National Dairy Council of Canada
Conseil National de l'Industrie Laitière du Canada

Guide to Energy Efficiency Opportunities in the Dairy Processing Industry

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WARDROP ENGINEERING INC.

6725 Airport Road, Mississauga, Ontario L4V 1V2
Phone (905) 673-3788 Fax (905) 673-8007

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DISCLAIMER

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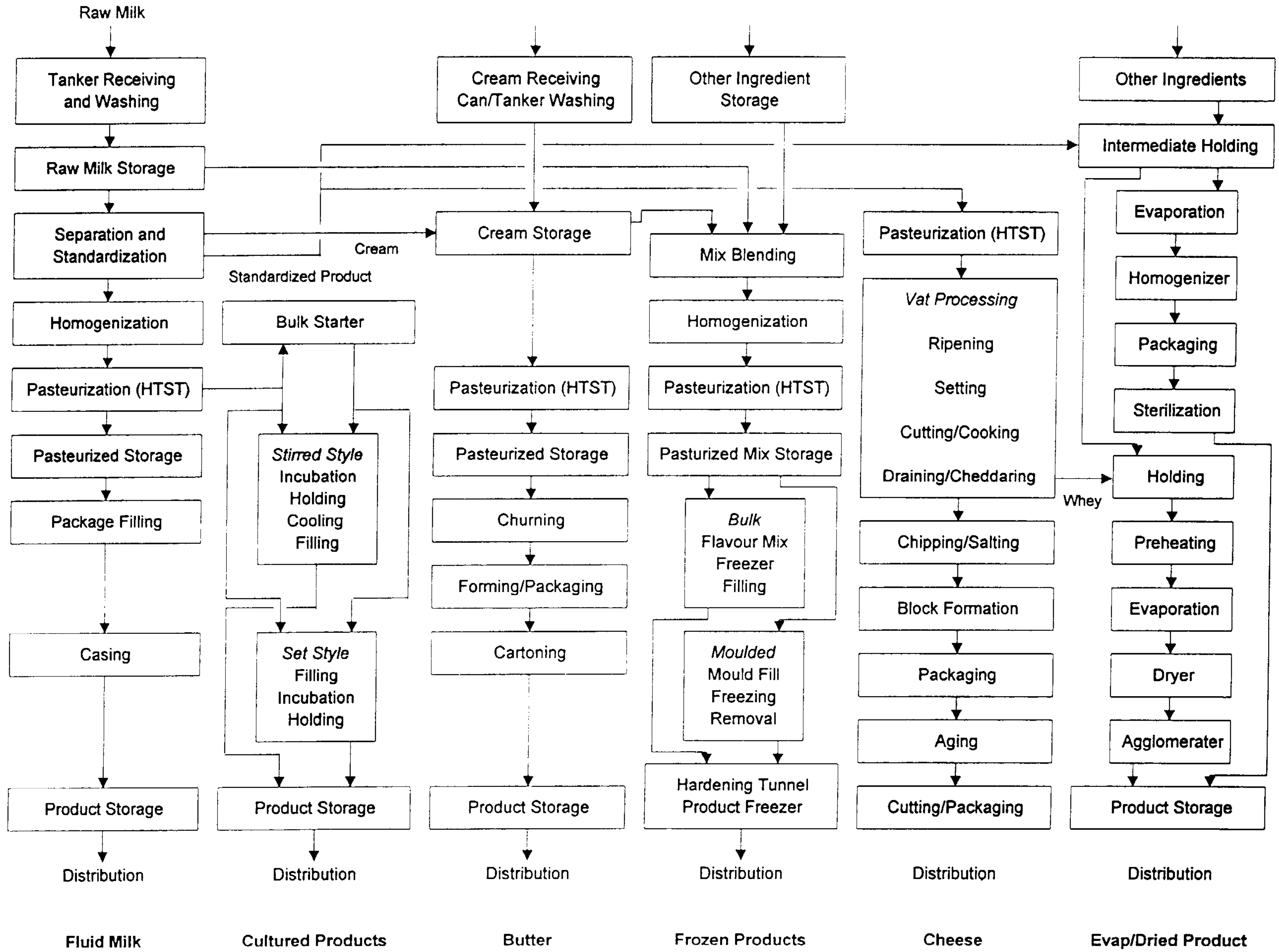
EXHIBIT 2.1: Simplified Generic Dairy Processing Sequences



1.0 INTRODUCTION

The National Dairy Council of Canada (NDCC) engaged Wardrop Engineering Inc. to prepare a concise guide on energy conservation and cost savings opportunities in the dairy processing industry. The purpose of this guide is to assist in the identification of energy efficiency improvements within dairy processing plants, and also to assist in the development and achievement of voluntary sector energy efficiency targets, under the auspices of the Canadian Industry Program for Energy Conservation (CIPEC). The primary audience for this guide is staff and managers directly involved in dairy plant operations.

This guide is based in part on an earlier work by Wardrop Engineering, entitled "Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Sector", which was prepared for the Ontario Ministry of Environment and Energy, and the Ontario Dairy Council in 1995.

2.0 SECTOR ACTIVITIES AND GENERIC PROCESSES

Dairy processing plants are traditionally divided into two separate categories for the purpose of production and energy statistical data presentation: fluid milk; and industrial milk. These two categories are described as follows:

- *Fluid milk processing* involves the pasteurization and processing of liquid milk for direct consumption, as well as creams, chocolate and other flavoured milks, and buttermilk (Canadian SIC 1041).

- *Industrial milk processing* involves the processing of milk into value-added products. These include cheese, butter, ice cream and other frozen products, condensed and evaporated milk, dried milk powder, yogurt and other cultured milk products (Canadian SIC 1049). The milk used in the manufacture of industrial milk products is also pasteurized before processing.

For the purpose of this guide, six major generic process sequences (one fluid and five industrial) have been considered. These processes, summarized in Exhibit 2.1, are:

- Fluid milk;
- Cheese;
- Ice cream and other frozen products;
- Cultured products;
- Butter; and
- Evaporated/dried products.

These generic process/product combinations were selected because they:

- Cover the wide range of product manufacturing activities undertaken;

- Represent the natural groupings of similar generic processes; and

- Coincide with the general process categories separately modelled in support of Hazard Analysis Critical Control Points (HACCP).

EXHIBIT 3.1: Typical Utility and Service Requirements

UTILITY	DEMAND REQUIREMENTS	SPECIFIC PROCESS
Cold Water: 10°C City 1-7°C Chilled	Rinsing, Washing. Recirculation Cooling, Product Cooling	All All
Hot Water: 90°C 70°C 50+°C	Pasteurizer Heating Mould Release Washup/CIP	All Ice Cream All
Steam: Approx 790 kPa abs Lower 790 kPa abs	Pasteurizer Heating (usually via Hot Water) Dryer Air Heating Evaporation Water Heating	All Dried Product Evap/Dried Prod All
Thermal: Furnace Boiler Heater	Space Heating Hot Water/Space Heating Dryer Air Heating	All All Dried Product
Refrigeration: -40°C -30°C -9°C -6°C 1°C 4°C	Mould Brine Freezer/Storage Ice Cream Maker Glycol for HTST Chilling Product Holding Cooler Milk/Product Cooling	Ice Cream Ice Cream Ice Cream All All All
Compressed Air	Valve Actuation, Air Blows, Conveying	All
Electrical (Direct Uses)	Conveyor, Centrifuge, Homogenizer, Packaging Unit Drives, Lights, Refrigeration	All

Note: All = Fluid Milk, Cheese, Ice Cream, Cultured Products, Butter and Evap/Dried Product

3.0 UTILITIES AND ENERGY-USE

Typical utility and service demands for dairy processing plants are summarized in Exhibit 3.1. The importance of the different utilities can vary between processes, as indicated. Utility requirements can also vary to some extent between different plants producing the same product.

Three utility parameters are relevant to energy-use in the operation of dairy plants, summarized as follows:

- *Electrical energy*, used for operation of refrigeration systems and various other drives and motors, as well as lighting. Within this guide all electrical energy values are indicated in units of kilowatt hours (kWh).

- *Thermal energy*, supplied as fuel primarily in the form of natural gas, fuel oil or propane, used for product, water and space heating. Within this guide all thermal energy values are indicated in units of mega joules (MJ).

- *Water*, approximately 60% of which is used for energy-related functions (e.g. for cooling water or for steam generation). Within this guide all water-use values are indicated in units of cubic metres (m^3 = 1,000 Litres), or Litres.

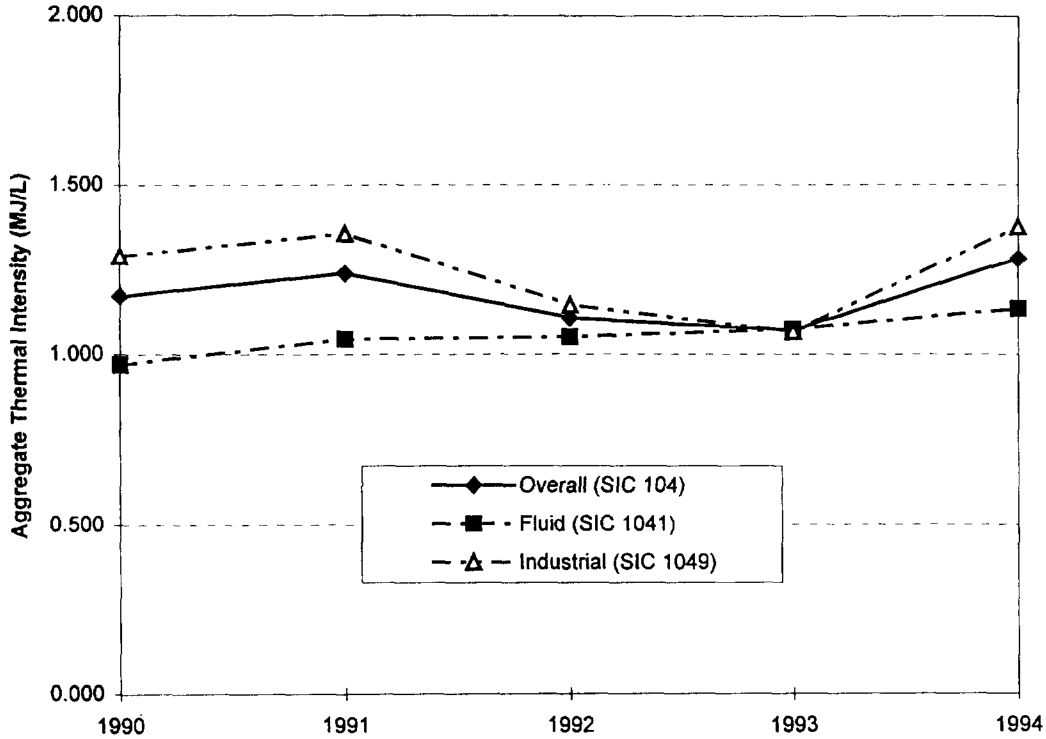
Liquid fuels, such a gasoline and diesel, are also used by dairy companies, however given that these are related to delivery and distribution fleets rather than plant operations, they are not considered further here.

Aggregate historical data on energy-use in Canadian dairy processing plants for the time period of 1990 to 1994 is provided in Exhibit 3.2. Data in Exhibit 3.2 is presented for the overall industry, as well as being subdivided for fluid and industrial operations. Highlights are summarized as follows:

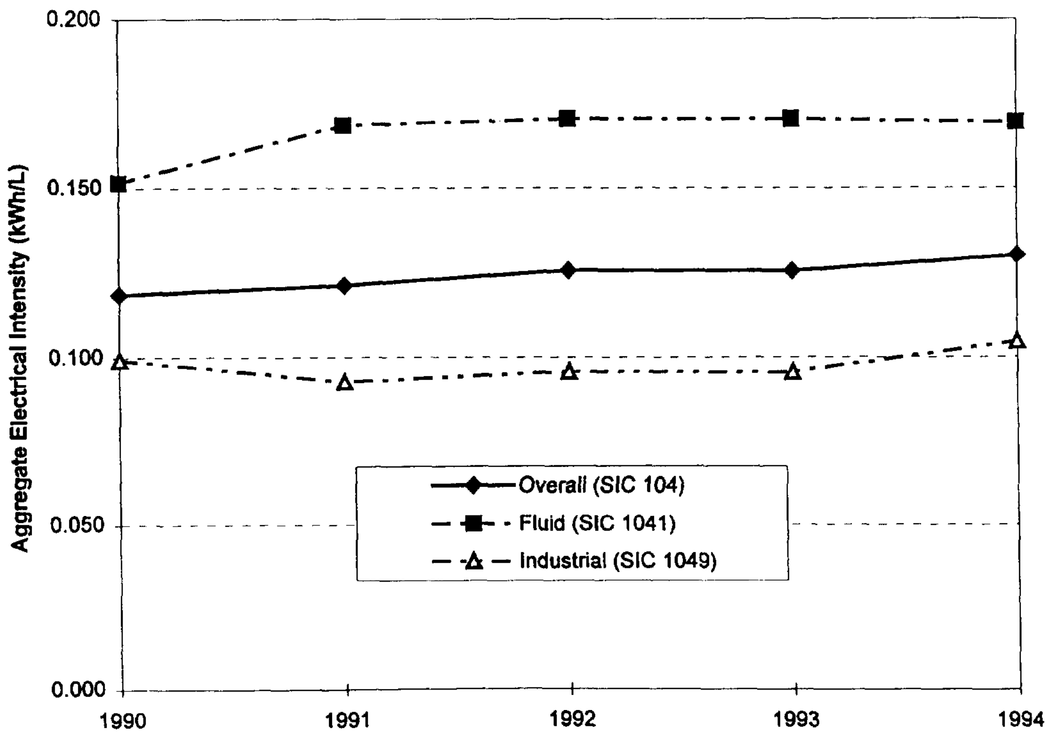
INDUSTRY SEGMENT	ELECTRICAL-USE INTENSITY	THERMAL-USE INTENSITY
Fluid (SIC 1041)	Relatively Constant Average ≈ 0.17 kWh/L	Relatively Constant Average ≈ 1.06 MJ/L
Industrial (SIC 1049)	Relatively Constant Average ≈ 0.10 kWh/L	Variable: 1.07 to 1.38 MJ/L Depends on product mix and milk volumes involved.

EXHIBIT 3.2: Historical Energy-Use Intensity for Dairy Processing

Aggregate Thermal Energy Intensity (MJ/Litre Raw Milk and Cream Received)



Aggregate Electrical Energy Intensity (kWh/Litre Raw Milk and Cream Received)



Aggregate historical energy cost data for Canadian dairy processing plants for the time period of 1990 to 1994 is provided in Exhibit 3.3, with highlights summarized as follows (note that transportation fuels are excluded):

- Average total energy cost per establishment has been increasing steadily by approximately $20,000 per year, an average increase of about 7% per year.

- Total energy cost intensity for Fluid milk (SIC 1041) has remained constant at approximately $0.010 per dollar of manufacturing shipments.

- Total energy cost intensity for Industrial milk (SIC 1049) has been increasing fairly steadily from approximately $0.010 per dollar of manufacturing shipments in 1990 to approximately $0.013 per dollar of manufacturing shipments in 1994.

- Total energy cost intensity for dairy processing is comparable to other food processing activities, but relatively low when compared to other manufacturing SICs. In 1990 the total energy cost intensity for overall food processing (SIC 10) was approximately $0.011 per dollar of manufacturing shipments, while the aggregate total energy cost intensity for all manufacturing was approximately $0.026 per dollar of manufacturing shipments.[1]

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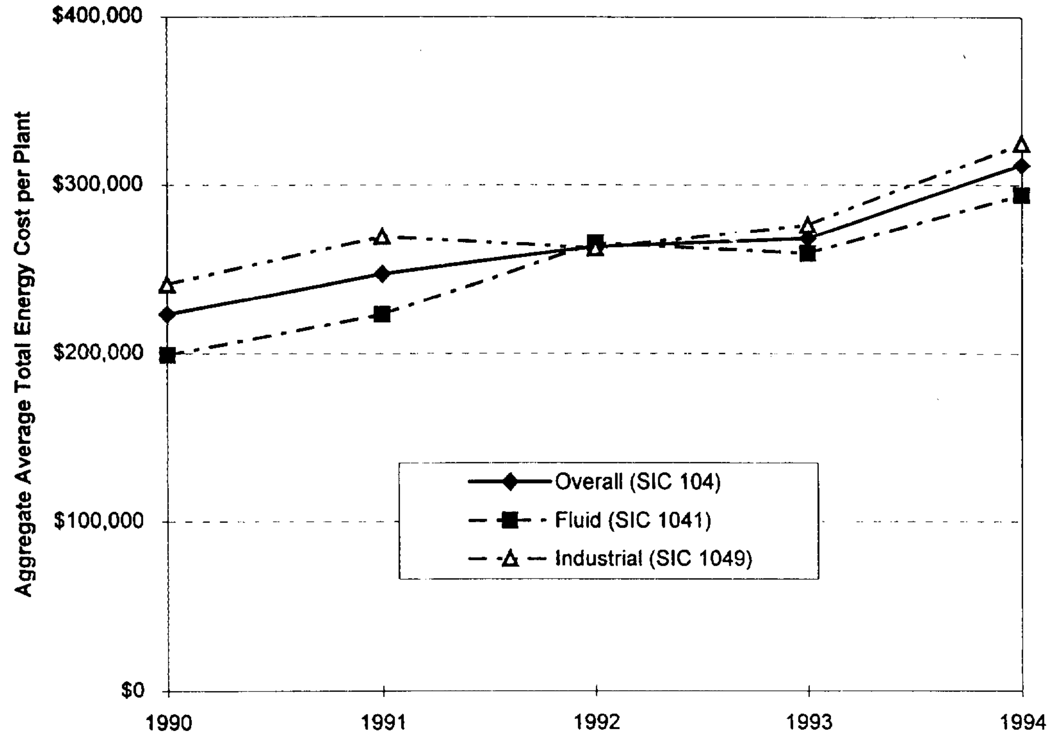
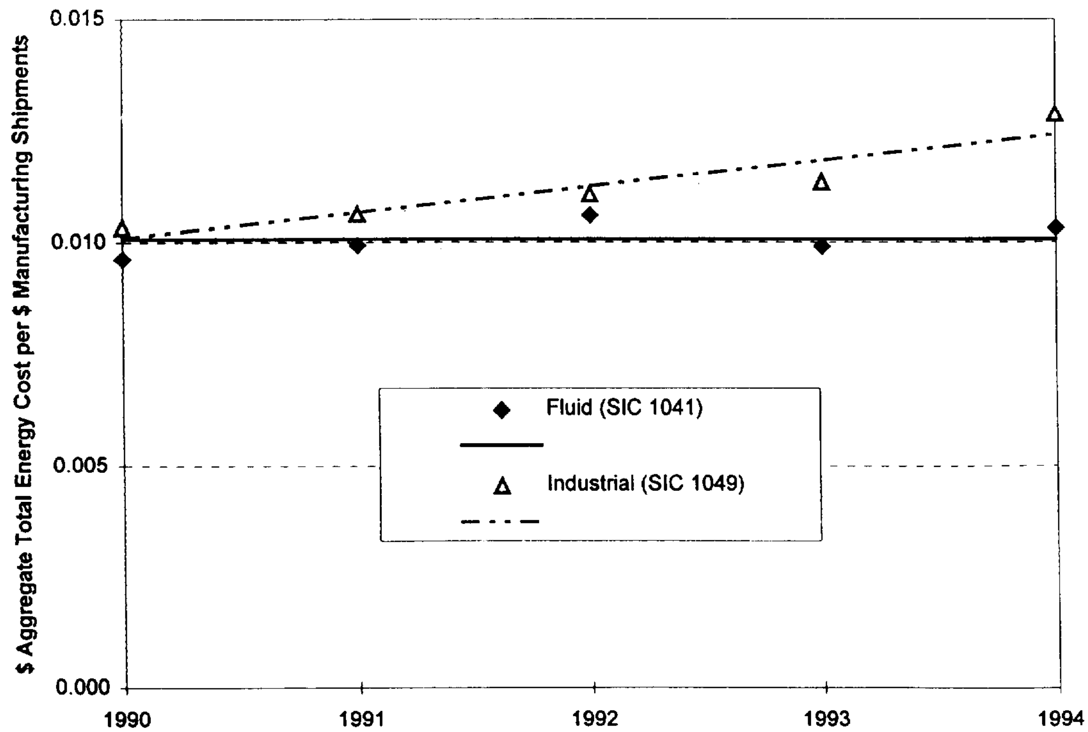
[1] Derived from Statistics Canada. 1994. Human Activity and the Environment.

EXHIBIT 3.3: Historical Energy-Cost Intensity for Dairy Processing

Aggregate Average Total Energy Cost per Establishment



Unit Aggregate Total Energy Cost Intensity ($ Energy Cost per $ Manufacturing Shipments)



4.0 IMPROVEMENT OPPORTUNITIES

For each of the six basic processes described earlier, a concise generic checklist of process improvement opportunities is provided in tabular form as follows:

- Fluid Milk Processing - Exhibit 4.1;
- Cheese Processing - Exhibit 4.2;
- Ice Cream and Other Frozen Products - Exhibit 4.3;
- Cultured Products - Exhibit 4.4;
- Butter - Exhibit 4.5.; and
- Evaporated and Dried Product Processing - Exhibit 4.6.

These checklists will assist in the identification of process-related improvement opportunities. Each table covers the sequence of operations for each process, and provides:

- Identification of thermal, electrical, and energy-related water-use implications;
- Low-cost/no-cost measures that can be implemented;
- Applicable retrofit technology options, cross-referenced to Exhibit 4.7; and
- Comments.

4.1 Low-Cost/No-Cost Opportunities

Low-cost/no-cost measures, involving minor capital equipment items, such as nozzles and hose valves, are identified as such in the process tables. The probable cost of implementing opportunities in this category is typically no more than approximately $5,000. The low-cost/no-cost measures also typically have paybacks in the range of no more than 1 to 1.5 years.

4.2 Retrofit Opportunities

In Exhibit 4.7, retrofit options applicable to direct process improvements are summarized and categorized into nine technology groups. For each, a range of probable capital costs, probable savings and resulting paybacks are presented. Each of these technology groups is generic. Information presented should be only used as a guide for assessing applicability and viability at specific plants.

EXHIBIT 4.1: Check List of Process-Related Improvement Opportunities for Fluid Milk Processing

PROCESS AREA	ENERGY IMPLICATIONS: Thermal	ENERGY IMPLICATIONS: Electrical	ENERGY IMPLICATIONS: Water	OPERATING, LOW COST/NO COST	RETROFIT	REF No.*	COMMENTS
Raw Milk Receiving and Tanker Wash (Raw Area)	Heated solution for CIP flow Possible space heating during winter if bay enclosed.	Receiving pump and CIP recirculation pumps Possible additional chilling of incoming raw milk prior to storage	Fairly steady CIP operation.	Nozzle maintenance for CIP to ensure minimize hot CIP use.			
					Infrared heating for receiving bay.	9	
					Exterior Tanker Wash with recycled water from elsewhere in plant.	3	
					CIP System Improvements	See Below	
Raw Milk Holding Silos (Raw Area)	Heated solution for CIP flow	Refrigeration to maintain at < 5 C.	Intermittent CIP.	Enhance silo insulation. Ensure sufficient mixing to minimize any temperature gradients.			
Processing and Pasteurization System (Raw Area):	Heated solution for CIP flow.		Intermittent CIP. Large flows per event.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
					CIP System Improvements	See Below	
Milk Separation and Standardization		Large motor on separator.	Operating and cooling water for separator.				
Homogenization		Large motor on homogenizer.	Piston flushing and cooling. See above for CIP.	Nozzles or flow restrictions to reduce flushing/cooling water flow to minimum necessary - refer to manufacturers.			
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for required 16 s hold time. Incorporate regeneration. Most existing units with 85% to 90%. Max 94% realistic.	Final chilling of product to <5 C using glycol.	Cooling water or recirc chilled water for partial cooling.	Maintenance to ensure leakage from plate-pack prevented.			
					Heated cooling water recovery.	3	Depends on flow and temperatures involved for specific systems, for example UHT systems.
					Improve efficiency by addition of plates.	4	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
Pasteurized Milk Storage (Pasteurized Area)	Heated solution for CIP flow.	Refrigeration to maintain product at 5 C.	Intermittent CIP. Large flows per event.		CIP System Improvements	See Below	
Filling, Product Conveying and Casing (Pasteurized Area)	Heated solution for CIP flow.	Filling system drives.	Intermittent CIP. Large flows per event.	Ensure use of nozzles on all flushing flows. Review type and positioning of spray nozzles.			
		Conveyor system drives	Conveyor sprays		CIP System Improvements	See Below	

Case Washing	Heated solution for wash flow.	Conveyor system drives	Water to case wash sprays		Recycled water from elsewhere in plant for initial case wash flush.	3	
Product Storage		Refrigeration to maintain cooler at 1 C			Free Cooling during Winter months.	5	
CIP Operations	Heated solution for CIP flow.	Recirc pumps.	Initial and final water rinses. Makeup to CIP solutions.	Volume, rather than time, based control on burst rinses and CIP flows to reduce water quantities.			
					Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Utilization of waste heat from identified utilities and services for heating/preheating of CIP washes and rinses as required.	3	Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
					Utilization of thermal storage for hot water requirements		Refer to Exhibit 4.8 for thermal storage opportunities.
					Recycle system on chemical washing solution, especially HTST washing chemicals, to reduce heating requirements	6	Most areas of plants incorporate recycle of chemicals for CIP. HTST wash chemicals in particular may not always be recycled.
Washup throughout plant	Warm water (<46 C) often employed to solublize butterfat.		Water for washup	Nozzles on hoses. Not left running			
				Dry ingredient spills treated as solid wastes, rather than flushed. Hoses should not be used as brooms.			
				Heated water or heat exchange rather than steam injection for heating Reporting of leaks to ensure chronic leakage problems addressed.			
					Thermal storage of recovered hot water for washup purposes.		Refer to Exhibit 4.8 for thermal strorage opportunties.

* NOTE: Reference number refers to Retrofit Opportunities in Exhibit 4.7

EXHIBIT 4.2: Check List of Process-Related Improvement Opportunities for Cheese Processing

PROCESS AREA	ENERGY IMPLICATIONS			OPERATING, LOW COST/NO COST	RETROFIT	REF No.*	COMMENTS
	Thermal	Electrical	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heated solution for CIP flow Possible space heating during winter if bay enclosed.	Receiving pump and CIP recirculation pumps Possible additional chilling of incoming raw milk prior to storage	Fairly steady CIP operation.	Nozzle maintenance for CIP to ensure minimize hot CIP use.			
					Infrared heating for receiving bay.	9	
					Exterior Tanker Wash with recycled water from elsewhere in plant.	6	
					CIP System Improvements	See Below	
Raw Milk Holding Silos (Raw Area)	Heated solution for CIP flow	Refrigeration to maintain at < 5 C.	Intermittent CIP.	Enhance silo insulation. Ensure sufficient mixing to minimize any temperature gradients.			
Processing and Pasteurization System (Raw Area):	Heated solution for CIP flow.		Intermittent CIP. Large flows per event.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
					CIP System Improvements	See Below	
Milk Separation and Standardization		Large motor on separator.	Operating and cooling water for separator.			2	
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for required 16 s hold time. Incorporate regeneration. Most existing units with 85% to 90%. Max 94% realistic.	Final chilling of product to <5 C using glycol.	Cooling water or recirc chilled water for partial cooling.	Maintenance to ensure leakage from plate-pack prevented.			
					Heated cooling water recovery.		Depends on flow and temperatures involved for specific systems, for example UHT systems.
					Improve efficiency by addition of plates.	7	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
Cheese Vat Processing Area (Pasteurized Area)	Heated solution for CIP flow. Heating during cooking operations.	Vat drives (stirring and cutting)	Intermittent CIP.	Operator attention to vat levels if manually filled to ensure no overfilling.			Reduction of losses reduces water and heating requirements.
				Operator attention to vat temperature if manually controlled, to ensure no excess cooking beyond necessary, during cooking process.			
					Automated filling control to eliminate over-filling.	7	
					Automated temperature controls to ensure no excess cooking	7	

					Membrane system for preconcentration of milk products.	8	
					CIP System Improvements	See Below	
Block Formation		Pressing					
Hoop Washing	Heated solution for wash flow.		Water flush		Recycling flush water to other uses, such as floors etc.	3	Reuse water, especially if heated.
Aging/Product Storage		Refrigeration to maintain at 2-10 C			Free Cooling during Winter months.	5	
Whey Processing (for Whey Powder - most common)	Large thermal load in evaporation and drying	Pumps	Large cooling water load in evaporator condenser.	Ensure all whey collected to minimize water and hot water requirements for cleaning.			
					Use condenser to heat cooling water for other purposes, such as washup water.	3	
					Preconcentration using membranes	8	Reduction of transportation volume for smaller plants.
CIP Operations	Heated solution for CIP flow.	Recirc pumps.	Initial and final water rinses. Makeup to CIP solutions.	Volume, rather than time, based control on burst rinses and CIP flows to reduce water quantities.			
					Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Utilization of waste heat from identified utilities and services for heating/preheating of CIP washes and rinses as required.	3	Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
					Utilization of thermal storage for hot water requirements		Refer to Exhibit 4.8 for thermal storage opportunities.
					Recycle system on chemical washing solution, especially HTST washing chemicals, to reduce heating requirements	6	Most areas of plants incorporate recycle of chemicals for CIP. HTST wash chemicals in particular may not always be recycled.
Washup throughout plant	Warm water (<46 C) often employed to solublize butterfat.		Water for washup	Nozzles on hoses. Not left running			
				Dry ingredient spills treated as solid wastes, rather than flushed. Hoses should not be used as brooms.			
				Heated water or heat exchange rather than steam injection for heating			
				Reporting of leaks to ensure chronic leakage problems addressed.			
					Thermal storage of recovered hot water for washup purposes.		Refer to Exhibit 4.8 for thermal storage opportunties.

* NOTE: Reference number refers to Retrofit Opportunities in Exhibit 4.7

EXHIBIT 4.3: Check List of Process-Related Improvement Opportunities for Ice Cream and Frozen Products Processing

PROCESS AREA	ENERGY IMPLICATIONS			OPERATING, LOW COST/NO COST	RETROFIT	REF No.*	COMMENTS
	Thermal	Electrical	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heated solution for CIP flow Possible space heating during winter if bay enclosed.	Receiving pump and CIP recirculation pumps Possible additional chilling of incoming raw milk prior to storage	Fairly steady CIP operation.	Nozzle maintenance for CIP to ensure minimize hot CIP use.			
					Infrared heating for receiving bay.	9	
					Exterior Tanker Wash with recycled water from elsewhere in plant.	3	
					CIP System Improvements	See Below	
Raw Milk and Cream Holding (Raw Area)	Heated solution for CIP flow	Refrigeration to maintain at < 5 C.	Intermittent CIP.	Enhance silo insulation. Ensure sufficient mixing to minimize any temperature gradients.			
Ice Cream Milk Blending (Raw Area)		Blending drives.		Dry ingredient spills should be treated as solids, rather than flushed, to reduce water use, especially hot water. Hoses should not be used as brooms.			
Processing and Pasteurization System (Raw Area):	Heated solution for CIP flow.		Intermittent CIP. Large flows per event.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
					CIP System Improvements	See Below	
Homogenization		Large motor on homogenizer.	Piston flushing and cooling. See above for CIP.	Nozzles or flow restrictions to reduce flushing/cooling water flow to minimum necessary - refer to manufacturers.			
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for required 16 s hold time. Incorporate regeneration. Most existing units with 85% to 90%. Max 94% realistic.	Final chilling of product to <5 C using glycol.	Cooling water or recirc chilled water for partial cooling.	Maintenance to ensure leakage from plate-pack prevented.			
					Heated cooling water recovery.	3	Depends on flow and temperatures involved for specific systems, for example UHT systems.
					Improve efficiency by addition of plates.	4	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
Pasteurized Ice Cream Mix Storage (Pasteurized Area)	Heated solution for CIP flow.	Refrigeration to maintain product at 5 C.	Intermittent CIP with initial and final rinses. Large flows per event.		CIP System Improvements	See Below	
Bulk Ice Cream Production/Filling	Heated solution for CIP flow.	Freezing unit refridgeration and drives. Filling system pump drives.	Intermittent CIP with initial and final rinses. Large flows per event.	Minimize leakage and losses of product to reduce energy requirements for manufacture.			

				Collect residual ice cream mix for rework.			
				Minimizing product line distance from freezing unit to filling to reduce reheating.			
Ice Cream/Novelty Moulding	Heated water for mould release.	Refrigeration of mould brine at -40 C. Mould conveyor drive.	Water to mould sprays	Ensure proper water flow controls for mould cleaning to ensure water use not excessive.			
				Ensure maintenance of brine temperature and warmup to avoid excess sticking in moulds. Ensure warmup well controlled to avoid excessive melting.			
					Utilization of waste heate or thermal storage for hot water requirements for mould release.	3	
					Recycling flush water to other uses.	3	Reuse water, especially if heated.
Product Freezer		Refrigeration to maintain freezer rooms at -30 C			Refrigeration system segregation.		Refer to Exhibit 4.8 for refrigeration system opportunities.
CIP Operations	Heated solution for CIP flow.	Recirc pumps.	Initial and final water rinses. Makeup to CIP solutions.	Volume, rather than time, based control on burst rinses and CIP flows to reduce water quantities.			
					Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Utilization of waste heat from identified utilities and services for heating/preheating of CIP washes and rinses as required.		Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
					Utilization of thermal storage for hot water requirements		Refer to Exhibit 4.8 for thermal storage opportunities.
					Recycle system on chemical washing solution, especially HTST washing chemicals, to reduce heating requirements	6	Most areas of plants incorporate recycle of chemicals for CIP. HTST wash chemicals in particular may not always be recycled.
Washup throughout plant	Warm water (<46 C) often *employed to solublize* butterfat.		Water for washup	Nozzles on hoses. Not left running			
				Dry ingredient spills treated as solid wastes, rather than flushed. Hoses should not be used as brooms.			
				Heated water or heat exchange rather than steam injection for heating Reporting of leaks to ensure chronic leakage problems addressed.			
					Thermal storage of recovered hot water for washup purposes.		*Refer to Exhibit 4.8 for thermal strorage opportunties.*

* NOTE: Reference number refers to Retrofit Opportunities in Exhibit 4.7

EXHIBIT 4.4: Check List of Process-Related Improvement Opportunities for Cultured Products Processing

PROCESS AREA	ENERGY IMPLICATIONS			OPERATING, LOW COST/NO COST	RETROFIT	REF No.*	COMMENTS
	Thermal	Electrical	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heated solution for CIP flow Possible space heating during winter if bay enclosed.	Receiving pump and CIP recirculation pumps Possible additional chilling of incoming raw milk prior to storage	Fairly steady CIP operation.	Nozzle maintenance for CIP to ensure minimize hot CIP use.			
					Infrared heating for receiving bay.	9	
					Exterior Tanker Wash with recycled water from elsewhere in plant.	3	
					CIP System Improvements	See Below	
Raw Milk Holding Silos (Raw Area)	Heated solution for CIP flow	Refrigeration to maintain at < 5 C.	Intermittent CIP.	Enhance silo insulation. Ensure sufficient mixing to minimize any temperature gradients.			
Processing and Pasteurization System (Raw Area):	Heated solution for CIP flow.		Intermittent CIP. Large flows per event.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
					CIP System Improvements	See Below	
Milk Separation and Standardization		Large motor on separator.	Operating and cooling water for separator.				
Homogenization		Large motor on homogenizer.	Piston flushing and cooling. See above for CIP.	Nozzles or flow restrictions to reduce flushing/cooling water flow to minimum necessary - refer to manufacturers.			
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for required 16 s hold time. Incorporate regeneration. Most existing units with 85% to 90%. Max 94% realistic.	Final chilling of product to <5 C using glycol.	Cooling water or recirc chilled water for partial cooling.	Maintenance to ensure leakage from plate-pack prevented.			
					Heated cooling water recovery.	3	Depends on flow and temperatures involved for specific systems, for example UHT systems.
					Improve efficiency by addition of plates.	4	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
Pasteurized Product Storage (Pasteurized Area)	Heated solution for CIP flow.	Refrigeration to maintain product at 5 C.	Intermittent CIP. Large flows per event.		CIP System Improvements	See Below	
Bulk Starter Culture and Main Culture Incumbation/Holding	Heating for incubation. Heated solution for CIP flow.		Intermittent CIP.		Active bacterial control in starter culture area to reduce potential contamination and losses.		
					CIP System Improvements.	See Below	

Cooling		Refrigeration for cooling					
Filling/Cartoning/Casing	Heated solution for CIP flow.	Filling system drives.	Intermittent CIP. Large flows per event.	Ensure use of nozzles on all flushing flows. Review type and positioning of spray nozzles.			
		Conveyor system drives	Conveyor sprays		CIP System Improvements	See Below	
Product Storage		Refrigeration to maintain cooler at 1 C			Free Cooling during Winter months.	5	
CIP Operations	Heated solution for CIP flow.	Recirc pumps.	Initial and final water rinses. Makeup to CIP solutions.	Volume, rather than time, based control on burst rinses and CIP flows to reduce water quantities.			
					Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Utilization of waste heat from identified utilities and services for heating/preheating of CIP washes and rinses as required.		Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
					Utilization of thermal storage for hot water requirements		Refer to Exhibit 4.8 for thermal storage opportunities.
					Recycle system on chemical washing solution, especially HTST washing chemicals, to reduce heating requirements	6	Most areas of plants incorporate recycle of chemicals for CIP. HTST wash chemicals in particular may not always be recycled.
Washup throughout plant	Warm water (<46 C) often employed to solublize butterfat.		Water for washup	Nozzles on hoses. Not left running			
				Dry ingredient spills treated as solid wastes, rather than flushed. Hoses should not be used as brooms.			
				Heated water or heat exchange rather than steam injection for heating Reporting of leaks to ensure chronic leakage problems addressed.			
					Thermal storage of recovered hot water for washup purposes.		Refer to Exhibit 4.8 for thermal strorage opportunties.

* NOTE: Reference number refers to Retrofit Opportunities in Exhibit 4.7

EXHIBIT 4.5: Check List of Process-Related Improvement Opportunities for Butter Processing

PROCESS AREA	ENERGY IMPLICATIONS: Thermal	ENERGY IMPLICATIONS: Electrical	ENERGY IMPLICATIONS: Water	OPERATING, LOW COST/NO COST	RETROFIT	REF No.*	COMMENTS
Raw Milk and Cream Receiving and Tanker Wash (Raw Area)	Heated solution for CIP flow	Receiving pump and CIP recirculation pumps	Fairly steady CIP operation.	Nozzle maintenance for CIP to ensure minimize hot CIP use.			
	Possible space heating during winter if bay enclosed.	Possible additional chilling of incoming raw milk prior to storage			Infrared heating for receiving bay.	9	
					Exterior Tanker Wash with recycled water from elsewhere in plant.	3	
					CIP System Improvements	See Below	
Can Washing (Raw Area)	Heated water flow to can washing	Conveyor drives.	Water flow to washer	Volume control raterh than time control in can washing.			
					Diversion of hot water from other areas for can washing, espeically for initial rinsing.		Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
Raw Milk Holding Silos (Raw Area)	Heated solution for CIP flow	Refrigeration to maintain at < 5 C.	Intermittent CIP.	Enhance silo insulation. Ensure sufficient mixing to minimize any temperature gradients.			
Processing and Pasteurization System (Raw Area):	Heated solution for CIP flow.		Intermittent CIP. Large flows per event.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
					CIP System Improvements	See Below	
Cream Separation from Milk		Large motor on separator.	Operating and cooling water for separator.				
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for required 16 s hold time. Incorporate regeneration. Most existing units with 85% to 90%. Max 94% realistic.	Final chilling of product to <5 C using glycol.	Cooling water or recirc chilled water for partial cooling.	Maintenance to ensure leakage from plate-pack prevented.			
					Heated cooling water recovery.	3	Depends on flow and temperatures involved for specific systems, for example UHT systems.
					Improve efficiency by addition of plates.	4	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
Pasteurized Skim Milk Storage (Pasteurized Area)	Heated solution for CIP flow.	Refrigeration to maintain product at 5 C.	Intermittent CIP. Large flows per event.		CIP System Improvements	See Below	

Churning/Butter Making	Heated solution for CIP flow.	Drives for butter production.	Intermittent CIP.		CIP System Improvements	See Below	
Forming/ Packaging/ Cartoning and Palletizing	Heated solution for wash flow.	Drives for butter production.	Intermittent CIP.				
Product Storage		Refrigeration to maintain cooler at 1 C			Free Cooling during Winter months.	5	
CIP Operations	Heated solution for CIP flow.	Recirc pumps.	Initial and final water rinses. Makeup to CIP solutions.	Volume, rather than time, based control on burst rinses and CIP flows to reduce water quantities.			
					Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Utilization of waste heat from identified utilities and services for heating/preheating of CIP washes and rinses as required.		Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
					Utilization of thermal storage for hot water requirements		Refer to Exhibit 4.8 for thermal storage opportunities.
					Recycle system on chemical washing solution, especially HTST washing chemicals, to reduce heating requirements	6	Most areas of plants incorporate recycle of chemicals for CIP. HTST wash chemicals in particular may not always be recycled.
Washup throughout plant	Warm water (<46 C) often employed to solublize butterfat.		Water for washup	Nozzles on hoses. Not left running			
				Dry ingredient spills treated as solid wastes, rather than flushed. Hoses should not be used as brooms.			
				Heated water or heat exchange rather than steam injection for heating Reporting of leaks to ensure chronic leakage problems addressed.			
					Thermal storage of recovered hot water for washup purposes.		Refer to Exhibit 4.8 for thermal strorage opportunties.

* NOTE: Reference number refers to Retrofit Opportunities in Exhibit 4.7

EXHIBIT 4.6: Check List of Process-Related Improvement Opportunities for Evaporated/Dried Product Processing

PROCESS AREA	ENERGY IMPLICATIONS			OPERATING, LOW COST/NO COST	RETROFIT	REF No.*	COMMENTS
	Thermal	Electrical	Water				
Raw Milk Receiving and Tanker Wash (Raw Area)	Heated solution for CIP flow Possible space heating during winter if bay enclosed.	Receiving pump and CIP recirculation pumps Possible additional chilling of incoming raw milk prior to storage	Fairly steady CIP operation.	Nozzle maintenance for CIP to ensure minimize hot CIP use.			
					Infrared heating for receiving bay.	9	
					Exterior Tanker Wash with recycled water from elsewhere in plant.	3	
					CIP System Improvements	See Below	
Raw Milk Holding Silos (Raw Area)	Heated solution for CIP flow	Refrigeration to maintain at < 5 C.	Intermittent CIP.	Enhance silo insulation. Ensure sufficient mixing to minimize any temperature gradients.			
Processing and Pasteurization System (Raw Area):	Heated solution for CIP flow.		Intermittent CIP. Large flows per event.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
					CIP System Improvements	See Below	
Milk Separation and Standardization		Large motor on separator.	Operating and cooling water for separator.				
Pasteurization using High Temperature Short Time (HTST) Plate Heat Exchanger	Heating to 72 C for required 16 s hold time. Incorporate regeneration. Most existing units with 85% to 90%. Max 94% realistic.	Final chilling of product to <5 C using glycol.	Cooling water or recirc chilled water for partial cooling.	Maintenance to ensure leakage from plate-pack prevented.			
					Heated cooling water recovery.	3	Depends on flow and temperatures involved for specific systems, for example UHT systems.
					Improve efficiency by addition of plates.	4	Only applicable if unit can be expanded. Likely only economic if existing regen is relatively low.
Pasteurized Milk Storage (Pasteurized Area)	Heated solution for CIP flow.	Refrigeration to maintain product at 5 C.	Intermittent CIP. Large flows per event.		CIP System Improvements	See Below	
Evaporation	Large thermal load for evaporation		Large cooling water for condenser		Membrane RO/NF preconcentration to reduce thermal load	8	
Post Evaporation Homogenization of Evap/Condensed Product		Large motor on homogenizer.	Piston flushing and cooling. See above for CIP.	Nozzles or flow restrictions to reduce flushing water flow to minimum necessary - refer to manufacturers.			
Filling, Product Conveying and Casing (Pasteurized Area)	Heated solution for CIP flow.	Filling system drives.	Intermittent CIP. Large flows per event.		Optical interface unit to monitor milk/wash flow rinse.	1	

		Conveyor system drives			CIP System Improvements	See Below	
Post-Filling Sterilization	Large thermal load for sterilization		Cooling water for cooling				
Drying and Agglomeration Spray and Fluid Bed	Large thermal load to heat drying air stream		Water to wet scrubber		Improved higher efficiency drying technologies.		Refer to Exhibit 5.1 for applicable new drying technologies.
CIP Operations	Heated solution for CIP flow.	Recirc pumps.	Initial and final water rinses. Makeup to CIP solutions.	Volume, rather than time, based control on burst rinses and CIP flows to reduce water quantities.			
					Optical interface unit to monitor milk/rinse water interface and water/CIP chemical interface	1	Allows more precise switch-over.
					Utilization of waste heat from identified utilities and services for heating/preheating of CIP washes and rinses as required.		Refer to Exhibit 4.8 for waste heat recovery opportunities, including flash steam, refrigeration condensers, compressors.
					Utilization of thermal storage for hot water requirements		Refer to Exhibit 4.8 for thermal storage opportunities.
					Recycle system on chemical washing solution, especially HTST washing chemicals, to reduce heating requirements	6	Most areas of plants incorporate recycle of chemicals for CIP. HTST wash chemicals in particular may not always be recycled.
Washup throughout plant	Warm water (<46 C) often employed to solublize butterfat.		Water for washup	Nozzles on hoses. Not left running			
				Dry ingredient spills treated as solid wastes, rather than flushed. Hoses should not be used as brooms.			
				Heated water or heat exchange rather than steam injection for heating Reporting of leaks to ensure chronic leakage problems addressed.			
					Thermal storage of recovered hot water for washup purposes.		Refer to Exhibit 4.8 for thermal strorage opportunties.

* NOTE: Reference number refers to Retrofit Opportunities in Exhibit 4.7

EXHIBIT 4.7: Check List of Retrofit Options for Dairy Products Processing

REF No.	RETROFIT	EQUIPMENT	COSTS	SAVINGS	PAYBACK	APPLIES TO	COMMENTS/ BENEFITS
1	Product/Water/Chemical Interfaces	Optical Interface Detection Unit	8-12k	3-12k	1-3 yrs	All Processes	Units tied to controls to initiate switch-overs during CIP and process operations. Reduces energy requirements, product losses, water flow requirements and chemical losses in CIP Also can act for detection of cross-contamination.
2	Active bacterial control in production and other areas. (Already used selectively, such as within filling units).	UV Lamp sets or units	0.2-2k	0.1-1k	1-2 yrs	All Processes	UV lamps have been used, but with limited success. Success depends on unit design and ongoing maintenance.
3	Washing duties not requiring potable water, including milk tanker exteriors and initial case washing.	Use of recovered secondary water from other relatively clean uses (e.g. CIP post-rinses).				All Processes	DPRIS considerations for tankers apply to washing of product contact surfaces. Holding tanks, piping and pumps for recovered water. Filtration may be required. Refer to Section 4.5 for precautions.
4	Improving HTST regeneration efficiency	Addition of plates, reconfiguration				All Processes	Refer to individual HTST system manufacturers for details
5	Reduced active chilling of coolers during Winter months.	Free cooling (during Winter months)	50-150k	20-80k	1-3 yrs	All where Cooler used	
6	Reduction of cleaning chemicals and energy requirements for CIP	Recycle of HTST chemicals.	20-40k	10-20k	1-3 yrs	All Processes	Often HTST cleaning solutions are not recovered.
7	Control of Cheese Vat filling and temperature control	Automatic control				Cheese	Minimize losses and heating during processing.
8	Reduction of thermal requirements for Whey or Milk product evaporation	Membrane RO/NF preconcentration	50-200k	50-100k	2-4 yrs	Dried Products	Reduction of thermal requirements. Could be employed by smaller plants to reduce transport volumes.
9	Directed or targeted heating in milk bays or loading docks, where general air or product heating is undesirable	Infrared heating systems	10-20k	3-12k	1-3 yrs	Fluid Primarily	

4.3 Utility-Related Opportunities

A checklist of generic utility improvements is presented in Exhibit 4.8, along with corresponding retrofit options.

4.4 Other Improvement Measures

In addition, to the low-cost/no-cost and retrofit technology opportunities described in Exhibits 4.1 through 4.8, it is also important to consider opportunities associated with management practices, training and awareness:

- *Management commitment to energy/water-use reduction.* Any effective energy/water management and reduction program must have the endorsement of top level management. A clear commitment by management is essential to achieving financial, image and societal benefits.

- *In-plant training and awareness of energy/water-use.* In dairy processing plants, operators often have discretion over the quantities of water and energy utilized in relation to tasks performed. Plant personnel should be trained in operational techniques that lead to cost reduction and improvement.

4.5 Precautions for Water Reuse Opportunities

A generic improvement opportunity cited is the recycle and reuse of water in cases where requirements under DPRIS are satisfactory. If water is to be recycled within plants, appropriate management measures must be undertaken to address any potential health and safety concerns, especially with regard to microbial content.

Addressing concerns could involve:

- Developing policies regarding the reuse of water;

- Conducting periodic analyses of water samples to ensure satisfactory quality is maintained; and

- Conducting active treatment and/or control to address and maintain quality. These could include:

    - Computer monitoring and control to ensure adequate bleed-out in recycled water systems;

    - UV treatment of water for active bacterial control; and

    - Addition of appropriate chemicals.

EXHIBIT 4.8: Check List of Improvement Opportunities for Utilities and Services

UTILITY SERVICE	ENERGY IMPLICATIONS: Thermal	ENERGY IMPLICATIONS: Electrical	ENERGY IMPLICATIONS: Water	OPPORTUNITY: LOW COST/NO COST	OPPORTUNITY: RETROFIT	COSTS (000's)	SAVINGS (000's)	PAYBACK (yrs)	COMMENTS
City Water			Variable, for process, washup and utility cooling	Water meters in different process areas to monitor consumption on an on-going basis.		low cost / site specific			Trend data to identify zones/ equipment/ crews with either inconsistent or inefficient performance.
				Enhanced insulation of cold water piping lines.		low cost / site specific			Reduce cooling load on chillers and heating load on boilers
				Pump impeller optimization (impeller changeout).		low cost / site specific			Ensure duty point is within optimum zone on pump curve.
				Pump maintenance program.		low cost / site specific			Regular inspection and maintenance to trend performance for early indication of failure.
				Recycle once-through cooling water to process or other uses.		low cost / site specific			Once through cooling water is inefficient and costly in terms of water and sewage. Reutilize in a cascade system.
					Closed loop cooling water systems (cooling towers).	25-100	15-50	1-3	Once through cooling water is inefficient and costly in terms of water and sewage.
					Variable speed pump drives to optimize flows.	5-20	3-12	1-3	Minimize costly bypass provisions which are wasteful for pumping systems.
Hot Water	Variable, for washup and process.			Enhanced insulation of HW tanks and lines, and hot process vessels.		low cost / site specific			Matching thermal services to demand requirements.
				Ensure appropriate water heating set points.		low cost / site specific			Minimize cold water tempering to reduce overheated water temperature to process conditions.
				Pump impeller optimization (impeller changeout).		low cost / site specific			Ensure duty point is within optimum zone on pump curve.
				Pump maintenance program.		low cost / site specific			Regular inspection and maintenance to trend performance for early indication of failure.
					Infrared heating system for large open areas.	10-20	3-12	1-3	Heats occupants rather than space.
					Segregate HW system according to temperature requirements to reduce unnecessary tempering.	10-30	5-15	2-4	Consider multiple boilers each feeding loads at a similar temperature. All loads should not be dictated by the highest temperature.
					High efficiency hot water heater system.	5-50	3-20	1-3	Many new units in 95% efficiency range with condensing heat recovery.
Steam	Natural gas typical			Tune boiler combustion air to achieve optimum fuel/air mixture.		low cost / site specific			Optimum operation point yeilds reduced gas costs and emissions.
				Use interruptible gas service at lower cost, if appropriate		low cost / site specific			Only essential loads should be on non-interuptible contracts.
				Blow down heat recovery (heating washup water, boiler feed water etc.)		low cost / site specific			Utilize heat from blowdown to preheat incoming city water and reduce city water tempering to discharge guidelines
				Identify and correct steam and condensate leaks		low cost / site specific			Leak represents a point through which contamination is possible.
				Collect all possible condensate and insulate steam and condensate return lines.		low cost / site specific			Waste of energy and and treatment chemicals.
				Steam trap maintenance program.		low cost / site specific			Ensure optimum performance of traps to reduce downtime of steam system.
				Chemical treatment program to maintain operating performance.		low cost / site specific			Reduce scaling and fouling factor losses at point of heat exchange. Scale build up increases pumping resistance.,
				Maintain control setting to ensure no overheating.		low cost / site specific			Wasteful practice to overheat, better quality and consistency in the product.
				Monitor steam consumption to avoid surges.		low cost / site specific			Trend data to identify equipment with either inconsistent or inefficient performance.
					Flash steam recovery from condensate.	5-10	3-5	1-3	Low pressure steam may be recovered from condensate for use elsewhere.
					Replace steam boiler with hot water heaters if appropriate	2-150	10-40	2-5	Hot water boilers operation and maintenance costs tend to be lower.
					Infrared heating system for large open areas.	10-20	3-12	1-3	Heats occupants rather than space.

					Steam powered condensate return pumps to replace electrical pumps.	2-10	1-5	1-2	Utilize steam power to return condensate rather than electricity.
					Flue gas heat recover, direct contact condensing heat recovery	10-40	5-12	2-5	Further preheating of feedwater with stack gases downstream of economizer.
					Heat exchange rather than direct injection	10-50	5-15	2-3	Steam injection consumes water which necessitates city water make up and heating.
Refrigeration		High electrical inputs		Schedule compressors or operation to reduce electrical peak demand		low cost / site specific			Eliminate classic mid day spike which plant is penalized for (electrical demand billing) as if it continuously operated at.
				Insulate cold process areas to reduce summer refrigeration loads		low cost / site specific			Reduce heat gain through structure, reduces load and allows equipment to be sized based more on a continuous process load vs a variable seasonal load.
				Clean evaporators and condensers		low cost / site specific			Reduce scaling and fouling factor losses at point of heat exchange. Scale build up increases pumping resistance.,
				Insulate refrigerant lines		low cost / site specific			Reduce cooling load on chillers.
				Reduce warm infiltration into cooled areas such as freezer and milk cooler		low cost / site specific			Consider doors/ curtains to reduce air currents from adjacent zones of varying climates.
					Thermal storage	25-50	15-30	1-3	Utilize less expensive "off peak" electrical rates to reduce electrical demand charges.
					Ammonia de-superheating heat recovery	5-20	3-10	1-3	Utilize heat for preheating and reduce cost of cooling in condenser or cooling tower.
					Segregation of refrigeration system according to temperature	10-50	10-25	1-2	Optimize the thermodynamic balance of the refrigeration cycle to dedicate equipment to the minimum required conditions for each process.
					Free cooling	10-50	10-15	1-3	Utilize ambient conditions to provide cooling to suitable loads during winter and shoulder seasons.
					Absorption cooling	100-300	50-200	1-3	If excess heat is available, this technology provides refrigeration without electrical energy input.
					Engine driven chiller unit.	150-400	75-100	1-3	Less expensive energy input, better part load efficiency than electrical motors, heat recovery from engine jacket and exhaust.
Compressed Air		Electrical drives		Analyze for air leaks and repair		low cost / site specific			Ultrasonic detection equipment available
				Enclose compressor to eliminate heat rejection into building space were not desired.		low cost / site specific			Ensure radiant heat from unit is not admitted to a cool space where it must be recooled.
					Engine driven compressor.	150-400	75-100	1-3	Less expensive energy input, better part load efficiency than electrical motors, heat recovery from engine jacket and exhaust.
					Buffer tank to regulate compressor duty cycle.	5-15	3-5	1-3	Newer systems tend to incorporate. Should be considered for older systems.
					Compressor heat recovery.	5-15	3-5	1-3	Recover heat from compressor for preheating rather than paying to cool it.
Electrical (Direct Uses)		Electrical drives		Reduce unnecessary lighting, replace with higher efficiency lights.		low cost / site specific			Ensure lights (heat sources) not left on unnecessarily in cold spaces. Utilize high efficiency, long life replacements.
					Variable speed drives.	5-20	3-12	1-3	Minimize costly bypass provisions which are wasteful for pumping systems.
					Power factor correction to reduce surcharge	10-25	4-12	2-3	Reduce penalty imposed by electrical utility for inefficient operaation by sizing a capacitor correction system.
					High efficiency motor drives	100-200	30-100	2-3	Substantial increases in efficiency. High efficiency motors replace standard motors when replacement is necessary.
Cogeneration					Combined thermal energy and power production	600-3000	150-800	3-7	One fuel source simultaneously providing 2 or more forms of energy.

5.0 NEW TECHNOLOGIES

A series of new technologies relevant to energy/water efficiency improvement in dairy processing plants are summarized in Exhibit 5.1. A total of seven relevant generic technologies have been identified. All these technologies are likely to be applicable within the next 5 to 10 years. They are either currently being researched and developed or, if commercially available, are not yet being used extensively in Canada.

Exhibit 5.1 is not intended to provide a comprehensive listing, and is only a starting point for site-specific evaluations. Other new technologies, relating more to product development or productivity improvement with little or no impact on energy savings, have been excluded. Seven categories of new technologies are presented in Exhibit 5.1 briefly described as follows:

- *Expert control systems.* Incorporate enhanced computer control to coordinate and optimize process operations, especially related to refrigeration and processes linked to water and energy use.

- *Non-thermal pasteurization methods.* A key focus of the relevant new technologies for dairy processing is non-thermal methods for pasteurization and bacterial control. Benefits of such technologies include reduced energy use and extended product shelf-life. Three potential pasteurization technologies at varying stages of development are identified: microfiltration; high hydrostatic pressure; and electrical field effects.

- *Ultraviolet light non-thermal bacterial control.* Ultraviolet light systems are already commercialized for such processes as water disinfection in breweries, but are not used extensively in dairies. Although not directly applicable to milk streams, UV systems of different types are applicable to bacterial control for disinfection of whey and water, such as for recirculated water flows.

- *Vacuum superheated steam drying.* This highly efficient drying method, allows for the reuse of recovered evaporation as useful steam. Vacuum operation is used to ensure adequately low operating temperature. The technology is commercially applied in Europe in other industries.

- *Pulsed drying systems.* A number of such technologies have been developed, which can reduce energy inputs to drying operations. Some technologies have been commercialized, although not yet extensively applied to dairy processing.

- *Enzyme-based cleaners.* The use of enzyme-based cleaners allows for a reduction of heating requirements for CIP operations. Enzyme-based cleaning chemicals are now being introduced into the market.

- *Just-in-time dairy concept.* This well known concept from automobile industry is now in research and development stage by equipment manufacturers. It could reduce/eliminate raw and product storage, and reduce refrigeration requirements.

EXHIBIT 5.1: New Technologies for Dairy Products Processing

REF NO.	NAME OF TECHNOLOGY	DESCRIPTION OF TECHNOLOGY	APPLICATION	
			PROCESS	ACTIVITY
1	Expert Computer Control Systems	Expert control systems incorporate enhanced computer control to coordinate and optimize process operations. Expert control systems are now becoming commercialized, but are not yet extensively used. The costs of these systems are still relatively high, but are decreasing. Relevant applications of expert systems include: - Refrigeration Control - Manufacturing Controls (Especially linked to water use)	 All, especially Frozen Products All Processes	 Cooling Processing
2 (a)	Non-Thermal Pasteurization Methods: Microfiltration	Microfiltration, which provides selective exclusion of bacteria, is the most advanced non-thermal method, being already commercialized within Canada. Technology already introduced for specialty milks, with main cited factors of flavour enhancement and extended product shelf-life (from typical 12-18 days to as high as 28 days). Process also results in reduced thermal requirements for processing, which affects energy consumption.	Primarily Fluid Milk	Pasteurization Bacterial Control
2 (b)	Non-Thermal Pasteurization Methods: High-Hydrostatic Pressure	Process commercialized in Japan for raw foods (e.g. jams and jellies). Has significant potential for Fluid milk and milk products such as cheese. Reduces thermal requirements, but may not deactivate naturally present degenerative enzymes.	Primarily Fluid Milk and Cheese	Pasteurization Bacterial Control
2 (c)	Non-Thermal Pasteurization Methods: Electrical Field Effects	Electrical field effect technologies have also demonstrated the ability to inactivate microorganisms in laboratory tests. However, such processes are still at an early stage of research and development.	Primarily Fluid Milk	Pasteurization Bacterial Control
3	Non-Thermal Bacterial Control: High- and Low-Intensity UV for Liquids	Technology already commercialized, but not applied in dairy industry. UV systems are not directly applicable to milk streams. The very low transmissivity of milk, as well as the potential for off-flavour development, preclude this technology. High-Intensity UV systems are applicable to bacterial control for whey. Low-Intensity UV systems are applicable to water, especially where water reuse might considered within plant.	 High Intensity for Whey (Cheese) Low Intensity for Water (All)	 Bacterial Control Bacterial Control

4	Vacuum Superheated Steam Drying (VSSD)	Superheated steam drying (SSD) is a highly efficient new drying technology that allows the reuse of recovered evaporation as useful steam. Such systems are already commercial in Europe for other industries but not yet for dairy processing.. Operation under vacuum conditions can be used to achieve sufficiently low operating temperatures in order to not degrade dried milk or whey products. Vacuum superheated steam drying was successfully pilot tested using milk powder in the late 1980's. The technology is not likely to be justifiable for a strict retrofit operation, however, could be very economical for a situation where a new or replacement dryer is required.	Dryed Milk and Whey Products	Drying
5	Pulsed Drying Systems	Pulsed drying technology has achieved some commercialization, but no extensive application to dairy processing. Such systems may incorporate pulsed combustion spray drying or pulsed fluidized beds, however the savings principal is the same. By providing pulsed or oscillating heating, such as rapidly alternating on-off pulsed combustion, the total energy input to the drying system is reduced significantly. Such technologies may be justified for some retrofits, and should be considered for new installations.	Dryed Milk and Whey Products	Drying
6	Enzyme-based cleaners to improve CIP operations.reduce energy, caustic and water use. Now being introduced.	A recent advance in cleaning chemical technology has been the introduction of enzyme- based cleaners for CIP operations. Such cleaners offer the potential to reduce caustic and post-wash flushing requirements, as well as heating requirements for CIP. This reduces energy input requirements for CIP. Enzyme-based cleaning chemicals are now being introduced into the market.	All	CIP
7	Just-In-Time (JIT) Dairy Manufacturing Concept	A radical potential improvement in dairy processing operations is the application of the just-in-time concept, which is a well established process in automobile assembly. This approach could reduce or eliminate raw and intermediate product milk storage, correspondingly reducing refrigeration requirements, as well as washing and CIP energy requirements. Such processes are not yet available, but are currently under development by dairy processing suppliers.	Primarily Fluid	Primarily Storage Related

6.0 OTHER HELPFUL INFORMATION FOR DAIRY PROCESSORS

Additional information relevant to dairy processing plants is summarized in the following sections.

6.1 Unit Performance Ratios

In assessing the performance of plants in reducing energy and water consumption, the use of unit performance ratios is highly useful. A series of these ratios is presented in the following section. The ratios are structured in a manner so as to provide valid assessment, but at the same time to maintain confidentiality. This would allow the collection of data from a broad range of plants for statistical analysis purposes if desired.

All the unit performance ratios are presented per Litre of raw milk input or equivalent, consistent with information presented earlier in Exhibit 3.2 and Exhibit 3.3. This is done to allow valid comparisons with available literature data, and between dairy processing operations. In the case of industrial milk processing operations, comparison on the basis of kilogram of milk solids instead may be more appropriate. To compensate for the use of different performance ratio units (e.g. Litres of raw milk or kilograms of milk solids), a conversion table is provided.

6.1.1 Unit Electrical Energy Use

This unit performance ratio would be calculated using the following formula, and reported in units of kWh per Litre of Raw Milk:

$$\textit{Unit Electrical Energy Use} = \frac{\textit{Total kWh Electricity Used Over 12 Month Period}}{\textit{Total Litres Raw Milk Received Over Same 12 Months}}$$

The range of values expected for this ratio is approximately 0.10 to 0.30 kWh per Litre, depending on the process involved.

6.1.2 Unit Thermal Energy Use

This unit performance ratio would be calculated using one of the following formulas, and reported in units of MJ per Litre of Raw Milk, based on standard fuel energy values as presented.[2]

[2] If the fuel energy value is known more precisely for a specific plant, it can be substituted for the typical energy values presented.

For a plant employing natural gas, the unit performance ratio is indicated as follows:

$$\textit{Unit Thermal Energy Use} = \frac{\textit{Total } m^3 \textit{ Natural Gas Used Over } 12 \textit{ Month Period} \times 37.2\ \textit{MJ/m}^3}{\textit{Total Litres Raw Milk Received Over Same } 12 \textit{ Months}}$$

For a plant employing light fuel oil (e.g. No. 2 oil), the unit performance ratio is indicated as follows:

$$\textit{Unit Thermal Energy Use} = \frac{\textit{Total Litre Fuel Oil Used Over } 12 \textit{ Month Period} \times 38.7\ \textit{MJ/L}}{\textit{Total Litres Raw Milk Received Over Same } 12 \textit{ Months}}$$

For a plant employing heavy fuel oil (e.g. No. 6 oil), the unit performance ratio is indicated as follows:

$$\textit{Unit Thermal Energy Use} = \frac{\textit{Total Litre Fuel Oil Used Over } 12 \textit{ Month Period} \times 41\ \textit{MJ/L}}{\textit{Total Litres Raw Milk Received Over Same } 12 \textit{ Months}}$$

For a plant employing propane the unit performance ratio is indicated as follows:

$$\textit{Unit Thermal Energy Use} = \frac{\textit{Total Litre Propane Used Over } 12 \textit{ Month Period} \times 26.6\ \textit{MJ/L}}{\textit{Total Litres Raw Milk Received Over Same } 12 \textit{ Months}}$$

The range of values expected for the unit thermal energy use ratio is approximately 0.60 to 5.2 MJ per Litre for a specific plant depending on the processes involved.

6.1.3 Unit Water Use

This unit performance ratio would be calculated using the following formula, and reported in units of Litres of water per Litre of Raw Milk, as follows:

$$\textit{Unit Water Use} = \frac{\textit{Total } m^3 \textit{ Water Used Over } 12 \textit{ Month Period} \times 1{,}000\ \textit{L/m}^3}{\textit{Total Litres Raw Milk Received Over Same } 12 \textit{ Months}}$$

This value is expected to be in the range of 1 to 3 Litres per Litre for fluid milk plants, and upwards of 5 Litres per Litre for industrial milk plants. Water employed in products or reconstitution is not to be included in total water use.

EXHIBIT 6.1: Summary of CADDET Case Studies Relevant to Dairy Processing

REFERENCE	COUNTRY	COMPANY	TITLE
NL 92.008/21.X00	Netherlands	Coberco Dairy	Continuous Production of Small Volumes in the Dairy Industry
2A.C05.NO.90.001	Norway	Namdalsmeieriet	Combined Heat Recovery and Purification Plant at a Dairy
JP 90.142./2A.H03	Japan	Meiji Milk Products Co.	Quadruple-effect Evaporator uses Mechanical Vapour Recompression
NL.92.505/2a.f04	Netherlands	Campina Melkunie	Energy Efficient Hardening Tunnel for Ice Cream
Dec-92	United States	Steuben Foods	"Pinch" Technology Applied to a Dairy Processing Plant
Dec-92	Netherlands	Netherlands Institute for Dairy Research	Cleaning of Heat Exchangers and Evaporators after Processing Milk or Whey
Dec-92	Australia	New South Wales Dairy Corporation	Ice Storage in Dairy Farms in New South Wales, Australia
AU-90-021	Australia	Ibis Milk Products Ltd.	Recovery of Contaminated Condensate from Milk
CH-89-001	Switzerland	Vallait S.A.	Recovering Waste Heat of the Refrigeration Plant in a Dairy
CH-89-007	Switzerland	Toni Dairy	Heat Recovery from Boiler Feedwater Degassing
CH-89-008	Switzerland	Toni Dairy	Heat Recovery from Flushing Water
CH-89-026	Switzerland		Heating of Cleaning Water by a Heat Pump in a Dairy
CH-89-009	Switzerland	PAG	Improved Control of Air Compressors and Heat Reovery Reduce Cost of Compressed Air
NL-87-064	Netherlands		Use of Condensate in the Dairy Industry
NL-92-011	Netherlands		Construction of a Cooling System with Heat Recovery in a Tofu Factory
NL-92-509	Netherlands	Coberco	Continuous Manufacture of Custard with Heat Recovery
NL-92-519	Netherlands	VHL	Application of New Generation of Homogenizers in the Dairy Industry
NL-93-531	Netherlands	Borculo Whey	Renewal Control of Lactose Dryers
NL-93-532	Netherlands	Borculo Whey	High Concentrating During Whey Processing
NL-93-534	Netherlands	Coberco	Fat Injection at an Evaporation Process
NL-94-533	Netherlands	Humelco	New Spray Drying Process
NO-88-003	Norway	L/L Sunmre Meieri	Reducing Whey using Mechanical Vapour Recompression
UK-87-016	United Kingdom	Magness and Usher	Insulated Trucks for Wholesale Milk Delivery
UK-87-034	United Kingdom	Unigate Dairy	Electrically Driven Heat Pumps for Waste Heat for Waste Heat Recovery
UK-87-174	United Kingdom		Mechanical Vapour Recompression Heat Pump in the Evaporation of Skim Milk Concentrate
UK-87-401	United Kingdom	Unigate	Gas-Fired Heaters Replace Steam at Dairy for inplace Tank Cleaning and Pasteurizing
UK-94-522	United Kingdom	Associated Dairies- MD Foods	Energy Monitoring and Target Setting at a Dairy
UK-94-526	United Kingdom	Romford Brewery	Variable Speed Drives on Secondary Refrigeration Pumps
US-89-101	United States		Energy Conservation in Food-Processing Plants, by Heat Recovery and Efficient Boiler Operation
US-89-103	United States		Energy Audit Demonstrates the Potential for Energy Conservation in an Operating Dairy Plant: Creamer

6.2 Advanced Analysis Methodologies

A comprehensive approach to analyzing energy and water use reduction is essential in the case of complex processes. An example approach, identified in a recent food industry sector technology study sponsored by Natural Resources Canada (referenced below), is the use of Energy Process Integration (EPI) or *Pinch* analysis for determining the most cost effective energy reduction opportunities.

6.3 Additional References Materials on Energy Improvements

Additional reference materials for dairy plants are described in the following sections.

6.3.1 Natural Resources Canada

Natural Resources Canada. 1994. CEMET Resource Catalogue: List and description of available energy efficiency products and services.

Natural Resources Canada. A Manager's Guide to Creating Awareness of Energy Efficiency. Efficiency and Alternative Energy Program.

Natural Resources Canada. 1994. Technical Information. Efficiency and Alternative Energy Program.

Canadian Industry Program for Energy Conservation. CIPEC Energy Efficiency Planning and Management Guide.

Maunder Britnell Inc. 1993. Energy Efficiency R&D Opportunities in the Food and Beverage Sector Phase 1 - Scoping Study. Report for Energy Efficiency Division, Efficiency and Alternative Energy Technology Branch, Natural Resources Canada. CANMET Contract No. EA9710-8-1. October, 1993.

6.3.2 Hydro Utilities

A series of Product Knowledge Reference Guides are available from Ontario Hydro, as follows: Power Quality; Adjustable Speed Drives; Motors; Membrane Technology; Fans; Pumps; and Refrigeration. Additional technology reports and case studies are available from Ontario Hydro.

B.C. Hydro also prepared a useful energy guide, as follows: B.C. Hydro. 1992. Guides to Energy Management: Efficiency initiatives produce savings and win certificate of merit for Dairyland Foods.

6.3.3 International Case Studies

A summary of case studies relevant to dairy processing plants prepared by the Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) is provided in Exhibit 6.1.

6.3.4 Ontario Ministry of Environment and Energy

Ontario Ministry of Environment and Energy, Industry Conservation Branch. 1995. Guide to Resource Conservation and Cost Savings Opportunities in the Dairy Processing Industry (Includes opportunities for energy, water and resource conservation and environmental improvement).

Case Study and Project Profile of Green Industrial Analysis: Becker Milk Co. Ltd., Scarborough, Ontario.

Project Profile of Green Industrial Analysis: Ault Food Limited, Winchester, Ontario.

6.3.5 Department of the Environment (United Kingdom)

Department of the Environment (UK), Energy Efficiency Office, Best Practice Programme. 1991. Guide 26: The Liquid Milk Sector of the Dairy Industry. October.

6.3.6 Canadian Business Environmental Performance Office Website

NDCC is currently a partner in the development of a website on environmental performance and improvement together with Industry Canada and Environment Canada. This website will contain useful tools and references. It will become accessible in the Fall of 1997, and will be linked to NDCC's own website.

6.3.7 Other Relevant Technology Information Website Locations

Canadian Committee for Electrotechnologies: www.cce.qc.ca

Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET): www.caddet-ee.org

Climate Change Voluntary Challenge and Registry Program: www.vcr-mvr.ca

Gas Technology Canada: www.gtc.ca

Natural Resources Canada, Energy Efficiency Branch: eeb-dee.nrcan.gc.ca

Netherlands Energy Research Foundation (ECN): www.ecn.nl/eii/main.html

Office of Industrial Productivity and Energy Assessment (U.S.):
oipea-www.rutger.edu

GLOSSARY OF ACRONYMS

AAFC	Agriculture and Agri-Food Canada
CADDET	Centre for the Analysis and Dissemination of Demonstrated Energy Technologies
CIP	Clean-in-Place
CIPEC	Canadian Industry Program for Energy Conservation
COP	Clean-Out-of-Place
DPRIS	Dairy Plant Regulated Inspection System
EPI	Energy Process Integration
HACCP	Hazard Analysis Critical Control Points
HTST	High Temperature Short Time Pasteurizer Unit
JIT	Just-in-Time Manufacturing Concept
NDCC	National Dairy Council of Canada
SIC	Standard Industry Classification
SSD	Superheated Stream Drying
VSSD	Vacuum Superheated Steam Dryer