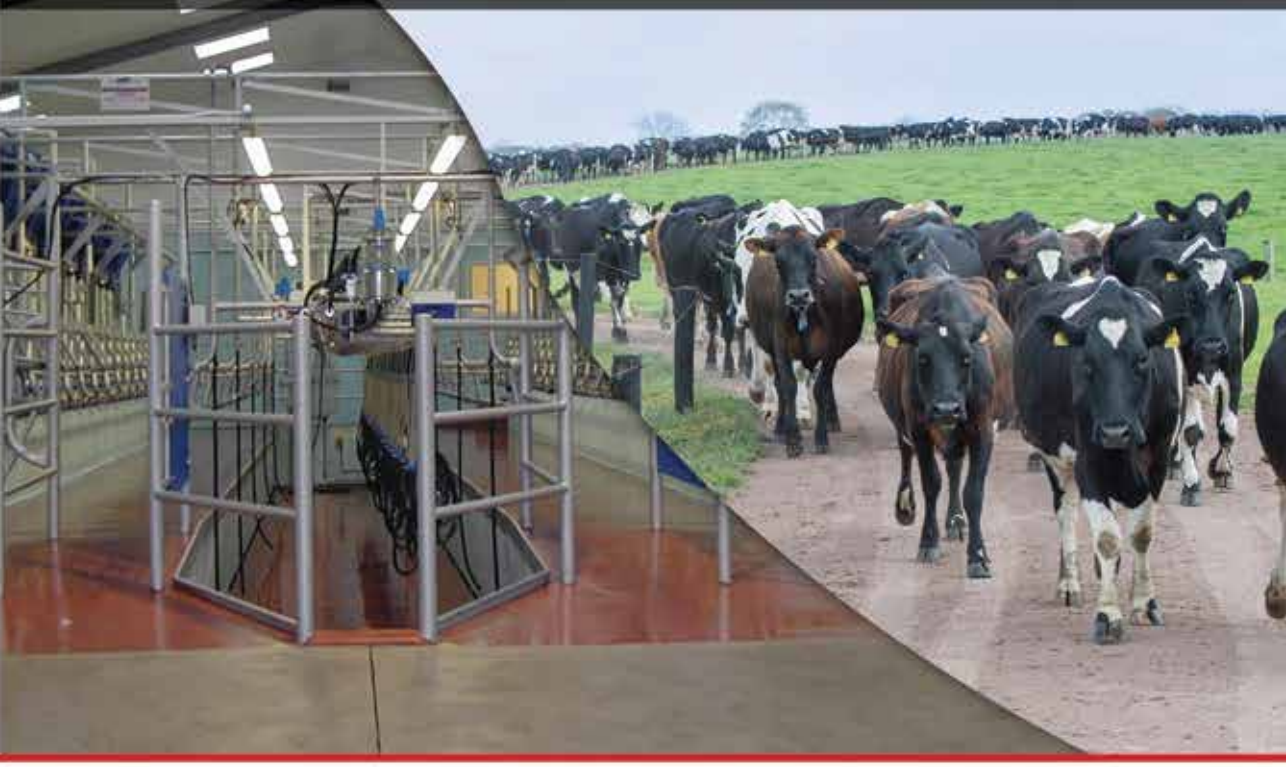
Animal & Grassland Research and Innovation Centre

Moorepark

Dairy Farm Infrastructure Workbook

Moorepark'19 Irish Dairying - Growing Sustainably

Wednesday 3rd July, 2019



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Teagasc,
Animal & Grassland Research and Innovation Centre, Moorepark,
Fermoy,
Co. Cork

www.teagasc.ie

Compiled by:
Pat Tuohy (Teagasc, Moorepark), John Upton (Teagasc, Moorepark),
Bernie O'Brien (Teagasc, Moorepark) and Francis Quigley (Teagasc, Kildalton)

Editor:
Pat Dillon (Teagasc, Moorepark)

Sponsor welcome

Ulster Bank is proud to be the key partner for the Infrastructure Workbook. It highlights the key grazing and milking technologies all dairy farmers require to best position themselves for future growth, efficiency and profitability.

At Ulster Bank, we are there to offer help and support – whatever your size, sector or location. Our Agri Managers understand farming and farmers. They have the experience and expertise needed to provide support and help in good times as well as in more challenging times. Our Agri managers are out and about connecting with farmers, meeting with them at their farm and discussing and understanding the issues facing the industry. Our Agri Managers are actively meeting farmers across the country and helping them grow while fulfilling their ambitions.

The Infrastructure Workbook aims to allow individual farmers to assess their own farm infrastructure, identify deficits and successfully plan for improvements. Many of the identified needs will need to be prioritised based on timescales, cost, stage of business development and availability of farm finance. At Ulster Bank, our Agri managers are available to discuss these development plans with you. We recognise the critical importance of good dairy farm infrastructure. The guiding principal is that its safe, produces quality milk from healthy animals using management practices that are sustainable from an animal welfare, labour efficient and economic and environmental perspective. This handbook has a key focus on grazing infrastructure and milking practices and energy. At Ulster Bank, our agri managers are available to discuss these valuable investments with dairy farmers.

Ulster Bank wants to help farmers make sustainable decisions and grow their business while simultaneously recognising the inherent challenges from weather, disease and economics. We believe all farmers need to continue to develop a broad range of skills.

Whether you are looking to grow your dairy business or just starting out, talk to Ulster Bank about our practical solutions that might help.

Pat Horgan

Head of Commercial Banking (Regions)

Ulster Bank

Introduction

This workbook is designed to act as an aid in assessing existing dairy farm infrastructure and planning for improvements in the areas of grazing infrastructure, milking practices and energy use. It should act as a guide through a review process which can take the form of a walk(s) of the farm/farmyard and discussions regarding the above elements. A number of issues around grazing infrastructure are generally apparent on all farms. Many of these issues are relatively minor in their own right but combine to create difficulties in grassland management and utilisation, animal performance and labour input, particularly in periods of poor weather and difficult grazing conditions. Similarly the milking process involves countless interactions between the milker, the milking facilities and the cow and there can be many opportunities for improved labour efficiency, milk quality and welfare of both the milker and the herd if the infrastructure and the process can be optimised. Likewise energy use needs to be carefully monitored and controlled and the economics of new technologies assessed to facilitate effective cost control and use efficiency.

Once the review is completed, a plan regarding priority areas of work needs to be decided and efforts made to complete various elements in this and future years. We would encourage you all to assess your own grazing and milking infrastructure and energy efficiency and consider where priority investments need to be made in the coming years. These improvements will be vital in our efforts to maximise grass production and utilisation, particularly in the shoulders of the grazing season, ensure a sustainable milking routine and general work schedule is achieved and control our energy demand and efficiency.

In this publication, sometimes there are references to commercial suppliers and to productions of particular manufacturers. By such reference, it is not intended to indicate these are the only products, suppliers and materials available, such references are for demonstration purposes only. It is strongly recommended that dairy farmers consult with their advisory officers before using the information provided.

Grazing infrastructure

Improved grassland management relies upon robust grazing infrastructure; suitably sized and shaped paddocks with multiple access points serviced by roadways of sufficient quality and adequate drinking water. It is vital to consider the quality of your grazing infrastructure and acknowledge where deficits have arisen in recent years. Increases in herd sizes have placed pressures on existing infrastructure which has knock-on effects on grass utilisation, cow performance and health and labour input. Maximum grazing efficiency will not be achieved unless all grazing infrastructure is sufficient for the needs of the farm. Often, existing farm layouts, roadways and water systems have been largely untouched in many years and it can be easy to overlook the restrictions these place on farm management. Review your farm in the areas detailed; ideally enlist the help of your advisor or another farmer or your discussion group to bring an outside perspective.

Paddock size and layout

Effective grassland management relies on a well-designed paddock system to partition the grazing area and facilitate adequate grass allocations and appropriate rotation lengths. Appropriately sized and shaped paddocks allow for ease of management and high grazing efficiencies and are the structure on which all other grazing infrastructure is based.

Calculate paddock size: (April–June)

Step 1: Establish cow numbers (plan for long term)

Step 2: Establish daily demand. e.g.100 cows X 17kg DM= 1,700kg DM for 24 hours

Step 3: Ideal pre-grazing yield is 1,400kg DM/ha in mid-season

Step 4: To calculate paddock size, divide herd demand by ideal pre-grazing yield.

- Two grazing 1,700/1,400
  = 1.2 ha for 100 cows in 24 hours
- Three grazing 1,700 X 1.5 days/1,400
  = 1.8ha for 100 cows in 36 hours

The remaining area is normally closed for silage during this period. It could also be divided into similar paddocks.

Peak grass growing months, April/May/June will normally determine paddock numbers. A number of commercial companies specialise in farm mapping. They use GPS to get exact paddock sizes and will lay out paddock, water and road systems to meet individual requirements.

Table 1. Paddock sizes required for various herd sizes

Herd size	Paddock size-24hr grazing (Ha)	Paddock size-36hr grazing (Ha)
50	0.6	0.9
100	1.2	1.8
150	1.8	2.7
200	2.4	3.6
250	3.0	4.5
300	3.6	5.4

Review

Paddock size	Yes	No	Comments	Priority actions
Are all paddock sizes appropriate?				

Paddock layout

Proper subdivision of grazing land into paddocks is essential to be able to successfully manage pastures and achieve desirable rotation intervals. An accurate map of the farm is essential.

The ideal paddock system should include:

- About 20 to 23 full sized paddocks and a few small paddocks near the parlour for sick cows etc.
- Paddocks to be rectangle to square in shape, ideally depth:width ratio should be 2:1.
- Wetter paddocks should have longest sides running adjacent to the roadways to avoid poaching in wet weather.
- Alter paddock shape to facilitate stock movement into and out of the paddock i.e. stock move down-hill to exit paddocks.
- Number the paddocks with a tag on the gate and on a map of the farm.

Creating paddocks

- Use farm maps to consider several different ways of laying out the farm and consider the positives and negatives of each one.
- Determine most suitable road layout to service each paddock (allowing for multiple entrances).
- Determine most appropriate water trough(s) position in each paddock.
- Chose the option which ticks the most positives and the least negatives.
- Mark the layout on the ground with marker pegs.
- Re-consider the layout both from the practicality of construction and operation and from the perspective of the cow. Does this actually make sense?
    - » Are the paddock entrances in dry ground?
    - » Will the roadway disrupt normal flow of water down a slope?
    - » Adjust as required!
- Record the final layout on an accurate map and make lots of copies. Get a very large one made that is suitable to put on a wall at the milking parlour.

Multiple access points allow for ease of management, reduced poaching damage at gaps and efficient stock movement. Gaps should be plentiful, well maintained and appropriately sized/orientated to allow ease of access in all conditions. Where limited in number or poorly maintained, stock movement and management will be restricted.

Review

Paddock layout	Yes	No	Comments	Priority actions
Are all paddocks well laid out?				
Are all paddocks suitably shaped?				
Are there sufficient access points?				
Are access points well designed/ maintained?				

Farm roadways

Farm roadways tend to vary significantly within farm, as those roads closer to the farmyard tend to be better developed and maintained while those servicing the outer extremities can be underdeveloped. There also tends to be staged development of these networks as the farm is developed or new land is acquired, or farm layout is reconfigured. As such, a patchwork of different roadway types can often form the roadway network, different elements will vary in terms of width, surface condition and durability. Stock will therefore encounter many different roadway types and configurations when walking. In many cases the core road network has been in place for many years and is designed for much lower stock numbers than currently exists. The roadways, even if well maintained, tend to be compromised in terms of width and as a result reduce stock flow and comfort when in use.

A well-designed, carefully built and properly maintained farm roadway system has many benefits, including, less lameness, less mastitis and better general animal health, faster and easier stock movement, cleaner cows and milk, less roadway maintenance and more efficient paddock access.

Roadway width

The width of roadways depends on the number of cows in the herd. Guidance on standard sizes is given below.

Table 2. Farm roadway width required for various herd sizes

Herd size	Roadway width (m)
50	3.5
100	4.0
150	4.5
200	5.0
250	5.5
300	6.0

The fence should be positioned about 0.5 m (20 inches) from the edge of the roadway. This will allow cows to utilise the full width of the roadway while at the same time prevent them from walking along the grass margin. A cow track in the grass margin usually means that the fence is too far out and the surface of the roadway is likely to be poor also.

Review

Farm roadways	Yes	No	Comments	Priority actions
Are roadway widths adequate?				

Ideal cow movement; heads down, well-spaced, using the full width of the roadway.

Roadway layout and configuration

The length of the roadway required will depend on the size and general layout of the farm. On farms with heavy soils a more intensive roadway system makes grazing management easier. The intensity or land area devoted to farm roadways ranges from 1-2% of the grazing area. Most paddock systems aim to have a roadway intensity of between 1.2-1.5% of the grazing area. The layout and configuration of roadways varies significantly within and between farms. Some of this variability will be due to landscape and farm shape (roadway slope or length) while more will be due to poor planning or construction (sharp bends, restrictive junctions, lack of crossfall).

The roadway must be designed to service the entire grazing area. A number of different roadway orientations may serve this purpose. Choose one that facilitates reasonably direct access from all parts of the farm to the milking parlour and clean well drained road surfaces. Avoid sharp turns at corners and junctions by using sweeping bends. Avoid any distractions or barriers to cow-flow; critically watch the cow movement and remove restrictions and distractions to cow-flow e.g. poor view, grassy margins, excessively close fencing etc. Remove excessive shade that will leave roadways dark, wet and dirty. On steep roadways; use ramps or channels to divert water at intervals, otherwise, flowing water will create tracks and wash away the surface layer. Locate water troughs away from paddock gateways and farm roadways. This will shorten the walk to water, prevent bottlenecks, and reduce the wear and tear at gateways. Align the roadway to let cows enter the collecting yard towards the rear. This lines-up the cows for milking makes it easier for them to adjust their social order for milking. Most importantly it is good to have an open mind in terms of the existing network. If it does not service current needs, then it may be best to move certain sections to allow for improvements to the overall system.

Cow tracks can be installed as extra roadways, as spur roadways off normal wider roadways or at the end of the main farm roadway. They are generally only suitable for short runs. They are useful for getting access to out of the way paddocks, to silage ground and making grazing management easier early and late in the season. They can make up for gaps in the main roadway network and are a useful and cheap alternative to standard roads in less trafficked areas.

Review

Farm roadways	Yes	No	Comments	Priority actions
Are all paddocks well serviced by roadways?				
Does the road layout suit the needs of the farm?				
Are additional roads/ cow tracks needed?				
Are there restrictions to cow-flow (sharp turns, restricted junctions, steep slopes, dirty/wet sections)?				

Roadway condition

Take a look at the condition of your farm roadways for defects that may be causing problems. These defects can include, potholes, a roadway that is level or almost level, wheel track depressions, a raised hump of soil under the fence at either side and (single-file) cow tracks made between the fence and the roadway or on the roadway.

Problems are caused by; pebbles and loose stones on the surface, a bumpy surface with secure stones, lodged/trapped water on the surface, very dirty section near the farmyard, and a roadway level with or lower than the field. The reasons for these defects are many but may be due to flawed construction methods, unsuitable materials and lack of maintenance. The appearance of the roadway now bears little resemblance to what it looked like when it was initially constructed.

The surface of the roadway has a big influence on the level of lameness in the herd. The surface needs to be smooth, fine and strong enough to support animals but with a little give in it also. Ideally, the footprints from the cows should be visible across the roadway, but not so much to damage the surface when the weather is wet. Rough surfaces with protruding stones, loose gravel or pebbles (either sharp or round) lying on the surface are a major lameness factor.

The presence of concrete roadways on farms is shown to increase the incidence of lameness, due to a higher risk of loose gravel or pebbles (either sharp or round) lying on the roadway surface. Therefore, if concrete roads are used for cows, care must be taken to ensure; that the junction between the concrete and the roadway is maintained in good condition, that the concrete is kept free of grit, and run-off from the concrete should be diverted away from the roadway. Regular brushing/cleaning of the concrete is required. Holding cows for long periods on concrete before and after milking should be avoided.

Fine surface material

Review

Roadway condition	Yes	No	Comments	Priority actions
Are roadways surfaces in good condition?				
Are roadways regularly maintained?				

Notes on roadway construction

New farm roadways must be laid in good weather when soil conditions are dry. This is primarily to ensure that the roadway material does not mix or get pressed into soft soil. Ideally remove a thin layer of topsoil before placing the roadway material. Be careful not to remove too much topsoil as the depth of the roadway will have to be increased to bring the roadway surface above field level. The finished level of the roadway must be above the level of the field, otherwise drainage will be onto the roadway instead of off it.

This foundation layer is made up of granular fill material. The usual depth is about 200-300 mm (8-12 inches). The biggest stones should be no bigger than about one third of the thickness of this layer. The intended slope should be formed in the foundation layer. This means that the surface layer will have the same slope and an even thickness.

Generally, 75 or 100 mm (3 or 4 inch) down material is used. This is a graded mixture of different sized stones from 75 or 100mm down to dust. Crushed rubble can also be used.

Compact with a vibrating road roller before the surface layer is spread. Compaction interlocks the material to give a stronger roadway and helps prevent loose stones from mixing with the surface layer.

Geotextile

Consider using a geotextile membrane between the road materials and the soil. A geotextile is a synthetic porous fabric used to separate the foundation layer from the ground underneath. It prevents the stones from becoming mixed with the soil and vica versa. The geotextile keeps the roadway foundation material clean, free-draining and therefore dry and strong. A geotextile is highly recommended where soil is heavy or wet. It won't solve drainage problems; therefore, any necessary drainage should be tackled beforehand. A geotextile also highly recommended on roadways used for heavy machinery. A geotextile suitable for farm roadways costs about 75 cent/square metre.

Crossfalls

Getting water off the roadway quickly will extend the life of the surface and reduce the cost of maintenance. Potholes will also be less likely to develop. To remove water quickly from roadways they should slope to one or both sides. A roadway that slopes to one side is easier to construct and machinery runs better on it. However, cows apparently spread out better on a roadway that slopes to both sides. A crossfall of between 1 in 15 and 1 in 20 is about right. Roadways on steeply sloping ground can be subjected to a stream of water running the length of a section of roadway during heavy rain. The 1 in 15-20 crossfall should be enough to divert this water away to the sides. However, where the ground falls considerably along the roadway crossfalls may be insufficient to prevent this scouring, so, low ridges, shallow channels or cut-off drains at intervals across the roadway will divert water before it builds up volume and momentum. The introduction of legislation requiring the prevention of direct runoff of water from farm roadways to open drains and watercourses by the 1st of January 2021 will bring this issue into sharper focus.

Surface layer

The roadway should be completed with about 50-75 mm (2-3 inches) of a fine material on the surface. If the surface is poor most of the benefits of having a farm roadway are gone. The surface layer needs to be laid evenly and compacted. Spread it out to the slope formed in the foundation layer. Many different types of fine material can be used for the surface layer.

Table 3. Key roadway design specifications	
Cross fall/ slope	1:25 one sided slope, 1:15 two sided slope
Construction	Geotextile (optional) 200 – 300 mm hard core plus 50-75 mm fine material
Cow walking speed	2-3 km on good road surface
Road slope	Max of 3:1
Fencing	50 cm from edge of road
Approx. cost	€18 – 30 / metre

Costs

A 4.0m wide roadway, with 300 mm depth of material will need one 25 tonne load to cover a length of approximately 10 metres. This assumes a density of about 2 tonnes per m^3 for the material used. A similar sized load would cover 45-50 metres with a 63mm (2½ inch) thick surface layer. The price of road making material, both crushed stone and dust for the surface, is typically €7-10 per tonne plus VAT. As the construction material amounts to over 80% of the overall cost, strict control over the depth and width of the roadway, in line with needs and good construction practice, is essential. Farm roadway costs range between €4 and €7.50 per square metre. Calculate costs in advance and monitor progress. VAT is refundable on new farm roadways but not on repairs.

Repairing an existing roadway

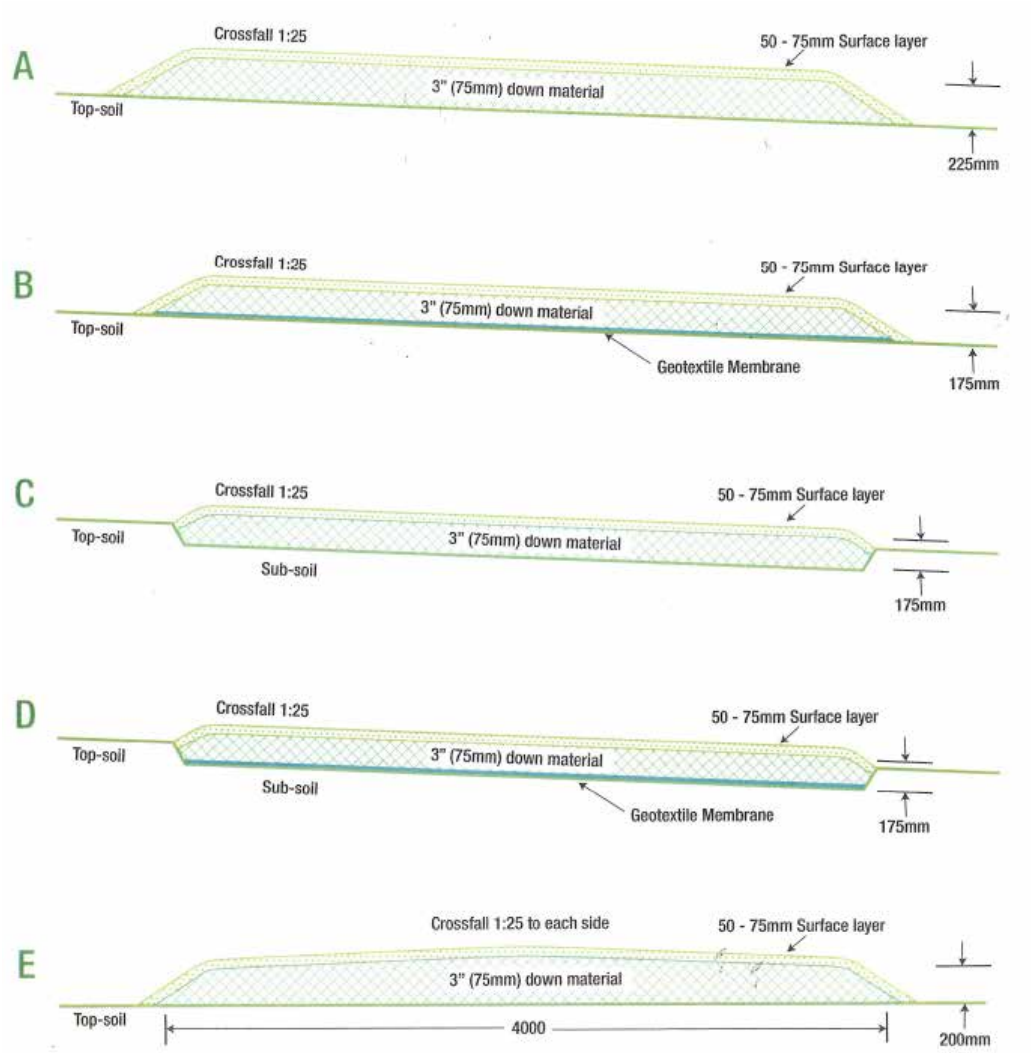
Roadways should be repaired as necessary - probably needing some attention every year. Pay particular attention to the most used part of the roadway, especially the first 50-100 m near the parlour. This area can get very dirty, worn and low. This dirties cows coming in and going out, leading to increased SCC levels, udder washing, raised TBC and sediment levels. It also predisposes foot disorders.

Typical areas that require on-going attention are drainage outlets, water diversion ramps/ channels, filling potholes and adding extra surface material to rough areas. Roadways that are in a bad state will need a major repair job to get them right. Remove any grass and clay from the edges and the centre. If the roadway is lower than the level of the field it will have to be raised. If there is no crossfall, one will have to be created.

Generally, 40 or 50 mm (1½ or 2 inch) down granular fill material is used to raise the level. If it has to be raised a lot you may have to use 75 mm (3 inch) down. This granular fill should be laid to the falls of the finished surface. Finish off with a suitable surface material and compact.

Cow tracks

A depth of about 150 mm of material is laid on the surface of the ground. This should be compacted and topped off with a fine surface layer and the surface layer should be compacted also. The width should range between 1.8 m and 2.5 m, costing €8-€11 /metre run.



Farm Roadway profile options

Fencing

Fencing is an essential element of grassland management. Good fencing is critical for controlled grazing where the farm target is to increase grass yield and maximise the utilisation of grass. The level of control you require is the most important consideration when erecting a fence. A permanent fence will require different design than a temporary one. Boundary fences may be designed differently than internal divisions.

Materials

The quality of materials will have a major influence on the longevity of the fence. The choice of posts, wire, insulators, gate openings etc. can vary. When erecting a fence use quality materials. These may not always be the cheapest but will be more reliable and require less maintenance in future years.

Strain posts

These form the backbone of any fence. For most fencers the strainer post should be 20 – 25 cm diameter (8-10 inches) and 2.1 - 2.5 m (7-8ft) long. This will allow approximately 1.2 m (4ft) of the post to be driven into the ground. These posts may be softwoods or hard woods provided they are treated. The distance between straining posts may be up to 200 m depending on type and topography of the land.

Intermediate posts

The ideal post for most fencers would be round posts 10-12cm (4 inches) diameter, 1.7 m (5ft 6ins) long. Square posts (7.5 cm X 7.5 cm/3 inches X 3 inches) are also suitable.

Wire

2.5 (12 gauge) high tensile wire is most suitable for electric fencing. Proper galvanised wire will have a life of 20-25 years, poor quality wire decays after 7 - 8 years.

Choice of fence

Single strand electrified fence

This is cheap, easy to erect and very effective against cows and adult cattle. It is most suitable for internal divisions such as paddocks. The height of wire for cows is 90 cm (35 inches). Intermediate post spacing should be 14 metres.

Double strand electrified fence

This is suitable for cows, cattle and calves. The height of top strand would be 90 cm with the second strand 37.5 cm (15 inches) lower.

Four/Five strand electrified fence

Cattle, sheep and lambs will be controlled. This fence requires annual maintenance. Grass and weeds underneath the fence must be continually cut or sprayed. The spacing for the five strand from the ground up is 12.5 (5 inches), 15 cm (6 inches), 17.5 cm (7 inches), 20 cm (8 inches) and 22.5 cm (9 inches). Intermediate posts are spaced at 10 m apart.

Temporary fencing of paddocks is widely practised for strip grazing. Geared reels with wire and white electrified tape are most suitable. There are flexible, light and easily moved.

Review

Fencing	Yes	No	Comments	Priority actions
Are internal and boundary fences adequate?				
Does the system allow flexibility of grazing area and access?				

Creosoted straining post at paddock entrance

Fencing equipment

Water system

A good water supply is extremely important for production, health and welfare of livestock. Common problems on most farms centre on inadequacies in areas such as, water source, pumping plant, pipe sizes, ballcocks and troughs.

Water troughs

The water troughs need to satisfy two criteria; 1. Water Volume and 2. Drinking Space.

The volume of the trough needs to allow for storage of 5-7 litres /cow, while 45 cm/18 inches of drinking space along the trough rim is required per cow. It is advisable that 10% of the herd can drink at the same time.

Table 4. Water trough volume and drinking space required for various herd sizes

Herd size	Volume required (litres)	Volume required (gallons)	Drinking space required (cm)
50	350	80	225
100	700	160	450
150	1050	240	675
200	1400	320	900
250	1750	400	1125
300	2100	480	1350

Carefully consider trough location; cows don't like to walk more than about 250 metres to get a drink. Locate water troughs away from paddock gateways and farm roadways. This will shorten the walk to water, prevent bottlenecks, and reduce the wear and tear at gateways.

Locate troughs to allow for ease of splitting paddocks with temporary fences, and to allow as much access as possible, i.e. not too close to fences or boundaries. Multiple troughs may be needed in many cases to ensure good supply, location and access, particularly in heavy ground where potential for poaching needs to be minimised.

Top-fill 500 gallon water trough servicing adjacent paddocks

Review

Water Troughs	Yes	No	Comments	Priority actions
Are your water troughs large enough?				
Are they accessible?				
Do locations allow for temporary fencing?				

Water flow-rate required

We need to calculate what volume of water is required for a range of herd sizes.

The volume of water required by cows varies with weather conditions and milk production. Typical volumes range from 60-110 litres /day or four litres of water/litre of milk produced.

This volume is not spread evenly throughout the day but tends to be concentrated in a three hour period after evening milking. Flow rate must be capable of supplying this peak in demand. If we assume a daily demand of 80 litres/cow and that half this volume needs to be consumed in a three hour period, then an hourly flow rate of 13 litres/cow/hour is required (i.e. 80 x 50%/3 = 13 litres/cow/hour).

Table 5. Water flow-rate required for various herd sizes

Herd size	Litres required/hour	Litres required/minute
50	650	11
100	1300	22
150	1950	33
200	2600	44
250	3250	55
300	3900	66

To check the water flow rate in a trough

- Mark the level of water in a trough.
- Tie up the ballcock and empty, say, 25 litres from the trough.
- Release the ballcock, hold it down and measure the time it takes (in minutes) to refill to the original mark.
- Divide the 25 litres by the time taken to refill, e.g. if it takes a minute to refill then the flow rate is 25 litres/minute (25/1 = 25).
- If the flow rate measured is less than that required for your herd, then your water supply system needs to be improved. Check the flow rate of troughs around the farm.

Review

Water flow rate	Yes	No	Comments	Priority actions
Is flow rate adequate in all troughs?				

Water Supply

There are a number of factors which will dictate the flow rate of water to each trough, namely:

- Water source/pressure
- Pipe size
- Pipe length/layout
- Ballcock jet size

Under each of these headings, there is much variation from farm to farm and often within a single farm.

Obviously, an adequate source of water is fundamental to the supply, and if this isn't capable of supplying the needs for drinking (as well as that required for other purposes, mainly milking plant/parlour washing and domestic needs), then efforts will need to be directed at improving supply whether from a private well, municipal source or local scheme.

Where source is limited, reservoirs and pumps can be utilised to buffer against shortages during periods of peak demand.

Once an adequate source is available, we must look inside the farm gate to ensure the required flow rates are being met. From here two elements dictate flow rate: pipes and ballcocks.

Review

Water flow rate	Yes	No	Comments	Priority actions
Can your water source be improved?				

Water pipes

The size, length and layout of the pipe network will dictate the pressure achieved at the ballcock and the flow rate from there is dictated by the valve and jet size in the ballcock.

Water pressure available at source is going to be reduced by travelling through the pipe network. The amount of pressure loss will depend on pipe length and pipe diameter.

Table 6 shows the pressure loss in psi for different pipe sizes over a range of flow rates per 100 metres length. The reason the flow rate reduces because of friction between the water and the inside surface of the pipe.

Table 6. Pressure loss in psi for different pipe sizes at various flow rates for 100 metres length of water pipe

Pipe bore (mm)	Flow rate m^3 / hour (litres / minute)				
	1 (17)	2 (33)	3 (50)	4 (67)	5 (83)
20	14.20				
25	3.27	11.50			
32	0.64	2.27	4.83	7.60	11.65
38	0.34	1.21	2.49	4.05	6.25
50	0.11	0.38	0.88	1.34	2.06

The table doesn't show values for 12.5 mm (1/2 inch) pipes because at any of the flow rates shown the pressure loss would be very high. Where 12.5 mm pipes are used on farms the flow rate is reduced to a trickle due to pressure loss.

Always bear in mind that a 20 mm (3/4 inch) pipe has approximately twice the cross-sectional area of 12.5 mm (1/2 inch) pipe. Similarly, a 25 mm (1 inch) pipe has four times the cross-sectional area of 12.5 mm (1/2 inch) pipe, although it's only twice the bore.

Review

Water pipes	Yes	No	Comments	Priority actions
Is water pipe size adequate?				
Where restricted, can it be improved?				

Ballcock jets

Very often the ballcocks are the weak link in an otherwise satisfactory water supply system. Ballcocks are frequently over restrictive, even on systems where the pipe sizes are adequate. A high pressure 12.5 mm ballcock in the drinking trough is not capable of allowing an adequate flow rate, which is in most situations about 16 to 22 litres /minute (3.5 to 5gal/min).

In general, standard ballcocks are described by their size and pressure. Ballcocks can have high, medium or low pressure jets.

Table 7 shows the combined effect of pressure and ballcock jet size on flow rate. Note that quadrupling the static pressure will double the flow rate while quadrupling the jet size will increase flow rate by a factor of 16.

For herd sizes between 50 and 100 cows (requiring 22-33 litre/minute flow rate), suitable combinations of pressure and jet size are shaded.

Table 7. Flow rate (litre/min) through ballcock at varying static pressure and ballcock jet size

Static pressure (P.S.I.)	Ballcock jet size			
	1/8"	¼"	3/8"	½"
0.5	0.9	3.7	8.4	14.9
1	1.3	5.3	11.9	21.1
2	1.9	7.5	16.8	29.9
4	2.6	10.6	23.7	42.2
7	3.5	14.0	31.4	55.9
10	4.2	16.8	37.6	66.8
15	5.1	20.5	45.9	81.8
20	6.0	23.7	53.2	94.6
25	6.6	26.5	59.1	105.5
30	7.3	29.1	65.0	115.9
35	7.9	31.4	70.5	125.0
40	8.4	33.6	75.0	134.1

Note: The pressure is at the ballcock and NOT at the pump.

Review

Ballcock jets	Yes	No	Comments	Priority actions
Is required flow rate achievable from the current water pressure available?				
Does the required flow rate require a change in ballcock jets?				

High, medium and low pressure jets

Case study farm example

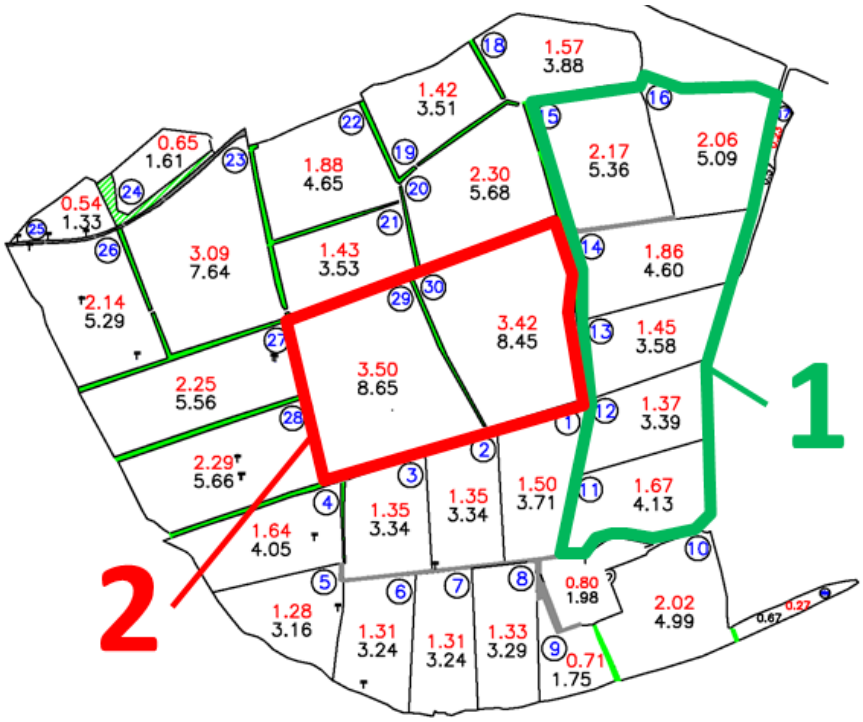
It is quite common on many dairy farms for grazing infrastructure to be neglected to some extent but efforts must be made to ensure it is setup to maximise the main resource we have; our grasslands. John O' Sullivan of Castleisland, Co Kerry went about improving grazing infrastructure in 2018 as he felt there were a number of deficiencies that needed to be addressed.

John milks 105 Cows on 43 ha of heavy land, which required improvements in grazing infrastructure to facilitate better grass utilisation and prevent excessive poaching and soil damage. Rainfall in the area is approximately 1300 mm /year. In winter/spring 2017/18, 855 mm was recorded in a six month period. This resulted in extremely difficult grazing conditions on the farm and provided the incentive for upgrading grazing infrastructure. "As in most of the country, we had a really wet difficult spring and it showed up some of the shortcomings of our infrastructure and because we couldn't get cows to some paddocks without causing huge damage, we had them indoors for more than we wanted in February and March" recalls John. A review of grazing infrastructure on the farm was carried out in May 2018 to assess the status of all elements described earlier, including, paddock size and layout, farm roadways, fencing and water systems. The overall aim was to identify weaknesses in the existing infrastructure and put a plan in place for new infrastructure that would help achieve more grazings on the farm at the shoulders of the grazing season and at other times when conditions are borderline. The key finding of the review was that a number of areas were identified which were poorly serviced by roadways or access from roadways and which could offer additional grazing in poor weather conditions. On heavy soils it is desirable that all parts of the grazing platform are within 75 m of a farm roadway or spur road. This was the criteria applied when laying out new roadways/spur roads on John's farm.

The main grazing infrastructure improvements required were:

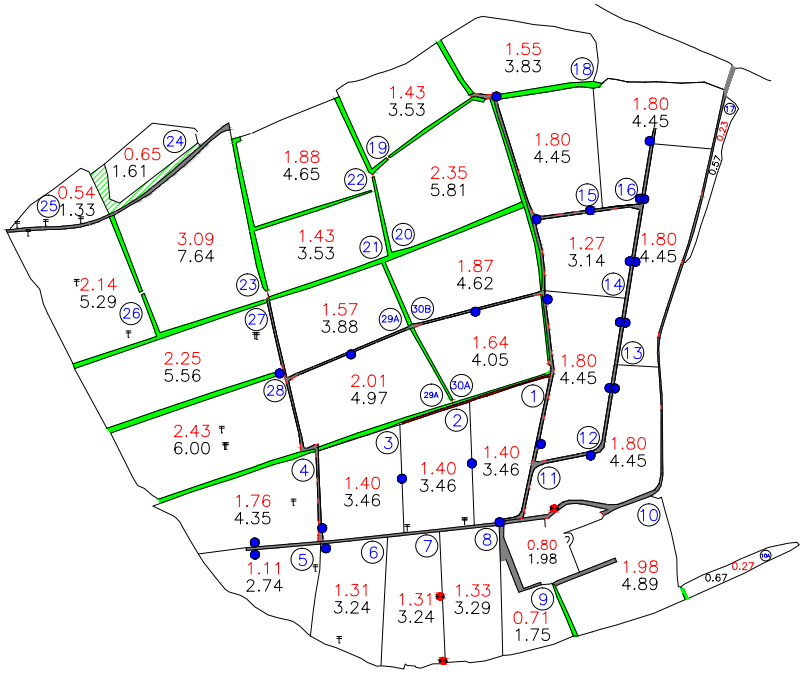
- New roadway (4 m wide x 570 meters) servicing a 10.6 ha area.
    - » Reconfiguring of paddock boundaries in this area and additional water troughs.
- Spur roads (2 m wide x 615 meters) to be laid to access seven ha of rented land
    - » Reconfiguring of paddock boundaries in this area and additional water troughs.
    - » These spur roads will also help access to 2.0 ha of owned ground in adjacent area.
    - » To facilitate more access points on rented land gaps need to be made in hedgerows.
- New Roadway (4 m wide x 550 meters) to service 14.0 ha of rented land.
    - » Reconfiguring of paddock boundaries in this area and additional water troughs.
- Road surfaces and access gaps, particularly those on rented ground need attention.

It was decided that items 1 and 2, in the areas highlighted below, would be implemented in 2018 with other elements to follow thereafter.



Focus areas 1 and 2 in which new grazing infrastructure was installed in 2018

Fortunately, the dry summer weather allowed these works to be completed in great conditions. The newly completed roadways are shown in the map below were completed in July/August of 2018.



Newly completed farm roadways and spur roads installed in the areas highlighted above

Benefits to-date

The cost of the works carried out in 2018 amounted to approximately €1,000/ha, including additional roadways, spur roads and, piping, troughs and fences. Grazing in 2019 began on February 12th and in total 30 grazings was achieved by the end of the month, which according to John would not have been possible without the new road infrastructure. With the exception of a short period in mid-march grazing continued generally uninterrupted despite relatively high rainfall (175 mm/7 inches in a 3 week-period). By April 1st 60% of the farm was grazed, a figure that would not have been achieved without the investment in grazing infrastructure. Research work has shown that each extra day grazing is worth €3/cow in spring and €2/cow in autumn. The benefits are seen in extra milk solids and greater labour efficiency, while silage stocks are maintained and slurry spreading costs are reduced. At these rates, it doesn't require huge amounts of additional grazings to pay for high quality grazing infrastructure. The grazings, particularly in spring will also stimulate additional growth. The goal of the Teagasc Grass10 campaign – 10 grazings in the year on each paddock – is not possible if you don't get at least one grazing done by late march. It is also worth bearing in mind that the objective is not to get cows out regardless of weather or ground conditions, but rather that when conditions are improving, cows may be able to be put out if infrastructure is good. Even if that's only for three hours, grass utilisation is improved. "Upgrading your infrastructure is a really good investment," says John, "It generates a very healthy return of 10% to 15% p/annum. We're always looking for ways to make better use of use of grass and this helps enormously. Having good infrastructure is also better for people, because it reduces drudgery and makes the job easier and possibly more attractive for the next generation".

The lessons learned on this Kerry farm are relevant for farmers from all parts of the country, even farms in much drier areas will have parts of the farm that are wet at particular times of the year and good infrastructure is needed to access grazable areas, also flexibility and access are key to any grazing system and need to be provided by well-planned and well maintained infrastructure.

Milking practices and energy use

Milking efficiency

Action points

- Benchmark your farms level of milking efficiency against other farms. The average level of milking efficiency is 57 cows milked/operator/hour and 750 litres of milk harvested/hour.
- Examine the time taken to milk one row of cows and identify bottle necks in cow flow through the milking parlour.
- Look at options to reduce total daily milking time to three hours/day (cups on to cups off).

Introduction

Milking, and its associated tasks of herding, pre- and post-milking and washing post-milking, in a pasture-based system accounts for 33% of the total annual farm labour input. The number of dairy herds in Ireland greater than 100 cows increased by 56% between 2013 and 2016. This increase in cow numbers has led to a corresponding increase in milk production, as shown by the fact that Irish milk production increased by 34.2% from the beginning of 2015 to the beginning of 2019. In a herd size expansion environment, a common solution to avoid increasing milking times is to add extra labour to the milking process to maximise use of existing capital infrastructure. However, there is currently an inadequate supply of skilled part, and full-time labour at farm level in Ireland. In order to attract new skilled employees, dairy farms must be desirable places to work. As milking times increase due to the continued growth of herd sizes, increased workloads may exert pressure on labour resources if changes to milking practices and milking infrastructure are not made. In order to make dairy farms more attractive for potential employees, the employees' workload needs to be carefully managed. Efficient milking facilities and milking management strategies can help to achieve this objective.

Why is milking efficiency important?

Efficient milking systems contribute to the goal of producing high quality milk, since the operator is less likely to become fatigued and hence, will have more time to identify and treat problem cows while paying attention to best practice in milking procedures. In the absence of adequate farm labour, increases in herd size necessitates investment in new milk harvesting equipment to avoid unsustainably long working hours, and errors occurring during the milking process. Furthermore, long working hours and difficulties attracting and retaining milking staff may lead to increased levels of stress (both physical and psychological) which is a strong predictor of farm injury and resulting safety behaviours, as well being a connector between financial problems and injury in farming. In recent years, dairy farmers have faced high levels of financial instability. In order to begin to address the issue of unsustainably long working hours on dairy farms, it is necessary to understand the time spent in each of the critical segments of the working day and benchmark efficiency levels across the main farm labour inputs. The following worksheet and explanations will facilitate calculation of key performance indicators of the milking process, enabling benchmarking against other farmers.

Performance parameters of the milking system

Milking performance is dependent on the milking facility which, in turn, is dependent on herd size, preferred milking duration, labour availability, level of automation, and capital investment. Various measures can be used to assess milking performance, but these measures must be interpreted in the light of the values of the owner of the system. For

example, a farmer may wish to spend more time preparing cows for milking in order to protect milk quality, and so, may prefer a less than optimum result for the cows milked/operator/hour performance measure.

Cows/operator/hour (1st cluster on to last cluster off)

Many farmers measure their performance in terms of cows/hour which is good where there is one milking operator in the parlour. However, larger parlours (with more than one milker) always appear better with this measure. Thus, the cows/operator/hour measure may be more appropriate in that instance.

Litres/operator/hour (1st cluster on to last cluster off)

This measure focuses on the productivity of the labour used in the parlour. From a labour productivity point of view, it is better to milk fewer, higher producing cows than a greater number of lower producing cows.

Calculating key milking efficiency parameters

The first step in improving milking efficiency is to understand current levels of performance. The basic milking efficiency metrics of cows milked per operator per hour, and litres of milk harvested per operator per hour can be computed using the following table.

Table 8. Milking efficiency key performance indicator calculations

	Parameter	Detail	Fill in this column
1	Herd Size	no. cows	
2	No. Milking Units	no. clusters	
3	No. Rows (sides)	1 ÷ 2 (round up)	
4	L milk harvested per day	Calculate from receipts	
5	Time cups on AM	hh:mm	
6	Time cups off AM	hh:mm	
7	No. labour units AM		
8	AM Milking time	6 - 5 (hours)	
9	Time cups on PM	hh:mm	
10	Time cups off PM	hh:mm	
11	No. labour units PM		
12	PM Milking time	10 - 9 (hours)	
KPIs			
13	Total daily milking time (hours)	8 + 12	
14	Total labour input per milking	(7 + 11) ÷ 2	
15	Cows per operator per hour	1 ÷ 14 ÷ 13	
16	Milk harvested per operator per hour	4 ÷ 14 ÷ 13	
17	Row time (mins)*	(13 x 60) ÷ 3	

* *Row time only relevant to herringbone milking systems*

Maximising milking efficiency

Milking parlours are run most efficiently when the capacity of the milking equipment matches the capacity of the labour input (i.e. person(s) milking the cows). The milking operator should not be waiting for the milking clusters to become available and the equipment should be fully utilised, not idle and waiting for the operator to catch up. Thus, efficiency is maximised when the equipment and labour are balanced. The degree

of efficiency to which this task is conducted can have a very significant impact on overall milking process time and the daily life of the operator.

Milking efficiency of Irish farms

A recent study compared a number of key milking efficiency parameters (e.g. total milking time, litres of milk harvested/operator/hour, number of cows milked/operator/hour) across 33 commercial farms in May 2016. Times of the day when milking occurred were also recorded. The average herd size of the study group was 125 cows on this sample of farms (range 41 – 265). All farms used herringbone milking systems and the average number of milking units was 14 (range 6-24). This resulted in an average of 10 rows of cows (range 6-18). The most common AM milking start time was between 06:30 and 07:00 (35%). The average AM milking duration was 134 minutes. Figure 1 shows the distribution of AM milking start and finish times for May. The most common PM milking start time was between 17:00 and 17:30 (24%). The average PM milking duration was 120 minutes. Figure 2 shows the distribution of PM milking start and finish times for May.

The average row time was 14 minutes. In terms of milking efficiency parameters, the number of cows milked/operator/hour was 57 (range 32 to 104). The number of litres of milk harvested/operator/hour was 749 in (range 285 to 1,290).

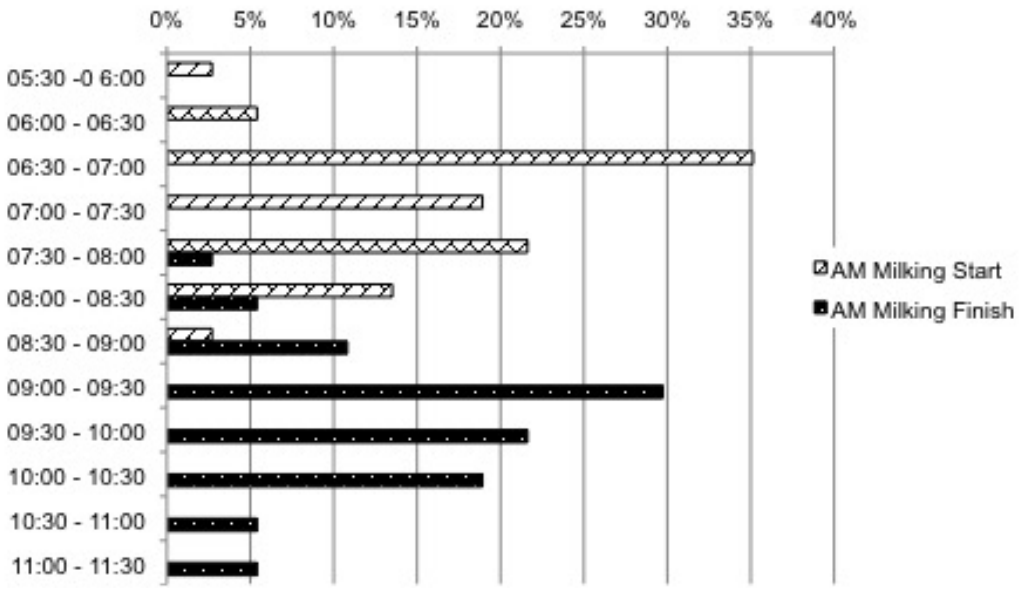


Figure 1. *AM milking start and finish time distributions for May on 33 farms*

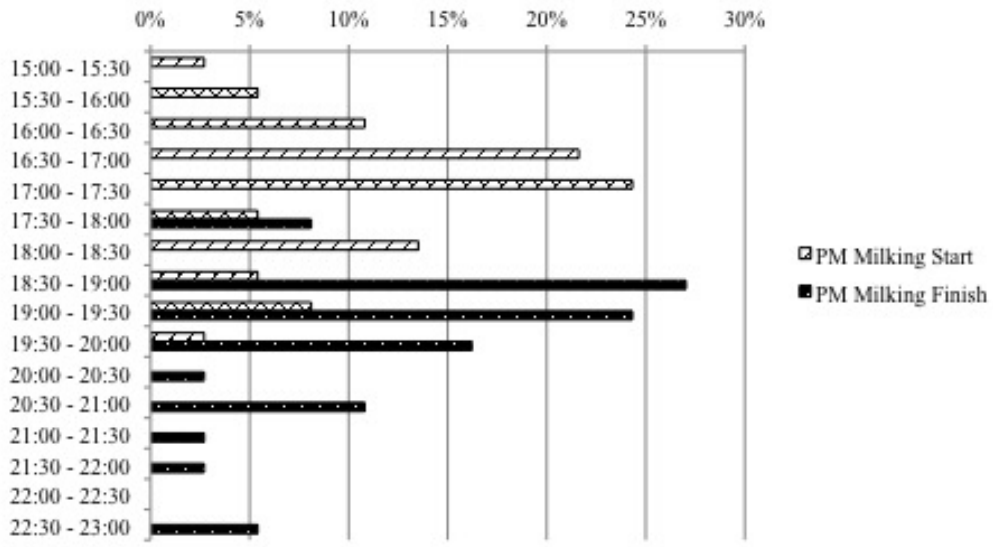


Figure 2. *PM milking start and finish time distributions for May on 33 farms*

It is unclear at this point how well the difference between AM milking start time and PM milking finish time represents the length of the working day on dairy farms. However, it is clear from the data presented that the majority of dairy farmers are working quite early in the morning and unusually late in the evenings by modern industrial worker standards. While there was quite a tight spread in AM milking start and finish times, we found that 11% of farmers started the PM milking after 19:00, resulting in PM milking finish times after 21:00. On average, 5% of farmers were finishing milking after 22:30 consistently, for the month of May, over the course of this study (Figure 2). Hence, in order to ensure safe working conditions and promote significant generational renewal within farming, much more focus is required on this topic.

Effect of changing milking interval (from 16:8 to 12:12) on milk production, composition and quality

On many dairy farms the morning and evening milkings give structure to the days' activities. Often the milking task is the first and last task to be conducted at the start and end of the day, respectively. Thus, if evening milking was completed earlier, this would leave more free time in the evening for family or other lifestyle choices. This option is often not considered because of a perceived reduction in milk yield with unequal milking intervals.

A short-term study was undertaken to investigate the effect of unequal and equal milking intervals on milk yield, composition and somatic cell count (SCC) of milk in cows yielding ~25 kg/day. Sixty-six spring-calved cows were assigned to 2 treatments for a 4-week period (April 16 to May 14). The majority of cows were at peak milk production (average 60 days in milk at the start of the experiment). Cows on treatments 1 and 2 were milked at 16:8h and 12:12h milking intervals, respectively. The average lactation yield was 5,037 kg. Both treatment groups grazed under similar conditions and were stocked at 4.49/ha.

There was no difference between the 16:8h and 12:12h interval with respect to daily yields of milk, milk protein and lactose. Daily milk fat yield and concentration were reduced ($P<0.05$) by the 12:12h interval but protein, lactose and SCC were not affected.

Message: A milking interval of 16:8h (rather than an interval of 12:12h) may be used without any negative impact on milk production, protein and lactose contents and milk SCC.

Example - scope for improving milking efficiency

Options for improving milking efficiency fall into three main categories:

- Optimising milking machine factors.
- Increasing the number of milking units to reduce the number of rows, and
- Improve cow flow through the parlour.

On the sample of farms in the study described here, average daily milking duration was four hours and 20 mins, which far exceeds the recommended maximum duration of three hours. In order to make significant improvements to milking efficiency and reduce total daily milking time towards three hours, all three categories described above need to be considered.

Firstly, numerous adjustments can be made to the milking machine which would have the effect of increasing milking speed (e.g. increasing system vacuum, increasing the milk phase of pulsation relative to the rest phase and installing a high compression teatcup liner), however it is vitally important that the cow remains comfortable in the parlour during milking in order to avoid kick-offs while enabling the milking machine to fully milk out the cow. Therefore it is strongly advised to bias the milking machine settings of system vacuum, pulsation rate and ratio and liner choice towards cow comfort rather than outright milking speed. In doing so, cows will remain calm during milking and the integrity of the teat end tissue will not become compromised over time.

Automatic Cluster Removers (ACRs)

- While cluster removers are often considered unnecessary in smaller parlours (less than 14 units), they offer great flexibility, especially in larger parlours. The installation of ACRs can help cows' health by eliminating the risk of over-milking.
- Cluster removers ensure consistency around the end-point of milking, which is beneficial if the milking task is carried out by a number of different people.
- Analysis of on-farm data shows that herds without cluster removers are prone to over milking towards the end of lactation. During the over milking period, short milk tube vacuum can approach system vacuum causing congestion (or swelling) of the teat tissue and hence delayed closure of the teat canal after milking. This delayed closure of the teat canal allows a window for mastitis causing bacteria to enter the udder.
- Swing arms are usually required for correct operation, i.e. to prevent clusters getting dirty and swinging free across the pit when detached, and to support the rams for cluster removers and also to support the long milk tube .
- If planning for the installation of cluster removers at a later date, swing arms should be installed making the fitting of cluster removers easier in the future.

The most effective milking machine setting to reduce milking times, while maintaining cow comfort, is the cluster removal settings. For example, milking times of slow milking cows can be reduced by approx. 10% by increasing the cluster removal take off settings from 0.2 kg/min to 0.4 kg/min. Hence, time savings in the order of one minute can be achieved per row through the implementation of this setting change. However, some means of flow rate monitoring and automatic cluster removers would be required to implement this setting. The effect of this adjustment on the total daily milking time of the farms described in this study would be in order of 20 minutes/day.

A New Zealand study carried out on dairy cows in late lactation reported that udder-level automatic cluster remover settings up to 0.8 kg/min reduced individual cluster-on times without affecting milk yield or indicators of udder health when using a milking routine with no pre-milking stimulation, as is common practice on pasture-based dairy farms. Increasing automatic cluster remover settings had no effect on indicators of udder health despite greater residual milk due to earlier removal of the cluster. The presence of residual

milk is thought by many farmers to be linked with mastitis. However, increasing evidence indicates that an increase in residual milk does not adversely affect somatic cell count (SCC) or rates of clinical mastitis. One study noted a 1% reduction in milk production (kg/day) as a result of applying a 0.4 kg/min udder-level cluster removal setting compared with 0.2 kg/min. Further work is required to quantify the effects of increasing cluster remover settings on SCC and milk yield under Irish conditions.

Secondly, increasing the number of milking units to reduce the number of rows of cows milked through the parlour to eight would require the addition of two extra milking units on average for the milking parlours used by the farmers in this study. This change would have the effect of reducing totally daily milking time by 30 minutes. Of course any modifications to the milking machine should be carefully planned. Consult with your registered IMQCS milking machine technician who can advise on a suitable solution. Further advice on this topic is available in the Teagasc dairy farm infrastructure booklet.

Thirdly, cow flow through the milking parlour has a large effect on the time taken to milk a row of cows. Row time on the farms in the present study was 14 minutes. Cow flow through the milking parlour is often a neglected factor when planning a milking facility. Loading and unloading rows of cows can take up to a third of total row time. Row time is influenced by many factors including the factors listed below:

Review

Row time	Yes	No	Comments	Priority actions
Collecting yard design: Is there sufficient space and are cows lined up towards the parlour entrance to maintain the herds social order?				
Parlour entrance and exit: Are the entrance and exit ways free from steps and obstructions?				
Lighting: Is the parlour entrance properly lit to enable cows to see clearly on the way into the parlour?				
Gates: Can both entrance and exit gate be operated from anywhere in the pit?				
Bailing systems: Are the cows properly positioned in the parlour, i.e. positioned by rump rails and/or feed mangers?				
The milking pit: Is the milking pit well organised? Are regularly used items (e.g. tail tape) readily accessible? Are teat sprayer nozzles available from anywhere in the pit?				
Drafting: Can cows be drafted for A.I. or treatment without leaving the pit?				

The majority of farms can make improvements to milking efficiency and reduce row times by addressing deficiencies on some or all of the points listed above. The potential time savings on the farms discussed in this milking efficiency study could reduce total daily milking times by over 30 minutes by implementing improvements in the area of cow flow, which is the largest area for savings of the three options discussed. Many of the improvements in the area of cow flow do not incur large capital costs, however they do require thought and planning. Further advice on the topic of cow flow is available in the Teagasc dairy farm infrastructure booklet.

Summary

This study on milking efficiency sheds new light on the main labour-consuming task in dairy farming. The average daily milking duration of 260 minutes in May (or 4 hours and 20 mins), while yielding an average of 749 litres of milk per hour shows that there is scope for improvement in terms of milking efficiency, especially given that these times did not include any herding tasks, or time spent cleaning down the milking facilities after the milking machine was turned off. The average milking durations were also much longer than the 90 minutes per milking session recommended by Teagasc. However through a combination of adjusting milking machine settings, increasing the number of rows and improving cow flow through the milking parlour, it was shown that milking times on this sample of farms could be reduced by 30% to an average daily milking duration of three hours (cups on to cups off).

Milking facilities worksheet

It is very important to ensure that dairy farm facilities are up to a high standard. Good infrastructure will help to make the farm more efficient and make your work easier but is also vital to maintain cow health. The table of questions below will act as an aid to carry out an evaluation of key farm infrastructure. The answers to these questions can then be used to build a prioritised to-do list for areas that require development or modernisation.

Review

Milking Facilities	Yes	No	Comments	Priority Actions
Is the lead up to the collection yard wide and level, does it allow free cow flow, and is it always clean?				
Is the collecting yard big enough for the entire herd (1.5m^2/cow); it is easy to clean after milking?				
Can cows enter the parlour freely, can the milker stay in the pit during milking ?				
I am very happy with my current parlour				
The structure and roof are in good condition				
The pit is correct depth for me				
The fall in the pit is equal to the milkline, I don't have to stretch for controls which are too high at one end of the pit				
The milking machine is less than 20 years old				
Concrete floors are in good condition are not worn, rails are all in good condition and not rusted or bending				
There is a good feeding system in the parlour which is easy to operate				
The vacuum pump and motor are located in a separate pump room				
All cows in the herd can be milked in 8 rows or less				
The first cows in the row are never fully milked out before I have the last unit on (If cows are milked out before the last units was attached, cluster removers may be required)				

Milking Facilities	Yes	No	Comments	Priority Actions
My teat sprayer droppers are easily reached from every cow position				
I can open and close the front and rear gates from any position in the pit				
Cows exit the parlour without holdup and can walk freely back to grass				
The drafting system currently in use is quick and works well, and I rarely miss a cow. It doesn't restrict the cow flow out of the parlour				
I can carry out tasks such as vaccination or tail painting easily and efficiently using my current system				

Based on the answers listed above, prioritise the top five items to address. Put down a target date for completing this work. Talk to your Teagasc advisor who can assist in putting together a workable solution for your farm.

Table 9. List of priority areas for action		
Item	Date	Advice needed

2019 milking equipment survey

In early 2019, an online milking facility survey was launched with the objective of assessing farmer feedback in relation to current milking facilities. Out of the survey participants, over 95% of respondent farmers were milking in a herringbone parlour. Around 6% of these were double up systems with units for cows on both sides of the parlour, 11% were recording jar plants. The percentage of respondents with rotary and robotic parlours was still very small, around 3% were using rotary parlours and less than 1% of farmers were using an automatic milking system.

Milking rows

Over 40% of the farms surveyed were milking 10 rows of cows or more, with 10% of farmers milking over 13 rows of cows, one farmer was milking 25 rows of cows. These high numbers of rows inevitably lead to very long milking times. It is difficult to maintain high standards of hygiene and milking procedure in the parlour for prolonged periods. Increased milking times can lead to increased levels of stress, and a tendency to take short cuts which can have an effect on the health of the cow.

Attracting and retaining farm staff will be more challenging if the milking time is excessive. It will be especially difficult to attract staff who will give the time and care to each cow from the first row to the last, over these prolonged periods.

The average milking time per row on Irish farms is at around 14 minutes, which indicates that there is great scope for improvements, since the cluster on time (i.e. milking portion of row time) is roughly 50% of this total row time. Ideally row times would be in the region of 11 minutes, which is achievable if cow flow through the parlour is good. Hence, best practice would be to size the milking machine to milk no more than 8 rows, while focusing on keeping row time to approximately 11 minutes. This would enable a total cups on to cups off time of less than 90 minutes. This coupled with herding the cows, washing up etc. means that the milking process would be completed in less than two hours for each milking. Finishing milking at a reasonable time in the evening promotes a better work-life balance, which is critical for wellbeing.

Technology

As part of the milking facility survey, farmers were asked to rate their satisfaction with current technologies and to pick the top three items they would like to add to their current parlours. Automatic cluster removers (ACRs) emerged as one of the most popular technologies. Of the farms that had them fitted already ACR's came out as one of the highest rated items, in-parlour feeding was also rated highly. ACR's were among the top items on farmer's wish list to add to their parlour.

Automatic cluster removers

Of the farmers surveyed, 75% currently using automatic drafting felt it was a great investment. It was the number one item on farmer's wish list to add to the parlour. Given that the survey was carried out during the breeding season this may have influenced the choice somewhat. Of the farmers surveyed, 20% felt investing in automatic drafting was an "alright" decision, and 5% were not happy with their investment. It is important to make sure that the drafting system chosen is easy to use, and the layout is well designed to ensure that there is a very low missed cow rate. Some of the farmers surveyed had replaced an existing drafting system with a newer more reliable system. Manual drafting systems were commonly used, but farmers felt that there were better solutions available. While a minority of survey participants had an auto heat detection system on their farms, 65% were very happy with the technology, but 35% felt it was a poor investment decision.

Technologies with the highest satisfaction rating

- Auto Cluster Removers
- Auto Drafting System
- In parlour feeding
- Auto washer on the milking machine

Automatic drafting system

Energy efficiency

Action points

- Benchmark your farms energy costs against other farms. The average cost of electricity usage on Irish dairy farms is €5/1,000 litres milk produced.
- Check the electricity unit cost against the best unit rates using a cost comparison website.
- Use night rate electricity for water heating and the morning milking. Night rate hours are from 11 pm to 8 am during winter time and 12 midnight to 9 am for summer time.
- Examine energy efficiency projects on a case by case basis using the Dairy Energy Decision Support Tool.

Introduction

The average cost of electricity on Irish dairy farms is €5/1,000 litres of milk produced. The main drivers of electricity consumption on dairy farms are milk cooling (31%), the milking machine (20%) and water heating (23%). There is a large variation in that figure – from €2.60 to €8.70/1,000 litres produced, or from €15 to €45/cow/year. It is challenging to deliver a set of generalised recommendations to farmers around energy efficiency because every farm is different in some key areas. These include herd size, infrastructure specification, farmer age & eligibility for grant aid and availability of grant aid for specific technologies. Hence, it is necessary to evaluate the cost/benefit of key energy efficiency and renewable technologies on a case by case basis on individual farms. A more detailed breakdown of energy consumption is illustrated in Figure 3.

Calculate your energy costs

The following electricity usage survey can be used as a template to guide these calculations. Once the survey has been completed, the energy audit template can be used to identify areas where outdated technology may be replaced with upgraded energy efficient technology.

Night Rate electricity Vs Day Rate electricity

Night rate is charged at ~€0.08 per KWh, and day rate is charged at ~€0.16 per KWh; exact costs vary by the electricity supplier. Checking your pricing and tariff structure against the best available rates can also yield significant savings. The cheapest supplier could be 20% less than the most expensive supplier.

Key points about night rate electricity

- Night rate hours are from 11 pm to 8 am during winter time and 12 midnight to 9 am for summer time.
- Where appliances are required to operate during night rate hours (e.g., electrical water heaters), digital time clocks with battery backup should be used.
- Analogue timers without battery back-up will become out of sync in power failures.
- Note: There is no charge from ESB networks to install a night rate meter. The meter standing charges increase from approx. €0.46/day to €0.60/day after moving to night rate electricity. This means that a minimum of 1.5 units of electricity would need to be used each night to offset the extra charges.
- A typical dairy water heater uses approx. 1.5 units of electricity per hour and takes about 6 hours to reach full temperature.

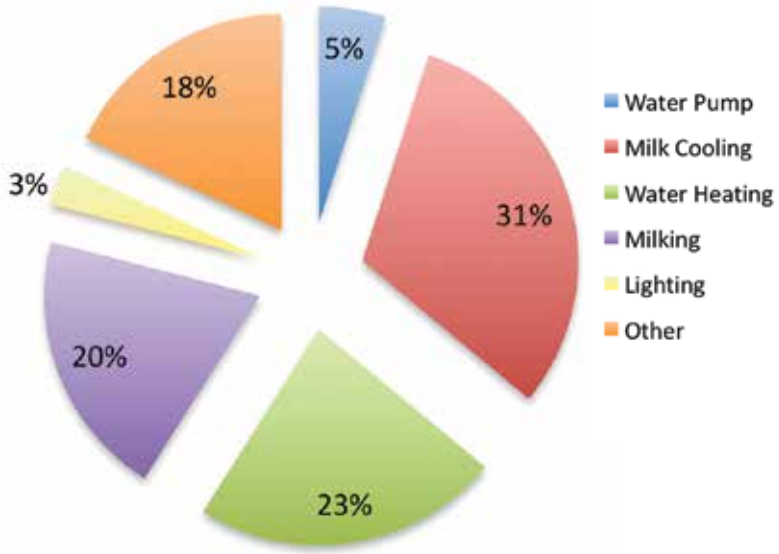


Figure 3. *Average component consumption on 60 commercial dairy farms*

Electricity usage survey

To complete this table gather electricity bills for a recent 12 month period, ideally January to December, but any 12 month period will suffice. Complete the table below from the data contained on the various bills.

Table 10. Electricity usage survey and calculation of key performance indicators				
	Opening	Closing	Usage	
Date				
Day rate (meter reading)				Transfer to 1 on below
Night rate (meter reading)				Transfer to 2 on below

1. Day rate use (kWh)		A
2. Night rate use (kWh)		B
3. % Night rate		B/(A+B)
4. Electricity used (kWh) (See notes below)		A+B = C
5. Total electricity charges (€) for the 12 month period, from bill*		D
6. Litres milk sold over the same period		E
7. Average number of cows milked over the same period		F
8. Calculate electricity used per litre of milk produced (Wh/L)		C*1000/E
9. Calculate electricity cost per litre (cent per L)		D*100/E
10. Calculate electricity cost per cow (€ per cow)		D/F
11. Electricity supplier		
12. Current day tariff		
13. Current night tariff		

* *Excluding standing charges, VAT and PSO levy*

Notes:

- The readings at both the beginning and end of the 12 month period chosen must be 'actual' (a) as opposed to 'estimated' (e).
- If the household electricity is included in the farm bill deduct 5,000 kWh from the total usage for an average 4 person household. For lower or higher occupancy work out usage based in 1,300 kWh per person or 41 kWh /m^2 of area as per http://www.seai.ie/Publications/Statistics_Publications/Energy-in-the-Residential-Sector/Energy-in-the-Residential-Sector-2013.pdf

Energy audit worksheet

Table 11. Energy audit template				
Farmer name				
1. Electricity supplier[1]				
2. Plate cooler	Yes		No	
3. What temperature does the plate cooler get the milk down to?[2]				
4. Is the milk cooling compressor radiator clean?	Yes		No	
5. Can the warm air from the cooling system escape easily?	Yes		No	
6. Night rate electricity?	Yes		No	
7. Water heater synchronised with night rate?	Yes		No	
8. Is the hot water pipe insulated?	Yes		No	
9. Is the farm in a hard water area?	Yes		No	
10. Is a water softener used?	Yes		No	
11. Variable speed milk pump	Yes		No	
12. Variable speed vacuum pump	Yes		No	
13. Solar thermal heating	Yes		No	
14. Heat recovery system (in addition to plate cooling)	Yes		No	
15. Thermostat temperature for hot water heater[3]				
16. Thermostat temperature for bulk tank[4]				
17. Have you any water leaks around the farm?	Yes		No	

[1] *Check www.bonkers.ie for price comparison and find the cheapest supplier. All you need is information about your present tariff, annual usage and night rate usage in order to make comparisons and calculate possible savings. If you decide to switch suppliers, it is important to read the small print. Check the standing charges and termination charges.*

[2] *The milk should be cooled to within 5 degrees of the well water temperature. e.g. if the well water is at 10 degrees, the milk should enter the tank at 15 degrees.*

[3] *75 degrees is adequate for washing the milking machine. When did you last check the hot water temperature? (Fill a jug with hot water from water heater and test temperature with a thermometer).*

[4] *60 degrees is adequate for washing the bulk tank. When did you last check the hot water temperature?*

Prioritising investments in energy efficiency projects

When deciding on the most feasible energy efficient projects to undertake, it is vital to base decisions on farm specific advice. To this end, Teagasc has partnered with Cork Institute of Technology and the Sustainable Energy Authority of Ireland under the Research Development and Demonstration funding programme to deliver an on-line decision support tool to aide farmers in making decisions regarding energy efficiency and technology investments. The tool, known as the Dairy Energy Decision Support Tool (DEDST) is available to use for free at: http://messo.cit.ie/dairy

The DEDST can be used to obtain farm specific recommendations relating to energy use, technology investments, CO_2 mitigation and renewable energy generation. It is an interactive and easy to use tool aimed at farmers, farm managers and farm advisors. It provides information to the user regarding key decisions that determine the energy efficiency and cost effectiveness of the milk production process, such as investment in certain technologies and changes in farm management practices. It can also be used to support government bodies in forming new policy relating to provision of grant aid for energy efficient and renewable energy technologies.

Description of the tool

The DEDST operates as a web based platform, and encompasses a user interface that supplies information to a mechanistic model for dairy farm energy consumption. The user enters details of a specific farm, including farm size, milking times, number of milking units, cooling system type, water heating type and electricity tariff. Details of an alternative technology to be evaluated on that farm can then be entered. Possible alternative technologies include plate coolers, variable speed drives, heat recovery systems, solar photovoltaics, wind turbines and solar thermal systems. The user may also enter economic details regarding potential future grant aid for the alternative technology, as well as renewable energy feed-in tariffs, and inflation. All energy and economic calculations are then computed by the model with the outputs being displayed on an easy to interpret output screen. The user can then easily change details relating to the farm or the alternative technology, with the displayed outputs updating accordingly.

Example – investment in a solar photovoltaic system

Solar photovoltaic (PV) cells generate electricity using energy from the sun, which in turn can be used by the farm. These systems can be stand-alone (i.e. the generated electricity is only used by the farm) or grid connected (where surplus electricity is fed into the national electricity grid). Unfortunately, in Ireland there is no payment for export of electricity to the grid from small scale PV systems. Hence, the most logical solution for Irish farmers would be a stand-alone system, sized so that all electricity generated is consumed by the farm. For a 100 cow spring calving herd, the ideal PV system size falls at around 6 kW of installed capacity, which would cost in the region of €7,500. In the absence of a capital investment grant, this system would have a payback period of 13 years. If a 40% grant was available, the payback period would fall to 8 years, while a 60% grant would make the payback period fall to 5 years. The inclusion of a 6kW PV system would result in 28% of the farm's electricity being provided by a renewable source and would offset more than 2.4 tonnes of CO_2 per year. PV systems qualify for accelerated capital allowances (i.e. the entire cost of the installation can be written off against tax in the year of purchase), which would further reduce the payback period.

Conclusion

The methods deployed in the development of this tool utilised resources from multiple sources to package a suite of scientific outputs into a user friendly decision support tool. The DEDST can now be used by farmers and advisors to make informed decisions around energy use and technology investments on a case by case basis. It will also allow policy makers to conduct macro-level analyses to inform decisions regarding provision of grant aid for specific equipment.

Supplementary material

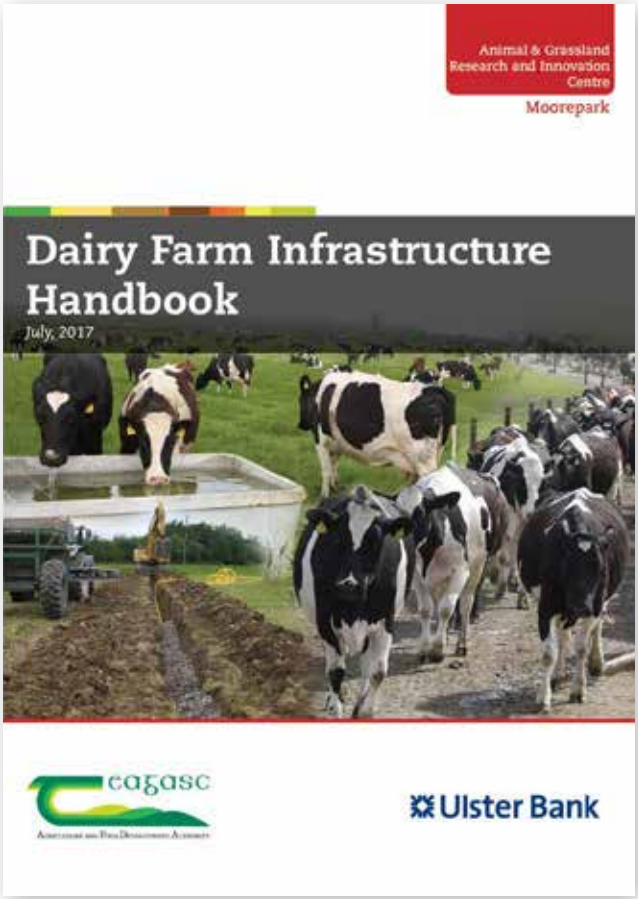
Dairy Farm Energy Fact Sheet #4, August 2016, available at https://www.teagasc.ie/media/website/publications/2016/04.-Dairy-Farm-Energy.pdf

Energy Usage on Dairy Farms

http://tnet.teagasc.net/dairy/in-service-training/2017/new%20dairy%20adviser%20training%20080317/dairy%20energy%20usage%20upton.pptx

Further Information

This workbook provides an overview of dairy farm infrastructure to facilitate a review process for your farm. The Dairy Farm Infrastructure Handbook published in 2017 provides greater detail on these issues and is available from the Teagasc website at https://www.teagasc.ie/publications/2017/dairy-farm-infrastructure-handbook.php



Notes

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the farming expertise to help.

Email: **agri@ulsterbank.com**

Contact Details

Moorepark Animal & Grassland Research and Innovation Centre,
Teagasc,
Moorepark,
Fermoy,
Co. Cork

Tel : 353 (0)25 42458
Fax : 353 (0)25 42340
Email:Moorepark_Dairy@teagasc.ie

www.teagasc.ie

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