Evaluation of Automatic Milking Systems for the United States

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Several companies are planning to introduce Automatic Milking Systems (AMS) to the U.S. market in the next year. Small to medium size farms operated by families are the presumed target market for the types of AMS likely to be introduced. The states that make up the traditional dairy belt are Wisconsin, Pennsylvania, Minnesota, Michigan, New York, and Vermont. The number of small and moderate scale dairy farms in these states has been declining in both absolute and relative terms (Boehlje, 1997). They are still home to half of all dairy farms and roughly 40% of all dairy cows in the country, however (USDA, 1999). The decline in the number of farms with less than 100 cows and increase in farms with more than 100 cows in Wisconsin from 1970 to the present is shown in Figure 1. Improved labor efficiency has been a major influence on these trends. The labor savings offered by AMS technology could have an important impact on the U.S. dairy industry in the traditional dairy states.

The viability of dairy farms is vital for the economic and social health of many rural areas of the United States. Farms operated by single-family units, milking fewer than 100 cows, with crowded, outdated and fully depreciated facilities are common in the traditional dairy states. The labor required to operate this type of farm is a major barrier to new starts or transfer of these businesses to the next generation. Milking comprises about half of the labor expended on small dairy farms amounting to 40 to 50 million person-hours per year in Wisconsin. Milking in parlors, and especially in stall barns, is a difficult and undesirable task and poses considerable risk for traumatic as well as repetitive stress injury. Health issues, unusual work hours, and working conditions have made obtaining reliable milking labor a major concern of dairy producers. If robotic milking becomes widely adopted, it will revolutionize the work routines on dairy farms and contribute to a significant improvement in the health and quality of lives of dairy producers and their families. AMS technology can provide an option for these farms to reduce the labor requirements of milking and allow some of these farms to continue dairy production and make them more attractive to new producers. The demographics of farm size and producers in the traditional dairy production regions of the U.S. are similar to those in Denmark and the Netherlands where AMS technology has been adopted rapidly.

Despite a decade of change, several regions of the U.S. continue to be dominated by small and moderate scale dairy farm operations that raise most of their own feed and rely principally on family labor. There are also many reasons to believe that the large-farm model of dairying will be slower to spread than it has been in other commodity sectors, like pork, chicken, and beef (Jackson-Smith and Buttel, 1999). Of course, small and moderate sized operations are hardly static (either in terms of scale or their use of production technology), and empirical studies suggest they are continually looking for ways to expand incrementally or adopt labor- and

capital-saving technologies that increase net profits or increase quality of life (Jackson-Smith and Barham, 2000).

Although there has been growth in the number of new large-scale, parlor-freestall dairy enterprises in this region, for many family-scale operations the capital and labor requirements of this high-end system are either impractical or unattractive (Buttel and Jackson-Smith, 1995). Herd expansion during the late 1990s has also been constrained because of a strong non-farm economy and lack of a reliable and affordable hired labor pool (Jackson-Smith and Barham, 2000).

Research suggests that at a herd size of about 200 cows, farm families begin to hire more labor than they provide to the operation themselves. Moreover, using conventional stanchion barn milking systems, it is difficult to milk more than 70 to 90 cows using only family labor. Many of the region's dairy farms are currently reaching this size threshold. The major options currently available to farms seeking to expand beyond that scale *while still relying on family labor* are low cost parlor designs (like swing parlors or flat barn renovations of stanchion barns) or intensive rotational grazing systems that provide more moderate labor demands on the cropping side of the operation.

One of the principal attractions of automatic milking systems is that they may provide an opportunity to break the labor barriers to expansion, particularly for the thousands of dairy operations that might be prepared to increase their herd size from a 50- to 99-cow herd up to the 100-199 cow range. There are a number of innovative applications for which AMS may also prove useful and economically attractive such as harvesting and sorting of high value milk containing pharmaceuticals, nutriceuticals, or 'premium' quality milk.

Social trends in Europe have placed increased emphasis on animal and environmental welfare. This trend is also apparent in the U.S. Automated milking may enhance economic opportunities for small to medium sized farms, which present a more positive milk quality and animal welfare image to the public, pose less of an environmental risk, and are generally more socially acceptable, especially near urban areas. Many of the traditional areas of dairy production in the US are also located near urban areas. Analysis of recent survey data suggests that the vast majority of dairy farms milking between 25 and 200 cows in Wisconsin operate enough cropland to safely dispose of nutrients in their dairy manure (Nevius and Jackson-Smith, 1998). However, a growing number of larger dairy farms (> 200 cows) maintain an inadequate cropland base for manure disposal and are forced to depend on formal and informal arrangements with neighboring crop farmers to meet nutrient planning goals or regulations. Additionally, the high concentrations of animals on larger dairies raise potential point-source pollution risks from possible manure lagoon leakage, overflow, or failures (Powell et al. 1998). In addition to the socio-economic benefits to farmers and rural communities, efforts to maintain mid-size dairy farms can also contribute to maintaining environmentally sound agricultural practices.

There are a number of potential societal benefits associated with the adoption of automatic milking systems that could include:

- Better quality of life and working conditions for dairy owners and employees,
- Improved economic and social vitality of rural communities, partly through the economic benefits of having a diverse and thriving family-dairy farm sector,

- Improved environmental quality and reduced environmental risk, associated with the revival of moderate-scale, diversified dairy enterprises in the region, and
- Support of a landscape dominated by moderate scale, family dairy businesses that is socially acceptable to local communities, increases local property values, and attracts potential tourism dollars.

The adaptation of new technologies in agricultural affects not only the economics of the farm enterprise itself, but also the manner in which those enterprises are intertwined with the broader regional economy and natural environment. Economically, the adoption of labor saving technologies alters the demand for labor in a multifaceted manner. For example, the demand for lower skilled workers may be diminished while the demand for higher skilled service workers may be heightened. The net impact of this change on the local economy is unclear. Will the increase in demand for higher paying – high skill workers compensate for the decline in demand for lower paying – low skill workers? In addition, as AMS technologies alter the profitability of individual farm enterprises, the impact of those changing levels on the local economy is equally unclear.

When economic change occurs, questions commonly raised include: who gains and/or looses from the change; does the change help or hinder local governments; if jobs are created, who will take those jobs; or how will the local housing market be affected by this change? Research has been proposed to assess the potential economic impact of the adoption of automated milking technology for family operated dairy farms we propose to use the Wisconsin Economic Impact Model System (WEIMS). There may be an opportunity to develop public policy to encourage forms of dairy production that would provide these benefits to rural as well as urban communities.

Regulatory Issues

AMS technology is undergoing a regulatory review in both Europe and the U.S. This process will continue for the next 3 to 5 years in the U.S. At present there are no automatic milking machines operating in the U.S. An AMS will be installed at the University of Wisconsin Research Station in mid-2000. There are also plans for several commercial installations in Wisconsin in 2000. A group of regulatory officials from the Wisconsin Department of Agriculture Trade and Consumer Protection (WDATCP) and the United States Food and Drug Administration (USFDA), faculty from the University of Wisconsin and equipment manufacturers have begun to address AMS regulatory issues. The rules that prescribe the minimum requirements for the production of milk that will be sold across state lines are established in the Pasteurized Milk Ordinance (PMO), which is issued by the USFDA.

While much of the current regulatory language will apply to AMS, there will be some parts of the PMO that will require expansion or revision. The current regulatory structure is based on the assumption that a person would be present during milking and cleaning of the milking machine. Changes in the PMO are proposed, debated and voted on at the National Conference of Interstate Milk Shippers (NCIMS). This organization meets every other year. Each state has a voting delegate to this conference and the USFDA has veto power over any proposals. It is anticipated that a proposal for a nationally approved pilot project for AMS technology will be made at the May 2001 NCIMS. If the performance of AMS technology is satisfactory during this pilot project a proposal for a general approval and modifications to the PMO would be

presented at the 2003 NCIMS. Some of the AMS regulatory issues that have already been identified are described below.

Location of the milking machine: The current PMO requires that milking equipment be protected from contamination by odors, insects or vermin during cleaning and storage. In milking parlors the area where the milking units are stored must be separated from animal housing areas when not being used for milking. Suggestions for AMS are that a reasonable separation will be maintained between areas where milking is performed and manure storage and/or a means to separate milking units from the animal housing area either through the use of a door or a sealed storage location. People should also have access the milking machine through a pathway that does not pass through animal housing or feeding areas. Positive pressure ventilation in the milking area will help to keep insects and odors out. The floor of the milking area and areas near entrances/exits should be designed so that manure can be washed away. Area where cows are milked should have cleanable surfaces and be kept reasonable clean, as is currently required for milk rooms.

Separation of milking and cleaning circuits: Cleaning solutions must not enter milk. The cleaning circuit (any parts of the system which contain cleaning solutions such as detergents and acids) shall be separated from milk handling surfaces by either 1. A physical break (disconnect piping) or 2. A block and bleed valve system (double block valves with a bleed or drain valve between). Some automated cleaning systems will perform a periodic rinse of parts of the system and a less frequent wash of the entire system. The periodic rinsing may be done with water or a sanitizing solution. Consideration has been given to developing a second category for rinsing solutions similar to the present requirements for backflush systems. These rinsing systems must be protected by a failure detectable apparatus whereas the cleaning circuit should be protected by a more stringent fail-safe apparatus

Milk quality detection and separation of abnormal milk: The detection and separation of abnormal milk has 3 aspects: 1. Accuracy of sensors for identification of abnormal milk. This is a technical issue unique to each machine and must be evaluated under field conditions. 2. Accuracy of cow identification is an issue particularly for cows treated with antibiotics. The management computer will make the decision to separate the milk from these cows if it has been given the proper information and if cow identification is accurate. 3. Adequacy of systems to remove antibiotic residues from milk contact surfaces. Some machines rinse milk contact surfaces after milking treated cows. This approach would require a change in the PMO, which currently requires a complete wash, and sanitize not just a rinse. The adequacy of the methods used by each type of machine will need to be assessed.

Washing Frequency: The PMO requires the manufacturer to specify a cleaning regime for every system. A minimum washing frequency of 3 times per day in regular intervals for the entire system has been suggested and some maximum idle (no cows being milked) time after which all or part of the machine must be cleaned. The various strategies to provide intermittent rinsing of parts of the system should be adequate to maintain low bacteria counts. Current regulations do not require the use of milk filters, although it is considered desirable and is widely practiced.

Teat washing and disinfection: Teats shall be effectively cleaned before milking. Cleaning solutions shall be effectively removed from the teats before teat cups are attached.

Sanitary Design: Milk contact surfaces shall comply with sanitary design as specified by the 3A standards. Exterior surfaces shall also be of washable material and design. Slip joints are

allowable but are classified as hand clean areas. Sanitary fittings are required for pipes and long hoses and any part of the machine not disassembled for cleaning.

Economics

The economics of labor, milk price and farm size are different in the U.S. than in Europe. The US does not have a quota system and government support of the milk price is being phased out. This creates a situation of high risk to the diary producer. Most small dairy farms grow most of their own forages and grains. One economic advantage of dairy production in Wisconsin is the ability to convert low-value feed crops into a higher value commodity, milk. Farms tend to purchase more feed and reduce the crop acres per cow as cow numbers increase. A study by Frank (1998) showed that farms with 50 to 100 cows had the lowest cost of production of any herd size. Some relevant statistics are presented in Table I. Small herds had the highest net farm income per hundredweight (cwt) of milk produced with an advantage of $1.21 per cwt over farms with more than 250 cows. This advantage is due largely to the difference in purchased feed costs.

Table I. Milk Production Costs in 1998 on Selected Wisconsin Dairy Farms.

Larger farms have an economic advantage in that the cost of automated herd management technology can be spread over more cows (milk recording equipment, increased milking frequency in automated parlors). Some of these management strategies are not practical on smaller farms because of the limitations on available labor or capital. The use of automated dairy management on smaller farms could close the gap in production per cow with the potential of up to a 13% increase.

A preliminary economic analysis was performed using a robotic milking system on a small farm (70-140 cows), a milking parlor on that same farm, and a parlor/freestall operation for 400 cows. The latter was chosen as a typical newly constructed production system in the Midwest. This analysis assumes that new facilities will be built for both systems. Special facilities and automated cow handling equipment are required so cows will voluntarily enter the milking area. It may be impractical or impossible to renovate traditional dairy housing for these special purposes.

Typical ranges of facilities costs are used for each scenario. The near term scenario for robotic milking systems is the projected price when the technology is introduced ($150,000 per unit milking from 50 to 70 cows). Maintenance will be critical for the success of these highly mechanized systems. A maintenance cost of 5% of the initial cost per year was assumed for the robotic systems and 3% for a conventional milking parlor. An annual interest rate of 9% with a 10-year life on equipment and 20-year life on buildings were assumed for both scenarios. A labor cost of $10.00 per hour was assumed for all scenarios. Results this analysis comparing AMS on a small farm (70-140 cows), a milking parlor on that same farm, and a parlor/freestall operation for 400 cows are shown in Table II.

Table II. Cost per cwt. For Milking Facilities and Milking Labor

In the near-term, robotic milking systems on small farms can approach the upper range of the cost of milking for large farms and will be a high economic risk in the near term. Robotic systems become more competitive using longer-term assumptions for the cost (30% reduction) and performance (20% improvement) of this technology. Even in the near term, the cost of robotic milking looks favorable in comparison to purchasing a modern milking parlor for a small

herd. Farms with 50 to 100 cows make up about a third of dairy farms (6000 farms) and 40% of cows and milk production in Wisconsin. The best managed farms in this size range account for the majority of the candidates for automated milking. The most profitable 10% of these farms are the likely near term candidates for automated milking technology this amounts to about 600 farms in Wisconsin.

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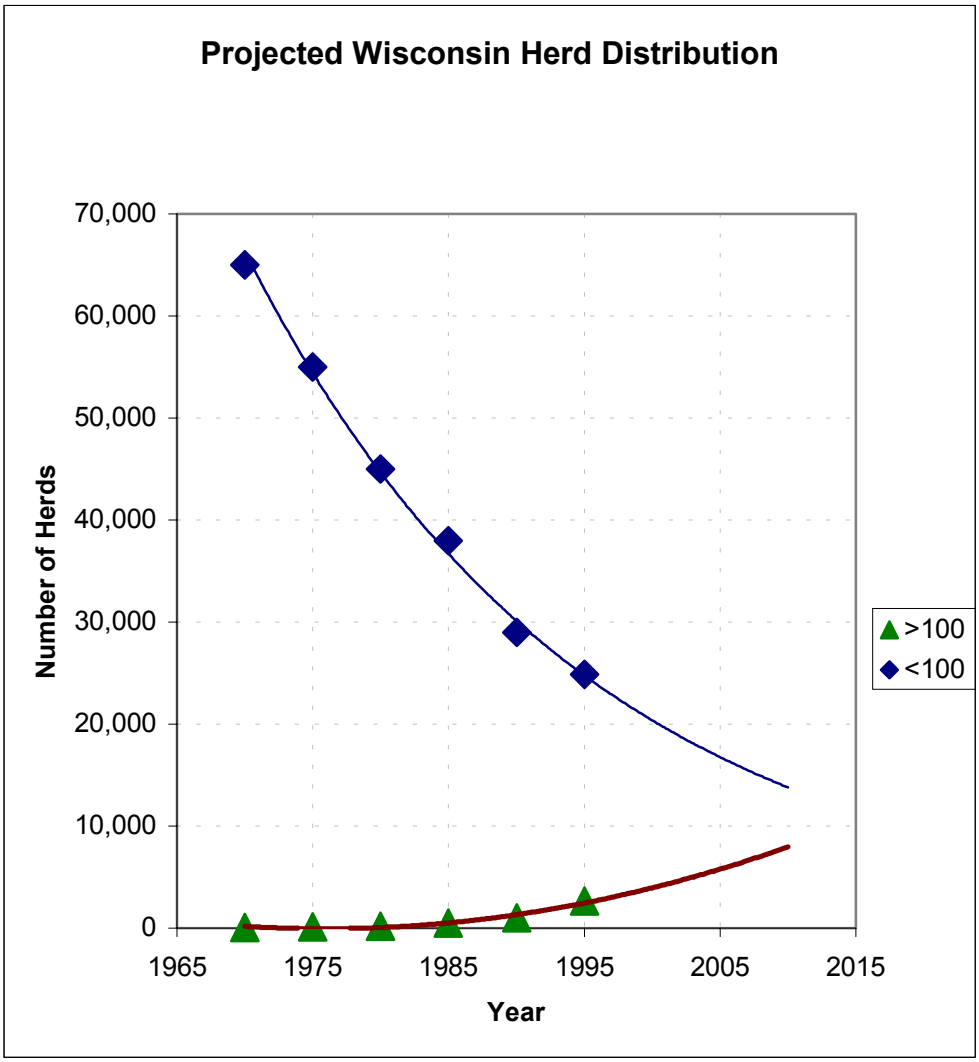
Table I. Milk Production Costs in 1998 on Selected Wisconsin Dairy Farms.

Herd Size	51 - 75	75 - 100	>250
Pounds of Milk Sold / Cow	19,243	19,984	22,018
Crop Acres / Cow	3.91	3.89	2.20
Basic Cost / Cwt	$7.84	$7.95	$8.43
Total Allocated Cost / Cwt	$11.90	$11.84	$13.05
Net Farm Income / Cwt	$3.51	$3.57	$2.36

Table II. Cost per cwt. For Milking Facilities and Milking Labor

Herd Size	70 to 140	70 to 140	400
Milking Technology	AMS	Parlor	Parlor
Near Term	$1.30 - $2.00	$2.15 - $3.65	$0.73 - $1.28
Longer term	$0.85 - $1.50	$2.15 - $3.65	$0.73 - $1.28


Projected Wisconsin Herd Distribution
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Number of Herds
1965
1975
1985
1995
2005
2015
Year
>100
<100