Energy use within dairy farming
Our position on energy use within dairy farming

How dairy farmers can conserve energy directly and indirectly by using leading technology and best practice on farms

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- Measuring energy consumption on dairy farms
- Where is the energy spent?
- Future energy trends on dairy farms
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Introduction – why this paper?

The demand for energy continues to grow. The world’s appetite for electricity alone will increase energy demand more than 70% by 2040, according to the International Energy Agency\(^1\). At the same time, most energy produced comes from non-renewable fuels causing pollution and other negative environmental impacts such as Global Warming. Energy conservation and the use of renewably produced energy are at the top of many nations political agendas.

There are a growing number of international and national commitments to reduce emissions of GHGs (greenhouse gases) and replace fossil fuels. The most important is perhaps the agreement made in Paris at the COP 21 in December 2015. Other examples are the UN’s Sustainable Development Goals number seven and number thirteen launched in September 2015.\(^2\) Several countries have made specific national commitments.\(^3\) These commitments reflect the importance of producing renewable energy and reducing climate-changing emissions.

Energy on dairy farms

So how can dairy farms use energy more effectively and reduce both cost and environmental footprint? Luckily there are many opportunities by either reducing the amount of energy used in production or by increasing the amount of milk produced using the same amount of electricity.

Animal agriculture uses energy directly and indirectly. The direct use comes from diesel to run machinery such as tractors or by electricity to run equipment indoors. Indirectly, diesel is also used to produce feed off-farm and to transport feed over long distances to farms. Additionally, the production of synthetic fertilizers requires a lot of electricity and sometimes natural gas for drying. The indirect energy use also includes what is required to produce all the equipment and consumables.

It has never been more important for farms to use energy effectively. The FAO (Food and Agriculture Organization of the United Nations) expects the total dairy demand to increase 58% by 2050 compared to 2010 levels.\(^4\) In the short term, the increased output will be achieved by either adding more cows to the herd or increasing the yield per herd. The developing world will likely try to add more cows while the developed world will focus more on increasing the yield per herd.\(^5\) As farms develop and become larger, more mechanized and automated, the direct use of electrical energy per farm increases. Longer term the focus is likely to shift to increased productivity worldwide.

At DeLaval, our vision is to make sustainable food production possible. The products and solutions we provide are designed to help dairy farmers around the world do more with less. These solutions can both reduce the direct and the indirect use of energy. To support the development of more productive dairy farms DeLaval is continuing to develop and offer increasingly sophisticated technological solutions that allow for individual monitoring and management of animals. The aim is to increase the Lifetime Daily Yield and thereby both the economic and environmental sustainability of the dairy farm.

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\(^1\) http://www.worldenergyoutlook.org/media/weowebsite/2015/WEO2015_Factsheets.pdf

\(^2\) https://sustainabledevelopment.un.org/topics


\(^4\) http://www.fao.org/docrep/014/i2373e/i2373e03.pdf

\(^5\) Page 121 of http://www.fao.org/3/a-i4738e.pdf
Measuring energy consumption on dairy farms

Larger, more technologically advanced farms use more electrical equipment increasing the farm’s electricity use but what is important is to improve the electricity productivity, i.e. the kWh per kg of milk produced. In other words, the general trends of rising energy costs per farm can’t be taken at face value.

There is sufficient knowledge today to bring down the global energy levels used per kg of milk produced. At DeLaval, we propose to understand energy use on dairy farms based on the amount of direct and indirect energy used to produce one kilogram of milk. This measure can be improved both by conserving energy used directly or indirectly and by increasing the yield of the animals provided the amount of energy remains or increases less than the milk production.

This means that many daily activities can be related to energy conservation. Reducing the periods between calving, preventing disease within the herd, optimising the feed for every cow, can all have a beneficial effect on both conserving energy and increasing the yield of the animals.

We see many opportunities for farmers to both cut their energy costs and improve the productivity of their herd. Already today, we see a great variation in both energy use per kg of milk produced and in an individual animal’s Lifetime Daily Yield (LDY). This point alone proves that the potential is there to reduce global energy levels on dairy farms if we make use of best practice.

The energy required per kg of milk should also be compared to other forms of food. To really understand energy use in the food industry one needs to understand what the output is in terms of nutrition versus input in terms of energy. Only then can we accurately compare how much energy is required to produce the nutrition offered by different food types. Work has already been done in this area.⁶

**Where is the energy spent?**

The use of energy varies largely between different regions and milking systems. The more advanced dairy farms use electricity for milking, cooling, ventilation and illumination.

The direct energy used on a dairy farm can mainly be related to diesel used to run machines and the electricity used to operate equipment. Some farms also use gas for drying crops or heating water. In more advanced countries there are also different solutions for recovering heat from the milk and the cooling systems. Increasingly farmers also use solar panels to heat water.

However, it is not only the total use of energy per kg of milk produced that matters, but also how the animals are managed as it can improve their productivity without increasing the direct or the indirect use of energy.

**Below is a typical list of both direct and indirect energy uses:**

<table>
<thead>
<tr>
<th><strong>Direct energy use on a dairy farm</strong></th>
<th><strong>Indirect energy use</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel for machinery</td>
<td>Bought-in feed</td>
</tr>
<tr>
<td>Vacuum pumps for milking</td>
<td>Fertilisers</td>
</tr>
<tr>
<td>Cooling of milk</td>
<td>Tractors and other machinery</td>
</tr>
<tr>
<td>Lighting</td>
<td>Milking equipment etc used in the barn</td>
</tr>
<tr>
<td>Ventilation</td>
<td>Consumables</td>
</tr>
<tr>
<td>Water and space heating</td>
<td>Animal medicine/Drugs</td>
</tr>
<tr>
<td>Crop drying</td>
<td>---</td>
</tr>
</tbody>
</table>

*Indirect energy use means the energy required to manufacture all the machinery, equipment and other products that is then used on a farm*

According to the International Farm Comparison Network, IFCN, there were about 127 million farms worldwide in 2015, producing 778 million tons of Energy Corrected Milk (ECM). The average dairy farm worldwide has 2.9 milk animals with an average milk yield of 2145 kg ECM milk per animal and year.

Of all farms, 96% are household farms with 10 animals or less, which produce 23% of all the milk using 60% of all dairy animals. The next group consists of five million family farms with 10–100 animals producing 37% of the global milk supply using 26% of the world’s dairy animals. Some 400 000 large farms with more than 100 animals produce the remaining 40% using just 15% of all animals.

The amount of energy used per litre of milk produced in the family and business farms varies across the globe depending both on the local climatic conditions, management practices and on how the animals are fed, i.e. grazing vs. feeding both concentrates and roughage.

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7 http://dairy.wisc.edu/PubPod/Reference/Library/Energy%20Corrected%20Milk
There have been a number of studies recently looking at energy consumption on dairy farms in the UK and Ireland (Cafre 2009; Upton 2009) and although total energy use is dominated by field activities, this is highly variable across dairy farms and often includes activities not specific to milk production.6

In New Zealand hot water heaters, rotary milking platforms, lighting and pumps are the main areas where electricity is used. But even in New Zealand, that figure can vary a lot depending on the type of farm. On irrigated dairy farms most of the energy bill, (73 %) is on irrigation with 10 % on pumps and 8 % on hot water.9

In the US, on the Eastern Seaboard – the figures show that ‘milk cooling’ is the highest energy cost (23 %) and ‘ventilation’ comes next (21 %) with ‘vacuum pumps’ and ‘lighting’ right behind (18 and 17 %).10 The West Coast paints a slightly different picture with ‘waste handling’, i.e. manure handling, coming in second behind ‘milk cooling’ and then ‘lighting’.11

Even when most of the variables are the same on a farm, the electricity consumption can vary greatly. A study in Italy to understand energy use and management in dairy farms found that the energy costs on two farms with 40–70 cows varied from 3kWh/100kg milk to 7.7 kWh/100kg.12

It means that it is extremely difficult to say exactly how much energy any single farm should be producing and what a suitable goal to aim for is. It’s better to look for ideal values to establish the farm’s specific consumption per area and then check if the best available technology is used according to best practice. In addition, the energy use per kg of milk can also be reduced if the productivity of the animals is kept high over their total lifetime. When building a new farm, smart energy use and opportunities for energy conservation should also be considered.
Future energy trends on dairy farms

Farms are becoming increasingly automated, cutting labour costs and increasing productivity. Many farms also invest in electricity-saving solutions.

Professional farms are becoming larger in most regions and there is a strong trend towards automation. Automation means more electrical equipment and therefore higher electricity usage per farm. It does also sometimes result in a decrease in the use of diesel as less tractor-use is required when mixer wagons are electrically operated.

An additional variable worth considering is that the level of electricity consumption is often related to the age and the number of electrically powered solutions that are used. As farm profitability and working conditions depend on other factors than low electricity consumption many farms actively take measures that increase their use of electrical equipment. For example, they replace labour with mechanisation and automation as well as improve the consistency and quality of the operations. As routines are appreciated by dairy animals this can also improve their welfare. At the same time, we also see that new versions of older equipment are more energy efficient than previous models.

Additional equipment is being devised to cut energy costs and there are new innovations on the market that can significantly cut the energy consumption on dairy farms. Certain technologies seem to be making greater ground when it comes to affecting energy consumption in both directions, ie, additional equipment is adding to the burden while new equipment is reducing the burden or adding efficiencies. In large parts of Europe pre-cooling of milk using plate heat exchangers have become ‘must-have’ items. Many farms also now change to more efficient illumination systems, where LED is now seen as the most efficient solution.
What can dairy farmers do to use energy more effectively?

There are several opportunities to reduce both direct and indirect energy use, but equally important are the opportunities to improve how the animals are managed as it can improve their productivity without increasing the use of energy.

Animal agriculture uses energy directly and indirectly. See the section above 'Where is the energy spent' to understand more in this area.

DeLaval’s recommendation to farmers is to map the energy use of different equipment. When possible, farms should use special advisors to conduct an energy audit. The table below shows what electrical equipment is typically used on farms, what power requirements different components can have and examples of typical running times. If one does a proper mapping it should list the components used, their power requirement for normal operations and normal running times.

Electrical components used on a dairy farm – listed according to maximum saving:

<table>
<thead>
<tr>
<th>Component</th>
<th>Power requirement at full load</th>
<th>Daily running time</th>
<th>Possible electricity savings according to literature</th>
<th>Maximum saving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum pump</td>
<td>2–4 kW/unit</td>
<td>Runs intermittent 3–24 h</td>
<td>20–70 %</td>
<td>70 kWh</td>
</tr>
<tr>
<td>Ventilation</td>
<td>4–25 kW</td>
<td>0–24 h 12 h</td>
<td>20 %</td>
<td>60 kWh</td>
</tr>
<tr>
<td>Milk cooling</td>
<td>4–16 kW</td>
<td>Runs intermittent</td>
<td>20–50 %</td>
<td>30 kWh (4h)</td>
</tr>
<tr>
<td>Water heating</td>
<td>2–16 kW</td>
<td>Runs intermittent</td>
<td>20–50 %</td>
<td>30 kWh (4h)</td>
</tr>
<tr>
<td>Cleaning</td>
<td>2–16 kW</td>
<td>1–2 h</td>
<td>20–50 %</td>
<td>16 kWh</td>
</tr>
<tr>
<td>Milk pump</td>
<td>&lt; 1 kW</td>
<td>3–24 h</td>
<td>20 %</td>
<td>4.8 kWh</td>
</tr>
</tbody>
</table>

Table based on DeLaval calculations related to one typical farm’s use of electrical components
This mapping will clearly be beneficial for the farmer in understanding where she/he is using most energy but also where it is easiest to make energy cuts. Without a baseline of how much and by what, it will be difficult for farmers to reach any significant energy reduction goals and difficult for them to make the right decisions when it comes to future investments.

Another recommendation is that farmers keep their equipment, including fans and illumination, clean and free of dirt. Well-functioning machinery results in more efficient machinery keeping the utility high for every kWh of energy used. Simply put, well-functioning machinery keeps costs down and avoids unnecessary repairs.

Thirdly, every farm should have a plan for preventive maintenance. This means either establishing routines, or retaining a serviceman for preventive maintenance to carry out performance reviews of critical equipment like vacuum pumps, compressors, pulsators, illumination and ventilation. Replacing liners, tubes and parts in time will keep farmers milking systems operating reliably and efficiently.
Finally, every farm should look at what machinery can be upgraded to increase efficiency on the farm both from an energy consumption perspective but also productivity perspective.

The first three recommendations can help most farms make energy cuts in a short timeframe. The final recommendation results in additional cuts in the medium term. Collectively, farms across the globe have the potential to cut energy costs wherever they are located.

**Indirect use of energy / Resource input efficiency**

When it comes to reducing the indirect use of energy the focus should be on making the best use of the feed produced on and off the farm to minimise waste and ensure maximum productivity by the herd. In addition by managing manure in a proper way it can be used as a fertilizer and thereby reduce the need for using artificial fertilizers.

**Animal welfare, cow longevity and energy efficient farms**

Increased animal welfare is a perfect example of a change that would result in improvements not only in energy and resource use but also farm profitability, as the average lifetime production is increased and improved. Making cows healthier also improves working conditions and better fulfils consumer and society expectations of animal welfare.

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Improved Lifetime Daily Yields (LDY) usually means higher profit per cow, as the cash flow of production pays off the investment made in raising the replacement animals. Ideally, a herd of healthy productive cows is maintained, and culling happens due to economic reasons, and not so-called involuntary culling. In addition we need to recognize that market issues also affect herd turnover rates.

At the same time, improved Lifetime Daily Yields means less greenhouse gas emissions and effluents will be produced per kg of milk. In other words the environmental impact of dairy production is reduced when the longevity of each cow and the efficiency of milk production are improved. Healthier cows clearly have less disease also which means improved milk production and lower environmental footprint overall.
Other general tips to reduce direct energy consumption and cost

- Keeping machines turned off when not in use. Preset switch timers are useful.
- Using machines when the price of electricity is low (this works for countries with low-peak electricity tariffs)
- Using natural light when possible and energy-efficient light bulbs otherwise.
- Installing the right pump. Larger pumps may consume up to 20% more energy than a smaller pump operation at a more efficient point on the pump curve.
- Solar energy is particularly interesting in countries with high levels of solar radiation.
- Looking at the total cost of ownership when making investments. For example, dairy farm pumps can vary a lot in price but there are considerable energy savings to be won by choosing the right pump.
- Heat recovery systems for reducing the heating costs are worth considering for any farm. These systems capture waste heat from the milk or refrigeration unit’s condenser and converting the incoming cold water into stored hot water.

“Dairy farm pumps can vary a lot in price but there are considerable energy savings to be won by choosing the right pump.”
What does DeLaval offer?

DeLaval supports hundreds of thousands of farms around the world, offering solutions that can reduce both direct and indirect energy consumption as well as the productivity of the animals in the herd.

DeLaval, as a producer of electrical equipment for dairy farms, sees that it has a role in finding more energy efficient methods to ensure that the energy cost per kg of milk is reduced.

Based on the recommendations that we make above and our sustainable farming model many of our solutions are aimed at helping farmers improve the amount of kWh’s of energy per kg of milk.
Below is a list of some of our solutions available to dairy farmers today that will help them either maximise the efficiency of their energy use or cut their energy use directly.

- **SERVICE TECHNICIANS.** Our DeLaval service engineers have the specialised tools and equipment needed to properly test, measure or adjust our products. Farming equipment can be professionally serviced by our technicians with the DeLaval preventive maintenance program. We use original parts engineered to fit any farmer's system. Replacing DeLaval original liners, tubing and parts in time maintains the milking equipment's performance. Regular replacement keeps the milking system operating reliably and efficiently.

- **LIGHTING.** When it comes illumination, DeLaval offers skylight options in barn construction to maximise the use of natural light and keep energy costs down while giving the herd enough light to ensure productivity. DeLaval also offers illumination solutions with metal halide lamps. Metal halide lamps produce a bright, white light with the best colour rendition among high-intensity lighting types.

- **COOLING.** A plate cooler can cut refrigeration energy costs by up to 60% by reducing the cooling load on the bulk tank. DeLaval offers a plate cooler BMSS designed for low to medium milk flow rates as well as the M6 solution for pre-cooling and instant cooling.

- **HEAT RECOVERY.** Compressor Heat Recovery is DeLaval’s heat recovery system that generates warm water during the milk cooling process. This solution can recover up to 60% of the heat extracted from cooling milk and convert it to hot water for use in pipeline and parlour cleaning. For every litre of milk cooled, 0.7 litres of warm water is produced. DeLaval heat recovery system generates warm water as soon as the milk cooling process begins. Water pumped through the plate heat exchanger reaches 50°C to 55°C. This temperature is then efficiently maintained in a well-insulated storage tank.

- **PUMPS.** Pumping is one of the most significant energy usage areas in the milking operation. Both the US and EU have adopted regulations for eco-design of electric motors. DeLaval has taken the decision to not only meet these new requirements, but also take an environmental lead position by using only electric motors with the highest energy efficient class, IE3, in vacuum pumps. DeLaval variable speed drive (VSD) for DeLaval vacuum pump (LVP) can cut energy costs by 70% and extend the lifetime of the pump.

- **VENTILATION.** Energy efficiency in ventilation systems is a result of both the technical efficiency of the motors driving the fans, the design of the blades but also the design and control of the complete system. DeLaval offers the entire solution to farms of all types.

- **BARN CONTROL.** To secure a high level of energy effectiveness it is essential to make sure that equipment is only used when necessary and at times when the electricity is less in demand and less costly. This can be done with our barn system controller (BSC). For example, illumination is one part of the barn environment that can be adjusted to adapt to external conditions. For the total productivity of the milk production it makes sense to secure that the barn is sufficiently illuminated for 16 hours a day and not less.
When it comes to reducing the indirect use of energy we can offer solutions such as silage inoculants that help preserve and enhance the nutritional content of roughage as well as feed additives that allows the animals to make better use of the feed they get. We also offer solutions for feeding that mix and distribute the feed. This offers more opportunities for the cow to satisfy her specific needs and thereby reduce feed waste and increase the effectiveness of the feed. See more.

Another way to reduce indirect energy consumption is to use our equipment for quickly and automatically cleaning the barn from fresh manure and to bring it to proper storage. This limits the losses of nitrogen and increases the manure’s value as a fertilizer. See more.

Animal productivity is based on healthy cows since they are the high performers. Every product we sell has animal welfare in mind in order to ensure prime cow health and high yields of the best quality. Our extensive research into calf-care and cow longevity has helped us in the design of barn systems, feeding systems and disease detection and prevention. When it comes to hoof care, we don’t just look at regular hoof baths but the bigger picture of clean and stable flooring, ventilation, mattresses and mats. Our manure management systems come into play here also. We have a full range of solutions depending on the farm type, size and location. See more.