Challenges and Opportunities for Large Scale Dairies

A Report for

NUFFIELD AUSTRALIA FARMING SCHOLARS

By Paul Lambert

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Executive Summary

The challenges and opportunities for large scale dairy farming are very broad and range from corporate structures to utilising the energy levels and growth rates of grass varieties. This study concentrates on some of the issues that are important for going forward in the Tasmanian industry. Robotic milking is fast becoming popular and in need of further research. Wind turbines, digesters and biomass gasification produce clean energy and could benefit farms in other ways.

As time passes the definition of large scale dairy farming is always expanding. Today a single dairy with a herd of six hundred cows is considered a large herd, but this is really only the beginning of large scale dairy farming. Some regions of New Zealand are averaging over eight hundred cows per dairy farm. Once herds get to this size some farmers have developed systems that can easily be copied onto the next farm and therefore they can easily have two or three farms running very efficiently. Some enterprises in New Zealand and South America have grown to over forty thousand head of dairy cows spread out over sixty farms. Managers and in-house consultants are employed to keep track of operations often in groups of seven thousand to ten thousand cows. Herd size seems to lose efficiency when single herds are over seven hundred and fifty cows and below five hundred cows in grazing systems.

In the pasture based dairy system in a temperate climate it is possible to produce milk more cheaply than any other large scale dairy system in the world. This is largely due to the fact that there is very little machinery and labour used to feed the cows. Most of the cows diet is grazed directly off the paddock and does not pass through a machine. This gives the added bonus that animals under this system can enjoy outdoor life and are not confined to indoor concrete sheds. It does mean though, that in some circumstances, the animals are subject to the elements and may require some form of shelter.

There have been few attempts at making a large scale pasture-based robotic milking system work. It has been said that we should forget the voluntary robotic system and stick with large herds being batch milked through rotary dairies as at present. In the next decade many robotic dairies will be installed for pasture based farming. It is important to plan the correct system now. Voluntary cow flow may need replacing with managed cow traffic using electronic gates at each paddock. It is true that cows can be trained to do just about anything, but when there are large numbers involved it is very risky to leave these herd movements to

chance. Things such as weather conditions, time of lactation, time of day, hunger levels, and what the rest of the herd is doing will greatly influence a cow's motivation to walk in the right direction.

A dairy set-up using robotics to milk two thousand two hundred cows at one central point in a pasture based system would be an efficient system. The cows would be split into three herds of seven hundred and thirty cow each. Milking would take place for 18 to 20 hours, milking twice per day and the hospital herd milked once per day. The main key to this system is keeping management as simple as possible. This system would more than double labour efficiency, and produce good returns.

Wind turbines in the right location, with good feed-in tariffs can be profitable, but most farmers in Europe simply lease to the energy companies the ground where the turbines are situated. This creates a good income source. Embedded generation systems in Tasmania, set up to generate electricity to offset usage costs, are currently this locations best option, with the power generated worth up to eight times more than selling power into the grid for a large scale generator.

Bio digesters are like a giant cow's stomach churning away on a feed of mostly dairy slurry and maize silage. These machines struggle to make money as maize silage prices go up, even with high European government subsidies. Dangerous gasses, breakdowns, and poor returns do not give digesters a very good reputation.

Biomass gasifiers are very common throughout India. Though not directly relevant to handling all dairy waste, they are very relevant to energy and biochar production. Biochar helps to enhance soil structure and nutrition as well as lock up carbon for many years. Municipal gasifiers could take in forestry, farm and municipal waste and turn it into both energy and biochar.

Any large expansion needs capital behind it. Corporates are starting to regard farming as a safe investment. Is there a way for existing farm owners to become part of a corporate structure and keep running the farm? Maybe there needs to be a closer relationship between the two.

Foreword

For many years European dairy farmers have enjoyed the benefits of technology in robotic milking, digesters, biogas and wind turbines. Manufacturers of this equipment are often found in the more highly populated areas with the greatest need. This has meant that these systems have generally been produced specifically to cater for the needs of the local farmers and farming systems, along with their associated government incentives and subsidies. Australian and New Zealand dairy farming, being generally pasture-based (due to the suitable climate), has struggled to adapt to robotic technology that has been designed for European barns. Freight, a new market area (for the manufacturer), inexperienced labour, expense, fear of new technology and lack of Government incentives have mostly lead to higher installation costs and slow market take-up.

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Introduction

Growing up on a dairy farm as a young man in Merseylea, northern Tasmania was always interesting and a lot of fun. Taking on this business and developing it to multiple large commercial dairy farms has been both challenging and rewarding. Building a new dairy sixteen years ago and another more recently brought on many thoughts of installing milking robots and surmising the most efficient way to make them work in our conditions. Over the last few years working with corporate dairy farmers has again been thought-provoking: how to make large farms run a little more smoothly and be better integrated. Using on-farm and municipal waste materials as an energy source and locking more carbon into our soils have also been interests. This study is a culmination of many years of thought and more recently many miles of travel. While robotic milking was the main theme of the study, India had a lot to look at for biomass gasification. Prince Edward Island and Holland were excellent places to study wind turbines. Germany, Holland and England have some great examples of bio digesters. New Zealand and South America have had some well-run corporate dairy farms. Over the last year and a half, over sixty flights, fifteen countries, two books of notes and countless interviews and farm visits, I have formed some very clear thoughts. Robotic milking in one dairy running three separate large herds of over seven hundred cows each is one of these thoughts.

Robotic Milking

1.1 Well proven in confinement

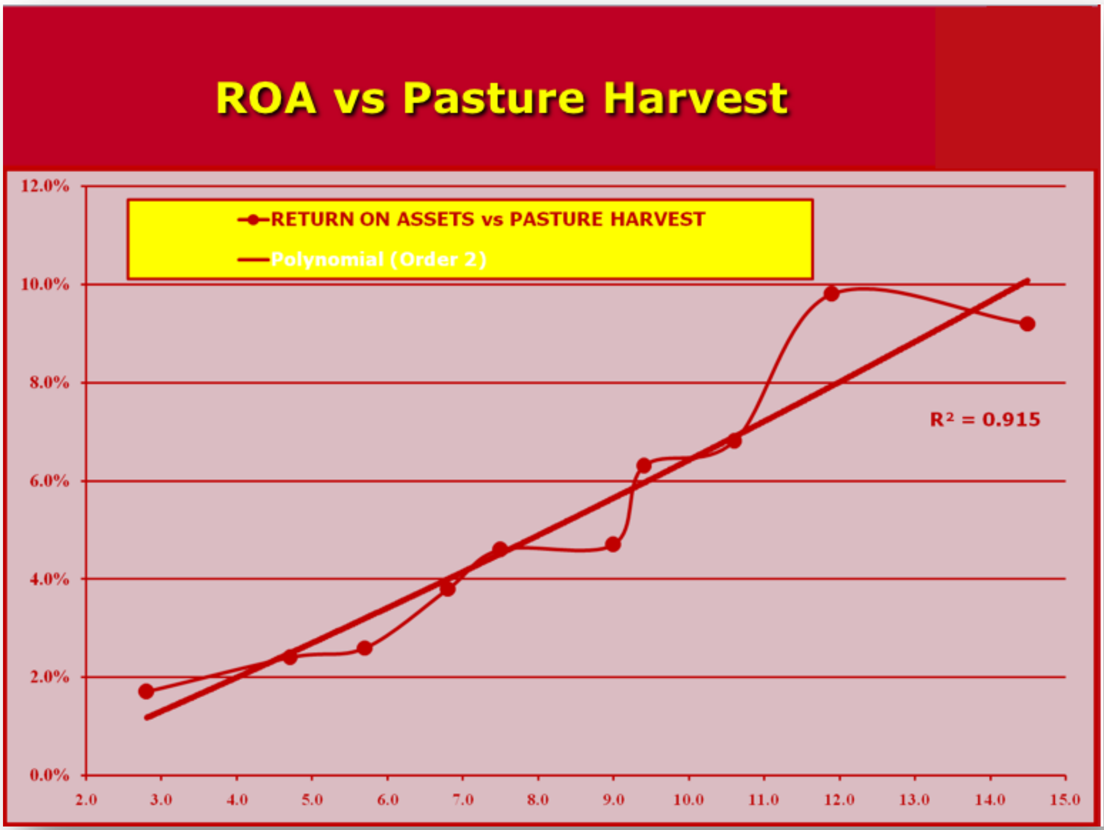
In Europe, particularity Holland and Denmark, milking robots have been around for almost twenty years. Almost half of all milk produced in these two countries is produced through milking robots, which is close to the equivalent of Australia's entire milk production. Uptake of the technology by northern hemisphere farmers is now a relatively simple decision based mostly on price of the equipment and lifestyle. These farms have large barns with all cows housed. Milking robots can be placed strategically through the barns and cows come and go to be milked almost as they please. This system works very well in barns, although on every farm there are still one or two cows that need to be rounded up and made to go through the milking robots twice every day. (Prins, 2011) When farmers who were visited were asked two simple questions about their robotic dairies the answers were always the same. The first of these questions was, "Are you happy with what you received in return for your money for your robotic dairy?" The answer was always that the equipment was too expensive, except for where some farmers were able to buy second hand equipment. The second of these questions was, "if you could turn back time would you still build a robotic dairy, or would you stick with conventional milking systems?" Here the answer was always the same and without hesitation, "no way, we love the lifestyle we have now" (Nrgaard, 2011), (Mathiasen, 2011).

The mature market for milking robots in Europe has led to a lot of competition in price and technological improvements by the manufacturers. Some of the manufacturing companies are now opening up factories in other countries to

produce more robots as demand continues to rise. Three of the factories visited are producing a combined total of almost two hundred robots per week. While this is a staggering number and represents fourteen thousand cows and fifty farmers per week taking up robotics, it is still only a very small percentage worldwide. Internationally there is a huge investment into this technology by farmers who need to make the systems work efficiently to be able to sustain their businesses. Europe is still the largest market for these machines with the United States starting to see increasing new installations; Australia and New Zealand are just starting to move into this area.

1.2 Pasture based systems

Australian and New Zealand dairy farming systems are mostly based on the dairy cows being farmed out in the open pastures, where we have a great climate which makes this possible. More than sixty per cent of Australia's milk production is for export into other countries. While this market is huge and mostly into Asia, we won't have an export market if we are not price-competitive. The only way that most Australian dairy farmers can produce milk at a competitive price, whether feeding large or small amounts of bought-in feed, is to maximise the cheapest source of feed input for the cow. This is in nearly all cases, pasture. It has been well proven, particularly in Tasmania, that there is a very strong link between pasture consumption and profitability of dairy farms.

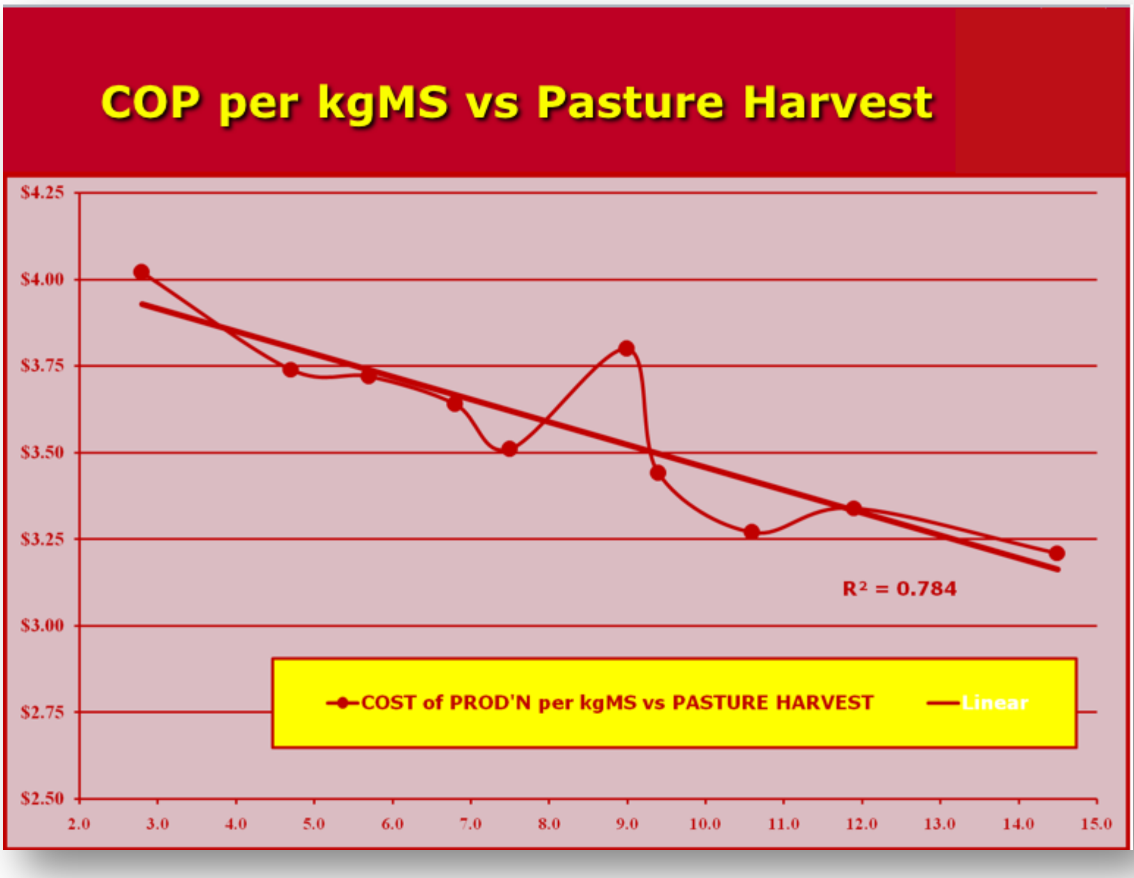


(Beca, Red Sky Data, 2008)

1.3 Keep efficient

This link of pasture consumption to profitability tells us that we must not allow anything to take away from our main source of efficiency if we want to continue to produce milk at a competitive price. This leads into how well we must manage pastures and pasture consumption regardless of what milking process is adopted, whether robotic or conventional. Robotic milking is happening on pasture based systems in Australia, New Zealand and to a limited extent in Europe. Observations and interviews with farm owners and managers, along with recent magazine articles (Dowie, C. *The Australian Dairy Farmer*, May-June 2012, p34-49) show that there is great difficulty in managing pastures efficiently with the current robotic systems that are being promoted as the best practice systems. This alone has the potential to keep this technology being used solely by the few elite top operators who are skilled enough to make the system work. Even these people admit to problems with grazing management and cow traffic becoming a nightmare and some have even recommended that robotics are not for pasture. While this may seem an extreme view, it is the strong opinion of some farmers.

This graph of Australian dairy farms shows the strong link between pasture utilisation and milk solids (MS) production cost



(Beca, Red Sky Data, 2008)

1.4 Labour

Labour is an issue that dairy farmers' worldwide struggle with. Even in places where it may be thought that there is a huge work force to choose from, labour is still a problem. From milking cows by hand in India to large scale barn operations in China, once employed labour is needed, managers and owners often struggle. Recently all eighty staff walked off one large Chinese farm because of a brucellosis outbreak. South America showed some examples of similar trouble on large farms. At one group of farms it was said that the managers spent all of their time trying to round up enough staff for the next milking, and sometimes the cows missed milkings due to lack of staff. Some dairy farmers in the USA would admit to their profitability being strongly linked to the availability of cheap Mexican labour at nine dollars per hour. David Beca, CEO of New Zealand farming systems Uruguay said, referring to staffing, that "dairy farms over one thousand cows have big problems and eight to nine hundred cows have many challenges." (Beca, CEO NZU, 2012). Sourcing labour in Australia is made even more difficult by some of the world's highest labour costs and by limited availability, mainly due to the mining boom. This all adds up to more reasons why Australian dairy farmers could benefit from robotic milking. It is anticipated that, with milking robots and farms correctly laid out, there could be twice as many cows milked per person as there currently is by the top ten per cent of farms. One of the main advantages would be in attracting more people to the industry. The art of profitable and enjoyable dairy farming is not in getting up at five o'clock every morning and milking cows. The solution is in having a system that's simple for others to follow, and then making it something that they want to follow.

1.5 Knowledge is power

Information on each cow that these milking robots generate is quite staggering, to the point that a sick cow can be quite easily identified by the machine. In fact one manufacturer in Europe has gone one step further and hooked up the milking robots to an on farm mini-laboratory (which they developed). This can then go on from where the others stop and by measuring hormones in the milk tell when cows are cycling, have certain illnesses, and when they are pregnant which for dairy farmers is valuable information (Mathiasen, 2011). Although with seasonal calving patterns in southern Australia some of this information may not be as important, it is an indication of trends we will see here in the not too distant future. Cycling cows can be found in a number of ways, and it seems that most of the robotic dairies use a pedometer around the cow's neck that measures movement. This information in most cases is downloaded by the computer at milking time. When cows have higher activity they are considered to be most likely to be coming into heat. These systems don't all work as well as we would hope in pasture-based farming because of the distance cows are walking. Some systems require the cows to be within antenna range all the time to take continuous readings which are compared to the entire herd for greater accuracy. This again works very well in barns, but struggles in grazing systems, particularly with undulating farms.

Mathiasen farm minilab in Denmark

1.6 Complex machines need maintaining

Robotic milking machines are extremely complex pieces of machinery with thousands of components that all need to work together to get the cows milked around the clock. Highly-skilled labour is required for maintenance of robotic dairies. This needs to be carefully considered by anyone looking at installing these machines. In Denmark there were examples of farmers buying a certain brand of milking equipment simply because of a lack of service backup for others. The robots themselves are mostly able to detect their own problems and send messages to the farmers or technicians to call for help or a replacement part. The cost of keeping each robot maintained is quite high, and could represent three to six per cent of the initial cost of each unit just for each year's maintenance contract. These contracts are quite common in Europe and generally have three levels of service to keep the robots running. The cheaper end of these contracts covers a service technician being available during work hours, most parts, some training for the farmer and a tool box of bits to fix what may go wrong outside of business hours. The middle of the road service does not include technicians over weekends and public holidays. The top end covers everything at any hour of the night or day.

1.7 Problems with voluntary milking on pasture

With the absolute necessity of good pasture management in the Australia and New Zealand setting, some new thinking is needed for there to be a greater uptake of robotic milking.

Current pasture based robotic milking systems commonly use a three way grazing system (known as 'ABC grazing') where the cows are never shut into paddocks. In this system the farm is divided into three areas, say A, B and C. Each area is broken down into paddocks. Often a feed pad is used at the dairy to allow waiting cows to eat and to encourage cows to come for milking. In some applications there are out-of-parlour grain feeding stations. This allows the cows to come back to the dairy voluntarily from area 'A' and then head out to some fresh pasture in area 'B' and then area 'C' following the next milking. After this they start back at the next 'A' paddock. In this system cows are always intended to move through the dairy by being motivated by food. Each milking the cow is sent to a new area of pasture.

It is expected that once the last cow leaves the paddock, that the paddock is grazed out. This is not always the case. Each paddock will wait to be grazed again in the next round of the farm, generally twenty to thirty days later. If the initial grazing is incomplete, the feed quality is reduced for the next grazing because dead leaves become part of the pasture sward.

Problems with this system include:

- Cows being pushed to or away from the dairy by bad weather.
- Too much pasture being allocated or cows breaking through a fence causing them to be so full that they are not motivated to move back to the dairy to be milked.
- Too little pasture being allocated can cause too many cows to come to the dairy at once.
- There are always some cows who just don't want to ever come to the dairy voluntarily to be milked.

In Europe, even with culling the non-voluntary cows, farmers have found that another cow or cows will move into that vacant position and refuse to be voluntarily milked (Prins, 2011). Kendra Kerrisk also adds that with larger Australian dairies, "…we know as the distances get further the cows are less willing to come back to the dairy," (Kendra Kerrisk, 2012).

The proposed new idea, as an alternative to this ABC grazing system described above, involves using a semi-voluntary batch milking system. This would mean that cow traffic is always controlled and that herds of cows could go straight back to the paddock where they have just come from to finish grazing if necessary. This concept is further explained in later sections.

Tasmanian pasture based dairy farming

1.8 Portable Robots

Portable dairies are not a new concept. In many places around the world these can be found and are used for various reasons. In South America some dairy farmers use portable herringbone dairies and move them around almost daily, along with a menagerie of equipment to go with them. These dairies have mostly been used on leased farms where they can easily be shifted to another farm. They don't have any concrete surrounding them, so in wet weather their position is changed every day to stop mud and effluent build up in the 'cow yard' which is simply an electric fence. Around them is a lot of equipment; a generator, grain silo, water tanker with milk cooling equipment, waste milk tanker and a milk tanker to cart the milk out to the road side for pick up. A lot to move each day! (Peluffo, 2012).

Portable herringbone dairy in Argentina

Holland had a robotic dairy set up on tracks. This was built purely to milk cows out in the pasture. It carts all of its own equipment around with it. The scale of this operation would not fit into the Australian and New Zealand systems unless farms were reduced to a series of seventy cow farmlets, which is unlikely to be acceptable. Another form of portable milking robot has been set up on a large trailer. This is lowered to the ground, attached to its generator, water supply and milk vats and left in this location for around a week. Bark is used around the dairy to reduce muddiness. A dual box robot is used and its capacity is around one hundred and twenty cows. This could be doubled up to bring it to two hundred and forty cows. It is moved around as cows graze different areas and works well. A tractor tows the milk tank out to meet the main tanker as in the previous instances. A well-constructed central lane way could be built for a factory milk tanker to directly pick up the milk. If a well-constructed central lane way exists, then it would probably be simpler and easier to walk the cows to a permanent dairy set up, particularly in the case of large herds.

Portable robotic dairy in Holland

1.9 Determining herd size by labour

Labour on dairy farms in Tasmania can be difficult, especially as farms become larger and businesses take on a more corporate structure and don't have the owner on-farm. Observations and discussions over many years have shown that one manager is best with just two to three people directly under them at one time. Beyond this it requires a fairly highly skilled manager to keep everyone working well in a busy dairy farming environment. This then almost dictates the maximum size of one single dairy farm as far as easy management goes. To explain this some more, if there is one manager, they will cope best with no more than three people around them at one time. The same applies to the second-in-charge (when the manager has time off). So over a seven day period with four people working each day including the manager and/or second-in-charge, all working five days on and two off or similar, there would have to be six staff on the roster. The average of the top ten per cent of farms in Tasmania milk one hundred and twenty five cows per person (at the peak busy times from calving through spring) (Doonan, 2012), equating to this team of six people milking seven hundred and fifty cows efficiently.

The hardest job on extremely large farms is often simply getting all of the cows through the dairy each day. Some of these farms have even gone to once-a-day milking to try to make life a little easier for everyone. With a large robotic dairy at the centre of a two thousand two hundred cow farm, labour would be greatly reduced. Robotic milking in this situation would result in huge staff satisfaction and labour efficiencies. Predicted staff levels of around one person to more than three hundred cows could be achieved. This would bring the management of this example of a large operation back to a scale where the average manager could cope with their small team around them.

1.10 Determining herd size by milking speed

Herd size in pasture based systems is determined by how quickly the cows can be moved along lane ways and how quickly they can be milked and travel back to the paddock. In Australia and New Zealand there are a few one thousand cow herds being milked through sixty to eighty unit rotary dairies. Mostly single herds are no greater than seven hundred and fifty, milked through fifty to sixty unit rotary dairies set up for a single operator. This creates many points of efficiency. The multiplication of herds becomes the next step from this point. Economics show that moving slightly up in numbers from one large herd to two or more smaller herds does not in most cases work for greater profits, and could in fact reduce profitability (Doonan, 2012). Financial consultants would encourage a dairy farm with multiple herds to keep them large. Large herds are more efficient for milking, feeding and walking. The largest dairy farms in Australia and New Zealand have multiple herds of one thousand cows each.

1.11 Determining herd size by walking distance

The next limiting factor is farm size and walking distance. Cows will walk up to two kilometres on flat ground without significantly affecting production. This could equate to eight kilometres in one day excluding grazing. A cross-bred or Jersey cow can still produce close to her body weight in milk solids in one year while requiring less than one tonne of supplementary grain, so long as she is fed adequate amounts of high quality pasture at these distances. With a dairy correctly placed close to the middle of a relatively flat, highly-productive farm stocked at three to four cows per hectare, three large herds could be placed in easy walking distance of a dairy. A farm of five hundred and fifty hectares could potentially run two thousand two hundred cows in three seven hundred and thirty cow herds. This would be efficient down to three separate five hundred cow herds and could have an envisaged maximum of three herds of one thousand cows each. Pasture-based farms of this magnitude do exist, but are difficult to manage because of their labour requirements.

Cows walking to the dairy, Tasmania

1.12 Robotic dairy types

Robotic dairies are mostly not designed for this sort of scale. It is not the author's intent to promote one make or type of robot over another, rather simply to work out a way to make a large-scale pasture-based system work effectively.

One company has set up a dual box robotic milking machine with one robotic arm in the centre that milks one cow on each side of itself. This machine is not quite twice as fast as two single box systems and its pricing reflects this.

Single or double box robotic dairies can easily be added to, to make very large systems. In Eastern Europe there are examples of up to thirty boxes on the one farm, but these are spread throughout many barns. Europe also has a few other designs.

Another European company has one robotic arm that runs along one side of a straight rail dairy with individual cow stalls that has up to five stalls per arm. These machines come in left- and right-handed versions, so that ten units could be set up with a robot working each side and a pit down the middle. An advantage with this machine is that it is easy for an operator to take over milking if the robot breaks down. This has often been necessary on one farm visited in Holland, where milking was performed on and off for twelve months by staff with some robotic 'teething problems' (Toon, 2011). These problems have now mostly been overcome.

Very recently a European company has publicly launched the world's first commercial robotic rotary dairy near Deloraine in northern Tasmania. This is a twenty-four unit internal rotary with five robotic arms, two for washing, two for attaching and one for teat spraying cows (Dowie, C. *The Australian Dairy Farmer*, May-June 2012, p34-49).

In New Zealand there are whispers of a company developing a robotic arm that can attach milking cups on a conventional rotary dairy, replacing an operator.

There are other smaller companies also developing milking robots and others building robots that are an older design under licence from the parent company.

Right now around the globe there seem to be at least eight different options of type and make of robotic milking machines available to purchasers. In addition, there are more options which use either second-hand equipment, or equipment that is currently being developed, including portable robotic machines.

Currently the most proven types of robots are the single and dual box machines, but this is quickly changing.

Single box robots at work

1.13 Training area for milking new animals

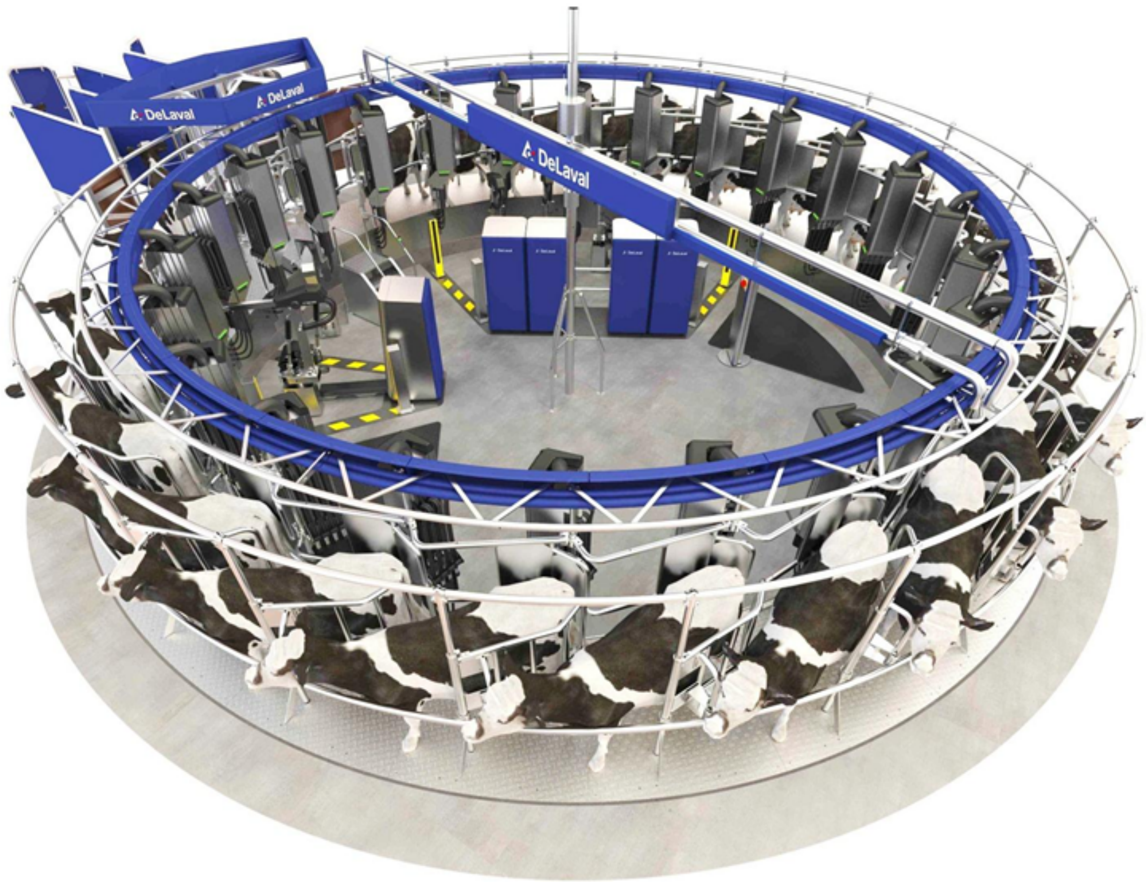
Many of the European farms using milking robots have small herds of cows with calving taking place all year around. These people have adequate time to deal with new heifers and troublesome cows. When farmers are calving large numbers of heifers and cows in a short period of time this could become quite a trying task, with even the most patient person sometimes becoming frustrated. Trying to train thirty to fifty heifers in one day in a conventional dairy and that many again the next day and the day after tests the patience of the best person, and even more so in a milking robot system. Farmers in Holland were observed bringing in their troublesome heifers and cows separately, putting them into the robots, restraining them and milking them manually. One farmer in New Zealand has a rule that if someone spends more than half an hour with one new animal in a robot, then they have to get someone else to take over before they became enraged. In a large robotic dairy installation a separate place to milk troublesome animals would be essential. This would need to appear similar to the robot so that an animal is not only becoming familiar to being milked but also familiar with its surroundings. Ideally this manual milking area would have a pit beside it to help with ease of milking, which could also be done with the actual robots.

1.14 Calculating dairy size

To work out the requirements for the two thousand two hundred cow farm proposed, we need to start at the maximum milking load at the peak compared with what the robotic machines can do.

At peak production in late spring there could be over sixty thousand litres of milk per day produced, depending on breeds used and the grain feeding regime. To allow for down-time and herd change-over, a milking time of ten hours needs to be used in calculating the size of the dairy. Single box robotic dairies can milk at a speed of nine cows per hour if cow flow is good (Everet, 2011). In this example at least twenty five robots would be needed and with two extra machines installed to cover for robot breakdowns this dairy would be able to milk at a speed of up to two hundred and forty cows per hour. This would be similar to the speed of a fifty to sixty unit rotary dairy at peak production. With the dual box system the number of stalls would be twenty per cent more than for the single box system, but of course there would be half that number in robotic arms, so this would amount to sixteen dual box robots.

The new Automatic Milking Rotary (AMR) can milk at a speed of ninety cows per hour. To achieve the milking speed of two hundred and forty cows per hour, three of these machines would be needed (Laval, 2012). In time it is likely that this sort of machine or another similar machine would have sufficient capacity to fit this position in its own right.



Automatic Milking Rotary (Laval, 2012)

1.15 Cost

For many years robotic dairies have been too expensive in Australia to even consider installing. With the advance of technology and the high Australian dollar, over the past few years they have gradually moved into a price bracket where people will at least consider them. A conventional fifty to sixty bail rotary dairy with full automation, set up for one person milking, is going to cost a little under half as much as a gang of robots to milk at a similar speed. After talks with manufacturers, it would seem that large gangs of milking robots could be made cheaper by sharing some common equipment and not putting all the 'bells and whistles' on all of the machines (Everet, 2011).

1.16 Further concepts

This style of semi-voluntary dairy farming system would be made a little easier with some new technology if it is to work at three hundred cows per person.

Controlling cow traffic in an orderly way around farms with multiple herds without having to have staff on bikes behind cows is a key to successful staff efficiencies both in this example and in current day enterprises. With multiple herds this becomes even more important. Also with robotic milking, cows can trickle into the dairy early in the morning and be milked as soon as they get there. Battery gate latches that work on timers to release and let cows start heading to the dairy early in the morning were developed in New Zealand many years ago. While these are quite useful and are currently in use in Australia and New Zealand this idea could be developed further to control cow traffic around farms. A simple remote-control gate that can be opened and closed from a computer or handheld device would facilitate locking cows away as well as encouraging them to come to the dairy. Portable automatic gates could be moved to paddocks where cows are, or ideally permanently placed at each paddock around the farm. These gates, like the current battery latches, would sound an alarm for a short time when opening to alert cows to come. Cow bells could even be attached to the lead cows to help encourage cows lower down in the pecking order to follow to the dairy. Herds would still need some fetching to the dairy, but it would be expected that most of the walking would be voluntary. The early morning herd would be mostly yarded and being milked before someone (or machine) would need to come and round up the final reluctant cows from the paddock. The subsequent herds could also work with this system, and the same for the afternoon milkings. The last herd to be milked in the evening, once shut into the dairy yard, would be left for the robots to milk and then be shut in the paddock automatically, or by using a one-way gate. Surveillance cameras would also be used to make sure everything is running as it should.

1.17 Autonomous Vehicles

The final touch to this system would be done with autonomous vehicles. There is a lot of work and money being poured into these sorts of vehicles around the world at the moment. This situation is ideal for this type of machine. They would be relatively slow moving and programmed to follow exact tracks and patterns to shift herds of cows with minimal stress. Automatic gates on each paddock would open and close by pre-programmed computer software. They would be used for moving the remaining reluctant cows from the paddock to the dairy. An ear tag scanner mounted on this machine would scan the paddocks to check for remaining cows. These sorts of vehicles could also perform weed spraying operations.

1.18 Other future options

Further into the future other options for cow traffic control may be available. Currently at the University of New England in Armidale New South Wales, GPS collars are being used to keep track of the location of a group of steers. This group of animals can be tracked and recorded to show all of their individual movements. The information can be accessed in the field on a smart phone or tablet and shows live data of each tracking tag.

While this in itself is not a lot of help, once it is connected to a device that can train the animal to respond to audible commands this could be quite useful for cow traffic control. ‘Audible signals emitted in response to a radio signal by a device worn by a steer are used now in some US rangeland farms to keep cattle away from sensitive and dangerous areas… Clearly cattle can be trained and they do respond to an assortment of stimuli’ (Yule, 2009). Alan Emerson and Jacqueline Rowarth from Massey University in their book ‘Future Food Farming’ devote a whole chapter to this topic. In the book this concept is taken further, to removing internal fences on farms and using the collars to move every animal individually (Rowarth, 2009). This idea though would require a very high degree of reliability to work one hundred per cent of the time. If any part of the electronic positioning system failed it would be nearly impossible for the farm to function in a manual way with labour.

1.19 Robotic conclusions

Plans for the immediate future can be safely made to install milking robots on large scale dairy developments in Australia and New Zealand. Quotes on a large number of new robots or similar to go into a greenfield site would be very competitive in today's markets. Setting up a large farm of this nature would be very similar to current large scale setups using conventional dairies. Electronic gates on each paddock would be desirable but not essential and would be the next gain in labour efficiency after the robotic dairy. These gates could be very easily built and installed at cost effective prices using off-the-shelf equipment currently available. A farm of the size discussed, set up properly, would be able to produce milk efficiently. This farm would also lend itself to being adaptable to future developments in autonomous vehicles and GPS animal directing collars.

Wind turbines

2.1 Clean energy

All over the world energy production is a concern and of particular concern is producing it without causing pollution. Parts of Europe are covered with wind turbines, some as large as four megawatts and one hundred and fifty meters tall, all for producing electricity.

Large wind turbines at work on a farm

2.2 Farmers well compensated

Holland in particular has a large number of wind turbines. Farmers with them installed on their land can do quite well financially from the land lease arrangement. For each turbine installed land owners are currently being offered fifteen thousand euros per megawatt per year (Vdmaat, 2012). For a three megawatt machine this would equate to forty five thousand euro or fifty five thousand Australian dollars per year. In a lot of cases this also involved a concrete lane way through their farms between wind turbines. This concrete protects the high voltage electrical cables buried under the ground. Farmers are allowed to use the laneway for any farm traffic that they wish to. The only possible downside may be the noise from these machines, but in reality there is more noise coming from nearby motorways.

2.3 More needed

Even though in Holland there are rows of wind turbines criss-crossing the entire country, they still only produce eight per cent of Holland's entire energy needs. These are made viable by government subsidies which keep the power feed-in tariffs high enough for alternative energy to be profitable.

2.4 Profitability

Prince Edward Island in Canada has recently installed a row of ten large, four megawatt wind turbines. When these are running at full capacity electricity can be exported back to the Canadian mainland. Consumer power prices here were the highest in Canada at eleven to twelve cents Canadian per kilowatt hour. Even at this price the wind turbines were only making a two per cent return on investment. This meant that there were not too many takers for investing into the project when it was in its infancy. The government ended up funding this venture so as to get it off the ground (Macquarie, 2011).

Wind turbines come in many different sizes and a few different shapes. The wind yield, power price and set up cost all factor greatly in influencing the profitability of these machines.

2.5 Tasmanian situation

In most cases Tasmania and much of Australia do not have feed-in tariffs high enough to be highly profitable on a small scale. This can be overcome on a local scale with embedded generation. Embedded generation is simply where a business is able to offset their own power usage by installing some sort of generation system that can replace or offset their power usage cost at up to one hundred per cent. In this sort of system, if one hundred per cent of the power produced can be used, the price received changes from around three cents per unit (into the grid) up to what is currently being paid for electricity. In Tasmania this would be up around twenty five cents per unit. At this price most efficient small generation systems are profitable (Yost, 2010).

Power prices in general in Tasmania are very high. Although this allows for good opportunities with embedded generation, the power price alone presents a problem to profitable dairy farming. Farmers need to make sure that they have efficient irrigation systems and dairies to reduce power consumption where possible. Wind turbines and solar panels on a small scale will help to reduce increasing power costs. However financial consultancy and budgeting are needed to determine what may be the best option at the time, due to ongoing changes in government rules and equipment costs.

Digesters

3.1 Common in the northern hemisphere

Many large dairy farms in USA and Europe have anaerobic digesters with variable results. The digesters work like a giant cow's stomach, and need close attention. The set up cost on large farms runs into millions of dollars and therefore they need to run efficiently most of the time to produce a justifiable return. The first example viewed was in Virginia, on the Van der Hyde family farm, milking over one thousand cows. After overcoming construction problems, the gas here is being burnt off into the atmosphere due to difficulties with contracts with local power companies. In a shed lies a four hundred and fifty kilowatt generator that has never run due to red-tape (Hyde, 2011). The blow out in construction costs and delay in electricity production has meant that financial returns, once up and running, will be minimal.

The Van der Hyde farm unused generator in Virginia

3.2 Subsidies help?

Europe has some high subsidies to help make digesters profitable. This has led to many being installed. These digesters are fed on a mix of slurry waste from the cattle and mostly maize or corn silage. The slurry normally attributes around twenty per cent towards energy production and the silage around eighty per cent. This has of course meant that the price of corn silage has gone up significantly, to the point where it is difficult to make money with a digester. To add to this many farmers have had problems with slurry tanks and generators. One farm visited in Holland, milking three hundred and sixty cows, had a digestate tank containing over a million litres burst. This was most likely a result of poor construction and could have easily killed people. The cost of this accident has amounted to some high financial burdens and eventually led to a decision to completely remove the remaining tanks and generators due to ongoing budgets showing losses on the system (Prins, 2011).

A burst digester tank at the Prins farm in Holland

3.3 Homework pays

England had some similar stories. A seven hundred and fifty cow farm had a pile of generator parts next to the plant. The generator had only run fifty per cent of its budgeted time and therefore even with a payment of twenty eight cents per kilowatt hour was only just making money. Another farm with a new plant just set up (unused), had a seven thousand ton corn silage bunker which was as much for the digester as the cows. This farm's budgets showed that the digester would make more money than his cows, something the other operators may have also thought. Some of the gasses produced by the digesters and generators are lethal to humans and animals. There have been a few cases of people dying due to these gases and in one place visited, the farmer knew that his plant had produced gasses above safe limits. One of the positive outcomes was that in one instance a local school received free heating from the generator cooling system. Digesters need a lot of homework doing on them before deciding on installation.

Biomass Gasification

4.1 India

Gasifiers come in many different sizes and types. A lot of research has been put into these machines, especially in India. The Bangalore Institute of Science has a whole area and faculty dedicated to their success. The Institute has patents on some kinds and has developed large units down to a small portable gasifier that is purely for household cooking. Gasification makes a lot of energy efficiently. It does this by cracking some of the complex chemicals contained in the biomass and causing then to recombine to form gasses that are then burnt. These gasses are less harmful to the environment and produce more energy when compared to direct burning of the biomass for energy production. Gasifiers can convert one kilogram of dry waste in approximately four kilowatts of heat energy or one kilowatt of electric energy.

Coconut shells run this gasifier at a Cochin rubber factory in India

A large hospital in Cochin heats all their hot water and does all their cooking with gas from a gasifier running on coconut shells. As with the digesters, to generate electricity gas is burnt through an internal combustion engine. Scrubbers are used to clean the gas before entering the engine to remove tars and avoid motor damage. These machines are producing over two thousand megawatts of energy in India today (electricity and heat), virtually all coming from waste material. It is estimated that India has “a cumulative biomass power potential of about 18,000 MW from surplus agro-residues” (Biopact, 2007). On top of this one of the by-products is biochar which is very good for our soils and can lock up carbon for thousands of years. In India the biochar is mostly sold for water purification filters.

4.2 Prince Edward Island

Prince Edward Island in Canada has a biomass gasifier running at a municipal waste site. Energy from this system is used for heating local houses and a school (Macquarie, 2011).

4.3 Australia

Biomass gasification is something that could be used more now in Australia, particularly with waste biomass. A lot of farm, forestry and municipal waste could all be turned into useful energy. Not only would this produce energy, it would also produce biochar that could be spread back onto the farm land. This would not only help the soil characteristics but also lock up carbon for possibly thousands of years. Some careful budgeting and planning would provide a clearer picture of the best places for this equipment in Australia.

Corporate capital

5.1 Combined efforts needed

Dairy farming ventures all over the world need capital to start up, expand and sometimes just to maintain the business through difficult times. Banks are the normal port of call for this and are certainly a good option. As more corporate businesses look at land and farming as a safe investment for the future, and are buying large parcels (Beca, CEO NZU, 2012), it would be good to have a combined effort to make it easier for private and corporate owners to work together. Farming needs to have easier ways for parties to move in and out of degrees of ownership without major repercussions in legal paperwork and tax (especially Australia). There are a few models that could be used for this.

5.2 Farms are becoming larger

As small farms become large farms, the financial strain can become worse in difficult times. Not only does income drop, but banks like to put up interest rates when farms are about to fail. If there is a bankruptcy the whole business is up for sale, and the farmer disheartened. Often in large scale enterprises the only buyer is a corporation, which may struggle to employ someone who has the skills and passion to run the business as well as the previous owner. Why not work together? People often don't like to see our farmland owned by corporates. One option could be joint ownership.

5.3 Multiple ownership

Joint ownership of farms between corporates and farmers is possibly the direction that needs to be taken. Tim McGavin, Laguna Bay Pastoral Company's chief investment officer says, "the only way to achieve elite returns is to joint venture with elite farmers." (Whitley, 2012) One option is to have different entities set up and contracts drawn up to enable more than one owner; this is not uncommon amongst farmers. For instance a corporate owner could own between fifty one and eighty per cent of the asset value. This would give the corporate the controlling share and the farmer enough equity to still share in the capital gain. The management package would be strongly linked to financial performance and animal health. The farm manager and the entity owning the smaller share would not necessarily be related. A mechanism to sell each portion of the farm separately from the other would be the most difficult part. The biggest down-side with this model would be in the case of the farmer wanting to sell his remaining share, if the corporate did not want to sell its portion and also did not want to buy the farmer's remaining portion, it could be very difficult to find an alternate buyer. Contracts would need to be drawn up to protect both parties from this eventuality.

New Zealand has many different examples of syndicates setting up a business with clear horizons for development and exit strategies. While this is a good model, it seems to rely more on banks than available corporate money.

The share market is a great example of businesses that are owned by multiple entities. The businesses are run with a high degree of reporting needed to the shareholders. A model such as this with publicly listed shares for farming would allow entities to move in and out of part ownership of a very large business quickly or slowly with a clear price on the day of trading. This would not only give corporate money an easy way into farming, it would allow farmers

to change their level of ownership in the business. Farmers could stay in management roles where they want to exit some or all their capital. It would initially mean selling the whole farm to the public company, and the farmer would become part of a much larger business. Young farm managers could gradually take equity in the business. Each farm would run on its own budget and ideally the manager would receive a percentage of the profit as well as a base wage and other incentives. Shares could also be used as part of a performance package.

5.4 Tax implications

One of the greatest obstacles in Australia to changing land ownership into any of these structures is the taxation system. To initially change the ownership into one of these models, the tax implications would initially be monumental. There would be stamp duty on the sale to the new entity and capital gains tax to the selling party. Once done though a system like this could work well.

Conclusion

Pasture based dairy farming has a bright future, because of its image around the world and efficiencies. Correct pasture management needs to be the main focus, as this has been proven to be the strongest profit driver. Technology is here now that can be successfully combined with good grazing management and staffing efficiencies in a non-voluntary robotic milking system. Large farms of fifteen hundred to three thousand head, having three herds of five hundred to one thousand cows could be set up now to make use of a large centrally located robotic dairy. Electronic gates on each paddock could provide further efficiencies, a part that is currently missing. These gates would help on today's farms whether conventional, voluntary robotic or non-voluntary robotic. Autonomous vehicles and GPS animal directing collars are other future areas of efficiency gain.

Corporate farming businesses are looking for scale and easy management, as well as top farmers to partner with. Large robotic farms would be ideal enterprises to be co-owned between corporate partners and local dairy farmers. Ownership entity structures would need to be well thought through and set up at the start to enable this sort of business to have future corporate (or other) buy in.

Producing energy on these farms, or nearby to offset electricity use and carbon emissions is something else that benefits everybody. Although bio-digesters are common in Europe, so are their problems. Gasifiers seem a better way to use farm and municipal waste to produce both energy and biochar. Biochar can be spread back onto farm land, locking up carbon for thousands of years and helping the soil. Wind turbines in the right size and location can also be of benefit. Most Australian farmers will benefit from embedded generation, where they are off setting their electrical energy usage by generating on a small scale.

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Plain English Compendium Summary

Project Title:	Challenges and Opportunities for Large Scale Dairies
Nuffield Australia Project No.: Scholar: Organisation: Phone: Fax: Email:	1109 Paul Lambert P&N Dairies Pty Ltd 040897900 03 64961999 p.n.dairies@gmail.com
Objectives	To investigate robotic milking, along with energy production and corporate dairy structures, with the idea of applying the findings in Australia.
Background	Dairy farming around the world, along with some of the integrated businesses, whether corporate or private, have always been of great interest and drove this study.
Research	Europe is where most of the research was conducted on robotic milking, wind turbines and bio digesters. Denmark and Holland have the highest number of milking robots in the world, New Zealand and Australia have been good places to see them being adapted to pasture. New Zealand, Australia and South America had examples of large pasture based corporate dairy farms. India has some very interesting research that has been done on gasification, with some excellent results.
Outcomes	Robotic milking is here to stay and will be used more and more along with on-farm energy production. As time goes by it is likely that we will see more corporate dairy farms. The main findings are: • Robotic dairies need to be adapted to suit the best grazing outcomes in Australia and New Zealand • Robotic dairies are quickly becoming affordable • Local farmers and municipal waste sites could work together using gasifiers to the advantage of both parties • Corporates and local farmers need to work together
Implications	Potentially robotic milking may become unpopular due to reduced grazing efficiency. In time, as larger dairies look to robotic milking solution for a solution to labour shortages, grazing systems using electronic gates will help with the integration. Corporate dairies could benefit most from this, especially by sharing both capital and management with local dairy farmers.
Publications	