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Energy demand on dairy farms in Ireland

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ABSTRACT

Reducing electricity consumption in Irish milk production is a topical issue for 2 reasons. First, the introduction of a dynamic electricity pricing system, with peak and off-peak prices, will be a reality for 80% of electricity consumers by 2020. The proposed pricing schedule intends to discourage energy consumption during peak periods (i.e., when electricity demand on the national grid is high) and to incentivize energy consumption during off-peak periods. If farmers, for example, carry out their evening milking during the peak period, energy costs may increase, which would affect farm profitability. Second, electricity consumption is identified in contributing to about 25% of energy use along the life cycle of pasture-based milk. The objectives of this study, therefore, were to document electricity use per kilogram of milk sold and to identify strategies that reduce its overall use while maximizing its use in off-peak periods (currently from 0000 to 0900 h). We assessed, therefore, average daily and seasonal trends in electricity consumption on 22 Irish dairy farms, through detailed auditing of electricity-consuming processes. To determine the potential of identified strategies to save energy, we also assessed total energy use of Irish milk, which is the sum of the direct (i.e., energy use on farm) and indirect energy use (i.e., energy needed to produce farm inputs). On average, a total of 31.73 MJ was required to produce 1 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 mainly resulted from milk cooling (31%), water heating (23%), and milking (20%). Analysis of trends in electricity consumption revealed that 62% of daily electricity was used at peak periods. Electricity use on Irish dairy farms, therefore, is substantial and centered around milk harvesting. To improve the competitiveness of milk production in a dynamic electricity pricing environment, therefore, management changes and technologies are required that decouple energy use during milking processes from peak periods.
Key words: energy use, milk production, smart metering

INTRODUCTION

The removal of the milk quota system in the European Union in 2015 is likely to increase milk production per farm and to decrease milk price (Lips and Rieder, 2005; Bouamra-Mechemache et al., 2008). In Ireland, for example, milk production has the potential to increase by 50% by 2020 (DAFM, 2010) if farmers respond to national policy frameworks and are encouraged by the abolition of European Union milk quotas in 2015, whereas milk price is expected to decrease by 33% (Lips and Rieder, 2005). Milk production systems in Ireland, therefore, will continue to focus on cost control and maximizing the amount of milk that is produced from grazed grass. The potential of Irish soils to grow grass throughout the year and success in utilizing grass are key factors affecting output and profitability of dairy production systems (Shalloo et al., 2004).

Efficient use of energy is one way to improve the cost competitiveness of the Irish dairy sector. At this moment, electricity costs on Irish farms are around 1.5% of the cost price of milk sold (Upton et al., 2011), but they are expected to increase because of introduction of dynamic electricity pricing. Besides a potential cost reduction, reducing electricity consumption has an environmental benefit, because electricity consumption has been shown to represent 25% of total energy use on pasture-based dairy farms in New Zealand (Wells, 2001). Hence, understanding electricity consumption trends will have the potential to reduce overall energy use and reduce production costs.

The new Irish electricity grid infrastructure is proposed by the Commission for Energy Regulation (CER) and implies a pricing system based on the electricity demand on the national grid, resulting in higher electricity rates during peak periods of consumption and lower rates during off-peak periods. The peak period is typically from 1700 to 1900 h. If dairy farmers carry

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out their evening milking during these peak periods they will be exposed to increases in energy costs. This dynamic pricing structure could, however, also present opportunities to reduce overall energy costs if equipment is managed intelligently to optimize energy use in off-peak periods (currently from 0000 to 0900 h). By 2020, about 80% of all electricity consumers are expected to be connected to the smart grid (CER, 2011). The electricity demand on the national grid not only varies during the day (i.e., peak in the evening), but also across seasons (i.e., peak in the winter; EirGrid, 2012). To use energy cost-effectively, therefore, dairy farmers need insight into the variation in electricity consumption during the day and across the year. To our knowledge, no research has been published that studied on-farm daily and seasonal electricity consumption profiles while providing detailed equipment electricity consumption information. This information, however, is required to identify strategies that reduce energy costs and that use electricity efficiently (i.e., aimed at a reduction in electricity use per kilogram of milk sold while maximizing its use in off-peak periods).

The main objective of this study, therefore, was to document electricity use per kilogram of milk sold from the farm and to identify strategies that can reduce its overall use while maximizing its use in off-peak periods. We assessed average daily and seasonal trends in electricity consumption on 22 Irish dairy farms, through detailed auditing of electricity-consuming processes. To determine the potential of identified strategies to save energy, our second objective was to assess total energy use along the production chain of Irish milk. We therefore performed a life cycle energy assessment of total energy use on 22 Irish dairy farms.

MATERIALS AND METHODS

Data Collection

We selected 22 commercial dairy farms from a database of advisory clients within Teagasc (Ireland), which are referred to as study farms. Selection criteria included availability of financial information, data on herd size, and the ability and willingness of the farmer to collect and maintain accurate data. All data were collected for 2011. All inputs and outputs necessary to compile the life cycle energy assessment were recorded using a combination of manual recording and wireless data transfer. General farm data were collected using a survey, including farm area worked and detailed information on farm infrastructure (e.g., type and size of milking equipment, milk-cooling equipment, manure-handling equipment, machinery, and winter housing facilities).

Monthly questionnaires were completed by each farmer. Data collected were quantity and type of fertilizer used, quantity of diesel or fuel oil consumed, area of land worked by contractors, amount and type of concentrate feed purchased, forage/manure/slurry imported or exported from the farm, quantity and type of farm chemicals used, and a stock take of all animals on the farm. To assess actual consumption of, for example, fertilizer or feed, opening and closing balances were obtained at the beginning and end of the monitoring period. In addition to these data, milk production and composition information was gathered from the milk processors.

Electricity consumption was recorded using a wireless monitoring system supplied by Carlo Gavazzi (Carlo Gavazzi Automation SpA, Lainate, Italy). Energy analyzers of type EM24 DIN together with Digi Connect wireless WAN cellular routers were used to measure and transport the electricity consumption data. Powersoft logging and recording software (Carlo Gavazzi Automation SpA) was used to record cumulative energy use (kWh) every 15 min for each electricity-consuming process behind the farm gate. Domestic electricity use was measured separately and subtracted for the dairy farm measurements.

Data Processing

Raw data from electricity monitoring were exported to spreadsheets and subsequently used to compute trends in electricity consumption of individual farms. To determine electricity costs of individual farms, we combined data on electricity use with day and night tariffs (day tariff was 0.18 €/kWh; night tariff was 0.08 €/kWh from 0000 to 0900 h). Furthermore, data obtained from questionnaires, dairy processors, and the wireless electricity monitoring system were used to perform a life cycle energy assessment.

Life Cycle Energy Assessment

We performed a single-issue life cycle assessment (**LCA**) by quantifying the total energy use according to the International Organization for Standardization (ISO, 2006). The 4 stages of an LCA are goal and scope, inventory analysis, impact assessment, and interpretation of results (ISO, 2006).

Goal and Scope Definition. The LCA related, in this case, energy use to a functional unit, which is the main function of a production system expressed in quantitative terms. The main function of our system was production of milk. To allow a comparison of our results with those presented in the literature (Wells, 2001; Cederberg and Flysjö, 2004; Hartman and Sims,