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Energy efficient dairying

Key external stakeholders:

Dairy farmers, Dairy advisors and planners, Milking system manufacturers, Academic staff working in the area of milking technology.

Practical implications for stakeholders:

The outcome of this project includes baseline energy consumption data for commercial Irish dairy farms and a list of recommendations for improving energy efficiency

- Methodologies for auditing of energy use have been developed
- Enhanced knowledge of energy consumption trends on Irish dairy farms
- Hotspots of energy consumption have been identified
- Opportunities to reduce costs associated with energy consumption have been identified

Main results:

- Electricity represents 12% of total energy use of Irish dairy farms
- Average electricity consumption on 22 dairy farms was 3.9 mega Joules per kg of milk solids (MJ/kg MS), range 2.25 – 6.75MJ/kg MS
- The major processes of electricity consumption were: milk cooling (31%), water heating (23%), milking machine (20%), pumping water (5%), lighting (3%), other miscellaneous consumption such as winter housing systems, air compressors and backing gates consumed 18% of the electrical energy.

Opportunity / Benefit:

The results of this project describe the energy consumption trends and energy costs associated with producing milk in Ireland. Adoption of the main results of this project at farm level would result in optimised energy use strategies for integration of energy efficient technologies, minimising energy costs and maximising return on investment.

Collaborating Institutions:

Cork Institute of Technology (CIT)
Wageningen University (WU)

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1. Project background:

In Ireland, milk production has the potential to increase by 50% by 2020 if farmers respond to national policy frameworks and are encouraged by the abolition of EU milk quotas in 2015. Milk production systems in Ireland, therefore, will continue to focus on cost control and maximising the amount of milk that is produced from grazed grass. 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 4% of milk production variable costs, but they are expected to increase because of rising global energy prices. 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. Hence, understanding electricity consumption trends will have the potential to reduce overall energy use and reduce production costs while improving sustainability.

2. Questions addressed by the project:

- What proportion of total energy use does electricity represent on Irish dairy farms?
- What is the energy consumption and energy cost associated with producing milk on Irish farms?
- What are the options for reducing energy consumption and energy costs on Irish dairy farms?

3. The experimental studies:

We selected 22 commercial dairy farms from a database of advisory clients within Teagasc. 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 a life cycle energy assessment were recorded using a combination of manual recording and wireless data transfer.
First, general farm data was 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).
Second, monthly questionnaires were completed by each farmer. Data collected was: quantity and type of fertiliser 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. In order to assess actual consumption of, for example, fertiliser or feed, opening and closing balances were obtained at the beginning and end of the monitoring period. In addition to this data, milk production and composition information was gathered from the milk processors.
Third, electricity consumption was recorded using a wireless monitoring system supplied by Carlo Gavazzi. Powersoft logging and recording software was used to record cumulative energy use in kiloWatt hours (kWh) every 15 minutes for each electricity consuming process behind the farm gate. Domestic electricity use was measured separately and subtracted for the dairy farm measurements.

This comprehensive data collection process provided a database of dairy farm electricity consumption trends which was subsequently analysed to provide answers to the questions posed above.

4. Main results:

The farms in this study operated grass-based milk production systems with spring calving herds and represented 0.14% of the specialised dairy farm population and supplied 0.24% of national milk in 2011.

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Energy Analysis. Total energy use averaged 31.73 MJ/kg MS, ranging from 15.28 to 49.00 MJ/ kg MS. About 57% of this energy use was accounted for by the production and transport of chemical fertilisers applied (range 40-80%). Other significant energy consuming processes included production and transport of purchased concentrate feed 21% (range 8-36%), electricity 12% (range 8-21%), and liquid fuels such as diesel, petrol and kerosene 8% (range 1-15%). Other items such as seeds and herbicides represented a small portion of total energy use 2% (range 0-15%).

Electrical Energy Inputs. Altogether 42.34 Wh (Watt-hours) of electricity was used per litre of milk produced (range 23.03-76.29 Wh/L). In total, 62% of all electrical energy used by the farms in this study was on the higher cost day tariff. The average cost of electricity on the study farms in 2011 was 0.51 Euro Cent per litre of milk produced (€ c/L) (range 0.26-0.87 € c/L). The major processes of electricity consumption were: milk cooling (31%), water heating (23%), milking machine (20%), pumping water (5%), lighting (3%), other miscellaneous consumption such as winter housing systems, air compressors and backing gates consumed 18% of the electrical energy. All farms were unirrigated. Electricity used in the dairy milking shed accounted for almost 80% of the total electrical energy used.

Daily Electricity Consumption Trends. The profile of electrical energy consumption trends from day to day followed a sinusoidal pattern; large peaks in consumption were a result of the morning and evening milkings. Figure 1 shows the average electrical demand of the study farms on the 14th of June 2011. Consumption peaks were present from 7:00 to 12:00 and again from 16:30 to 19:30, these peaks can be attributed to the twice a day milking routine practiced by the farmers.

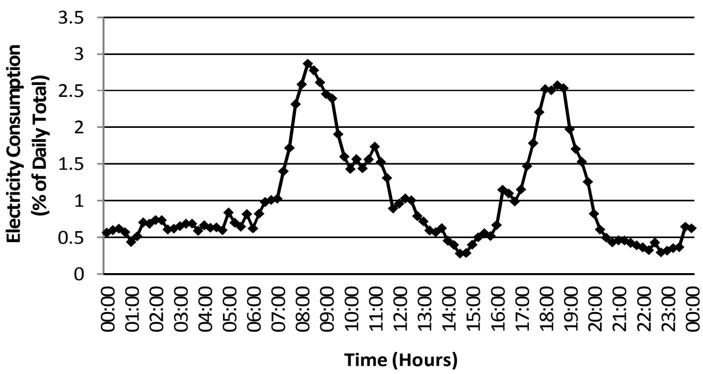

Figure 1. Average percentage of daily electricity consumption for 22 commercial farms in Ireland on the 14th June 2011, data points at 15 minute intervals

Seasonal Electricity Consumption Trends. The seasonal effect of electricity consumption follows the milk production curve due to the fact that over 80% of consumption is by equipment associated with milk harvesting. Consequently, 20% of electrical energy consumption is independent of the amount of milk produced. Electricity consumption by milk cooling equipment, water heating plant and the milking machine pumps are linked to milk production and they follow the milk production curve. Consumption of other items is decoupled from milk production and rises from November to February.

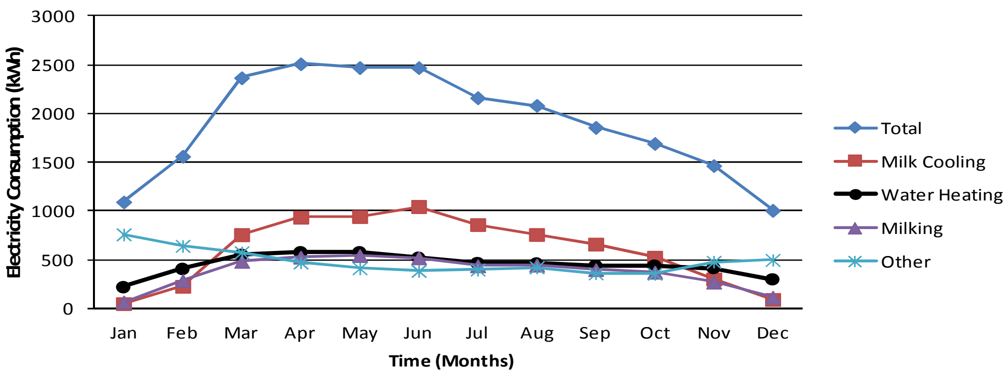

Figure 2. Monthly electrical energy consumption (kWh) for 22 farms over 12 months for all major energy consuming processes

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5. Opportunity/Benefit:

A two-pronged approach to minimise energy costs at farm level will be required.
Firstly, increasing the proportion of off-peak energy use by large energy users such as milk cooling and water heating systems, by shifting them to off-peak periods will be required. Milk cooling has the largest electrical energy consumption (31% of total electricity consumption) on Irish dairy farms. Over 60% of milk cooling electricity consumption currently occurs on the more expensive day rate tariff (from 9am to 12 midnight). Managing the cooling of milk to ensure a high portion of off-peak electricity is utilised to cool the morning milking (in the case of direct expansion milk cooling systems) or using a milk cooling system that decouples the cooling load from these peak electricity times would be useful in mitigating the impact of rising day rate electricity prices. This practice together with optimised use of a plate cooler with ground water to milk ratio of 2:1 would reduce energy use and energy costs associated with milk cooling.
Secondly, efficiency gains and lower energy costs can be realised through application of energy efficient technology. For example, there is scope to reduce the electricity consumed by vacuum pumps, through the application of variable speed drive (VSD) technology, by 60%. Similarly, the use of solar thermal water heating systems can reduce the electricity use of the water heating system by 45%. With all these energy efficiency measures an upfront capital investment is required and the return on investment for the farmer should be computed on a case by case basis, as payback figures vary according to on-farm energy consumption.

6. Dissemination:

Main publications:

Murphy, M., O'Mahony, M. J., Upton, J. (2012). A load shifting controller for cold thermal energy storage systems. IEEE International Conference on Green Technologies (ICGT12). Trivandrum, India.
Upton, J., M. Murphy, and P. French. 2011. Lessons Learned from Teagasc Energy Audits. Proceedings of the Teagasc National Dairy Conference:101-106.
Murphy, M., O'Mahony, M. J., French, P., Upton, J. (2012). A dynamic model for the prediction of milk yields from dairy cattle. International Proceedings of Chemical, Biological and Environmental Engineering (selected for publication from the 3rd International Conference on Agriculture and Animal Science, Bangkok, Thailand).

Popular publications:

Upton J., Murphy M. (2010). "Meeting your Hot Water Demand." Teagasc TResearch 5(3): 26-27
Boland, A., Murphy, Paul, Upton, J., Mihailescu, E., Yang, M. and Humphreys, J. (2010). DAIRYMAN- bringing together the best in knowledge and innovation. Todays Farm 21 (4) 16-17

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