CONSIDERATIONS FOR DIRECT TANKER LOADING ON DAIRY FARMS

by

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ABSTRACT

The objective of this thesis is to examine the factors that a producer will want to consider when choosing the milk cooling and storage system for the dairy farm. The two systems studied are the traditional, on-farm, bulk tank system and the more recently developed, direct tanker loading system that uses glycol chilling plates.

As a long-term investment, the choice of the refrigeration and storage system will have an impact on at least four dimensions of the dairy business. The capital cost of the milk cooling/storage system can range from 2% to 5% of the total capital investment in the farm. Milk cooling costs can also account for as much as 25% of the farm's total electric costs. The system selected can also have an impact on the hauling charges and the hauling charges can account for as much as 10% of the dairy's gross revenue. Lastly, the storage system selected may influence the range of markets available to the producer as not all processors accept milk from farms using direct tanker loading.

Using an economic engineering approach, three hypothetical farm sizes were considered: milking 700, milking 1,400, and milking 2,100 cows. Capital and operating cost data were collected from three major dairy equipment manufacturers that service the Upper Midwest. Capital expenses for each size farm were priced for conventional bulk tanks and then also priced for glycol plate chiller systems that load directly into tanker trailers.

The comparison of annualized costs of ownership for all three farm sizes shows only minor differences in the two systems. For the 700 cow farm, a direct tanker loading system saved 0.24% over the total capital investment; for the 1,400 cow farm, a direct tanker loading system saved 0.97%; and for the 2,100 cow farm, a direct tanker loading system saved

1.19%. Thus, differences in hauling charges, which will vary with each situation, become critical to the choice. Because the overall cost of the two systems are so close, one can expect that the peripheral and non-economic issues may be much more influential on each producer's decision.

Given the known differences in hauling charges, one can conclude that for the 700 cow farm, conventional tanks would be the preferred choice. For the 1,400 cow farm and the 2,100 cow farm, the determining factors come down to the differences in hauling charges and long-term goals for the farm business.

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I consider myself fortunate to be in the dairy business. In many ways, the dairy business behaves like an extended family. Dairy producers and industry people alike are often willing to assist anyone in the business, in any way that they can. Other industries may not be as fortunate.

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Finally, thanks to my wife, Dawn, who's had a very boring and crabby husband for the past three years.

DEDICATION

This work is dedicated to my maternal grandfather, Anthony F. Raski. A second generation American who with his wife, Anna, raised ten children on a Pennsylvania dairy farm, through the Great Depression, with a lot of hard work, grit, and determination.

He was known to have told his children, “Either you learn to use your brains or else you’ll have to use your brawn.”

It was from him, that I inherited the love of the dairy farm.

CHAPTER I: INTRODUCTION

1.1 The Question and Who will be Interested

Until recently, milk has been stored on most dairy farms in a refrigerated bulk tank. From there it was then pumped onto a tanker truck by the milk hauler and taken to the processor. More recently, large dairy producers have begun to use direct-tanker loading (DTL). With DTL, milk is cooled rapidly and loaded immediately onto a tanker trailer as the milk is harvested from the cows. The hauler exchanges an empty tanker for the full tanker, which the hauler delivers to the processor. Nationwide, Dairy Farmers of America (DFA) has 58 farms using DTL. The average herd size of those 58 farms is 1,673 cows. In DFA's ten state area, known as the Central Area Council (CAC), there are 18 farms averaging 1,200 cows that use the DTL system.

Existing producers using on-farm refrigerated bulk tanks are increasingly interested in the economic feasibility of direct tanker loading. DTL is also of interest to prospective producers who are considering large new facilities or major expansions. The primary target of this work is those dairies seeking information on the feasibility of the direct load option for their operations—generally producers milking 700 or more cows.

The findings in this thesis will help producers evaluate the feasibility of direct loading for their farms. In DFA's Central Council Region, 54 farms have herds of more than 700 milking cows of which 36 farms have more than 1,000 cows. Producers considering DTL want to select a system that makes the most efficient use of their capital without negatively impacting other aspects of their business. Because direct loading impacts other stakeholders, the findings here will be of use and interest to milk haulers, milk marketing organizations, processors, regulatory agencies and equipment manufacturers.

The study used enterprise style partial budgets to compare costs of conventional bulk tanks, contrasted to direct tanker loading, for three different farm sizes. In addition, the study identifies and evaluates other factors that should be considered and provides guidelines for producers to use for modifying an existing dairy or to use when selecting the storage method for a new operation.

1.2 Thesis Objective

This thesis is an analysis of the milk storage considerations faced by three different sized dairy farms: 700-cow dairy, 1,400-cow dairy, and a 2,100-cow dairy. The objective is to perform an annualized enterprise partial budget style comparison of conventional farm bulk tank(s) and the direct tanker loading system (DTL). Enterprise style partial budgets with annualized capital requirements and annual operating costs for each strategy are constructed and compared. The impact of capital rationing on the choice of system is also examined.

Primary factors besides capital and operating cost that will influence a producer's choice of storage system include market requirements, processor requirements, and regulatory demands. Secondary considerations and preferences include milk sampling issues, milk quality concerns, hauler availability, quality of service backup, and weather contingencies. All of these and others factors ultimately impact the choice of storage and cooling system.

1.3 Significance

Milk storage and cooling systems are a significant capital investment for the dairy producer. The system of milk storage has a definite impact on the transportation charges too. The capital equipment costs for cooling and storage can easily range from 2% to 5% of the total initial investment. The annual cooling costs typically run close to 25% of the producer's total electricity charges (Hogan). DTL systems may have higher transportation costs because of the cost of having a trailer parked on the premises instead of the bulk tank.

1.4 Benefit to the Producer

The deliverable from this thesis project is a series of structured spreadsheets and a decision matrix to help dairy producers and consultants analyze a dairy farm's milk storage options, refer to appendix A. The decision matrix (and accompanying user's guide, refer to appendix B) will also address ancillary questions that will arise when producers consider the direct-load option. No comprehensive analysis such as this is available, now, for dairy producers. Existing large-scale dairy producers, those considering expanding, and those contemplating starting up large scale dairy farms should find this study helpful.

1.5 Information Sources

Data and information for this analysis was drawn from a number of sources. The capital costs for major capital items such as tanks, chillers, and silos are based on prices obtained from three milking system manufacturers. The same manufacturers provided most of the data on energy consumption, water demands, and installation costs. Building construction estimates were obtained from dairy barn builders.

Transportation cost data were obtained, mostly, from contract haulers. They are familiar with current equipment and operational costs. Other transportation cost data was obtained from dairy marketing organizations, which have departments and employees quite familiar with current hauling cost structures.

Getting a candid assessment from processors has been more of a challenge. Delivery options and milk sources are typically addressed in milk supply negotiations between milk marketing cooperatives and processors. Since the author is a cooperative employee, it is understandable that processors may have been reluctant to disclose their complete opinions and policies on DTL loads.

CHAPTER 2: INDUSTRY AND LITERATURE REVIEW

2.1 Conventional Milk Storage in the U.S.

Dairy producers have been storing milk on their farms in refrigerated bulk tanks since the nineteen fifties. Most dairy farms typically have a bulk tank large enough to accommodate 48 hours (or more) of milk production. The insulated tank with its own refrigeration system has the capacity to cool the milk as it is harvested from the cows. The bulk tank holds the milk in a refrigerated state until it is picked up by a bulk-milk hauler. The on-farm tanks have ranged in size of 50 gallons (in the early days) to 6,000 gallons and larger today (Cady). Today, 1,000 to 2,000 gallon tanks are very commonly used.

There has been a large increase over the past decade in the size of the average dairy farm. For example, the number of US herds larger than 500 cows has gone from 2,336 in 1997 to 3,215 in 2007—a 38 percent increase. In 1997, those large herds were milking 24.4% of the nation's cows. In 2007, those large dairies were milking 54.1% of the nation's cows (U.S. Department of Agriculture). As time goes on and dairy farms grow, more and more dairy farms are able to ship truckload volumes of milk, which eliminates the need for the hauler to visit multiple farms to obtain a load. Typically, such dairy farms milk 700 or more cows.

As producers, managers, and owners contemplate either construction of new large-scale dairies or expansion of existing dairies, a common question is, what is the optimal milk storage system for farms shipping full truckloads of milk? For dairy farms that have the milk volume to fill a milk truck, direct tanker loading is an alternative to the conventional on-farm, bulk tank. Unlike the conventional, on-farm refrigerated bulk tank, the milk simply goes through a rapid plate chiller before loading on the trailer. The plate chiller refrigeration system has the capacity to cool the milk to around 35 degrees.

2.2 Previous Studies

Studies of direct-load systems are limited. Mooney, in an article in *Dairy Today,* discusses the challenges faced by a Pennsylvania dairy producer, and in turn, by dairy producers in other states when installing a DTL system. According to Mooney, hauler arrangements, processor requirements, and sampling concerns are the principle considerations as he recounts the many considerations and challenges encountered by several early adopters of DTL. Although the article provides some thoughtful insights, it does not address the economics of DTL versus the traditional bulk tank.

Manning and Angstadt provide a general guideline to assist producers prior to building a DTL system. They recommend involving the milk hauler and the milk marketer in the earliest planning phases of such a system. They argue that any producer considering such a system must produce enough milk to fill a tanker in 24 hours (approximately 50,000 lbs). They found that regulatory approval of DTL systems installed on dairy farms has been, mostly, on a case-by-case basis. This fact increases the number of unknowns associated with the decision of whether or not to install a DTL system. No producer wants to invest hundreds of thousands of dollars to find later on that the system is not compliant with regulatory officials. With those concerns, Manning and Angstadt discuss the few existing regulatory requirements for a DTL system.

All regulatory oversight of Grade "A" milk production falls under the auspices of the Pasteurized Milk Ordinance (U.S. Department of Health and Human Services), which has specific requirements for DTL systems. Those include recording thermometers, standards for obtaining a representative sample, hose connection specifications, and facilities construction specifications. Other more miscellaneous requirements are vague and subject to interpretation by local authorities (Manning and Angstadt).

Since the Manning and Angstadt guidelines were published, the National Conference on Interstate Milk Shipments (NCIMS) in accordance with the Food and Drug Administration (FDA) has recommended changes in the Grade "A" Pasteurized Milk Ordinance (PMO), which were incorporated in the 2007 revision of the PMO. Those revisions to the PMO clear up some of the previously undefined PMO requirements as they apply to DTL.

The Federal Milk Market Administrator's Office in Minneapolis relates many of the challenges in any milk logistics study (Freije). The office suggests that hauling charges shown on the producer's milk check often do not reflect the actual cost of getting that milk to market. Many handlers or cooperatives may subsidize the actual cost of hauling as a producer procurement tool. This further confounds an accurate assessment of the actual transportation costs.

Hauling and cooling expense represents a significant portion of a dairy producer's total cost of production. Hauling can vary considerably; depending on the geographic region of the country where the dairy is located (Genske) and can even vary within the same state (Freije). It can also vary greatly, depending on the hauling distance. Depending on the gross pay price, hauling can account for as little as 1% upwards to 10% or more of the gross revenue.

Cooling costs are more difficult to determine. Edens et al. found that in Tennessee, refrigeration is the second greatest consumer of electricity in a dairy center, a close second to the energy use of the vacuum pump. Earlier studies (Peebles, Reinemann, and Straub) indicated that cooling costs can range from 10% to 18% of a dairy farm's total energy use. More recently, Hogan reported that cooling energy made up about 25% of dairy producers' electricity bill. Edens et al. concluded that total cooling energy use was closely correlated with pounds produced and the ambient temperature. They also found the KwHr/cwt for cooling milk was actually a little higher than reported in previous studies, with a mean of 1.02 KwHr/cwt. Hogan had reported an average cost of 0.752 KwHr/cwt with a range of 0.40 KwHr/cwt to 1.40 KwHr/cwt.

Milk producers that are more distant from processing plants have explored other options for reducing hauling costs. Reverse osmosis and ultrafiltration have been studied as milk concentration possibilities to cut hauling costs significantly (Howie). Those measures are capital intensive and also limit the final utilization options of milk so treated.

Karpoff and Webster sought other alternatives to increase efficiency in milk hauling. They reported fuel savings in South Dakota of 40% by using two full-size trailers in tandem instead of two tractor- trailer units.

2.3 Why Choice of On-farm Cooling System is Important

Businesses constantly seek increased efficiencies and greater returns through better practices and structures. Dairy producers are very sensitive to improvements (or detriments) in their milk marketing. Kilmer, Lee, and Carley concluded that overall monetary returns are the singular most important factor in the dairy producer's choice of market. Storage systems are a significant capital investment for the dairy producer. The method of milk storage selected impacts the energy costs for cooling the milk and the transportation costs. The capital costs and annual costs can range from 1% to 10% (or more) of the producer's gross revenue. The DTL system presents an alternative to conventional bulk tank method of cooling and storage. It offers the potential to streamline the process of taking raw milk from the cow to the processor.

CHAPTER 3: THEORY

On the typical U.S. dairy farm, milk cooling, storage, and transportation are inevitable and inescapable costs of doing business. The only means of escaping these aspects of the business would apply to the few producers who choose to become *producer-handlers* or cheese-makers such that they can immediately convert the raw milk into some form of finished product. In that case, they may reduce the costs of cooling and reheating and the cost of transporting raw milk to a processor site. However, the *producer-handler* has many other challenges and costs associated with that business structure. For the vast majority of dairy producers, cooling, storage, and transportation costs are inescapable.

3.1 The Macro Considerations

3.1.1 Profit Maximization

In the U.S., the dairy producer is a *price taker*. The producer may be able to enhance his pay price in some markets with premiums for such things as volume, quality, or milk components; however, these premiums (while certainly important to the producer) typically make up a small portion of the gross pay. In economic terms, the milk market (more or less) could be described as a *perfectly competitive market.* As such, profit ($\prod$) = price x output (*PQ*) minus cost (*CQ*) where price is independent of volume the farm produces (Baye 2006). Therefore, milk producers have an interest in minimizing cost to maximize profits.

3.1.2 Minimizing Cost

In a market system, cost minimization is a basic tenet of doing business. "Because scarcity is an economic reality, producers are interested in *cost minimization* – that is, producing output at the lowest possible cost" (Baye). Dairy producers, like any other business, will pursue cost minimization given the level of output.

On the typical U.S. dairy farm, cooling, storage, and transportation can account for up to 10% or more (Genske) of the cost of production. Any reduction in these costs would have a definite impact on the profit margin.

3.1.3 Supply Chain Efficiency

Chopra and Meindl define supply chain efficiency as "The cost of making and delivering a product to the customer. Increases in cost, lower efficiency." Dairy producers have an incentive to keep costs low (Manning and Angstadt), yet one must consider the impact of milk-handling techniques on other stages of the supply chain, particularly the hauler and processor. This study seeks to explore which means of milk storage is the more cost efficient over the whole supply chain. Direct tanker loading eliminates the need for a bulk tank and thereby eliminates one step in the milk supply chain. A question that remains to be answered is whether eliminating this step is a benefit to the producer and/or to the other members of the supply chain.

3.1.4 Capital Rationing

Capital rationing affects the choices made when a business is purchased, constructed, expanded, and operated. Brealey, Meyers, and Allen define capital rationing as "limitations of the investment program that prevent the company from undertaking all such projects". Dairy farms, like all businesses, are faced with choices in the construction phase because capital is always limited. For this reason, dairy producers are interested in their milk cooling and storage system since it represents a major capital investment and also directly impacts their annual operating costs.

3.2 The Micro Considerations

This study constructs enterprise style partial budgets for analysis of the cooling and storage cost per hundred-weight of milk produced for the two different methods of milk handling. In the final analysis, this issue is very much a farm specific issue as no two dairy farms are completely alike. In an effort to have a better understanding of the impact of the farm size on this question, budgets for 700 cow, 1,400 cow, and 2,100 milking cow operations will be developed for each method. Other factors that may influence the choice are the size of the parlor, the actual number of cows milked per hour, and the number of hours milking per day. The breed of cattle and the average milk production per cow will also have some influence. In general, the greater the rate of milk flow, the greater the BTU transfer per hour capacity needed in the refrigeration system. For very large herds, there is an upper limit of how much milk a direct expansion bulk tank system is able to handle (Pretz).

3.3 Discussion of Other Considerations Affecting all Farms

Other issues will influence a producer's choice of milk storage system. Some have cost implications while others involve marketing and management factors. The choice of system should not be made using cost factors alone, but in conjunction with other realities.

3.3.1 Marketing Considerations

Perhaps the foremost consideration for the milk storage/cooling system is the local milk market. Some markets simply do not accept direct loads (Pretz, Harris). In such a market, any consideration of direct loading is purely hypothetical. Other markets accept direct-loads on a conditional basis. Still others have no limitation at all on direct loading. Thus, the first step is to have a clear understanding of requirements concerning milk handling for the producer's actual milk market.

3.3.2 Management Considerations

Transportation is a major issue in a direct load system. Depending upon the milk market, the producer may be working with contract haulers or company haulers or provide his own trucks and/or drivers. Success of the system is critically dependent on a capable trucking system. With the direct load system, a tanker absolutely must arrive on time at the farm. If the truck isn't on time when the tanker on the farm is full, harvested milk will go into the waste lagoon.

Another management challenge with the DTL system is the whole issue of accurate sampling of the load. Sample custody can also present some challenges. In most markets, the dairy producer is paid, based on the components of the milk. With the DTL system, an accurate sample can be difficult to obtain. Farm bulk tanks have built-in agitators that enable accurate sampling. Tankers do not have built-in agitation, which can make accurate sampling a problem. A question to be addressed in the planning process is where the tanker will be sampled and how.

These issues above are but two management considerations a producer needs to address. This study will explore those and other issues to provide guidance to a producer deliberating on the choice of system that is optimal for his farm.

CHAPTER 4: METHODS

This study provides the dairy producer with an overview and comparison of milk cooling and storage systems. The cooling and storage system on a dairy is specifically planned for the expected milk output of that farm now and into the near future. This study is an effort to present all the relevant factors that should be considered before a cooling and storage system is actually purchased and installed.

4.1 Description of the Methods Used

Quantitative estimates are used to provide the dairy producer with a comparison of systems costs. Enterprise style partial budgets are used to compare the annualized capital and operating costs.

The literature review reveals virtually no academic studies on the topic and little useful quantitative data. Therefore, some of the analysis is based on experience, conversations, and correspondence with industry experts who have installed and worked with milk refrigeration systems in the field. Information from those sources is used to prepare enterprise style of budgets of current costs for three different sized milking operations.

4.2 What was Done

This study uses partial budgets constructed using data and experiences from three different system manufacturers. The data is also combined with the experience of regulators, marketing agents, haulers, producers, and other industry experts with many years of experience in the field.

The challenge is to bring in all the relevant factors that could impact the profitability of a dairy farm. It is also important to realize that not all the choices in this arena have easily measurable economic impacts but do have an influence on how the farm is managed or operated. Data has been collected, organized and summarized for this study.

4.3 How it was Done

The vast majority of the data collection was done by personal communication, mainly by direct conversations, phone discussions, and e-mail. Once collected, that data was used to develop the budgets for each scenario.

Enterprise partial budgets were created using depreciation, interest, and selected significant operating costs. Depreciation and interest are two of the components of the DIRTI-5, which is an acronym for depreciation, interest on average value, repairs, taxes, and insurance. For the purposes of this study, the PMT function in Excel was used to calculate the amortized monthly payment in lieu of calculating principal and interest. The interest rate used was 8.0%. This is an intentionally conservative value as current intermediate loans are closer to 6.5% (Vosters).

For the purposes of this study, the depreciation of the two systems is assumed to be twenty years and with an end salvage value of zero. In visiting with equipment professionals (Bouwman), useful lifespan, depreciation, and salvage value of the two systems is roughly equal but very dependant on installation, routine maintenance, and overall farm management. Most likely, twenty year old equipment will have some residual value; however, for cash flow purposes at startup, actual loan amortization payment is used.

The operating costs used were bulk tank washing cost and cooling energy cost. Sensitivity analysis was provided for the hauling cost. The estimated bulk tank washing costs are shown for the bulk tank farms while the DTL farms have no washing cost. Cooling energy costs were estimated using KwHr charges that are typical for the Upper Midwest ($.075/KwHr). This cost will vary considerably, depending on the location. It is also safe to assume that electricity rates will increase over time.

For the purposes of this study, the bulk tank farms are assumed to have 6,400 gallon tanks or larger although the three manufacturers vary the actual sizes available. 6,400 gallons of milk @ 8.6 pounds/gallon equals 55,040 pounds of milk. Whether using a DTL system or bulk tank system, it is assumed that a "truckload" is going to be very similar since haulers will be striving to maximize their legal gross weight, regardless of the system. In the three state areas of Iowa, Nebraska, and South Dakota, typical milk tanker net cargo weights are 52,000 pounds.

With the non-economic considerations (such as support available from equipment dealer), the study will use a more subjective and descriptive evaluation of how current producers and haulers have handled such issues.

4.4 Why it was Done in the Specified Manner

These methods were chosen for this study to best answer the principle objective, which is to assist dairy producers to make the most profitable decision for on-farm milk storage and cooling. Three different sized operations (by herd size) were selected. A reader can extrapolate and estimate potential values for particular farm situations. The spreadsheet format includes the essential milk cooling and storage expense categories that are typical for large dairy operations. The categories will be those typically used by agricultural accountants and academia.

No "best answer" solution is given. A dairy farm is a combination of various systems, and every dairy farm is different. This work explores the various inputs that make up the cooling and storage system so the producer can make an informed choice.

CHAPTER 5: ANALYSIS

This chapter compares the capital costs and annual operating costs. Other considerations which are difficult to quantitatively measure are also examined in order to more fully compare a DTL system to a conventional, on-farm bulk tank system.

5.1 Capital Costs and Operating Costs

5.1.1 Descriptions and Assumptions of Scenarios

Total facility construction costs were based on October 2008, Kansas State University projections of \$5532/cow for a 708 cow dairy and \$4671/cow for a 2,832 cow dairy.

These partial budgets list the key differences in a bulk tank system compared to a DTL system. It needs to be emphasized that these scenarios are partial budgets only. They do not cover the total cost of building a milkhouse but identify the key capital cost differences that distinguish a DTL system from a bulk tank system.

The first item on the list is the bulk tank itself and the accompanying accessories. The three manufacturers price and package these items differently so the total dollar figure in the columns represents the average cost in total for the tank installation. The three manufacturers do not make the same size of tank. For the purposes of this study, the tanks are assumed to range in size of 6,400 gallons to 7,000 gallons. For the DTL system, this value is much less since there is no bulk tank and it is assumed that the producer owns no trailers or any of the trucking equipment.

As approved by the 2007 Pasteurized Milk Ordinance ("PMO"), an Anderson weigh and sampler system is included in calculating the cost of the DTL system.

The 700 cow farm is priced with one bulk tank; the 1,400 cow farm is priced with two bulk tanks, and the 2,100 cow farm is priced with three bulk tanks. Each system is then priced with the appropriate accompanying equipment.

For the 700 cow scenario, this hypothetical farm is not very realistic for either a DTL system or for a single bulk tank. In reality, it is questionable whether a farm of this size could successfully use a DTL system due to the on-board milk temperature exceeding plant delivery requirements. It is also questionable if using a single bulk tank could provide sufficient time window to empty and wash the bulk tank.

Sioux Dairy Equipment, Inc. is a GEA WestfaliaSurge dealership in northwest Iowa that has built many milking facilities, some with conventional milkhouses and some with DTL facilities. Herbst, the owner, cites four key construction items that will vary considerably, depending on which facility is built, refer to Table 5.1.

Table 5.1: Differentiation of Additional Milkhouse Building Costs

	700 Cow		1,400 Cow		2,100 Cow	
	Bulk Tank	DTL	Bulk Tanks	DTL	Bulk Tanks	DTL
Ceiling Height	$2,500	$0	$5,000	$0	$7,500	$0
Framing/Doors	$1,000	$4,000	$2,000	$6,000	$3,000	$8,000
Tank Footer	$2,500	$0	$5,000	$0	$7,500	$0
Trailer Slab	$0	$3,000	$0	$4,500	$0	$6,000
Total Additional	$6,000	$7,000	$12,000	$10,500	$18,000	$14,000
Net System	+	$1,000	+ $1,500		+ $4,000	

The ceiling height is an area of potential savings for the DTL milkhouse. In general, the DTL milkhouse ceiling can be as much as four feet lower than a milkhouse with conventional tanks. In other words, the conventional milkhouse may have sixteen feet sidewalls and a comparable DTL milkhouse may only have twelve foot sidewalls, refer to Figure 5.1. This offers a potential construction savings of approximately $5,000 (Herbst).

Figure 5.1: Conventional Tanks through the Wall

The next area of differentiation is the load-out doors required for a DTL system, refer to Figure 5.2. The doors, bumpers, framing, and construction add about $2,000 per door. This is contrasted to a conventional milkhouse that would require the cost of $1,000 per tank for additional framing to permit the tank to stick out though the wall (Herbst).

Figure 5.2: DTL Load out Doors

A third area of differentiation is the concrete footer required for each bulk tank. At today's cost, the materials and labor is estimated to cost approximately $2500 per tank (Herbst).

The final significant item is the cost of a concrete slab where the trailers will be parked for loading at a DTL farm, see Figure 5.3. It appears that most states (Chloupek) are requiring an impervious, sloped, and self-draining surface for DTL trailers to be parked on while loading. The cost of a concrete slab will vary, depending on the number of trailers it is to accommodate. Conventional barns have no such requirement and a gravel drive-way up to the milkhouse is sufficient.

Figure 5.3: DTL Barn with Concrete Loading Slab

5.1.2 Purchase Price Spreadsheets

These spreadsheets are a compilation of the three manufacturers' data for the three different hypothetical farms (700, 1,400, and 2,100 milking cows). The cost data represents the three manufacturers' suggested dealers' prices, in the Midwest, in 2009. The manufacturers' proprietary pricing data was averaged to create the values used for the systems.

Table 5.2: Equipment Cost for Bulk Tank vs. DTL System on a 700 Cow Dairy

	Bulk Tank	DTL
Equipment		
(1) Bulk Tank, Tank Washer, & Recording Thermometer	$55,695	$873
Flow Controls	$1,591	$4,399
Condensing Units	$11,534	$17,592
Glycol Chiller & Glycol	$0	$16,065
Plate Cooler	$7,851	$12,163
Inline Sampler	$0	$9,800
Pumps	$2,720	$2,720
Total of Key Component Equipment Cost	$79,391	$63,612
Installation, Labor, Dealer Margin, and Freight	$20,000	$23,636
Total Cost, Installed	$99,391	$87,248
Milkhouse Construction Difference	$0	$1,000
Grand Total Cost	$99,391	$88,248
Difference (Bulk Tank - DTL)		$11,142
*Total Facilities Investment (without cattle)		$4,563,900
Difference as % of Total Investment		0.24%

*Assuming: Total Cows, Milking and Dry = 825
Total Facility Investment per Cow = $5,532

Table 5.3: Equipment Cost for Bulk Tank vs. DTL System on a 1,400 Cow Dairy

	Bulk Tank	DTL
Equipment		
(2) Bulk Tanks, Tank Washer, & Recording Thermometer	$110,440	$873
Flow Controls	$2,291	$4,399
Condensing Units	$30,802	$27,730
Glycol Chiller & Glycol	$4,139	$28,069
Plate Cooler	$10,545	$13,323
Inline Sampler	$0	$9,800
Pumps	$2,720	$2,720
Total of Key Component Equipment Cost	$160,936	$86,914
Installation, Labor, Dealer Margin, and Freight	$36,550	$30,445
Total Cost, Installed	$197,486	$117,360
Milkhouse Construction Difference	$1,500	$0
Grand Total Cost	$198,986	$117,360
Difference (Bulk Tank - DTL)		$81,626
*Total Facilities Investment (without cattle)		$8,416,650
Difference as % of Total Investment		0.97%

*Assuming: Total Cows, Milking and Dry = 1650
Total Facility Investment per Cow = $5,101

Table 5.4: Equipment Cost for Bulk Tank vs. DTL System on a 2,100 Cow Dairy

	Bulk Tank	DTL
Equipment		
(3) Bulk Tanks, Tank Washer, & Recording Thermometer	$158,128	$873
Flow Controls	$9,033	$11,142
Condensing Units	$37,286	$36,231
Glycol Chiller & Glycol	$11,222	$35,364
Plate Cooler	$13,778	$16,398
Inline Sampler	$0	$9,800
Pumps	$2,720	$2,720
Total of Key Component Equipment Costs	$232,167	$112,528
Installation, Labor, Dealer Margin, and Freight	$51,895	$38,491
Total Cost, Installed	$284,062	$151,019
Milkhouse Construction Difference	$4,000	$0
Grand Total Cost	$288,062	$151,019
Difference (Bulk Tank - DTL)		$137,043
*Total Facilities Investment (without cattle)		$11,560,725
Difference as % of Total Investment		1.19%

*Assuming: Total Cows, Milking and Dry =	2475
Total Facility Investment per Cow =	$4,671

5.1.3 Annual Operating and Fixed Costs Spreadsheet

A general rule of thumb is that the energy required for cooling of a bulk tank is 80% of a DTL system (Bouwman, Daley). This is due to the efficiency of a direct expansion bulk tank. A refrigerated bulk tank makes only one heat transfer, from the warm milk to the refrigerant. On the other hand, the DTL system uses a two step process. When cooling milk with a DTL system, the milk heat is transferred to the glycol in the plate chiller and then the glycol transfers the heat to the refrigerant in the cabinet chiller. Physics dictates that this two-step process will inherently be less energy efficient. This is the technology as it currently exists. In the future, systems may be designed with improved efficiency that eliminates this two-step process and its inherent energy loss (Bouwman).

It is estimated that the daily electrical energy required to cool the milk from 700 cows is 300 KwHr with the bulk tank system and 375 KwHr for the DTL system. With an energy price of $0.075/KwHr, the annual cost to cool the milk from 700 cows is $8,213 with the bulk tank system and $10,266 for the DTL system. Assuming the costs are proportional to herd size, the costs will double for 1,400 cows and triple for 2,100 cows.

An advantage for the DTL system is not having a bulk tank to wash. The DTL system eliminates that step. For the purposes of this study, all DTL wash charges are being assumed by a party, other than the producer.

In order to calculate the tank washing costs for the bulk tank system, it is assumed the cost of wash water is $2 per thousand gallons. On average, it takes 180 gallons per wash for the 700 cow scenario. The annual wash water cost is 180 gal/wash x 365 washes/year x $2/1,000 gallons = $131/year. The chemical costs for the 700 cow scenario averages $2.20 per wash, or $803 for the annual cost. In total, the water and chemical costs for the 700 cow scenario is $934 per year for the bulk tank system.

Again, assuming that the costs are proportional to herd size, the combined annual water and chemical costs to wash bulk tank(s) is $1,868 for the 1,400 cow scenario and $2,802 for the 2,100 cow scenario.

Table 5.5 summarizes the key quantifiable differences that distinguish the DTL farm from the bulk tank farm by summarizing the relevant annualized costs for these three scenarios. With all the costs now known, it is possible to determine the savings or added cost for the DTL system.

Table 5.5: Partial Budget of Selected Annual Operating and Fixed Costs

Farm Cooling and Storage Costs	700 Cow Bulk Tank	DTL	1,400 Cow Bulk Tank	DTL	2,100 Cow Bulk Tank	DTL
Bulk Tank Washing Cost	$934	$0	$1,869	$0	$2,803	$0
Cooling Energy Cost	$8,213	$10,266	$16,425	$20,531	$24,638	$30,797
Amortized P & Int (pd monthly)	$9,976	$8,858	$19,973	$11,780	$28,914	$15,158
Total (with no addl hauling chg)	$19,123	$19,123	$38,267	$32,311	$56,354	$45,955
Cost Savings with DTL		**-$1**		**$5,956**		**$10,399**
Addl. $.02/cwt Hauling for DTL	$0	$3,833	$0	$7,665	$0	$11,498
Total Cost with Added Hauling	$19,123	$22,955	$38,267	$39,976	$56,354	$57,453
Cost Savings with DTL		**-$3,832**		**-$1,709**		**-$1,098**
Addl. $.04/cwt Hauling for DTL	$0	$7,665	$0	$15,330	$0	$22,995
Total Cost with Added Hauling	$19,123	$26,788	$38,267	$47,641	$56,354	$68,950
Cost Savings with DTL		**-$7,665**		**-$9,374**		**-$12,596**
Addl. $.08/cwt Hauling for DTL	$0	$15,330	$0	$30,660	$0	$45,990
Total Cost with Added Hauling	$19,123	$34,453	$38,267	$62,971	$56,354	$91,945
Cost Savings with DTL		**-$15,330**		**-$24,704**		**-$35,591**
Addl. $.12/cwt Hauling for DTL	$0	$22,995	$0	$45,990	$0	$68,985
Total Cost with Added Hauling	$19,123	$42,118	$38,267	$78,301	$56,354	$114,940
Cost Savings with DTL		**-$22,995**		**-$40,034**		**-$58,586**

Table 5.5 illustrates when hauling charges are equal (for the bulk tank farm and the DTL farm), as one goes from the 700 cow farm, to the 1,400 cow farm, to the 2,100 cow farm, the economic benefit of using DTL increases. However, if the farm is assessed any additional hauling charges for DTL, any benefit would immediately shift to the bulk tank system.

For the 700 cow scenario, annual operation cost is practically the same, if there are no additional hauling charges. If a farm of this size is assessed any additional hauling charges, the advantage becomes even greater for the bulk tank system. The table illustrates clearly the impact of any added hauling charge.

For both the 1,400 cow scenario and the 2,100 cow scenario, the annual costs are fairly close if the DTL farm is being assessed an additional $.02/cwt hauling charge. However, as hauling charges exceed $.02/cwt for the DTL farm, the advantage shifts to the bulk tank system for both size farms.

5.2 Market Considerations and Demands

Probably the most significant factor in deciding whether or not to go with a DTL system, are the marketing requirements. After all, installation costs are meaningless if no processor is willing to accept DTL shipments.

5.2.1 Plant Benefits/Disadvantages

One possible benefit that a DTL farm can offer is lower bacteria counts on in-coming milk. Because the load comes from a single farm, there is less chance of bacterial contamination than from a comingled, multi-farm load. Grade “A” milk standards even recognize this fact in that co-mingled loads are allowed SPC bacterial counts of 300,000 per mL whereas individual farms are limited to 100,000 per mL SPC (PMO). This is tacit recognition of the reality that co-mingled loads can have a higher SPC. Any farm with the ability to load a single transport from a single tank would have this same benefit.

By design, the milk from DTL farms comes into contact with one fewer vessel (no bulk tank). This eliminates the possibility of contamination from a poorly washed tank and valves since there is no bulk tank.

DTL shipments, however, have the disadvantage of potentially having the butterfat stratified. Milk tankers don’t have agitators; since the trailer is filled while milking, the butterfat will tend to stratify. The longer the trailer sits, the greater the stratification. This can be a deterrent for plants without an agitator. The plant would need to invest in a plant-based agitator to get an accurate measurement of butterfat and other milk components.

Because of this agitation and sampling issue, there are plants that simply refuse to accept milk from DTL farms (Rogers, Harris). Accurate sampling of DTL tankers would either require agitation at the plant or an accurate inline sampler. Both of these options have costs associated with them. As a business, any processor is free to make whatever business decisions it feels is in its best interest. Some plants simply chose not to accept DTL milk (Rogers, Harris).

5.2.1.1 Fewer Pumpings

Milk from DTL farms undergoes one fewer pumping because the milk never goes into a bulk tank but goes directly from cooling plates to the tanker trailer. Increased pumping and handling of milk has been shown to increase hydrolytic rancidity of butterfat (Schmidt). For the processor who bottles fluid milk, DTL milk has the potential of being higher quality, which could create an advantage in the market place by extending shelf-life or improved flavor. However, this is a quality that is not routinely measured. It does not have a quantifiable, monetary value and so processors have no incentive to demand or pay extra for DTL milk at this time.

5.2.1.2 Chart Weight vs. Scale Weight

Processors pay for raw milk based on the pounds recorded on the shipping manifest. Bulk tanks have the potential of occasionally shorting the processor since tank weights are calculated by the use of calibration charts. If a bulk tank is not thoroughly pumped out, the potential exists for the processor to be billed for more pounds than was received. This can be significant if the tank is running too cold so that it is forming ice on the inside walls. The weight gets recorded according to the chart and yet many pounds remain frozen in the tank. This can be a loss to the processor.

With a DTL farm, the frozen milk problem is avoided because the manifest weight will often be an actual net weight from scaling the truck. However, scaling trailers can also present problems if trailers are coming in, loaded down with exterior road ice (Harris).

Finally, the milk film, alone, remaining on a 6,000 gallon bulk tank can amount to about 60 pounds per tank load (Johnson). While this is a miniscule loss to the processor, it ultimately ends up as an additional organic load for the producer’s waste water system. Sixty pounds multiplied by 365 days equals almost half a tanker load of milk per year.

5.2.2 A DTL Producer may have Fewer Marketing Options

Due to the previously discussed items, a producer with a DTL system could be "locked into" fewer marketing options which may not include the best paying alternatives. The author is familiar with a situation where a particular farm had a convenient market at a nearby plant. However, when the plant closed, the producer was forced to make major changes in hauling arrangements. Instead of using one trailer, it now required three trailers to service the farm because the plant is so much further away, and the farmer's hauling charges have increased significantly.

There are other situations where smaller, specialty plants may pay higher premiums but simply refuse to accept DTL milk because they don't want to invest in agitation or sampling systems to accommodate the DTL tankers (Rogers, Harris).

5.3 Hauling Considerations

5.3.1 700 Cow Farm vs. 2,100 Cow Farm and Loads per Day

Presumably, a 700 cow farm will be shipping about one tanker load per day and the 2,100 cow farm would be shipping about three tankers per day. In my discussions with trucking companies (Hines), haulers (Sudbeck), and cooperatives (Kennison), the number of loads from a given farm makes a tremendous difference in trailer utilization.

At a minimum, the 700 cow, DTL farm would require two trailers dedicated to that farm at all times. Unless the plant was very close, it would most likely require three trailers. At $60,000 to $70,000 per trailer (Sudbeck), this ties up $120,000 to $210,000 worth of trailers to service that farm. This is a relatively large capital investment in order to handle a single load per day. If another DTL farm were in the area (certainly not always the case), trailer utilization could improve. With the DTL farm, the hauler would benefit from a time savings of about thirty minutes a day since there's no lost time, pumping from a bulk tank. This would save about 30 minutes x 365 days x $20/hr = $3650 per year. This time savings does not offset the additional cost of a trailer. Most likely, the cost of that trailer will be passed along to the producer either in the form of higher hauling rates or reduced price paid for milk.

As the number of loads per day increases, the DTL farm would benefit from better trailer utilization. Eventually, a point is reached where the DTL farm is filling trailers at a sufficient rate that they begin to equal or exceed the utilization of conventional trailers or transports. This is due to the "lost time" required to pump from the bulk tank to the trailer. It would appear that this occurs on the very largest farms that are producing eight loads or more per day (approximately 5,000+ milking cows). At that level of trailer utilization, the likelihood is that haul rates would be identical for both systems.

5.3.2 Distance to Market

For many of the same reasons mentioned in the previous section, distance to market will influence the number of trailers required to service a farm. For example, Northwest Iowa has multiple plants in close proximity to many large dairy farms. In some cases, the plant is virtually next door. Obviously, this reduces trailer turn-around time and enhances trailer efficiency. Conversely, other dairy producers may be hundreds of miles away from the nearest plant. Then the DTL farm will require more trailers to allow for road time.

For the three hypothetical farms in this study, the 700 cow farm would have to be practically next door to the destination plant; otherwise the required number of trailers to service the farm would quickly become impractical when compared to the conventional tank farm.

For example, if a 700 cow dairy was located within minutes of its destination plant and is filling a trailer every 24 hours. It would be reasonable to assume two trailers would be sufficient to service the farm. In all likelihood, the loaded trailer could leave the farm, be pumped off and washed at the plant and return to the same farm, all within 24 hours. However, if the processing plant was 500 miles away, more trailers would be required to assure the farm always had sufficient storage for milk as it is harvested.

5.3.3 Plant Receiving Hours

Also impacting trailer utilization is the receiving hours for the market of choice. In the case of the DTL farm, the only storage vessel is the tanker trailer. The producer and hauler need to have an understanding of the destination plant's receiving hours and how quickly the trailers can return to the farm. Some plants may only receive for eight or twelve hours a day; from early morning to mid afternoon. Regardless, limited receiving hours at the plant could increase the number of trailers required, which could increase the hauling charges to the producer.

5.3.4 Hauling Services Available

This is a very complex topic (Freije). In any given area, there can be radical differences in hauling services available. In some areas, a producer could have multiple contractors and companies vying for the farm's hauling business (Parsons). In other parts of the country, the producer may have just one hauler available. When one has alternatives, it is easier to negotiate terms. In either case, this aspect of the business needs thorough investigation and understanding before a producer ever commits to one system or the other.

In some parts of the country and particularly in the western states, the use of double tanker trailers or "pups" can be an efficient form of hauling. The double tanker haul rate may be available for bulk tank farms but not DTL farms. Regardless, the producer needs to have a good understanding of what's available and the different hauling rates before making the capital investment.

5.4 Sampling Issues Become Pay-Price Issues

5.4.1 Component Accuracy

Dairy producers are paid and processors are billed, based on the components of the raw milk. Producer pay-price will vary depending on where the farm is located. Some milk marketing orders pay based on multiple component pricing, others pay on skim-fat, and still others may not be located in a federal order. Regardless, it is essential that an accurate, representative sample of the milk be obtained for testing. Accurate sampling is also essential for accurate antibiotic testing, which is also done at the processing plant.

Traditional, on farm bulk tanks have a built in agitator. The hauler is required to agitate for a prescribed period of time prior to sampling and loading to assure a representative sample has been drawn. Tankers do not have built in agitators. When milk is loaded directly into a tanker, the butterfat, somatic cells (a quality measurement), and antibiotics (if present) can tend to stratify and rise to the top. The longer the trailer is stationary, the more the milk could stratify. Once DTL milk is delivered to the plant, obtaining a representative sample can be a challenge. Some states require that the plants agitate the load, but this is currently an ambiguous area in milk handling. The decision to agitate the DTL tanker at the plant and the method is left to the processor. At some plants, agitation takes on the form of an aggressive, physical stirring of the milk with a pneumatic powered agitator. Other plants bubble in pressurized air for a prescribed time period, and still other plants do nothing, assuming that the road travel has provided sufficient agitation. In this author's opinion, the only definitive method to assure a representative sample is to use a drop-in paddle agitator in the receiving bay. Refer to the figure in appendix C.

5.4.2 For the DTL Farm, Bacterial Quality is Dependent on Plant Washing

Traditionally, the bacterial quality of the milk sample was entirely dependent on farm conditions. Certainly the quality can be compromised later, but at least the milk was of a determinable bacterial quality before it left the farm. It is substantiated by the sample pulled from the farm tank at the time of loading. In the case of a DTL farm, the bacterial quality of the producer's sample is impacted by the cleanliness of the tanker since the "producer sample" is actually pulled at the plant. In most situations today, the tankers are washed at the plant and are therefore dependent on the quality of washing done at the plant. Old or cracked tankers can also be a washing problem that can impact the producers' quality premiums. Essentially, in the DTL system, the producer's net price can be impacted by quality and cleanliness of the trailer which is beyond the control of the dairy producer.

5.4.3 Limited Antibiotic Testing On-Farm

The "PMO, Appendix N", requires that all milk be tested for antibiotics upon delivery to the plant. All tankers are opened, sampled and tested for antibiotics at the receiving plant. It is questionable whether a producer with a DTL system is able to obtain a representative sample to test from the tanker before it leaves the farm unless he has a drip sampler, but it is common practice on many dairy farms with bulk tanks to do such antibiotic testing before the load is pumped onto the trailer.

With conventional, bulk tank storage, antibiotic testing has always been a matter of pulling a tank sample and performing the test. The milk in the tank could be tested at any time. With DTL, the tanker is typically sealed and inaccessible until it reaches the processor. That is a strong argument for the producer spending the extra money for an in-line drip sampling system at the farm, refer to Figure 5.4. Since a drip sampler provides a representative sample, it can be tested for antibiotics at any given time. This is particularly helpful in those cases where a possible positive antibiotic cow has been accidently milked, early in the filling of the trailer. If an antibiotic test shows “positive”, the partial trailer amount (or bulk tank) could be dumped (rather than the entire tank or trailer load). For the purposes of this study, the cost of an in-line drip sampler is included in all the DTL scenarios.

As of this writing, there is still some ambiguity in the use of drip samplers (Thompson). Drip samplers require diligent cleaning and maintenance. Figure 5.4 shows a common set up for a drip sampler. Some states require the person maintaining the samples to be licensed (Chloupek).

Figure 5.4: On-farm, In-line Sampler with Refrigerated Sample Storage

5.5 The Producer's Long-Term Plans at this Facility

5.5.1 May Want to Stay at or Under 1,000 Animal Units for EPA CAFO Limits

Long-term plans for the facility will certainly impact the cooling/storage system selected. Some producers may intentionally choose to keep herd size under the 1,000 animal units in order to avoid EPA CAFO (concentrated animal feeding operation) regulations. (One-thousand animal units equates to 700 head of milking cows). For that reason alone, some producers may never intend on exceeding 700 head of milking cows.

5.5.2 May Want to Allow for Future Expansion at This Site

For some owners, continual expansion is a given. The author is familiar with one South Dakota producer that currently cannot ship enough milk to justify a DTL system. However, the owner has designed the facilities to be able to easily adapt to a DTL system when the operation reaches sufficient size.

5.6 Equipment Dealer Back-up/Expertise

5.6.1 Strength/Expertise

Conventional bulk tanks have been around for many years. Their refrigeration systems are not all that different than refrigerated grocery cases or other common, commercial refrigeration applications. DTL systems are more complex and more closely resemble the specialized refrigeration equipment one would see in an ice cream or dairy plant, see Figure 5.5. The DTL refrigerants are not inherently risky but require volumes not typical for most local service personnel. For that reason, qualified and knowledgeable service technicians may be many hours away from the farm.

Figure 5.5: Cabinet Chiller and Bank of Condensers for a DTL System

In reality, the DTL system essentially has no "back up". If for some reason, the milk isn't sufficiently chilled before being pumped into the tanker, it cannot be pumped back out and re-chilled. Milk requires refrigeration to limit bacterial growth; milk quality will deteriorate very rapidly if insufficiently refrigerated.

In practice, with a DTL system, all milking that occurs during a refrigeration failure is destined for the waste lagoon and will continue that way until the refrigeration plant is repaired. Thus, the more distant the service personnel, the more milk sent to the lagoon.

Conversely, conventional bulk tanks do provide some level of "back up". If a tank should fail partially though a milking shift, at least the warm milk is being continually blended with the already chilled milk. If repairs are made in a reasonable amount time, the tank's refrigeration system may be able to cool the milk in the tank before quality has suffered irreparably.

Having multiple bulk tanks on any farm provides immediate redundancy. Should one tank fail, there still remains the working tank(s). A DTL system has no such redundancy.

5.7 Weather Contingencies

Storage and cooling considerations need to factor in location and adverse weather conditions. Facilities located in remote locations, prone to challenging weather, will certainly want to consider having excess storage capacity.

Discussions with producers found that some producers believed a DTL system could provide the opportunity to pre-position extra tankers on the farm in times of impending impassable roads. That may be only minimally helpful because extra empty trailers are not likely to be available in times of impending bad weather. In the event of impassable roads, any storage system is going to be challenged. Whether using farm tanks, silos, or a DTL system, sooner or later, trucks have to haul off the milk.

Much of the Upper Midwest was hit with blizzard conditions around Christmas 2009. Thirty plus inches of snow and high winds for several days severely tested the region's ability to transport milk. Many producers were forced to fill bulk tanks to over-flowing. There were anecdotal reports of producers intentionally draining the lower butterfat milk from the bottom of their tanks, retaining the higher solids for when they were finally able to have their milk picked up. In extreme situations such as this, farms with raw milk silos would likely benefit the most. Regardless of the system, the PMO requires that all raw milk tanks be washed at least every 72 hours.

5.8 Required Level of Management

5.8.1 Antibiotic Testing

Regardless of the system, all dairy producers are required by law to diligently manage and exclude any antibiotic treated milk from being offered for sale. Because of limited testing opportunities, the DTL system requires a higher level of management in order to obtain accurate, representative samples.

In situations familiar to the author, DTL tanker access points are sealed before leaving the plant to assure security. Additionally, states that do not require DTL trailers to be loaded inside a building (as shown in Figure 5.6), do not allow routine opening of the trailer dome for sampling milk (Chloupek). Therefore, an effective drip sampler is about the only way a producer can obtain a representative sample of what's in the tanker, once loaded. The author is familiar DTL farms with no means of approved sampling on the farm.

Figure 5.6: DTL Trailer Backed into Loading Position (no External Shelter)

5.8.2 System Freeze-ups

Earlier models of plate chillers have been known to freeze up when milk flow through the chiller is erratic. Dealers (Herbst) and producers (Atsma) report that current installations have been improved with multi-speed or variable speed pumps at the balance tank/ third receiver. The constant flow from such pumps has improved cooling efficiency as well as eliminated freeze ups (Bouwman).

5.8.3 Coordination with the Hauler

The DTL system requires a much closer coordination with the milk hauler. With conventional farm tanks, the hauler typically stops on a routine schedule. A farm using a DTL system may result in filling trailers at some interval other than 24 hours. There are some haulers that have an automated notification system that informs them as each tanker is filled at the farm (Sudbeck). Regardless, the farm needs to have a close working relationship with the hauler.

To simplify this study, the 700 cow scenario was set up with only one 6,400+ gallon tank. In reality, the 700 cow setting almost needs two tanks since the hauler would likely have a very brief pick up/wash window. In such cases (and they do exist), the producer must work very closely with the hauler to avoid sending milk down the drain.

5.8.4 Downtime for Tank Washing

With conventional farm tanks, the farm manager must factor in downtime for tank washing. This process requires about an hour per wash.

5.9 Sustainability/Water Use/Carbon Footprint

Much could be discussed on this topic. Government policy that influences water and energy use may become more influential as time goes on.

5.9.1 Lagoon Water

A benefit of the DTL system is that the trailers are washed off the farm. Additionally, the DTL system eliminates one whole step in the storage process, resulting in one fewer tanks to wash. With conventional tanks, all tank washing water and the milky residue end up in the producer’s waste storage system. This is waste water that requires storage and eventual disposal by the producer. The volume of that waste water is estimated in Table 5.6.

Table 5.6: Annual Gallons of Wash Water for Bulk Tanks

	Min 125 gal	Average 180 gal	High 250 gal
700 Cows	45,625	65,700	91,250
1,400 Cows	91,250	131,400	182,500
2,100 Cows	136,875	197,100	273,750

5.9.2 Energy Requirements

From a carbon footprint/total energy use perspective, a DTL system will generally require 20% more energy for cooling. This is due to the two step (milk to glycol, glycol to refrigerant) cooling process that is inherently less efficient (Bouwman, Daley). To truly assess a comparative carbon footprint of the two systems would require a study that goes beyond the scope of this paper.

5.10 Owners' Personal Attitudes (Ego Trip, Out-do All the Neighbors)

In some producers' minds, a DTL system elevates one to the "big leagues". While the neighbors' perception has little business justification, it is still a factor.

5.11 Transfer of Ownership of the Milk

Some ambiguity remains even now as to when the change of ownership of the milk actually takes place. This question can become contentious in cases of quality issues such as antibiotic contamination, bacteria, or any other problem that could cause rejection at the plant. With conventional bulk tanks, the producer has offered his milk for sale once it is pumped onto the truck. With DTL, the milk is always being pumped immediately on to the truck. Some markets will consider DTL milk "offered for sale" once the truck is filled and leaves the farm. If that's the case, the producer still does have the opportunity to test (and dump if necessary) the tanker before it has actually left the farm. Producers that "self-haul" would likely have the same opportunity. This issue can be further clouded depending on whether the hauling is being done by the plant, a contract hauler, the cooperative, or producer hauled. Regardless, there needs to be a clear understanding among the hauler, the buyer, and the producer, as to who owns the milk, and when.

Ownership of the milk also has implications from a regulatory standpoint. Raw milk is tested for antibiotics at the first receiving location. This is a concern for all producers and why they must have a clear understanding of their potential liability.

5.12 Other Alternatives and Considerations

In addition to conventional farm tanks and DTL, there are other alternatives being used on dairy farms today.

5.12.1 High-speed Load-out Pumps with" Transports"

Traditionally, most farm bulk tanks were picked up by a farm route truck. Unlike typical, industrial transports, traditional milk route trailers are equipped with an on-board pump and a cabinet at the rear of the tank to accommodate the milk-hose and the ice chest for the farm samples. This cabinet adds about $10,000 to the cost of the trailer (Sudbeck). The added weight of the cabinet also reduces the cargo capacity of the trailer.

In recent times, some farms have gone to using a high capacity pump that remains on the farm. This pump can then be used to load the lighter and less expensive "transports". Such pumps can load a tanker in about 30 minutes, approximately half the time required for the pump on the conventional tanker. Some processors (or markets) pay premiums and/or charge less for hauling for farms that can load "transport" style trailers that have no pumping equipment on the trailer.

5.12.2 Using Non-refrigerated Silos &/or Tanks

A farm with a plate chiller refrigeration system may also have the flexibility of adding non-refrigerated storage tanks. The author is familiar with one situation were a large DTL farm added a silo, that was purchased by the contract hauler. It can hold two tanker's worth of milk. It provides the hauler with a long term hauling commitment from the farm and helps even out his manpower requirements. It provides storage for the producer with no direct impact on his cash flow. This extra storage capacity is also a benefit to the nearby plants that use that flexibility to smooth out deliveries to the plant. This is an example of a cooperative alliance that has the potential to benefit all the parties involved.

In another situation, producers have been able to purchase used, non-refrigerated plant tanks at a fraction of the original cost. These large vessels can easily be integrated into a DTL system and provide the storage back-up lacking on most DTL systems.

Table 5.7: Capital Cost Savings of the DTL System over the Bulk Tank System

Savings in Capital Cost of the DTL System Over the Bulk Tank System

Facility Size and Cost:	700 Cow ($4,563,900)	
	Bulk Tank	DTL
System Purchase Price	$99,391	$88,248
Difference (Bulk Tank - DTL)		$11,142
Difference as % of Total Investment		0.24%
Facility Size and Cost:	1,400 Cow ($8,416,650)	
	Bulk Tank	DTL
System Purchase Price	$198,986	$117,360
Difference (Bulk Tank - DTL)		$81,626
Difference as % of Total Investment		0.97%
Facility Size and Cost:	2,100 Cow ($11,560,725)	
	Bulk Tank	DTL
System Purchase Price	$288,062	$151,019
Difference (Bulk Tank - DTL)		$137,043
Difference as % of Total Investment		1.19%

5.13 Discussion and Recommendations

The results in Table 5.7 demonstrate some significant points. The actual difference in capital costs between the two systems (DTL and bulk tanks) range from 0.24% to 1.19% of the total facility construction cost. This is contrary to most producers' expectations. Typically, producers assume that the capital costs for a DTL system will be much less than for a bulk tank system; essentially eliminating the $80,000 bulk tank(s).

The criteria used for the 700 cow farm for this project is not very realistic; most farms of this size would have two bulk tanks. Adding a second bulk tank would make the cost of ownership more closely resemble the costs listed for the 1,400 cow farm. Even so, the 700 cow farm has other challenges that make DTL a difficult choice at best. A farm of this size would be filling a tanker-trailer, roughly every 24 hours. During warm weather, it would be questionable whether the on-board milk would remain cool enough to meet plant delivery temperature requirements. Additionally, for a farm of this size, the hauling charges could have a significant impact since the DTL option will most likely require at least two, dedicated trailers.

For a 700 cow farm, there are certain situations, where DTL could be a viable option. For example the farm may sell directly to a dairy plant that is very close by and that plant does not require delivery temperatures below the standard of 45 degrees (some dairy plants require lower delivery temperatures). Even if such conditions did not exist, the producer still needs to carefully discern if choosing DTL would "lock him in" to long term situation with a less than desirable market.

For the 700 cow farm, DTL may also be feasible if the farm definitely plans on expanding the herd size in a relatively short timeframe. On the other hand, conventional bulk tank(s) would be the best choice for a farm of this size if the plans are to remain at 700 cows.

For the 1,400 cow farm, the choice is less clear. Table 5.7 illustrates that the initial capital cost savings for a DTL installation is about $82,000 less (or about 1% savings on the total facility investment) than a farm with two bulk tanks.

A 1,400 cow farm would be shipping about two tanker-trailers every 24 hours. At minimum, this would require three dedicated tanker-trailers to service a DTL farm of this size. For a farm this size, the hauling differential (if any) would be the decisive economic factor. As Table 5.5 shows, a $.04 hauling differential for the DTL farm would push the economic benefit to the conventional tank farm. A hauling differential of $.02 (or less) would mean that either system is roughly the same cost.

Loading a trailer every 12 hours is probably sufficiently rapid that the delivery temperature would not be as much a concern as it was for the 700 cow, DTL farm.

In 2,100 cow example, Table 5.5 shows the annualized cost is approximately equal if the DTL farm is being charged $.02 greater for hauling. Depending on the location, a farm of this size could be reaching sufficient volume that there is no DTL hauling differential. If that were the case, the economic benefit would definitely shift to the DTL farm.

5.13.1 Sorting Through the Hauling Charges

For all the scenarios, the sensitivity analysis (Table 5.5) demonstrates that the hauling charges have a significant impact on the total annual cost. It is likely that producers will be considering multiple factors when choosing a cooling and storage system. For example, by choosing a DTL system, the producer may be focusing on his core competency of milk production and willingly outsourcing the milk storage and related tasks. However, in order to make the best decisions, the producer will be well served to know to what extent hauling costs will impact the total costs.

The Federal Milk Market Administrator's Office in Minneapolis relates many of the challenges in any milk logistics study (Freije). In many parts of the country, the line on the milk-check titled "hauling" probably does not reflect the actual cost of hauling. In some parts of the country, reduced hauling charges (or "free" hauling) are often utilized as a means to procure producers. In reality, the actual hauling costs are then camouflaged, somewhere in a reduced gross pay price. Gross pay price is difficult to compare between farms because of multiple component pricing.

In visiting with managers with a number of milk marketing organizations in various areas, it would appear that the most accurate DTL hauling schemes are where the farm is assessed some "fee" for supplying the trailers. Logically, this fee would reflect back to the cost of leasing the tanker trailers. In most DTL situations, the farm will require at least two trailers on the farm at all times. This would be the rationale for assessing the farm the lease cost for two trailers.

For example, a 2,100 cow DTL dairy farm is shipping three loads per day. It is charged the same rate as a bulk tank farm plus the cost of leasing two trailers. If those trailers lease for $800 per month each, then the farm is assessed $1,600 per month additional hauling. This would equate to an additional $0.0355/cwt. The limited hauling data available would suggest that DTL would be a more costly option for all three size farms in this study.

For the producer considering DTL, it is suggested to investigate, carefully, the hauling charge differential between the two different systems. Negotiation of such charges may be well worth the time and effort.

5.13.2 Insights Gained at a Dairy Trade Show

In visiting with the owners of several large herds; when asked why they selected a DTL system, the typical, immediate response was, “reduced capital cost”. It would suggest they have concluded that they can eliminate the entire $80,000 cost per bulk tank(s). This is evidence that some degree of capital rationing had affected their initial investment.

A second justification among these producers for choosing DTL was the reduction in water used since the DTL system does not require the routine washing of bulk tanks. Reducing waste water decreases the frequency of having to empty the lagoon. The cost and time of meeting environmental concerns with the lagoon becomes a management choice. The choice to out-source these tasks is further evidence of both capital and management rationing. Both may be of limited availability, given the alternative needs for both.

CHAPTER 6: CONCLUSIONS

As is so often the case in agriculture, specific solutions for farm milk cooling, storage, and transportation is farm specific. This study is an effort to analyze three hypothetical farms and to draw conclusions based on the given assumptions; fully understanding that in real life, every farm situation is unique.

For the 700 cow, one tanker-load per day farm, a primary question to be asked is, "does the capital savings at the time of construction (e.g., $11,142) offset the annual difference in operating costs?" For example, if the farm is being charged an additional $.04/cwt as a charge for providing trailers, this means the farm would be almost paying an additional $8,000/year, for the next twenty years.

The critical question for the producer to ask is, "What will be the hauling cost if this farm uses DTL instead of bulk tanks or silos on the farm?" Assuming gross pay price is the same, this is about the only way to determine the actual difference in hauling.

6.1 Implications for New Construction

The implications for a green-field construction project are many. If a brand new dairy is to be established, the owner needs to consider the difference in capital construction cost, the available markets, the hauling considerations, long term plans for that site, managerial effectiveness and a whole host of secondary considerations. At a new site, the owner has the luxury of considering all the factors and their potential impact.

6.2 Implications for Expansion of Existing Operations

Existing operations will already have some form of milk cooling and storage on the farm. An expansion will have to be a carefully choreographed project that is done in close collaboration with the dairy equipment dealer. If milking is to continue, the service staff will have to work around the milking shifts.

As a conventional, bulk-tank farm expands, a DTL system may be the logical progression in the growth of the business. If the existing tank(s) remains on the farm, it can provide a welcome back-up system in the event of refrigeration problems or in the event that empty trailers can't be delivered to the farm. This value needs to be weighed against the cost of retaining the tank assets.

6.3 Conclusions and Long Term Goals of the Producer

At first glance, most producers may be inclined to assume that the DTL system is simply less capital intensive because no bulk tanks are purchased. While the capital cost savings are significant, the savings are still a relatively small proportion of the overall facility expenditure. The owners' long term goals should be carefully weighed and balanced against the immediate capital cost savings.

Regarding all the factors previously discussed, it appears that the DTL system becomes more competitive as the farm gets larger than the scenarios in this study. Another suggested area for further study would be the use of silos and non-refrigerated tanks in concert with glycol plate chillers.

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APPENDIX A

Decision Matrix for Conventional Tanks or Direct Load (DTL)

	Conventional Tank	**Direct Truck Load**
A) Cooling/ Storage Systems Cost:		
1) System Capital Cost: (and/or)	$-------------------	$---------------------
2) Annualized Cost:	$-------------------	$---------------------
B) Marketing Options:		
1) Number of choices:	-------------------	---------------------
C) Hauling Considerations:		
1) Options Available:	( ) Contract Hauler ( ) Co-op/Plant Truck ( ) Self Haul	( ) Contract Hauler ( ) Co-op/Plant Truck ( ) Self Haul
2) Number of Dedicated Trailers Available?	-------------------	---------------------
3) Quoted Hauling Charge:	$-------------- /cwt	$--------------- /cwt
4) Plant Distance:	←---→ Far Miles Close	
5) Comfort/Trust:*	----------------- %	------------------- %
D) Refrigeration Service/Dealer Support:		
1) Dealer Distance:	-------------- Hours	--------------- Hours
2) Capabilities:	Refrig: ( ) Yes ( ) No	DTL: ( ) Yes ( ) No
E) Long Term Plans for This Facility:		
	←---→ Little Likelihood Of Addl. Growth 700 cows, CAFO Limited	Growth & Expansion Likely 2,000 cows +

*This is a relative "confidence" in the hauling system the producer has in place. E.g., the producer may already have a relationship with a particular hauler and want to change over to DTL; will that existing hauler be able to assure that he can always have an empty trailer when needed?

APPENDIX B

User's Guide for Decision Matrix

The decision matrix is a device to aid the producer/owner/investor to make the decision, whether or not to use a DTL system on the farm. Obviously, every situation will be unique. Whether evaluating an existing dairy or simply viewing a drawing on a page, this is an attempt to summarize the key factors that should be considered. The author suggests involving all stakeholders (the milk market, haulers, equipment dealers, state sanitarians, architects, extension, etc) to benefit from their broad range of perspectives.

A. Cooling/Storage Systems Cost

To the extent possible, it would be desirable to have a firm bid from the equipment dealer of the installed cost of each system, conventional tank and DTL. Care must be taken to include all relevant components (such as a load-out pump if going with conventional tanks or a refrigerated sampling system if going with DTL).

Annualized cost would take a lot of input from the dealers but would help provide a fuller picture of the cost of operation.

B. Marketing Options

Given the location of the farm, how many marketing options are there available? Verify that each market is willing to accept milk from DTL farms.

C. Hauling Considerations

1. Options Available

Check the appropriate boxes for the options available under each system.

2. Dedicated Trailers Available

To the extent possible, for each system, it would be helpful to know that the hauler is going to be up to the task of serving the farm without equipment breakdowns or shortages. Does the hauler have back-up tractors and trailers in the event of breakdowns or accidents?

3. Quoted Hauling Charge

To the extent possible, have a good understanding of how hauling charges are calculated. Is there a flat $/cwt? Is there a stop charge? Are there waiting charges? Mileage? Is there a "max haul" ceiling per month, above which there are no further charges?

4. Plant Distance

This may or may not be relevant. In situations where the farm is located very close to the plant, the same trailer can be turned more than once in a 24 hour period. Depending on the hauling situation, this could be a benefit. With long distance destinations, standard transports may be more desirable than the specialized DTL trailers.

5. Comfort/Trust

Is the hauler up to the task? What kind of performance history does the hauler have? Is the hauler able to hire and retain good drivers? Should the hauler prove unable to do the job, what are the alternatives?

D. Service/Dealer Support

This concerns the people that will back up your refrigeration system. Does your particular equipment dealer have other installations, similar to yours? This may or may not be the same service personnel that installed the milking equipment since there may be refrigeration specialists that could be closer by. Whether conventional tanks or DTL, it's a good idea to know how many hours distant is the qualified refrigeration expert.

E. Long Term Plans for this Facility

This is an effort to justify the system selected. With a smaller project, conventional tanks may be more desirable because of resale value or ease of service. Is the location likely to eventually be limited for expansion? Will manure storage limit expansion?

F. Any Other Notes or Items, Specific to this Location?

APPENDIX C

This is an example of a pneumatic agitation system for DTL trailers.