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An Analysis of the Marketing Cost Impacts of Reverse Osmosis Concentration of Milk

by

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INTRODUCTION

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This paper examines the potential to reduce marketing costs by reverse osmosis concentration of milk. In such a system, milk would be concentrated at a local assembly point and the concentrate would then be shipped to a secondary processing plant. Primary savings would result from the reduction in volume to be hauled from the assembly point to the main plant. Secondary savings could result from the use of a concentrated rather than a full-volume milk as an input at the main plant.

Reverse osmosis has several characteristics which, upon preliminary investigation, recommend its consideration for milk processing. The energy requirements are low. In addition, reverse osmosis appears amenable to small-volume processing. Also, minimal labor is required to run the equipment since it is fully automated and mechanically simple. Milk quality, aside from water content, is not appreciably altered during reverse osmosis therefore, the milk's food value and palatability should not be greatly impaired. Consequently, the processed milk is not restricted in final use although in some cases re-constitution may be required. Finally, capital and operating costs do not appear prohibitively high. This list of characteristics is considered to be of sufficient strength to merit a study of the feasibility of reverse osmosis use in milk marketing.

A comparative analysis is used in this study to determine feasibility of using reverse osmosis to reduce costs of milk assembly. Costs and returns for traditional milk receiving stations, a baseline system, and shipment to final processing plants are compared to costs and returns for a hypothetical assembly system that concentrates the milk by reverse osmosis before transport to the final processing plant.

The analysis involves two steps. First the capital requirements and operating costs for alternative reverse osmosis systems are developed. Secondly, net present value analysis is used to determine profitability of the alternatives. With this traditional receiving station milk system in Minnesota milk is picked up at the farm in bulk or can by trucks, and then shipped to a manufacturing plant or fluid milk processing facility. These receiving stations frequently serve only as reload stations and perform no milk processing. They handle relatively small volumes of milk, often handling about 100,000 pounds of milk per day. Reverse osmosis assembly system would replace these receiving stations. These reserve osmosis centers would continue to function as reload centers, transferring milk from small to the larger trucks, and, in addition, reduce the milk's water content by approximately one half. To take advantage of economies of size in reverse osmosis processing, these centers may incorporate the volumes of several receiving stations.

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REVERSE OSMOSIS: BASIC PROPERTIES AND APPLICATION TO MILK

Reverse osmosis is a complex and not completely understood technology. In reverse osmosis a solution is pumped into contact with a semi-permeable membrane which permits the solvent to pass through but rejects the solute. The driving force is the pressure difference over the membrane. No phase change is involved, liquids remain liquids and gases remain gases. As the name suggests, reverse osmosis is the mirror image of osmosis. During osmosis a solvent is driven through a semipermeable membrane until the osmotic pressures on either side of the membrane are equalized. In reverse osmosis the pressure on the feed side is raised above the osmotic pressure, forcing the solvent through the membrane.

While the theory of membrane transport is incomplete, the factors affecting transport efficiency are quite well understood and are of considerable practical importance. In a dilute solution, temperature and pressure are the primary determinants of efficiency of flux (is the rate of flow of milk through the system). An increase in pressure will enhance flux without a loss in separation quality. Excessive pressure may, however, cause membrane damage. This damage may take several forms, notably compaction or rupture. Membrane damage is a major concern in light of the high cost of reverse osmosis membranes.

An increase in temperature also causes an increase in flux. This flux increase in a dilute solution is largely due to an enhancing of the solubility of the solute in the membrane. The flux effects may be substantial. However, membranes are senstive to excessive heat, and if exposed to temperatures above 45°C, will deteriorate rapidly. This heat sensitivity restricts operating conditions and has important implications for membrane cleaning procedures.

The level of concentration also affects flux. Because reverse osmosis operates by exceeding the osmotic pressure of a solution and forcing the solvent through a membrane, the osmotic pressure is directly related to the concentration of the solute in the solution. The magnitude of the differential between operating and osmotic pressure determines flux rates, i.e., the larger the differential, the higher the flux. Therefore, for a constant operating pressure, flux declines as concentration and, hence, osmotic pressure increase. Because concentration and flux vary inversely, the first x percent of solvent is less expensively extracted than the second x percent, and the second more cheaply than a third, and so forth. The first x percent also involves a larger volume than subsequent x percents; therefore, costs per unit of solvent extracted increase rapidly.

Solute concentration throughout a solution is not necessarily uniform, and this also affects the rate of concentration. During reverse osmosis solute and solvent are continually flowing toward the membrane where the solvent passes through and the solute is rejected. If the rate at which solute moves toward the membrane is not matched by back diffusion of the solute into the main body of the solution, then solute concentration at the membrane interface will rise relative to the average solute concentration. This enhanced concentration of solute at the membrane interface is known as concentration polarization. Back diffusion is inhibited in more concentrated solutions; therefore, concentration polarization is increasingly likely as the average solute concentration increases. As concentration polarization increases flux rates decline.

The backflow rate rises as the temperature rises, especially if the temperature increase reduces the solution viscosity. In addition, at a high temperature concentration polarization may be less troublesome since this raises the solubility and, hence, the solubility limits of the solute, and therefore, the solute is less likely to precipitate on the membrane. Turbulence promoters, as the name suggests, act directly to increase backflow.

A more complete description of the parameters affecting reverse osmosis is available in the 1974 Journal of the Society of Dairy Technology article by Donnoly et al. entitled "Reverse Osmosis Concentration Application". Readers interested in a more detailed discussion of the effect of temperature, pressure of solution concentration on reverse osmosis efficiency may wish to consult this article.

Reverse osmosis concentration of skim milk has been used for several years in commercial dairy plants. However, present temperature tolerances of membranes preclude commercial reverse osmosis of whole milk. Unless milk fat can be processed in liquid state, which is not possible under present membrane heat tolerances, fat fouling on the membrane becomes a serious problem.[1]

Quality changes are critical factors in determining feasibility of any milk concentration process. The ideal concentrated milk product contains all the milk components of full-volume milk with the exception of water. In addition, the concentrate should consist solely of milk components, and those components should remain in their original form. For example, denaturation of whey protein would be undesirable.

Milk concentrate by reverse osmosis is not a perfect substitute for unprocessed milk because some of the smallest milk components are lost. A reverse osmosis concentrate is, however, free from the taste and nutritional defects introduced by heat treatment, and if proper processing and cleaning techniques are employed, it will be free from microbial contamination.

1/ Arnold Spicer (ed.) Advances in Preconcentration and Dehydration of Foods, New York, Wiley and Sons, 1974, pp. 213-250.

Milk component losses are primarily restricted to Vitamin C, which passes freely through the membrane. In addition, there are minor losses in nicotinic acid, vitamin B_6, the ash (which includes much of the milk's mineral content) and lactose. These losses are presented in Tables 1 and 2. In Table 1, note that the protein retention is 100 percent and that the percentage of total solids in the skim permeate is only 0.6 percent. Table 2 is a presentation of the vitamin retention. All Vitamin C is lost. However, market milk contains only about 10 milligrams of Vitamin C per liter and the adult daily requirement is 70 to 100 milligrams. Thus, the loss may not be critical.

The second quality consideration is that the product should not include components not found in full-volume milk. This facet of quality includes chemical addition or change or possible biological contamination from processing. Reverse osmosis, in general, is a process requiring no phase change. Pretreatment, however, is often used to enhance flux. In the case of milk processing, concentration pretreatment consists of separating the milk fat from the skim and heating the skim to 161^{o}F. This heat treatment should not adversely affect concentrate quality as 161^{o}F is a standard pasteurization temperature.

Bacteriological contamination may result from processing and or from inadequate cleaning. Processing at ambient temperatures eliminates thermal degradation but creates an opportunity for bacterial growth. This growth can be satisfactorily controlled by either rapid processing or by processing below 10°C.

Contamination from improperly cleaned equipment is usually avoidable through proper cleaning procedures. The cleaning of membranes is complicated by their inability to withstand temperatures above 113^{o}F, by the membrane's senstivity to high and low pH, their lack of physical strength, and by the necessity of keeping membranes wet at all times. The latter two restrictions necessitate cleaning in place.[2]

Cleaning is perhaps more damaging to membranes than actual processing, and membrane life expectancy is often more closely linked to cleaning procedures than to solution processing. Cleaning is especially damaging to membranes if the water used has a high mineral content.[3]

2/ Spicer, op. cit.

3/ Glover, Frank, Paul Skudder, Philip Stothart and Evan Evans, "Review of the Progress of Dairy Science: Reverse Osmosis and Ultrafiltration in Dairying," Journal of Dairy Research, Vol. 45, 1978, pp. 291-318.

Table 1. Composition of full-volume skim milk, skim milk concentrate, and skim milk permeate obtained by skim concentration by reverse osmosis.

Constituent	Original skim milk	Skim concentrate	Skim permeate
		Percent	
Total solids	8.70	24.98	0.600
Lactose	4.90	14.38	0.022
Protein	3.12	8.76	--
Ash	0.76	1.50	0.370
NPN (nonprotein nitrogen)	0.20	0.69	0.230

Source: Donnelley, J.K., A.C. O'Sullivan, and R.A.M. Delaney, "Reverse Osmosis Application", Journal of the Society of Dairy Technology, 27:3 (1974)

Table 2. Retention of vitamins as percent of original content in reverse osmosis concentrated milk.

Item	Vitamin C	Pantohenic acid	Ribo-flavin	Biotin	B_{12}	Thiamin	B_6	Folic acid	Nicotinic acid
Molecular weight	176	219	376	344	1,357	301	170	441	122
Reverse os-mosis whole milk	--	100%	100%	100%	100%	100%	96.6%	100%	92.1%

Source: Donnelley, J.K., et al. op. cit.

As noted previously, the major choice parameters in designing a system are temperature and concentration. Membrane and skim milk characteristics constrain the maximum temperature and concentration levels to below 104°F and to a three-to-one concentration or less. In more highly concentrated milk, lactose cystallization becomes a problem as it tends to foul the membranes and results in a unsatisfactory milk concentrates. Optimizing the temperature and concentration is a complex technical question; thus, for our anlysis, a membrane expert was consulted. For centers of the type comtemplated here, he recommended that processing temperature be between 85° and 90°F and that the concentration ratio be two to one.

In addition, a membrane configuration must be selected. Cellulose acetate membrane systems are built in a variety of configurations, of which two are commonly used in food application.[4] These are the plate and frame, and the tubular systems. Both perform satisfactorily in skim milk concentration. Plate and frame systems consist of flat membrane sheets mounted on porous or grooved plates. Adjacent membranes are separated by spacer plates which serve to create flow channels ranging from 0.5 to 3 millimeters in width. Solution is pumped through the membrane and the plate, in the case of porous plates, or along the grooves if the plate is grooved. Tubular reverse osmosis systems consist of a porous membrane-lined tubes with internal diameters ranging from 9.525 to 25.4 millimeters. The solution is pumped through the tubes where the solvent passes through the membrane and the tube. The choice between plate and frame, and tubular in concentration of the skim milk is, for purposes of this study, arbitrary. The reverse osmosis centers specified for our analysis are designed with tubular membrane systems.

4/ Donnely, J. K., A. C. O'Sullivan and R. A. M. Delaney, "Reverse Osmosis Application." Journal of Dairy Technology Vol. 27:3, 1974.

CAPITAL AND OPERATING COSTS FOR REVERSE OSMOSIS CENTERS

Method of Analysis

Costs of operating the baseline assembly system and capital and operating costs for replacement systems with reverse osmosis processing are developed in this section. Estimating the net present values of investing in such a change is described and presented in the following section.

The Baseline System

Unlike the reverse osmosis centers, the baseline system is not synthetically generated. It is based on a part of a milk assembly system now in use by a large central Minnesota dairy product manufacturer. We selected, for study, several receiving stations shipping to that processor that were judged by the manager to be efficiently run and to reduce milk assembly cost over direct assembly. The interstation and station-to-main-plant distances for these plants are given in Table 3.

The cost of operating a receiving station was estimated from accounting data obtained for these stations. The data were adjusted to remove costs for various functions performed by the stations as they now operate but not to be performed by the stations in this study. The costs removed were those for management and bookkeeping expenses that could be performed by the main plant or general cooperative offices because management is assumed to be centralized. The implicit assumption that consolidating management at

Table 3. Interplant and plant-to-main-plant distances one-way, in over-the road miles.

Station	Station A	Station B	Station C
A	--	19	--
B	19	--	30
C	--	30	--
Main Plant	80	70.5	84

the main plant would not be higher cost than maintaining separate management in the field was judged acceptable. The estimated costs of running a receiving station that processes 113,000 pounds per day in 1982 are presented by expense item in Table 4 below.

Basic capital costs for these receiving stations are not considered because the choice facing the milk assembler is not whether to build receiving stations or reverse osmosis centers. Rather, the decision is whether or not the receiving stations now in use should be replaced with reverse osmosis centers. The relevant capital costs of the receiving stations therefore are simply the present value of any expected investment in new plant and equipment, assumed here to be zero. Salvage cost was also treated as zero. This is probably a fairly accurate reflection of reality as receiving station buildings have few remodeling opportunities, contain equipment with low resale value, and are typically situated on small plots of relatively low-value land.

Table 4. Receiving station operating costs, 1982.

Item	Cost
	- dollars -
Labor	9,202
Electricity	4,430
Fuel oil	5,199
Repairs	1,695
Insurance	2,535
Miscellaneous	1,228
Supplies	5,474
Telephone	399
Property taxes	1,048
Total	31,210

Reverse Osmosis Center Specifications

The reverse osmosis centers are synthetically engineered, i.e., their capital and operating costs are based on estimates and probable costs rather than the actual experience of centers now in operation. The major cost components, capital and operating, can be inferred from following the flow of product through the center. A schematic description of the flow is presented in Figure 1.

The milk arrives at the plant in 30,000-pound-capacity bulk tank trucks and is tranferred to one or two silos, where it will be held until processed. The dual silo system permits processing to continue without interruption and the cleaning of the silo while the center is in operation. An initial milk temperature of 40°F is maintained in the storage tanks. The milk is drawn from the silo into the high-temperature, short-time (HTST) pasteurizing system,where it is heated to 161°F, held for pasteurizing, cooled to 90°F, and then separated into skim and 40 percent butterfat cream. This heating and cooling process is partially regenerative, i.e., the milk flowing from the pasteurizing unit helps to warm the incoming milk awaiting pasteurization. The cream is cooled to 40°F and stored in cream tanks where the temperature is maintained at 40°F through cooling units and gentle agitation to assure uniform temperature. The skim, meanwhile, is pumped directly into the reverse osmosis modules, where half the water is removed. Following reverse osmosis processing, the concentrate is cooled to 40°F again, partially by regeneration and stored in concentrate silos where it maintains temperature without cooling. As 50,000-pound lots accumulate, the concentrate is hauled away. The permeate is discarded without further processing although if desired the permeate may be kept for use as cleaning water. The processing is automatically controlled.

After processing is complete, the center is thoroughly cleaned. For the most part, the equipment and silos are cleaned in place (CIP), saving both on labor and chemical costs. A few pieces of equipment, such as the positive pumps, must be disassembled and cleaned manually, and the processing area must be hosed down.

Four assembly plant sizes were specified for analysis. There are two 226,000 pound-per-day plants operating at 10 and 20 hours processing, respectively and two plants processed 339,000 pounds per day, again in either 10 or 20 hours. All plants, regardless of size, require an additional 4 hours for cleaning. Therefore, if the plants are numbered I, II, III, and IV, from smallest to largest volume processed per hour, the progression is 11,300 (226,000 at 20 hours), 16,950 (339,000 at 20 hours), 22,600 (226,000 at 10 hours), and 33,900 (339,000 at 10 hours).

Capital Costs for Reverse Osmosis Centers

Building Requirements and Costs. The building costs were determined by laying out the plant equipment and then costing space at a flat rate per

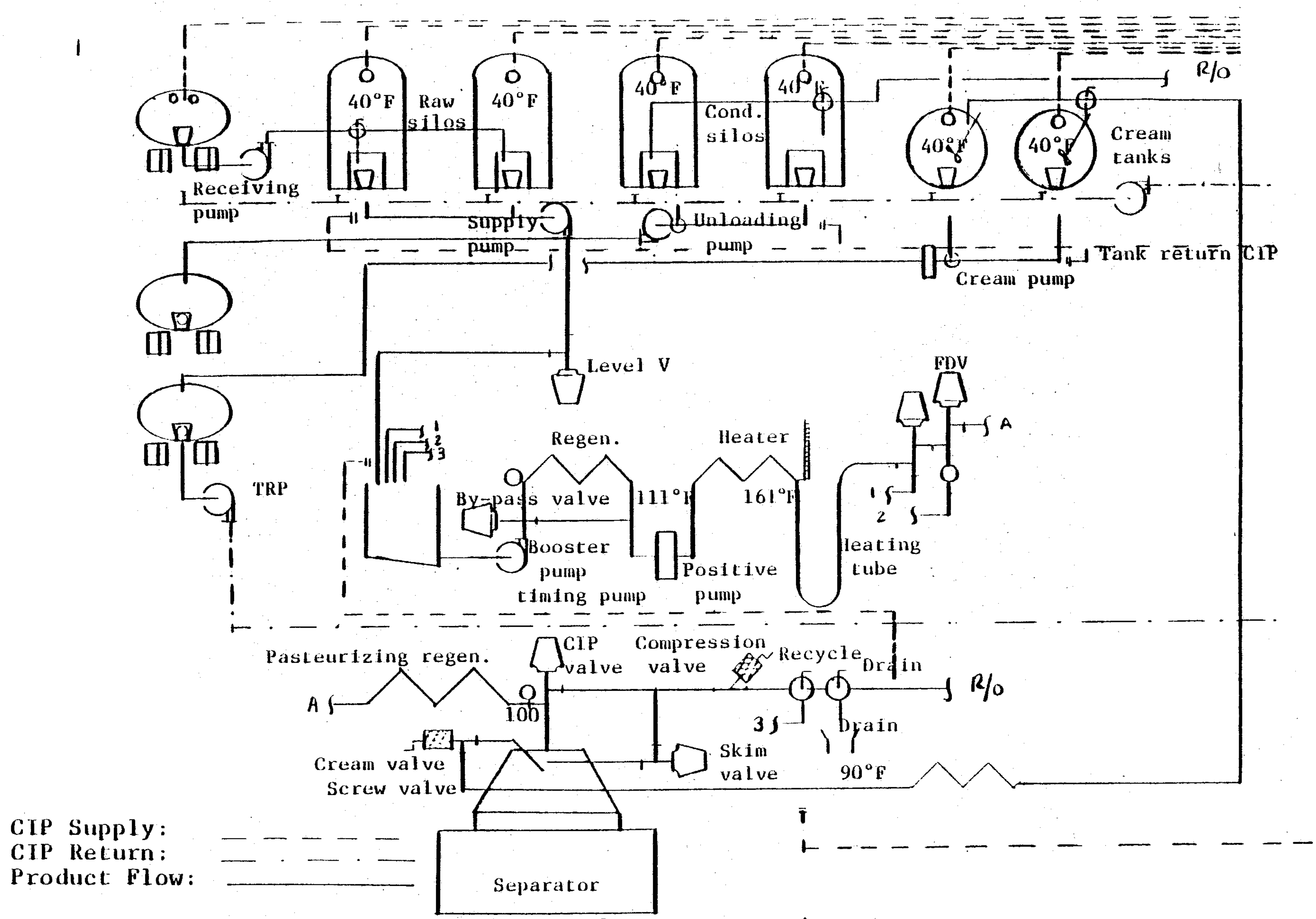

Figure 1. Schematic diagram of a reverse osmosis center

square foot. The building is one story, with 15-foot, 8-inch ceilings with an additional 2 feet for ceiling girders. The floor and walls are water resistant and constructed of easily cleaned materials. All storage silos are external to the building. There are two main rooms -- one for processing equipment, the other for cleaning equipment, the boiler, and the ice building. Opening off the latter room is a storage room and a restroom. In addition, there is an enclosed but unheated receiving area designed to accomodate one truck, but without truck washing facilities.

The building costs were developed using $61 per square foot for the main building and $39 per square foot for the receiving station.[5] The estimated square footage required for the center and the total building costs are presented in Table 5 below.

Table 5. Building and receiving area capital costs.

Plant size (lbs. of milk processed/day)	Main building	Receiving area	Cost subtotal	Cost of electricity	Total cost
	------ sq. ft.-----		------------- dollars -------------		
I-226,000 (11,300 lbs./hr. for 20 hrs.)	1,720	640	129,880	15,000	144,880
II-339,000 (16,950 lbs./hr. for 20 hrs.)	1,768	640	132,808	15,000	147,808
III-226,000 (22,600 lbs.hr. for 10 hrs.)	1,912	640	141,592	15,000	156,592
IV-339,000 (33,900 lbs./hr. for 10 hrs.)	1,976	640	145,496	15,000	160,496

5/ Costs provided by Frank Barta, Environmental Process, Minneapolis, Minnesota.

Equipment Requirements and Costs. The equipment requirements and costs are listed in Table 6 for each option. An extra 10 percent is allowed for equipment too minor to merit separate mention. Installation costs for the major pieces of equipment are listed separately in Table 7.

Operating Costs

Energy. The energy required for equipment operating was calculated from the horsepower of the motors used in the BTU's of heating and cooling used. Efficiency rates of BTU conversion for heating and cooling were assumed to be 75 to 65 percent, respectively. The boiler is to be fired with Number 3 fuel oil at 142,250 BTU's per gallon. Double energy use was assumed for the first hour of processing to allow for equipment warm up. A 10 percent energy use surcharge was included for processing equipment in order to incorporate the miscellaneous energy needs.

Energy costs were determined by multiplying energy requirements for fuel oil and electricity by the prevailing mid 1982 prices. Fuel oil was charged at $0.92236 per gallon, which includes a 5 percent sales tax and a 50 mile delivery charge. Electicity was charged at the rural central Minnesota rate of $0.074 per kilowatt hour.

Table 7 Installation costs for major equipment for a reverse osmosis centers.

Item	Cost
	Dollars
Boiler*	50,000
HTST	3,000
All Silos And Tanks	6,000
CIP	1,600
Separator	1,000
TOTAL	61,000

* Includes tank for oil.

Table 6. Equipment requirements and costs for four sizes of reverse osmosis centers.

Item	Plant size in pounds of milk processed per day: I-226000 (11300 lbs/hr for 20 hrs)	II-339000 (16950 lbs/hr for 20 hrs)	III-226000 (22600 lbs/hr for 20 hrs)	IV-339000 (33900 lbs/hr for 10 hrs)
	----dollars----			
1. Balance Tank: I, II, III,* 50 gallons; IV, 70 gallons	$ 1,984	$ 1,984	$ 1,984	$ 2,284
2. By-Pass Valve, 361-133-A-210: I & II, 2" size, III & IV, 2½" size	880	880	985	985
3. Pressure Differential Switch, Taylor 447 KN	1,875	1,875	1,875	1,875
4. Holding Tube: I, 2½" (28); II, 3" (28); III, 3" (38); IV, 3" (57)	3,750	3,750	4,250	4,250
5. Thermometer, Anderson VDL	165	165	165	165
6. Flow Diversion Valve, 262-121: I & II, 2"; III & IV, 2½"	2,725	2,725	3,100	3,100
7. Stainless Steel Control Panel	8,000	8,000	8,000	8,000
8. HTST Controller RFH-J673 Partlow	1,978	1,978	1,978	1,978
9. Sight Glass C-54 MP: I & II, 2"; III & IV, 2½"	480	480	649	649
10. V. Breaker 44-A-2S	182	182	182	182
11. Compression Valve D-60Y-MMP-2	715	715	715	715
12. Recycle Valve 11RC-2	447	447	447	447
13. Level Control - Tank Mate	1,025	1,025	1,025	1,025
14. Level Control Valve 371-10-A-2101½	645	645	645	645
15. Interpiping HTST	2,500	2,500	2,500	2,500
16. Hot Water Set	6,000	6,000	6,000	6,000

Table 6. Continued.

Item	Plant size in pounds of milk processed per day: I-226000 (11200 lbs/hr for 20 hrs)	II-339000 (16950 lbs/hr for 20 hrs)	III-226000 (22600 lbs/hr for 20 hrs)	IV-339000 (33900 lbs/hr for 10 hrs)
17. Drain Valve 11-RC-2	$ 447	$ 447	$ 447	$ 447
18. Plate Heat Exchanger, Pasilac 1070-CR1S: I, 116 Plates Plus 3 Connectors; 11, 141 Plates Plus 3 Connectors; III, 179 Plates Plus 3 Connectors; IV, 274 Plates Plus 3 Connectors	13,412	14,940	16,896	23,069
19. Cream Separator: I, MSB-60-20; ii, MSA-90-35; III, MSA-130-35; IV, MSA-170-50	87,185	112,574	153,940	198,448
20. Booster Pumps C-216: I, ½-1750; II & III, 3/4-1750; IV, 1-1750	848	866	866	871
21. Timing Pump PR: I, 25-1; II, 60-1, III, 60-1.5; IV, 125-2	3,355	4,525	4,717	5,413
22. HTST CIP Pump, C-216-7½-3500	1,481	1,481	1,481	1,481
23. Raw Silos (2), Walker: I & II, 30,000-gallons; II & IV, 40,000-gallons	62,000	76,000	62,000	76,000
24. Storage Silos (2), Walker: I & III, 15,000 gallons; III & IV: 20,000-gallons	43,000	50,000	43,000	50,000
25. Cream Tanks (2), Walker: I & III, 2,500 gallons; II & IV, 3,500-gallons	30,000	33,000	30,000	33,000
26. Boiler, 509 Series: I, 100 HPF; II & III, 125 HPB; IV, 150 HPB	30,000	32,000	32,000	36,000
27. Ice Builder, Girton: I, 6106; II, 7168; III, 6106-15-150; IV, 7168	19,051	29,650	19,051	29,650
28. CIP Unit, 3-Tank Return System	27,155	27,155	27,155	27,155

Table 6 Continued.

Item	I-226000 (11300 lbs/hr for 20 hrs)	II-339000 (16950 lbs/hr for 20 hrs)	III-226000 (22600 lbs/hr for 20 hrs)	IV-339000 (33900 lbs/hr for 10 hrs)
	Plant size in pounds of milk processed per day:			
29. CIP Unit, RWJ-150	$ 6,850	$ 6,850	$ 6,850	$ 6,850
30. CIP Return Pump Trucks, C-218-5-1750	1,528	1,528	1,528	1,528
31. CIP Return Pump Tanks, C-218-5-1750	1,528	1,528	1,528	1,528
32. Receiving Pump, SP-4410-10-1750	3,790	3,790	3,790	3,790
33. Supply Pump, C-216: I, 3/4-1750; II, 3/4-1750, III, 2-1750; IV 3-1750	866	866	1,368	1,423
34. Unload Pump, C-328, 7½, 1750	1,716	1,716	1,716	1,716
35. Cream Pump, PRED-60-3	6,181	6,181	6,181	6,181
36. Hi-Lo Level System	10,000	10,000	10,000	10,000
37. Piping	30,000	30,000	30,000	30,000
Subtotal	412,216	478,448	487,533	579,350
Plus 10%	41,222	47,845	48,753	57,935
Total	$ 453,438	$ 526,293	$ 536,286	$ 637,285

SOURCE: Food Process and CIP Design and Consulting, St. Paul, Minnesota.

* Indicates plant size as indicated in column headings.

The horsepower and BTU requirements for processing are given in Table 8. Table 9 presents the various energy costs for the equipment for each of the four plant sizes.

A number of nonlabor operating costs are incurred in addition to energy costs. These include expenses for cleaning chemicals, for membrane replacement, and some provision for miscellaneous expenses. The estimates of these costs are given in Table 10.

Labor Costs. Labor requirements and costs are rather difficult to assess for milk receiving and reverse osmosis centers. Even though the reverse osmosis centers are almost entirely automated, prudence suggests that an operator should be in attendance or in the vicinity at all times. Except during cleanup periods his or her time will not be fully occupied and is, therefore, available for alternative tasks. In this study, the reverse osmosis centers are assumed to be associated with small feed and farm supply stores. This processing plant-feed store combination is modeled after similar systems at the receiving stations studied. These stations have a laborer who performs all station activities and, when not required for these, assists with the feed store. Thus daily labor cost is considerably reduced, and the productivity of labor is considerably improved. In addition, the feed store personnel are available should extra hands be needed to work with maintanance problems or equipment startup.

The labor requirements for a reverse osmosis are 3.6 man years for plants I and II and 1.8 man years for Plants III and IV. These are computed using a 20 hour day plus a 4-hour cleanup period for I and II and 10 hours per day plus a 4-hour cleanup period for plants III and IV. Of this labor, 10 hours per day are charged at one-half cost because of the split with the feed store, as described above. The remaining 4 or 12 hours are charged at full cost. Full time-employees are assumed to work a 40-hour week and receive 2 weeks of vacation, including national holidays and provision for illness. In addition, they receive a portion of their medical insurance paid. Part-time employees are paid on a prorated basis, i.e., their vacation and insurance benefits are scaled by the percentage time they work. The cost per full-time worker is $14,726, Table 11. Annual labor costs for each plant size are listed in Table 12.

Other Operating Costs. The final cost category of operating costs includes heating and lighting expenses, property taxes and property insurance. These additional expenses are listed in Table 13.

Additional Assembly Cost

In addition to their operating expenses, reverse osmosis centers may incur additional assembly cost. This expense arises if daily volume at the reverse osmosis center is larger than that of the existing receiving station. Reverse osmosis stations receiving the volume of the existing receiving station were rejected as too small to take adequate advantage

Table 8. Horsepower and BTU requirements of processing equipment for alternative reverse osmosis centers[a/]

Item[b/]	Plant size in pounds of milk processed per day: I-226000 (11300 lbs/hr for 20 hrs)	II-339000 (16950 lbs/hr for 20 hrs)	III-226000 (22600 lbs/hr for 20 hrs)	IV-339000 (33900 lbs/hr for 10 hrs)
16	5 HP	5 HP	5 HP	5 HP
18				
heater	474,600 BTU/hr	711,900 BTU/hr	949,200 BTU/hr	1,423,800 BTU/hr
cream cooler	57,446 BTU/hr	86,112 BTU/hr	114,891 BTU/hr	172,168 BTU/hr
cond. cooler	271,200 BTU/hr	461,040 BTU/hr	614,720 BTU/hr	922,080 BTU/hr
19[c/]	20 HP	35 HP	35 HP	50 HP
20	0.5 HP	0.75 HP	0.75 HP	1 HP
21	1 HP	1 HP	1.5 HP	2 HP
22[d/]	7.5 HP	7.5 HP	7.5 HP	7.5 HP
25	4 HP	4 HP	4 HP	4 HP
27	5 HP	5 HP		
28	2,100,000 BTU/hr	2,100,000 BTU/hr	2,100, 000 BTU/hr	2,100,000 BTU/hr
28 (500-gal.)[d/]	10 HP	10 HP	10 HP	10 HP
30[d/]	5 HP	5 HP	5 HP	5 HP
31[d/]	5 HP	5 HP	5 HP	5 HP
32	10 HP	10 HP	10 HP	10 HP
33	0.75 HP	0.75 HP	2 HP	3 HP
34	7.5 HP	7.5 HP	7.5 HP	7.5 HP
35	3 HP	3 HP	3 HP	3 HP
29[d/]	5 HP	5 HP	5 HP	5 HP
16[e/]	1 HP	1 HP	1 HP	1 HP
26[e/]	5 HP	5 HP	7.5 HP	7.5 HP
27	25 HP	25 HP	30 HP	30 HP

[a/] PHE at start-up energy used factor 2.0; other miscellaneous equipment to add 10 percent of total.

[b/] See Table 4.4 note for listing of equipment.

[c/] Used during processing and CIP.

[d/] Working only during CIP.

[e/] Used sporadically.

Table 9. Energy costs for alternative reverse osmosis center.

Item	I-226,000 (11,300 lbs./hr. for 20 hrs.)	II-339,000 (16,950 lbs./hr. for 20 hrs.)	III-226,000 (22,600 lbs./hr. for 10 hrs.)	IV-339,000 (33,900 lbs./hrs. for 10hrs.
	Plant size in lbs. of milk procedded per day:			
	dollars/day			
Noncooling processing	62.63	79.46	39.32	48.56
Heating processing	82.17	123.26	82.17	123.26
Cooling processing	219.31	365.11	243.43	365.09
Ten-percent surcharge	36.41	56.78	24.34	53.69
One-hour surcharge	18.21	28.39	24.34	53.69
Electricity for CIP	13.04	15.53	16.76	18.19
Heating CIP	81.81	75.81	81.81	75.81
Reverse osmosis processing	87.00	130.00	80.00	109.00
Total	600.58	874.34	592.17	847.29

Table 10. Other nonlabor operating costs for reverse osmosis center.

Item	I-226,000 (11,300 lbs./hr. for 20 hrs.)	II-339,000 (16,950 lbs./hr. for 20 hrs.)	III-226,000 (22,600 lbs./hr. for 10 hrs.)	IV-339,000 (33,900 lbs./hrs. for 10hrs.
	Plant size in lbs. of milk processed per day:			
	dollars/day			
Cleaning Chemicals for Support Equipment	54.79	57.79	54.79	54.79
Membrane Replacement	39.00	53.00	69.00	88.00
Cleaning Chemicals for Reverse Osmosis Equip.	22.00	25.00	29.00	36.00
Miscellaneous Expenses	13.70	13.70	13.70	13.70
Total	129.49	146.49	166.49	192.49

Table 11. Annual cost per full-time employee.

Item	Amount
	dollars/year
Wages at $6 per hour	12,480
Taxes at 7.76 percent of wages	$968
Insurance Benefits	$420
Workman's compensation	$856
Total	14,724

Table 12. Annual labor requirements and annual labor costs for reverse osmosis centers

Plant size	Worker years	Total labor costs
	number	dollars/year
I & II	3.5975	52,970
III & IV	1.7725	26,098

Table 13. Other operating expenses for reverse osmosis centers.

Plant size	Insurance	Lighting	Heating	Property taxes	Total
(lbs. of milk processed/day)			dollars/year		
I-226,000 (11,300 lbs./hr. for 20 hrs.)	7,610	1,118	$1,114	4,818	14,660
II-339,000 (16,950 lbs./hr. for 20 hrs.)	8,181	1,149	$1,145	4,818	15,293
III-226,000 (22,600 lbs./hr. for 10 hrs.)	8,609	725	$1,239	5,150	15,723
IV-339,000 (33,900 lbs./hr. for 10 hrs.)	9,738	749	$1,280	5,316	17,088

SOURCES: Insurance, Warren Higgens; lighting and heating. Jacus Associates, Inc., Minneapolis; property taxes, Benton County Assessor's Office.

of economies of scale. The reverse osmosis centers defined for the analysis are two and three times larger in daily volume than the receiving stations they replace.

The reverse osmosis centers would replace the baseline receiving stations described earlier. Plants I and III would assemble and concentrate milk from B's and A's assembly areas. Plants II and IV would process milk assembled from A's, B's, and C's areas.

Combining of assembly areas increases assembly distances. The additional distances per truck would cost $0.8227 per loaded mile and $0.5485 per return mile. (Table 14) These figures were derived from estimates published in a University of Vermont study.[7] In that study cost of truck ownership for 1979 were estimated at $0.656 per mile. Adjusting for inflation of 13.5 percent for 1980 and 10.5 percent for 1981 yielded a cost of $0.8227 for 1982.

Cost Savings From Alternative Plant Designs

The preceding costs are estimates of the capital and operating expenditures required with present technology to build and operate an entirely new osmosis center. The following describes several alternatives with respect to plant construction and design.

Remodeled Receiving Station Processing Separated Milk. One alternative to a new plant is to remodel an existing receiving station. Remodeling was estimated to run 15 percent of the cost of a new building. In addition, it permits use of the boiler, a raw milk silo, and various other equipment used by the existing receiving stations. Operating costs, for the most part, are unchanged. Total capital costs are reduced by about $250,000 for all

Table 14. Additional assembly costs for RO plants for 1982.

Plant size	Additional one-way mileage per day	Additional cost
	miles	dollars/year
I & III	9.5	16,641
II & IV	23.0	40,289

7/ Karpoff E., F. Webster, and E. Saunders, "Bulk Milk Hauling: Rate Structure in Vermont", Bul. 689, University of Vermont Agricultural Experiment Station, Burlington, Vermont, 1981.

systems, Table 15. Annual operating costs are reduced by $2984 to $3552 (see Table 16).

New Construction with Processing Whole Milk. The second alternative option for reverse osmosis assumes that technology has advanced to the point of permitting the membrane to be operated at temperatures high enough to melt milk fat. Molten milk fat does not foul membranes as does nonmolten fat. Consequently, the milk could be concentrated without separation. A membrane manufacturer indicated that a breakthrough in membrane temperature tolerance is likely in the near future, hence, the selection of this option. Cost reductions from eliminating separators and their operating costs are quite large. Capital cost savings range from $125,007 to $243,082 (see Table 17). Furthermore, because the milk is already heated to pasteurizing temperature, there would be no additional expense incurred by raising the concentrating temperature. The estimated annual cost reductions achieved through eliminating milk separation range from $27,420 to $37,547 (see Table 18).

Remodeled Station Processing Whole Milk.. The final option is simply a combination of options I and III. A center constructed under option IV is a remodeled receiving station concentrating milk without separation. Capital cost savings are greatest with this option, reaching $511,260 for plant size IV (Table 19). Operating cost savings are quite similar to those from simply eliminating the separation process.

Economies of Size

The capital and operating cost data presented above are converted to a hundredweight basis in Tables 20 through 21. Table 20 is the capital cost per cwt. of daily volume. Table 21 is the operating cost per cwt. of processed milk. Tables 20, on preliminary examination, suggests economies of size in reverse osmosis centers. Economies of scale in volume processed per day are reflected in lower costs per cwt. of milk processed or in per hundredweight of daily capacity for Plant II as compared to Plant I, and for Plant IV as compared to Plant III. Recall that these pairs have the same length workday, but that the first member of each pair processes one third more volume. Therefore, where the workday is held constant, the effect on costs is presumably due to changes in volume processed per day. In all cases, Plant II operating and capital costs are lower than those of Plant I. Analogously, Plant IV consistently out-performs Plant III.

Length of Workday

The impact of length of workday on costs is also indicated in Tables 20 and 21 by comparing Plants I and III and Plants II and IV. Recall that Plants I and III process the smaller daily volume at 14 and 24 hours respectively, while II and IV process the larger volume in 14 and 24hours respectively. The costs per cwt. listed in the Tables 21 indicate

Table 15. Capital cost savings derived from remodeling, an existing receiving station into reverse osmosis operation.

Plant size (lbs. of milk processed/day)	Building	Boiler and installation	Raw milk silo	Receiving pump	Unloading pump	Electrical hookup	Total
			---dollars---				
I-22600(11300 lbs/ hr for 20 hrs)	110,395	80,000	31,000	3,790	1,716	15,000	241,904
II-339000(16950 lbs/ hr for 20 hrs)	112,887	82,000	38,000	3,790	1,716	15,000	253,393
III-226000(22600 lbs /hr for 10 hrs)	120,353	82,000	31,000	3,790	1,176	15,000	253,859
IV-339000(33900 lbs/ hr for 10 hrs)	123,672	86,000	38,000	3,790	1,716	15,000	268,178

Table 15. Annual operating cost savings derived from remodeling an existing receiving station into reverse osmosis operation.

Plant ize (lbs. of milk processed/day)	Insurance	Property taxes	Total
	---dollars per year---		
I-226000(11300 lbs/hr for 20 hrs)	584	2,400	2,984
II-339000(16950 lbs/hr for 20 hrs)	598	2,400	2,998
III-226000(22600 lbs/hr for 10 hrs)	637	2,732	3,369
IV-339000(33900 lbs/hr for 10 hrs)	654	2,898	3,552

Table 17. Capital cost reductions derived from elimination of separation in reverse osmosis plants.

Plant size (lbs. of milk processed/day)	Separator	Cream tank and installation	Piping	Cream pump	Plate heat exchanger	Total
			----dollars----			
I-226000(11300 lbs/ hr for 20 hrs)	87,185	32,000	2,000	6,181	2,641	126,007
II-339000(16950 lbs/ hr for 20 hrs)	112,574	32,000	2,000	6,181	3,008	154,763
III-226000(16950 lbs/ hr for 10 hrs)	153,940	32,000	2,000	6,181	3,558	193,679
IV-339000(33900 lbs/ hr for 10 hrs)	198,448	32,000	2,000	6,181	5,453	243,082

Table 18. Annual operating cost reductions derived from elimination of separation in reverse osmosis plants.

Plant size (lbs. of milk processed/day)	Separator	Cooling	CIP energy	CIP chemicals	Insurance	Total
			----dollars----			
I-226000(11300 lbs/ hr for 20 hrs)	9,364	5,404	7,742	5,000	1,037	28,447
II-339000(16950 lbs/ hr for 20 hrs)	15,308	8,221	7,742	5,000	1,276	37,547
III-226000(22600 lbs/ hr for 10 hrs)	7,654	5,472	7,742	5,000	1,602	27,470
IV-339000(33900 lbs/ hr for 10 hrs)	10,676	8,229	7,742	5,000	1,996	33,643

Table 19. Capital and operating cost reductions derived from constructing a reverse osmosis center from a remodeled receiving station and eliminating separation.

Plant size (lbs. of milk processed/day)	Capital cost production	Operating cost reduction
	dollars	dollars/year
I-226,000 (11,300 lbs./hr. for 20 hrs.)	367,911	31,431
II-339,000 (16,950 lbs./hr. for 20 hrs.)	408,156	40,545
III-226,000 (22,600 lbs./hr. for 10 hrs.)	447,538	30,839
IV-339,000 (33,900 lbs./hr. for 10 hrs.)	511,260	37,195

Table 20. Capital costs of reverse osmosis center per hundredweight of milk processed per day.

Plant size (lbs. of milk processed day	For completely new plant milk separation	For remodeled plant with separation	For completely new plant without separation	For remodeled plant without separate operating cost
	dollars per cwt. of daily capacity			
I-226,000 (11,300 lbs./hr. for 20 hrs.)	3.84	2.79	3.29	2.22
II-339,000 (16,950 lbs./hr. for 20 hrs.)	2.91	2.16	2.45	1.70
III-226,000 (22,600 lbs./hr. for 10 hrs.)	4.73	3.61	3.87	2.75
IV-339,000 (33,900 lbs./hr. for 10 hrs.)	3.78	2.99	3.06	2.27

Table 21 operating costs of a reverse osmosis center per hundredweight of milk.

Plant size (lbs. of milk processed day	For completely new plant milk separation	For remodeled plant with separation	For completely new plant without separation	For remodeled plant without separate operating cost
	dollars per cwt. of milk			
I-226,000 (11,300 lbs./hr. for 20 hrs.)	.334	.344	.316	.309
II-339,000 (16,950 lbs./hr. for 20 hrs.)	.314	.314	.287	.282
III-226,000 (22,600 lbs./hr. for 10 hrs.)	.336	.336	.308	.300
IV-339,000 (33,900 lbs./hr. for 10 hrs.)	.259	.259	.236	.230

that longer workday plants incur higher operating costs than the short workday plants. However, capital costs are consistently higher for the short workday plants than for comparable long workday centers. Thus, there is a trade-off between operating and capital costs in the choice of workdays.

RETURNS TO INVESTMENT IN REVERSE OSMOSIS CENTERS

The Method of NPV Analysis

Profitability of the alternative milk handling techniques, in this study, is assessed through use of net present value (NPV) analysis. NPV analysis includes two basic precepts. First, the value of a project is assumed wholly contained in its cash flows. Secondly, because of the time value of money, future returns are assumed to be progressively less valuable than current returns. To adjust for this progressive decline in value, the cash flows are converted to a common base, the present, which is normally assumed to be the starting point of the project. The sum of these adjusted flows, otherwise known as present values, may be considered to contain the value added to the firm by the project. NPV is mathematically expressed as follows:

$$NPV = c_0 + \frac{c_1}{(1 + d)} + \frac{c_2}{(1 + d)^2} + \frac{c_3}{(1 + d)^3} + \ldots + \frac{c_n}{(1 + d)^n} \quad (1)$$

where c_i = net cash flow in period i

d = opportunity cost of capital

n = periods over which project generates cash flows

The cash flows represented by c_i are the sum of all cash inflows and cash outflows incurred by the project during each period i. Therefore, the purchase of a major asset would be fully charged against the period of purchase rather than split among the periods during which it is expected to be in use. In general, all uses and sources of cash resulting from the project are included in the flows. However, interest is deleted because it is already implicitly represented in the opportunity cost of capital.

The opportunity cost of capital is the rate of return foregone in order that the project be undertaken, and serves in NPV analysis as the discount rate. The rate foregone depends on the riskiness of the project. Lower risk projects imply a lower rate foregone than do higher risk projects; therefore the opportunity cost of capital is the rate foregone on comparable risk investments rather than the average return on all investments, the average industry return, or some other such measure of return.

The cash flows of most investments occur over a number of periods. Frequently, they trace a pattern of initial negative net flows, followed by a series of positive net flows, perhaps declining as equipment deteriorates or becomes outdated, and possibly concluding with a salvage value or salvage cost. Where feasible, all cash flows, even those of the distant future, should be included, as all contribute to the value of the project.

The Discount Rate for Privately Owned Firms

The discount rate for NPV analysis for profit seeking privately owned firms and cooperatives includes several components: a risk free, no inflation component, a number of risk premiums and the expected inflation component. Algebraically, the expected rate of return for any investment, i, is:

$$E(r_i) = r_f + P_1 + P_2 + P_3 + E\,(r_\pi) \qquad (2)$$

where $E(r_i)$ is the nominal expected return on investment i,

r_f is the risk-free inflation free rate,

P_1 is the systematic risk premium,

P_2 is the unique risk premium,

P_3 is the risk premium not included in P_1 or P_3, and

$E(r_\pi)$ is the expected rate of inflation.

The risk free rate (r_f) for the private firm can be estimated from the inflation adjusted rate for riskless investments. Short-term treasury bills are usually considered to be risk-free investments. The historical average of these rates after adjusting for inflation is 1 to 2 percent. However, the rate seems to have increased considerably in the 1980's. In mid-1982, the treasury bill rate was 14 percent. With inflation at 6 percent this left a real rate of return of 8 percent. Two explantions for this apparently high time preference for money may be advanced. In the first case, investors were indeed demanding a higher return for their funds, perhaps to shield themselves from the unanticipated inflation, which had left many of them earning negative real rates of return in the 1970's. Another explanation is that investors fully anticipated a return to the high inflation rate of the 1970's and do not see these as high real rates. We assume that two sets of expectations are operating simulataneously, and that in the relatively short run they will move to equilibrium. In other words, either inflation will rise or interest rates will fall, or some combination of the two.

For the analysis that follows, we assume a real risk-free interest rate of 4 percent. Although this rate is considerably above the historical average rate, it is not believed to be unrealistically high. It reflects a situation where investors have adjusted their time preference for money upward for longer term investments where the effects of inflation are difficult to predict.

The risk premium has three major components. The first form, often call unique risk, is concerned with the variability of returns resulting from random events specific to the firm. If these deviations are random and normally distributed, they tend to be equally distributed between positive and negative impacts on the firm's cash flow. Therefore, over a diversified portfolio of investments they tend to cancel out, leaving the portfolios actual return close to the expected return.

The remaining two forms of risk, however, are nondiversifiable. The first of these is the tendency of investments to vary with the business cycle. This systematic risk causes deviations in expected returns to move upward or downward in concert with the business cycle. Therefore these risks in investments do not cancel.

The remaining risk component are neither firm specific as required for unique risk nor closely related to the business cycle as required for systematic risk. These risks include such factors as unanticipated inflation which would erode investors real returns, and unexpected shifts in world or national affair with impacts on investment returns. We estimated the combined effect of the risk premium, P_1, P_2 and P_3 to increase the discount rate by 2.034 percent for private dairy processing firms.[8]

The inflation component of the discount rate was set at two levels for our analysis. In scenario one, the rate is 10 percent, that rate which prevailed during much of the 1970's. A 6 percent rate was also used to represent moderate inflation of recent months. The two inflation rates yield two expected discount rates for analysis of investment returns to private firms. With high inflation the rate is 16.034 percent and for low inflation the rate is 12.034 percent.

The Discount Rate for Cooperatively Owned Firms

The appropriate discount rate for farmer-owned cooperatives differs from that for privately owned firms. It differs because of the financial structure of farmer cooperatives and their tax treatment with respect to income tax. Returns to owners of farmer cooperatives are in the form of both equity retains and enhanced milk prices. These are returns that in conventionally owned firms are distributed to stock-holders according to capital ownership.

Our method of estimating returns for cooperatives assumes that dairy farmer owners operate under externally imposed capital rationing. Under this assumption, the farmers invest in the highest risk-adjusted return projects until either the risk-adjusted return is no longer sufficient or the capital is no longer available. Due to the presumed capital rationing condition, farmers are assumed to consider only investments in their farms or their cooperatives. Farm investment is assumed to yield a constant expected risk-adjusted rate of return, at least within the limits of the available capital. The farmer therefore decides to invest in the cooperative (by marketing through the cooperative) only when the risk-adjusted rate of return is above that available on the farm. The risk-adjusted rate of return available on the farm, therefore, is the opportunity cost of capital and is the discount rate for the cooperative.

The determination of the appropriate discount rate for the cooperative is simplified by this assumption of equivalent risk for investment in both farm and cooperative. With this assumption, the problem reduces to the manipulation

8/ Winchell, Elizabeth " A Study of the Economies of Milk Concentration to Reduce Milk Marketing Costs," M.S. Thesis, University of Minnesota, of the formula for quantifying the effect of financial leverage, as stated below.

$$R_a = R_d \left(\frac{D}{D + E}\right) + R_e \left(\frac{E}{D + E}\right) \qquad (3)$$

where R_a = expected return on assets

R_d = expected return on debt

R_e = expected return on equity

D = total debt outstanding

E = total equity outstanding

The expected return on farm assets can be estimated given the expected returns on farm equity, the expected return on farm debt, and the farm debt and equity levels. This expected return on assets is then the minimum rate of return from the project, i.e., the discount rate. Note that expected rather than actual returns to debt, assets, and equity are used in this equation.

Consider first the rate of interest on farm debt. This is conveniently measured by the interest rate charged plus any necessary adjustments for tax deductible interest payments or additional loan expenses. This rate for mid 1982 intermediate term agricultural loans was 17.5 percent. Farmers, however, may deduct interest expenses from taxable income and thereby reduce the effective interest rate of the loan. The median dairy farmer is in a 35 percent marginal tax bracket, and, therefore, his effective interest rate fell to 11.38 percent, as indicated by the equation below:[9]

$$R_d = 17.5\% \, (1 - 0.35) = 11.38\%$$

The final rate of return required to solve for the expected return on cooperative assets is the expected return on farm equity. For this, the historical average from 1970 to 1981 was used, on the presumption that expectations as to returns to farm assets are primarily based on recent experience. the data used to determine average return on equity are for all U.S. farms, Table 22. Data focusing on dairy farms would be preferable but are not available. Returns to equity here include two components. The first of these includes the returns to labor over and above the cost of hiring the required labor and management expertise at the prevailing non-family wage rate. The second includes the nominal returns to physical assets valued at market prices.

9/ This figure is based on rates for members of Minnesota Farm Management Association.

Table 22. Rates of return on farm equity

Year	Return on farm equity %	Year	Return on farm equity %
1970	8.625	1976	21.523
1971	13.491	1977	15.144
1972	36,756	1978	24.963
1973	38.506	1979	21.954
1974	16.646	1980	11.446
1975	20.785	1981	9.033
		1970-81 ave	18.133

SOURCE: Economic Indicators of the Farm Sector Income and Balance Sheet Statistics, Economic Research Service, U.S. Department of Agriculture.

The return to farm assets were computed using the 1981 debt and equity levels of farms $162.7 billion and $817.5 billion respectively. The equity is in market value terms. However, the debt is in accounting terms except for those loans which are variable rate loans. Variable rate loans are linked to market rates and, therefore, for such loans the market value debt equals the book value.

The after tax discount rate computed by substituting from these returns and debt and equity values into equaiton (3) is 16.996 percent, as shown below:

$$R_a = .1138 \frac{162.6}{162.6 + 817.8} + .18133 \frac{817.8}{162.6 + 817.8}$$

$$= .16996$$

As in the case of the private firm, an additional risk premium is added. Adjustment for this factor resulted in a cooperative risk premium or 1.7 percent. Two inflation rates were used for the final component of the coop discount rate, 10 percent and 6 percent. At the 10 percent inflation rate, the total discount rate is 18.71 percent. The lower inflation and interest rates scenario discount rate for cooperatives was set at 15.09 percent. This rate is calculated under the assumption that (1) inflation drops 4 points to a 6-percent rate, (2) return to equity drops 4 points to 14.113, and (3) the rate for farm debt falls by 4 percentage points to 13.5 percent.

Projecting Cash Flows

Having chosen an evaluation technique and determined the discount rate, the next step is to fit the estimated costs and savings into the NPV equation. Capital cost estimates appear as negative flows in year 0 and require no adjustment. However, because the discount rate is in nominal terms and therefore includes an inflation term, the operating income must be adjusted to reflect anticipated inflation. Additional adjustments to the flows are, in some cases, necessary to reflect the impact of income taxes, tax credits, and tax deductions.

The annual inflation rates used in the adjustment of cash flows were 6 and 10 percent, depending on the inflation scenario. Energy-related flows were projected to rise one third faster, and therefore to inflate at 8 percent and 13.3 percent respectively. The greater part of the project's cash flows were judged energy-intensive, and therefore to inflate at the increased rate. Included in the energy-intensive category are additional assembly expenses, operating expenses, concentration savings, and transport savings. Only property taxes were inflated at the overall price level rate, while insurance expenses were assumed constant to reflect the decline in equipment values.

The Cash Flow of Cooperatives Cash flows are different for cooperatives and private firms because of the difference in tax treatment. For cooperatives the cash flows are stated in nominal terms as described above and fit in as the c_i in the model. The one adjustment required is to include an investment tax credit, which cooperatives are permitted to pass back to their members, who then apply it to their personal taxes. This tax credit varies with the expected life of the equipment, but here is equal to one tenth of the cost of equipment.

The Cash Flows of Private Firms Estimation of cash flows for the privately owned firm is more complicated than for cooperative firms. Private firms are subject to income taxes, payable to both the state and federal governments. The existence of taxes necessitates consideration of tax shields such as interest deductions and depreciation. The applicable cash flows taking taxes into account are:

$$c_i = (1-t)\ EBIT_i + d_i \qquad (4)$$

where c_i = cash flow in year i

t = marginal tax rate

EBIT = earnings before interest and taxes in year i.

(These are equivalent to cash operating income (COI) minus depreciation.)

d_i = depreciation expense in year i.

By substitution of terms this may be restated as

$$c_i = (1-t)\ COI_i + td_i \qquad (5)$$

where COI_i = cash operating income in year i.

The appropriate discount rate under income taxation is $[1 + D(1-t)]$ where D is the discount rate which would prevail in the absence of taxes.

The cash flow for a project also is influenced by the depreciation. Since tax law provides selection of alternative depreciation schedules, a firm should select the depreciation schedule that maximizes net present value of the project's cash flow. To determine the optimal depreciation schedule and the applicable marginal tax rate, the cash flows of the firm as a whole must be examined. For our analysis, we assumed a $40,000 net taxable income for the firm under present assembly techniques To this, the cash flows, negative or positive, derived from the center--all inflated as necessary to reflect the period in which they occur, were added. Depreciation rates and procedures were selected for each alternative such that the NPV of that operation was maximized. The depreciation rate in no case was allowed to exceed the maximum provide by law. These flows were then grouped on the basis of the depreciation schedule they could support for alternative distances from the final milk processing plants. Plants II and IV for private plants were not evaluated for this phase of the analysis.

The plants were grouped according to four depreciation schedules. Group 1 are those centers that have sufficient cash flows to cover the fastest possible depreciation allowed by law. The depreciation schedules for equipment and plant are shown in Appendix Tables A1 and A2. These firms are taxed at the maximum combined federal and state rate of 46 percent federal plus 12 percent state, or 58 percent. The state rate is that applicable in Minnesota. In general, the fastest depreciation permitted by income or law is preferred by this group.

Group 2 firms have insufficient income to cover the depreciation schedule used by Group 1 above but sufficient to cover a 10-year straightline schedule. Under this schedule equipment is depreciated at 10 percent of the purchase cost each year for 10 years. Buildings are depreciated at 5.5 percent per year for 15 years. This depreciation schedule may be nonoptimal for many firms within the group. They might be better served by a 7 or an 8 year schedule, for instance. This could lead to the NPV of some members of the group to be slightly understated. Firms in this group are taxed at the 42 percent marginal tax rate.

Group 3 is composed of firms unable to generate income sufficient to charge off equipment over 10 years but sufficient for 20 years straightline depreciation. Here all plant and equipment is depreciated over 20 years at 5 percent per year. The reservation expressed in reference to optimality in the discussion of Group 2 applies here as well. The marginal tax rate applicable to this group is 31 percent.

The final group includes all firms with income insufficient to cover even 20-year straight-line depreciation. The NPV's of reverse osmosis assembly for these firms were not calculated but would in every case be negative.

The depreciaton group into which each center option was placed is tabulated in Appendix Table A3. Note that the 20-mile incremental hauls were intended for hauling manufacturing milk and therefore assign value to concentration. The 100-mile incremental hauls are intended for long distance hauling of fluid-use milk and assign no value to concentration. Hauls up to 1,000 miles were evaluated. All plants hauling over 500 miles fell into Group 1, and therefore are not included in the table. These centers are intended for use in manufacturing assembly. They fall into one of three groups, depending on the distance the concentrate is to be hauled. The smallest volume centers (Size I) under the high-inflation scenario, and less than 110 miles from the final processing plants have insufficient income to support any depreciation schedule. Centers shipping 110 miles to less than 150 miles may use a 20-year straight-line schedule. Centers shipping 150 to 250 miles may use a 10-year straight-line schedule. None of the centers have sufficient income at the distances studied to support the fastest depreciation schedule in manufacturing milk assembly. The depreciation rates for concentration for centers concentrating for fluid uses can be accelerated. A center with a 200-mile haul generates sufficient income to qualify for the 10-year schedule, and hauls of 400 miles or more qualify for the fastest depreciation schedule.

Estimated Net Present Values

The NPV's of each size reverse osmosis center by business organization, physical option, and inflation assumption for short and long distance hauls are listed in Table 23 through 38. The cash flows for the analysis were spread over 20 years, the expected life of the equipment. Equipment salvage costs is assumed to be zero. The short distance hauls are intended to represent manufacturing use of the concentrated milk. The concentrate is therefore valued at the cost of in-plant concentration in milk processing. The long distance hauls represent concentrated milk for reconstituted fluids use. In this case, concentration is assumed of zero value.

As may be recalled, the plant's cost savings are directly related to the distance hauled; therefore, for each center there is a minimum distance of hauling required for the plant to achieve positive NPV. These minimum distances or breakeven points are reported in Table 39. Note that the break-even points for all plants with current technology range from 90 to 200 miles.

The results reported in Table 40 are those for reverse osmosis centers that replace the baseline system described previously. Table 40 includes the NPV's of each center size by construction option, business organization, and inflation assumption at the baseline shipment distance of 70 miles.

Table 23. Net present value of investment of full-construction, separation-required reverse osmosis centers by hourly volume and business organization, assuming high inflation, 50 to 250 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
50	-1,595,440	-1,687,910	-1,606,120	-1,019,000	—	—
70	-1,363,650	-1,455,520	-1,257,530	-670,418	—	—
90	-1,130,660	-1,223,130	-908,949	-321,832	—	—
110	-898,272	-990,736	-560,363	26,753	—	—
130	-665,881	-758,346	-211,777	375,339	-492,374	-526,377
150	-433,491	-525,955	136,309	723,925	-179,026	-213,029
170	-201,100	-293,565	485,395	1,072,510	263,790	259,408
190	31,290	-61,174	833,980	1,421,110	580,095	575,713
210	263,681	171,216	1,182,570	1,769,680	396,401	392,018
230	496,071	403,607	1,531,150	2,118,270	1,212,710	1,208,320
250	728,462	635,997	1,899,740	2,466,850	1,529,010	1,524,630

Table 24. Net present value of investment in full-construction, separation-required reverse osmosis centers by hourly volume and business organization, assuming low inflation, 50 to 250 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	-dollars-					
50	-1,501,960	-1,608,700	-1,526,650	-1,061,510	—	—
70	-1,301,900	-1,408,640	-1,226,560	-761,427	—	—
90	-1,101,840	-1,208,580	-926,479	-461,342	—	—
110	-901,786	-1,008,530	-626,394	-161,257	—	—
130	-701,729	-808,470	-326,309	138,838	-527,790	-596,293
150	-501,672	-608,414	-26,224	438,913	-293,317	-351,820
170	-301,616	-408,357	273,861	738,997	48,142	14,623
190	-101,559	-208,301	573,946	1,039,080	282,297	248,777
210	98,497	8,244	874,031	1,339,170	516,491	482,932
230	298,554	191,312	1,174,120	1,639,250	250,606	717,086
250	498,610	391,369	1,474,200	1,939,340	984,760	921,241

Table 25. Net present value of investment in remodeled receiving station, separation-required reverse osmosis centers by hourly volume and business organization, assuming high inflation, 50 to 250 miles from plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
50	-1,298,630	-1,370,390	-1,298,490	-684,480	---	---
70	-1,066,240	-1,138,460	-969,907	-335,894	---	---
90	-833,848	-960,069	-601,321	12,692	---	---
110	-601,457	-673,678	-252,736	361,277	-519,185	-531,027
130	-369,067	-441,288	95,854	709,863	-111,222	-95,494
150	-136,626	-208,897	444,436	1,058,950	205,083	220,312
170	95,714	23,493	793,022	1,407,030	521,388	537,117
190	328,105	255,384	1,141,610	1,755,620	928,204	353,422
210	560,495	488,279	1,490,190	2,104,210	1,233,340	1,169,730
230	792,886	720,665	1,838,780	2,452,990	1,538,400	1,486,030
250	1,025,280	953,055	2,187,360	2,801,380	1,843,620	1,802,340

Table 26. Net present value of investment in remodeled receiving station, separation-required reverse osmosis centers by hourly volume and business organization, assuming low inflation, 50 to 250 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	-dollars-					
50	-1,211,240	-1,298,520	-1,225,130	-734,283	---	---
70	-1,011,180	-1,098,470	-925,068	-434,198	---	---
90	-811,126	-898,411	-624,983	-134,113	---	---
110	-611,069	-698,354	-324,899	168,972	-516,282	-555,596
130	-411,013	-498,297	-24,813	466,057	-271,306	-203,996
150	-210,956	298,241	275,271	766,142	46,267	30,158
170	-10,899	98,184	575,356	1,066,230	280,422	264,313
190	189,157	101,372	875,441	1,366,310	514,576	498,468
210	398,214	301,929	1,175,530	1,666,400	748,276	732,622
230	589,270	501,985	1,475,610	1,966,480	955,784	966,777
250	789,327	702,042	1,776,700	2,266,570	1,163,290	1,200,930

Table 27. Net present value of investment in full-construction, no-separation reverse osmosis centers by hourly volume and business organization, assuming high inflation, 50 to 250 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
			- dollars -			
50	-1,112,450	-1,152,960	-999,682	-357,660	—	—
70	-880,061	-920,073	-631,096	-9,073	—	—
90	-647,671	-687,682	-282,510	339,512	-525,306	-519,469
110	-415,280	-455,292	66,076	688,098	-211,958	-206,121
130	-182,890	-222,901	414,661	1,036,680	211,224	236,677
150	49,501	9,489	763,247	1,385,270	527,529	552,982
170	281,891	241,884	1,111,830	1,733,860	843,334	869,287
190	514,282	474,270	1,460,420	2,082,440	1,255,250	1,185,590
210	746,672	706,661	1,309,000	2,431,020	1,560,390	1,501,900
230	979,063	939,051	2,157,590	2,779,610	1,365,530	1,914,410
250	1,211,450	1,171,440	2,506,180	3,128,200	2,170,670	2,219,550

Table 28. Net present value of investment in full-construction, no-separation reverse osmosis centers by hourly volume and business organization, assuming low inflation, 50 to 250 miles from plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
			- dollars -			
50	-1,068,600	-1,120,740	-969,795	-458,306	—	—
70	-868,546	-920,686	-665,710	-158,221	—	—
90	-668,489	-720,629	-365,625	141,864	-542,784	-559,668
110	-468,432	-520,516	-65,540	441,949	-298,311	-314,595
130	-268,376	-320,516	234,545	742,034	28,759	27,835
150	-68,319	-120,459	534,629	1,042,120	262,914	261,990
170	131,737	-79,597	834,714	1,342,200	497,069	496,144
190	331,799	279,654	1,134,800	1,642,290	742,187	730,299
210	531,851	479,710	1,434,350	1,942,370	949,695	964,453
230	731,907	679,767	1,734,970	2,242,460	1,157,200	1,173,540
250	931,964	879,824	2,035,050	2,542,540	1,364,710	1,381,050

Table 29. **Net present value of investment in remodeled receiving station, no-separation reverse osmosis center by hourly volume and business organization, assuming high inflation, 50 to 250 miles from main plant.**

Miles from final plant processing	Net present value of: Cooperative plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	Large daily volume: II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	Private plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
			- dollars -			
50	-815,637	-835,406	-671,885	-24,983	---	---
70	-583,247	-603,015	-323,299	323,603	-552,117	-524,919
90	-350,856	-370,625	25,286	25,286	-163,789	-211,571
110	-118,465	-138,234	373,372	373,372	152,516	198,081
130	113,925	94,156	722,458	722,458	548,369	514,386
150	346,316	326,547	1,071,040	1,071,040	353,509	330,691
170	578,706	558,937	1,419,630	1,419,630	1,158,650	1,258,070
190	311,097	791,328	1,768,220	1,768,220	1,463,790	1,530,210
210	1,043,490	1,023,720	2,116,300	2,116,300	1,768,730	1,335,350
230	1,275,380	1,256,110	2,465,390	2,465,390	2,074,070	2,140,490
250	1,508,270	1,488,500	2,813,970	2,813,970	2,379,210	2,445,630

Table 30. Net present value of investment in remodeled receiving station, no-separation reverse osmosis center by hourly volume and business organization, assuming low inflation, 50 to 250 miles from main plant.

Miles from final plant processing	Net present value of: Cooperative plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	Large daily volume: II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	Private plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
			- dollars -			
50	-777,386	-810,569	-664,131	-132,922	---	---
70	-577,829	-610,513	-364,046	167,163	-521,270	-518,391
90	-377,773	-410,956	-63,961	467,248	-207,270	-273,398
110	-177,716	-210,400	236,124	767,333	26,384	43,321
130	22,341	-10,343	536,209	1,067,420	261,039	279,526
150	222,397	189,714	836,294	1,367,500	506,533	511,680
170	427,454	389,770	1,136,380	1,667,590	714,041	744,653
190	622,510	589,327	1,426,460	1,967,670	921,550	952,162
210	822,567	789,383	1,736,550	2,267,760	1,129,060	1,159,670
230	1,022,620	989,940	2,036,630	2,567,340	1,336,570	1,367,180
250	1,222,680	1,190,000	2,336,720	2,867,930	1,544,080	1,574,690

Table 31. **Net present value of investment in full-construction, separation-required reverse osmosis center by hourly volume and business organization, assuming high inflation, 200 to 1,000 miles from main plant.**

Miles from final plant processing	Net present value of: Cooperative plants with: Small daily volume I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	Large daily volume II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	Private plants with: Small daily volume I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-1,341,470	-1,433,930	-1,225,150	-638,030	---	---
300	-170,517	-271,981	517,783	1,104,900	293,168	288,785
400	982,436	889,972	2,260,710	2,847,830	1,968,560	2,044,890
500	2,144,390	2,015,920	4,003,640	4,590,760	3,494,260	3,527,250
600	3,306,340	3,213,880	5,746,570	6,333,690	5,019,960	5,052,950
700	4,468,290	4,375,830	7,489,500	8,076,610	6,545,660	6,578,640
800	5,630,250	5,537,780	9,232,430	9,819,540	8,070,360	8,104,340
900	6,792,200	6,699,730	10,975,400	10,156,250	9,597,060	9,630,040
1,000	7,954,150	7,861,690	12,718,300	13,305,400	11,122,300	11,155,700

Table 32. Net present value of investment in full-construction, separation-required reverse osmosis center by hourly volume and business organization, assuming low inflation 200 to 1,000 miles from main plant.

Miles from final plant processing	Net present value of: Cooperative plants with: Small daily volume I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	Large daily volume II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	Private plants with: Small daily volume I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-1,283,320	-1,390,060	-1,198,680	-733,545	---	---
300	-283,035	-389,777	301,743	766,379	69,389	36,370
400	717,248	610,506	1,803,120	2,267,300	1,210,710	1,307,140
500	1,717,530	1,610,790	3,302,540	3,767,730	2,248,250	2,244,360
600	2,717,810	2,611,070	4,803,020	5,268,150	3,285,800	3,282,410
700	3,718,100	3,611,360	6,303,440	5,768,580	4,323,340	4,319,950
800	4,710,380	4,611,640	7,803,860	8,269,000	5,360,880	5,357,490
900	5,718,660	5,611,920	9,304,290	9,769,430	6,398,420	6,395,030
1,000	6,718,950	6,612,200	10,804,700	11,269,990	7,435,960	7,432,580

Table 33. Net present value of investment in remodeled receiving station, separation-required reverse osmosis center by hourly volume and business organization, assuming high inflation, 200 to 1,000 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-1,044.650	-1,116,880	917,519	-303,506	---	----
300	117,298	45,077	825,410	1,439,420	550,765	566,494
400	1,279,250	1,207,030	2,568,340	3,182,350	2,177,100	2,277,630
500	2.441.200	2,368,980	4,311,270	4,925,280	3,702,300	3,753,330
600	3.603.160	3,530,930	6,054,200	6,668,210	5,228,500	5,279,070
700	4.765.110	4,692,890	7,797,130	8,411,140	6,754,200	6,804,730
800	5.992,060	5,854,840	9,540,050	10,154,100	3,279,900	8,330,420
900	7.089.010	7,016,790	11,283.000	11,897,000	9,305,600	9,356.120
1,000	3.250.990	3,178.740	13,025.900	13,639,900	11,331,300	11,331,300

Table 34. Net present value of investment in remodeled receiving station, separation-required reverse osmosis center by hourly volume and business organization, assuming low inflation, 200 to 1,000 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-992.600	-1,079,390	-897,186	-406.316	---	---
300	7,681	-79,604	603,238	1,094,110	302.169	286,061
400	1,007,960	920,679	2,103,660	2,594,530	1.390.007	1,400,960
500	2,008,250	1,920,960	3,604,090	4,044,960	2,427,620	2,438,510
600	3,008,530	2,921,290	5,104,510	5,595,380	3,465,160	3,476,050
700	4,008,810	3,921,530	6,604,940	7,095,810	4,502,700	4,513,390
800	4,009,100	4,921,810	8,105,360	8,596,230	5,540,240	5,551,132
900	6,009,380	5,922,040	9,605,780	10,096,760	6,579,790	6,588,680
1,000	7,009,660	6,922,380	11,106,200	11,597,100	7,615,330	7,626,220

Table 35. Net present value of investment in full-construction, no-separation reverse osmosis center by hourly volume and business organization, assuming high inflation, 200 to 1,000 miles from main plant.

Miles from final plant processing	Net present value of: Cooperative plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	Large daily volume: II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	Private plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-858,478	-898,489	-589,708	23,314	---	---
300	303,475	263,463	1,144,220	1,766,240	873,211	898,665
400	1,465,430	1,425,420	2,887,150	3,509,170	2,504,150	2,553,030
500	2,627,380	2,587,390	4,630,080	5,252,100	4,029,850	4,078,730
600	3,789,339	3,749,320	6,377,010	6,995,030	5,555,555	5,604,430
700	4,951,290	4,911,270	8,115,940	8,737,960	7,081,240	7,130,130
800	6,113,240	6,073,230	9,858,370	10,980,900	8,606,970	8,655,830
900	7,275,190	7,235,180	11,601,800	12,223,800	10,132,600	10,181,500
1,000	8,437,140	8,437,140	13,344,700	13,396,670	11,658,300	11,707,200

Table 36. Net present value of investment in full-construction, no-separation reverse osmosis center by hourly volume and business organization, assuming low inflation, 200 to 1,000 miles from main plant.

Miles from final plant processing	Net present value of: Cooperative plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	Large daily volume: II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	Private plants with: Small daily volume: I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-489,965	-902,105	-637,328	-130,339	----	----
300	150,318	98,177	862,596	1,370,090	518,316	517,392
400	1,150,600	1,098,460	2,363,020	2,870,510	1,591,490	1,607,830
500	2,150,880	2,048,740	3,863,440	4,370,930	2,629,040	2,645,370
600	3,151,170	3,099,030	5,363,870	5,871,360	3,666,580	3,682,910
700	4,151,430	4,099,310	6,864,290	7,371,780	4,704,120	4,720,450
800	5,151,730	5,099,540	8,374,720	8,872,210	5,741,660	5,758,000
900	6,152,020	6,049,880	9,865,140	10,372,600	6,779,210	6,795,540
1,000	7,152,300	7,100,160	11,365,600	11,873,600	7,316,750	7,333,000

Table 37. Net present value of investment in remodeled receiving station, no sparation reverse osmosis center by hourly volume and business organization, assuming high inflation, 200 to 1,000 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-561,663	-581,432	-290,911	355,991	-523,014	-495,316
300	600,290	580,521	1,452,020	2,098,920	1,186,990	1,176,370
400	1,762,240	1,742,470	3,194,950	3,841,850	2,712,690	2,779,110
500	2,924,140	2,904,430	4,937,380	5,584,750	4,238,390	4,304,810
600	4,086,150	4,066,380	6,680,800	7,327,710	5,764,090	5,830,510
700	5,248,100	5,228,350	8,423,730	9,070,640	7,289,790	7,356,210
800	6,410,050	6,390,280	10,166,700	10,813,600	8,315,480	8,381,910
900	7,572,010	7,552,240	11,909,600	12,556,500	10,341,200	10,407,600
1,000	8,733,960	8,714,190	13,652,500	14,299,400	11,366,900	11,933,300

Table 38. Net present value of investment in remodeled receiving station, no-separation reverse osmosis center by hourly volume and business organization, assuming low inflation, 200 to 1,000 miles from main plant.

	Net present value of:					
	Cooperative plants with:				Private plants with:	
	Small daily volume		Large daily volume		Small daily volume	
Miles from final plant processing	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)	II-339000 lbs (16950 lbs/hr for 10 hrs)	IV-339000 lbs (33900 lbs/hr for 10 hrs)	I-226000 lbs (11300 lbs/hr for 20 hrs)	III-226000 lbs (22600 lbs/hr for 20 hrs)
	- dollars -					
200	-359,249	-591,932	-336,164	195,045	-498,570	-495,660
300	441,034	408,351	1,164,260	1,695,470	733,314	767,582
400	1,441,320	1,408,630	2,664,680	3,195,890	1,770,860	1,301,470
500	2,441,600	2,408,920	4,165,110	4,696,320	2,308,400	2,839,010
600	3,441,880	3,409,200	5,665,530	6,196,740	3,345,940	3,876,530
700	4,442,170	4,404,480	7,165,960	7,697,170	4,383,480	4,914,100
800	5,442,450	5,409,770	8,666,380	9,197,590	5,921,030	5,951,640
900	6,442,730	6,410,050	10,166,800	10,698,000	6,958,570	6,989,180
1,000	7,443,010	7,410,330	11,667,200	12,198,400	7,996,110	8,026,720

Table 39. Minimum distance in miles between reverse osmosis center and main plant required to achieve positive NPV by construction requirements, by plant size, firm type, and inflation assumption.

	Minimum distance to achieve positive NPV for:			
	-----Cooperatives ----		------- Privates -----	
Plant description	High inflation	Low inflation	High inflation	Low inflation
	---------------------- miles	----------------------		
Full construction:				
Plant Size I	188	201	154	166
Plant Size III	196	211	154	169
Plant Size II	143	152	--	--
Plant Size IV	109	121	--	--
Remodeled and separation:				
Plant Size I	162	172	138	147
Plant Size III	168	180	137	148
Plant Size II	125	132	--	--
Plant Size IV	90	99	--	--
Full construction, no separation:				
Plant Size I	146	157	117	128
Plant Size III	150	163	116	128
Plant Size II	107	115	--	--
Plant Size IV	71	81	--	--
Remodeled, no separation:				
Plant Size I	121	128	106	113
Plant Size III	122	132	104	113
Plant Size II	89	95	--	--
Plant Size IV	52	59	--	--

Table 40. Net present value of investment in reverse osmosis center for baseline assembly (70 miles).

Organization and option	Plant size in lbs. of milk processed per day: I-226,000 (11,300 lbs./hr. for 20 hrs.)	II-339,000 (16,950 lbs./hr. for 20 hrs.)	III-226,000 (22,600 lbs./hr. for 10 hrs.)	IV-339,000 (33,900 lbs./hr. for 10 hrs.)
With assumption of high inflation				
Cooperative				
Full construction	-1,363,050	-1,455,520	-1,257,520	-670,418
Remodeled, separation required	-1,066,240	-1,138,460	-949,907	-335,894
Full construction, no separation	-880,061	-920,073	-631,096	-9,073
Remodeled, no separation	-583,247	-603,019	-323,299	323,603
Private				
Full construction	---	---	---	---
Remodeled, separation required	---	---	---	---
Full construction, no separation	---	---	---	---
Remodeled, no separation	-163,789	-211,571	---	---
With assumption of low inflation				
Cooperative				
Full construction	-1,301,900	-1,408,640	-1,226,560	-761,427
Remodeled, separation required	-1,011,180	-1,098,470	-925,068	-434,198
Full construction, no separation	-868,546	-920,686	-665,710	-158,221
Remodeled, no separation	-577,829	-610,513	-364,046	167,163
Private				
Full construction	--	--	--	--
Remodeled, no separation	--	--	--	--
Full construction, no separation	--	--	--	--
Remodeled, no separation	-521,270	-518,351	--	--

Effect of Inflation and Business Organization on NPV. Two trends may be observed throughout the results. First, centers evaluated under the high-inflation assumption achieve consistently higher NPV than do those under the low-inflation assumption. For example, the NPV of a cooperatively owned center of size I under the full cost option at 190 miles is $31,290 (Table 23) while the NPV of the same center at the same distance under the lower inflation scenario is $-101,559 (Table 24). This relationship is consistently maintained.

The second general result is the consistently larger NPV of private versus comparable cooperatively owned firms. For example, consider the size I centers at 190 miles in Table 23. The NPV of the center if owned by a cooperative is $31,290, while the NPV under private ownership is $580,095.

The consistently higher NPV of private as compared to cooperatively owned centers is due to two factors. The primary factor is the structure of the tax laws which are designed to encourage investment. While cooperatives may take advantage of the investment tax credit, they derive no benefit from the depreciation or interest tax shields. This factor makes the centers more profitable to private firms than to cooperatives. An additional factor enhances this effect. Recall that the opportunity cost and, hence, the discount rate of the private firm is several percentage points lower than that of the cooperatively owned firm. Thus, present value of a cash stream will, all else constant, be higher the lower the discount rate.

Implications of Length of Workday for NPV. The analysis suggests that the effect of shifting the centers from a 14 to a 24-hour workday is relatively small. This can be most clearly seen by examining the small differences between the breakeven points for a given scenario of sizes I and III, and sizes II and IV in Table 39. These size pairs correspond to the same daily volume but two length workdays. Note, that the breakeven point for a privately owned size I center under full cost and high inflation is 154 miles. The breakeven point for an analagous size III plant is also 154 miles. The variations in breakeven points between sizes II and IV are somewhat larger. A new construction cooperatively owned size II center under high inflation breaks even at 143 miles while a comparable size IV center has a 104-mile breakeven point.

The preferred workdays based on relative NPV show a definite pattern. For cooperatives, size I is consistently preferred to size III and size IV is consistently preferred to size II. The longer workday is preferred in the first instance, the shorter in the latter. For privately owned firm, size I appears to be preferred over size II for the full cost and remodeled (with separation) option. It should be noted that these preferences for privately owned firms are based on extremely small differences in expected returns.

In practice, size III and IV may be preferred over I and II in all instances. While the results indicate that the trade-off between productivity of labor, and productivity of capital, is almost even, this fails to take into account the effect of longer workday on equipment life. The shortening of equipment life should necessitate additional repair costs and early retirement of equipment.

Effect of Volume per Day on NPV. There appear to be substantial NPV benefits to larger processing centers (Tables 23 through 38). This is evident from comparing the NPU given distance and construction option for the larger centers, sizes II and IV, with the smaller centers, sizes I and III. For example, a size IV center with remodeling, high inflation, and cooperatively owned at 130 miles has a NPU of $767,333 while a comparable size II cooperatively owned center has a NPU of $22,341 (see Table 30). In fact, size IV cooperatively owned centers are preferred to comparable size III centers under either private or cooperative ownership.

Net Present Value Analysis of Conversion of Baseline Assembly to Reverse Osmosis Centers The NPV of simply replacing the baseline assembly systems with reverse osmosis centers is presented in Table 40. These centers would be located at a distance of 70 miles from the centralized processing plant. Positive NPV's in the Table indicate the investment is worthwhile. If the NPV is negative, the investment is expected to decrease the value of the firm by that amount, and the investment, therefore, is unprofitable. The NPV's in Table 40 indicate that reverse osmosis assembly for manufacturing purposes at this distance is profitable only in the case of size IV with a remodeled receiving station housing the equipment and no separation necessary. If, however, firms intended to ship the milk long distances presumably for fluid use, the centers would prove profitable at distances in excess of 200 miles in the case of the privately owned firms and in excess of 100 miles in the case of the cooperatively owned firms. More exact distances required to achieve positive NPV's may be interpolated using Tables 31 to 38.

The results for the baseline system are quite descriptive of the probable overall impact of reverse osmosis on milk assembly. Under presently available technology, reverse osmosis is unlikely to be profitable for the typical manufacturing firm. This is especially the case if existing receiving stations are not available for minimum cost remodeling. From Table 39 it is evident that only firms able to utilize the larger volume and hauling milk 109 miles or more would find a completely new plant profitable. A minimum 90-mile shipment would still be required if remodeling opportunities are available. Most existing firms in Minnesota would fail to meet either or both the volume or the distance requirement.

Both forms of business organization may find the long distance shipment option attractive with current reverse osmosis technology. Note that shipments of 500 miles in Tables 31 through 38, not an unusually long distance for a milk shipment to fluid deficit areas, yielded positive NPV's for all centers. Even the least profitable center, size III with full construction, low inflation, and cooperatively owned, has an NPV of $1,610,790 at this distance (Table 32). The most profitable center within the technology constraints, size IV, with separation, remodeling, high inflation, and cooperatively owned yields an NPV of $4,925,580, as shown in Table 33.

If technology advances to permit concentration without separation, the door to reverse osmosis assembly for manufacturing use is open. Elimination of separation reduces capital costs substantially and has a major impact on operating costs as well. This decline in capital and operating costs significantly reduces the distance required for the centers to break even. For instance, a larger volume center with completely new construction is estimated to break even at 71 or 81 miles, depending on the inflation rate (Table 39). If the larger center is a remodeled receiving station, the break-even distance is reduced to 52 or 59 miles, depending on the inflation rate. Those distances are well within the range of normal assembly for many plants. The breakeven points are reduced for the smaller centers as well, however, the reduction will not be sufficient in most instances for reverse osmosis assembly to become feasible. For example, a cooperatively owned smaller center built from a remodeled receiving station is estimated to have a breakeven distances of 122 to 132 miles (Table 39). A comparable privately owned center would break even at somewhat shorter distances from 104 to 113 miles.

Even under the more favorable circumstances, relatively few smaller centers would prove profitable. In most instances, milk would simply not be assembled in sufficient volume at assembly points to meet minimum size requirements for reverse osmosis processing. Because reverse osmosis appears to offer promise for substantial returns to larger firms but not to smaller firms, it could introduce additional structural adjustments into the industry. The competitive position of larger firms would be strengthened. It would be another factor contributing to the decline in dairy firm numbers.

The advantages of eliminating separation prior to processing are less clear for the long distance hauling. Fluid defict areas are frequently not fat deficit. They frequently require skim rather than a whole milk. If they are indifferent between the two forms of concentrate, then eliminating separation enhances the profitability of long distance hauling of whole concentrate over that of hauling skim concentrate. The least profitable center without separation, - Size III with low inflation, all new construction and cooperatively owned - has a NPV of $2,048,740 for 500 mile shipments (Table 36). The most profitable center operating without separation, - size IV with high inflation, a remodeled station, and cooperatively owned - has a NPV of $5,584,780 (Table 37). Private firms would find the 500-mile haul profitable as well. For instance, a size III remodeled station under high inflation would have a NPV of $4,304,810 under private ownership (Table 37).

Institutional Considerations. The profitability of long distance shipment of reverse osmosis concentrated milk is operationally contingent on the removal of several institutional barriers. Sanitary and health standards may prevent its use in fluid products. Currently an association of state health boards is considering the granting of 3A status to reverse osmosis equipment. If such status is granted, Grade A milk processed by reverse osmosis will be eligible for Class I or fluid use. This is not anticipated to be a major problem. The second barrier, however, could be more troublesome. The Federal Orders, which regulate Grade A milk pricing follow pricing policies designed to encourage the use of local Grade A supplies before supplies from outside the order region regardless of real cost advantages. These rather complicated pricing regulations effectively remove the incentive to transport concentrated milk for later reconsitution and fluid use. They would, therefore, have to be modified if long distance shipment of reverse osmosis concentrated milk is to be profitable. Institutional barriers were assumed nonexistent for the purpose of this study.

SUMMARY

This study provides estimates of the cost advantages of concentration of milk by reverse osmosis at assembly points in milk producing areas prior to shipment to other plants for final processing. Reverse osmosis offers a number of advantages over more conventional milk concentration techniques. Because milk concentrated by reverse osmosis need never be heated above pasteurization temperature, the milk should retain the taste characteristics of an unconcentrated product. Secondly, the membranes are sufficiently selective that only a minute quantity of nonwater milk components is lost to the permeate. Therefore, the nutritional quality of the concentrate closely resembles that of natural milk. The process is appealing from an economic viewpoint because of low energy requirements in comparison to conventional thermal concentration and its adaptability to the small volumes at which intermediate-point processors would need to operate. This study addresses the question of the economic feasibility of reverse osmosis assembly of milk in two contexts. In the first case the milk is hauled relatively short distances for use in dairy product manufacturing. In the seond case, milk is hauled long distances to milk deficit areas for fluid use.

As a first step in evaluating economic feasibility, four hypothetical reverse osmosis centers were designed, processing from 11,300 to 33,900 pounds of milk per hour. These four centers correspond to two volumes per day and two daily hours of operation. Two daily volumes were examined in order to gain some insight into the economies of scale involved, while the two lengths of workday were studied in an effort to evaluate the trade-offs between labor and capital.

The cost data were largely synthetically generated, although some actual costs sizes and assembly data were used from receiving stations that the reverse osmosis centers were envisioned as replacing. The direct reverse osmosis costs were provided by the membrane manufacturers. The extensive accessory equipment costs estimates were prepared by an independent food process consultant.

One set of costs was generated with the assumption that the reverse osmoisis center was a completely new facility and that the milk required separation prior to processing. Three additional scenarios were developed relaxing these assumptions. These were as follows:

1. A remodeled receiving station with separation prior to reverse osmosis processing,

2. A completely new facility with no separation prior to reverse osmosis processing, and

3. A remodeled receiving station with no separation prior to reverse osmosis processing.

The latter two scenarios require that membrane technology advance to the point of allowing whole milk processing.

The economic feasibility of the various centers was analyzed through the net present value (NPV) technique. This method involves simply summing the present values of each of the expected net cash flows to be generated as a result of the investment. NPV analysis was done for the two forms of buisness organizations that commonly exist in dairy processing--cooperatively owned firms and small closely held private firms.

The results of analysis suggest that only the largest center transporting milk unusually long distances will find reverse osmosis assembly profitable for manufacturing milk assembly under present technology. However, if anticipated membrane improvements allow concentration withour prior separation, then reverse osmosis concentration would become more attractive for manufacturing milk assembly. Long distance shipments, either with or without improvements in technology, appear to be profitable at common shipping distances for all center sizes.

The NPV of a given center is relatively invariant with length of workday. This occurs because the trade-off between the productivity of labor, which is higher under the shorter workday, and the productivity of capital, which is higher under the long workday, is relatively even.

The implications of reverse osmosis for the dairy industry under present technology are largely limited to long distance hauling, although a few larger firms may find reverse osmosis assembly for manufacturing use profitable. All centers were found profitable at shipping distances above 400 miles and many at less than 300. These distances are within the normal range of many long distance shipments to deficit areas.

If anticipated advances in membrane design are perfected and whole milk processing becomes an option, reverse osmosis could find wide application in milk assembly for manufacturing. The larger volume center break-even points will, under the least favorable conditions, drop to about 80 miles and under the most favorable to about 50 miles. Centers processing the smaller volume would retain relatively high breakeven points of 100 miles or more. All firms, however, would find reverse osmosis highly profitable for shipment 300 miles or more to deficit areas.

Reverse osmosis, therefore, is potentially profitable in several situations with present technology, primarily in long distance shipping of milk. If processing of whole milk becomes possible, firms will find reverse osmosis at assembly stations for manufacturing plants to be attractive as well.

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Appendix A

Table Al. Depreciation schedule for equipment. Group 1.

Year	Percent charged to depreciation per year
1	15
2	22
3	21
4	21
5	21

Table A-2. Depreciation schedule for buildings, Group 1

Year	Percent charged to depreciation per year
1	12
2	10
3	9
4	8
5	7
6	6
7	6
8	6
9	6
10	6
11	5
12	5
13	5
14	5
15	5

Appendix Table A-3. Depreciation schedule applicable to various reverse osmosis plants, by hourly volume and distance from main plant.

Option and distance milk hauled	Depreciation Option: High inflation: Group 1 Maximum allowable depreciation	High inflation: Group 2 Equip-10yrs Bldg. 55% per yr.	High inflation: Group 3 Equip & Bldg-20% straight line	High inflation: Insufficient income at any depreciation rate	Low inflation: Group 1 Maximum allowable depreciation	Low inflation: Group 2 Equip-10yrs Bldg. 55% per year	Low inflation: Group 3 Equip & Bldg-20% straight line	Low inflation: Insufficient income at any depreciation rate
Plant Size I, full construction: (Concentrate used for manufactured dairy products)								
50				x				x
70				x				x
90				x				x
110			x					x
130			x				x	
150		x					x	
170		x				x		
200				x				x
210		x				x		
230		x				x		
250		x				x		
(Concentrate used for fluid products)								
300		x				x		
400	x				x			
500	x				x			
Plant Size III, full construction: (Concentrate used for manufactured dairy products)								
50				x				x
70				x				x
90				x				x
110				x				x
130			x				x	
150			x				x	
170		x				x		
190		x				x		
200				x				x

Appendix Table A-3 (Continued)

Option and distance milk hauled	High Inflation: Group 1	High Inflation: Group 2	High Inflation: Group 3	High Inflation: Insufficient income	Low Inflation: Group 1	Low Inflation: Group 2	Low Inflation: Group 3	Low Inflation: Insufficient income
210		x				x		
230		x				x		
250		x				x		
(Concentrate used for fluid products)								
300		x				x		
400	x					x		
500	x				x			
Plant Size I, separation & remodeling: (Concentrate used for manufactured dairy products)								
50				x				x
70				x				x
90				x				x
110			x				x	
130		x				x		
150		x				x		
170		x				x		
190	x				x			
200				x				x
210	x				x			
230	x				x			
250	x				x			
(Concentrate used for fluid products)								
300		x				x		
400	x				x			
500	x				x			
Plant Size III, separation & remodeling: (Concentrate used for manufactured dairy products)								
50				x				x
70				x				x
90				x				x

Appendix Table A-3 (Continued)

Option and distance milk hauled	High Inflation Group 1	Group 2	Group 3	Insufficient income	Low Inflation Group 1	Group 2	Group 3	Insufficient income
110			x				x	
130		x				x		
150		x				x		
170		x				x		
190		x				x		
200				x				x
210		x				x		
230		x				x		
250		x				x		
(Concentrateused for fluid products)								
300		x				x		
400	x				x			
500	x				x			
Plant Size I, no separation & full construction; (Concentrate used for manufactured dairy products)								
50				x				x
70				x				x
90			x				x	
110			x				x	
130		x				x		
150		x				x		
170		x				x		
190	x				x			
200				x				x
210		x				x		
230		x				x		
250		x				x		
(Concentrate used for fluid products)								
300		x				x		
400	x				x			
500	x				x			

Appendix Table A-3 (Continued)

Option and distance milk hauled	High Inflation				Low Inflation			
	Group 1	Group 2	Group 3	Insufficient income	Group 1	Group 2	Group 3	Insufficient income
Plant Size III, no separation and full construction:								
(Concentrate used for manufactured dairy products)								
50				x				x
70				x				x
90			x				x	
110			x				x	
130		x				x		
150		x				x		
170		x				x		
190		x				x		
200				x				
210		x						x
230	x				x			
250	x				x			
(Concentrate used for fluid products)								
300		x				x		
400	x				x			
500	x				x			
Plant size I, no separation and remodeling:								
(Concentrate used for manufactured dairy products)								
50		x				x		
70			x				x	
90		x				x		
110		x				x		
130	x					x		
150	x				x			
170	x				x			

Appendix Table A-3 (Continued)

Option and distance milk hauled	High Inflation Group 1	High Inflation Group 2	High Inflation Group 3	High Inflation Insufficient income	Low Inflation Group 1	Low Inflation Group 2	Low Inflation Group 3	Low Inflation Insufficient income
190	x				x			
200							x	
210	x				x			
230	x				x			
250	x				x			
(Concentrated use for fluid products)								
300	x				x			
400	x				x			
500	x				x			
Plant Size III, no separation & remodeling:								
(Concentrate used for manufactured dairy products)								
50				x				x
70			x				x	
90			x				x	
110		x				x		
130		x				x		
150		x				x		
170	x				x			
190	x				x			
200			x				x	
210	x				x			
230	x				x			
250	x				x			
(Concentrate used in fluid products)								
300		x				x		
400	x				x			
500	x				x			

*Group 1, full depreciation; Group 2, 10-year, straight-line depreciation; Group 3, 20-year, straight-line depreciation.