in the Italian region, while the dairy sector in Missouri has continuously declined over the last 40 years from over 300,000 milking cows in 1975 to less than 100,000 in 2013 (MU,

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Table 1
Indicators for milk production in Missouri and Emilia-Romagna.

Indicator	Missouri	Emilia-Romagna
Number of farms	1248 ^a	4266 ^c
Number of cows	92952 ^b	303023 ^d
Average herd number	74	71
Milk production (kt)	605 ^a	2576 ^d
Milk per cow (kg)	6514	8502

Source:

^a Horner et al. 2015.

^b USDA, 2012a, b, c and d.

^c Benini and Pezzi, 2011.

^d CLAL, 2013.

2000, USDA, 2014) mainly due to the competition from other States, like California and Wisconsin, where farming is more intensive and milk production has increased by a factor of 4 and 1.5 respectively in the same period (USDA, 2012c). However, pasture based dairying is becoming more popular in Missouri and could reverse this declining trend in the near future (Ikerd, 2009). Final consumption presents a different picture: milk from farms in Emilia-Romagna is utilized mainly for the production of Parmigiano Reggiano, whose tradition dates back at least to the Middle Ages (Boccaccio, 1351), while in Missouri most milk is directly consumed and only a fraction is used to produce cheese. For this reason, the present study is limited to energy use up to the farm gate, in order to compare similar products.

2. Materials and methods

This study was based on data from fifteen dairy farms, seven located in Missouri and eight in Emilia. This small sample size was necessary because of the very intensive nature of data collection process. This approach is comparable to most studies of this nature. The greater detail required for this type of analysis makes a smaller sample necessary. The farms were chosen using a snowball sampling approach; discussions with experts and suggestions from the same farmers allowed us to identify a suitable sample of farms.

Three farming systems were studied:

- grain based* (G), when cereals, soy and other by-products constitute more than 40% of the mass of the total daily ration;
- forage based* (F), when pastures or hay represent more than 60% of the diet;
- organic* (O), when all feed and fertilizers follow the regulatory requirement for organic certification. In principle, organic may be grain or forage based, but all organic holdings surveyed for this study were predominantly pasture and hay based.

Forage based farms use different feeding practices in the two regions. In Missouri, animals are kept on pasture all year, directly pasturing, while in Emilia-Romagna cattle are confined to barns, and alfalfa and grass are mechanically cut and dried to provide the feed.

All farms are indicated by a code to ensure the confidentiality of respondents: grain based farms (G1, G2, G3, G4 and G5), forage based farms (F1, F2, F3 and F4) and organic forage based farms (O1, O2, O3, O4 and O5). Farm characteristics are shown in Table 2, while their approximate locations are indicated in Fig. 1.

2.1. System boundaries and functional units

Given the goal of this study, a cradle to farm gate perspective was adopted. As shown schematically in Fig. 2, the system boundary included all direct energy inputs occurring at the farm level (fuels and electricity) and all indirect energy inputs immediately related to:

Table 2
Farms surveyed in the case study according to the use of chemicals and type of feed.

Farm	Herd size (N)	Farm area (ha)	Lactations (N)	Milk per cow (kg yr ⁻¹)	
				Raw	ECM
Missouri	G1	187	–	11408	12083
	G2	30	8,2	6622	9303
	F1	95	83	5835	6691
	F2	547	160	3976	4599
	O1	49	49	4139	4580
	O2	45	45	6804	7783
	O3	67	67	3049	3622
	G3	850	820	10706	11334
	G4	587	400	9478	10473
	G5	1250	1225	10694	10950
Emilia Romagna	F3	36	25	7188	7682.7
	F4	45	19	6154	6944
	O4	42	26	6129	6456
	O5	48	36	7368	7588
	O6	180	140	9125	9359

Source: authors' elaboration. Farm G1 has no owned land since it purchases all feed.

- building construction (barns, feed storage facilities, warehouses and parlors);
- machinery manufacturing (tractors and implements);
- forage and grain grown on the farm for milking cows and heifers;
- forage and crops purchased on the market.

The methods employed to compute indirect inputs are detailed in the following paragraphs. All information on direct energy inputs, structures, machinery, materials and feed were collected during field visits

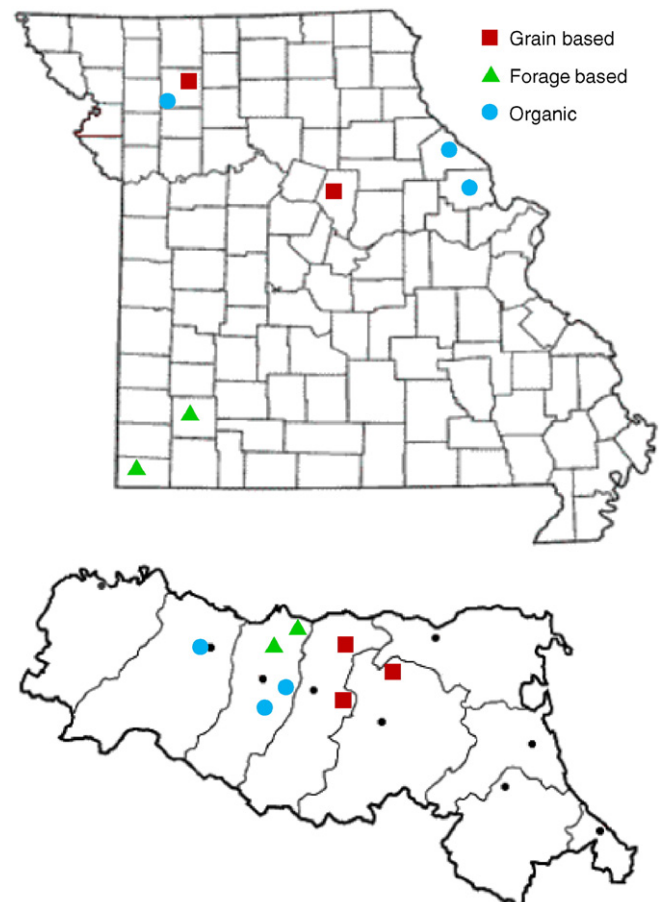


Fig. 1. Location of surveyed farms within the State of Missouri (above) and the Emilia-Romagna region (below). The two maps are not drawn on the same scale.

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