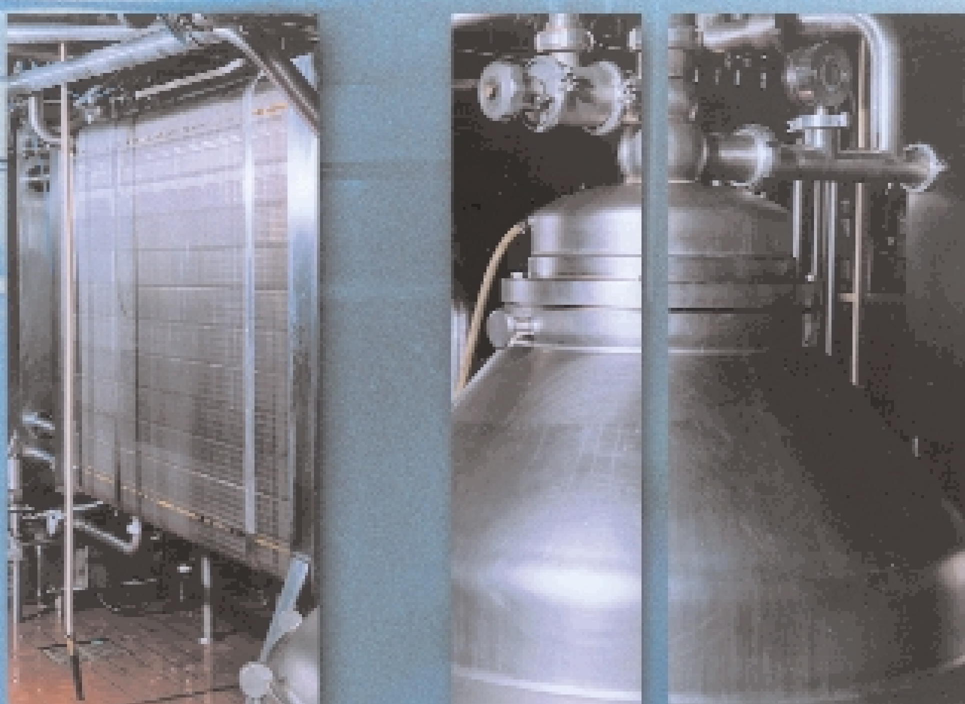
CIPEC

Energy Performance Indicator Report: Fluid Milk Plants

Prepared for the National Dairy Council of Canada



Natural Resources Canada
Office of Energy Efficiency

Ressources naturelles Canada
Office de l'efficacité énergétique

Canada

Energy Performance Indicator Report: Fluid Milk Plants

Prepared for the National Dairy Council of Canada
by Natural Resources Canada's Office of Energy Efficiency

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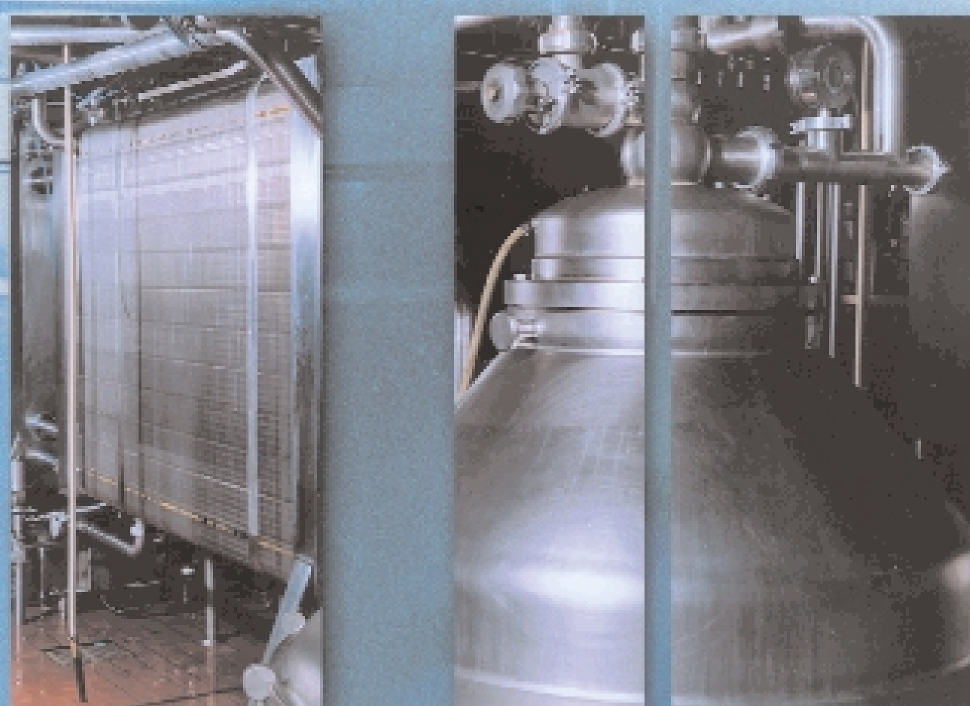

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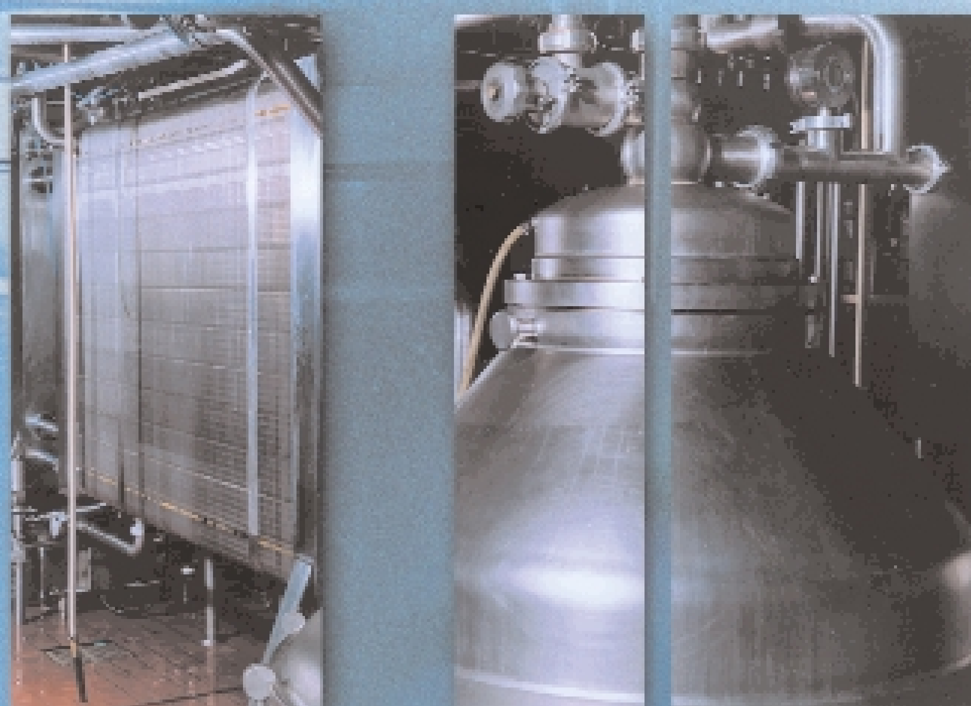


1. Introduction

Natural Resources Canada (NRCan) has been promoting the more efficient use of energy in the Canadian economy for a number of years. The Canadian dairy sector, through its involvement in the Canadian Industry Program for Energy Conservation (CIPEC), has participated actively in these energy initiatives. The National Dairy Council of Canada (NDCC) co-ordinated this study and NRCan provided the funding.

Objectives

The Competitive Analysis Centre Inc. (CACI) proposed the following objectives of this study to the NDCC:

- develop benchmarks for energy efficiency that address consumption, composition and costs in Canadian fluid milk plants;
- develop and apply benchmarks at the plant level and by stage of production;
- establish a methodology for examining energy performance of fluid milk plants; and
- review potential energy savings ideas for fluid milk plants that arise from this and other studies.

Layout of Report

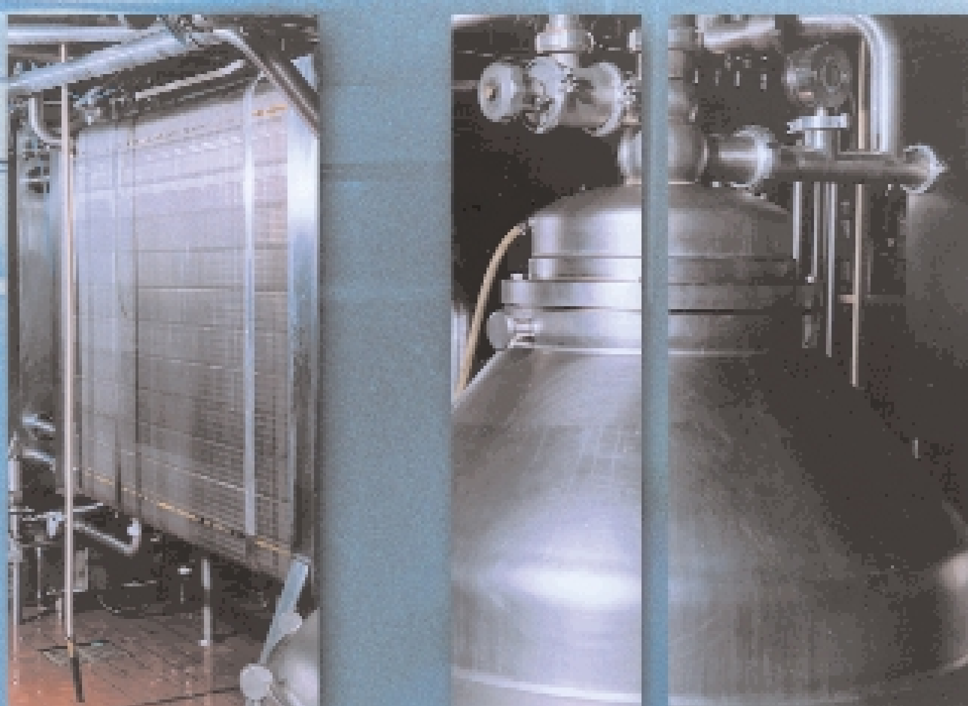
This report begins by providing some background information on Canada's fluid milk sector in **Chapter 2**. This information was included in CACI's report on greenhouse gases (GHGs) to Agriculture and Agri-Food Canada.

Chapter 3 describes the methodology used to develop and apply energy efficiency and cost-related benchmarks. These benchmarks are established at the plant level and by stage of production.

The principal findings are reported in **Chapter 4**. This chapter begins by outlining the benchmark targets. First, the results for the 17 participating plants (representing over 50 percent of Canadian output) are analysed at the plant level. Next, data from the participants are analysed by eight categories (five stages of production and three plant services) at the sub-plant level. The total incentives for achieving the benchmark targets on efficiency and unit costs are then estimated.

Chapter 5 provides a brief summary of potential energy-saving ideas. These ideas have arisen from recent analyses of the fluid milk sector.

2.
Background:
Fluid Milk Industry



2. Background: Fluid Milk Industry

The food and beverage industry forms the third largest manufacturing subsector in Canada. Within this subsector, fluid milk processing accounted for 6.4 percent of shipments and 5.1 percent of value added in 1996. The fluid milk processing industry consists of dairy processors that are primarily engaged in processing fluid milk products – including milk, cream and flavoured products – for direct consumption. The industry is highly concentrated, with the leading four businesses accounting for the majority of shipments.

The following section presents the industry's historical data on shipments, value added, establishments, employment, investment, trade and energy use.

2.1. Shipments

The industry has experienced a steady downturn in shipments over the past decade. From 1986 to 1997, shipments in constant dollars have declined at an annual rate of 1.0 percent per year. Shipments (in constant 1986 dollars) were $2.6 billion in 1997. In Canada, per-capita (for each person) consumption of fluid milk is decreasing. However, this decrease was offset by an increase in population. As a result, shipments should remain fairly constant for the industry as a whole.

2.2. Value Added

Value added is the amount by which the value of an article is increased at each stage of its production, exclusive of initial costs. Like shipments, value added for the fluid milk processing industry has declined slightly, falling from $855 million in 1986 to $815 million in 1997 (in constant dollars), a rate of 0.5 percent per year. Concurrently, value added in the food sector has grown by 1.2 percent per year. There is growing emphasis on producing products with higher added value, such as ultra-high temperature (UHT) milks and extended shelf-life products. So the decline in value added should not be as significant as the decline in shipments.

2.3. Establishments

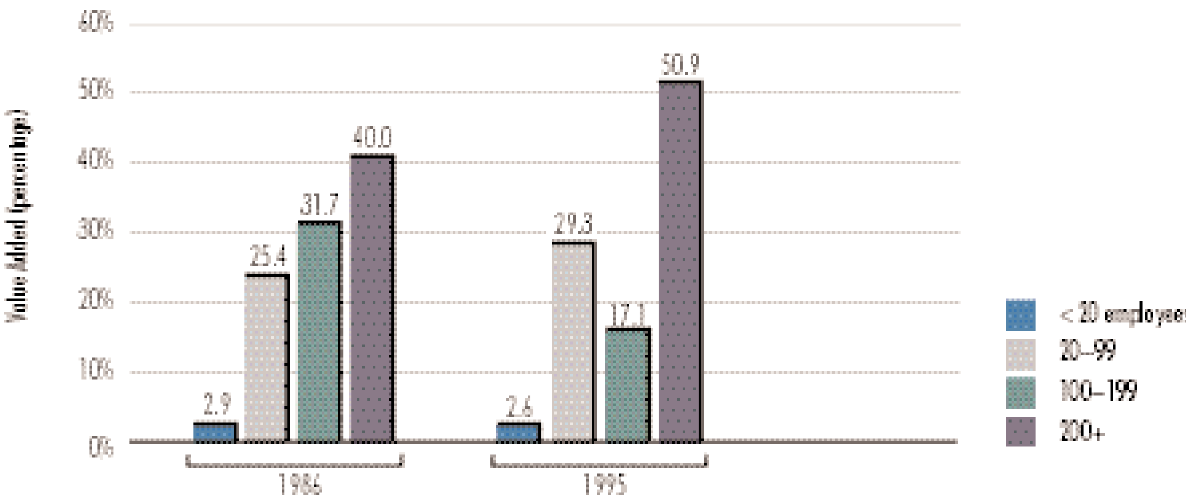
In general, fluid milk processors have severely streamlined their operations over the last 10 years (see Table A). More than 33 percent of establishments with fewer than 100 employees and more than 52 percent of those with 100 to 199 employees have disappeared. Conversely, the number of large plants – those with more than 200 employees – actually increased by over 14 percent from 1986 to 1996.

Table A
Fluid Milk Processing Establishments, 1986–1996

	Number of Establishments		
Number of Employees	**1986**	**1996**	**Change (%)**
1–49	95	63	(33.7)
50–99	30	19	(36.7)
100–199	21	10	(52.4)
200+	14	16	(14.3)
Total	**160**	**108**	**(32.5)**
Total Number of Employees in All Establishments	13 647	9733	(28.7)

The high degree of concentration of ownership within the industry has increased in the past decade (see Figure 2.1). Firms with more than 200 employees accounted for 40.0 percent of the industry's value added in 1986. In 1995, this number increased to 50.9 percent.

Figure 2.1 Concentration of Value Added by Establishment Size



The number of establishments has fallen steadily in the 1990s, from a high of 160 in 1986 to a low of 108 in 1996. Consolidation trends are expected to continue.

2.4. Employment

The number of employees has gradually decreased from a high of 13 647 workers in 1986 to a low of 9733 in 1996, a drop of 2.7 percent per year. This development was consistent with the industry's restructuring over the last decade. Currently, there are approximately 10 000 workers in the industry. Employment will likely continue to decline as firms seek out opportunities to increase energy efficiency in the face of relatively flat shipments.

2.5. Investment

Investment by the dairy industry (NAICS 3115) has fluctuated from $123 million per year to $244 million per year during the 1990s. With the industry's restructuring, plants have generally invested in upgrading existing facilities rather than building new ones. Investment trends, therefore, will likely be flat.

2.6. Value Added per Establishment

Value added per establishment has grown relatively steadily in the past decade and should continue to do so. As value added declines and the number of establishments falls at a much higher rate, value added per establishment will increase.

2.7. Value Added by Region

The majority of production in the fluid milk processing industry is concentrated in Ontario and Quebec. In 1996, these two provinces accounted for 68.5 percent of the industry's value added. This geographic distribution is not expected to shift dramatically, as the dairy industry is based on supply management. Regional relationships should be maintained.

2.8. Trade

Generally speaking, fluid milk products have heavy trade limitations. Tariff rate quotas place import restrictions on these products. As a result, no fluid milk products are imported.

In 1997, the industry exported 1.0 percent of its final product ($25.8 million), up from 0.3 percent ($8.0 million) in 1990. Imports in 1997 ($58.7 million) accounted for 2.2 percent of domestic consumption, up from 0.05 percent ($1.2 million) in 1990.

The industry's trade balance, which in 1990 stood at $6.8 million, slipped to a $32.8-million trade deficit in 1997. During this period, the industry increased its international trade marginally. Fluid milk processing, though, is still considered a domestic industry with low trade exposure.

2.9. Energy Use

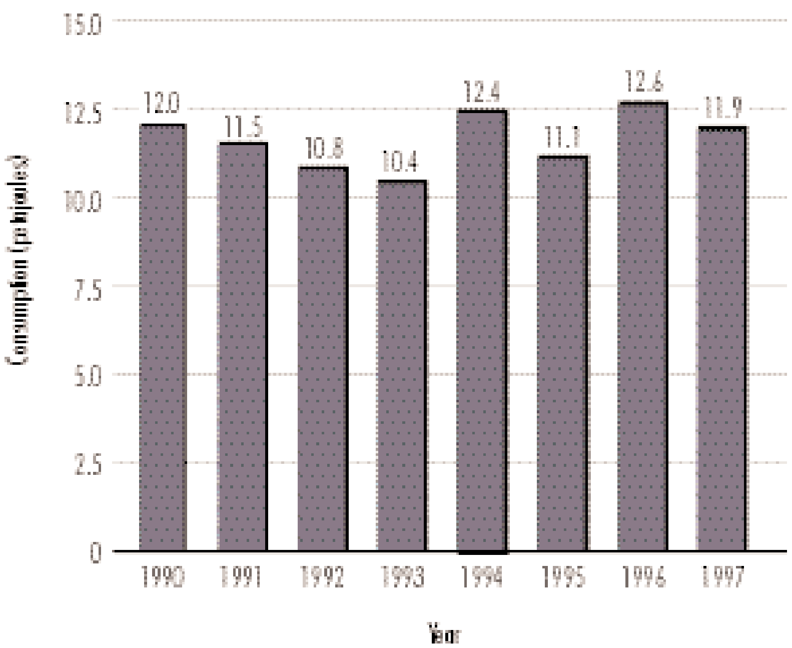
This report focuses on energy consumption in the fluid milk processing industry. Additionally, Statistics Canada collects energy data for the dairy industry as a whole (i.e. both fluid and industrial). Energy consumption, as illustrated in Figure 2.2, remained constant – from 12.0 petajoules in 1990 to 11.9 petajoules in 1997.

The following opposing forces will affect future energy consumption:

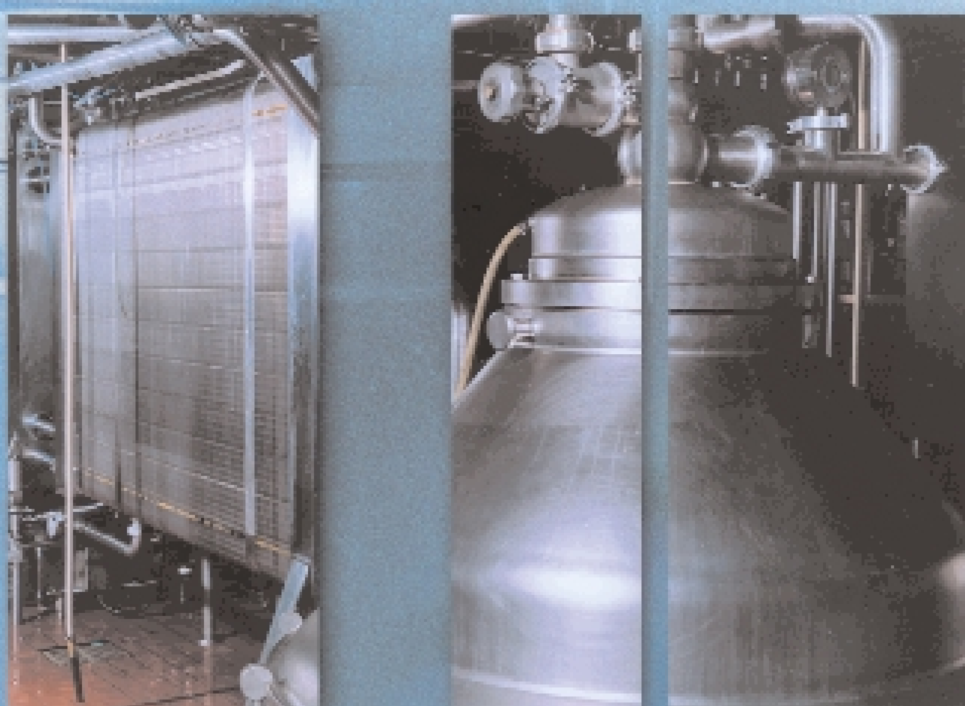
- As large plants increase their share of total industry production, they will realize further energy efficiencies.
- At the same time, plants will continue to produce more value-added products, such as UHT milk and extended shelf-life products, which require higher energy usage per litre. This will cause energy demands to increase.

In conclusion, energy consumption is expected to remain fairly constant in the dairy industry.

Figure 2.2
Energy Consumption in the Dairy Industry



3. Approach

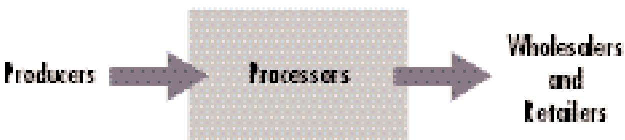


3. Approach

3.1. Focus of the Study

In keeping with past studies by the Competitive Analysis Centre Inc. (CACI), this study on energy efficiency of Canadian fluid milk processing plants was conducted in the context of the value-added chain.

The study focused on fluid milk processing facilities, including the energy required to transform raw milk into an array of products. The analysis began with raw milk being delivered from the farms to the plant's silos and ending with shipment. The following chart shows the flow of key players through this process:



The analysis focused primarily on basic fluid milk products. It excluded the energy requirements for processing other dairy products (such as ice cream mixes and yogurt mixes) in plants where these items are produced.

3.2. Fluid Milk Processing Plants

In 1998, CACI completed a comprehensive benchmarking analysis of 18 fluid milk plants for the National Dairy Council of Canada (NDCC). Seventeen of these plants – all that remain in operation – participated in this study, which was undertaken in 2000.

Consistent with the 1998 NDCC study, CACI focused on two categories of fluid milk plants: basic plants and complex plants.

Basic Fluid Milk Plants (Eight Participants)
Products include the following:

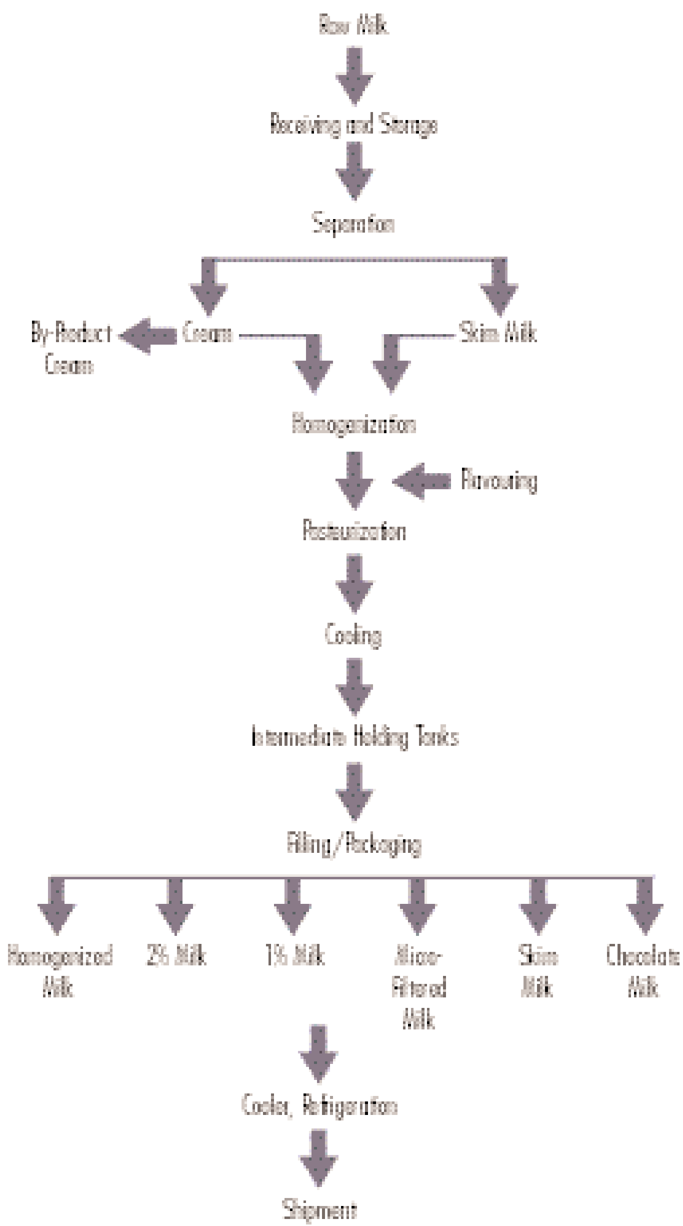
- regular milk;
- creams (may or may not be UHT-treated);
- chocolate milk; and
- micro-filtered milk.

Complex Plants (Nine Participants)
Products include those of the basic plants and the following:

- UHT cream;
- ice cream mix; and
- yogurt mix.

In the case of **basic fluid milk plants**, all stages of production – from milk receiving to shipments – were included in the analysis. A representative flow chart is illustrated in Figure 3.1.

Figure 3.1
Flow Chart of Basic Fluid Milk Through Production



In the case of **complex plants**, the study focused only on the energy requirements for fluid milk products. As illustrated in Figure 3.2, products such as yogurt, ice cream, mixes and UHT creams were not studied. Complex plants produce a diverse range of these products, and it would not be possible to make meaningful comparisons between plants.

Figure 3.2
Flow of Production Through Complex Fluid Milk Plants

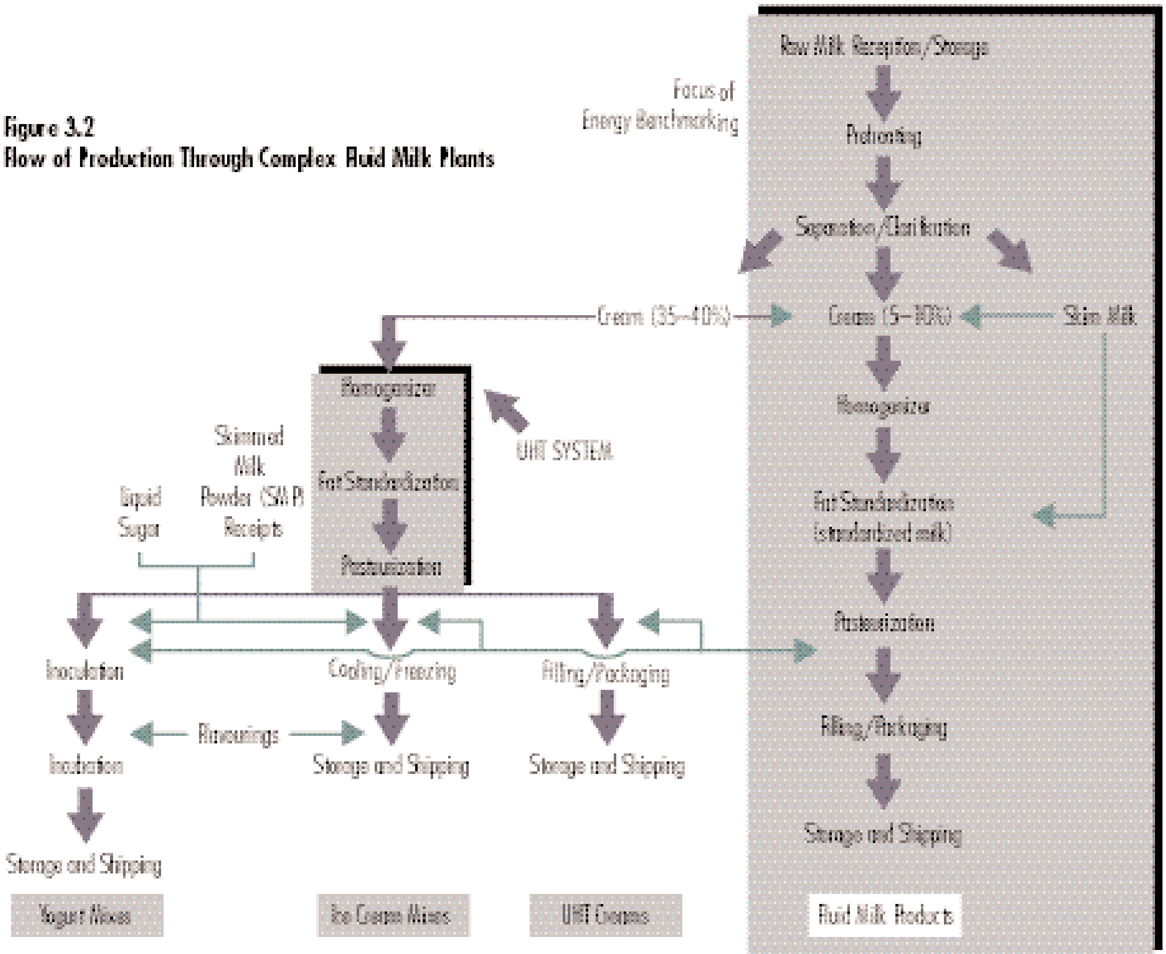
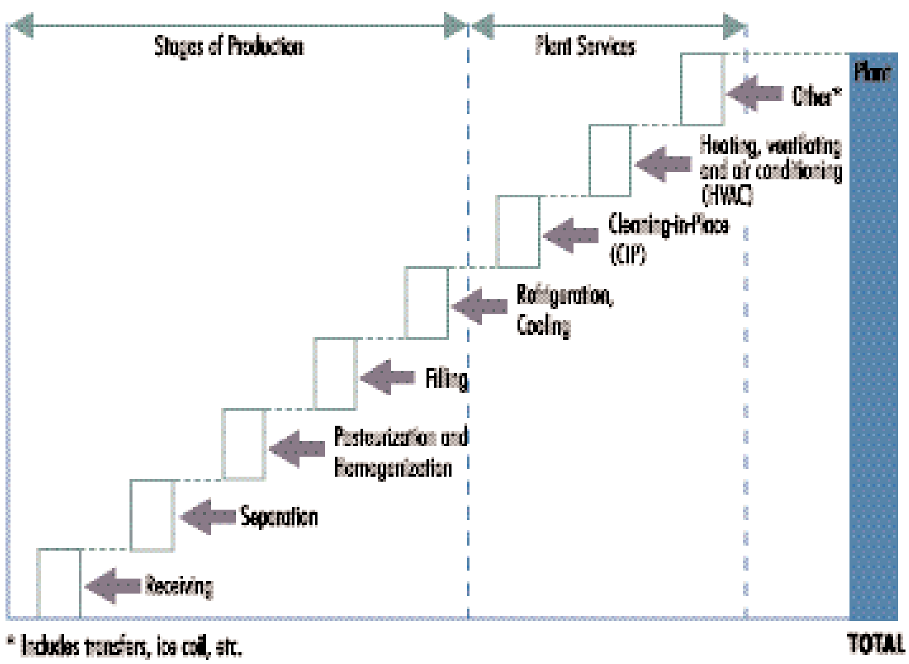


Figure 3.3
Benchmarking: Intra-Plant Comparisons



For both basic and complex plants, the objective was to focus on five stages of production and three categories of plant services (Figure 3.3).

3.3. The Sample

The 17 plants participating in this study represent about 56 percent of all fluid milk processed in Canada. The five leading fluid milk processors (in terms of throughput) had at least one plant in this survey.

The geographic distribution of the participants was as follows:

Location	Number of Plants
Western Canada	4
Ontario	5
Quebec	4
Atlantic Canada	4
TOTAL	**17**

The size distribution of the participants was as follows:

Annual Volume (millions of litres)	Number of Plants
< 20	0
20 to 40	5
40 to 80	5
> 80	7
TOTAL	**17**

3.4. Information Retrieval: Participating Plants

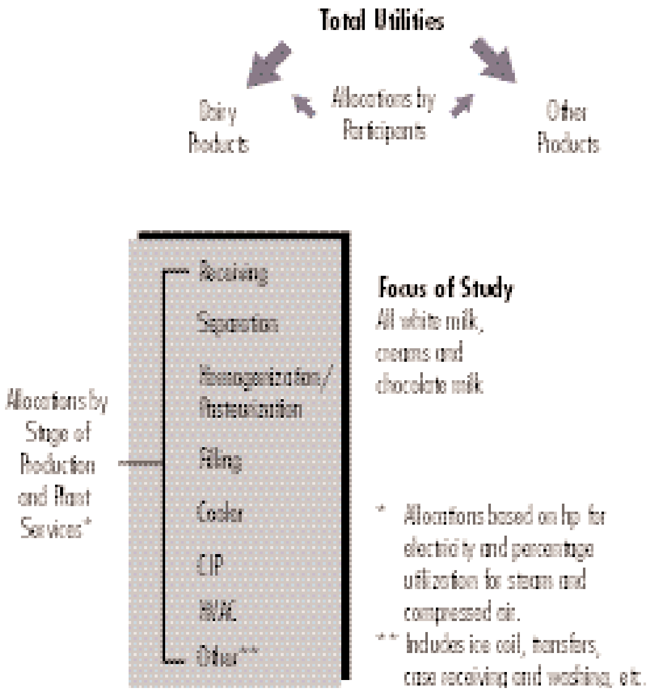
Detailed information was collected from each of the 17 plants to determine utility usage and costs. These utilities included electricity, natural gas and other fuels (including light fuel oil, bunker C and propane). CACI allocated this energy within basic and complex plants into eight categories of use (i.e. the five stages of production and the three categories of plant services). The procedures are described below.

Basic Plants

a) Participants allocated energy between dairy products and other products (juices, mixes, etc.).

b) The energy for dairy products was, in turn, allocated to the eight categories of cost. Participants allocated electricity based on horsepower (hp) and hours of usage; they estimated the percentage allocation for steam and compressed air.

Figure 3.4
Utilities Distribution: Basic Plants



Complex Plants

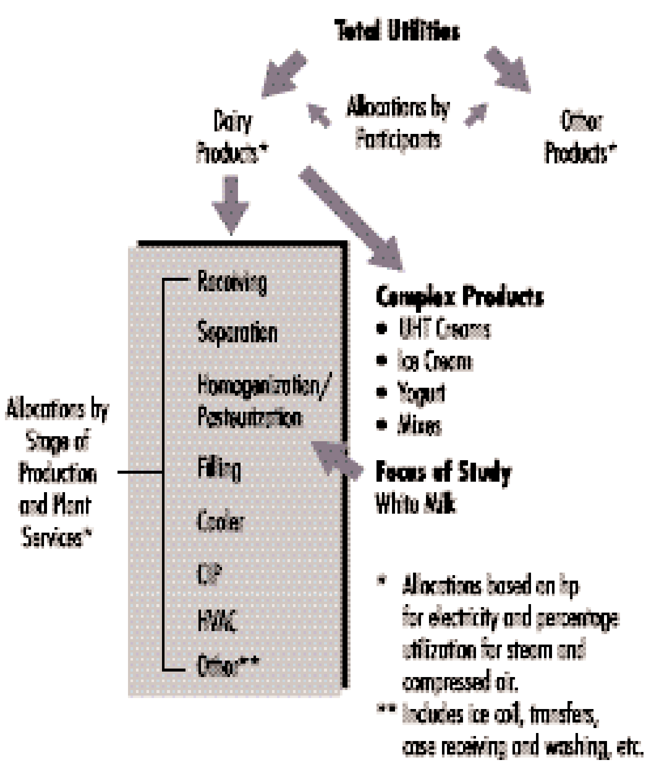
a) Participants allocated energy between dairy products and other products.

b) They allocated electrical energy between white milk products and complex products (ice cream, yogurt, mixes, etc.) based on horsepower and hours of usage.

c) Participants also estimated the percentage of steam and compressed air allocated to white milk and complex products.

The allocation of energy for white milk produced in the eight categories of cost (stages of production and plant services) was based on horsepower and hours of usage for electricity and the participants' estimates for steam and compressed air.

Figure 3.5
Utilities Distribution: Complex Plants



3.5. Benchmarking: Common Unit of Measurement

The 17 plants participating in the study used significantly different percentages of energy sources – natural gas, bunker C, light fuel oil and propane, in addition to electricity. To establish benchmark targets and to make comparisons between plants, all energy was converted to kilowatt-hour (kWh) equivalents. The conversion factors are illustrated in Table B.

Table B
Energy Conversion Factors

Fuel Type	Unit	kWh Equivalent
Electricity	kWh	1.00
Natural Gas	m^3	10.58
Propane	m^3	7.09
Liquefied Petroleum Gas (LPG)	kg	13.78
Light Fuel Oil	L	10.74
Diesel	L	11.67
Heavy Fuel Oil	L	11.59

3.6. Establishing Benchmark Targets

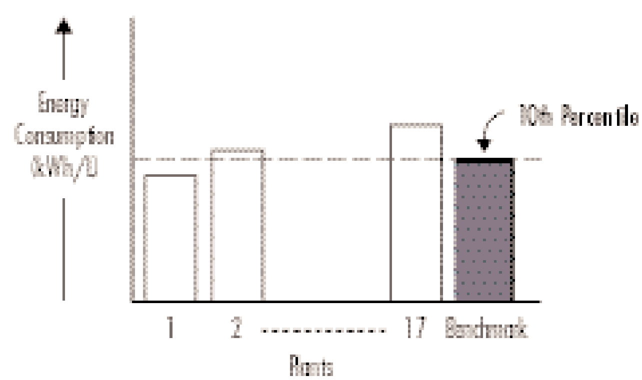
Establishing benchmarks involved setting standards first for energy usage, then for energy unit costs.

Fulfilling these objectives involved benchmarking the following:

- energy consumption;
- composition (by energy source);
- usage by energy source;
- unit energy costs; and
- total energy costs.

3.6.1. Benchmarking: Total Energy Use

Using the common energy unit (kWh equivalents), the plant benchmark usage was established at the 10th percentile of the 17 plants in the sample.

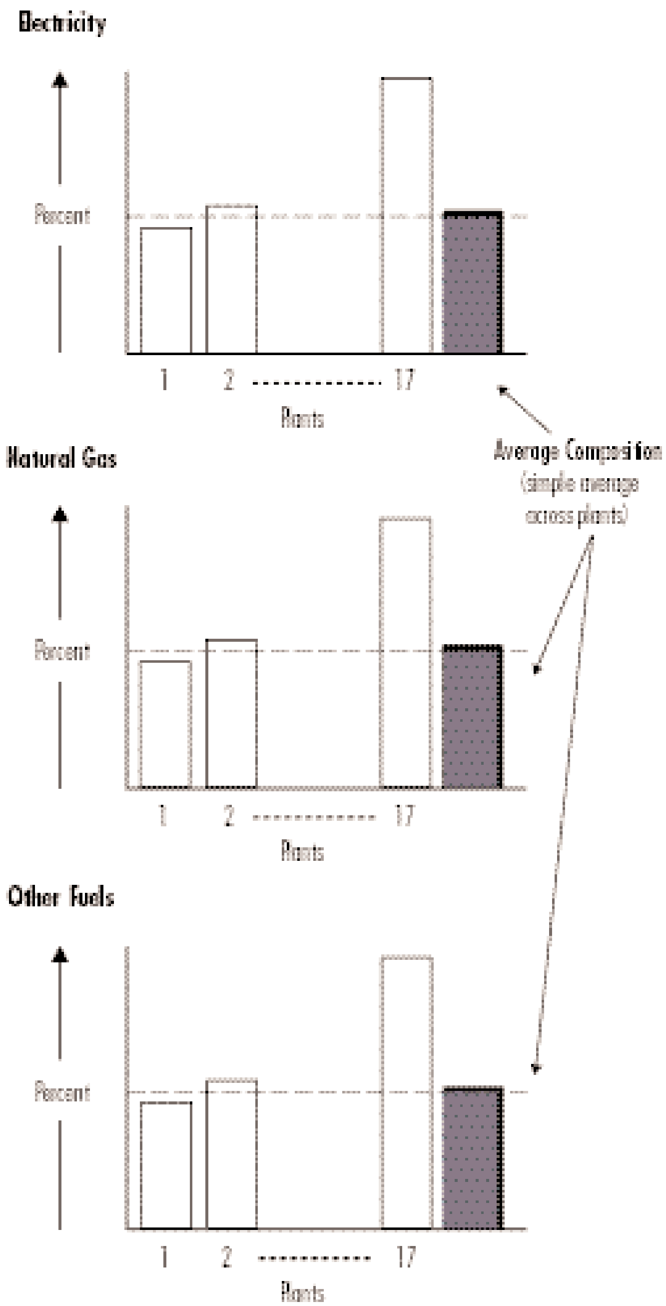


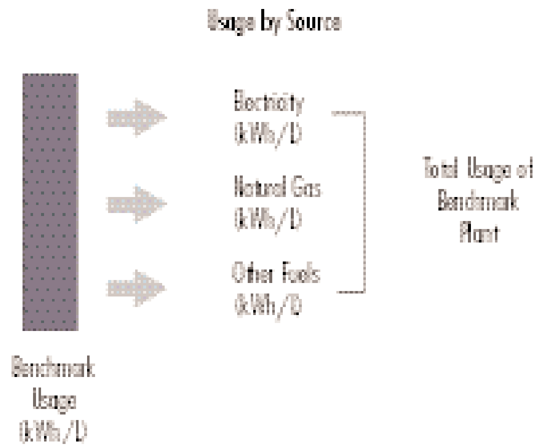
3.6.2. Benchmarking: Energy Composition

Having established the benchmark usage, the next challenge was to determine the energy composition of the benchmark. This composition was established based on a "simple average" of the 17 participants in the study. Three energy sources were used: electricity, natural gas and other fuels (including bunker C, light fuel oil and propane).

3.6.3. Benchmarking: Usage by Energy Source

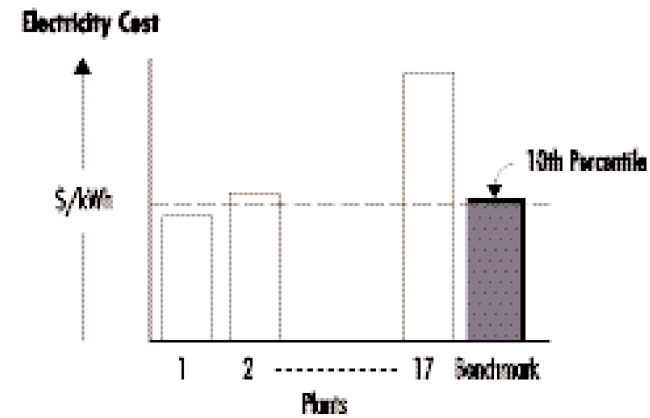
The benchmark for usage by energy source was determined based on the benchmark usage and composition described in the preceding. Subdividing benchmark data by source is necessary for establishing benchmark unit costs, as described in the following diagram:

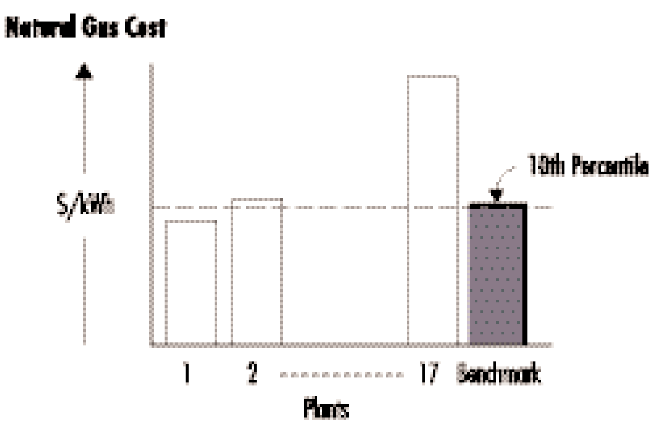


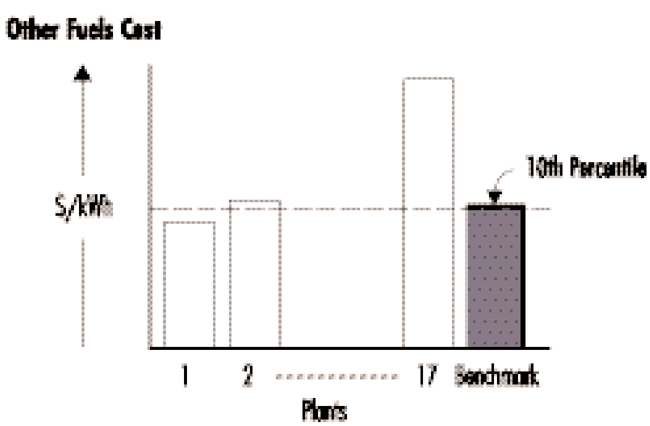


3.6.4. Benchmarking: Unit Energy Costs

The benchmark unit costs by energy source were established at the 10th percentile of the costs of the plants actually using the energy.

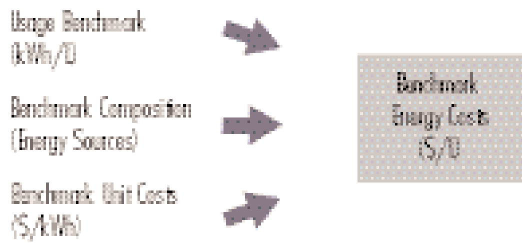






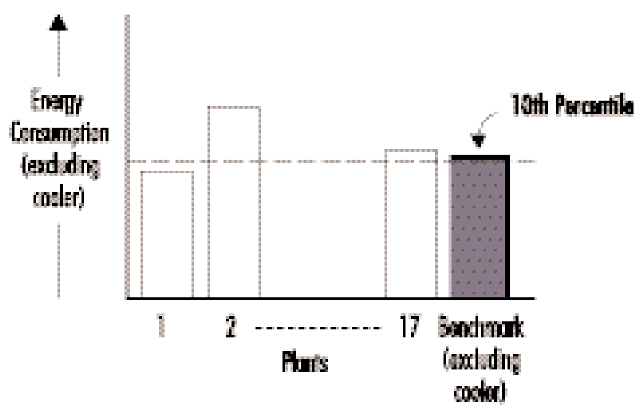
3.6.5. Benchmarking: Total Energy Costs

The unit costs, usage and compositions in the preceding sections were used to arrive at the benchmark energy cost. The following diagram shows this approach:



3.6.6. Benchmarking Energy Usage: Excluding Cooling (Refrigeration)

Coolers are used for different purposes in different plants. In some cases, coolers serve only as temporary storage of fluid milk products before these products are transferred to warehouses for further distribution. Other plants use their coolers as principal distribution centres. In addition, plants store other dairy and non-dairy products in their coolers. Purposes varied so much that it was impossible to break down cooler energy consumption. Therefore, another set of benchmarks for total plant energy consumption – excluding the cooler – was established as follows:



3.6.7. Benchmark Energy Usage: Stage of Production and Plant Services

Benchmark targets were established for five stages of production and three categories of plant services. The energy use targets were based on subdividing the above total energy use target supported by the evidence from the 17 plants.

Table B
Benchmarking by Stage of Production

Stage of Production	Energy Use (kWh/L)
Receiving	xx
Separation	xx
Homogenization/ Pasteurization	xx
Filling	xx
Cooler*	xx
Plant Services	
Cleaning-in-Place (CIP)	xx
HVAC	xx
Other**	xx
TOTAL	XXX ← Plant Benchmark

* Cooler use differs significantly between plants; comparisons between plants should therefore be made with caution.

** Includes ice coil, transfers, and case receiving and washing.

3.7. Plant-Level Analyses

The principal analyses at the total plant level involved comparing the participants' energy consumption (kWh equivalents) and energy costs ($/kWh) to the benchmarks, as shown in Figures 3.7 and 3.8.

Figure 3.7
Energy Consumption: Plant Level

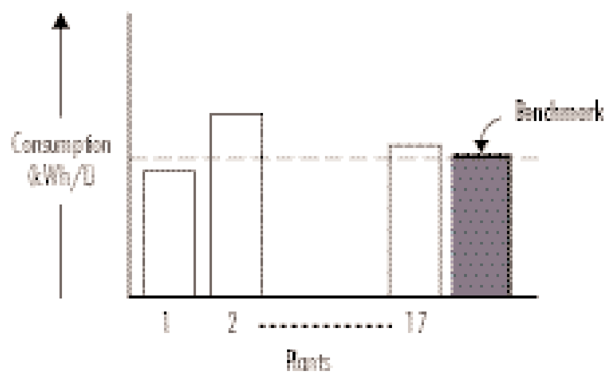
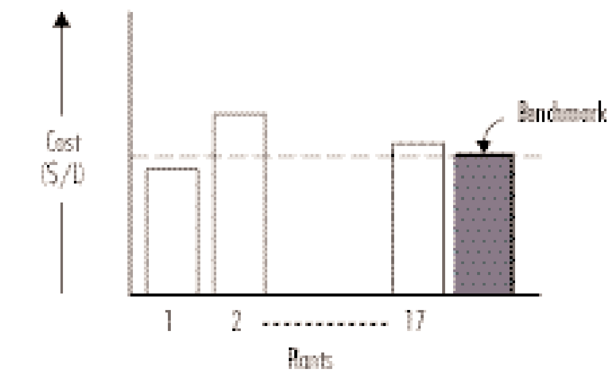


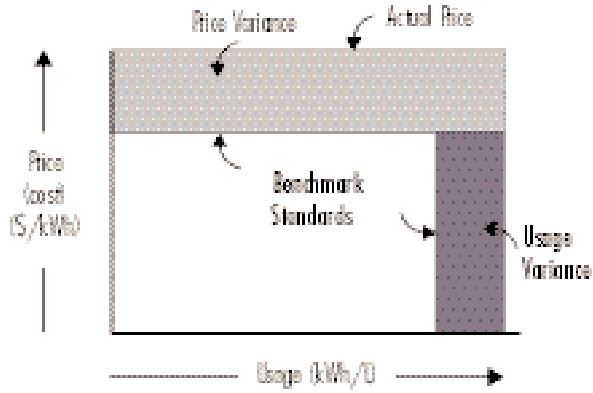
Figure 3.8
Energy Cost: Plant Level



The above results are presented with and without the cooler, given that it fulfils different roles in different plants.

A variance analysis documented the costs of failing to achieve benchmark standards. These cost variances were subdivided into a usage (i.e. energy consumption) variance and a price (cost) variance. The variance analysis is illustrated in Figure 3.9.

Figure 3.9
Variance Analysis



3.8. Intra-Plant Analyses

As described earlier, the energy usage and costs within plants were divided into five stages of production and three plant level services. In all cases, the usage (energy consumption – kWh/L) and cost ($/L) were compared with the benchmarks, as shown in Figures 3.10 and 3.11.

Figure 3.10
Usage or Energy Consumption

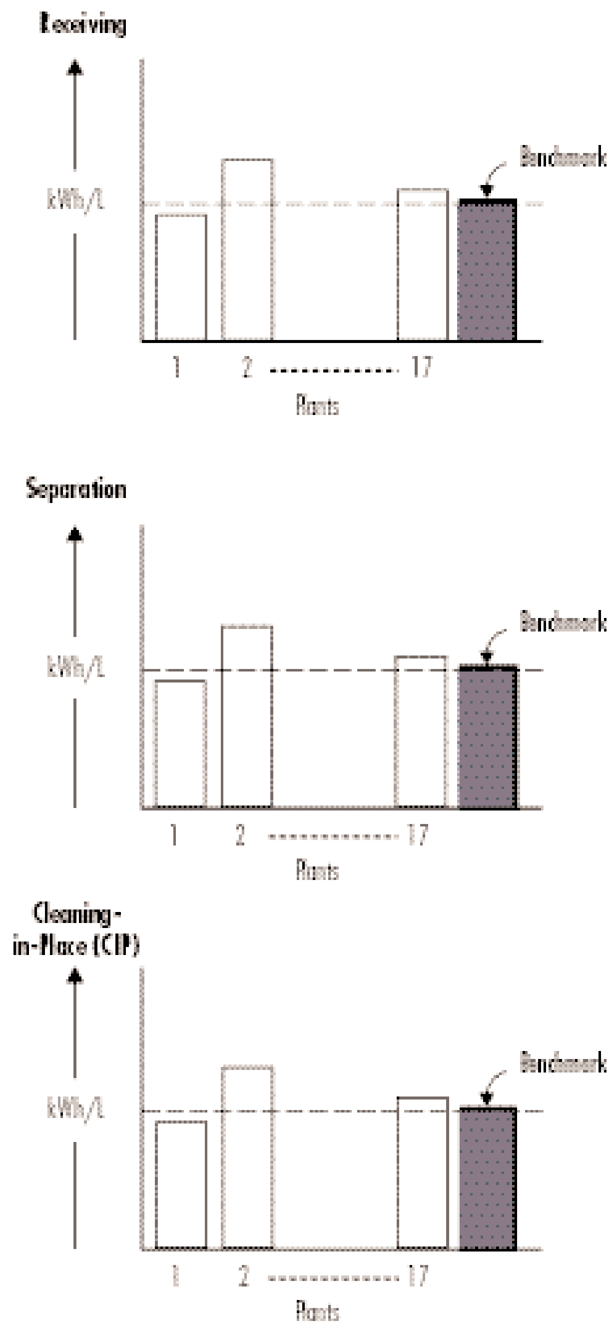
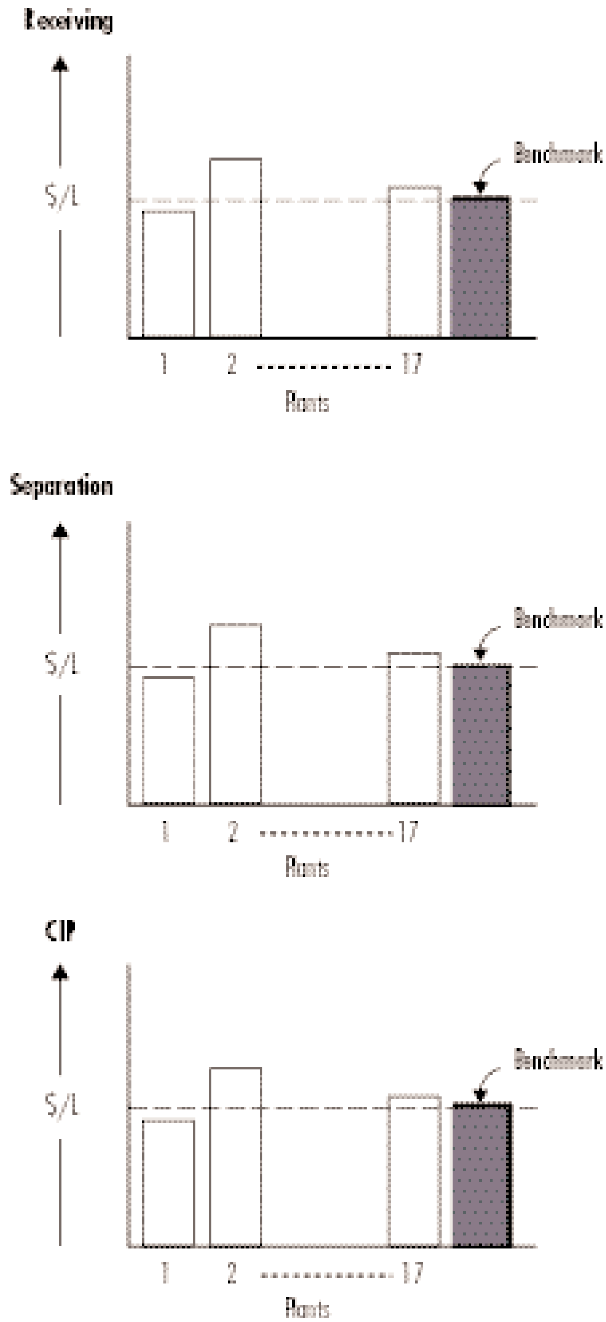
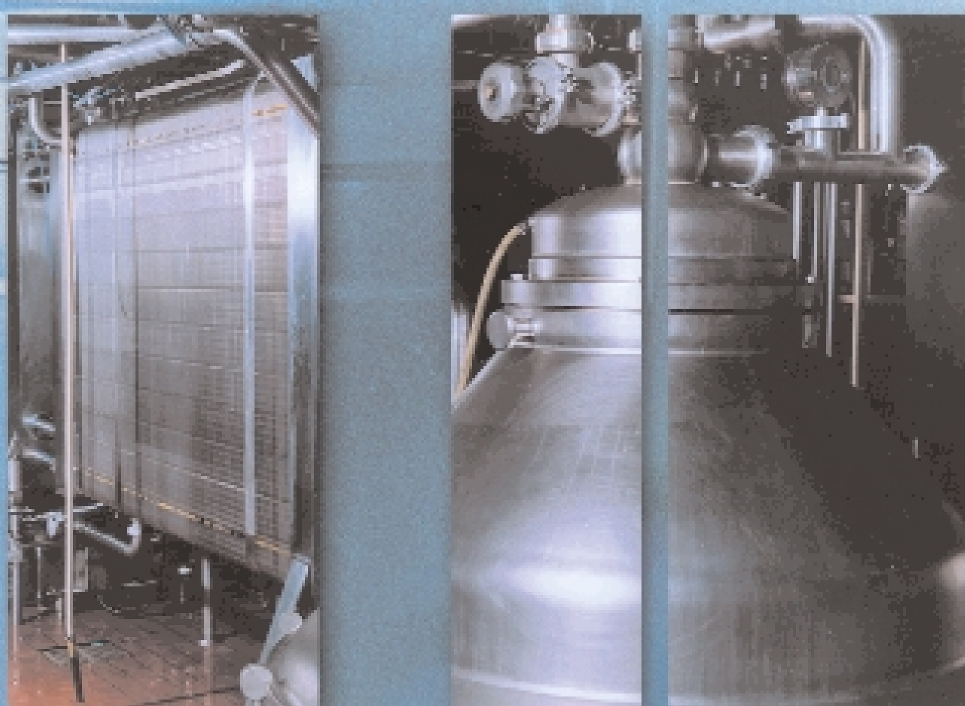


Figure 3.11
Energy Cost ($/L)



4.
Results



4. Results

4.1. Benchmarking

(a) Total Plant Usage (kWh/L)

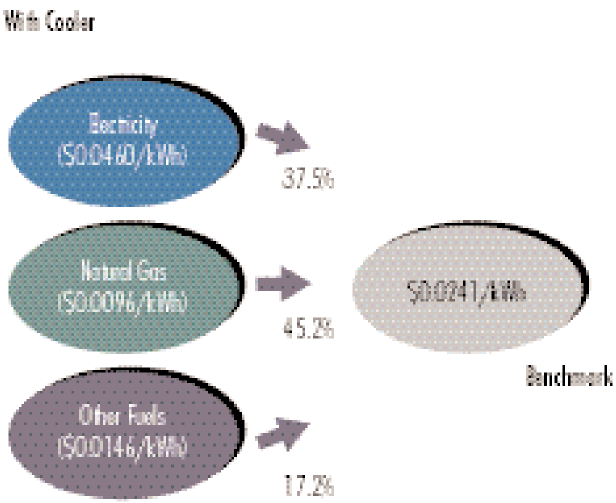
The benchmark energy usage target was 0.1183 kWh/L. This usage reflected the 10th percentile of the plants in the sample.

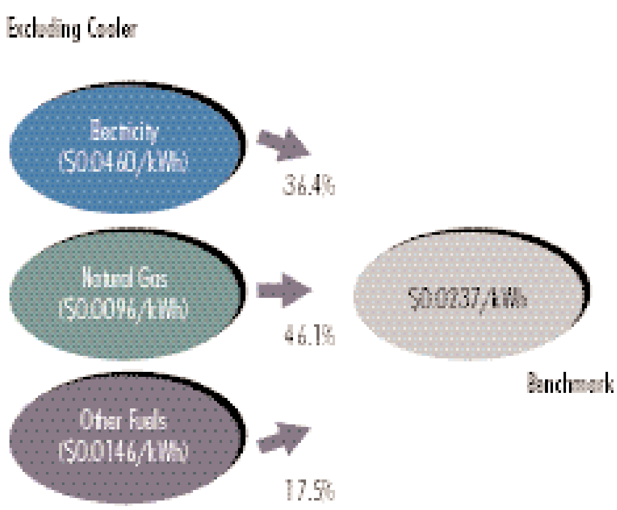
(b) Plant Usage Excluding Coolers (kWh/L)

The benchmarking target for the total plant, excluding the coolers, was 0.1162 kWh/L (i.e. 0.1183 minus 0.0021)

(c) Energy Unit Cost ($/kWh)

The energy unit cost benchmark was determined to be $0.0241/kWh with the cooler and $0.0237/kWh excluding the coolers, as illustrated below.





The difference in the benchmarks results from a change in energy composition.

(d) Benchmarking Usage by Stage of Production

The following benchmarks by stage of production were established:

Stage of Production	Energy Usage (kWh/L)
Receiving	0.0050
Separation	0.0050
Homogenization/ Pasteurization	0.0526
Filling	0.0100
Cooler	0.0021
Plant Services	
Cleaning-in-Place (CIP)	0.0300
HVAC	0.0050
Other*	0.0086
TOTAL	**0.1183**

* Includes ice coil, transfers, and case receiving and washing.

4.2. Plant-Level Analyses

The analyses at the plant level involved comparing the data for the 17 plants with the above benchmark targets. The plant-level analyses describe the following:

- total plant energy consumption;
- total plant energy consumption excluding the cooler;
- total energy unit costs for electricity, natural gas and other fuels; and
- energy costs for fluid milk products.

In addition, this report analyses the variances in unit costs from benchmark targets attributed to consumption (i.e. energy efficiency) and unit costs (i.e. difference in unit costs).

Table C below establishes the factors used to convert all energy to kWh in the comparisons to follow.

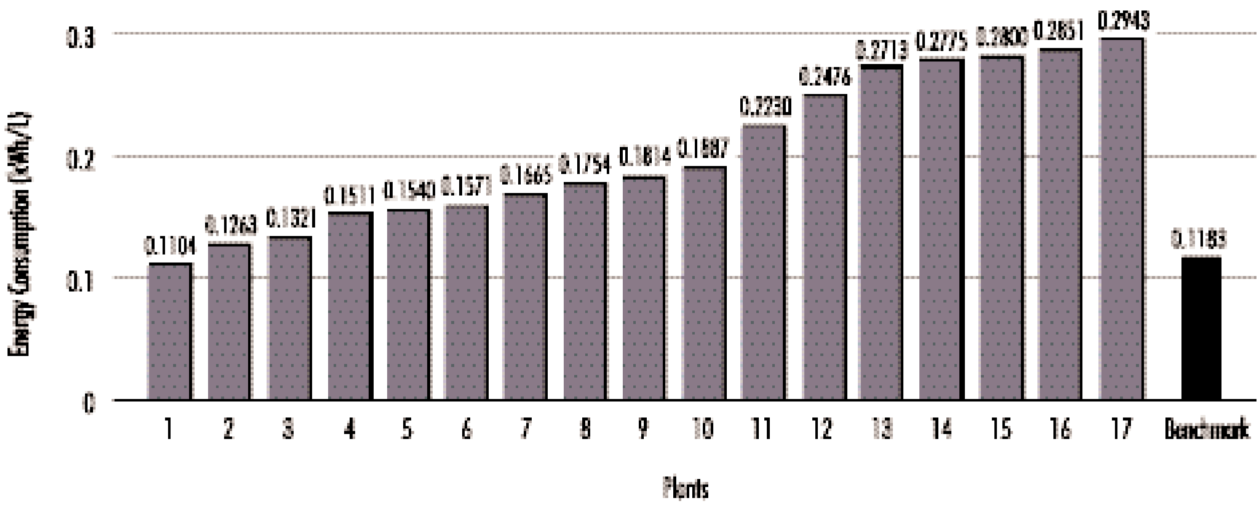
Table C
Energy Conversion Factors

Fuel Type	Unit	kWh Equivalent
Electricity	kWh	1.00
Natural Gas	m^3	10.58
Propane	m^3	7.09
Liquefied Petroleum Gas (LPG)	kg	13.78
Light Fuel Oil	L	10.74
Diesel	L	11.67
Heavy Fuel Oil	L	11.59

4.2.1. Plant Consumption (Energy Efficiency)

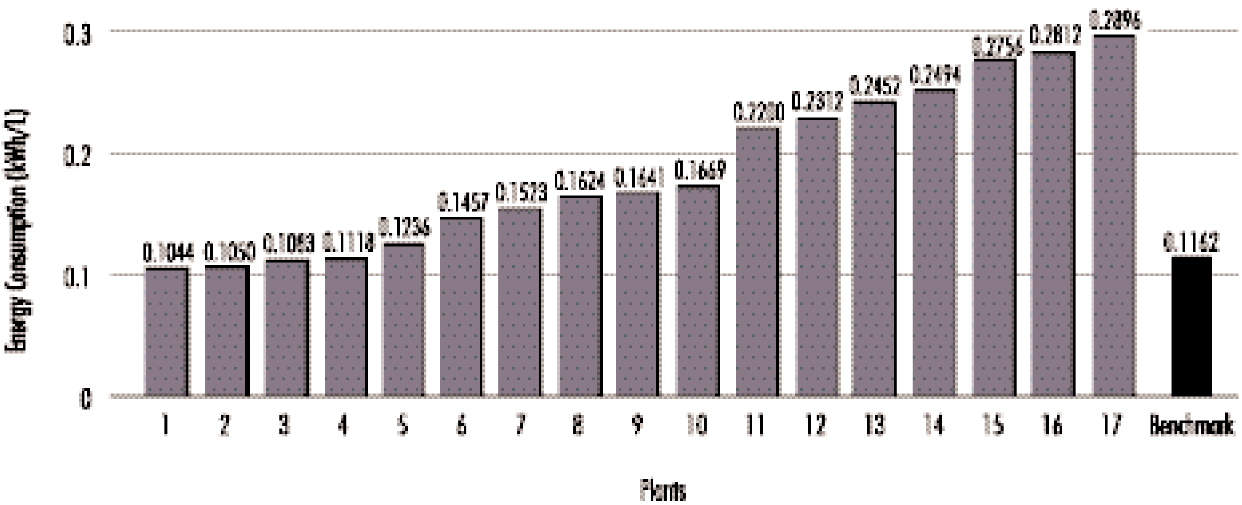
The energy efficiencies for the total plant were determined, based on the total plant and the total plant excluding the cooler. See Figures 4.1 and 4.2.

Figure 4.1
Total Plant Energy Consumption* (kWh/L)



* In all charts, the plants are ordered from the lowest to the highest; hence, there is not necessarily any continuity of numbering between charts.

Figure 4.2
Energy Consumption: Total Plant Excluding Cooler (kWh/L)

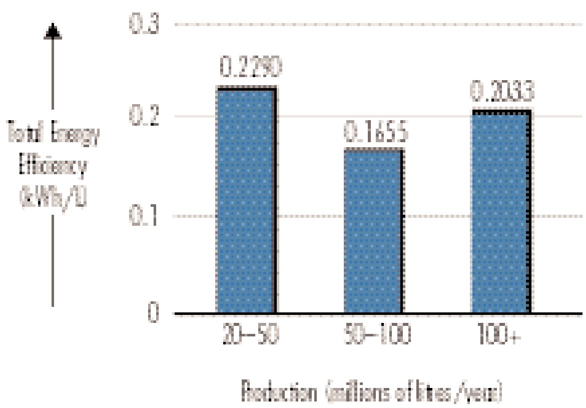


As illustrated above, energy consumption varies significantly among plants – from 0.1104 to 0.2943 kWh/L for the total plant, and from 0.1044 to 0.2896 kWh/L for the plant excluding the cooler.

Unit energy consumption varies from 90 percent to 275 percent of the benchmark levels.

It was anticipated that the results could illustrate economies of scale in energy usage. The results of comparing unit energy consumption with the throughput are illustrated in Figure 4.3.

Figure 4.3
Energy Efficiency: Economies of Scale



Energy costs do not exhibit the economies of scale normally found in fluid milk plant analyses; however, energy makes up only a small percentage of total costs.

4.2.2. Energy Mix

The surveyed plants use different complements of energy sources. The differences between plants are described below for electricity, natural gas and other fuels (such as bunker C, light fuel oil and propane).

Electricity

Electricity represents a significant percentage of total energy for all plants. The proportion of total plant energy usage devoted to electricity (on an equivalent kWh basis) ranged from 21.9 to 54.7 percent, as illustrated in Figure 4.4.

Figure 4.4
Electricity Consumption
(percent of total plant kWh from electricity)

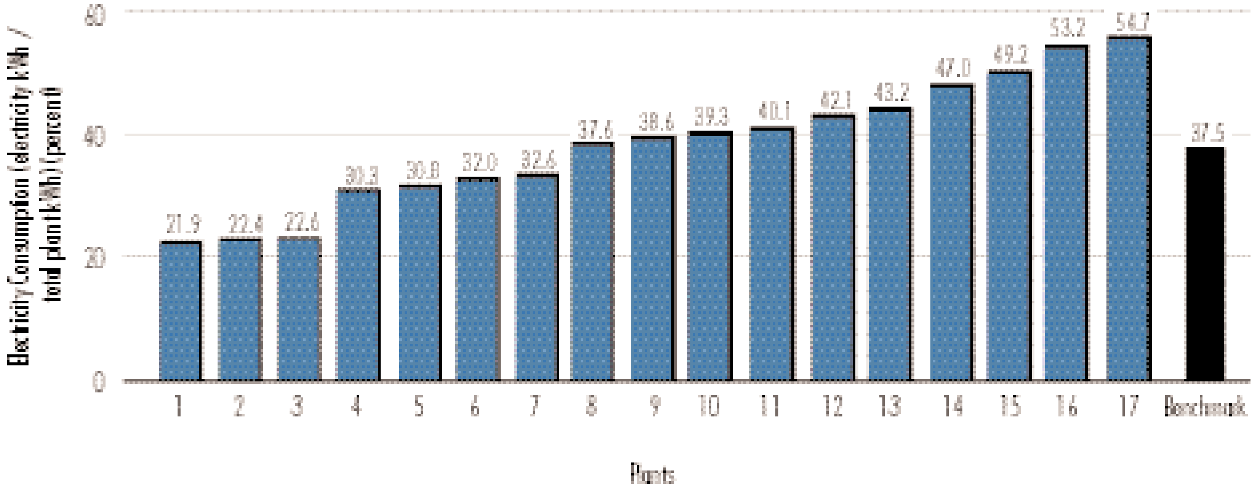
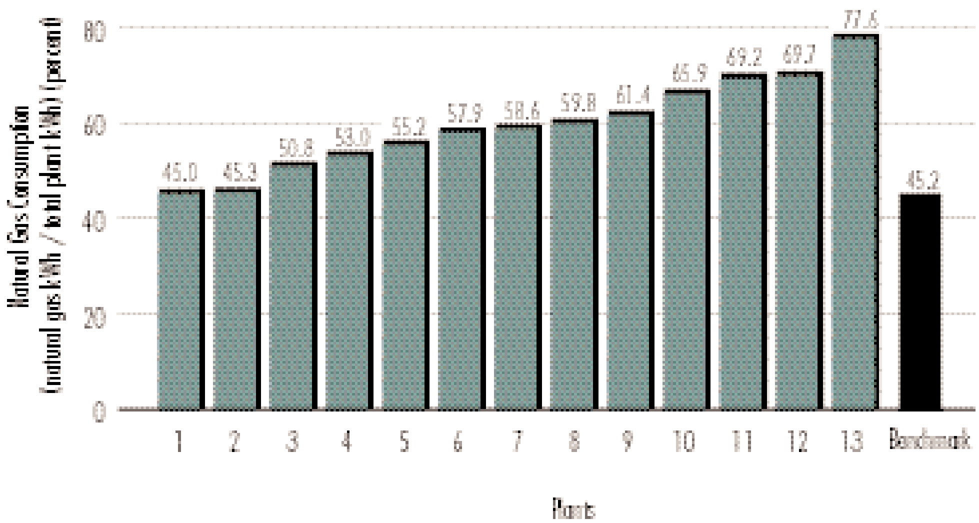


Figure 4.5
Natural Gas Consumption
(percent of total plant kWh from natural gas)



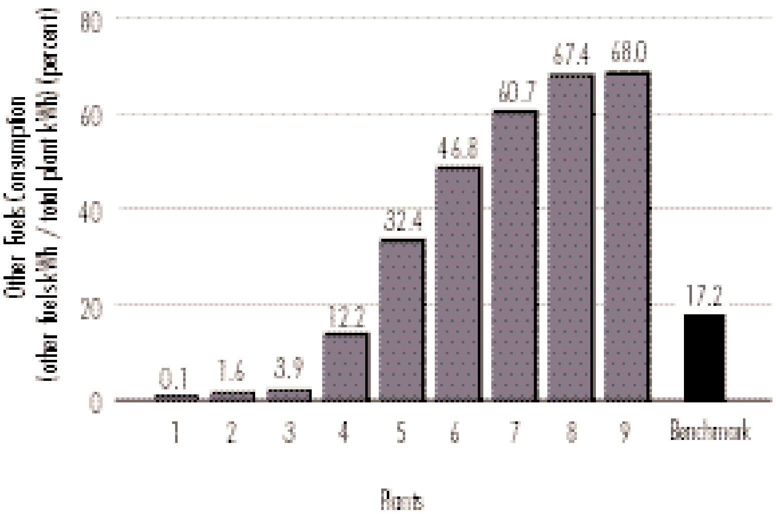
Natural Gas

Natural gas was used by 13 of the 17 plants. Natural gas as a percentage of total plant energy usage (on an equivalent kWh basis) varied from 45.0 to 77.6 percent, as illustrated in Figure 4.5.

Other Fuels

Nine of the 17 plants used other fuels (including bunker C, light fuel oil and propane). Usage of other fuels as a percentage of total plant energy usage (on an equivalent kWh basis) varied from 0.1 percent to 68.0 percent, as illustrated in Figure 4.6.

Figure 4.6
Other Fuels Consumption
(percent of total plant kWh from other fuels)



4.2.3. Energy Unit Costs

The unit costs differed significantly among plants. These differences existed for the total complement of energy and the unit costs of electricity, natural gas and other fuels.

Weighted Average Unit Energy Costs

Unit energy costs varied by both fuel type and plant. An average utility rate for each plant was calculated by weighting the specific unit energy costs for electricity, natural gas and other fuels based on their relevant equivalent kWh consumption. The benchmark rate was set at $0.0241/L (the 10th percentile). The weighted average unit energy costs ranged from a low of $0.0178/kWh to a high of $0.0455/kWh, as illustrated in Figure 4.7.

Figure 4.7
Weighted Average Unit Energy Costs ($/kWh)

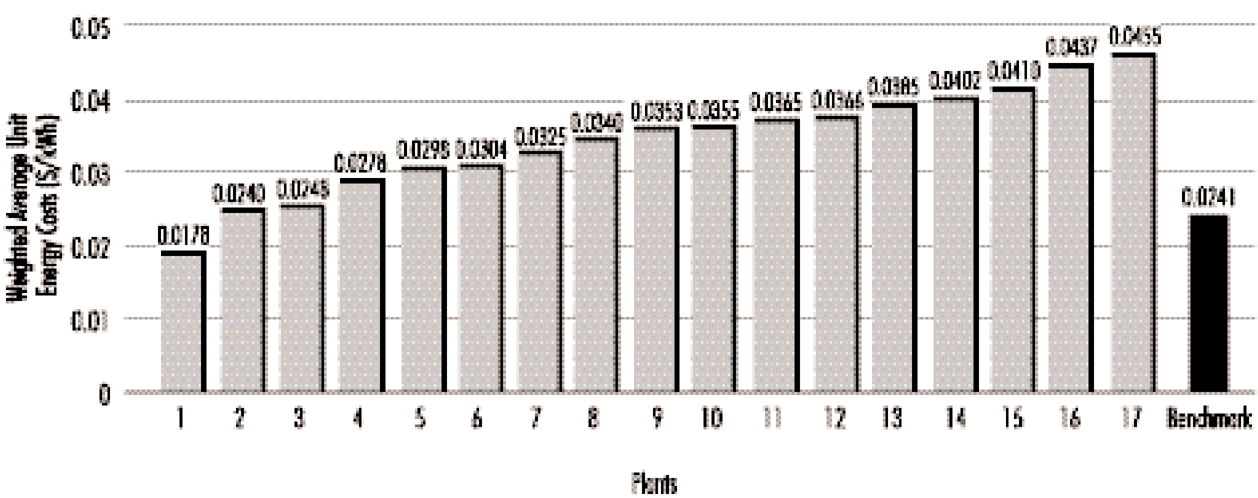
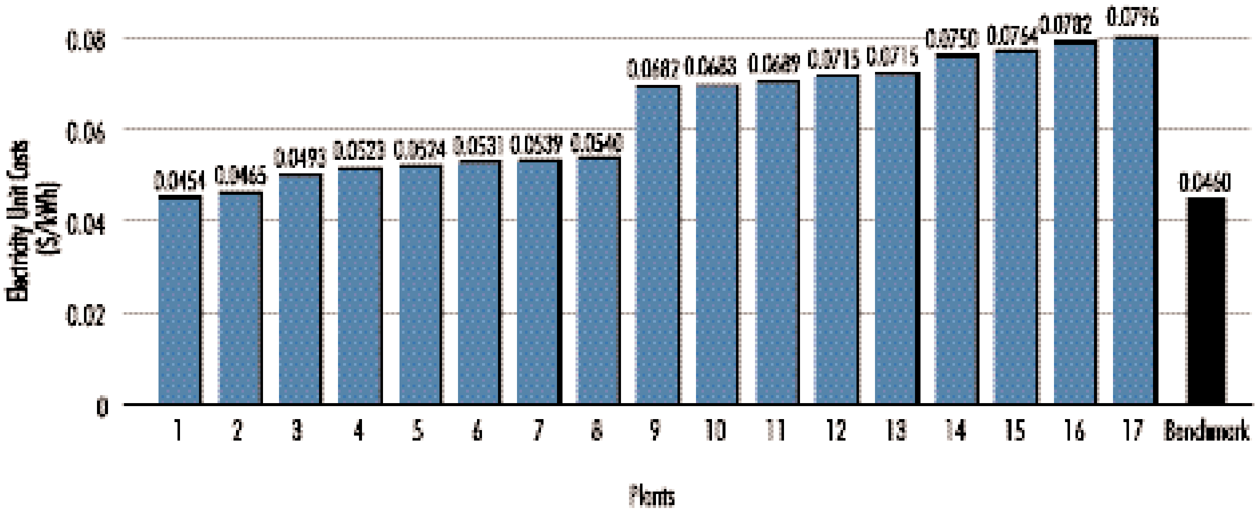


Figure 4.8
Electricity Unit Costs ($/kWh)



Electricity Unit Costs

Electricity unit costs varied from a low of $0.0454/kWh to a high of $0.0796/kWh. The benchmark rate was set at $0.0460/kWh, as shown in Figure 4.8.

Natural Gas Unit Costs

Natural gas unit costs, on an equivalent kWh basis, varied significantly among the 13 plants that used natural gas, from a low of $0.0094/kWh to a high of $0.0205/kWh ($0.0999/m^3 to $0.2172/m^3). The benchmark rate was set at $0.0096/kWh or $0.1018/m^3, as shown in Figures 4.9 and 4.10.

Figure 4.9
Natural Gas Unit Costs ($/kWh)

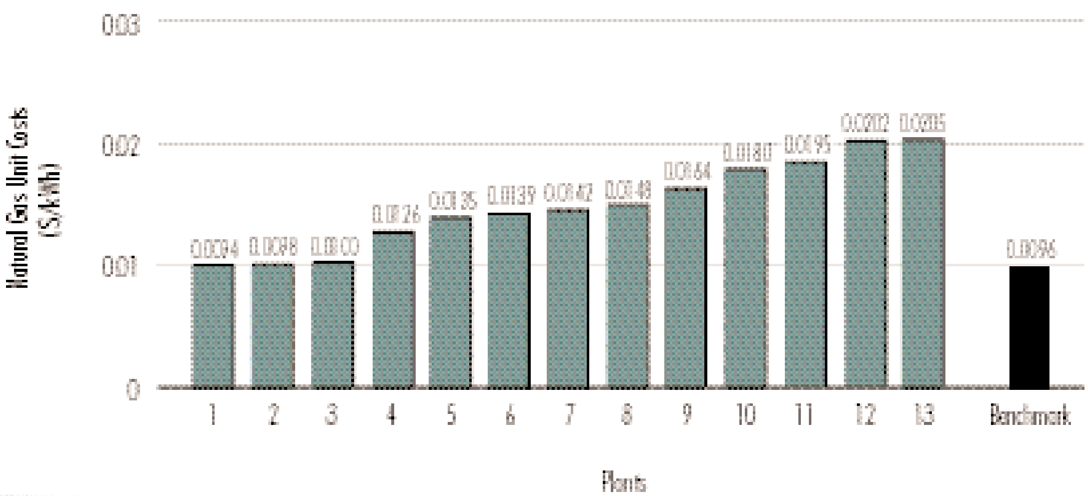


Figure 4.10
Natural Gas Unit Costs ($/m³)

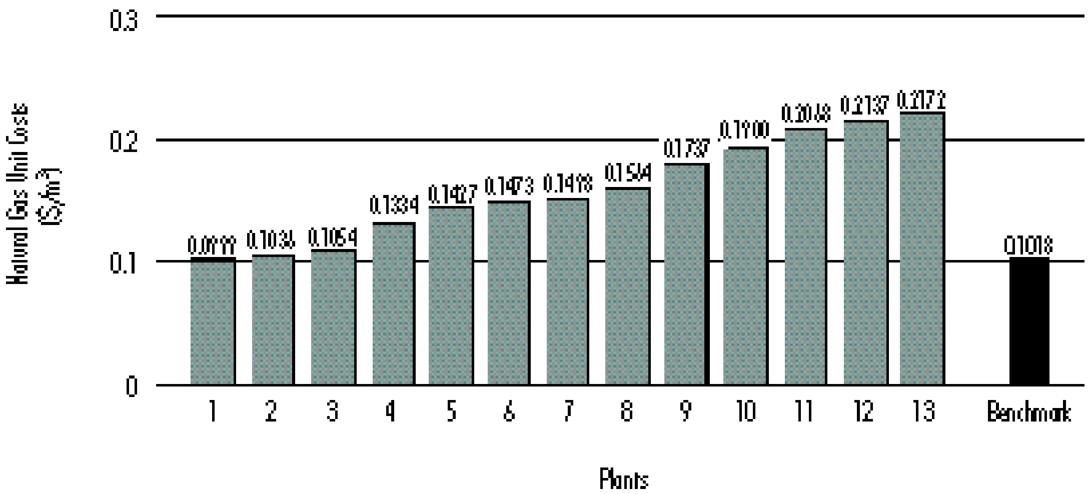
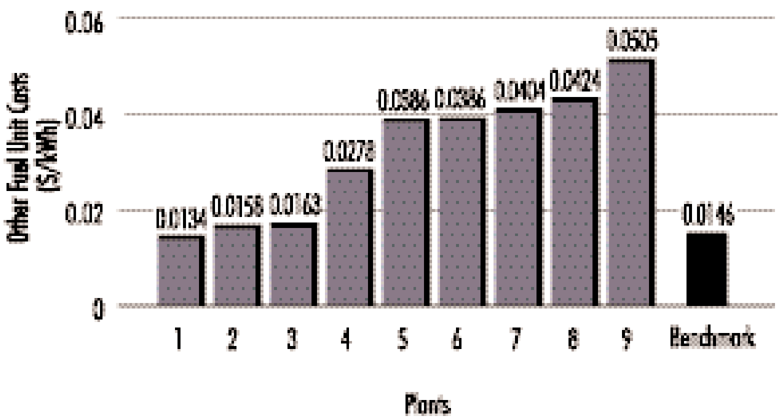


Figure 4.11
Other Fuel Unit Costs ($/kWh)



Other Fuel Unit Costs

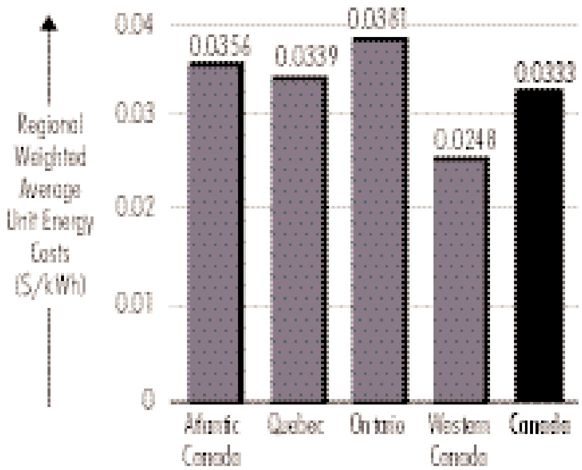
The unit costs of other fuels, on an equivalent kWh basis, varied widely among the nine plants that used these fuels, from a low of $0.0134/kWh to a high of $0.0505/kWh. The benchmark rate was set at $0.0146/kWh.

Regional Weighted Average Unit Energy Costs

There were also significant differences among regions in the unit costs. These differences existed for the total complement of energy and for the unit costs of electricity and natural gas.

Unit energy costs varied by plant location. The regional weighted average unit energy costs varied from a low of $0.0248/kWh in western Canada to a high of $0.0381/kWh in Ontario, as illustrated in Figure 4.12.

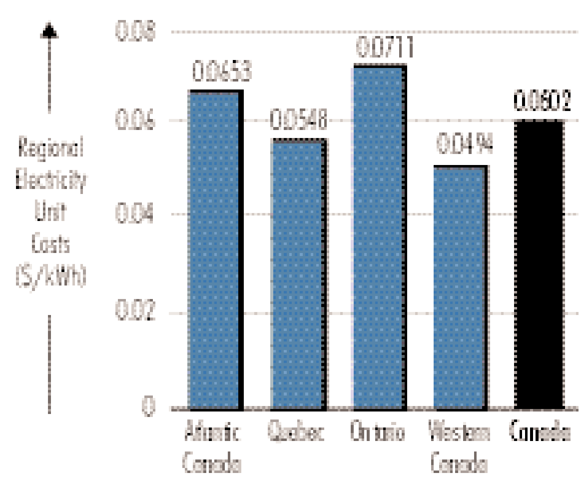
Figure 4.12
Regional Weighted Average Unit Energy Costs ($/kWh)



Regional Electricity Unit Costs

Electricity unit costs varied by region, from a low of $0.0494/kWh in western Canada to a high of $0.0711/kWh in Ontario.

Figure 4.13
Regional Electricity Unit Costs ($/kWh)



Regional Natural Gas Unit Costs

Natural gas unit costs, on an equivalent kWh basis, varied by region, from a low of $0.0127/kWh ($0.1341/m³) in western Canada to a high of $0.0162/kWh ($0.1717/m³) in Quebec.

Figure 4.14
Regional Natural Gas Unit Costs ($/kWh)

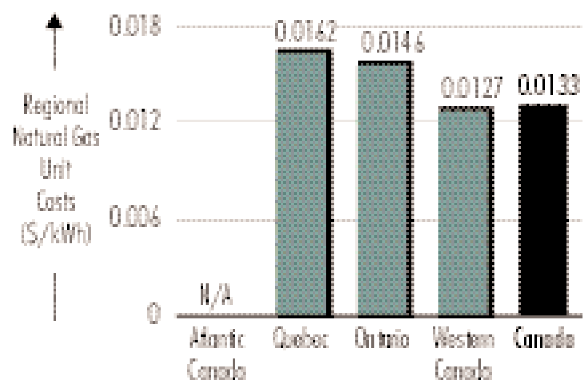
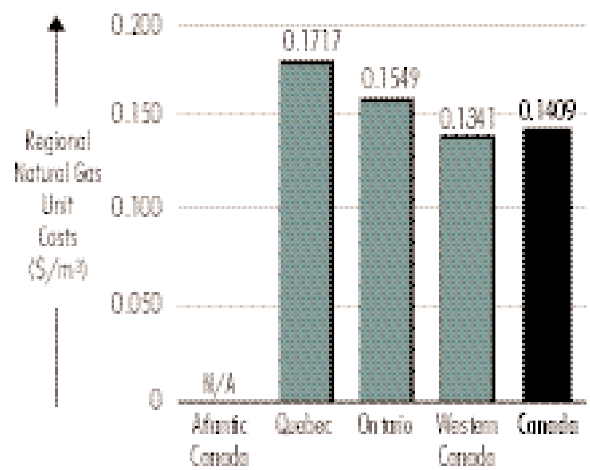


Figure 4.15
Regional Natural Gas Unit Costs ($/m³)



4.2.4. Energy Unit Costs: Fluid Milk Products

The total energy costs per unit of fluid milk products were calculated on two bases: for the total plant and for the total plant excluding the cooler.

The energy costs for each plant were derived from the weighted average of consumption and the unit costs by energy source. The energy costs by plant are illustrated in Figures 4.16 and 4.17.

4.2.5. Variance Analysis

Having established the energy costs for the plants, the differences attributed to energy efficiency (consumption) and energy cost (price) were analysed.

The total energy costs of the 17 plants were compared with the benchmark plant's total energy costs of $0.0028/L, for production requirements excluding refrigeration and cold storage. Total variances ranged from a negative variance of $0.0004/L to a high of $0.0084/L, as illustrated in Figure 4.18.

Figure 4.16
Total Energy Costs ($/L)

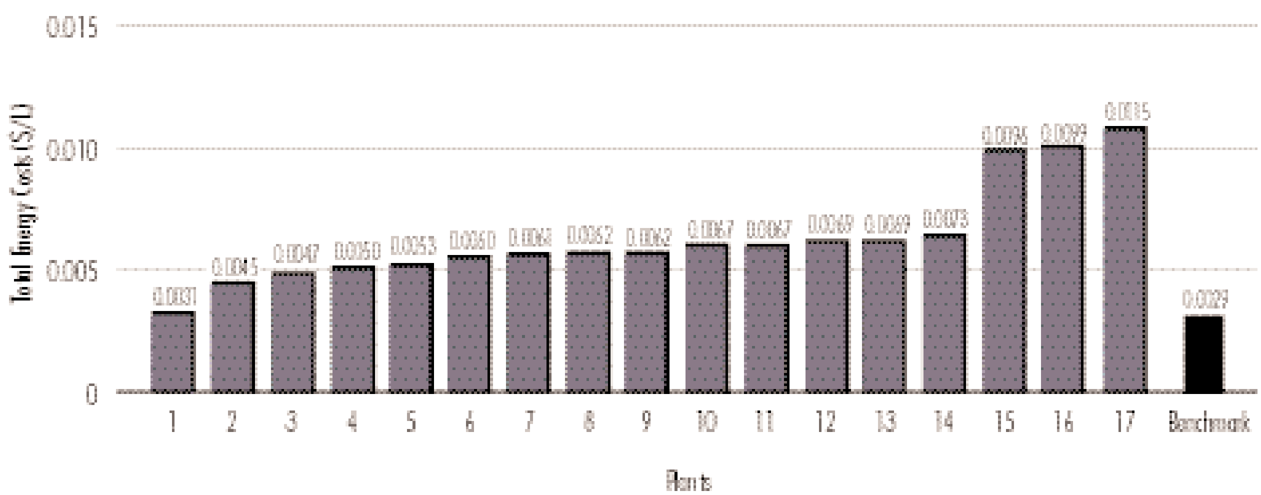


Figure 4.17
Total Energy Costs
Excluding Refrigeration and Cold Storage ($/L)

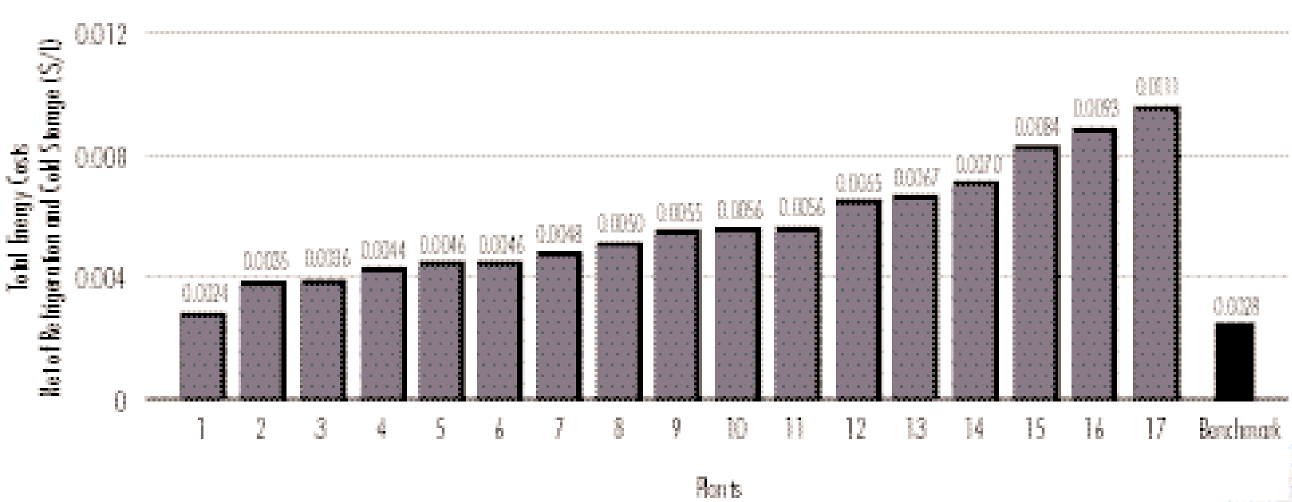
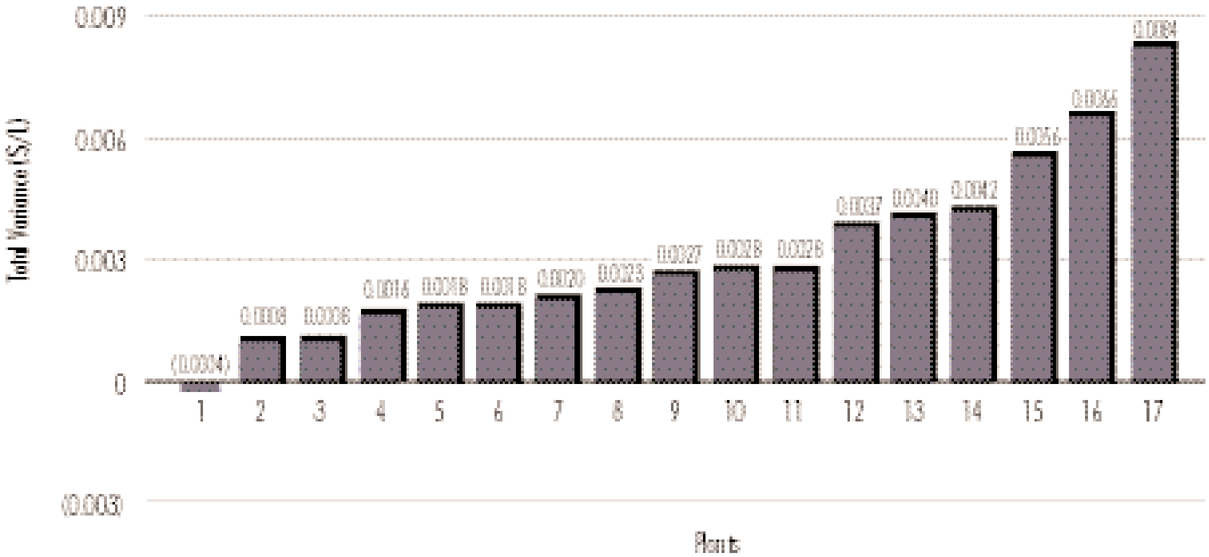


Figure 4.18
Total Variances ($/L)



The above total variances for energy were subdivided into the following:

- Usage variance – reflects the difference between a plant's usage and the benchmark usage (0.1162 kWh/L). This usage variance was valued at the benchmark cost ($0.0237/kWh).
- Price variance – reflects the difference between the cost (price) to the plant and the benchmark price ($0.0237/kWh). This price variance was based on the plant's actual usage.

The determination of the variances for energy is illustrated in Figure 4.19.

Figure 4.19
Price and Usage Variances

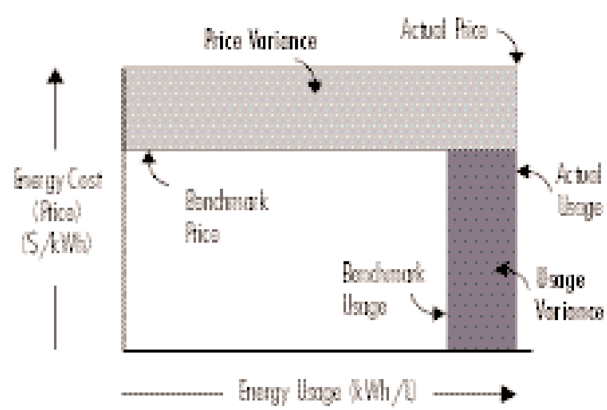


Figure 4.20
Usage Variances ($/L)

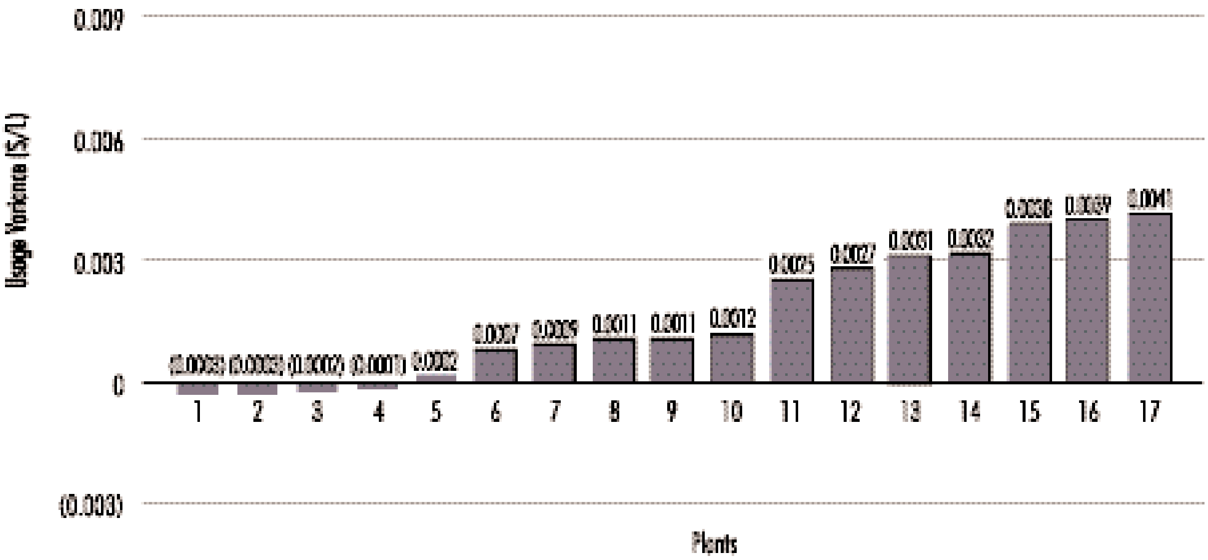
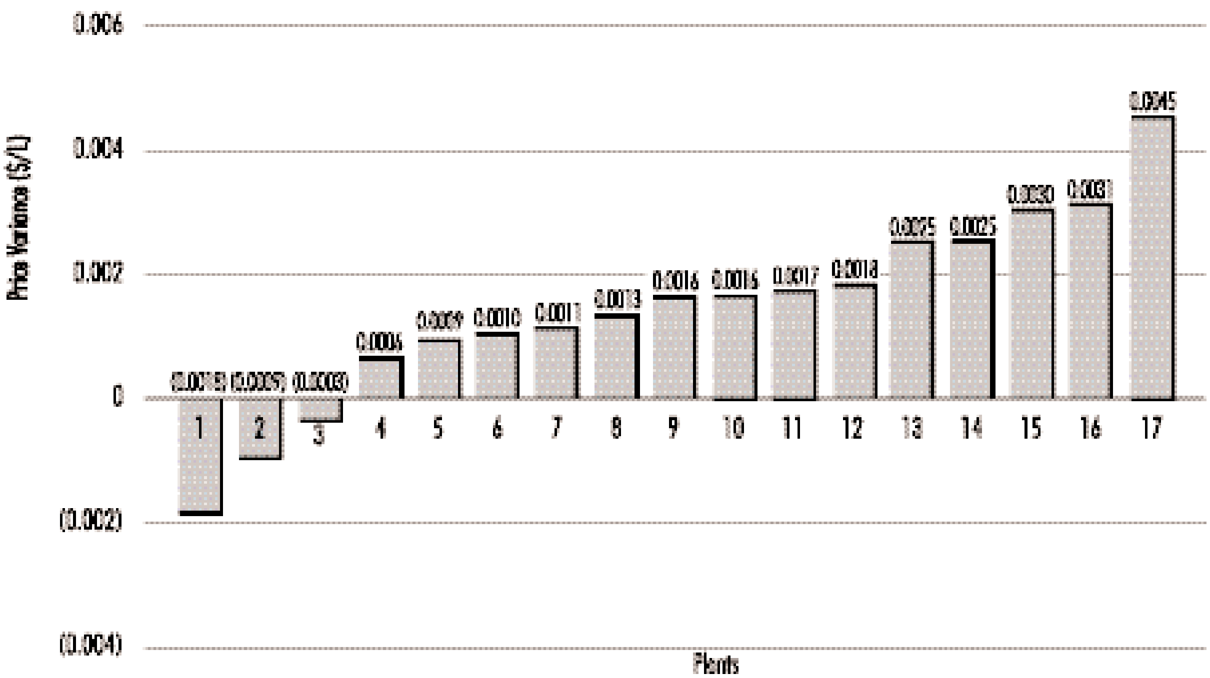


Figure 4.21
Price Variances ($/L)



Usage Variances

Usage variances ranged from a negative variance (i.e. below benchmark usage) of $0.0003/L to a positive variance (i.e. above benchmark usage) of $0.0041/L, as illustrated in Figure 4.20.

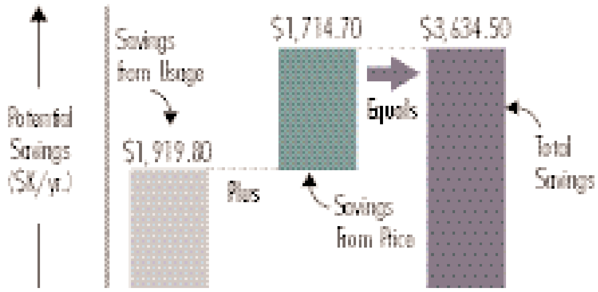
Price Variances

Price variances resulted from the difference between a plant's actual unit energy costs and the benchmark's unit energy costs. Price variances ranged from a negative variance of $0.0018/L to a positive variance of $0.0045/L, as illustrated in Figure 4.21.

Potential Savings to Participants

The above variances represent significant annual potential savings for the 17 plants, as estimated in Figure 4.22.

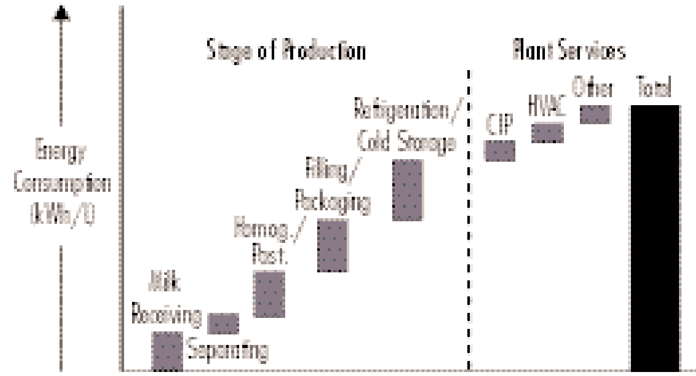
Figure 4.22
Potential Total Savings: Attaining Benchmark Levels



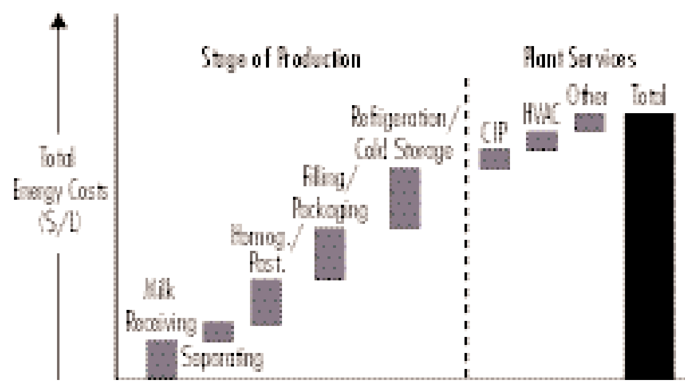
4.3. Analyses by Stage of Production

To expand our understanding of energy consumption in dairy plants, the study segmented energy usage and the corresponding cost of that energy into stages of production. Electricity allocations were based on horsepower requirements and hours of operation at the various stages of production. Compressed-air allocations were based on percentage of time used. Allocations for natural gas and other fuels were based on the percentage of use for steam.

First, energy consumption was broken down into the following stages of production:



Second, the study developed total energy costs by stage of production. Energy consumption (kWh/L) by electricity, natural gas and other fuels was costed at their respective unit costs ($/kWh) to derive a measure of total energy costs by stage of production.



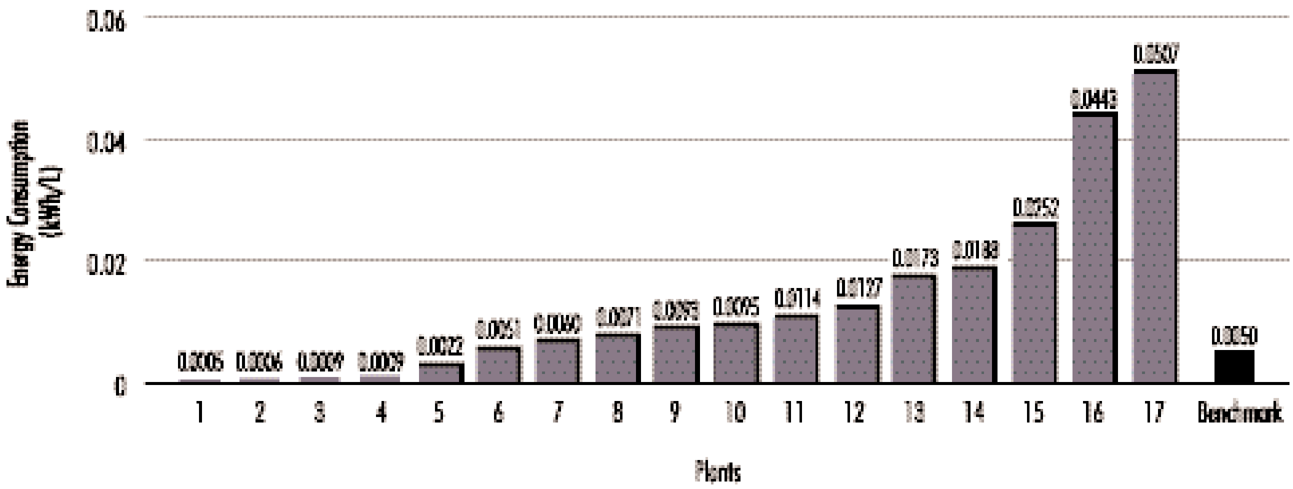
4.3.1. Energy Consumption (Energy Efficiency): Unit of Production

Next, energy consumption (efficiency) by the five stages of production and the three plant services was examined. The benchmark targets, outlined above, were compared with the individual plant operations. Following are the results.

The main energy-consuming activities at this stage of production are receiving, weighing and cooling milk; pumping milk into silos; and washing trucks. Total energy consumption at this stage for the 17 plants in the sample varied from a low of 0.0005 kWh/L to a high of 0.0507 kWh/L.

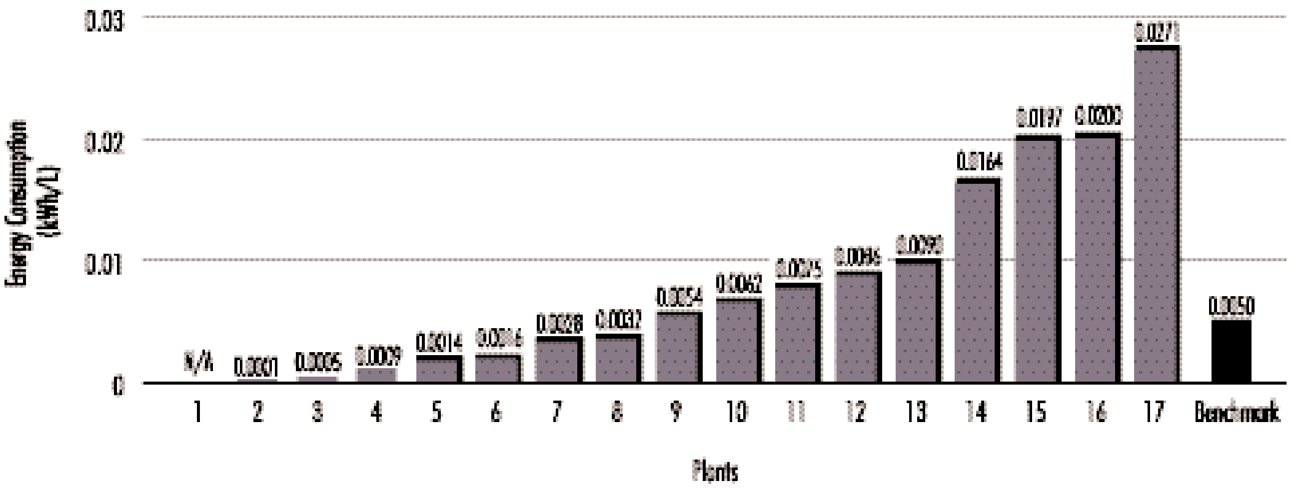
Milk Receiving: Energy Consumption

Figure 4.23
Total Energy Consumption: Receiving (kWh/L)



Separating: Energy Consumption

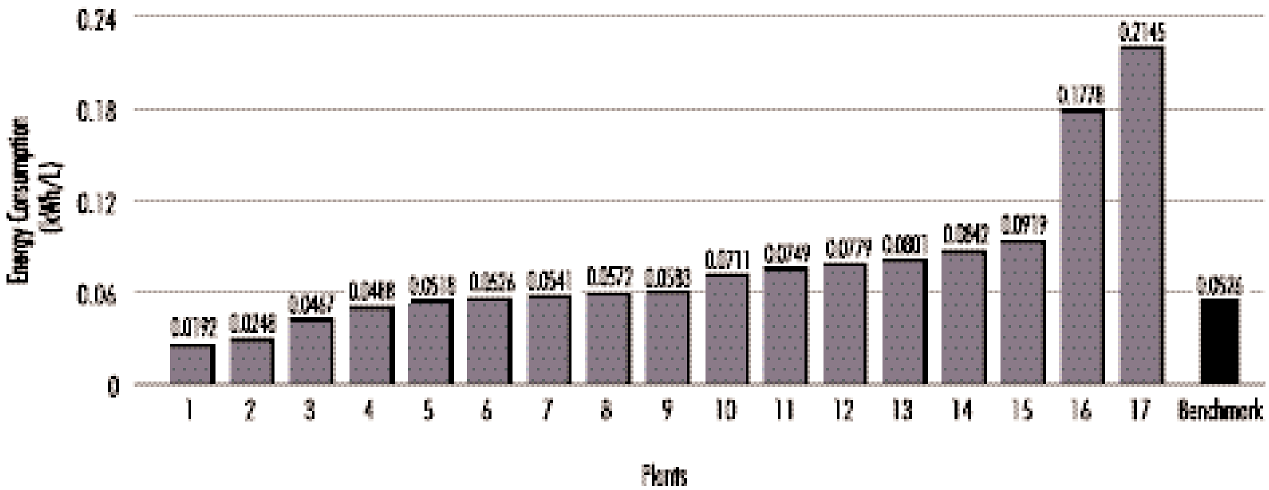
Figure 4.24
Total Energy Consumption: Separating (kWh/L)



The main energy-consuming activity at this stage of production is separating raw milk into its skim and cream components with a centrifugal separator. Total energy consumption at this stage for 16 plants in the sample varied from a low of 0.0001 kWh/L to a high of 0.0271 kWh/L. (One plant in the sample did not allocate energy consumption specifically to this stage of production.)

Homogenization and Pasteurization: Energy Consumption

Figure 4.25
Total Energy Consumption: Homogenization and Pasteurization (kWh/L)



Total energy consumption at this stage for the 17 plants in the sample varied from a low of 0.0192 kWh/L to a high of 0.2145 kWh/L.

Filling and Packaging: Energy Consumption

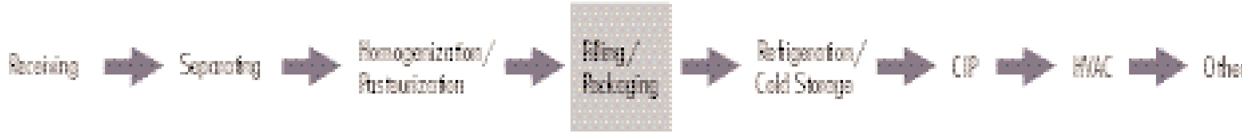
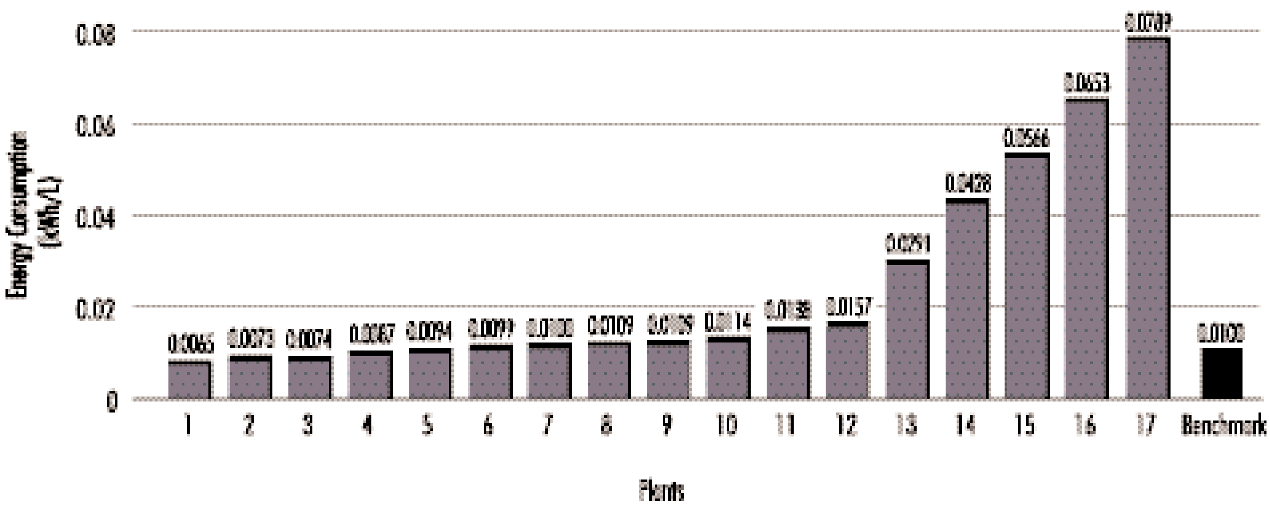


Figure 4.26
Total Energy Consumption: Filling and Packaging (kWh/L)



Total energy consumption at this stage for the 17 plants in the sample varied from a low of 0.0065 kWh/L to a high of 0.0789 kWh/L.

Refrigeration and Cold Storage: Energy Consumption

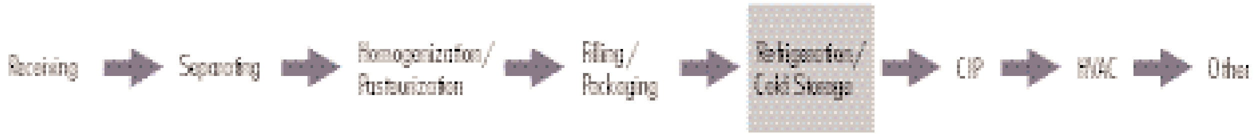
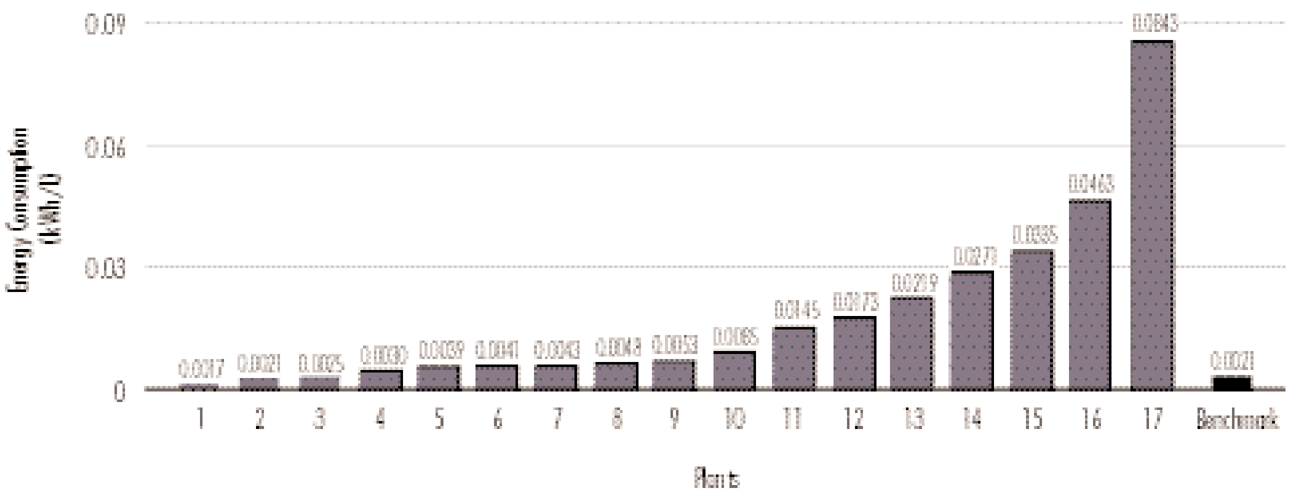


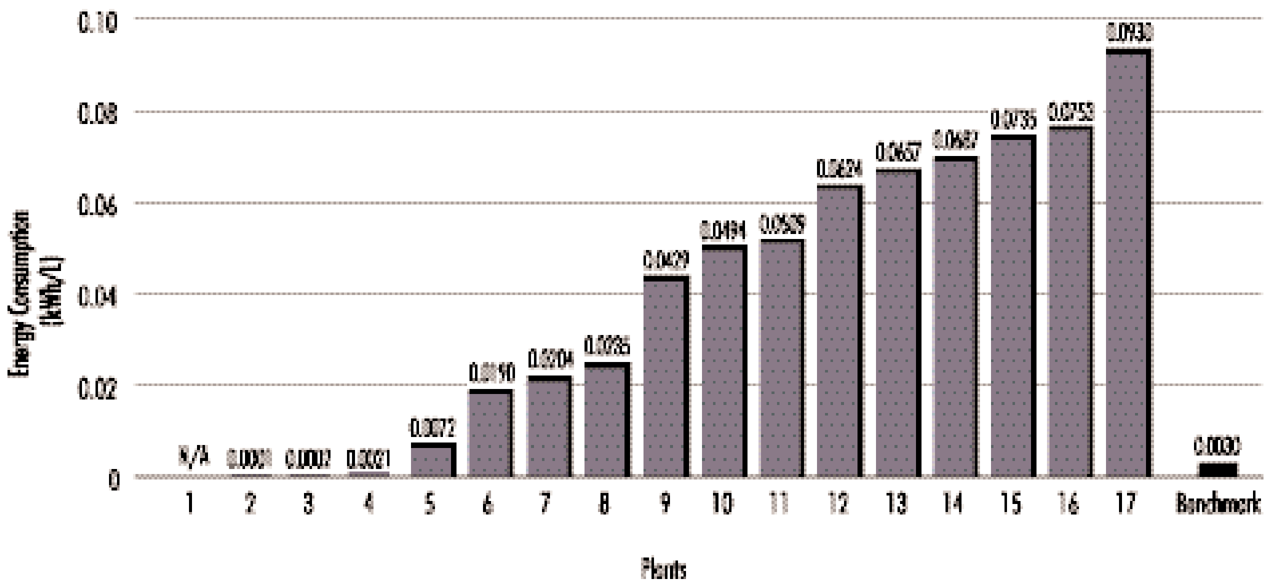
Figure 4.27
Total Energy Consumption: Refrigeration and Cold Storage (kWh/L)



Total energy consumption at this stage for the 17 plants in the sample varied from a low of 0.0017 kWh/L to a high of 0.0843 kWh/L.

Cleaning-in-Place (CIP): Energy Consumption

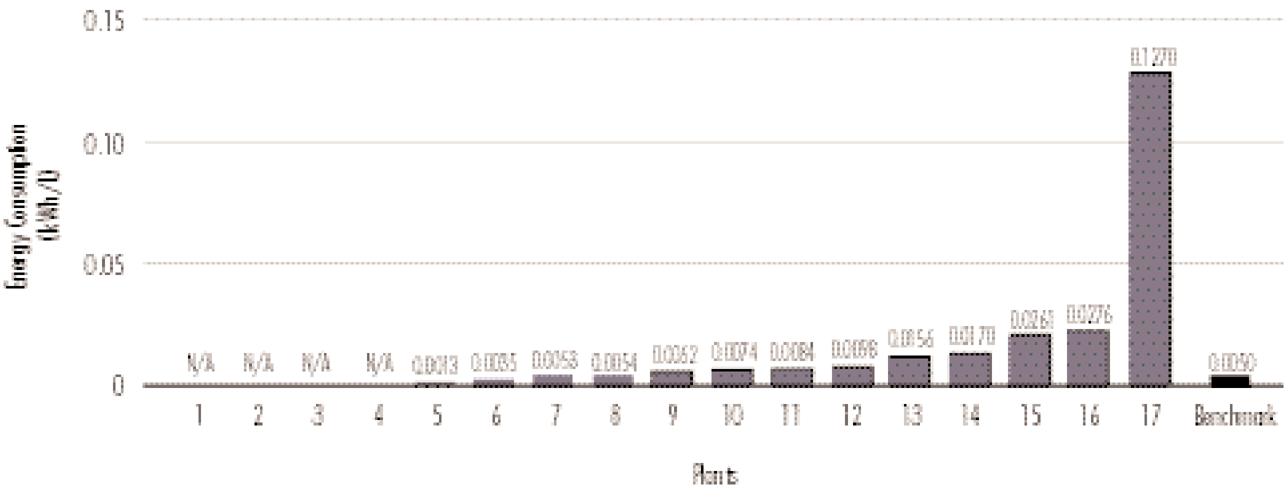
Figure 4.28
Total Energy Consumption: Cleaning-in-Place (CIP) (kWh/L)



Total energy consumption for CIP for 16 plants in the sample varied from a low of 0.0001 kWh/L to a high of 0.0930 kWh/L. (One plant in the sample did not allocate energy consumption specifically to CIP.)

Heating, Ventilating and Air Conditioning (HVAC): Energy Consumption

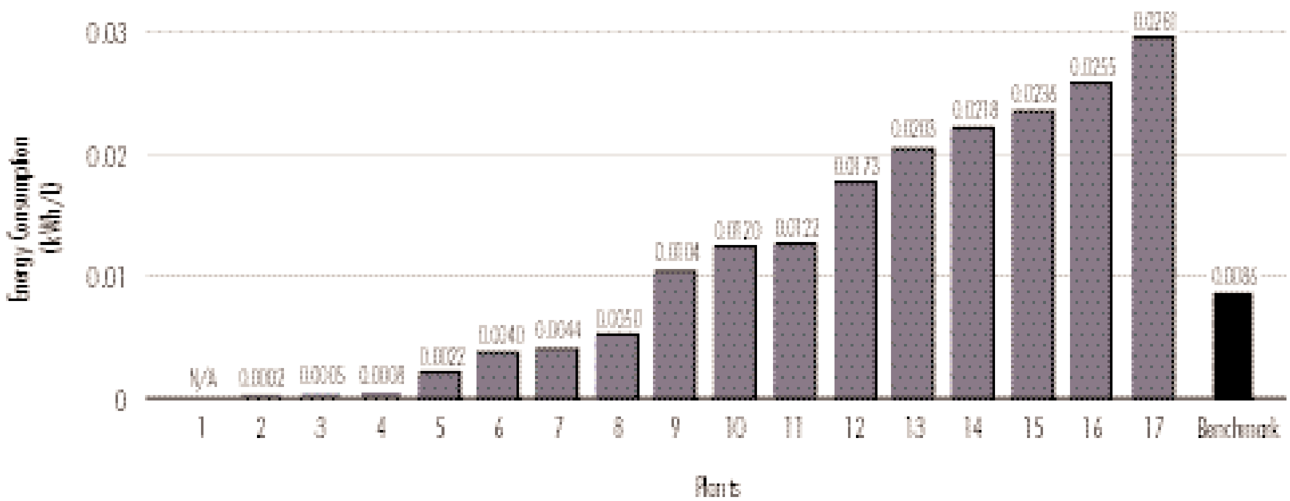
Figure 4.29
Total Energy Consumption: Heating, Ventilating and Air Conditioning (HVAC) (kWh/L)



Total energy consumption for heating, ventilating and air conditioning (HVAC) requirements for 13 plants in the sample varied from a low of 0.0013 kWh/L to a high of 0.1270 kWh/L. (Four plants in the sample did not allocate energy consumption specifically to HVAC.)

Other Uses: Energy Consumption

Figure 4.30
Total Energy Consumption: Other Uses (kWh/L)

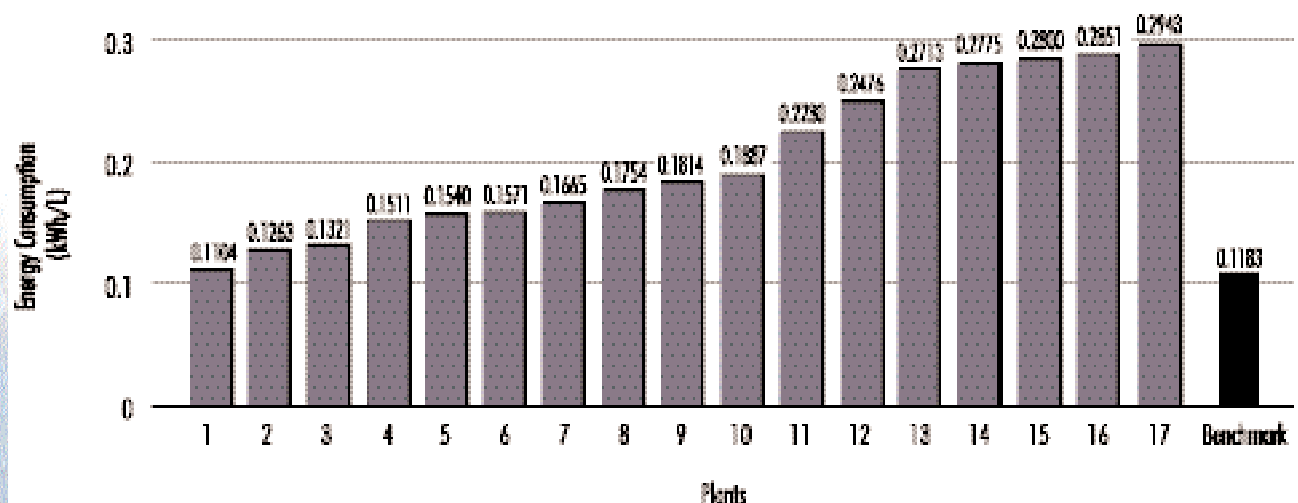


Energy-consuming activities that fall into the "other uses" category include lighting, operating ice coils, transferring milk to holding tanks, and receiving and washing cases. Total energy consumption for these uses for 16 plants in the sample varied from a low of 0.0002 kWh/L to a high of 0.0281 kWh/L. (One plant did not provide a breakdown for miscellaneous energy consumption.)

All Stages: Energy Consumption

In summary, and as reported earlier, total overall energy consumption for the 17 plants in the sample varied widely, ranging from a low of 0.1104 kWh/L to a high of 0.2943 kWh/L.

Figure 4.31
Total Energy Consumption:
All Stages of Production and Plant Services (kWh/L)



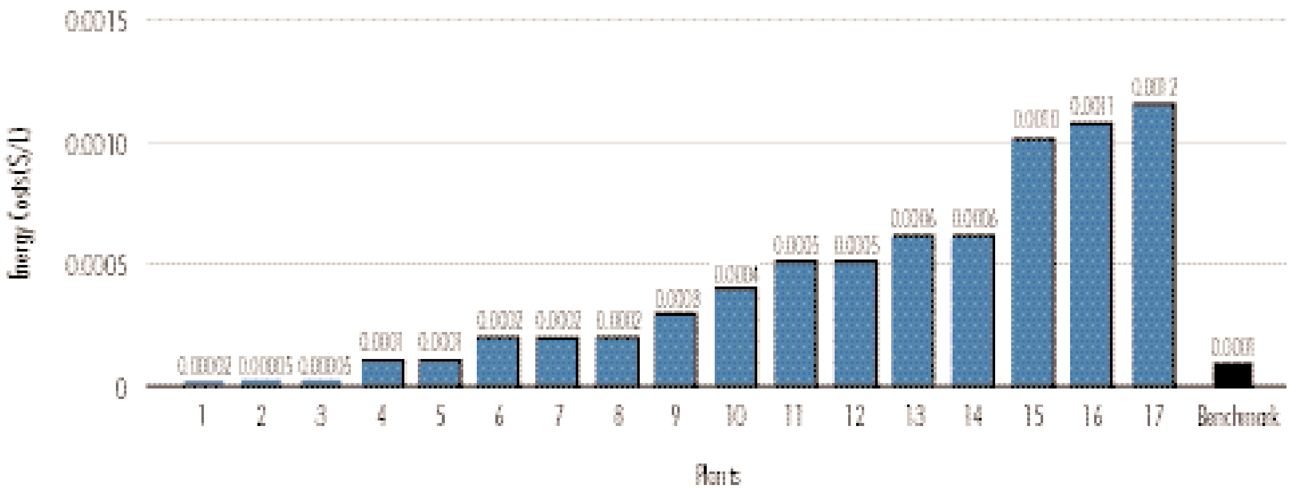
4.3.2. Energy Costs: Unit of Production

The cost of energy consumed to produce white milk products represented a second important perspective. As illustrated earlier in the plant-level analyses, the total costs ($/L) include variances in both usage (kWh/L) and price ($/kWh) from the benchmark levels. The energy costs per litre of white milk are provided below for the five stages of production and the three categories of plant services.

As mentioned previously, the main activities at this stage of production are receiving, weighing and cooling milk; pumping milk into silos; and washing trucks. Total energy costs at this stage for the 17 plants in the sample varied from a low of $0.00002/L to a high of $0.0012/L.

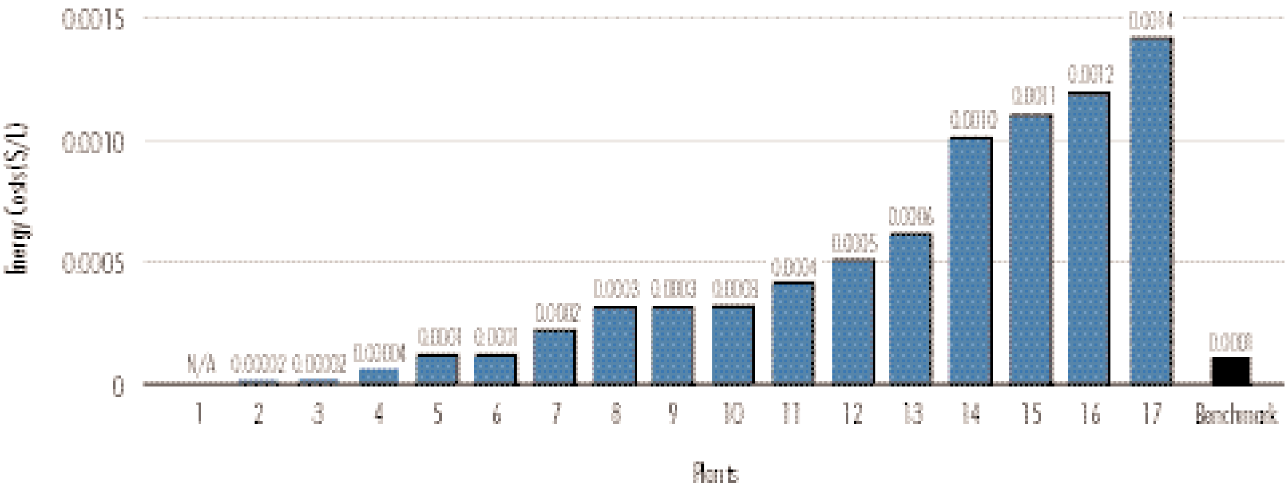
Milk Receiving: Energy Costs

Figure 4.32
Total Energy Costs: Receiving ($/L)



Separating: Total Energy Costs

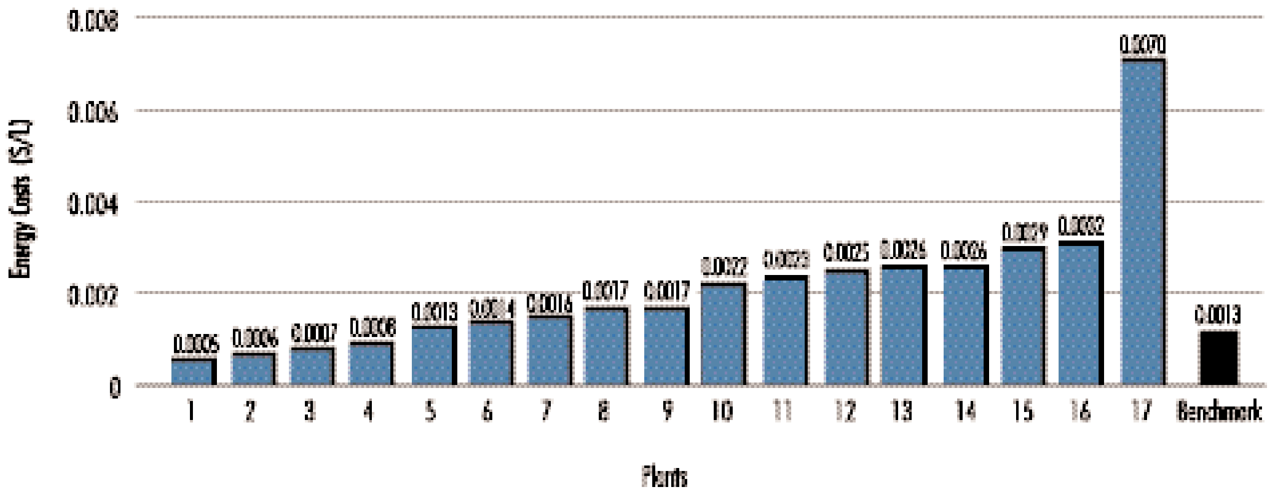
Figure 4.33
Total Energy Costs: Separating ($/L)



As mentioned previously, the main energy-consuming activity at this stage of production is separating raw milk into its skim and cream components with a centrifugal separator. Total energy costs at this stage for 16 plants in the sample varied from a low of $0.00002/L to a high of $0.0014/L. (One plant in the sample did not allocate energy consumption specifically to this stage of production.)

Homogenization and Pasteurization: Total Energy Costs

Figure 4.34
Total Energy Costs: Homogenization and Pasteurization ($/L)



Total energy costs at this stage for the 17 plants in the sample varied from a low of $0.0005/L to a high of $0.0070/L.

Filling and Packaging: Total Energy Costs

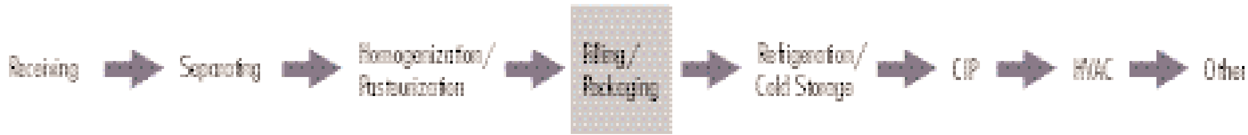
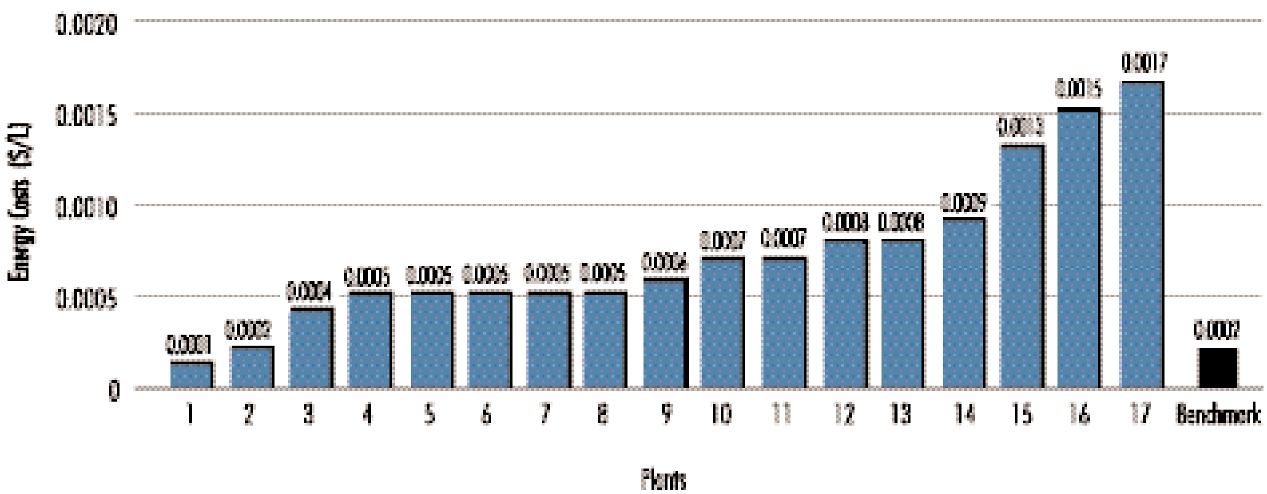


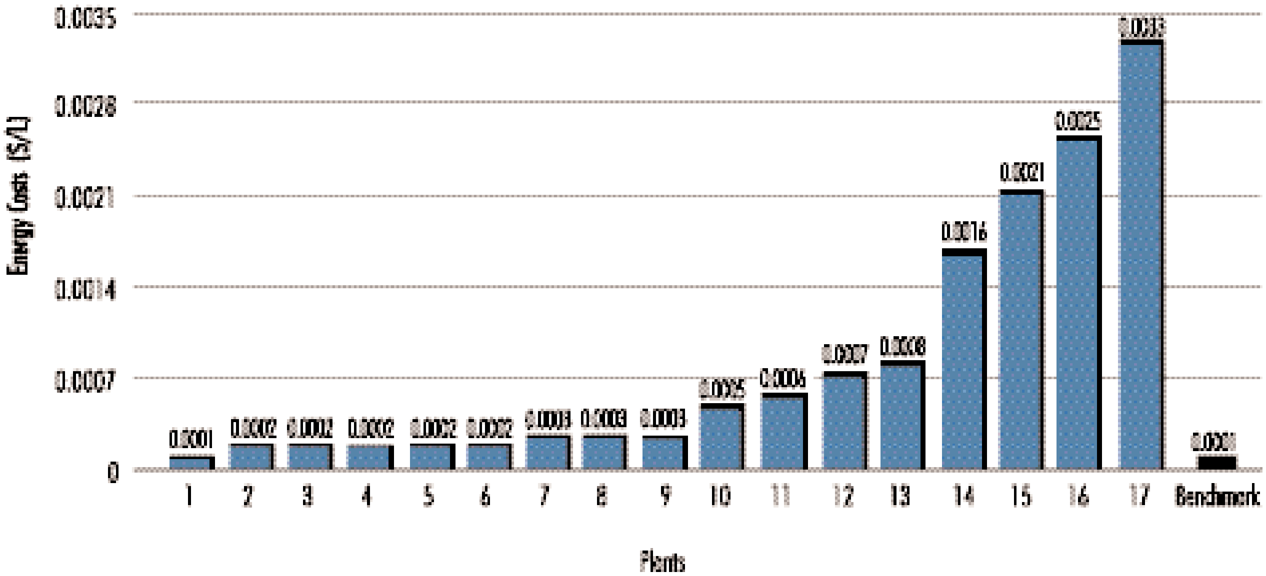
Figure 4.35
Total Energy Costs: Filling and Packaging ($/L)



Total energy costs at this stage for the 17 plants in the sample varied from a low of $0.0001/L to a high of $0.0017/L.

Refrigeration and Cold Storage: Total Energy Costs

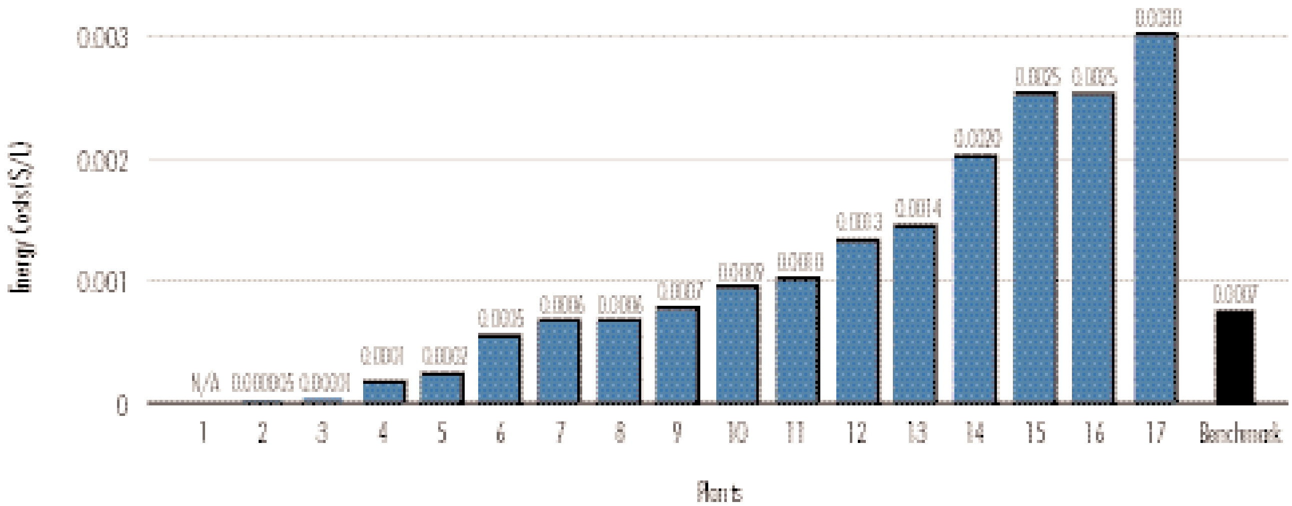
Figure 4.36
Total Energy Costs: Refrigeration and Cold Storage ($/L)



Total energy costs at this stage for the 17 plants in the sample varied from a low of $0.0001/L to a high of $0.0033/L.

Cleaning-in-Place (CIP): Total Energy Costs

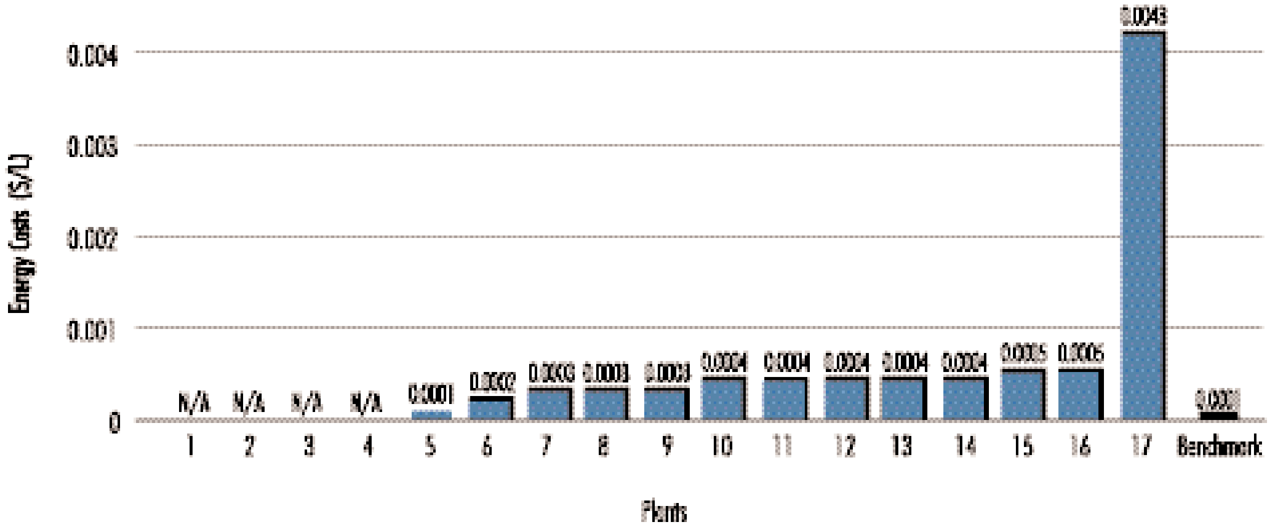
Figure 4.37
Total Energy Costs: Cleaning-in-Place (CIP) ($/L)



Total energy costs for CIP for 16 plants in the sample varied from a low of $0.000005/L to a high of $0.0030/L. (One plant in the sample did not allocate energy consumption specifically to CIP.)

Heating, Ventilating and Air Conditioning (HVAC):
Total Energy Costs

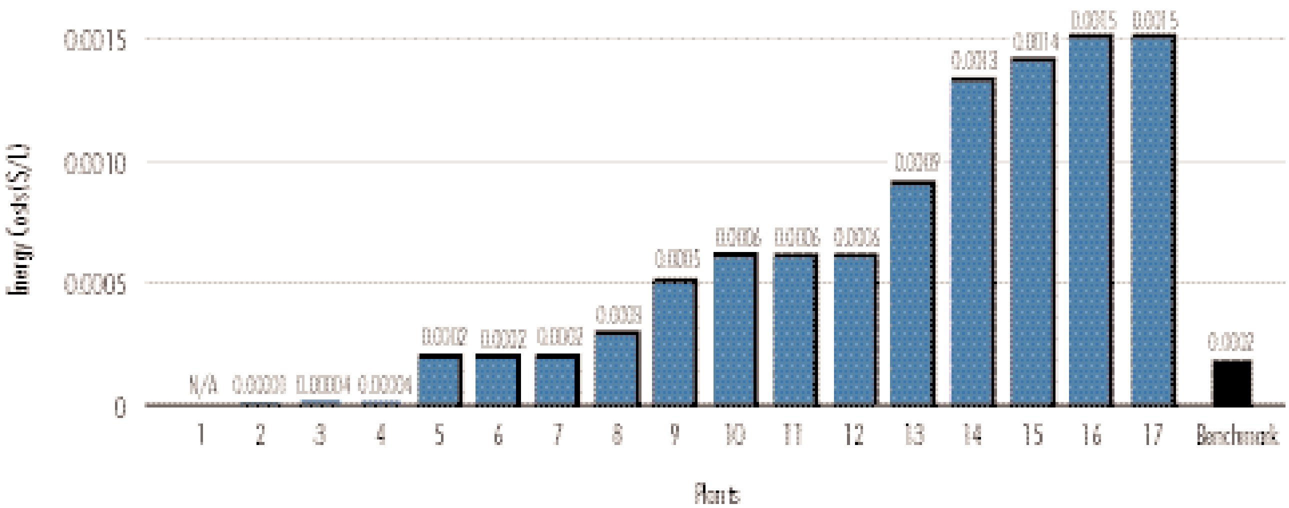
Figure 4.38
Total Energy Costs: Heating, Ventilating and Air Conditioning (HVAC) ($/L)



Total energy costs for heating, ventilating and air conditioning for 13 plants in the sample varied from a low of $0.0001/L to a high of $0.0043/L. (Four plants in the sample did not allocate energy consumption specifically to HVAC.)

Other Uses: Total Energy Costs

Figure 4.39
Total Energy Costs: Other Uses ($/L)

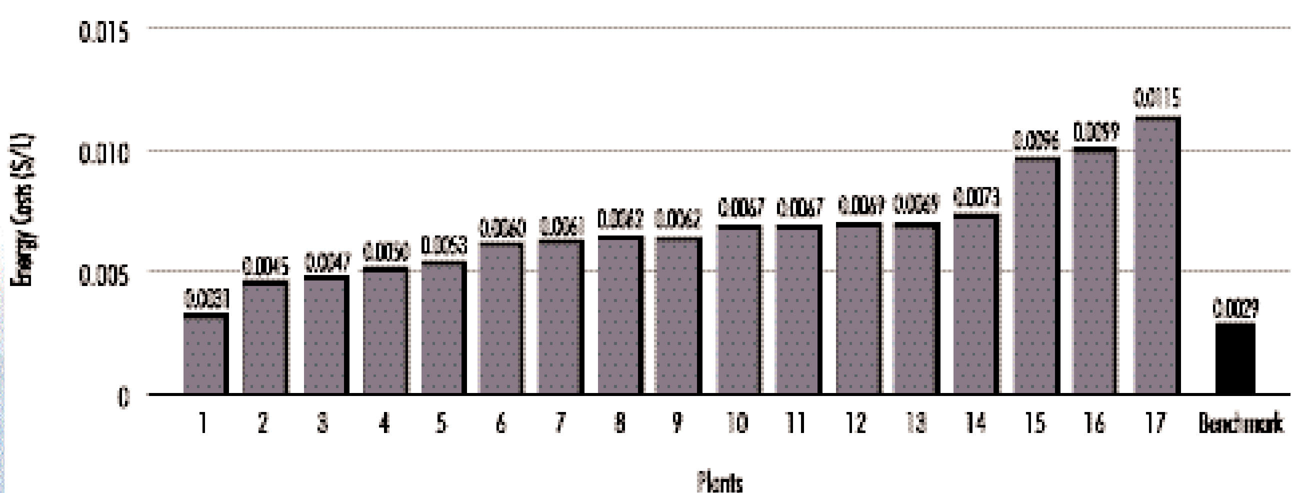


Total energy costs for other uses for 16 plants in the sample varied from a low of $0.00001/L to a high of $0.0015/L. (One plant did not provide this breakdown.)

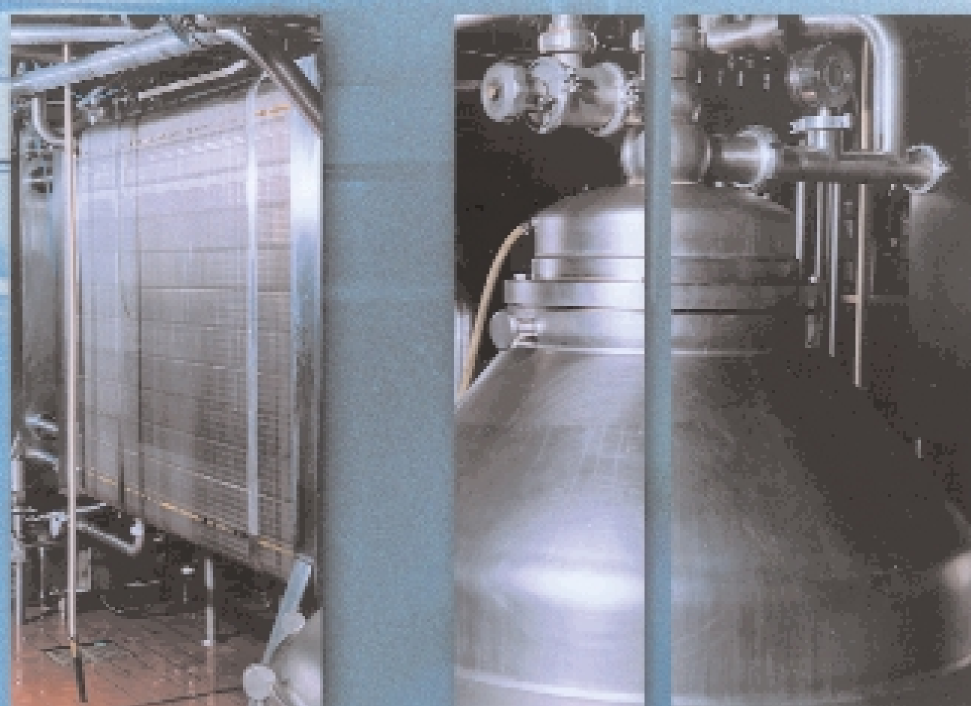
All Stages: Total Energy Costs

In summary, and as reported earlier, total energy costs for the 17 plants in the sample varied widely, from a low of $0.0031/L to a high of $0.0115/L.

Figure 4.40
Total Energy Costs:
All Stages of Production and Plant Services ($/L)



5. Approaches to Potential Energy Savings



5. Approaches to Potential Energy Savings

The preceding sections documented potential areas for significant energy savings. This section offers several ideas for saving energy, excerpted from the following reports:

- Competitive Analysis Centre Inc. *Food Processing Industry: Foundation Paper and Options Analysis*. Submitted to Agriculture and Agri-Food Canada, August 1999.
- Marbek Resource Consultants Ltd. *Industrial Performance Indicator Reports*. Submitted to Natural Resources Canada, March 1999.

5.1. Competitive Analysis Centre Inc. (CACI) Study

Five firms participated in the CACI study, which outlined these potential electricity and natural gas savings.

Electricity

The vast majority of energy savings projects at Canada's other dairy products processing plants have already been carried out. However, these plants could reduce their electricity use by up to 10 percent with the following initiatives:

- install energy-efficient lighting;
- establish better monitoring practices; and
- change work practices (i.e. move to a seven-day week, extend the period between clean-ups).

Natural Gas

Although plants should not expect to reduce their overall natural gas use by more than 10 percent, specific practices such as the following may reduce consumption by more than 10 percent for certain areas of the plants:

- mechanical vapour recompression;
- replace older boilers with newer, more energy-efficient models;
- establish better monitoring practices; and
- change work practices (i.e. move to a seven-day week, extend the period between clean-ups).

5.2. Marbek Resource Consultants Ltd. Study

The Marbek report identified the following energy conservation opportunities.

Hot Water Conservation Measures

Fluid milk processing plants use a great deal of energy to produce hot water. An energy-efficient plant can reduce its hot water consumption by implementing a number of low-cost measures, such as the following:

- Use efficient nozzles on clean-up hoses.
- Control burst rinses and clean-in-place operations by volume rather than time.
- Treat dry ingredient spills as solid waste rather than flushing them.
- Use water heated to the proper temperature rather than injecting steam.
- Ensure that hot water hoses are turned off and that flushing operations in cleaning-in-place procedures take the correct length of time.
- Maintain hot water and steam pipes against leaks.

A plant that conserves hot water consumes five percent less fuel than a plant that does not.

Free Cooling During Winter Months

A significant amount of energy is used in plants to refrigerate products. As outside temperatures drop, plants can take advantage of the cold weather to cool their products at virtually no cost. In other words, if the outside temperature is below the temperature of the product cooling space, outside air can replace the refrigeration system.

Properly applied, this no-cost cooling system can reduce energy consumption by 15 percent in plants in most parts of Canada.

Boiler Efficiency Controls

Plants can improve their boilers' efficiency by installing additional low-excess air controls. These controls continuously measure the level of oxygen in the stack gases and control the flow of air to the exact amount for proper combustion.

This type of control upgrade can reduce total fuel consumption by up to two percent.

Heat Recovery From Liquid Effluent

In most plants, large volumes of hot water are exhausted to the sewer or drain. Plants should recover as much heat as is practical from this water before discharging it. Heat exchangers placed in hot water exhaust systems can be used to preheat process water or boiler make-up water.

An extensive heat recovery system could reduce boiler fuel requirements by five to 10 percent.

Compressed-Air System Monitoring and Upgrading

Most dairy processing facilities have centralized systems that supply compressed air throughout the plants. Such systems can become very inefficient if not monitored constantly, but plants can improve efficiency by 10 percent or more by installing better controls, testing and monitoring leaks and installing more efficient air-drying systems.

Adjustable Speed Drives on Ventilation Fans

Building ventilation systems usually require a significant amount of horsepower. The actual flow required depends on weather conditions and activity in the building. Using adjustable speed drives on these fans can reduce energy consumption by 20 to 40 percent.

Adjustable Speed Drives on Pumps

In fluid milk production, milk is frequently pumped from one tank to another. Rather than relying on valves to control pumping volume (which depends on the pressure in the lines and tank levels), plants can install adjustable speed drives to increase efficiency.

Cogeneration

Because of their continuous need for hot water, many fluid milk plants would benefit from cogeneration plants. Equipped with reciprocating engines or micro-gas turbines, these plants would simultaneously produce electricity and hot water. In many locations, the cost of producing this electricity in plants is lower than local utility rates.

High-Efficiency Motors

Electric motors vary in their energy efficiency; installing more efficient motors can save energy. Larger high-efficiency motors (100 hp and more) are one percent more efficient than the average. For smaller motors (10 hp), the difference is about three percent.

CIPEC

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The Office of Energy Efficiency of Natural Resources Canada is a dynamic organization with a mandate to renew, strengthen and expand Canada's commitment to energy efficiency in order to help address the challenges of climate change.