Whole Farm Impacts of Automatic Milking Systems

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Take Home Message

- A comprehensive assessment is needed when considering the purchase of an automatic milking system because many aspects of the farm are impacted beyond the obvious effects on milking equipment and labor requirements.
- An automatic milking system normally cannot be justified on an economic basis, but the long-term costs and returns can be similar to conventional parlor systems when herd size is well matched to milking capacity.
- The decision to adopt automatic milking is normally driven by non-economic issues such as the producer's interest in new technology and the desire or need to alleviate the daily milking routine.

Introduction

Automatic milking systems now provide an alternative to the demanding milking routine that dairy farmers have faced for many years. Automatic milking systems employ robotic technology to milk animals throughout the day according to their schedule. This proven technology is now used on many farms in northern Europe and on a small number of farms in North America.

Adoption of an automatic milking system (AMS) must be viewed as more than the purchase of new milking equipment. Use of an AMS obviously has a major impact on the way cows are milked, but it also influences many other parts of the farm. Some of these impacts are not so obvious. When considering the purchase of an AMS, a whole-farm evaluation should be considered.

Some of the obvious impacts of an AMS are the initial and operating costs of the milking equipment and the labor required for milking. Other aspects include required changes in the milking, housing, and feeding facilities. Less obvious

factors also include the impact on milk production, milk quality, feed use, and even the amount and nutrient content of manure produced.

When considering the purchase of an AMS, the economic costs and returns are important considerations. By integrating all the impacts of an AMS in a whole farm model, the long-term economic value of this technology can be assessed. Other non-economic issues such as the personality and interests of the farm manager also have an important role in the adoption of this technology.

■ Labor Requirements

Labor is normally the most important consideration in the adoption of automatic milking. This technology can greatly reduce and likely eliminate the twice or three times daily milking chore. Automatic milking systems still require labor though. More time is needed in reviewing and managing animal records. The equipment occasionally fails to milk certain animals, which requires human assistance. Even though the milking chore is removed, time must still be spent watching and interacting with the animals for heat detection and to spot disease at an early stage.

Overall, there should be a reduction in labor requirement with automatic milking. The daily labor requirement for maintaining an AMS and the additional time needed for reviewing records and watching animals is probably 1.5 to 2 minutes per cow. The amount of labor saved varies dependent upon the traditional labor requirements to which it is compared. Typical labor savings in milking and animal management vary between 0 and 50%. As farm size increases and larger more efficient parlors are used, the potential labor savings with AMS declines.

Adoption of an AMS will always require a shift in the way labor is used. Routine chore labor will be replaced with labor for equipment and animal management. This shift will be welcomed by some farm managers and rejected by others. Those who like working with this type of technology will succeed. An AMS requires that a farm manager be on call 24 hours a day to respond to problems and system failures. For some, this may be a greater burden then the normal milking routine. For others, the more flexible schedule provides a more desirable life style.

■ Milking Equipment

Automatic milking equipment is complex and thus costly. AMS manufacturers use two primary designs. The first is normally referred to as a single box unit. This design uses one robot for each milking stall. As multiple units are used to

increase milking capacity, each unit contains a robot to perform the milking functions. The other option is a multiple box unit. In this design, a single robot serves up to four milking stalls. The robot moves on a track to attach individual milking units in each stall.

There are advantages to both designs. Single box units are more expensive, but they provide a greater milking capacity. Since each milking stall has a robot, the robot is always available for attaching the milking unit when the cow enters. In a multiple box unit, a cow may wait in a milking stall while the robot is servicing another stall. This reduces the milking capacity per stall. Because the robot is shared across multiple stalls though, the initial cost per stall is less.

The initial cost of an AMS is greater than that of a traditional milking system. How much greater is very dependent upon the cost of the system to which it is compared. The first AMS stall installed on a farm will cost $(US)150,000 to $175,000. The first stall of a multiple box unit may cost a little more than one single box unit. If additional single box units are used on the farm, the additional stalls will cost about 10% less. For a multiple box system, additional stalls cost $40,000 to $60,000. The initial equipment cost of a double 12 parlor with full automation is about the same as that for a single AMS unit. The milking capacity of this parlor is greater though, so three or more AMS milking stalls are needed to handle an equivalent-sized herd. Compared to a lower cost parlor such as a swing parlor design, the initial investment in AMS is much greater. A smaller structure is required to house an AMS, which can provide a small reduction in the facility cost.

Operating costs must also be considered. The major operating cost is for repair and maintenance of the equipment. AMS manufacturers offer maintenance contracts that cover the routine maintenance and sometimes upgrades of the system. The annual cost of these contracts is $4,000 to $5,000 for the first stall and about $3,000 per stall for additional single box units. For multiple box units, the cost for additional stalls is less at about $1,000 per stall. Additional repair costs will be variable, but an additional annual cost of 2% of the initial cost should be planned.

Utility requirements should also be considered. The primary utilities are water and electricity. Water use with an AMS is similar to that used in a traditional parlor. Electrical use is not well documented, but it appears to be greater than that of conventional milking systems. Limited available information indicates that the total electrical requirement for milking and cleaning with a single box AMS is between 400 and 600 kwh/cow per year (Rotz et al., 2002). This can be compared to an annual requirement of 250 to 400 kwh/cow for traditional parlors. This additional electrical use of 200 kwh/cow will have an annual cost of about $20/cow. With multiple box units, electrical use per stall may be even a little greater than that of a single box.

Other operating requirements include detergents, filters, water heating, milk cooling, and milk storage. These costs are generally similar for AMS and traditional milking systems.

■ Milking Capacity

Milking capacity is an important consideration when selecting the appropriate sized AMS for the dairy herd. Milking capacity is the number of milkings the equipment can handle, which sets the number of animals served, and it can affect the milk production obtained. When capacity is available to allow each cow to be milked up to three times per day, an increase in production is expected. When capacity restricts milking frequency, production will likely drop.

A number of factors influence the milking capacity of an AMS including the type of AMS used, production level of the animals, and animal traffic patterns. The capacity of a single box unit is normally given as 60 cows. This should be considered as a maximum. For a typical herd where about 15% of the cows are dry at any given time, only 51 of the 60 cows would need to flow through the milking system. With this considered, a single box AMS will handle a 60-cow herd.

Milking capacity is the available time divided by the time to milk one animal. Available time is about 20 h per day allowing 4 h for cleaning and maintenance activities. Ideally, we would like to have an animal in each stall being milked every available hour, but this does not occur. The efficiency (hours used divided by available hours) varies across farms and throughout the day. This efficiency is influenced by cow traffic, which is largely controlled by animal housing and feeding layout and the resulting incentive for cows to move through the milking system. In addition, AMS use is generally lower in the early morning (2:00 am to 6:00 am) then during other parts of the day. A reasonable assumption is that milking stalls will be used 80% of the 20 h available providing 16 h per day of actual milking time (Rotz et al., 2002).

Time required to milk each animal is the actual milking time (daily production divided by milk removal rate) plus a preparation time of 2 min/cow per milking. Milk removal rate increases with the amount of milk obtained per milking from a low of 1.8 kg/min at low milk yields to over 3.2 kg/min at high yields (Rotz et al., 2002; Ipema, 1997). This provides unit capacities for a three times daily milking frequency of 48 to 52 lactating cows. As the number of animals per AMS unit is increased further, the milking frequency will decrease. If the herd average drops below 2.5 milkings per day, herd milk production will likely decrease to a level at or below that obtained with a traditional parlor with twice daily milking.

The capacity per stall for a multiple box system will be less due to more idle time waiting for the robot to complete other stalls. For these systems, a

separate stall is normally used for cleaning and preparation of the animal. This improves efficiency by reducing the time the animal spends in the milking stall and the operations required by the robot. With both effects considered, a two-stall system will match a herd of about 100 cows (lactating and dry), a three-stall system will handle about 130 and a four-stall system will handle 150.

■ Barn Design

The layout of the barn can affect cow flow through the milking system and the resulting milking frequency, milk production, and farm profit. The goal in laying out the barn is to encourage animals to move through the milking station, and to do this without limiting feed intake. Some concentrate is fed in the AMS to encourage more frequent visits, but this is not enough to meet their need. Forage must be fed in a separate location along with additional concentrate.

Barns can be designed for free cow traffic or forced traffic (Ipema, 1997). With free traffic, the barn essentially has no gates. Animals can freely move at will between the resting, feeding, and milking areas. This has the advantage of providing more freedom for the animals, and it requires less equipment. With complete access to feed, the AMS should never restrain intake. Milking frequency with this approach will likely be lower though, because the cow has less incentive to visit the milking station. Only the cow's desire for milking and the concentrate in the milking station encourage visits to the AMS.

Forced traffic requires separate areas for resting, feeding, and milking and one-way gates force animals to move in one direction. When a cow leaves the milking stall, she enters the feeding area where forage and additional concentrate are provided. When finished eating, cows move to the resting area. To leave the resting area, they move through a selection gate. If it has been less than a minimum amount of time (about 5 h) since the last milking, that cow is returned to the feeding area. Otherwise, they move into a holding area and through the milking stall to the feeding area. This forced flow tends to encourage more milking visits, and when properly managed, feed intake is not constrained. When well designed, this approach also offers the flexibility of free traffic by opening the gates. Forced flow can then be used to acclimate cows, after which free flow may work successfully.

A selection gate is an important component for controlling cow traffic. For smaller herds, the AMS can serve as the selection gate. When an animal enters the AMS, they are sent to the feeding area if milking is not required. This saves the cost of a separate selection gate ($2,000 to $4,000), but the added traffic through the AMS reduces its efficiency of use and milking capacity. Thus, the added selection gate is normally a good investment. Cows prefer to visit the feeding area 7 to 8 times a day with milking occurring at most 4 times. This pre-selection can reduce cow flow through the AMS up to 50%.

Selection may also be done at the outlet of the AMS. Animals that did not milk properly or that were detected for mastitis or another concern can be diverted to a separate area. Feed, water, and a rest area must be provided to hold them until the manager can attend to their needs.

Current animal facilities can be adapted for use with an AMS, but this may require additional costs compared to designing a new facility around the needs of automatic milking. The AMS should be located near the resting area to enable easy access by the animals. For improved hygiene, an enclosure may be required to separate the milking station from other areas. A clean, well-bedded resting area is important to maintain clean animals and thus reduce the potential for improper udder cleaning and contamination of milk.

■ Milk Production

Use of an AMS will affect milk yield and quality. Milk yield should improve through more frequent milking. In practice, this has not always occurred, but most do report some increase. A major factor is adequate milking capacity to allow a good milking frequency. Well-managed herds average about 2.8 milkings per cow per day with automatic milking. At this frequency, a production increase of 5 to 8% can be expected compared to traditional systems with twice daily milking. Three times daily milking in a parlor provides about a 15% increase. The increase is smaller using AMS primarily due to a less even milking pattern throughout the day. Milking intervals typically vary between 5 and 12 hours depending upon the cow's motivation for milking.

Under a milk quota system, increased production has a cost. More quota must be purchased to cover the increase. The other option is to maintain the same herd production by milking fewer cows. In this way, milk is produced a little more efficiently with less feed and fewer animal expenses.

Use of automatic milking affects milk solids content. Milk fat concentration is typically reduced about 0.2 percentage units, and milk protein may be reduced a small amount. The apparent cause is the more frequent and less uniform milking schedule. This decrease in milk solids content decreases mailbox milk price about 2%, but this is dependent upon the pricing strategy used.

A number of other milk quality characteristics can also be affected. An extensive study on Danish farms found that bulk milk total bacterial count, spores of anaerobes, somatic cell count, and freezing point increased when automatic milking was initiated on farms and the frequency of milk quality failures almost doubled (Rasmussen et al., 2002). With improved management through a self monitoring program though, bulk-milk somatic cell count was reduced to a level similar to that before AMS was used, and the frequencies of milk quality failures was reduced. Management was not able to reduce the

frequency of high bacterial counts and the freezing point of the bulk milk to the level of traditional milking systems.

■ Feeding

The use of automatic milking affects the way cows are fed and their feed requirements. The first consideration is providing the proper amount of concentrate feed. An appealing concentrate must be fed in the milking stall to encourage more frequent and consistent animal flow. Since not all concentrate is fed in the milking stall, more must be provided by another means. One option is to use additional computerized concentrate feeders. The amount consumed in the milking stall can be controlled and monitored, and this information is then linked with the additional feeders to assure that each animal receives the appropriate total amount.

On most of our dairy farms, total mixed rations have become the preferred feeding method. A total mixed ration cannot be used with automatic milking, but this approach can be adapted. A partial mixed ration can be fed that includes all the forage and a base amount of concentrate. The concentrate fed in the milking stall can then be used to complete each cow's daily requirement.

Since cows normally produce more milk with an AMS, their feed intake will increase accordingly. With a 5% increase in production, about 3% more feed is needed. An increase in production may also change the feed mix in the ration. Slightly more protein and energy supplementation may be desirable. These dietary changes also affect manure production. If the same number of animals is maintained on the farm, a little more manure will be handled with an AMS. If animal numbers are reduced to maintain the same production quota, then those animals will use feed more efficiently. A little less manure will be handled and the nutrient contents of that manure may be affected a slight amount.

Cows should have access to water at all times. It is recommended that water be available near the entrance and exit of the milking stall.

For dairy farms that prefer to use grazing, there is an additional challenge in using automatic milking. Grazing and automatic milking do not work well together, but this combination is possible (Meskens et al., 2001). There are farms successfully milking grazing herds with an AMS. A greater milking capacity is recommended for the AMS when used with grazing. Since cows are gregarious, they tend to return from pasture in groups. Added milking capacity will allow those groups to be milked a little faster. The AMS will then sit idle for longer periods while the animals are grazing. For grazing herds, the AMS should be designed with an overcapacity of about 25%. The investment required for this added capacity will substantially increase production costs.

Forced cow traffic should be used with grazing animals. The amount of pasture provided should be no more than what the animals consume in half a day. As the pasture is depleted, the cows have more incentive to return to the barn. They should return to the resting area where they can move through the milking stall. Following milking, they receive supplemental feed and then return to a new paddock in the pasture. One-way gates at the barn entrance and exit can assure that the cows move through the cycle toward the new pasture paddock. Distance to the pasture should be as short as possible to encourage greater traffic through the milking system.

■ Animal Health and Well-Being

Automatic milking may offer benefits in the health and well-being of the cows, but this potential benefit is difficult to define. There is not a consensus on health benefits, and arguments can be made in favor or in opposition to automatic milking. Since use of an AMS indirectly affects many other parts of the farm, indirect effects from animal handling, feeding, and manure handling may also cause positive and negative effects on the animal.

With automatic milking, the cow can set her milking schedule, and this schedule should better fit a natural pattern of more frequent milking. More frequent milking will allow less stress on the udder, particularly in early lactation. This reduces udder pressure, reduces stress on udder ligaments, and provides more comfort for the animal, particularly when lying. More frequent milking may also reduce the time for the growth of mastitis organisms.

More frequent and longer milking time may increase the stress on teats (Meskens et al., 2001). This can lead to an increased number of teat end erosions and eruptions. Since one set of teat cups serves a greater number of animals on a daily basis, the spread of bacteria may be greater from a cow with mastitis or a high somatic cell count.

Healthier animals normally respond better to an AMS. Good legs and feet will encourage greater mobility and more frequent visits to the milking and feeding areas. Some animals will not adapt well to an AMS, which will increase the culling rate or at least the type of animals culled. Cows with reasonably symmetric udders are desirable. The robot will malfunction more often on asymmetric udders lowering the milking capacity of the AMS and requiring human intervention to complete the milking. Thus, these cows should be culled. Cows with a nervous temperament may also not adapt well to the use of AMS equipment.

If the AMS capacity is undersized (too many cows per milking unit), younger and weaker cows will likely suffer. They will tend to hang back and thus miss milkings and perhaps visits to the feeding area. In a well-managed AMS,

farmers note less stress among cows and fewer hierarchical battles within the herd (Meskens et al., 2001).

■ Economic Considerations

Economic feasibility is an important consideration for many producers considering automatic milking. Because of the many factors involved, economic feasibility is not easily determined, and it is specific to the conditions of each farm (Rotz et al., 2002).

To determine economic feasibility, the long-term milk production costs or farm profit using an AMS must be compared to the alternative. This assumes that a milking system change is required due to obsolescence, expansion, or both. The long-term production cost is the sum of the annual ownership and operating costs. The primary ownership costs are depreciation and interest on the initial investment in the equipment and facility changes required. For an AMS, this is the greatest cost. Other ownership costs include property tax and insurance. Property tax should not be affected much by the AMS, and it could even be reduced by eliminating or reducing the size of a separate facility for milking. Insurance will cost about 0.5% of the initial cost of the equipment and facility.

Operating costs include repairs, maintenance, electricity, water, labor, and other requirements for operating the AMS. Each of these requirements is addressed above in the milking equipment section.

The most difficult part of the comparison is to determine the costs of the traditional system to which the AMS is compared. Many different milking systems are available which cover a wide range in initial investment. Less expensive parlors normally require more labor, and they will not provide production data. Perhaps the most suitable comparison is to compare an AMS to a parlor that provides individual animal production information similar to that obtained from an AMS. This type of parlor may be similar in cost to a single AMS on a small farm, but parlors are more efficient and offer a greater milking capacity on large farms.

Since automatic milking affects milk production and quality, production costs do not tell the whole story. More milk may be produced or a similar amount may be produced with fewer animals. In addition, a lower milk solids content can reduce milk price. An estimate of farm profit (total income minus production costs) provides a more complete comparison. Farm profit for herd sizes of 30 to 270 cows using either traditional or automatic systems is illustrated in Figure 1. A description of the analysis and assumptions used to develop these economic values can be found in Rotz et al. (2002).

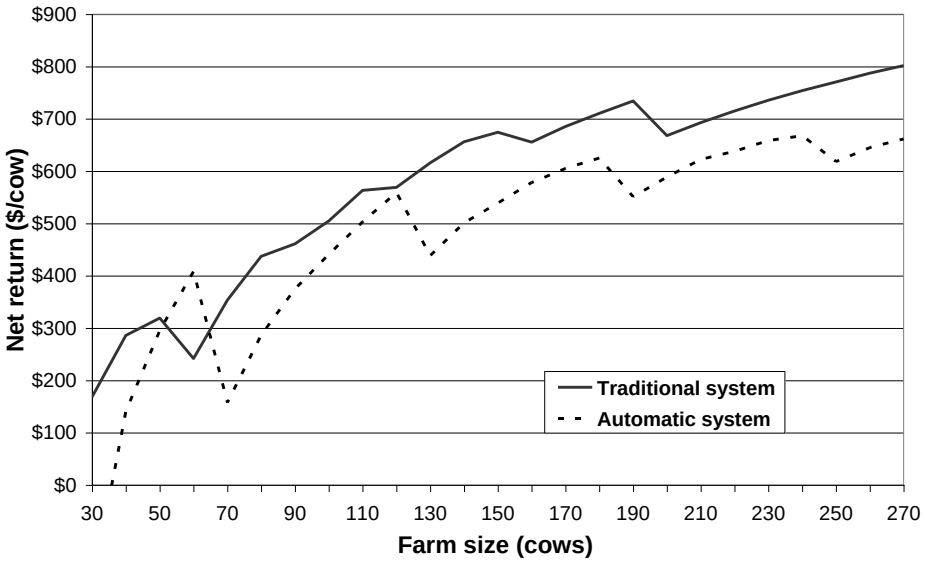

Figure 1. Annual net return of farms with 30 to 270 cows at a moderate milk production level (8,600 to 9,000 kg/cow per year) as influenced by milking system (Rotz et al, 2002).

On a small farm of 50 to 60 cows, an AMS can be very competitive and perhaps even offer an economic benefit over traditional milking systems. On larger farms where the herd size is well matched to the capacity of the AMS, the economic loss using AMS may be relatively small. When herd size is not well matched to capacity (the AMS is oversized for the animals milked or undersized restricting animal flow and milk production) the potential economic loss can be substantial. For larger farms than those shown in Figure 1, the comparison would not change much from that shown for 200 cows or more.

Figure 1 is based upon the use of single box AMS units. With this assumption, the most suitable herd sizes are around 60, 120, 180, and 240 cows. A multiple box system will have different capacities, thus providing better economic benefit for some of the farm sizes between these 60 cow increments. The important consideration is that the herd size must be large enough to keep the AMS operating at full capacity. With up to 10% additional animals, the milking frequency and production will drop with little economic impact. With further imbalance though, the effects of the imbalance are too great to justify.

The question remains on the economic feasibility of an AMS. My conclusion is that adoption of automatic milking is difficult to justify for most situations purely on an economic basis. With our efficient parlors and current prices for milking labor, cows can normally be milked at a lower cost and better return with

traditional milking systems. Other non-economic issues normally have more influence on the decision to adopt automatic milking. These issues include a desire for relief from the milking routine and an interest in electronic technology. When the AMS is well matched to herd size, the small economic loss may be acceptable to the producer considering the non-economic benefits received.

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