

Automatic Milking Systems

*An introduction to automatic milking in
New Zealand pastoral dairy systems*



DairyNZ

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Foreword

Automating milking is considered one of the last challenges of modern dairy farming – and to automate this task would indeed change the New Zealand dairy industry.

In 2001, the DairyNZ Greenfield Project was established with the rather audacious goal of turning milking into a background activity on dairy farms.

The approach was to develop alternative farm layouts that incorporated internationally developed automatic milking technology and take advantage of the considerable behavioural abilities of cows.

The objective was to develop a farming system that reduced the requirement for physical labour and increased the farms productive potential.

Within the wider automatic farm development, opportunities for productivity gains through automation of other tasks including monitoring milk quality and animal health, fencing, reproduction and herd testing have also been researched.

This project has proved that automated milking can be successful within a New Zealand pastoral system leading to the launch of the first commercial dairy farms using automated milking technology in 2008.

Automated milking is now an option for many New Zealand dairy farmers to consider.

This booklet provides an introduction to automatic milking, outlining some of the key findings from the research to date, as well as providing answers and guidelines for farmers exploring the introduction of automated milking to their own farm business.

Tim Mackle, *CEO DairyNZ*

Tony Wilding, *Chairman Waikato Automated Milking Farmer Group*

What is an AMS?

An Automatic Milking System (AMS) refers to a system that automates all the functions of the milking process and cow management currently undertaken in conventional milking by a mix of manual and machine systems.

They are often referred to as robotic or voluntary milking systems. They typically consist of a milking stall or crate with a robotic arm that attaches the teat cups to each cow without human intervention, an electronic identification system and a milking machine, and sensors to assess animal health and milk quality.

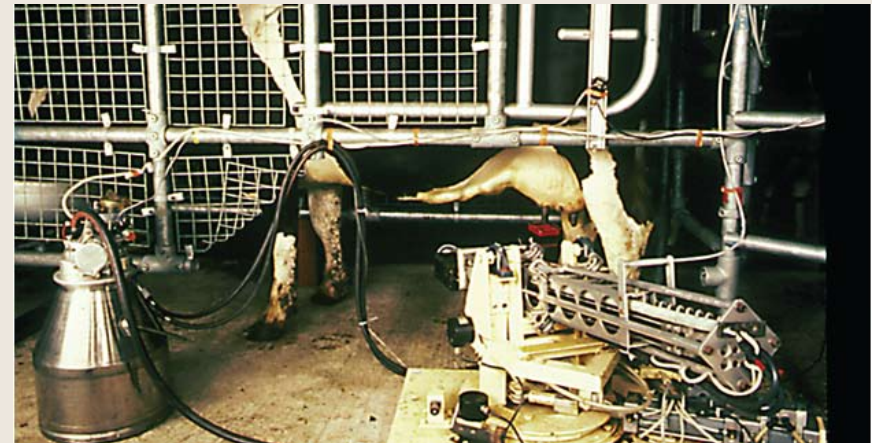
But I thought that automatic milking was only for European farms?

The technology was originally developed in Europe, for small, housed herds on family operated farms that needed to counter increasing costs of inputs and falling milk prices by increasing their output per man-hour. AMS allowed farmers to achieve a higher milking frequency and provided greater flexibility and lifestyle. Automated milking systems are now in more than twenty countries with varying farming methods.

Grazing is not yet common with AMS, mainly because it is difficult to achieve the higher milking frequencies when cows are turned out to pasture – as opposed to being housed indoors.

While farmers in other dairy processing countries, particularly Northern Europe, have been using automatic milking systems for some time it is still a very new technology for New Zealand farms.

Timeline of automatic milking system development



One of the first successful attempts to attach a teat cup to an udder with a robotic arm, Silsoe Research, UK. (Picture: J E Hillerton)

- 1985*** First milking cup is attached to a cow using a robotic arm under experimental setting
- 1992** First commercial AMS installed on a farm in The Netherlands
- 2000** Approximately 800 farms worldwide using AMS
- 2001** First cow milked in New Zealand using an AMS (Greenfield Project, Hamilton)
- 2003** Greenfield Project herd is expanded to 180 cows milked by two AMS
- 2007** Approximately 8000 AMS units in operation on farms in 22 countries worldwide
- 2008** First commercial AMS farms established in New Zealand

**approximate*

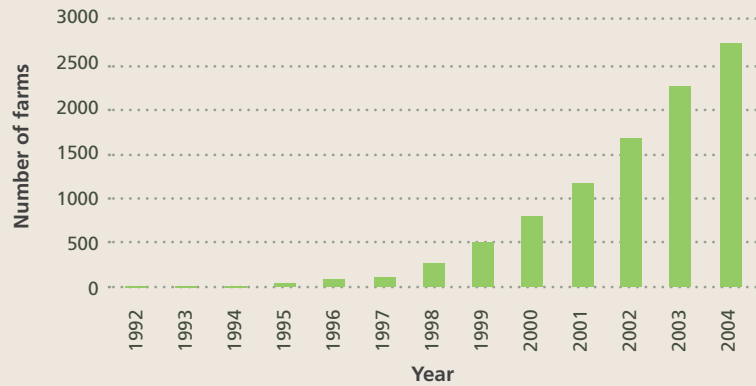


Figure 1. Use of automatic milking systems on commercial farms worldwide. Source: M. Dam Rasmussen 2005

The adoption of automatic milking went slowly until 1998. Since 2004 the numbers of farms adopting automatic milking have continued to grow exponentially and now there are approximately 8,000 units in operation worldwide.

What are the main differences between automatic and conventional milking?

- One cow is milked at a time in a single stall AMS (or if multi-stall AMS are used up to 5 cows can be milked at a time)
- Cows are milked throughout 24-hours, the farm never stops
- The cows must volunteer for milking (i.e. they must walk from their paddock to the dairy housing the AMS)
- The interval between milkings will be variable and dependent upon a combination of cows' willingness to report to the dairy and operator settings
- Every cow is not seen by staff every day, some cows will always milk at night so information from sensors that indicate milk quality and animal health is critical.
- Milking is on a quarter basis – each teat cup is attached sequentially and removed based on milk flow from that particular quarter
- Fewer clusters are used to milk a herd (e.g. 3 AMS could milk 270 cows compared with say 20 clusters in a herringbone dairy)

What can an AMS do?

(Adapted From Baines 2002)

An Automated Milking System CAN....	An Automated Milking System CANNOT...
Admit cow to milking stall	Bring cows to milking stall
Identify cow	Distinguish teats from dirty hair on udder
Determine the expected yield or milking frequency to decide when cow is due to be milked	Milk cows with unsuitable udder conformation
Decide whether cow is due to be milked, based on operator settings	Treat sick cows
Dispense feed, as per operator settings	Call the veterinarian
Determine the level of concentrate feeding for the cows	Inseminate cows
Clean teats	Cure cows already infected with mastitis
Attach teat cups	Manage and deliver roughage feeding
Remove teat cups when flow rate falls to pre-determined level	Clean down the milking area
Spray post milking teat disinfection	Order semen
Allow cow to leave stall	Refill chemical containers
Reject milk, as per operator settings	Order new supplies of feed and chemicals
Record milk yield	Replace worn or damaged rubber components
Access and report on milk quality using in-line sensors	Service itself
Draft cows as per operator settings or using sensor data	Become frustrated and angry and fail to turn up to work!
Raise alarm lists, as per operator settings	
Page the operator in emergency, as per operator settings	
When combined with a cow traffic management system it can also manage paddock grazing.	

Is AMS an option for your farm?

Automatic milking systems are now available in New Zealand – but how do you know if they are an option for your farm?

How reliable are the machines?

There are now more than 8,000 automatic milking systems operating on commercial dairy farms across the world with predictions of over 2,000 units to be sold in the coming 12 months. It is proven technology.

Regular preventative maintenance is required, with fortnightly farmer services (mainly checking equipment) and less frequent technical services completed by company technicians.

It is important to realise that while it is no longer necessary to milk the cows staff must be able to be contacted via pager or cell phone to attend to any alarms - which could occur at any time. The latest models allow you to attend to some alarms remotely and reset the milking station using a laptop computer.

How does automatic milking change labour on farms?

A change to automatic milking will mean a change in the tasks that people are required to carry out on-farm. Many routine jobs must still be completed but the timing of those jobs is more flexible. Automatic milking has exciting potential for those managing multiple farms. Because of the flexibility in work routines and low physical demands of the tasks that need to be carried out on an automatic milking farm, staff and work routines could be scheduled or staggered across farms allowing for more efficient labour use and more reasonable hours of work. One person could be on-call to attend out-of-hours alarms for several sites.

With the exception of training cows, each task can be completed by one person, regardless of herd size. A basic high level of technical ability will be required for automatic milking farms. Good animal husbandry skills are essential. Staff must be able to interpret information provided by the system to make informed decisions regarding cow health and feeding levels.

The importance of people in the success of automatic milking operations should not be underestimated. Not all people will be suited to this technology. For those wanting to reduce the manual workload and spend more time on what matters most like feeding, pasture management, cow health and reproduction, then this technology offers exciting potential.

What farm system is best suited to automatic milking?

Dairy farms in New Zealand are classified as system 1 to 5 based on the level of bought feed (including grazing off) used and fertiliser applied. In general the higher the level of imported feed the easier it should be to implement and get the full benefit of automatic milking and individual cow feeding, particularly if supplementary feed is offered at the dairy.

A small level of concentrate is required to maintain efficient cow flow through the milking stations, meaning automatic milking is less suited to system 1 farms. The DairyNZ research farm (Greenfield Project)

successfully operates within the criteria of a system 2 farm. Within conventional systems emphasis is on milk production per ha. This is equally applicable to automatic milking, however milk production per milking station is another very important performance indicator for system profit. The focus should be on maximising the 24-hour use of the automatic milking system, whichever farm system is operated.

How many milking stations do I need to milk my herd?

The most common automated milking systems milk one cow at a time but operate 24-hours a day. The number needed to milk a herd will depend on how often the cows are milked, the peak yield of the herd and what level of utilisation of the milking stations can be achieved.

Each milking has a fixed set-up time, so the aim is to increase the yield per milking by increasing the time between milkings but not to the extent that per cow production is compromised.

Is there conflict between pasture utilisation and automatic milking?

No, but you will need to manage both pasture and AMS utilisation in unison.

Successful automatic milking goes hand in hand with excellent pasture management, which is good news given New Zealand's pastoral farming systems. This is because voluntary cow movement is largely determined by pasture availability. Looking at post-grazing residuals, along with production and milking frequency data available from the management software, provides a key gauge of feeding level, ensuring pasture harvested is maximised.

To achieve high AMS utilisation with approximately 90 cows per milking station, without extended cow waiting times, requires good control of cow traffic. This is achieved using drafting units or selection gates, either in the dairy or along the raceways remote from the dairy, which automatically allow targeted cows to enter a new grazing area, be returned to older pasture or sent to the dairy for milking. Typically two or three new areas of pasture are available to the herd daily, with one of these occurring near midnight to ensure the milking stations are kept busy during the early morning hours.

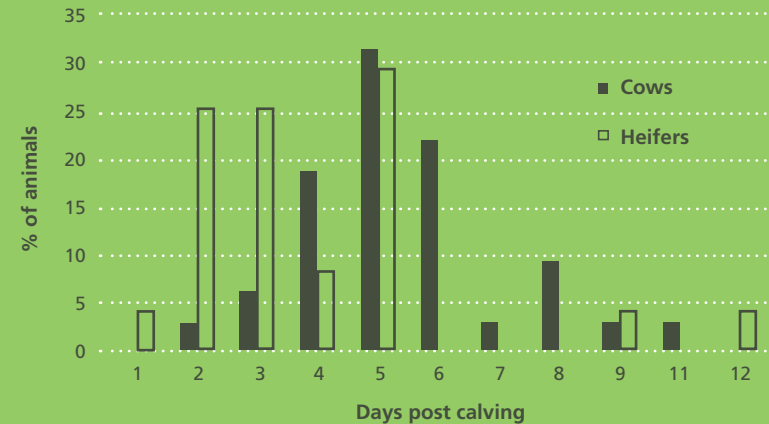


Figure 2. Speed of adaption of cows and heifers to automatic milking measured by days post calving until a voluntary and unassisted milking is achieved. Data are from research undertaken at the Greenfield Farm in 2004.

How easy is it to train cows?

Experience has shown that more than 99% of cows can be trained to use automatic milking systems and can learn to milk themselves. Training is labour-intensive and critical to a successful operation. Ninety per cent of cows will learn within seven days. Surprisingly, heifers have not posed a problem, with the exception of smaller animals.

How is mastitis detected?

All brands of machine are equipped with multiple sensors (e.g. electrical conductivity, somatic cell count) that measure milk quality and udder health at every milking. Some brands have the ability to draft cows automatically if mastitis is suspected. While each cow is not sighted every day, in an automatic milking situation the herd manager has much more information to determine if a cow has mastitis than in most conventional systems. Experience has shown that as long as the alert reports are routinely checked and acted on mastitis detection is not a difficult task.

Do I need to change my grazing system?

The simple answer is no!

Profitable operation of pastoral dairy systems is based on the correct feed allowance per cow that will result in optimal/profitable feed conversion efficiency per cow and hectare. Research indicates this is approximately 80 - 90 kg LWT/t DM.

Grazing systems have been developed to utilise pasture efficiently and allocate feed to the herd in a manner that balances cow production and profit. There are grazing 'tools' in use that enhance this (e.g. pre-graze mowing, returning cows to a grazed area until the desired residual is achieved), and pastoral AMS utilises many of the same 'tools'.

...But you will need to change the grazing method.

Within a batch milked system control over access to grazing and milking frequency are directly imposed in the day-to-day operation of the farm.

By contrast, automatic milking relies on voluntary cow movement from the grazing area to the AMS. Control of the operational running of the farm is then a shared function between farm staff and the cows themselves. It is important that rotational grazing is balanced to induce cow movement. To achieve this at least 2 and preferably 3 allocations of fresh pasture (or other feed) are offered each day.

How does it work for an all pasture system?

Many people believe that all grass dairy systems cannot work with voluntary milking. DairyNZ research has shown that with appropriate cow traffic systems in place 24-hours, milking can be achieved with just 2.5% of the diet being concentrate fed through the AMS and over 13 T/ha DM can be harvested from the farm.

Feed availability is a prime motivator of cow movement, in particular pasture residual mass is a critical factor that motivates the cows to move. Voluntary cow movement is necessary to obtain a desired milking frequency, which affects milk yield. The effect is a cyclic pattern of linked events that will determine productivity of the system (Figure 1).

As pasture residual levels increase cows reduce voluntary movement and therefore milk less frequently resulting in reduced yield. This creates a reduced feed demand, which in turn will result in higher residual mass level. The direction of this cycle is critical for pastoral AMS.



Figure 1. Cyclic pattern of pasture harvested, milking frequency, and milk yield within an AMS.

What if the feed balance changes?

A flexible approach to manual cow movement has a positive effect especially during periods when pasture supply exceeds demand. Typically, cows remaining in a grazed area would be manually moved from that break twice daily. Adopting a flexible approach to the timing of these manual moves can allow for greater control over post-grazing residuals and therefore intakes. There are other flow-on benefits in terms of increasing milking frequency and AMS utilisation. The timing of manual moves is determined by cow traffic patterns, paddock location, time of day and grazing residual.

Will AMS maintain my system productivity?

The association between pasture utilisation and milk yield are important in both conventional and automatic milking, however the emphasis on the two within automatic milking has additional benefits to the system (i.e. cow flow). This means that an effective automatic milking farm is equivalent to a highly effective conventional farm. DairyNZ research has produced results from a low input system (2.5% of feed imported) that are equivalent to a 'best practice' conventional system.

How is cow movement controlled?

Multiple incentives are needed to encourage cows to and from grazing areas. These can include:

- water (in the dairy and/or in selection units)
- fresh pasture
- feed in the AMS at milking (e.g. concentrate or molasses)
- forage near the dairy

Experience has shown that an AMS, with a high reliance on pasture as the feed supply, requires control over cow movement remote from the dairy (i.e. in the paddock). Selection units, located at key points in the raceways, can control cow movement around the farm. A selection unit is a small yard and a set of computer controlled 3-way drafting gates.

Cows visit the selection units throughout the day and night, motivated by the prospect of a fresh break of pasture or water. When due for milking (as determined by pre-set milking intervals and/or last-milking yield), individual cows are directed toward the dairy through a series of one-way gates, then return to pasture. Cows not due for milking return to the same paddock or to a fresh break if available.

What affect will introduced feed have on AMS?

Voluntary milking systems are reliant on motivation within the system for cow movement. All AMS have a feed bin at the front of the stall in which meal can be dispensed. The introduction of imported feed requires no labour input as the feed is allocated to the cow as she is milking. As the feed allocation at the AMS increases so does the motivation to 'visit' the AMS.

The 1-5 farm system definitions used by DairyNZ are based on the feed imported, and a system that is totally reliant on pasture, as the feed supply, will require efficient pasture management skills. DairyNZ research has demonstrated that the system is effective with 97.5% of the diet from pasture. As the quantity of imported feed increases the emphasis shifts from intense grazing management to ration balancing skills. In essence the same factors that are applied to a conventional system when increasing the feed input (i.e. importing feed) will apply to an AMS. With the exception that the infrastructure required is reduced (i.e. feeding concentrates 'in bail' is an existing facility).



But my farm is hilly – will that be a problem?

Most pasture-based farms using AMS technology are flat so the impact of rolling to hilly country is relatively untested. One exception is the Sydney University FutureDairy farm where cows must walk up a steep hill to reach the dairy housing the AMS. Other farms are operating where the cows are unsighted from the dairy so we know they will easily follow the raceways to get to the AMS. It is likely that rolling country will not be a problem but as the land becomes steeper more manual intervention will be required.

Are there any limits to herd size and walking distances?

The Greenfield farm has a herd of 180 cows and two AMS. An Australian farm is comfortably milking about 250 cows with 4 AMS. The first commercial farms in New Zealand will milk around 300 cows with 4 AMS. Milking larger herds in grass based systems is unproven, however there are some very large farms in the USA that have 32 AMS units milking close to 2,000 cows, but using interconnected barns and clusters of 8 AMS.

Walking distance will become a problem – the point at which this occurs is not known yet. Farms are operating where cows are walking up to 1km from the paddock to the dairy. The maximum limit will depend upon farm layout and desired milking frequency.

Will AMS suit me?

It is becoming apparent that as well as the technical performance of the AMS and the design of the dairy and grazing system, another key factor in a successful AMS installation is the operator.

While it is important that the user is comfortable with technology and is not overwhelmed by hardware and software, it is essential that they are capable of taking a step back and trusting the technology. Frequent intervention and constant adjustment to the settings of the AMS will reduce attachment rates and overall performance.

It is also essential the operator recognises the importance of regular planned maintenance and cleaning and implements a routine external cleaning and maintenance programme. It is also important that the operator recognises that while the AMS will harvest milk from the cows, the daily management of the herd is still required.

AMS is not a substitute for good farm management practices.



AMS - The Financial Considerations

Many factors must be considered when looking at the installation of an automatic milking system on a farm. However, a major factor is the economics of such a system and how it stacks up against a conventional dairy farm.

Historically, when looking at funding new projects or capital ventures the majority of farmers and their bankers have looked at the capital required, cash flows and capital appreciation over time. When comparing two or more options such as a conventional conversion with a rotary shed versus an AMS farm, an investment analysis is required.

One investment tool is the Net Present Value (NPV) calculation. This looks at the capital requirements, expected lifetime of the investment, cash flow, residual value and looks at the returns of that investment in today's (present) dollar terms. It includes taxation and depreciation. The majority of this information can be sourced by the farmer, although someone with the skills to calculate a NPV, such as an accountant, may be required.



Capital Requirements

Farm conversion

New building requirements

- Roof and shelter over the milking robots
- Office
- Machine room
- Storage area
- Concrete floor area to include waiting area, machines, entry, exits and a feed area if included
- Area for the main vat and holding vat
- Effluent system as with any dairy operation
- Pipe work – Generally less pipe work due to lower numbers through the shed and resulting lower pressure from stock

Selection system

- Pre-selection system – at the farm dairy and/or out on the farm
- Power and compressed air to the pre-selection system
- Concrete area under the units (high traffic)

Farm races

- Will depend on the farm design, but only small races required as there is little need to traffic the whole herd at once
- Big enough to get farm machinery down
- In some cases these will need to be set up to allow two lanes on the race

Water system

- The same volume and quality of water is required, but potentially fewer troughs, water lines and fittings are required. One option is to only have water at the farm dairy and/or selection units

Plant, AMS and stock identification

- AMS including herd management software, vacuum pump and compressors
 - The number of AMS are dependant on the farm system and how many cows are going to be milked
 - The desired specifications of the machines
- Vat
 - Buffer tank/vat (for when tanker takes milk and main vat awaits washing)
 - Specialist vat – for example for colostrum or specific milk from certain cows in the herd (may be supplied by the dairy company)
- Cow identification
 - Electronic tags (neck, ear or leg mounted)
- In-shed feeding system
 - There is a basic requirement to feed a small amount of concentrates in the shed. What farm system do you plan to run and how much concentrate will be fed at the machines and what system is required to store and deliver it?

Fencing

- This will depend on the design. Initially look at setting up blocks A, B and C with permanent fencing, but using temporary fences to allocate pasture within blocks

Housing and vehicles

- Given staff numbers, what are the housing and vehicle requirements?

Existing dairy farm

Farm dairy

- Can the existing farm dairy be modified to house the AMS?
- Pit area will need to be filled in
- Are there other buildings on farm that can house the AMS?

Farm races

- Can the races be modified to traffic cows around the farm?

Otherwise all factors related to the design, machines, selection units and farm is the same as for a new conversion.

Cash Flow Implications

Income

In the first year budget on 5-10 percent less milk production per cow as cows are trained and people get used to the system. Subsequent years can be comparable to a conventional system whether seasonal supply or all year milking. Unless there are plans to supply specialty milk, budget on the normal milk supply.

Expenses

Go through individual budgeted items and see what will change using automatic milking. The main items are:

- Labour – will fewer people be required to run the farm?
- Animal Health – less stress and its impact on lameness and in-calf rates?
- Feed costs – what will it cost to feed concentrates at the AMS

- Herd testing – can herd test just once a year as the machines collect milk volume and quality information each milking
- Farm dairy and robot servicing costs – servicing of the robots is a major cost difference and will depend on the servicing contract – check it out with the supplier

If looking to compare a conventional system with an AMS, then collect all the information as above for the conventional farm.

Replacing an existing conventional farm dairy with an AMS is unlikely to be economic due to the capital involved. However, if converting a farm or replacing an old farm dairy and plant, then analyse and see if the two systems are comparable!

Where to find out more

If considering automatic milking it is important to research the different options thoroughly. Lely Ltd, DeLaval, SAC, Westfalia, Zenith and Fullwood (UK) all supply equipment internationally and Lely NZ are actively marketing the technology locally.

Visit New Zealand and Australian research farms that have implemented automatic milking (DairyNZ Greenfield Project research farm, Hamilton; University of Sydney FutureDairy) and enquire about visiting commercial farms such as Stradsbroke Farm, Ashburton, and the Warren Farm located two hours from Melbourne).

Take advantage of the knowledge of experienced independent DairyNZ researchers based in Hamilton or visit the DairyNZ website for more information.

For more information on automated milking visit the DairyNZ website: www.dairynz.co.nz or call **0800 4 DairyNZ** (0800 4 324 7969)

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DairyNZ

Corner Ruakura and Morrinsville Roads

Private Bag 3221

Hamilton 3240

0800 4 DairyNZ (0800 4 324 7969)

www.dairynz.co.nz

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