JULY 2003

DAIRY FARM ENERGY AUDIT SUMMARY

New York State
Energy Research and Development Authority

NOTICE

This report was prepared pursuant to the Flexible Technical Assistance Program (hereafter "FlexTech") administered by the New York State Energy Research and Development Authority (hereafter the "NYSERDA"). The opinions expressed in this report do not necessarily reflect those of NYSERDA or the State of New York, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it. Further, NYSERDA and the State of New York make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods, energy savings, or other information contained, described, disclosed, or referred to in this report. NYSERDA and the State of New York make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no responsibility for any loss, injury, or damage resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

DAIRY FARM ENERGY AUDIT SUMMARY

REPORT

Prepared for

FlexTech Services
New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203-6399

Kerry Hogan
Project Coordinator

Prepared by

David Ludington
Eric L Johnson

DLtech, Inc.
PO Box 3910
Ithaca, NY 14852

July 2003

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Under the New York State Energy Research and Development Authority's (NYSERDA) FlexTech Program, DLtech, Inc. conducted 32 energy audits on dairy farms across central and northern New York. A substantial amount of data/information has been collected and analyzed in the preparation of the individual reports. These reports have been summarized to highlight their collective patterns of basic farm data, energy usage and energy utilization indices [EUI]. Also, to look at the existing and recommended energy conservation measures [ECM], the breakdown of energy uses on these dairies, and identify relationships of present and future energy conservation options.

The data for the 32 audits has been subdivided according to the type of animal housing used [tiestall / freestall] on the farm. There are 14 farms with tiestall housing and around-the-barn pipeline milking systems. The remaining 18 have freestall barns and various forms of milking parlors. Milk production per cow for both farm types was significantly greater than the 2001 New York State average (17,527 pounds/cow/yr). A broad range in farm size was encountered for both tiestall and freestall farms. The number of dairy cows ranged from 42 to 140 on tiestall farms, and from 65 to 860 cows on freestall farms.

EUI's for overall farm, vacuum pump and refrigeration for the farms were compared. These EUI's allow comparison of energy use between farms and establish a benchmark of relative efficiency. Based on these numbers, farms with total use of less than 750 kWh/cow-yr, vacuum pump use less than 50 kWh/cow-milking-yr, and 0.7 kWh/cwt (hundredweight-100 lbs of milk produced) for milk cooling would be considered energy efficient. The range within these EUI's indicates the potential energy conservation that can be accomplished with analysis, management and appropriate ECM.

The top four categories (milk cooling, lighting, ventilation, and vacuum pumps) accounted for 88% of all electric energy used on all farms audited. ECM's proposed to conserve energy concentrated in these areas, with the exception of ventilation. ECM options to manage energy use in this category would involve replacement with energy efficient fans and premium efficiency motors.

The distribution of fuel sources used for water heating on audited farms was distributed fairly evenly (Electric – 31%, Fuel Oil – 34%, Propane – 28%). In terms of aggregate energy use, Btu consumption was more heavily weighted (76%) toward fossil fuels (Fuel Oil & Propane). Larger tiestall and most freestall farms were found to utilize fossil fuel water heating. The larger volumes of hot water consumed by these farms attributed to the dominance of fossil fuel on a Btu basis.

The most prevalent ECMs encountered on all farms audited, was the existence of some form of energy-efficient lighting. Application of efficient lighting can take on a myriad of forms. These can be very simple, such as installation of screw-in compact fluorescent bulbs, to high-intensity discharge (HID) lighting systems in large freestall barns and milking complexes.

The wide variety of lighting options available makes energy-efficient lighting the dominant ECM.

The presence of existing ECM's can indicate the acceptance of an energy-saving technology due to its historical performance. The wide use of refrigeration heat recovery, for example, has proven effective in reducing water-heating costs for two decades, and is the second most common form of energy-saving equipment found.

Proposed ECM's have focused on implementing the application of new energy-efficient technologies. The proposed ECM, with the greatest potential savings, is the installation of a variable speed drive (VSD) on the vacuum pump. The savings from VSDs are almost as large as the next two ECM's combined. The VSD slows the vacuum pump down to meet airflow requirements, instead of the vacuum controller venting excess capacity. Paybacks on this technology are better on farms with long milking hours, where the larger accumulated savings offset capital costs faster.

Milk plate pre-coolers are the next major ECM proposed because their effectiveness is tied to the volume of milk produced, and the volume and temperature of the water available. Again, large farms with greater amounts of milk cooling offer the shortest paybacks. Plate-coolers can be economic on tiestall farms when properly sized, with adequate volumes of milk and cooling water.

The greatest number of proposed ECMs was for energy-efficient lighting. This is due to the many options available to improve lighting efficiency. The longer paybacks are attributed to the incremental savings that occur when a new generation of efficient lighting technology replaces existing lighting technology.

DAIRY FARM AUDIT SUMMARY REPORT

The 32 dairy farm energy audits conducted by DLtech, Inc., under the New York State Energy Research & Development Authority's (NYSERDA) FlexTech Program, have been reviewed and summarized in the preparation of this report. The objective of the individual reports is to help dairy farm operators make informed decisions regarding energy use on their farms. The reports catalog and categorize all electrical equipment, develop an estimate of energy usage, compute and compare baseline Energy Utilization Indices [EUI], provides recommendations to improve equipment efficiency, and identify appropriate Energy Conservation Measures [ECM] and their economic impacts.

The data for the 32 audits has been subdivided according to the type of housing used [tiestall / freestall] on the farm. In tiestall farms, animals are housed, milked, consume feed and water in individual stalls. An around-the-barn milk pipeline is used on tiestall farms, where the milker moves from cow to cow. On freestall farms, animals are housed, and consume feed and water in a separate barn. Milk harvest is carried out in a milking parlor, where the cows are brought in groups to be milked. Data for all farms and for the tiestall and freestall farms is given in Table 1.

Of the 32 farms, 18 dairy farms used freestall barns with various forms of milking parlors and 14 farms used tiestall housing with around-the-barn milk pipelines. Total annual electrical use of 3,983,742 kWh, is broken down with 75 % in the freestall farms and the remaining 25 % in the tiestall farms. Milk production per cow for both farm types was significantly greater than the 2001 New York State average (17,527 pounds/cow/yr). This tendency of above average production, might have contributed to the operators of the audited farms being interested in improved management of their farms energy consumption. A broad range in farm size was encountered for both tiestall and freestall farms

The 14-tiestall farms had a combined annual electrical energy use of 1,009,794 kWh. The average electrical energy per tiestall farm was 72,126 kWh and ranged from 29,805 kWh to 134,754 kWh annually. These 14 farms produced 221,670 per hundred weight (cwt) of milk from 1,077 cows. The number of dairy cows per farm ranged from 42 - 140, with an average of 77 cows. Annual milk production per cow was 20,582 pounds.

Total annual electrical energy use for the 18-freestall farms was 2,973,946 kWh. Average electrical energy consumption on freestall farms was 165,219 kWh ranging from 48,880 to 775,909 kWh. These farms averaged 244 cows per farm, with a range of 65 – 860 cows. Milk production on these 18 farms totaled 1,093,994 cwt from 4,934 cows, for an average of 60,777 cwt per farm and 24,897 pounds per cow.

The milk production per cow for the audited farms was significantly greater than the 2001 New York State average (17,527 pounds/cow/yr). This tendency of above average production might have contributed to farm operators' interest in improving energy efficiency of their farms' energy consumption.

Energy Utilization Indices [EUI]:

Generally, dairy farms use between 800 and 1200 kWh/cow-yr. These EUI's are used to compare overall energy use between farms, and establish a benchmark of evaluation. All EUI's found in Table 1, are significantly higher for the tiestall farms. This is an indication the adoption of energy-saving technology has taken place on freestall farms because of economies of scale, and incorporation of these technologies when expansions are made. The Total Farm EUI's reported in the audits for 9 of the freestall farms, include an estimate of electric water heating equivalent, to represent the fossil fueled water heating that is used on those farms. This was done to allow for comparison of Total Farm EUI between farms with electric and fossil fuel water heating.

The greatest Total Farm EUI of 1736 kWh/cow-yr, and the least, of 424 kWh/cow-yr, both occurred in the freestall farms. The tiestall farm total EUI, ranged from 542 – 1561 kWh/cow-yr. The wide span of EUI's in both categories of farms is an indication of the potential energy conservation that can be made to push these indices down.

The broadest magnitude of EUI for vacuum pump also occurred on the freestall farms, where the range was from 12 to 149 kWh/cow-yr. The tiestall farms had a similar spread of 42 to 140 kWh/cow-yr. The EUI's on the low end are result of installation of a variable speed drive [VSD] on the vacuum pump. The VSD allows the vacuum pump to efficiently produce the airflow needed to match milking demand and yield substantial energy savings.

A wide range of existing ECMs were observed on the farms audited. They ranged from "state of the art" in some of the large new milking center complexes in freestall farms, to no energy efficient-measures.

The EUIs for the major users are summarized in Table 1.

Table 1: Summary of Energy Use and Related Farm Data

	Tiestall Barn	% of Total	Freestall Barn	% of Total	Total All Farms
Number of Farms Audited:	14		18		32
Farm Electrical Energy Use:					
Total kWh	1,009,794	25%	2,973,948	75%	3,983,742
Average kWh	72,128		165,219		124,492
Range	(29,805 - 134,754)		(36,895 - 775,909)		
Farm Fossil Fuel Use, Total:					
Propane - Gal	486		8,352		8,838
Fuel Oil - Gal	3,619		5,840		9,459
Farm Data Summary:					
Milk Shipped, cwt	221,670	17%	1,093,994	83%	1,315,664
Ave. CWT per Farm	15,834		60,777		41,115
Cows Milked	1077	20%	4394	80%	5471.2
Ave. Cow per Farm	76.9		244.1		171
Range	(42 - 140)		(65 - 860)		
Ave. Milk per Cow (#)	20,582		24,897		24,048
Energy Utilization Index (EUI)					
Farm - kWh/cow-yr.	934		811		865
Range	(542 - 1561)		(424 - 1736)		
Vacuum Pump - kWh/cow-yr-milking	71.9		54.4		62.1
Range	(33 - 116)		(12 - 149)		
Refrigeration - kWh/CWT	0.915		0.752		0.824
Range	(0.435 - 1.8)		(0.40 - 1.4)		

Energy use by Equipment Category:

The use of electric energy that was identified in the individual audits has been summarized into the following categories: milk cooling, vacuum pumps, lighting, ventilation, water heating, feeding, manure handling, and miscellaneous. The totals for all farms are listed in Table 2 and shown in Figure 1. Milk production equipment (milk-cooling, vacuum pumps, water heating) comprises 46% of all energy used. Lighting and ventilation equipment were responsible for another 46% of total use. The more specialized uses of feeding and manure handling, and miscellaneous accounted for the remaining 8%.

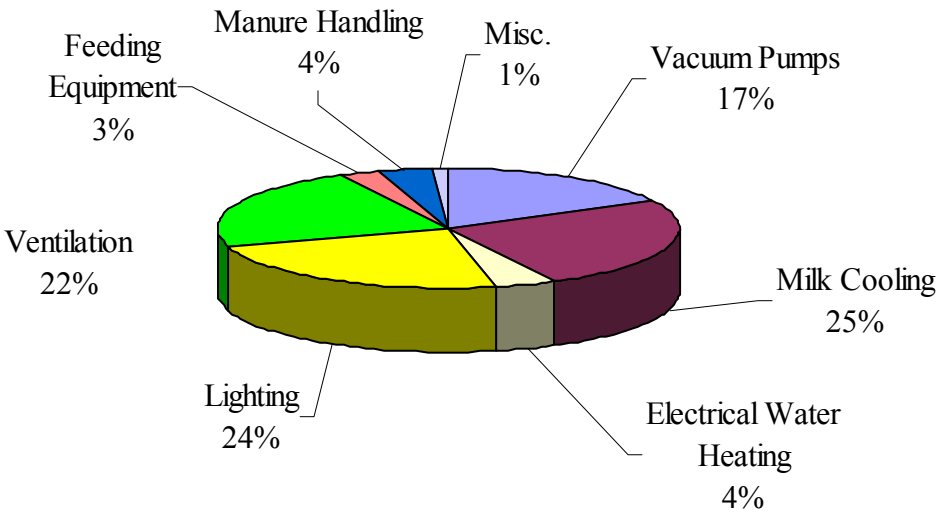


Figure 1: Energy Use by Equipment Category – All Farms

Energy use distribution patterns shown in Figure 1 are similar on both types of farms. Milk cooling was the largest consumer of electric energy on both tiestall (23%) and freestall (27%) farms. The combination of milk cooling, vacuum pumps, ventilation, and lighting accounted for 92% of all electrical energy used on freestall farms. These same four categories accrued 79% of use on tiestall farms, with water heating, feeding, manure handling, and miscellaneous comprising the remaining 21%. The lighting category was the second largest end-use of electricity on all farms, ahead of the more traditional agricultural uses of ventilation, vacuum pumps, feeding, and manure handling equipment. A comparison of the breakdown of energy use between tiestall and freestall farms is shown in Table 2 and is shown graphically in Figure 2.

In spite of long operating times (up to 20-23 hrs/day), VSDs demonstrated energy efficiency, using significantly less electricity than lighting and ventilation.

Table 2: Summary Energy Use by Equipment Category: Tiestall and Freestall

	Tiestall	Freestall	Total
	kWh/yr.	kWh/yr.	kWh/yr.
Milk Cooling	196,753	654,030	850,783
Vacuum Pumps	152,526	428,579	581,105
Lighting	140,714	653,893	794,607
Ventilation	177,700	551,311	729,011
Electric Water Heating	86,721	53,088	139,809
Feeding Equipment	61,110	35,033	96,143
Manure Handling	22,255	109,387	131,642
Miscellaneous	9,051	29,104	38,155
Total	846,830	2,514,425	3,361,255

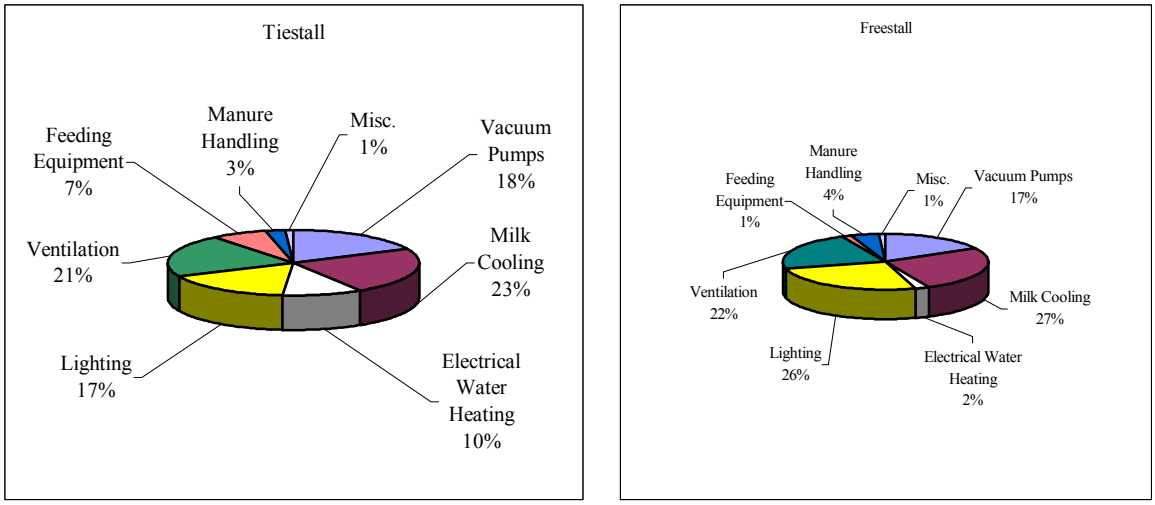


Figure 2: Tiestall and Freestall: Energy Use by Equipment Category

Electric water heating consumed more kWh on tiestall, than freestall farms. This was due to greater number of tiestall farms with electric water heating. Energy consumption by feeding equipment was also greater in tiestall farms. Chiefly due to larger numbers of tower silo unloaders and associated material handling (conveyors, mixers, feeders, augers) equipment. Very little feeding equipment was encountered on freestall farms.

Ventilation was a major non-milking related load on both tiestall and freestall farms. Many forms of ventilation were recorded on both types of farms, including "tunnel" ventilation on tiestall farms and numerous types of cow-cooling ventilation on freestall farms. Although the total horsepower of ventilation load is low, long running times contribute to its high-energy consumption. Feeding and manure handling are relatively large horsepower loads, with limited run times that use less energy.

Water Heating Summary:

The distribution of water heater energy sources found on the audited farms is split evenly between electric (31%), propane (28%), and fuel oil (34%). Figure 3 shows the breakdown of water heating fuel sources employed. Fuel oil and propane water heating predominated on larger tiestall and freestall farms.

Electric water heating was more prevalent on tiestall farms. This was due to smaller volumes of hot water necessary, simplicity of installation, and absence of fuel storage required

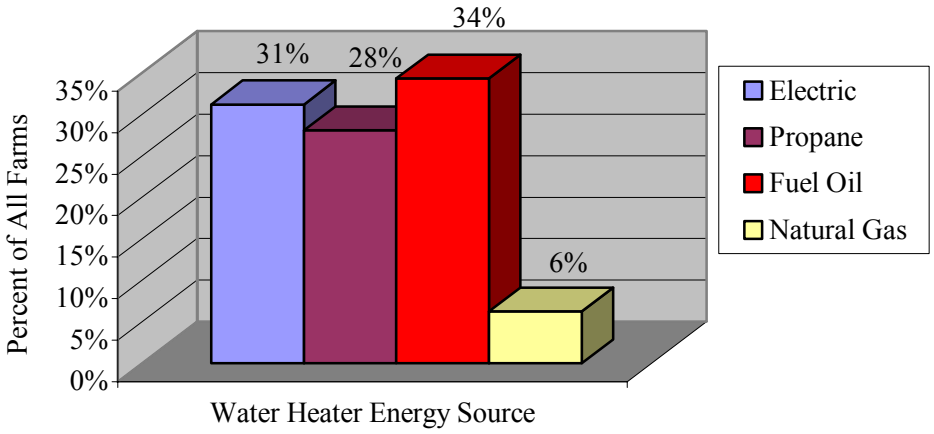


Figure 3: Water Heating – Fuel Source

The energy used to heat water has been converted to a kWh equivalent in Figure 4. The trend toward fossil fuel is even more apparent when comparing energy used for heating water on a kWh equivalent. Fuel oil supplies 46%, propane 30 % and electric 24%, of the total energy consumed for heating water. Greater energy consumption by fossil fuel sources is attributed to larger volumes of water heating required on large tiestall and freestall farms. Fossil fuel water heating was present on 62% of farms audited and used 76% of the total energy needed. Energy consumption data was not available for the farms using natural gas.

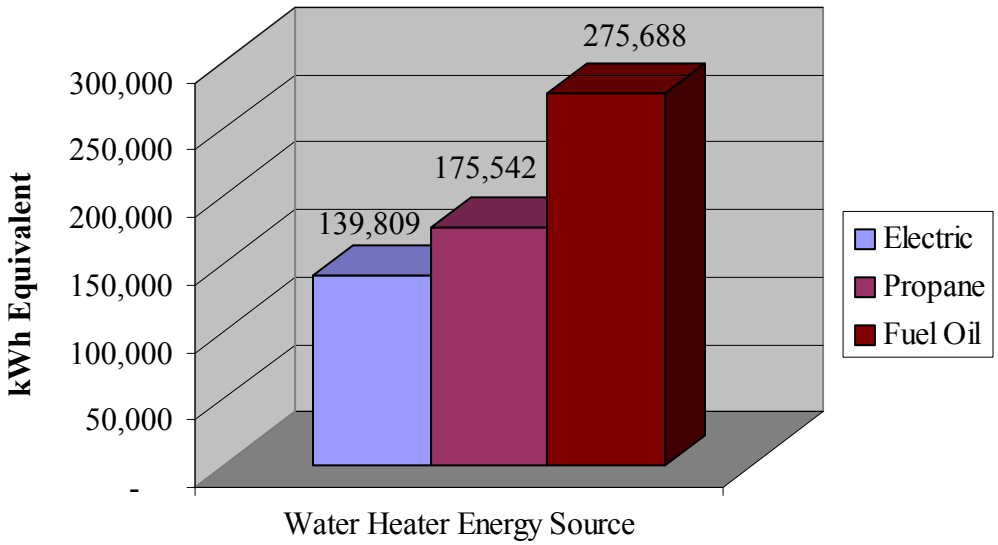


Figure 4: Water Heating – kWh Equivalent

Because fossil fuel water heaters have faster recovery and lower operating costs, they are better able to supply the large volumes of wash water used by milking parlors on freestall farms.

The broad impact of refrigeration heat recovery on water heating costs was not quantified in the audits. But it has been implemented on almost two thirds of farms audited and provides a substantial energy savings with all types of water heating.

Existing Energy Conservation Measures [ECM's]:

The incidence of existing ECM's for energy-efficient lighting, refrigeration heat recovery, milk plate pre-cooler, VSDs on vacuum and milk pumps on audited farms was recorded. The existence of all five ECMs was found on only four farms, while over a third of the farms had one or no ECMs in place.

Figure 5 provides an indication of the ECMs that were found in existence on audited tiestall farms. The existence of some form of energy-efficient lighting was the most common form of energy conservation on tiestall farms. Eighty-six percent of all tiestall farms had some form of efficient lighting technology. This could include single applications of compact fluorescent lights replacing incandescent bulbs, to complete fluorescent light systems with energy-efficient T-8 lamps and electronic ballasts. The application of energy efficient high intensity discharge [HID] light sources, high-pressure sodium [HPS] and metal halide [MH] were also found, especially for outdoor-lighting.

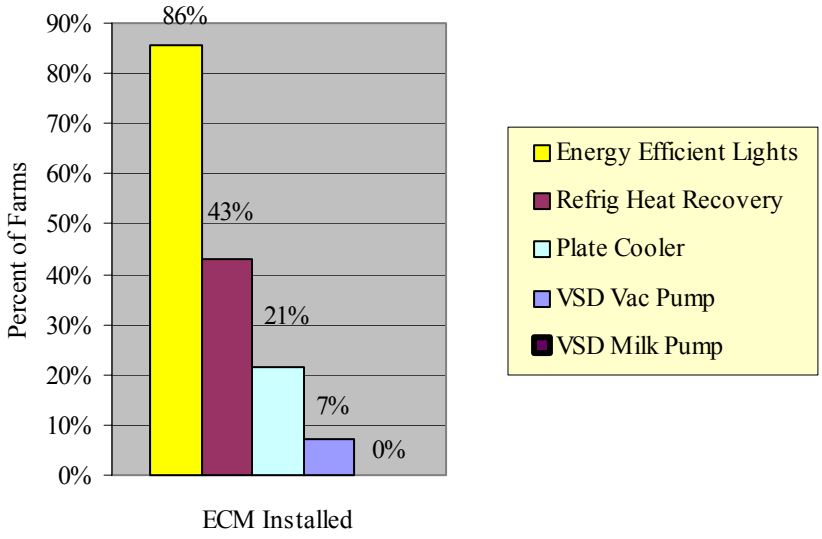


Figure 5 – Existing ECMs – Tiestall farms

Refrigeration heat recovery was found to be in place on forty-three percent of the tiestall farms. All tiestall farms used around-the-barn pipelines for milking, and could use the waste heat from milk cooling to preheat water for cleansing the milking system.

A smaller percentage (21%) used plate milk pre-cooling, as a method of reducing energy required to lower milk-cooling costs.

Only seven percent of tiestall farms had a variable speed drive [VSD] installed to control operation of the vacuum pump. This relatively new application of VSD's offers a large potential for conservation, which will be further addressed in the area of recommended conservation measures.

None of the tiestall farms had VSD's installed on the milk transfer pump to maximize heat transfer with an existing milk plate cooler.

Seventy eight percent of all freestall farms had refrigeration heat recovery systems, to use the waste heat from milk cooling for preheating of wash water. See Figure 6. The large volumes of hot water required to wash milking parlors, have made this a widely used ECM.

The installation of some form of energy-efficient lighting was implemented on two-thirds of the freestall farms. Applications of energy efficient fluorescent lights in the milking center/parlor, and HID lights in freestall barns and outdoor applications were most common.

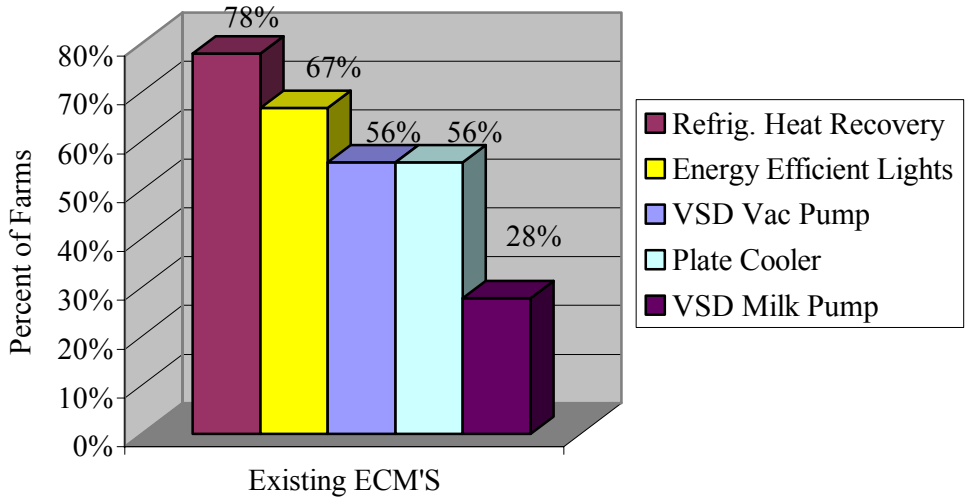


Figure 6: Existing ECMs – Freestall Farms

Slightly more than half of the freestall farms have employed the use of milk plate pre-coolers and VSDs on vacuum pumps. The greater penetration for both of these technologies is due in part to the larger size of the freestall operations, higher energy requirements to offset, and better economics from larger energy savings.

Twenty-eight percent of freestall farms are currently using VSDs on milk transfer pumps, to optimize the transfer of heat thru a milk plate pre-cooler. These applications, are mainly evident in new milking systems, but should offer energy savings to all large dairies with pre-coolers.

Recommended Energy Conservation Measures [ECMs]

ECMs recommended for installation included VSDs on vacuum pumps, refrigeration heat recovery, plate milk pre-coolers, and the adoption of energy-efficient lighting technology. Energy-efficient lighting was the most frequently proposed ECM, on twenty of the farms audited. VSDs for vacuum pumps were recommended on nineteen farms and milk plate pre-coolers on 14 farms.

Analysis of the data/equipment inventory for all farms audited identified the ECMs shown in Figure 7. The total annual savings in kWh for all measures identified was 402,946 kWh. This represents a savings of 10.1 % of the total electrical energy used by all farms audited.

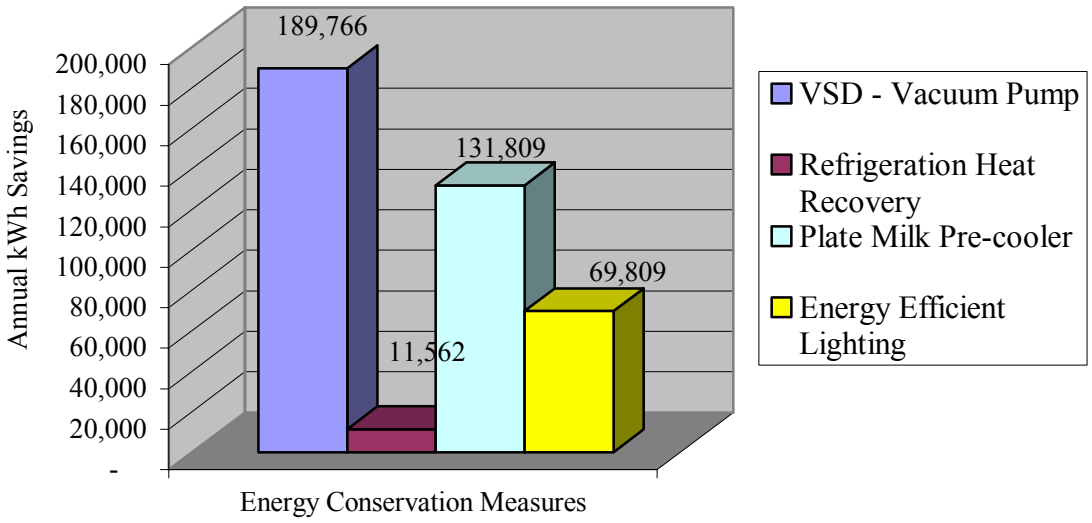


Figure 7: Energy Savings for Recommended ECMs – All Farms

The major portion of total savings identified in Figure 8, were the application of VSDs on vacuum pumps (47%), installation of milk plate pre-coolers (33%), and various forms of energy-efficient lighting (17%). Eighty-three percent of the identified savings were allocated to milking equipment, (VSDs on vacuum pumps, refrigeration heat recovery and plate milk coolers). The remainder of identified savings was found in energy-efficient lighting.

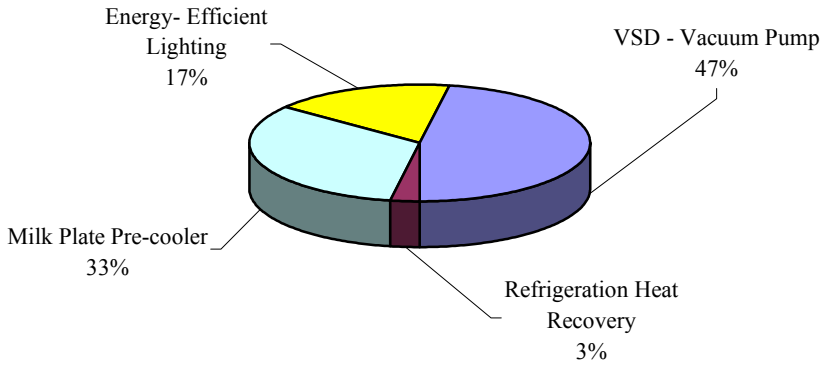


Figure 8: Classifications of ECM Savings – All Farms

The installation of VSD's on all farms would reduce the energy used by the vacuum pump by 33%. While the addition of milk plate pre-coolers would reduce milk-cooling energy use by 15%, and application of various forms of energy-efficient lighting could reduce consumption by 9%.

The total energy and dollar savings of individual ECMs for tiestall, freestall, and total of all farms are shown in Table 3. Forty-four percent of the annual kWh savings identified are found on tiestall farms, although only 25% of total electric energy was used on these farms. The average simple payback presented in Table 3 is obtained by averaging all the paybacks reported for a proposed ECM from each audit. This number represents the average of all paybacks identified for that particular ECM.

The average installed cost listed in Table 3 was developed from the savings identified and the payback calculated for the proposed ECM in each audit. The installed cost of each proposed ECM was calculated and then averaged for tiestall, freestall, and total of all farms.

The installation of milk plate pre-coolers produced the fastest simple payback on freestall farms. The addition of energy-efficient lighting provided the best payback on tiestall farms. The recommendation to install VSDs on vacuum pumps provided the largest amount of energy that could be saved on both types of farms.

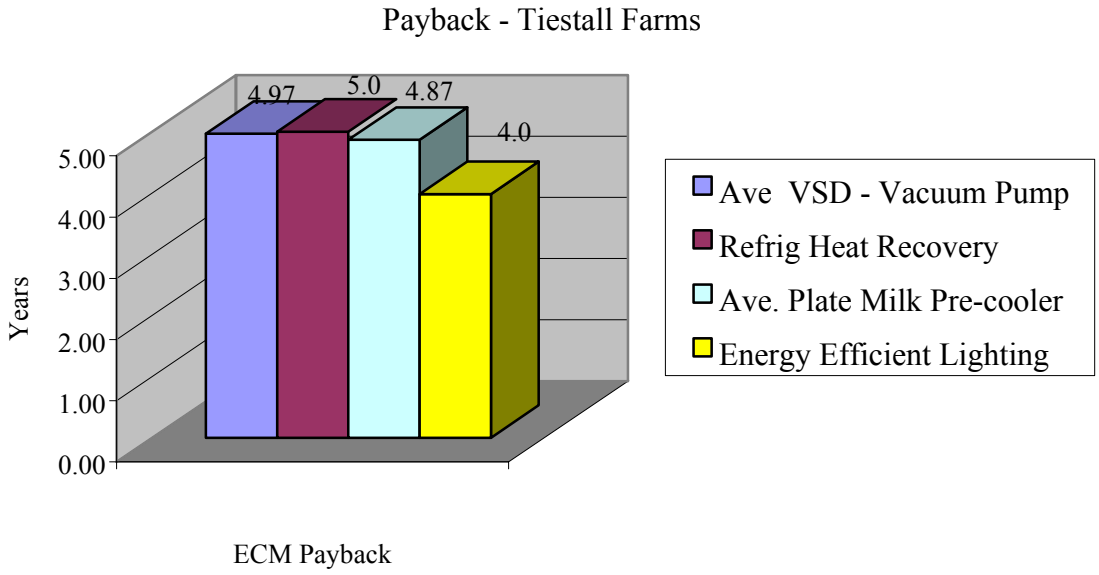
Table 3: Summary of Energy Savings for Recommended ECMs.

14 Tiestall Farms Proposed ECM – (No. Farms)	Annual kWh	Total Savings $$$	Ave. Installed Cost	Ave. Payback Years (Range)
Install VSD on Vacuum Pump – (12)	92,589	$9,178	$3182	4.97 (2.1-10.0)
Add Refrigeration Heat Recovery – (2)	11,562	$1,158	$2861	5.00 (4.5-5.5)
Install Plate Milk Pre-cooler – (6)	36,740	$3,392	$2336	4.87 (2.2-11.2)
Install Energy Efficient Lighting – (10)	37,649	$3,828	$1448	3.98 (2.0-10.0)
Total Savings – Tiestall Farms	**178,540**	**$17,556**		

18 Freestall Farms Proposed ECM – (No. Farms)	Annual kWh	Total Savings $$$	Ave. Installed Costs	Ave. Payback Years (Range)
Install VSD on Vacuum Pump – (7)	97,177	$10,976	$3,621	4.54 (0.6-10.0)
Install Plate Milk Pre-cooler – (8)	95,096	$9,871	$3149	3.71 (1.3-6.9)
Install Energy Efficient Lighting – (10)	32,160	$3,059	$1499	4.90 (2.0-10.0)
Total Savings – Freestall Farms	**224,406**	**$23,905**		

Total All Farms Proposed ECM – (No. Farms)	Annual kWh	Total Savings $$$	Ave. Installed Costs	Ave. Payback Years (Range)
Install VSD on Vacuum Pump –(19)	189,766	$20,154	$3401	4.73 (0.6-11.0)
Add Refrigeration Heat Recovery – (2)	11,562	$1,158	$2861	5.00 (4.5-5.5)
Install Plate Milk Pre-cooler – (14)	131,809	$13,262	$2472	4.22 (1.3-11.2)
Install Energy Efficient Lighting – (20)	69,809	$6,887	$1473	4.50 (2.0-10.0)
Total Savings – All Farms	**402,946**	**$41,461**		

All paybacks were in a comparatively narrow range from 3.98 to 5.0 years. The availability of any energy-efficient incentive programs would help reduce the actual paybacks.



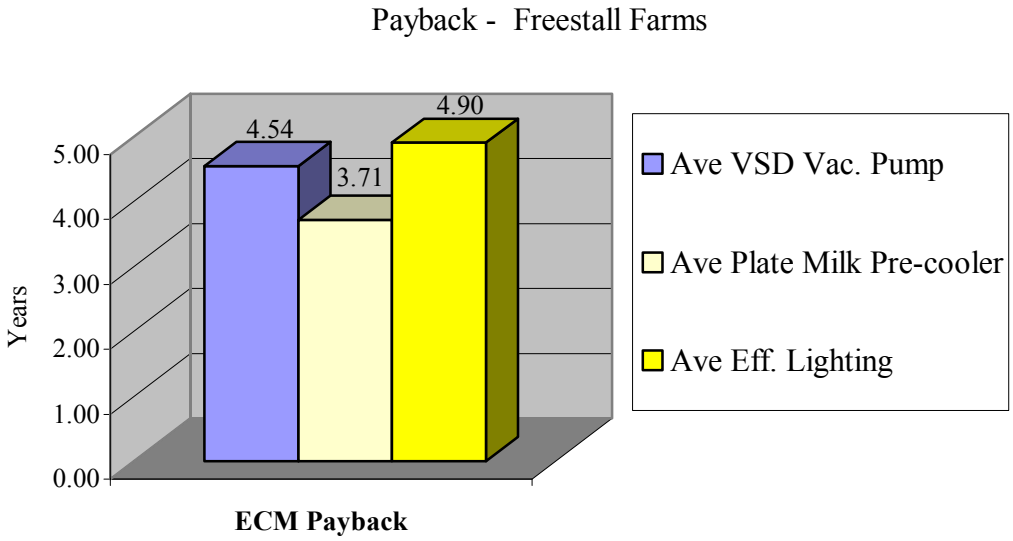


Figure 9: Simple Payback for Proposed ECMs – Tiestall and Freestall Farms

The above graphs in figure 9 compare the simple paybacks of proposed ECMs in both types of farms. The shortest payback (3.71 yr) was obtained on freestall farms for the application of milk plate pre-coolers. The large volume of milk that must be cooled and the Btu's the plate cooler is able to extract before the refrigeration, directly influences this payback.

The next best payback (4.0 yr) is for energy-efficient lighting in tiestall farms. Shorter paybacks for lighting on tiestall farms were largely due to more replacement of incandescent

light sources with fluorescent. Lighting improvements on freestall farms consisted of upgrading fluorescents with more efficient tubes and ballasts, and replacement of mercury vapor with high-pressure sodium (HPS) or metal halide (MH) lights. These incremental increases in efficiency caused longer paybacks.

The longer than expected paybacks on proposed VSD's on vacuum pumps in freestall barns was due to the largest farms already having installed them. This concentrated the proposals on the smaller farms, where shorter milking times limit the savings. Relatively short operating times for vacuum pumps on smaller (40-65) cow farms tend to distort the average payback of VSDs. Deleting these smaller farms reduces the average payback, by about 16 months, to 3.59 yr. Demonstrating the effectiveness of this ECM. Another way of representing this is shown in Figure 10.

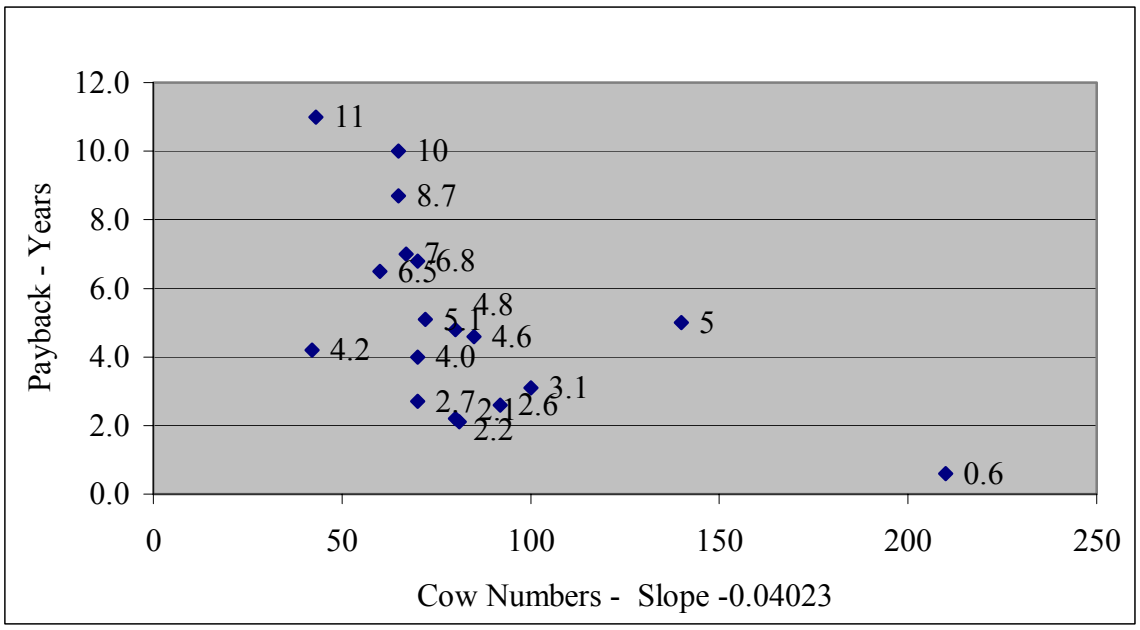


Figure 10: VSD Payback vs. Cow Numbers

Plotting average payback versus cow numbers illustrates the enhanced economics of VSDs on larger farms. This is due to the longer vacuum pump run times on larger farms, where the VSD can yield significant energy savings.

A similar relationship was evident between average payback and cow numbers for the installation of milk plate pre-coolers as shown in Figure 11. The larger farms with greater volumes of milk production were able to achieve greater energy savings and faster paybacks.

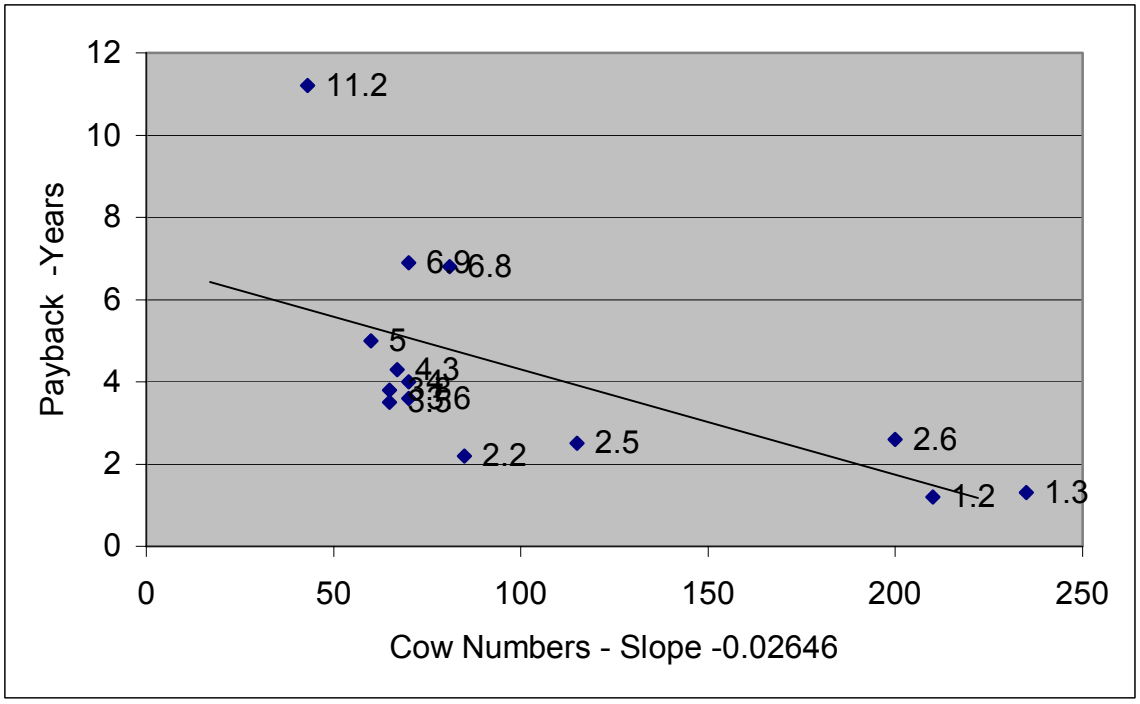


Figure 11: Plate Cooler Payback vs. Cow Numbers

No recommended ECM's were encountered on any of the farms audited for improving the efficiency or effectiveness of the existing ventilation equipment. Ventilation was the third largest category of energy use, but energy efficient alternatives have not been identified to offer as ECM's.

APPENDIX A - FARM ENERGY AUDIT SUMMARY REPORT DATA - TIESTALL BARN FARMS

	Basic Farm Data				EUIs			Existing ECMs		
Farm No.	Annual kWh Use	Electic Rate*	No. Cows Milked	Annual cwt Milk	Farm kWh/ cow-yr	Vac Pmp kWh/ cow-yr	Refrig. kWh/ cwt	VSD Vac Pmp	VSD Milk Pmp	Heat Rec Refrig
1	61,950	RTOU	70	17,000	791	70.1	0.85	No	No	Yes
2	65,719	RTOU	67	17,819	891	52	0.77	No	No	No
3	134,754	RTOU	115	29,930	*1335	33	1.1	Yes	No	No
4	63,451	RTOU	80	10,950	673	65	0.6	No	No	Yes
5	101,698	RTOU	140	28,470	*730	57.5	0.435	No	No	Yes
6	92,598	RTOU	85	13,000	928	63	0.9	No	No	Yes
7	41,598	RTOU	60	12,600	820	86.6	0.9	No	No	No
8	65,083	RTOU	42	7,503	1242	89.7	1.8	No	No	No
9	96,326	RTOU	81	19,345	1056	116	1.3	No	No	No
10	51,030	R	72	13,688	542	71	0.8	No	No	Yes
11	64,560	RTOU	100	20,075	584	64	0.76	No	No	Yes
12	85,132	RTOU	80	17,520	822	104	0.8	No	No	No
13	56,090	RTOU	42	8,395	1107	81	0.7	No	No	No
14	29,805	RTOU	43	5,375	*1561	54	1.1	No	No	No

Rtou - Residential time of use
R - no time of use

* includes electric water heating equivalent

APPENDIX A cont.

	Existing ECMS		Proposed ECM Savings VSD - Vacuum Pump			Heat Recovery Refrigeration			Plate Milk Pre-cooler			Energy Efficient Lighting		
Farm No.	Precooler Milk	Efficient Lighting	Annual kWh	Annual Cost	Pay Back Yrs	Annual kWh	Annual Cost	Pay Back Yrs	Annual kWh	Annual Cost	Pay Back Yrs	Annual kWh	Annual Cost	Pay Back Yrs
1	No	HPS	6,300	$610	4.0				5,000	$490	4.0			
2	No	No	3,625	$357	7.0	6,562	$647	4.5	5,826	$575	4.3			
3	No	Fluor							11,972	$1,265	2.5	8,269	$874	2.2
4	No	HPS	6,405	$816	4.8							5,059	$645	2.7
5	Yes	HPS	10,360	$800	5.0							2,480	$198	2.0
6	No	Fluor	6,481	$649	4.6				6,752	$676	2.2	6,202	$621	2.2
7	No	Yes	7,000	$540	6.5				5,040	$386	5.0			
8	Yes	Yes				5,000	$511	5.5				4,860	$486	10.0
9	Yes	No	14,729	$1,193	2.1							906	$73	4.9
10	No	Fluor	6,559	$662	5.1									
11	No	Yes	7,770	$911	3.1							5,645	$662	2.9
12	No	Yes	13,705	$1,531	2.2							1,229	$148	4.3
13	No	Yes	7,183	$800	4.2							1,086	$121	6.6
14	No	Yes	2,472	$309	11.0				2,150	$268	11.2	1,913	$239	2.0

APPENDIX A cont.

Annual Energy Use by Equipment Category

Farm No.	Vacuum Pump	Milk Cooling	Lighting	Ventilation	Feeding Equipment	Manure Handling	Water Heating			Misc.
							Electrical kWh	Propane Gallons	Fuel Oil Gallons	
1	9810	14180	5935	12348	3980	706	6552			
2	6975	13700	4994	17972	1847	1430	13887			
3	7512	29998	23374	26768	1297	4024			1145	9051
4	10405	6461	13344	9540	7977	938	6997			
5	16097	13534	28676	19286	3064	4292			383	
6	10731	11317	15158	18291	4825	2176	11820			
7	10397	12322	6233	6552	2653	358			270	
8	7532	14200	3851	5909	2917	179	18780			
9	18779	25614	12789	18234	7461	544			1365	
10	10159	10962	2917	8225	1968	2423	5033			
11	12770	15332	9234	8841	8943	1926	3285			
12	16704	14587	6491	19533	2482	1431			456	
13	10033	8736	4949	5097	10425	1471	20367			
14	4622	5810	2769	1104	1271	357		486		

APPENDIX B FARM ENERGY AUDIT SUMMARY REPORT DATA - FREESTALL BARN FARMS

Farm No.	Basic Farm Data				EUIs			Existing ECMs				
	Total kWh Use	Electric Rate	No. Cows milked	Annual cwt milk	Farm kWh/ cow-yr	Vac Pmp kWh/ cow-yr	Refrig. kWh/ cwt	VSD Vac Pmp	VSD Milk Pmp	Heat Rec Refrig	Precooler Milk	Efficient Lighting
1	184,020	RTOU	270	75,000	*1,018	39.8	0.7	Yes	Yes	Yes	Yes	Yes
2	46,327	DTOU	81	20,601	*821	35	0.637	Yes	No	No	Yes	No
3	48,880		70	7,848	515	70	1.4	No	No	No	No	Yes
4	212,497	R	235	54,750	904	28.2	1	Yes	No	Yes	No	Yes
5	63,351	RTOU	100	23,360	*601	30	1.04	Yes	No	Yes	Yes	Yes-HPS
6	170,934	RTOU	210	62,050	719	94	0.8	No	No	No	No	No
7	73,072	DTOU	92	17,520	*1,736	97	0.7	No	No	Yes	No	Yes
8	98,553	RTOU	200	42,500	*510	37	1	Yes	No	Yes	No	Yes
9	36,895	RTOU	65	14,965	677	69	0.511	No	No	No	Yes	No
10	77,904	RTOU	65	17,155	*1,103	149	0.963	No	No	Yes	No	Yes
11	390,580	RTOU	750	180,310	616	12	0.583	Yes	Yes	Yes	Yes	Yes
12	87,127	RTOU	250	60,000	424	46	0.603	Yes	No	Yes	Yes	No
13	72,017	RTOU	65	15,695	846	50	1.2	No	No	Yes	No	No
14	52,335	RTOU	70	12,775	*939	94	1	No	No	Yes	No	No
15	775,909	RTOU	860	240,900	*1,234	23	0.5	Yes	Yes	Yes	Yes	Yes
16	176,240	RTOU	384	80,300	540	18.5	0.4	Yes	Yes	Yes	Yes	Yes
17	317,700	DTOU	500	136,875	700	62	0.4	No	Yes	Yes	Yes	Yes
18	89,607	RTOU	127	31,390	*694	25	0.5	Yes	No	Yes	Yes	Yes

RTOU - Residential time of use
R - No time of use
DTOU - Demand time of use

* includes electric water heating equivalent

APPENDIX B cont.

Proposed ECM Savings

Farm No.	VSD - Vacuum Pump			VSD - Milk Pump			Heat Recovery Refrigeration			Plate Milk Pre-cooler			Energy Efficient Lighting		
	Annual		Pay Backs	Annual		Pay Back	Annual		Pay Back	Annual		Pay Back	Annual		Pay Back
	kWh	Cost	Yrs	kWh	Cost	Yrs	kWh	Cost	Yrs	kWh	Cost	Yrs	kWh	Cost	Yrs
1															
2							Oil	$442	5.6	6,000	$470	6.8			
3	6,292	$719	4.2							6,758	$773	3.6	2,925	$334	3.0
4										25,940	$2,505	1.3			
5													530	$47	2.0
6	43,271	$4,763	0.6							23,940	$2,635	1.2	3,336	$367	4.4
7	13,321	$1,768	2.6												
8										12,750	$1,243	2.6			
9	2,860	$304	10.0				oil	$300	7.0						
10										8,000	$1,024	3.5	880	$108	10.0
11													4,060	$382	6.7
12													4,780	$495	4.6
13	3,314	$332	8.7							7,848	$786	3.8	2,032	$204	3.9
14	9,619	$1,090	2.7							3,833	$434	6.9			
15															
16													9,600	$722	4.5
17	18,500	$2,000	3.0										4,017	$400	5.0
18													588	$65	4.9

APPENDIX B cont.

Annual Energy Use by Equipment Category

Farm No.	Vacuum Pump	Milk Cooling	Lighting	Ventilation	Feeding Equipment	Manure Handling	Water Heating			Misc.
							Electric kWh	Propane Gallons	Fuel Oil Gallons	
1	32,265	37,573	51,870	10,627	0	6,868			2,112	
2	5,694	14,600	4,906	5,447	2,683	708			691	
3	9,792	10,864	6,887	5,137	22	38		787		
4	17,667	56,017	38,796	37,820	0	21,462	29,565			
5	6,006	26,754	10,718	13,777	2,575	0			185	
6	59,021	52,041	15,904	15,868	3,676	0			968	
7	17,921	12,990	4,275	12,314	179	12,423		2,382		13,310
8	14,845	41,526	12,048	8,843	596	0		760		3,378
9	8,943	8,110	10,094	12,455	118	0	Nat Gas			
10	19,316	16,876	9,156	15,918	2,957	0		264		
11	28,105	105,076	58,094	135,817	0	0			1,715	12,416
12	11,498	36,642	12,078	982	0	19,316		562		
13	6,564	19,418	5,789	0	9,909	298	7,554			
14	13,119	12,599	5,841	0	3,346	0		780		
15	59,021	109,030	281,520	153,388	0	21,516	15,969			
16	21,294	32,111	41,792	26,630	0	9,274		1,056		
17	91,159	57,660	36,568	85,906	0	16,590		1,761		
18	6,349	4,143	47,557	10,382	8,972	894			169	

State of New York
George E. Pataki, Governor

New York State Energy Research and Development Authority
Vincent A. DeIorio, Esq., Chairman