CIPEC

BENCHMARKING ENERGY USE AND COSTS IN

SALT-AND-DRY FISH PROCESSING AND LOBSTER PROCESSING

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1

INTRODUCTION

1. INTRODUCTION

Background

Energy costs for Canada's fish processing sector are becoming an increasingly important component of the total cost of operations. Directly and indirectly, energy use in the fish processing sector also contributes to Canada's greenhouse gas emissions. There are, therefore, competitive as well as environmental reasons for fish processing operations to examine their energy consumption comprehensively.

In association with the Canadian Industry Program for Energy Conservation (CIPEC), the Fisheries Council of Canada (FCC) retained Corporate Renaissance Group (CRG) to work with fish processing companies to establish energy benchmarks for salt-and-dry processing operations in Nova Scotia and lobster processing operations in Prince Edward Island. Companies that participated in this project have received detailed reports specific to their operations, under separate cover, as well as the findings of this report.

CIPEC consists of 25 task forces, representing the various industrial sectors in Canada, and it is a partnership of industrial associations, industry and the Government of Canada, represented by the Office of Energy Efficiency (OEE) of Natural Resources Canada (NRCan). The CIPEC Task Forces act as focal points for identifying energy efficiency potential and improvement opportunities, establishing sector energy efficiency targets, reviewing and addressing barriers, and developing and implementing strategies for target achievements.

The FCC sponsored this energy benchmarking analysis of the fish and lobster plants in Canada's Atlantic Provinces. Two separate but parallel studies were undertaken: first, a study of energy consumption among five salt-and-dry fish processing operations in Nova Scotia; and second, a study of four lobster processing plants in Prince Edward Island.

The OEE of NRCan has provided assistance for this work. This study is a part of ongoing NRCan efforts to stimulate more effective use of energy in Canada.

Methodology

This benchmarking analysis of the Canadian fish processing sector examines the energy consumption and costs for appropriate production stages for each fish processing group. The analysis is limited to the ongoing operations of the processing plants, starting with the landing of the fish/lobster and ending with freezer/cooler storage of the final product. Among other things, fuel used by the fishing fleet and in delivery trucks is excluded from this analysis.

The initial phase of each study involved interviews with management personnel at a number of plants in order to lay out a reasonable process flow diagram for each type of operation (salt-and-dry and lobster). These diagrams identified the series of stages of production for which energy consumption could be separately analysed during the project. They also identified a number of shared services that are used in several stages of production (e.g. material handling equipment) or for several products (e.g. coolers).

At the beginning of the second (data collection) phase, a CRG consultant visited each plant participating in the study in order to collect detailed information on the following:

- annual plant production for a recent complete year
- total plant energy consumption and costs for the year, by fuel type
- an inventory of energy-consuming machinery and equipment, including energy consumption rates (or operating parameters) and hours-in-service for the year
- where a plant processes products other than those that are the focus of the study (i.e. other than lobster or salt-and-dry fish), an estimate of the proportion of total use for each process or piece of equipment that is related to these other products
- in the case of shared services, the proportion of energy consumption that can be assigned to each stage of production

Following these site visits, CRG worked with each plant through a series of follow-up telephone, e-mail and fax enquiries to complete the collection of all of the data required to proceed with the benchmarking analysis. In the frequent cases where estimates of various operating parameters were required, these estimates were reviewed with plant personnel.

At the completion of the data collection process, CRG prepared a separate (confidential) report for each plant, providing a summary of the energy use, production data, assumptions and a preliminary analysis of each plant’s energy use profile by stage of production. Each plant was asked to review the equipment inventory, estimated energy consumption for each piece of equipment and the summaries by stage of production within the context of total plant energy consumption and costs. In particular, plants were asked to ensure that no transcription errors had been made in the equipment inventory record, that reasonable hours-of-use estimates were being used in the analysis, and that estimates of production volumes for each stage of production were appropriate.

After participating plants had provided revisions, the energy consumption and costs per short ton (ton) were calculated for each stage of production. Then this final report was prepared to provide the following:

- revised estimates of energy consumption by stage of production
- energy costs per ton of fish/lobster processed at each stage of production

- total energy consumption and costs associated with production of a standard product – in the case of fish, one ton of skin-on, ordinary-cure dried fish produced from purchased fresh fish; in the case of lobster processing, three distinct products were compared: frozen tails, frozen vacuum-packed/canned lobster meat, and frozen whole lobster

- a detailed inter-plant comparison of energy consumption and costs per ton among the participating plants, for each stage of production

In all cases, energy consumption was based on kilowatt hour equivalents (kWh equivalent). The conversion factors for other categories of energy are illustrated below. These conversions were derived from energy content factors reported in *Canada's Energy Outlook 1996–2000* (Natural Resources Canada, April 1997).

Table 1. Fuel Conversion Factors

Energy	Units	kWh equivalent/Unit
Diesel	L	10.74
Gasoline	L	9.63
Natural Gas	m^3	10.31
Light Fuel Oil	L	10.40
Bunker C	L	11.59

The inter-plant comparisons were based on the following unit costs and disaggregation into components for both fish- and lobster-processing facilities.

- **Salt-and-Dry Fish Processing**

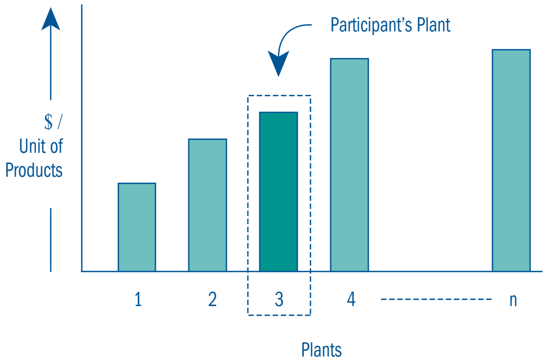
$$\left[\frac{\$}{\text{Ton of product}}\right] = \left[\frac{\$}{\text{kWh equivalent}}\right] \times \left[\frac{\text{kWh equivalent}}{\text{Ton of product}}\right]$$

- **Lobster Processing**

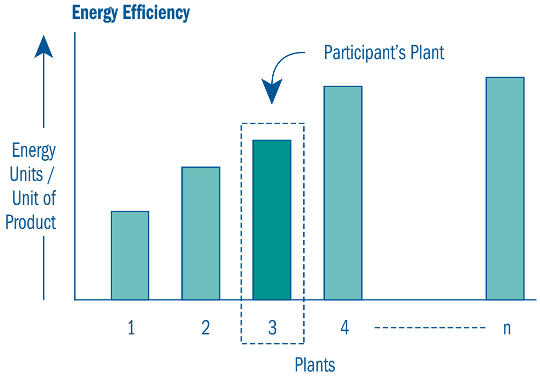
$$\left[\frac{\$}{\text{Ton of product}}\right] = \left[\frac{\$}{\text{kWh equivalent}}\right] \times \left[\frac{\text{kWh equivalent}}{\text{Ton of product}}\right]$$

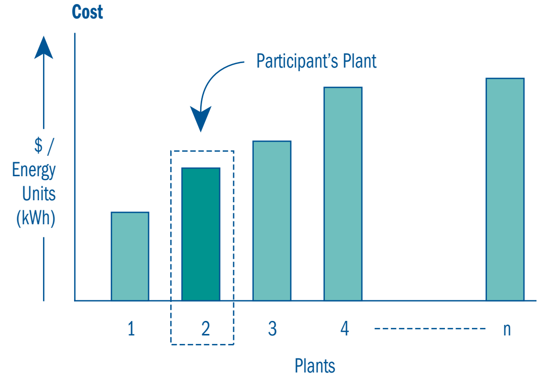
Comparative Energy Costs

Study participants learned about their plants' total energy costs per unit of output and by particular process relative to study participants producing similar products. The figure below illustrates the relative positioning of Plant 3 on the basis of total energy costs per unit of output.



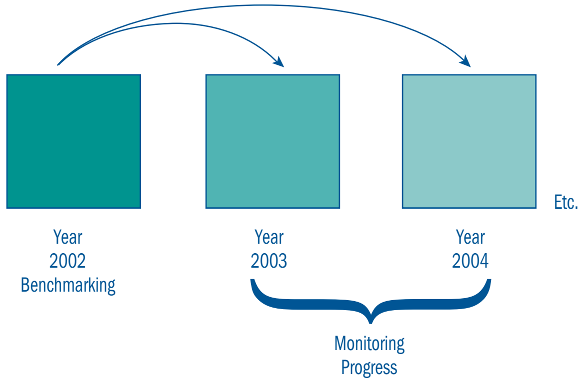
Moreover, participants learned whether their challenge was energy cost or energy efficiency, as illustrated below.





Use for Results

Undertaking an energy benchmarking study (based on year 2002 data) provides the beginning point for subsequent monitoring at plant and production stage levels.



Having information on the relative rankings of their plants with respect to both the cost of energy and its efficient use will enable plants to assess the competitive impact of their energy use. Furthermore, with energy data at the production stage level, plants are directed to process stages, where they have a competitive advantage/disadvantage, for more intensive analysis. This analysis would impact future investment decisions regarding the implementation of more energy-efficient technologies. Relative energy pricing information also provides an incentive for assessing the cause of differential pricing among energy suppliers.

2

INTER-PLANT COMPARISONS — SALT-AND-DRY FISH PROCESSING

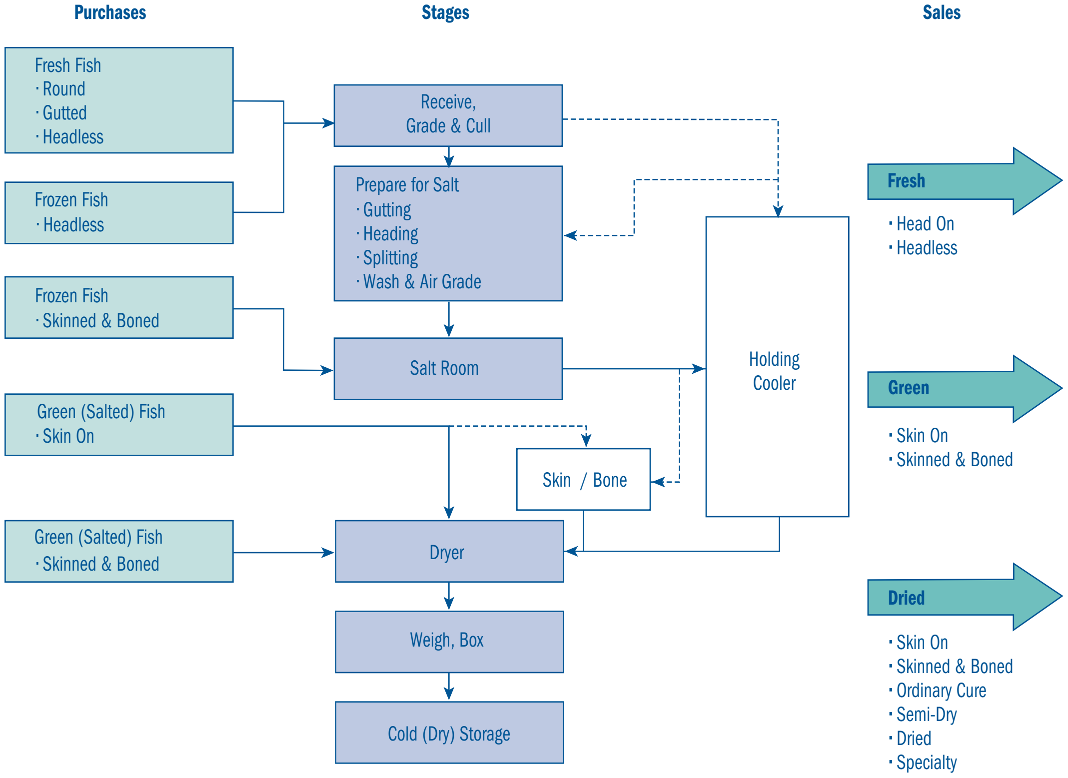
2. INTER-PLANT COMPARISONS — SALT-AND-DRY FISH PROCESSING

This study examined the salt-and-dry operations of five plants located within 200 kilometres of Yarmouth, Nova Scotia. Although salting and drying operations were the primary activity, these plants also prepared and sold fresh fish. Several also maintained (seasonal) live lobster processing facilities. In the CRG analysis, the energy consumption and costs for these "excluded" activities have been estimated and removed from the inter-plant comparisons that follow. Certain activities that were not integral to the salt-and-dry operation, or which were only present at one or two plants, were also removed for the inter-plant comparisons. These activities included bait freezers, ice-making for the fishing fleet, and trucks used for collecting fresh fish for processing or for delivering the plant's output to other sites.

Salt-and-Dry Process Description

A simplified view of the salt-and-dry production process is presented below for the one-year period covered in this study.

Figure 2-1. Generic Salt-and-Dry Production Process



Fishing boats deliver freshly caught fish directly to the wharf of the processing plant. At the plant, these fish are first graded, basically to identify those that are suitable for fresh sale and those that are to be salted and dried. The fish are then gutted and cleaned – if this has not already been done aboard the fishing boat. Fish that have been gutted and cleaned are termed "round" fish. At this stage, fish that are to be shipped to market for "head-on" fresh sale are packed in ice and shipped immediately or stored. The next stage of processing involves removing the head of the fish (deheading). Some of these fish are then shipped for (headless) fresh sale.

To supplement a local catch that is insufficient to fill a plant's processing capacity, some operators purchase additional fresh or frozen fish from other sources, notably other local plants. Some salt-and-dry operations also make bulk purchases of frozen (headless) fish from the north Atlantic or Pacific oceans caught by offshore trawlers. These fish are stored at the plant and are thawed and introduced to the salt-and-dry production line as required.

Next, headless fish that are to be salted are "split," an operation that removes the backbone. The split fish are then packed in layers with salt for several weeks (as long as 28 days in winter, perhaps only 16 days in summer). This salting operation begins the process of removing moisture from the fish flesh, which is approximately 70 percent water by weight, prior to salting. By the time the salting operation is completed, the fish are soaked in a brine solution in which the salt draws the moisture out of the fish flesh. The fish lose approximately 30 percent of their weight during the salting operation. Fish prepared in this way are referred to as "green."

After salting, some plants remove the skin and bones from a small proportion of the green fish. Plants sometimes sell a portion of their salted fish output (both "skin on" and "skinned and boned") to other salt-and-dry plants that have drying capacity that exceeds the output of their own salting operations.

At any time during these first production stages, when the fish have to be stored prior to further processing, they are placed in "wet" coolers. After the salting operation, the fish are stored in "dry" coolers. Customarily, these coolers are large, refrigerated warehouses within the plant itself, accessible by loaded forklifts. At some plants, additional cold storage has been acquired by purchasing trailers that were originally produced for portable storage on ocean-going trawlers. These trailers are similar in size to the freight containers hauled by 18-wheelers and have self-contained cooling systems that have been adapted to run on utility-supplied electrical current.

To begin the drying process, the green fish are laid out on wooden racks that are piled four to six feet high on pallets. Forklifts move the pallets into the drying rooms. The temperature of the drying rooms is maintained at approximately 21°C (70°F) as banks of fans constantly recirculate the warm air to advance the drying process. Moisture is removed from the air by large dehumidification units contained within the drying rooms.

Salted/green fish enter the drying process at approximately 55 to 60 percent moisture content. Three standard levels of dry products are produced – depending on the remaining moisture level of the fish. “Ordinary cure” (the most common) product has between 44 and 48 percent moisture remaining when packed for market. “Semi-dry” product has 40 to 44 percent moisture, and “dry” product has 38 to 40 percent moisture. Reported drying times vary from 6–20 hours for ordinary cure and 36–40 hours for dry product.

Study Sample

At each plant, energy consumption and costs were examined for a recent full year of operations. Although plants were unable to report for precisely the same time period, there is significant overlap in the periods for which data were available. All the annual reporting periods analysed in this study commenced between August 2001 and April 2002; that is, the analysis covered the majority of the 2002 summer season (April through July) at all plants in the study.

In total, the five plants included in this study handled more than 18 million pounds of fresh fish, 7 million pounds of green fish, and 4 million pounds of frozen fish during the one-year period examined. More than 15 million pounds of fish were salted, and total dried fish production was over 10 million pounds.

Total annual energy consumption for all operations (including “excluded” activities) was as follows: over 4 million kWh of electricity, more than 83 000 pounds of bottled propane (used exclusively in forklift trucks), and almost 64 000 litres of heating oil (used for space heating of plants and offices). Expenditures for all energy sources totalled more than $400,000.

The total quantity of fresh, frozen and green fish received at the plants covered in this study varied from 3.4 million pounds to 11.1 million pounds per plant. One plant purchased no frozen fish; while at the other four plants, frozen fish accounted for between 9 and 21 percent of all inputs. Two plants purchased no green fish, but among those that did, the green purchases accounted for between 22 and 70 percent of all inputs. The plants salted between 27 and 64 percent of all of the fish received. Total dried production among the plants varied from 13.6 to 69.7 percent of the total tonnage received.

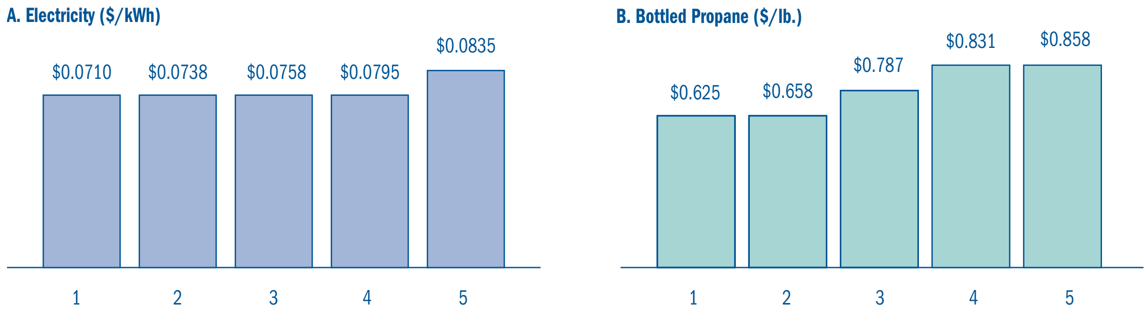
Unit Energy Costs

The unit prices paid by the participating plants for electricity and fuels are compared in Figure 2-2. Note that these prices do not include (refundable) provincial sales taxes.

There was considerable variation in the unit prices of electricity and fuels reported by plants for this study. Because all of the participating salt-and-dry plants were located in southwestern Nova Scotia, within 200 kilometres of Yarmouth, regional price influences were not a factor.

In part, the different prices reflect the different reporting periods involved. Two plants reported for relatively early annual periods, beginning between August and October 2001. The other three plants reported for somewhat later periods, starting between January 2002 and April 2002 (i.e. their reports covered some part of the winter of 2002–2003). These late reporters had the three highest costs for propane and heating oil. Electricity prices were less related to reporting period; the most isolated plant (a late reporter) had the highest electricity costs, but another late-reporting plant had the lowest electricity costs.

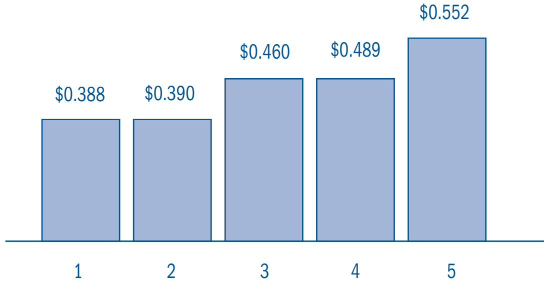
Figure 2-2. Unit Energy Costs



A. Electricity ($/kWh)

B. Bottled Propane ($/lb.)

C. Heating Oil ($/L)



Inter-Plant Comparisons by Stage of Production

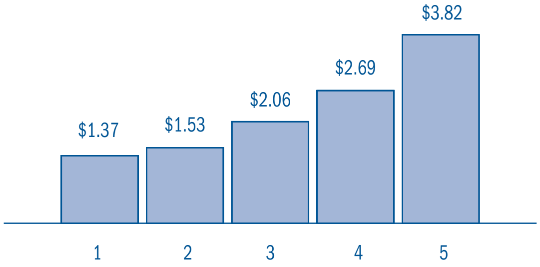
Each of the following sections presents a set of three bar graphs. First, ranked energy costs per ton of fish processed through that stage of production are shown for the five plants. Then, the two components (consumption and unit costs) are shown, also ranked from lowest to highest. Note that a plant may have three different ranks on the three sub-graphs shown (i.e. the lowest cost plant may not have the lowest consumption or the lowest unit costs). Only the managers of each participating plant have been provided with a confidential "key" that identifies that plant's position (rank) on each of the charts in this section.

Note that energy consumed by haul/delivery trucks is excluded from this analysis and that all plant heating and lighting energy consumption is reported as “Other Plant Energy.”

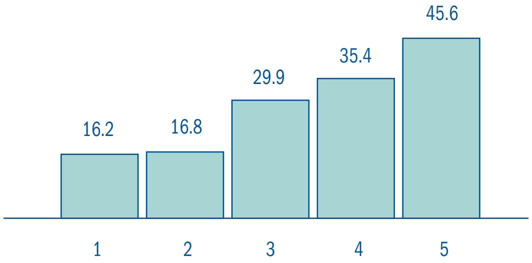
Receiving and Grading

Equipment found in this stage included small (0.5–3 horsepower [hp]) conveyors, hoists and bucket unloaders. Large (10 hp) water pumps were major energy consumers in receiving areas. The plant with the largest consumption per ton also operated a flume water system for fish unloading. Plants reported using 10 to 22 percent of their propane for forklift operations.

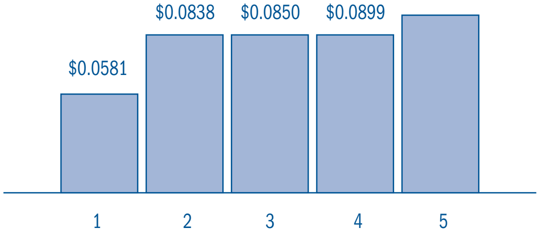
A. Energy Costs ($ per Ton of Fish Processed)



B. Energy Consumption (kWh equivalent per Ton of Fish Processed)



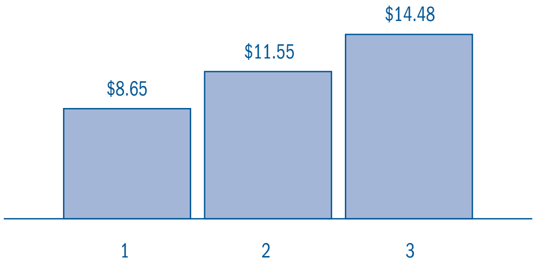
C. Unit Energy Costs ($ per kWh equivalent)



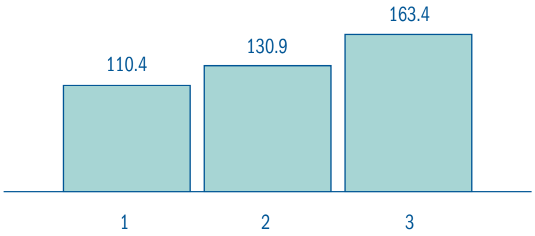
Holding Freezers

Frozen fish purchases ranged from 200 tons to 1000 tons. Although four plants reported purchases of frozen fish, only three stored these purchases in freezers on-site. Compressors of 6–12 hp and banks of recirculating fans with fractional horsepower were the major consumers of electricity. Consumption also included 10 to 20 percent of forklift propane (or, in one case, electricity).

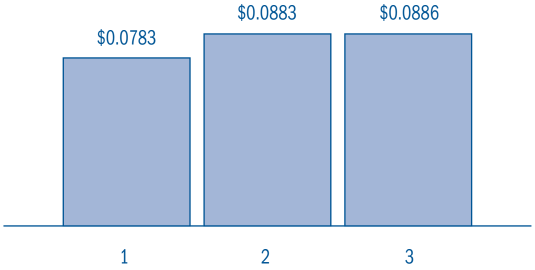
A. Energy Costs ($ per Ton of Fish Processed)



B. Energy Consumption (kWh equivalent per Ton of Fish Processed)



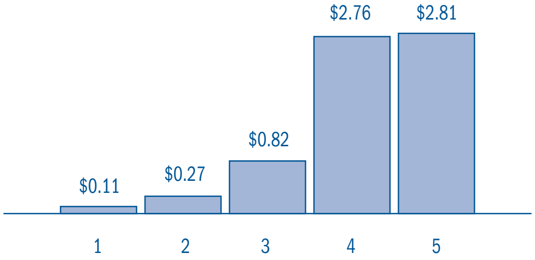
C. Unit Energy Costs ($ per kWh equivalent)



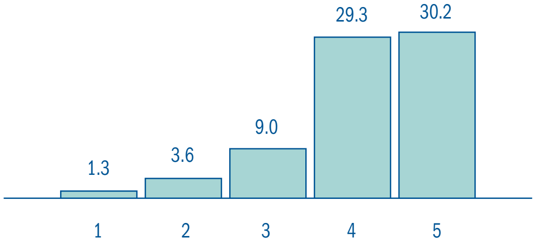
Preparation for Salting

This stage included the gutting/dressing of fish, which was almost exclusively a manual operation. Deheading and splitting operations usually employed machines, but these had relatively small motors (2–5 hp). The occasional use of small (1–3 hp) conveyors, likewise, did not amount to very much energy consumption. Water supply and forklift operations were the main contributors to the larger consumption figures reported at two plants. In all cases, however, the preparation of the fish for salting did not account for very much of total plant energy consumption or costs.

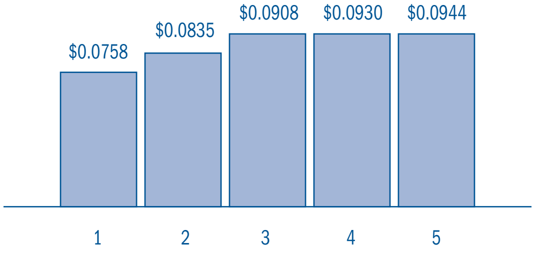
A. Energy Costs ($ per Ton of Fish Processed)



B. Energy Consumption (kWh equivalent per Ton of Fish Processed)

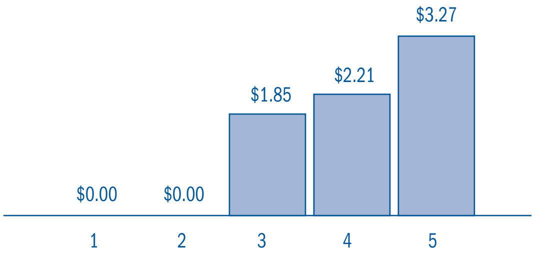


C. Unit Energy Costs ($ per kWh equivalent)

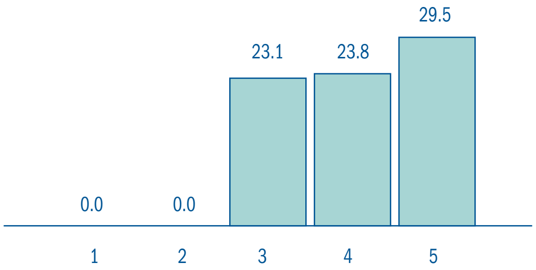


Salt Room

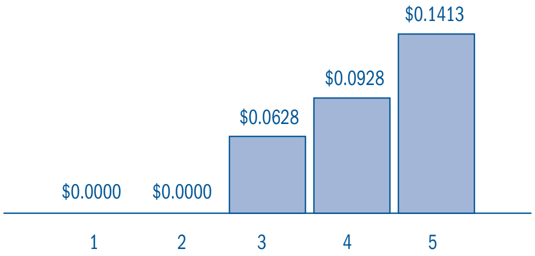
Salt room operations were largely manual, with only one plant employing small conveyors and a “salt shaker” in its operation. Water supply, pressure-wash equipment and/or forklifts were the major consumers of energy in salting operations.



A. Energy Costs ($ per Ton of Fish Processed)



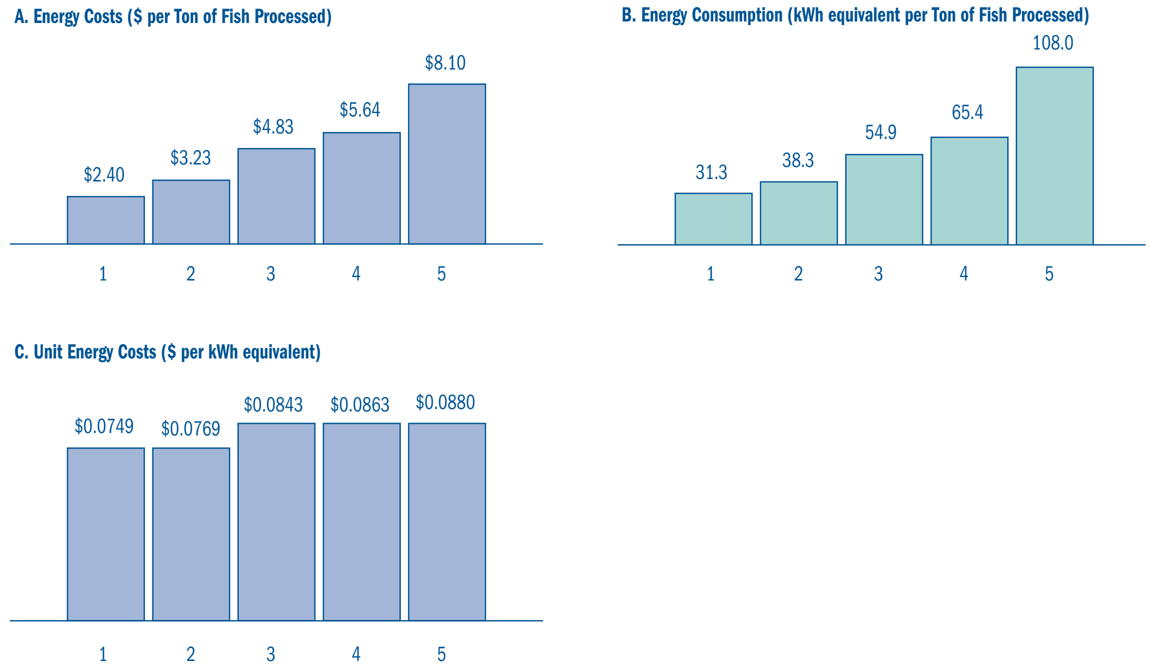
B. Energy Consumption (kWh equivalent per Ton of Fish Processed)



C. Unit Energy Costs ($ per kWh equivalent)

Wet Coolers

Wet coolers were usually large, custom-built refrigerated rooms within the plants. Forklifts would be used to bring in fish for temporary storage at various stages of processing between grading and drying. Typically, fish exiting the salt room would be stored in wet coolers for two weeks or more to allow the salting process to finish. Energy consumption for wet coolers also includes 10 to 30 percent of the total energy consumed in forklift operations.



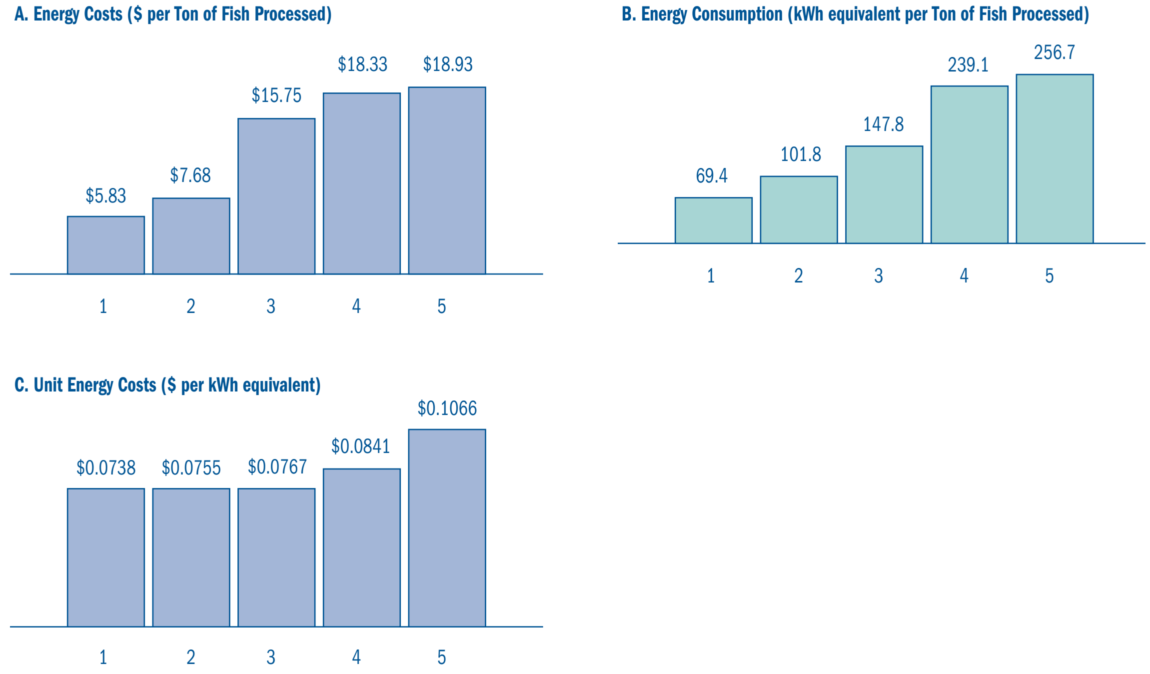
A. Energy Costs ($ per Ton of Fish Processed)

B. Energy Consumption (kWh equivalent per Ton of Fish Processed)

C. Unit Energy Costs ($ per kWh equivalent)

Drying

Drying operations were usually the most energy-intensive operations at salt-and-dry plants (on a per-ton basis). At four plants, the average dryer load was approximately one ton. The plant with the lowest energy consumption per ton, however, had much larger dryers and average loads of approximately five tons. There appears to be considerable additional dryer capacity available – at some plants, dryers were operated for less than 1000 hours during the year.



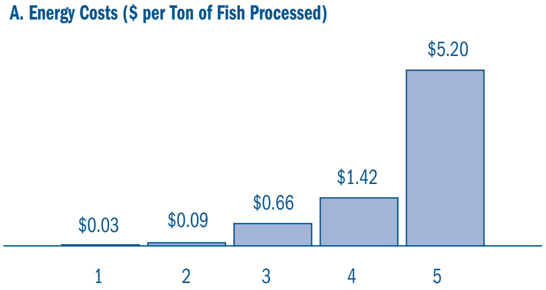
A. Energy Costs ($ per Ton of Fish Processed)

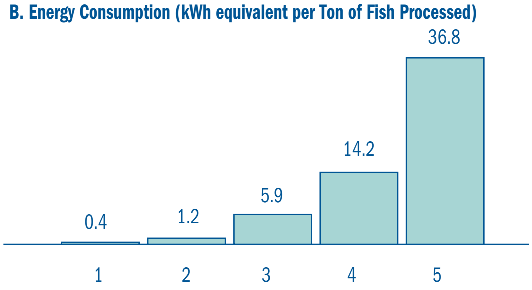
B. Energy Consumption (kWh equivalent per Ton of Fish Processed)

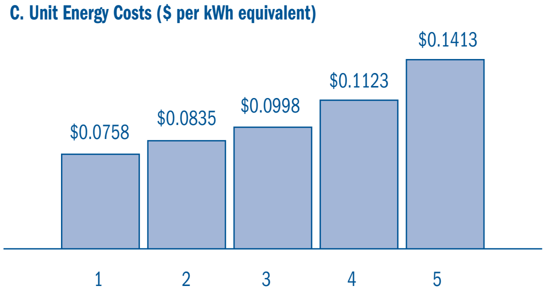
C. Unit Energy Costs ($ per kWh equivalent)

Packaging

Energy consumption in packaging operations was negligible – only a few staple guns and associated air compressors and small strapping/sealing equipment. Most of the energy consumption reported here was allocated (0 to 15 percent) from forklift operations.



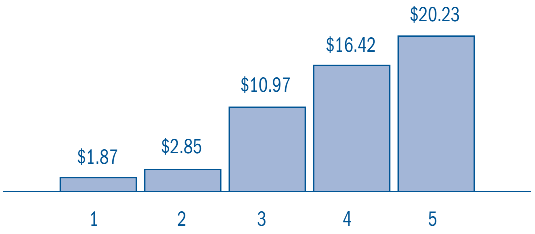




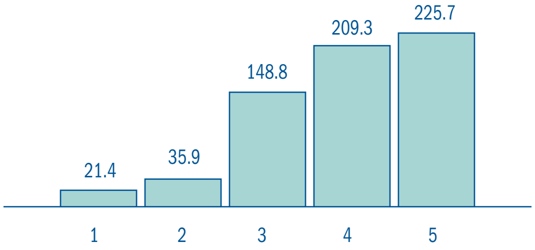
Dry Coolers

Dry coolers were used to temporarily store packaged finished product before it was shipped to market. These were custom-built refrigerated storerooms inside plants. Occasionally, additional cooler storage was provided by self-contained containers originally built for use on ocean-going vessels. The primary energy source for this production stage was electricity.

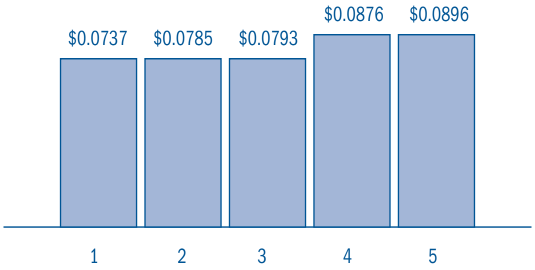
A. Energy Costs ($ per Ton of Fish Processed)



B. Energy Consumption (kWh equivalent per Ton of Fish Processed)



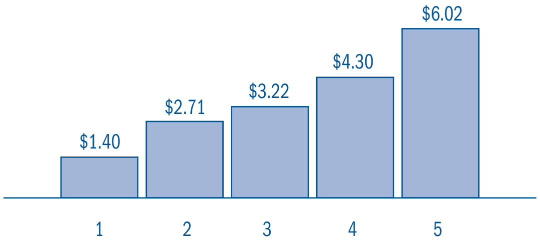
C. Unit Energy Costs ($ per kWh equivalent)



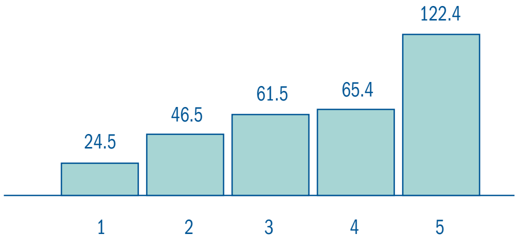
Other Plant Energy

Plant heating and lighting is the major component of energy consumption reported. Most plants used electrical radiant heaters in working areas. The smallest plant participating in the study was the only one to make extensive use of central oil heating; this plant had the lowest reported unit costs for energy for this stage, but consumed more energy (per ton) than the other plants and experienced the highest energy costs per ton.

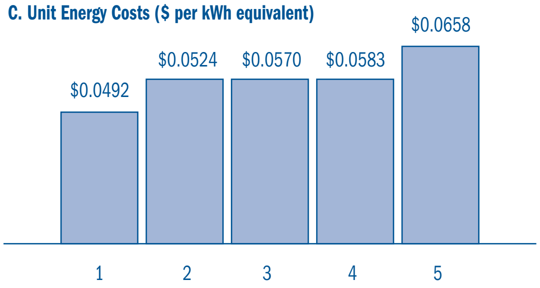
A. Energy Costs ($ per Ton of Fish Processed)



B. Energy Consumption (kWh equivalent per Ton of Fish Processed)



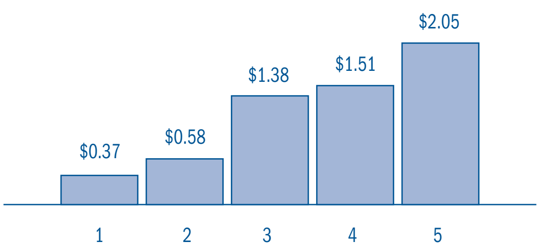
C. Unit Energy Costs ($ per kWh equivalent)



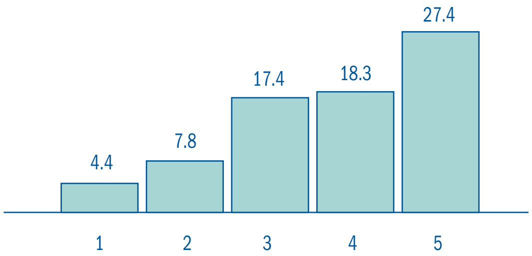
General and Administrative (G&A) Energy Use

This stage was used to report energy consumption in office areas – lighting, heating and miscellaneous electrical power for equipment.

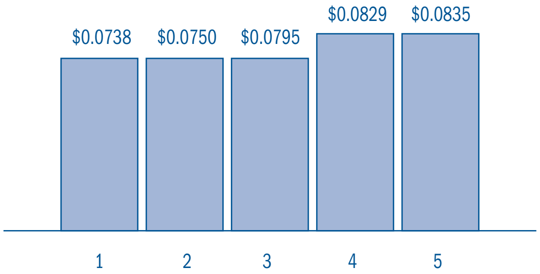
A. Energy Costs ($ per Ton of Fish Processed)



B. Energy Consumption (kWh equivalent per Ton of Fish Processed)



C. Unit Energy Costs ($ per kWh equivalent)



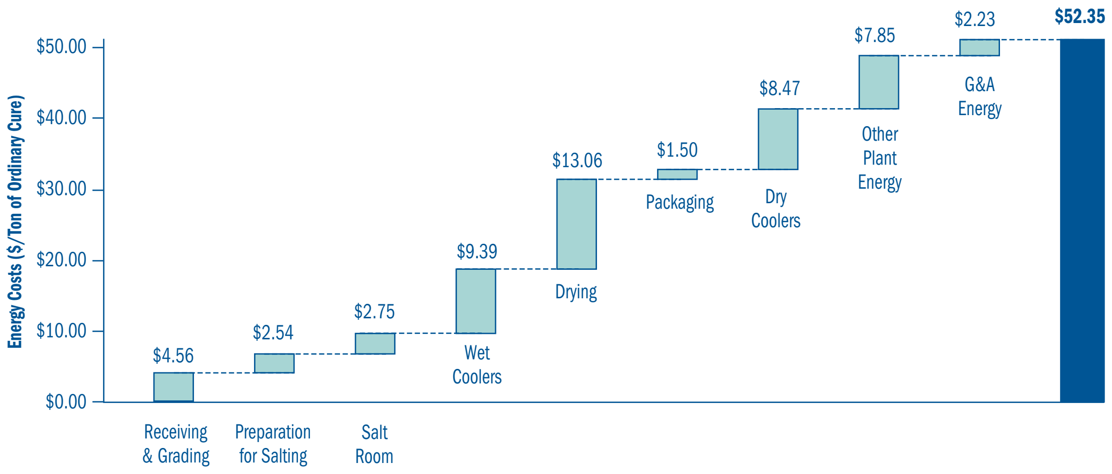
Total Plant Energy – Per Ton of Ordinary Cure

The inter-plant comparisons of total energy consumption and costs per ton are based on production of a standard product at each plant – a ton of skin-on, ordinary-cure product produced from purchased fresh fish. Note that, besides fresh fish (round and/or dressed), plants in the study also purchased and processed large amounts of frozen (head-off) fish and/or green (salted) fish for further processing at their own facilities. In keeping with the definition of the standard product, the energy consumed in holding freezers (for storage of purchased frozen fish) and in skinning and boning operations has been excluded from this inter-plant comparison of total energy consumption and costs.

All of the previous comparisons reported in this study have been based on the tonnage actually processed through each stage of production. This analysis of total consumption and costs varies in that it relates to the volumes processed through each stage in order to yield one ton of skin-on, ordinary-cure final product. On average, the plants in this study needed to receive, grade and process over 4500 pounds of fresh fish in order to produce one ton of the standard product, implying an overall yield of 44.2 percent for the salt-and-dry operation. Individual plant production of the standard skin-on, ordinary-cure product averaged 286 tons and varied from 150 to 560 tons.

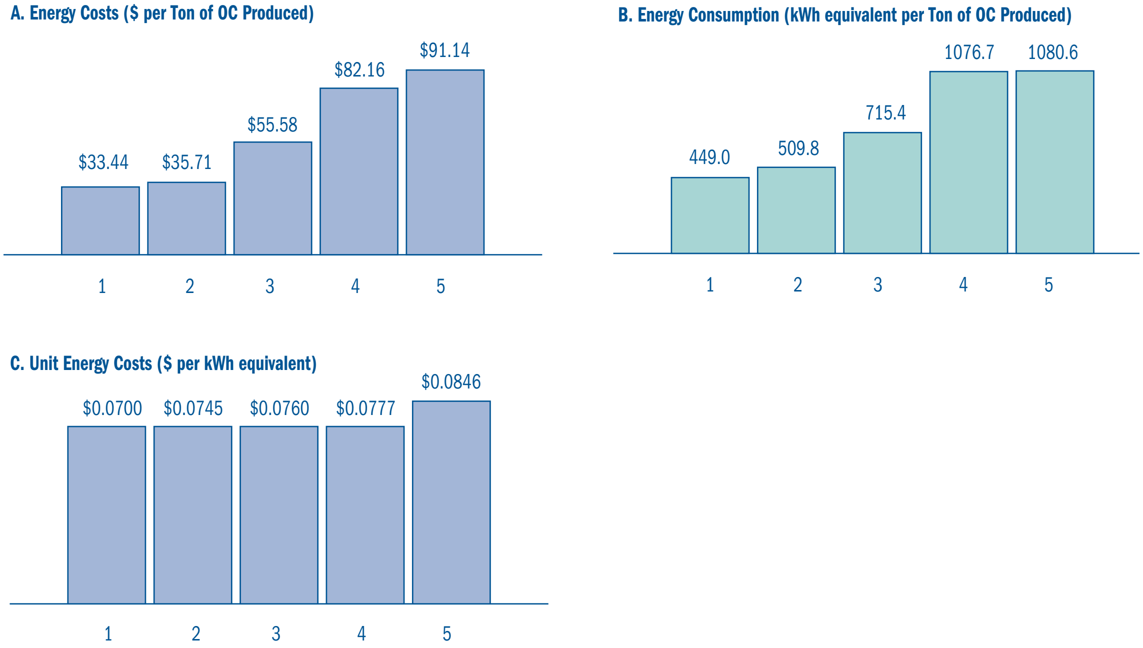
Figure 2-3 summarizes the weighted average energy costs per ton of ordinary-cure final product, by stage of production, that were reported by the five plants participating in this study.

Figure 2-3. Average Energy Costs Per Ton (of Ordinary Cure), by Stage



The largest single contributor to energy costs is the drying operation, followed by wet and dry coolers, and plant heating and lighting (Other Plant Energy). Together, these four stages account for almost 75 percent of the total energy costs incurred in salt-and-dry operations.

Figure 2-4. Inter-Plant Comparison – Total Energy Costs Per Ton (of Ordinary Cure [OC])



As illustrated in Figure 2-4, considerable variation was seen in the energy efficiency of the plants participating in this study. Although two plants were able to produce a ton of standard product with only 450–510 kWh equivalent of energy or less, two other plants consumed at least twice this amount of energy per ton.

Smaller plants tended to report higher energy consumption and costs per ton, and the two largest plants (based on dryer throughput) reported the lowest total consumption and costs per ton.

3

INTER-PLANT COMPARISONS — LOBSTER PROCESSING

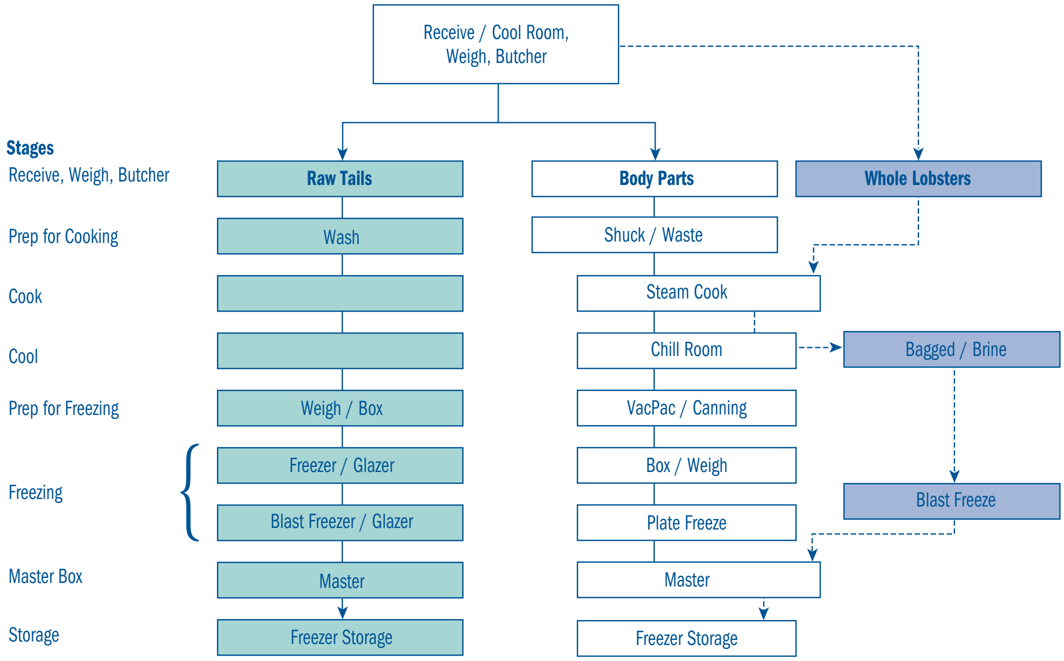
3. INTER-PLANT COMPARISONS — LOBSTER PROCESSING

This study examined the lobster processing operations for three distinct products at four plants located in Prince Edward Island. Although lobster processing operations were a major activity, these plants also processed other seafood products. Certain activities that were not integral to the lobster processing operation, or which were only present at one or two plants, or for which data were considered unreliable were removed for the inter-plant comparisons. These activities included categories such as roadway maintenance, other general and administrative (G&A) energy costs, and the use of trucks for delivering plant output to other sites.

Lobster Process Description

A simplified view of a lobster production process is illustrated below.

Figure 3-1. Generic Lobster Production Process



The dominant stages of energy consumption for each of the product categories were as follows: raw tails (blast freezing), body parts (steam cooking) and whole lobster (steam cooking).

Study Sample

At each plant, energy consumption and costs were examined for a recent full year of operations. Although plants were unable to report for precisely the same time period, there is significant overlap in the periods for which data were available. The annual reporting periods examined in this study were for the 2002 lobster seasons, approximately May through June and August through September.

The total quantity of live lobsters received at the four plants covered in this study was more than 8.5 million pounds, with individual plants receiving from 1 million to 3 million pounds. In total, the four plants produced more than 4 million pounds of processed lobster products during the one-year period examined. Total annual energy consumption for all operations was as follows: about 2.2 million kWh of electricity (primarily used in freezing/cooling operations), over 19 500 litres of propane, almost 328 000 litres of heating oil (used primarily for cooking purposes and for space heating in plants and offices), and over 10 000 litres of gasoline. Expenditures for this energy totalled about $337,000.

The energy benchmarking results are presented as follows:

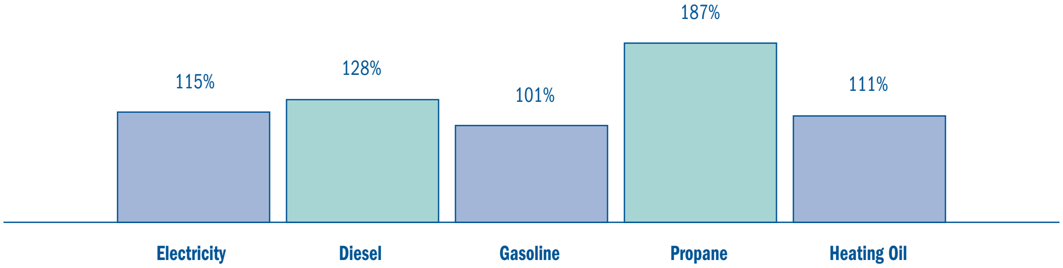
1. Individual energy costs, by source, are compared across participants.

2. The lobster processing operations are compared for the four establishments.

Unit Energy Costs

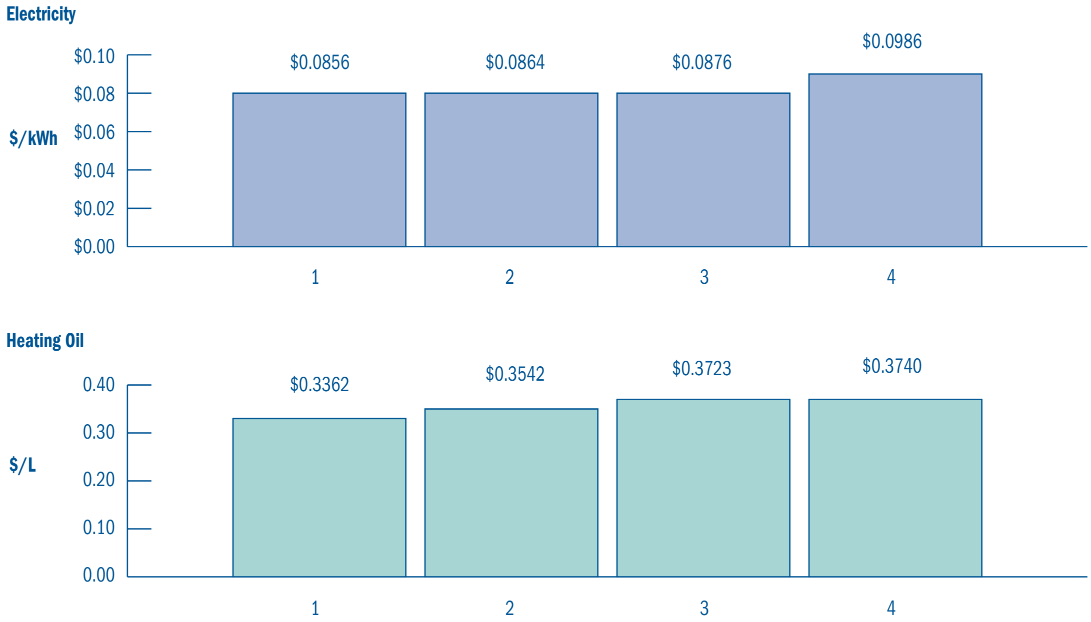
Considering the relatively small size of Prince Edward Island, it was somewhat surprising to see significant variation in energy costs by source, particularly with respect to electricity and heating oil, which are major energy inputs to lobster processing. This variation is illustrated in the chart below.

(Highest as % of Lowest)



This significant variation in the unit prices of electricity and fuels reported by plants for this study is illustrated in Figure 3-2. Note that these prices do not include (refundable) provincial sales taxes. In the majority of the plants, the dominant energy source was heating fuel used for both cooking and heating. The second most important energy source was electricity used in cooling and refrigeration operations. Propane and gasoline were generally used in forklifts and pallet movers. In general, there were no prohibitive factors affecting availability of energy source supplies.

Figure 3-2. Unit Energy Costs*



*Diesel, gasoline and propane prices have been omitted due to the limited number of users.

Inter-Plant Comparisons by Product and by Stage of Production

Sufficient information was received from the four lobster processing operations to enable comparisons at the total operations level for each of frozen tails, lobster meat and whole lobster product (to compare costs and energy consumption per ton of product processed) and for each of the stages of production (receiving, cooking, freezing, etc.).

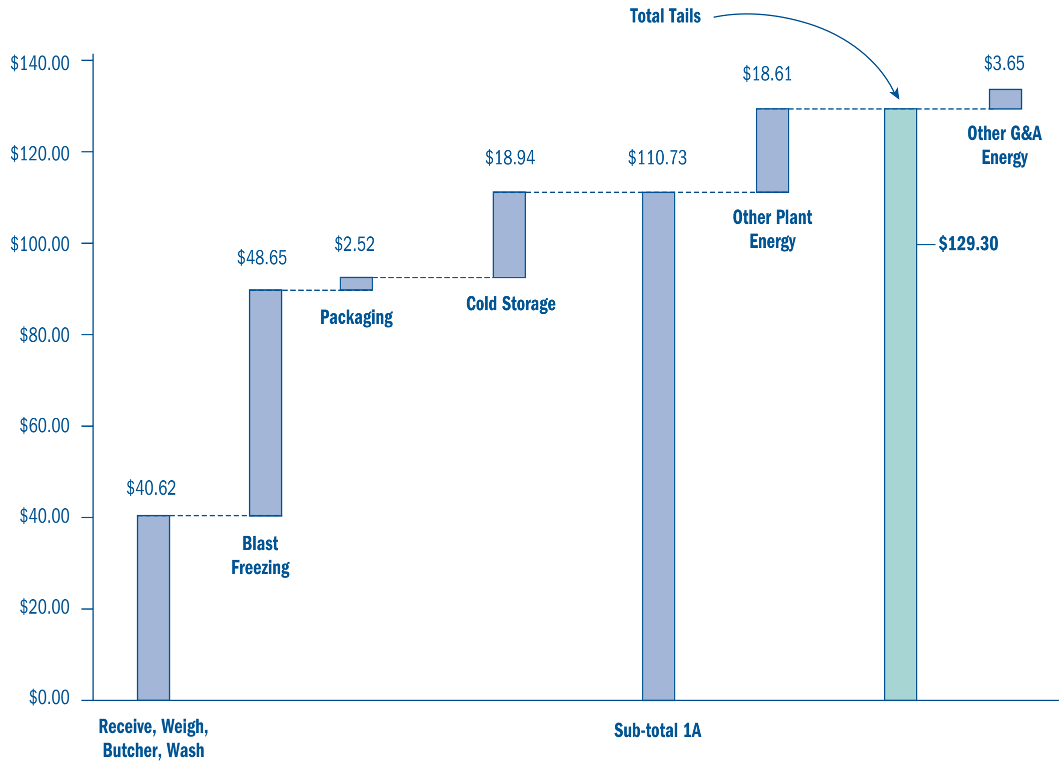
A set of three bar graphs is provided in each of the following sections. First, ranked energy costs per ton of product are shown for the four plants. Then, the two components (consumption and unit costs) are shown, also ranked from lowest to highest. Note that a plant may have three different ranks on the three sub-graphs shown (i.e. the lowest cost plant may not have the lowest consumption or the lowest unit costs). Only the managers of each participating plant have been provided with a confidential "key" that identifies that plant's position (rank) on each of the charts in this section.

Note that haul/delivery trucks are excluded from this analysis and that all plant heating and lighting energy consumption is reported as "Other Plant Energy." To enable meaningful inter-plant comparisons (and maintain confidentiality), certain energy cost categories had to be combined: chill rooms, chill tanks, brine tanks and freezing became cooling and freezing; vacuum packaging and canning operations became packaging and mastering. Also, the category of energy use described as "Other G&A Energy" has been excluded because of the unreliability of the data. For most plants, this was not an important energy cost.

Frozen Tails

Processed frozen tail output varied between 30 tons and 133 tons among the four participants. Average costs by stage of production are illustrated in Figure 3-3.

Figure 3-3. Average Energy Costs Per Ton, by Stage of Production – Frozen Tails

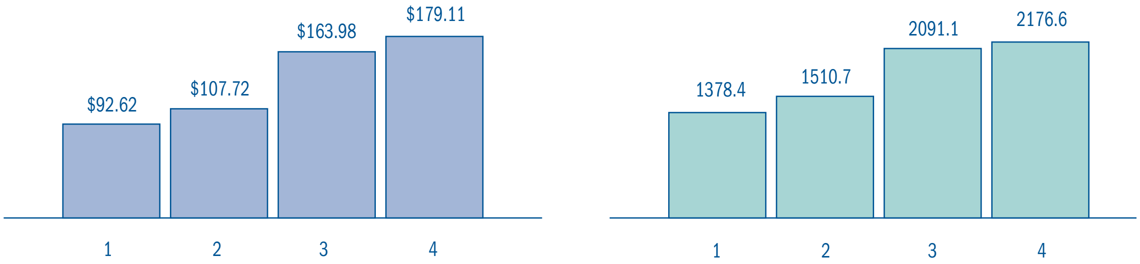


The largest single contributor to energy costs was the freezing operation. Electricity, used in freezing/cooling operations throughout the frozen tail production process, accounted for the primary source of energy costs.

A comparison of energy costs and use by process stage among the four frozen tail lobster processors is illustrated below.

As illustrated, there was considerable variation in the energy efficiency of plants participating in this study. Although two of the plants were able to produce a ton of frozen tails with about 1500 kWh equivalent or less, two other plants required at least 40 percent more. The two lowest cost producers represented both a large producer and a relatively small producer. It should not be concluded, however, that scale economies are not important, because operations are not always continually run at full capacity due to lack of available product.

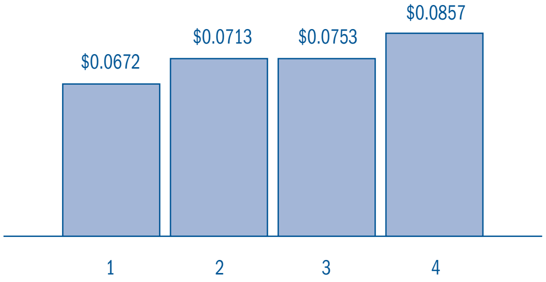
Figure 3-4. Inter-Plant Comparison – Total Energy Costs Per Ton of Frozen Lobster Tail



A. Energy Costs ($ per Ton of Final Product)

B. Energy Consumption (kWh equivalent per Ton of Final Product)

C. Unit Energy Costs ($ per kWh equivalent)

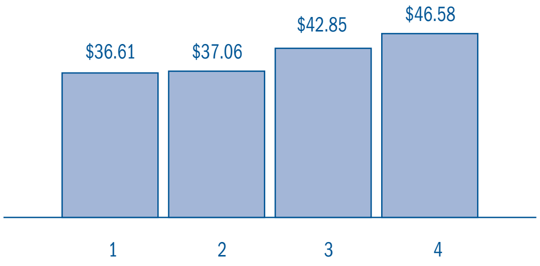


Inter-Plant Comparisons by Stage of Production (Tails)

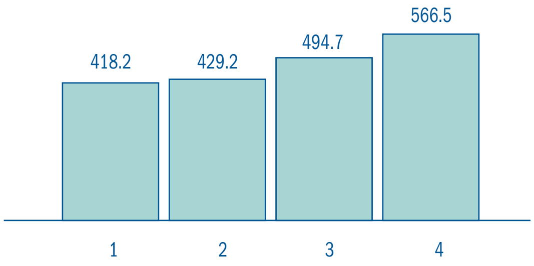
Receive/Grade/Butcher

Some of the equipment used in this stage included graders, conveyors, ice-making machines and gearbox drives. Electrical energy consumed in the process of ice making tended to be the dominant energy draw in this particular stage. The almost 25 percent variation in unit energy costs contributed significantly to the large variation in energy costs per ton of product produced. In view of the relatively small geographic size of the island, this cost variation was somewhat surprising.

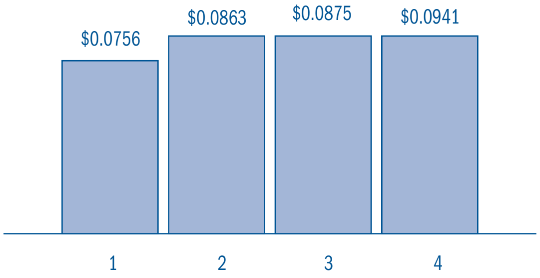
A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)



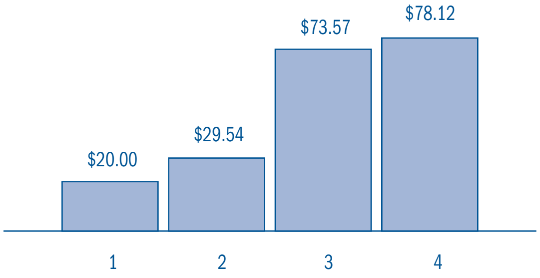
C. Unit Energy Costs ($ per kWh equivalent)



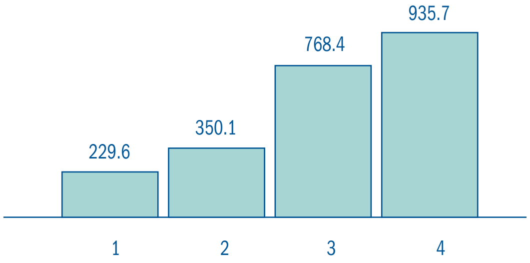
Blast Freezing Operations

This stage of production (incorporating both brine and freezing operations where relevant) was particularly energy intensive, accounting for a major portion of the energy consumed in the production of frozen tails. It was therefore surprising to see the wide variation in energy consumed, ranging from 229.6 to 935.7 kWh equivalent per ton of production. It should be noted, however, that in the case of the most energy-intensive plant, the energy consumed for blast freezing also included energy consumed in a brine operation step. The resulting product differentiation presumably enabled the company to recoup the cost of additional energy consumed in the brine and subsequent freezing processes.

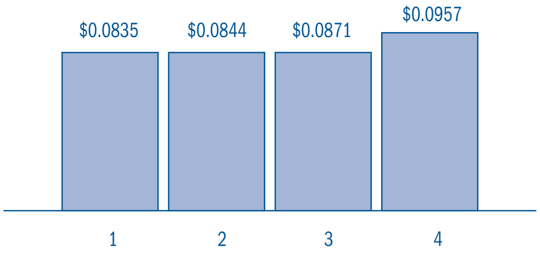
A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)

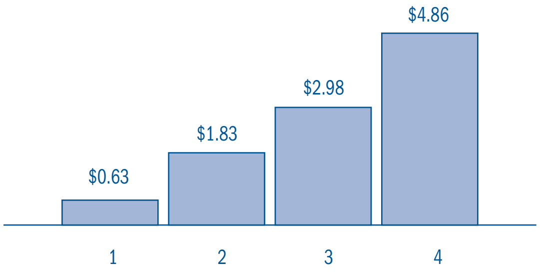


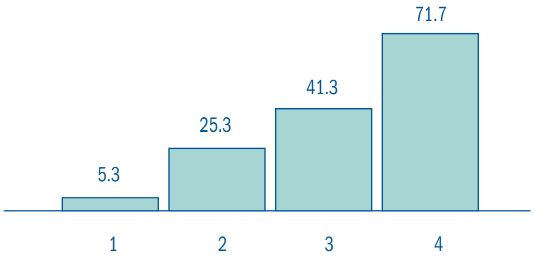
C. Unit Energy Costs ($ per kWh equivalent)

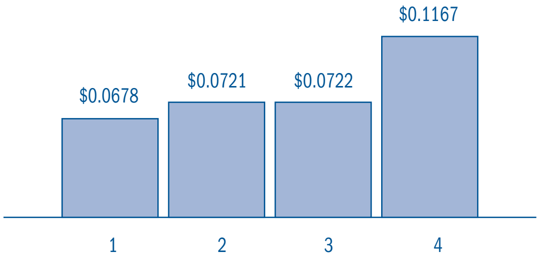


Packaging/Boxing

The packaging stage included all activities related to packaging the product prior to and including the mastering step. Although the energy cost component of frozen tails processing was the smallest, energy consumption ranged dramatically from 5.3 to 71.7 kWh equivalent per ton. An important factor contributing to this variation was the extent to which the packaging operation was mechanized as opposed to manual.

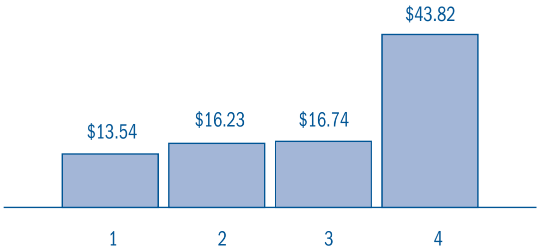

A. Energy Costs ($ per Ton of Final Product)

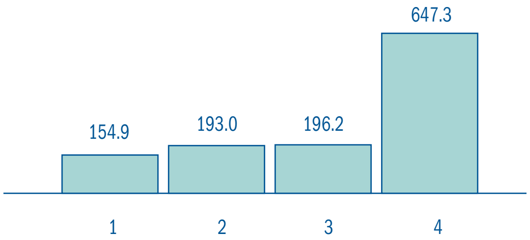

B. Energy Consumption (kWh equivalent per Ton of Final Product)

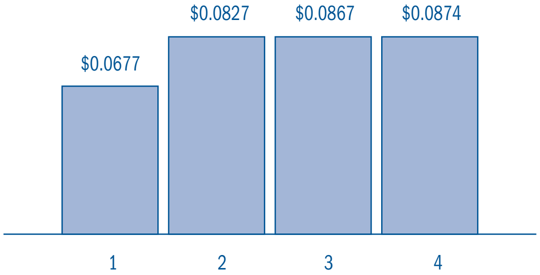

C. Unit Energy Costs ($ per kWh equivalent)

Cold Storage

This stage was the third largest user of energy. Variation in energy use between the most efficient and the largest consumer of energy for this stage was quite significant – more than 400 percent. Two factors may account for this large variation: duration of storage and/or underuse of storage capacity.

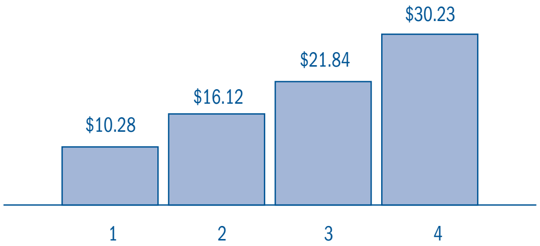

A. Energy Costs ($ per Ton of Final Product)

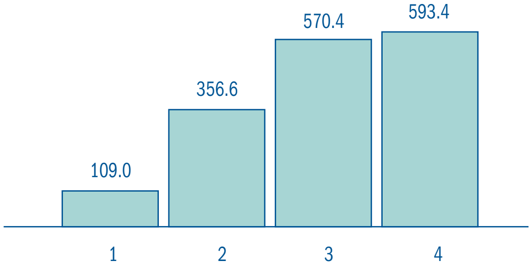

B. Energy Consumption (kWh equivalent per Ton of Final Product)

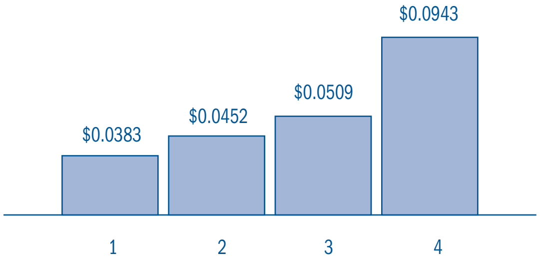

C. Unit Energy Costs ($ per kWh equivalent)

Other Plant Energy

This category of energy consumption consisted primarily of plant heat. Virtually all operations had a central steam plant that supplied heat for both cooking and heating purposes. The amount of energy allocated to plant heating varied from 1 to 30 percent, with the average being about 16 percent. The plant with the lowest energy consumption in the category of other plant energy also allocated the least amount of energy from the steam plant for this purpose. The significant variation between the high-unit, energy-cost plant and the others was related to the degree to which low-cost heating fuel was used.


A. Energy Costs ($ per Ton of Final Product)


B. Energy Consumption (kWh equivalent per Ton of Final Product)


C. Unit Energy Costs ($ per kWh equivalent)

Lobster Meat (Body Parts)

The four plants participating in the study produced about 689 000 pounds of lobster meat with production varying between 91 000 and 219 000 pounds among the plants. Average energy costs per ton, by stage of production, are illustrated in Figure 3-5.

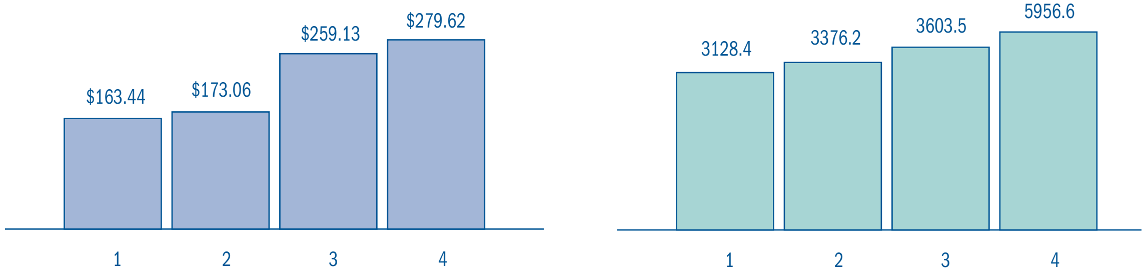
Figure 3-5. Average Energy Costs Per Ton by Stage of Production – Lobster Meat

According to Figure 3-5, the two dominant energy-intensive production stages are cooking and freezing, accounting for about 60 percent of the cost of energy consumed per ton of product produced.

Figure 3-6 illustrates a comparison of energy costs and use among the four lobster processors for the production of lobster meat.

It should be noted that in this comparison, no distinction is made between a vacuum-packaged product and a canned product. In those cases where steam produced was used for more than one product (e.g. clams, mussels), energy consumed was pro-rated on the basis of weight. Nevertheless, the significant difference in energy consumed between the lowest and highest energy use per ton of final product is likely attributable to excess capacity.

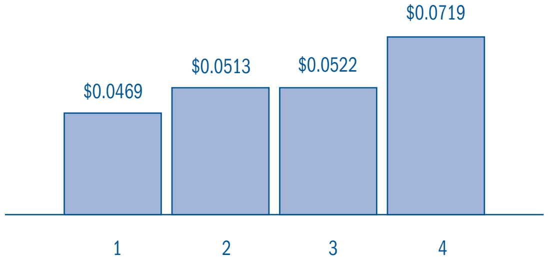
Figure 3-6. Inter-Plant Comparison – Total Energy Costs Per Ton of Lobster Meat



A. Energy Costs ($ per Ton of Final Product)

B. Energy Consumption (kWh equivalent per Ton of Final Product)

C. Unit Energy Costs ($ per kWh equivalent)



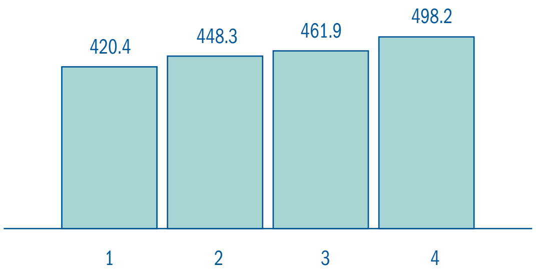
Inter-Plant Comparisons by Stage of Production

Receive/Grade/Butcher

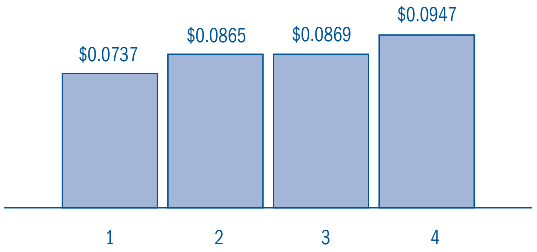
As in the case of frozen tails, equipment used in this stage included graders, conveyors, ice-making machines and gearbox drives. Energy consumed in the process of ice making tended to be the dominant energy draw in this particular stage. Unit energy costs varied by as much as 28 percent.

A. Energy Costs ($ per Ton of Final Product)

B. Energy Consumption (kWh equivalent per Ton of Final Product)

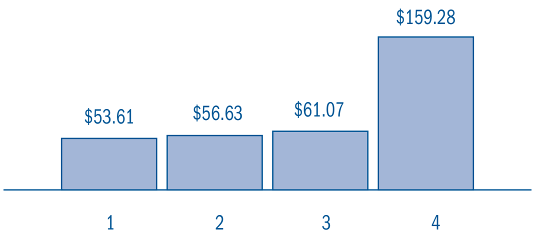


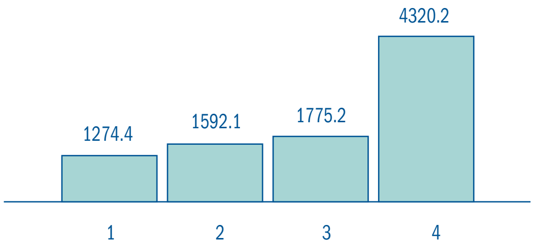
C. Unit Energy Costs ($ per kWh equivalent)

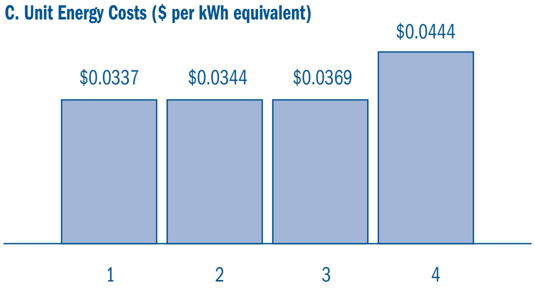


Cooking

Energy used for cooking generally accounted for the highest proportion of total energy consumed in lobster meat processing. This energy was derived from central steam plants, which produced heat for both cooking and heating purposes. In those instances where equipment was used for cooking products other than lobster, energy consumed in the cooking process was allocated pro rata on a per-pound basis. Multi-product use had the added benefit of achieving higher capacity use and therefore improved efficiency. An additional factor that may partially explain the significant variation between the highest and lowest energy consumers in this category was the considerable variation in the amount allocated for plant heating.

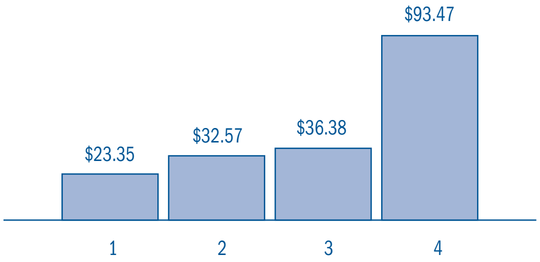

A. Energy Costs ($ per Ton of Final Product)

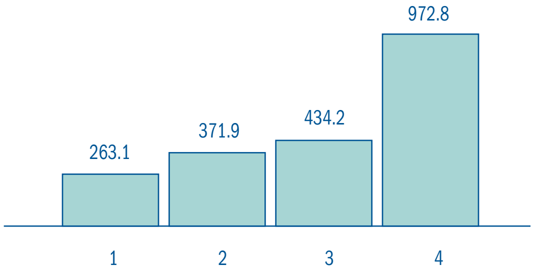

B. Energy Consumption (kWh equivalent per Ton of Final Product)

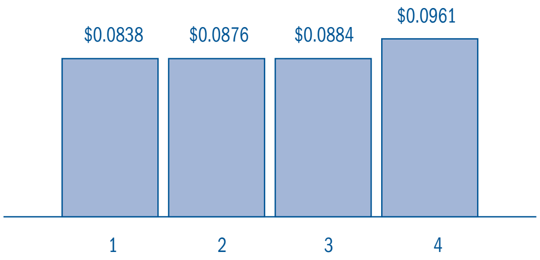

C. Unit Energy Costs ($ per kWh equivalent)

Cooling and Freezing

This production stage category included energy consumed both in the cooling process after cooking and in the freezing process after vacuum packaging or canning. The freezing technology used was primarily plate freezing, although blast freezing was also employed. The huge variation between the highest and lowest energy consumption can be in part attributed to a brine process used by the high energy user.

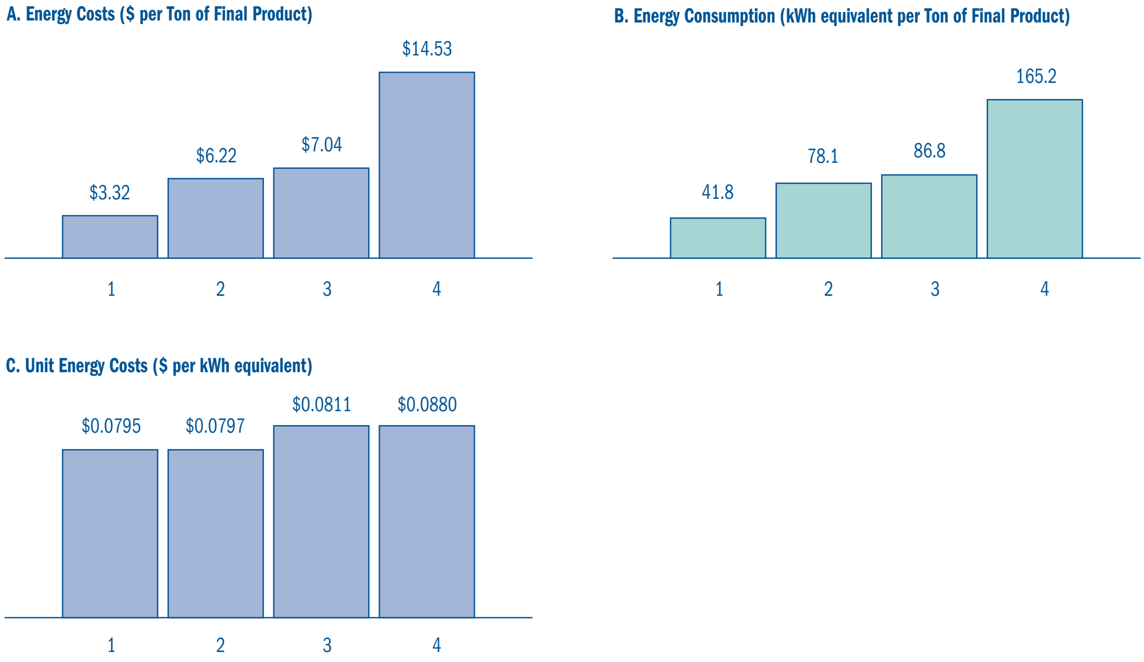

A. Energy Costs ($ per Ton of Final Product)


B. Energy Consumption (kWh equivalent per Ton of Final Product)


C. Unit Energy Costs ($ per kWh equivalent)

Vacuum Packaging/Canning

Vacuum packaging/canning was not a highly energy-intensive operation in the processing of lobster meat. Generally this step accounted for less than 5 percent of the total energy consumed.

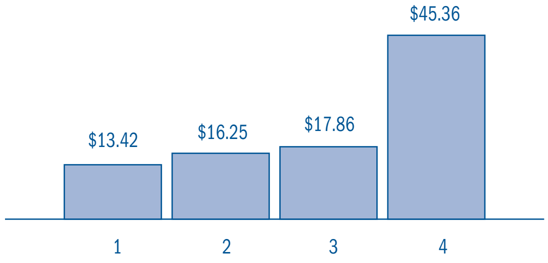

A. Energy Costs ($ per Ton of Final Product)

B. Energy Consumption (kWh equivalent per Ton of Final Product)

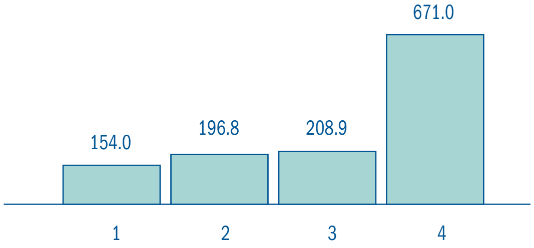
C. Unit Energy Costs ($ per kWh equivalent)

Cold Storage

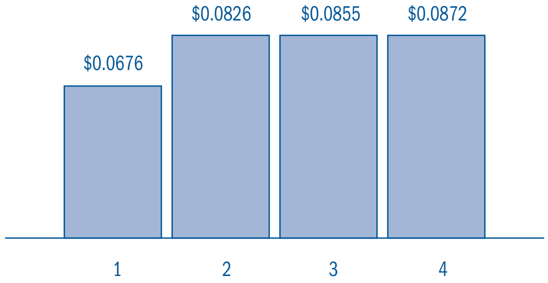
The wide variation in energy storage costs and energy intensity was in part attributable to the technology used in supplying the cooling. Refrigeration processes included central, separate, diesel-powered reefers, and off-site refrigeration. Other factors contributing to this variation included the significant range in energy pricing (29 percent) and the degree of capacity use.



A. Energy Costs ($ per Ton of Final Product)



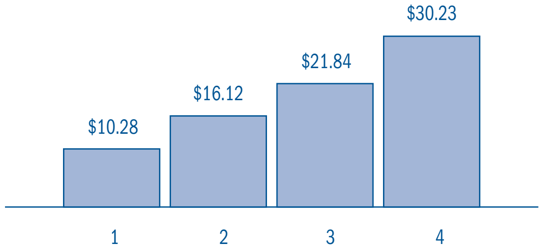
B. Energy Consumption (kWh equivalent per Ton of Final Product)



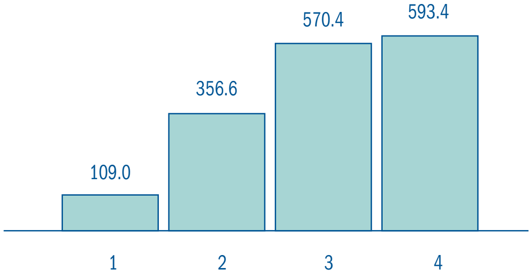
C. Unit Energy Costs ($ per kWh equivalent)

Other Plant Energy

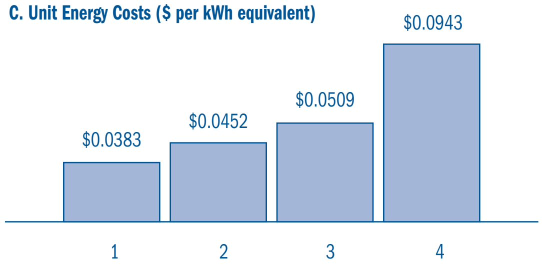
As in the case of frozen tails, this category of energy consumption primarily consisted of plant heat. Virtually all operations had a central steam plant, which supplied heat for both cooking and heating purposes. The amount of energy allocated for plant heating varied from 1 to 30 percent, with the average being about 16 percent. The plant with the lowest energy consumption in the category of other plant energy also allocated the least amount of energy from the steam plant for this purpose.



A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)

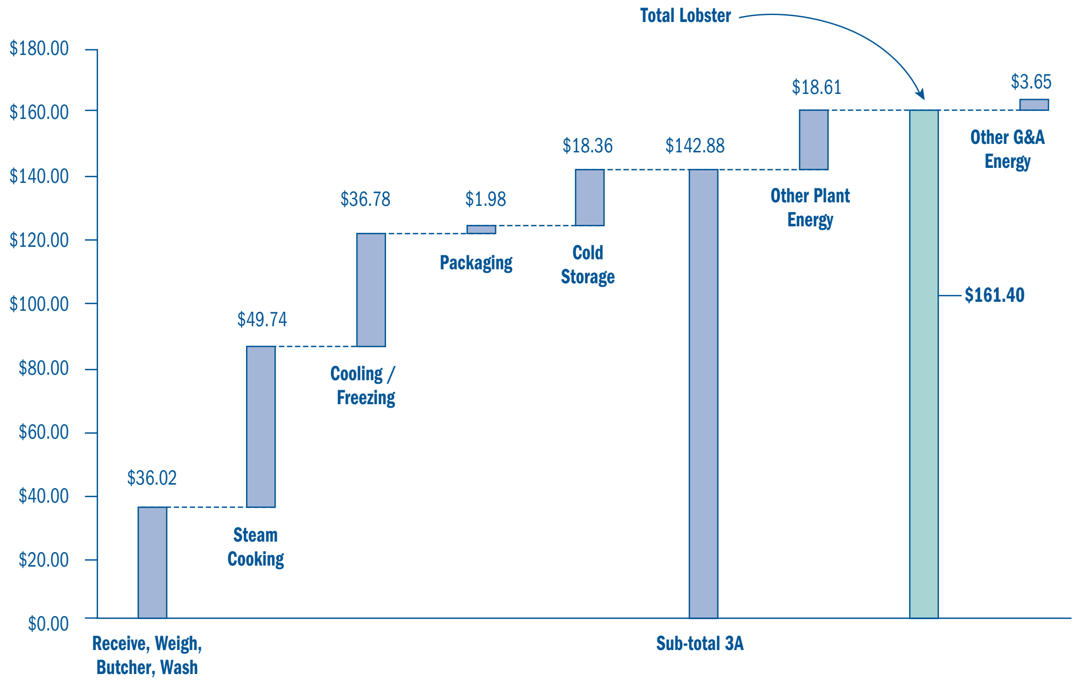


C. Unit Energy Costs ($ per kWh equivalent)

Frozen Whole Lobster

The four plants participating in the study produced about 2 725 400 pounds of frozen whole lobster, with production varying between 352 800 and 1 383 000 pounds among the plants. Average energy costs by stage of production are illustrated in Figure 3-7.

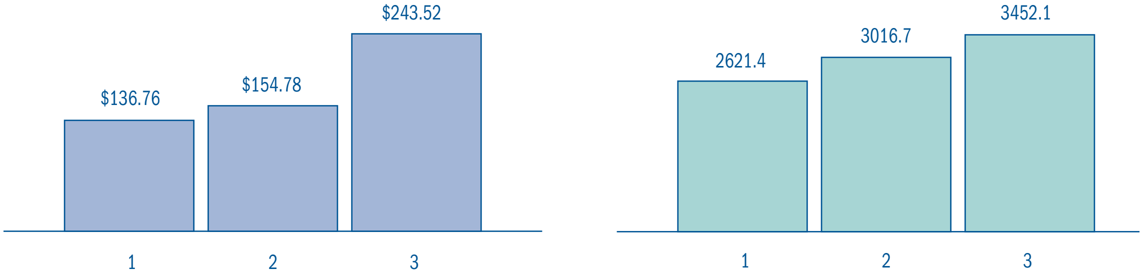
Figure 3-7. Average Energy Costs by Stage of Production – Frozen Whole



The three dominant energy consuming operations of receiving, cooking and freezing accounted for almost three quarters of the average energy cost per ton of whole frozen lobster produced. It was interesting to note that the energy cost involved in the cooking phase significantly exceeded that involved in the freezing phase.

Figure 3-8 illustrates a comparison of energy costs and use among the three lobster processing plants for the production of frozen whole lobster. The fourth company did not process frozen whole lobsters.

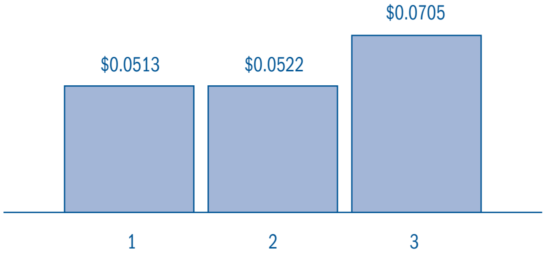
Figure 3-8. Inter-Plant Comparison – Total Energy Costs Per Ton of Frozen Whole Lobster



A. Energy Costs ($ per Ton of Final Product)

B. Energy Consumption (kWh equivalent per Ton of Final Product)

C. Unit Energy Costs ($ per kWh equivalent)



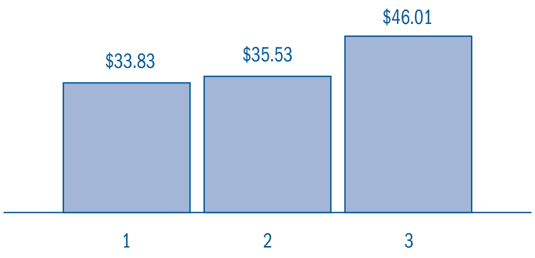
As evident above, there was considerable variation in the energy efficiency of plants participating in this study. A significant factor contributing to the high use of energy in the production process was whether or not it included a brine operation. Another important consideration was the degree to which refrigeration capacity was used and whether it was centralized.

Inter-Plant Comparisons by Stage of Production for Frozen Whole Lobster

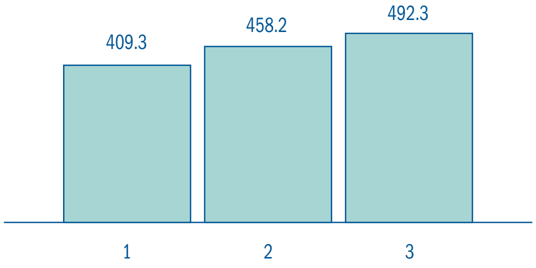
Receive/Grade/Butcher

As in the case of the previous lobster products, equipment used in this stage included graders, conveyors, ice-making machines and gearbox drives. Energy consumed in the process of ice making tended to be the dominant energy draw in this particular stage. The fact that unit energy costs varied by as much as 28 percent was a significant contributing factor to the large variation in average energy costs per ton of product processed.

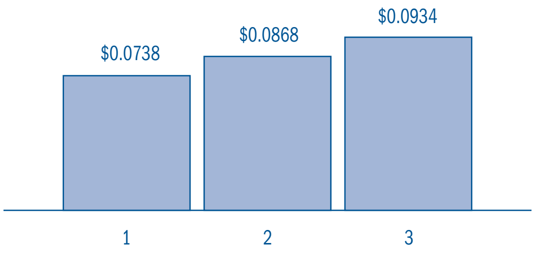
A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)

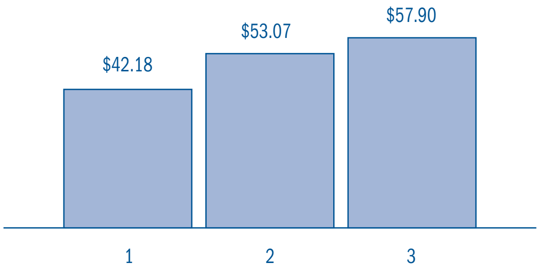


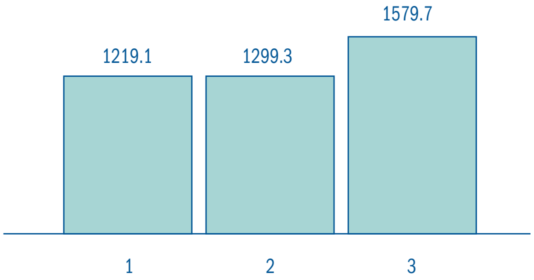
C. Unit Energy Costs ($ per kWh equivalent)

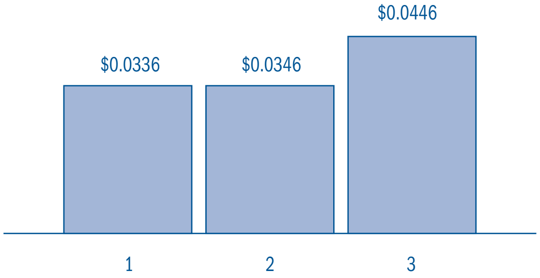


Cooking

The cooking stage accounted for the highest energy consumption per ton of frozen lobster produced. A major contributing factor to the variation in cooking energy costs per ton produced was the large range in fuel pricing – almost 33 percent between the highest and lowest plant.

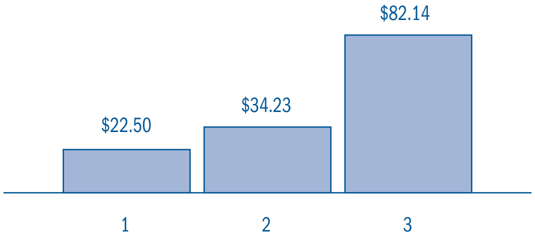

A. Energy Costs ($ per Ton of Final Product)

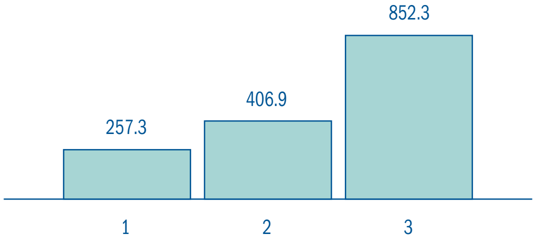

B. Energy Consumption (kWh equivalent per Ton of Final Product)

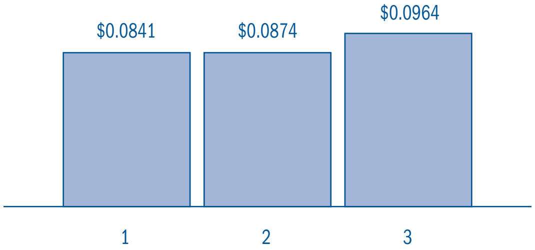

C. Unit Energy Costs ($ per kWh equivalent)

Cooling/Blast Freezing

The rather significant variation in energy costs per ton of product produced for this energy-intensive production stage was partially explained by the different processing technologies used (not all of the producers incorporated a brine operation in their production process). Furthermore, high energy-intensive use per ton of final product was affected by the degree of central refrigeration, as well as capacity use.


A. Energy Costs ($ per Ton of Final Product)

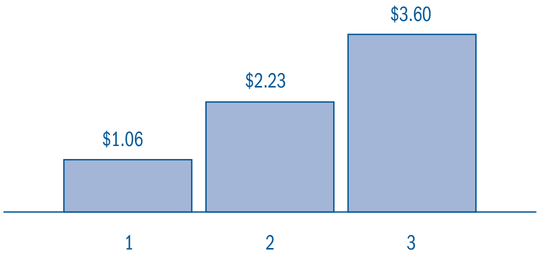

B. Energy Consumption (kWh equivalent per Ton of Final Product)


C. Unit Energy Costs ($ per kWh equivalent)

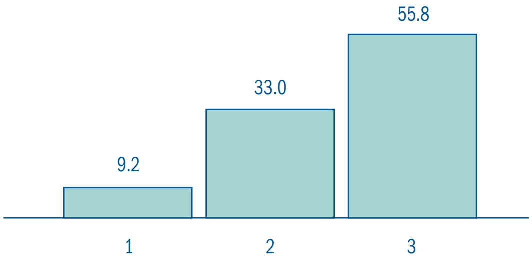
Packaging

Packaging (including mastering) was the single lowest energy cost component of the frozen whole lobster process. The large variation was partly attributed to the degree of manual labour used in this step of the production process.

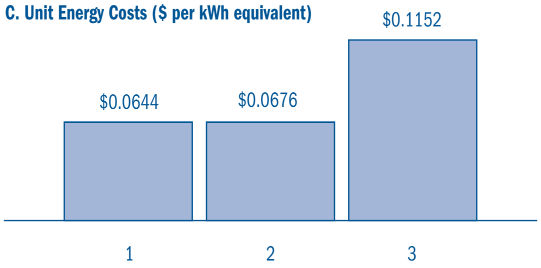
A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)



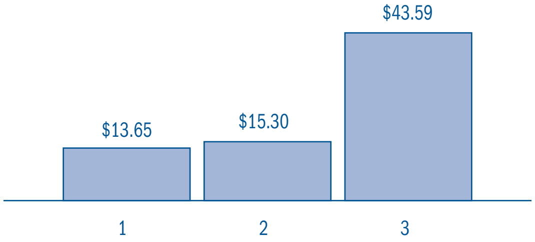
C. Unit Energy Costs ($ per kWh equivalent)



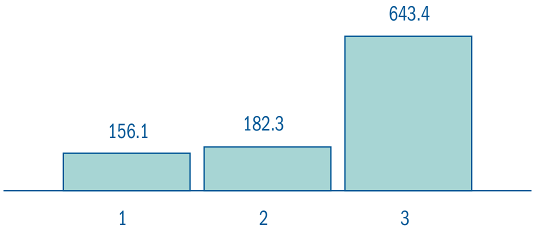
Cold Storage

Although not dominant, storage energy costs were important. As previously mentioned, variation in storage energy costs and use were partly attributable to the technology used in supplying the cooling. Refrigeration processes included central, separate, diesel-powered reefers, and off-site refrigeration. Other factors contributing to this cost variation included the significant range in energy pricing (28 percent) and capacity use.

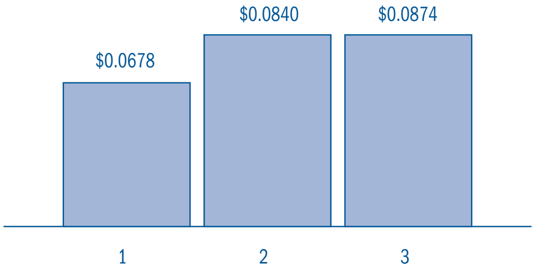
A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)



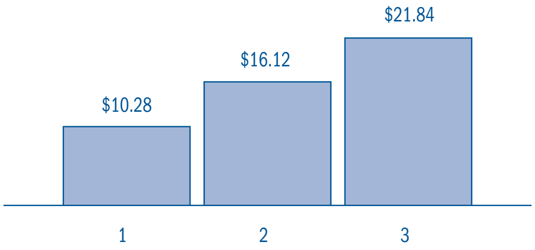
C. Unit Energy Costs ($ per kWh equivalent)



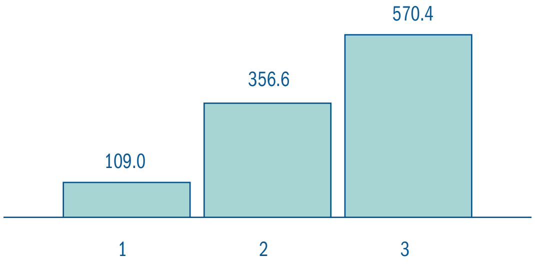
Other Plant Energy

As with tails and lobster meat, this category of energy consumption consisted primarily of plant heat. Virtually all operations had a central steam plant, which supplied heat for both cooking and heating purposes. The amount of energy allocated for plant heating varied from 1 to 30 percent, with the average being about 16 percent. The plant with the lowest energy consumption in the category of other plant energy also allocated the least amount of energy from the steam plant to this purpose.

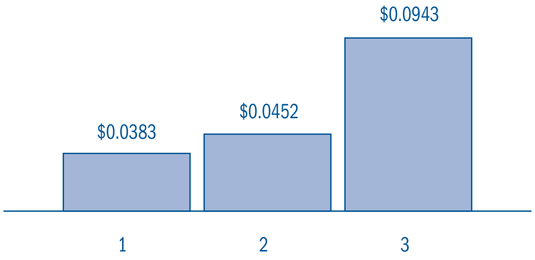
A. Energy Costs ($ per Ton of Final Product)



B. Energy Consumption (kWh equivalent per Ton of Final Product)



C. Unit Energy Costs ($ per kWh equivalent)



4

EMISSIONS AND ENERGY SAVINGS

4. EMISSIONS AND ENERGY SAVINGS

Greenhouse Gas Emissions

This section reports on the greenhouse gas (GHG) emissions generated by the salt-and-dry fish processing and lobster processing facilities that participated in the benchmarking study. To calculate the total GHG emissions for the plants, the emissions factors shown in Table 2 have been used.

Table 2. GHG Emissions Factors

	Electricity (g/kWh)	Diesel (g/L)	Gasoline (g/L)	Propane (g/L)	Heating Oil (g/L)
Carbon dioxide	–	2730	2360	1530	2830
Methane	–	0.07	0.19	0.7	0.006
Nitrous oxide	–	0.1	0.39	0.09	0.013
Carbon dioxide equivalent					
- Nova Scotia	0.780	–	–	–	–
- Prince Edward Island	0.546	–	–	–	–

Salt-and-Dry Fish Processing Operations

The total amounts of each fuel consumed in salt-and-dry-related operations at the five participating plants are summarized in Table 3, along with the fuel consumption attributable to the production of ordinary-cure dried products. As these figures indicate, ordinary-cure production accounts for between 30 and 50 percent of salt-and-dry activity. The remaining energy consumption is related to production of semi-dry and dry products, and to fish that are only partially processed at the plants and then sold as fresh or green/salted.

Table 3. Total Energy Consumption – Salt-and-Dry Fish Processing

	Electricity (kWh)	Heating Oil (Litres)	Propane (Litres)
Salt-and-Dry	3 137 434	61 757	63 883
Ordinary Cure	976 804	28 579	25 951
Ordinary Cure as Percentage	31.0%	46.3%	40.6%

The total GHG emissions for salt-and-dry operations are shown in Table 4.

Table 4. Total GHG Emissions (kg) – Salt-and-Dry Fish Processing

	Salt-and-Dry	Ordinary Cure
Carbon dioxide	273 425	116 310
Methane	1.9	0.9
Nitrous oxide	8.7	3.9
Carbon dioxide equivalent	2 447	760

Lobster Processing Operations

The total amounts of each fuel consumed in lobster processing at the four participating plants are summarized, by product, in Table 5.

Table 5. Total Energy Consumption – Lobster Processing

	Electricity (kWh)	Diesel (Litres)	Gasoline (Litres)	Propane (Litres)	Heating Oil (Litres)
Frozen Tails	416 011	3 147	2 439	1 385	949
Lobster Meat	467 411	3 334	2 128	3 850	79 413
Whole Lobsters	1 420 534	17 241	7 786	15 381	176 384

The total GHG emissions for lobster processing operations are shown in Table 6.

Table 6. Total GHG Emissions (kg) – Lobster Processing

	Tails	Meat	Whole
Carbon dioxide	19 111	244 638	587 681
Methane	0.8	1.3	4.3
Nitrous oxide	1.8	3.0	10.6
Carbon dioxide equivalent	227	255	776

Potential Energy Savings

Context

In this section, some general estimates are presented of potential energy savings to be made by attaining the performance of the most energy-efficient operations. To determine the related potential cost savings, weighted average costs were used for each source of energy.

It should be noted that the potential savings identified may not be realizable for a number of practical reasons. For example, savings may be related to insufficient product availability to achieve scale economies, or customer requirements may dictate the use of a particular technology thereby precluding the use of a more energy-efficient one.

Nevertheless, offsetting arguments may be advanced regarding the size of potential savings when one considers the following:

- There are opportunities for improvement in the lowest-cost, most-efficient facilities. The fact that the leading firm is different for different stages of production further underscores the existence of future potential.

- Operations may exist that did not participate in this survey and that function more efficiently and at lower cost.

Taking into account the above observations, we present the following simplified estimate of the potential savings achievable if each participant were to process their product at the level of energy consumption of the most efficient producer in their product category.

Table 7. Potential Energy Savings

	Weighted Average kWh equivalent/ton	Lowest kWh equivalent/ton	Savings kWh equivalent/ton	Weighted Average $/ kWh equivalent	Total Savings ($000)
Tails	1 770	1 378	392	0.0736	8.8
Lobster Meat	4 157	3 128	1 029	0.0529	17.3
Whole Lobster	2 930	2 621	309	0.0541	24.3
Salt-and-Dry OC*	633	449	184	0.0785	29.2
Total					**79.6**

*Ordinary cure

With respect to lobster processing operations and salt-and-dry fish processing operations, potential energy savings represent cost savings of about $50,400 (i.e. approximately 14 percent) and $29,200 (i.e. approximately 30 percent), respectively.

In summary, using the most efficient operations as the benchmark, potential annual energy savings of about $79,600 (about 17 percent of total energy costs) were identified, as applied to the nine study participants.

On a cautionary note, it should be recognized that these savings are hypothetical and may not be realizable due to circumstances faced by each processor, as discussed above.