LOUISIANA COOPERATIVE EXTENSION SERVICE
LOUISIANA STATE UNIVERSITY AGRICULTURAL CENTER

SEAGRANT

A Result Demonstration

In

Small Grocery Stores/Seafood Markets
Refrigeration Servicing

Sponsored By

Louisiana Cooperative Extension Service
LSU Agricultural Center
Baton Rouge, Louisiana

and

Louisiana Cooperative Extension Service
Jefferson & Orleans Parishes

Supported By

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Air Conditioning and Refrigeration Dealer Association of Louisiana, Inc.

Conducted In

Jefferson and Orleans Parishes

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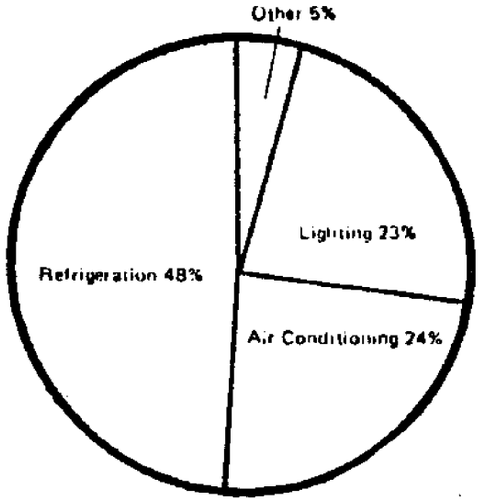
I. Design of Study

Background & Purpose

Small grocery stores, with long operating hours, large refrigeration requirements, and bright lighting levels, use more energy than do the more conventional retail stores. In many respects seafood markets are similar to small grocery stores in their energy use patterns since both have relatively large refrigeration requirements. Both are important fixtures in the New Orleans area. These are the types of stores considered in this work.

The typical store in the New Orleans Metro Area requires little energy for heating but uses large amounts of electricity for freezing and refrigerating their products. For example, in a study of a similar store, refrigeration accounted for almost half of the electricity consumed[1]. Air conditioners and lights used the remainder in almost equal amounts. These portions are illustrated in the usage graph.



Preventative maintenance of air conditioning equipment has been demonstrated to restore capacity, and lower utility costs[2 & 3]. Since refrigeration equipment and air conditioning equipment are similar in many ways, it would be expected that similar benefits could be obtained by preventative maintanance of refrigeration equipment. A survey of refrigeration manufacturers, service personnel, university research, and trade associations failed to provide information on the magnitude of the effect in a typical commercial operation, and in particular, for a typical operation in the New Orleans area. Several references deal with the increase of energy consumption from dirty condenser coils, blockage of air flow across the condenser coils, short circuiting of air flow, dirty fan blades, and dirty evaporator coils.

However, the references consider the increased consumption from a qualitative rather than quantitative standpoint, and thus can not be used to compare the cost of servicing to savings from servicing. It is also generally recognized that dirty condenser units can increase head pressures and shorten equipment life and that dirty evaporator coils can greatly reduce capacity.

Because of the importance of small grocery stores/seafood markets in the Metro area, the Orleans Parish Energy Advisory Committee decided that a result demonstration dealing with energy conservation in these types of stores would be appropriate.

Accordingly, the Louisiana Cooperative Extension Service in conjunction with the Orleans Parish Energy Advisory Committee (Metro New Orleans Area) elected to develop a refrigeration result demonstration that would emphasize maintenance.

II. Demonstration Objectives

1. Establish the potential for lowering utility costs to the consumer through preventative maintenance and service.

2. Develop information through result demonstrations to be incorporated into future educational programs.

3. Compare open and closed freezer display cases.

4. Obtain other applicable information which may become evident during the course of the work.

III. Selection of Sites and Definition of Study

Louisiana Cooperative Extension Service agents from Orleans and Jefferson Parishes and Louisiana Cooperative Extension Service engineering specialists from LSU, Baton Rouge, met with the Louisiana Grocers Association for help in obtaining cooperators for the demonstration. The Louisiana Grocers Association published an article in their trade journal which explained the demonstration and gave participation details. As a result thirty three volunteers received a walk through inspection and preliminary evaluation.

At the completion of the preliminary evaluation, the team met with the Orleans Parish Energy Advisory Committee (Metro New Orleans Area) and selected six stores to participate. The stores were selected on the basis of obtaining a representative cross section. Three of the businesses were in Jefferson Parish (both westbank & eastbank) and the other three were in Orleans Parish.

Three primary energy conservation opportunities were found during the preliminary evaluation. They were maintenance (cleaning) of the units, proper ventilation for the units and equipment selection.

Maintenance on the units varied from a monthly maintenance service by refrigeration professionals to "fix it when it breaks", the latter being far more common. In between these extremes was servicing performed by store personnel.

The most serious common ventilation problem was that many condenser units would be located close together where the hot exhaust from one would supply the "cooling" air to another or recycle it to

itself. The tendency for these units to be in a closed area, perhaps because of space limitations or security reasons, increases the likelihood of this problem occurring. The other common problem was the tendency to stock items in front of the intake grill of self contained units.

A particularly striking revelation, at one store, was that it was often heated in the summer time, otherwise it would be too cold for comfort. This store had a large number of open refrigerated and freezer display cases. It was apparent to us that there was considerable refrigeration loss from these boxes and that it was much more from open than from closed units.

Because of these observations it was decided that the effect of maintenance on refrigeration units which were serviced on a regular basis by store personnel, and on units which were serviced on a "fix it when it breaks" basis should be demonstrated. No service was to be done at the two stores with a preventative maintenance contract, however, it was decided to use one of the stores to demonstrate the relative efficiency of open versus closed boxes and to serve as a source of a baseline for weather effects. The effect of improper ventilation of the condenser units was of great interest but was not as amenable to demonstration because of the necessity of altering physical structures to accomplish a change. It was decided to try to piggyback this onto a demonstration of maintenance and thus one of the chosen units was one located in a closed in lean-to with other condensing units. It was initially planned that after sufficient data on the effect of cleaning was obtained, we would attempt to increase ventilation by opening up the lean-to and observe the effect.

IV. Methodology

The six small grocery store owners/supervisors were requested to operate their refrigeration units on a routine basis even though monitoring equipment was installed. They were briefed that daily visits by Louisiana Cooperative Extension Service agents would in no way interfere with their normal business operation. They were further advised that the duration of the demonstration would last six weeks. In addition they were asked to monitor the loading of the boxes in order that any variation in load over the test period could be accounted for.

The demonstration was divided into two three week periods. The first three week period consisted of monitoring the electrical usage of the refrigeration units with a KWH meter wired to each condenser unit. This provided a base line of energy consumption before servicing. During this time ambient conditions and observations were recorded.

Three units had only 20 days instead of 21 days of recorded data in the first time period. Consumption data was adjusted for these units by adding an average days' consumption in the first period to the total consumption in that period.

At the end of the first three week period, the refrigeration units were serviced by a local refrigeration service company.

The preventative maintenance services performed were variable from unit to unit and were based upon the judgment of the licensed professional and a reasonable level of practicality. These services were performed under the restraint that service be reflective of those performed in a routine preventative maintenance call.

The services performed on the refrigeration units were:

1. Condenser coils cleaned, chemically on all outside condenser units, with compressed gas on condenser units located in the store.
2. Evaporator coils checked and cleaned with brush or compressed gas as required.
3. Amp draw and sight glass checked and freon added as required.
4. Fan belts, pulleys, and component parts inspected.

The monitoring by Louisiana Cooperative Extension Service agents consisted of:

1. Inside and outside sling psychrometer readings.
2. Kilowatt hour meter reading.
3. Demand reading on selected equipment.
4. Observations of foodstuff storage in monitored boxes.
5. Conferences with owners/managers concerning any irregularities in operation or changes in load conditions.
6. Other pertinent observations.
7. Time of day each reading was taken.

Three units were not serviced. Two of these had roof mounted condenser units and were being professionally serviced monthly on a contract basis. The third unit was completely contained in a garage and was serviced on a "fix-it-when-it-breaks" basis. These three units provided a control to account for a variation in weather conditions.

Monitoring was continued for three weeks following the servicing.

V. Data Collection Instrumentation

Instrumentation

Instrumentation for the demonstrations consisted of:

1. Two sling psychrometers.
2. Kilowatt hour meter (four with demand).

VI. Results and Discussion

The data taken during the six week demonstration period is summarized in Table 1. A brief discussion of each unit will follow:

Table 1. Data Summary

Unit #	KWH 1st Period 9/17 - 10/7	KWH 2nd Period 10/7 - 10/28	KWH Change	% Change of KWH	Notes
		Control			Group
1	695*	654	-41	-5.9	Closed freezer in garage, 40" high X 80" long X 27" deep, nominal 1½hp
2	1,239	1,349	110	8.9	Open freezer, 43" high, X 12' long 30" deep, split unit 3 phase, nominal 7½ hp
3	561	596	35	6.2	Closed freezer, 54" high X 10' long X 27" deep split unit, 3 phase nominal 5 hp, monthly service
		Monthly cleaning by store personnel			
4	406	395	-11	-2.6	Meat case, 28" high X 98" long X 24" deep, self contained unit, nominal 1½ hp, serviced 10/7
5	449	411	-38	-8.5	Open freezer, 21" high X 88" long X 28" deep, self contained nominal 3/4 hp bad defrost timer, serviced 10/7
		Fix it when it breaks maintenance			
6	1,423*	1,076	-347	-24.4	Open refrigerated case, 40" high X 20' long by 36" deep, split unit, nominal 3 hp, serviced 10/7
7	434*	329	-105	-24.2	Open meat case with cover, 8" high X 12' long X 35" deep, split system, nominal 1½ hp, serviced 10/7
8	907	658	-249	-27.5	Walk in refrigerator, 8 3/4' high X 9½' X 13', split system nominal 5 hp, serviced 10/7

* Adjusted to 21 days of operation.

Unit 1 was a closed freezer located in the garage. There was no regular preventative maintenance performed on this unit. No maintenance was performed for the purpose of this demonstration. Thus, this unit served as a check on the affect of weather changes on the energy requirements. This unit had 20 days of monitored operation during the first period of operation.

During the first period 695* kilowatt hours were consumed. There were 654 kilowatt hours consumed in the second period. There was a net reduction of 41 kwh or 5.9% in energy consumption. According to the store owner, there was essentially no change in the loading of the freezer from one period to the next.

Units 2 & 3 were located in the same store. Both had roof mounted condensers and both were serviced under a monthly service contract by a professional refrigeration company. The loading on both boxes was similar from one period to the next and the amount of food loaded did not change substantially. In addition, the foodstuffs were loaded into the freezer in a frozen condition so they did not constitute a large additional load.

Unit 2 was an open freezer (vertical display) with 43 square feet of face area and a depth varying from 30" to 17". Products were frequently stacked so that they extended beyond the recommended placement line. It is our opinion that this contributed to the flow of refrigerated air into the store. This unit consumed 1,239 kilowatt hours of electricity during the first period of the study and 1,349 during the second period. The consumption thus increased by 110 kwh or 8.9%.

* Adjusted to 21 days of operation.

Unit 3 was a closed case freezer (vertical display) with 45 square feet of face area and a depth of 27". It was a much newer case than the open freezer and consumed only 561 kilowatt hours during the first period and 596 kilowatt hours during the second period. This represented a 35 kwh or 6.2% increase.

Units 4 & 5 were located in the same store and both received regular service by store personnel. Service consisted of blowing out the condenser coils monthly with a CO_2 cylinder. The professional servicing on both boxes consisted of pulling the condenser out and thoroughly cleaning the condenser with compressed gas.

Unit 4 was a closed meat display case. It consumed 406 kilowatt hours during the first period and after servicing by a professional refrigeration company, it consumed 395 kilowatt hours during the second period. This represents a reduction of 11 kilowatt hours or 2.6% after servicing.

Unit 5 was an open chest freezer which had a bad defrost timer and the evaporator coils were frosted over. It consumed 449 kilowatt hours during the first period and 411 kilowatt hours during the second period after professional servicing. No servicing was done on the defrost timer because it was an expense that would not normally be associated with preventative maintenance calls. After servicing, 38 less kilowatt hours were consumed than before servicing a difference of 8.5%.

* Adjusted to 21 days of operation.

Unit 6 was a large open refrigerated case used for fruit and vegetable display. It operated under "service-it-when-it-breaks" maintenance scheme. This unit had 20 days of monitored operation during the first period of operation. It consumed 1,423* kilowatt hours during the first period and 1,076 kwh during the second period after service. This represents a 347 kilowatt hour reduction in consumption or 24.4%. Servicing consisted of chemically cleaning the outside condenser coils and adding freon to the system.

Unit 7 was an open meat display case. There was a plastic covering placed over the case to contain cold air. It was operating on a "service-when-it-breaks" maintenance basis. This unit had 20 days of operation during the first period of operation. During the first period 430* kilowatt hours were consumed and 329 kilowatt hours were consumed during the second period. This represents a 101 kilowatt hour reduction or 23.5%. Service consisted of chemically cleaning the outside condenser coil. The condensing unit was housed with other condensing units on a closed lean-to on the exterior wall of the building. On the evening of the second day of monitoring, one of the condensing units in the lean-to over heated. To correct this, the sides of the lean-to were torn off to provide better air circulation.

Unit 8 was a walk in cooler with a remote condenser located on the roof. The usual mode of servicing was "service-when-it-breaks", however, just prior to the start of the demonstration, the interior was cleaned by store personnel since it had gotten to a point where

* Adjusted to 21 days of operation.

performance was suffering. During the first period 907 kilowatt hours were consumed and 658 kilowatt hours were consumed during the second period after professional servicing. This is reduction of 249 kilowatt hours or 27.5%. Loading of the walk in cooler was essentially the same from one period to the next. Service consisted of chemically cleaning the outside condenser coils. Inspection of the interior evaporator coils revealed that the store personnel had done a good job in cleaning them.

There are three natural groupings for the units in the demonstration. The first is on those units where no service was performed for the purpose of the demonstration. These are units 1, 2, and 3. In performing no service on the units, the effect of weather can be estimated. The first unit had a 5.9% decrease in kilowatt hour consumption while on units 2 and 3 the consumption increased 8.9% and 6.2% respectively. The owners stated that loading of the boxes was essentially the same in both periods. The weather during this time was cooler during the first period than during the second.

There was no consistent pattern in the change of consumption. One unit had a decrease in consumption, two had an increase. The entire unit which had decreased consumption was located in a garage. This decrease in consumption corresponded with a 13°F decrease in dry bulb temperature and 12.7°F decrease in wet bulb temperature. The units which had an increase in consumption were both located in the same store and were split systems. The conditioned boxes experienced a 3.2°F dry bulb and 1.5°F degree wet bulb temperature decrease during the second part of the study. The boxes which were serviced all had a decrease in consumption. The temperature which the conditioned boxes were exposed to decreased in a range of 2.1 to 4.9°F dry bulb and 2.3 to 4.6 wet bulb.

The percentage change of consumption was greatest for the units which had increased consumption. If these results were applied directly, predicted energy consumption (without professional servicing) would be higher in the second period than in the first. Since one would usually expect a decreased energy consumption with cool weather, and the control group exhibited opposite tendencies, a conservative approach of discounting any weather effects on energy consumption was adopted.

Units 2 and 3 present a good comparison between energy consumption of the open and closed freezers. The capacity of the closed freezer was actually slightly higher than that of the the open freezer and the energy consumption was less than ½ of the open freezer. Although the closed box was a newer model than the open box, much of the difference can be attributed to the design of the open versus closed freezer. As was noted previously there was a considerable amount of refrigerated air lost from the open freezer. In fact there was so much refrigeration being dumped into this store that the heater was activated in the summer so it would not be too cold for the customers.

The second grouping would be the two units which were regularly serviced by store personnel. These are units 4 and 5, both located in the same store. Unit 4 was a meat case and was well maintained. During professional servicing, very little dust or dirt was removed from the unit. There was an 11 kilowatt hour decrease in consumption after professional cleaning, which was relatively small. The second unit was an open chest freezer which had more difficult access to the condenser coils. When it was professionally cleaned quite a bit more dirt was removed than from the refrigeration unit. The decrease in kilowatt hour consumption was 38 kilowatt hours or 8.5%. Again, even though this was more than the previous unit, it is a modest decrease.

The next grouping would be those units serviced on a fix-when-it-breaks basis. These consisted of units 6, 7 and 8. All three of these units had over a 20% reduction of energy consumption after servicing.

Unit 6, an open refrigeration case had a 347 kilowatt hour or 24.4% reduction in energy consumption after servicing. Unit 7, an open meat case with a cover, had a 101 kilowatt hour reduction in consumption or 23.5%. This is the unit which had ventilation problems due to its location in a closed lean-to. After two days of monitoring the lean-to was opened up to provide better air circulation for the condensing units. The first two days 58 kilowatt hours were consumed for an average of 29 kilowatt hours per day. The remanding 18 days in the first period accounted for 372 kilowatt hours or an average of 20.7 kilowatt hours per day. This was a 8.7 kilowatt hour reduction in consumption or 30% change. This is obviously a significant factor. If the consumption is taken the same as the average over the following 18 days then there would be 434 kilowatt hours consumed prior to service on a 21 day basis, and 329 kilowatt hours consumed after service. The service resulted in a 105 kilowatt hour reduction in consumption or 24.2%.

Unit 8 had a 249 kilowatt hour reduction (27.5) in energy consumption after service.

As would be expected, maintenance had the most significant effect in reducing energy consumption on those units which were poorly maintained. Those units were the ones maintained on a "fix-when-it-breaks" basis. If we adjust the data for unit 7 to account for the effect of opening up the

lean-to (which results in less saving) then the kilowatt hour savings per month ranges from 150 kilowatt hours for this unit to 496 kilowatt hours for unit 6. The average monthly kilowatt hours savings for the three units was 334. If electricity costs an average of 8¢ per kilowatt hour the resulting savings per unit would range from $12.00 per month to $39.68 per month. The average saving would be $26.72 per month for each unit. If these savings could be maintained for an entire year it would result in $320.64 average yearly savings per unit. The savings, of course, range depending upon the consumption of the unit. But, even the smallest unit savings of $12.00 per month will result in $144.00 savings if maintained for a 12 month period.

The group of units which were serviced prior to the demonstration by store personnel exhibited savings ranging from 16 to 54 kilowatt hours per unit per month. At 8¢ per kilowatt this is an equivalent range of $1.28 to $4.32 per unit per month or an average of $2.80 per month for each unit. Yearly savings for each unit would range from a low of $15.36 to a high of $51.84 for an average annual savings for the two units of $33.60 per unit. These savings are modest and approach the cost of servicing if only one or two units are serviced. If the store had more units the cost per unit for servicing would decrease since payment would be for additional service time rather than for the trip out plus service time. The economic benefit of professional servicing under these conditions is not nearly as apparent as under the previous conditions. It almost appears to be a toss up. There is an additional consideration in that a yearly servicing could also be viewed as a preventative check

up which may prevent problems from occurring, perhaps saving the food contained in the refrigerated food display unit. It can be easily seen that there is a definite value of maintaining the unit by store personnel as compared to a "fix-it-when-it-breaks" maintenance schedule.

Two other energy conservation measures indicated very large potentials for savings. The first of these was providing proper air circulation for the condensing units. Unit 7 exhibited a potential savings of 261 kilowatt hours per month (29.6%) due to reduction in restriction of air circulation to the condensing units. At 8¢ per kilowatt hour this would result in a $20.88 per month savings for the single unit or $250.56 per year. Greater savings should be obtained for each of the other units in the lean-to since this was one of the smaller units in terms of energy consumption. Providing proper ventilation is imperative and could be the most cost effective energy conservation measure since it will benefit all the units in the area and help prevent breakdowns. It should be noted that this was also an open case unit but had a cover over the open area. Because it had the lowest energy consumption of any unit after servicing, we feel this is an indication of a potential savings by using such a covering. It may be more viable to cover the case only at night so that the display of the meat would not be hampered.

The other area of savings indicated was in the choice of refrigeration case. We compared an open freezer to a closed freezer of approximately the same size. Both freezers were vertical display and were maintained under a monthly service contract. During the same period

the open freezer consumed 2,588 kilowatt hours while the closed freezer consumed 1,157 kilowatt hours. This savings is the equivalent to 1,022 kilowatt hours per month. At 8¢ per kilowatt hour this would result in an $81.76 per unit per month savings or $981.12 per year. It is recognized that the data is not definitive but because of the magnitude of indicated savings it is an interesting potential area of energy conservation.

VII. Conclusions

Based upon the results of this demonstration it can be concluded that yearly preventative maintenance by a professional refrigeration mechanic is cost effective for refrigeration units which have no regular service. On a yearly basis the average savings was $320.64 per unit. Even the lowest unit savings of $144.00 per year would be more than enough to pay the cost of service. Savings obtained for the year may not be as high as quoted depending on how long the effect of the servicing lasts, but, even if only half the savings were generated, it would still be more than cost effective, particularly if there is more than one refrigeration unit in the store, as is usually the case.

On units maintained by the store owners the economic benefit of the yearly professional cleaning may not be justified strictly on the basis of energy savings. The average annual savings was $33.60 per unit. If the savings were only half of this or $16.80 it would be necessary to have four or five units in order to justify the cost of service on an energy savings basis.

If the condenser units are placed too close together or do not have adequate air circulation significant increases in cost of operation will occur. Thus, care should be taken to provide adequate ventilation and air movement for condensing units. In addition it appears there is a significant difference between the cost of operation for open and closed (vertical display) freezing units and quite possibly, by extension, refrigeration units.

Further demonstrations and study along the lines of those suggested by this demonstration would be helpful in clearly quantifying the benefits of maintenance, closed versus open cases and adequate ventilation for condenser units. Among other factors it would be interesting to know how long the benefits of servicing continue.

In conclusion, the typical grocery store/seafood market could benefit by applying the results of this study to their operations. Furthermore, there is an educational need by this sector of the community. This need can be met by the Louisiana Cooperative Extension Service programs.

VIII. References

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IX. Appendix

TABLE 2

UNIT 1

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-17	100								Installed meter
9-18	845			92	76	1.6	36	36	
9-19	1215			90	78	1.5	29	65	
9-22	1110			87	73	1.5	97	162	
9-23	1130			93	77	1.5	34	196	
9-24	100	90	80	93	84	1.5	34	230	In garage
9-25	1200	88	80	92	82	1.5	31	261	
9-26	1130	87	78	88	81	1.5	33	295	
9-29	1200	89	81	91	82	1.5	111	405	
9-30	1130	88	79	89	78	1.5	22	427	
10-1	315	91	78	94	77	1.6	39	466	
10-2	315	91	76	96	76	1.5	33	499	
10-3	1200	88	79	89	79	1.4	39	538	
10-6	1200	89	76	91	76	1.4	90	628	
10-7	200	81	78	80	72	1.5	34	662	
TOTAL		882	785	1266	1098		662		
AVG.		88.2	78.5	90.4	78.4				
10-8	140	80	73	81	74	1.4	42	704	
10-9	1130	79	73	80	73	1.4	33	737	
10-10	1135	80	74	80	74	1.4	28	765	
10-13	1130	76	72	74	72	1.6	87	852	
10-14	1200	71	65	70	64	1.4	31	883	
10-15	1200	72	62	78	62	1.4	31	914	
10-16	1145	70	57	73	59	1.4	30	944	
10-17	1230	72	59	72	60	1.4	32	976	
10-20	1245	75	63	76	64	1.4	92	1068	
10-21	1240	74	62	76	62	1.4	29	1097	
10-22	1145	73	62	74	65	1.4	30	1127	
10-23	1205	75	70	77	75	1.4	33	1160	
10-24	1140	78	73	79	78	1.4	30	1190	
10-27	145	79	63	75	62	1.3	95	1285	
10-28	125	74	60	74	62	1.3	31	1316	Removed meter
		1128	988	1139	1007		654		
		78.2	65.8	81.3	71.9				

TABLE 3

UNIT 2

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-16									Installed meter
9-18	430	74	61	93	79		112	112	
9-19	1045	74	62	92	78		42	154	
9-22	1140	73	62	88	80		184	338	
9-23	145	75	60	98	78		66	404	
9-24	1045	72	57	91	80		52	456	
9-25	1230	74	60	88	78		65	521	
9-26	1200	78	59	88	79		60	581	
9-29	1030	68	62	91	82		80	761	
9-30	105	73	59	95	79		65	826	
10-1	115	74	62	94	77		61	887	
10-2	145	75	61	94	78		61	948	
10-3	1030	73	60	92	79		52	1000	
10-6	1000	72	63	88	78		181	1181	
10-7	1000	70	55	76	74		58	1239	
TOTAL		1025	843	1268	1099		1139		
AVG.		73.2	60.2	90.5	78.5				
10-8	1100	70	58	81	74		70	1309	
10-9	1000	68	54	77	72		66	1375	
10-10	145	74	63	83	75		74	1449	
10-13	1245	71	59	78	76		189	1638	
10-14	300	70	61	71	62		72	1710	
10-15	1015	70	55	73	62		50	1760	
10-16	1030	69	65	67	57		61	1821	
10-17	1100	68	54	70	56		68	1889	
10-20	1130	70	65	74	61		189	2078	
10-21	130	72	59	77	67		59	2137	
10-22	130	72	64	85	76		66	2203	
10-23	115	70	56	74	70		61	2264	
10-24	1245	71	60	79	73		64	2328	
10-27	1030	68	54	77	67		198	2526	
10-28	930	68	54	72	61		62	2588	
		1051	881	1138	1009		1349		
		70.0	58.7	75.8	67.2				

TABLE 4

UNIT 3

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-16	900								Installed meter
9-18	430	74	61	93	79		66	66	
9-19	1045	74	62	92	78		22	88	
9-22	1140	73	62	88	80		87	109	
9-23	145	75	60	98	78		27	49	
9-24	1035	72	57	91	80		23	45	
9-25	1230	74	60	88	78		28	50	
9-26	1200	78	59	88	79		35	57	
9-29	1030	68	62	91	82		79	101	
9-30	115	73	59	95	79		19	120	
10-1	115	74	62	94	77		26	146	
10-2	145	75	61	94	78		36	182	
10-3	1030	73	60	92	79		11	193	
10-6	1035	72	63	88	78		81	274	
10-7	1000	70	55	76	74		21	295	
TOTAL		1025	843	1268	1099		561		
AVG.		73.2	60.2	90.5	78.5				
10-8	100	70	58	81	74		29	324	
10-9	1000	68	54	77	72		23	347	
10-10	145	74	63	83	75		29	376	
10-13	1245	71	59	78	76		80	456	
10-14	900	70	61	71	62		31	487	
10-15	1015	70	55	72	62		22	509	
10-16	1020	69	65	67	57		27	536	
10-17	1100	68	54	70	56		30	566	
10-20	1130	70	65	74	61		90	656	
10-21	130	72	59	77	67		32	688	
10-22	130	72	64	85	76		29	717	
10-23	115	70	56	74	70		29	746	
10-24	1245	71	60	79	73		28	774	
10-27	1030	68	54	77	67		89	863	
10-28	930	68	54	72	61		28	891	
		1051	881	1137	1009		596		
		70.0	58.7	75.8	67.2				

TABLE 5

UNIT 4

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-16	1100								Installed meter
9-18	200	87	72	91	85		42	42	
9-19	1030	86	74	93	78		18	60	
9-22	1030	85	76	86	78		55	115	
9-23	1030	82	71	89	80		20	135	
9-24	1120	83	71	90	82		21	156	
9-25	1100	83	68	83	78		19	175	
9-26	1045	85	73	89	80		20	195	
9-29	1115	81	73	89	81		58	253	
9-30	1045	83	70	87	79		18	271	
10-1	1415	85	72	91	84		23	294	
10-2	1430	85	71	96	79		20	314	
10-3	1130	86	71	92	78		17	331	
10-6	1120	83	72	88	78		56	387	
10-7	1145	82	72	78	76		19	406	Serviced the unit
TOTAL		1176	1006	1242	1116		406		
AVG.		84	71.8	88.7	79.7				
10-8	1045	85	74	75	73		19	425	
10-9	120	72	68	78	74		22	447	
10-10	1030	83	73	77	73		17	464	
10-13	1045	80	68	79	78		55	519	
10-14	1108	65	60	80	68		20	539	
10-15	1015	82	66	72	67		19	558	
10-16	1100	79	63	68	56		19	577	
10-17	1145	80	62	75	56		20	597	
10-20	1200	81	68	75	64		55	652	
10-21	1120	80	64	75	60		17	669	
10-22	1115	83	69	73	65		19	688	
10-23	1100	82	70	75	68		20	708	
10-24	1100	82	71	76	73		18	726	
10-27	1300	83	67	74	61		58	784	
10-28	1030	81	66	79	65		17	801	
		1198	1009	1131	1001		395		
		79.8	67.2	75.4	66.7				

TABLE 6

UNIT 5

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-16	1100								Installed meter
9-18	200	87	72	91	85	2.6	47	47	
9-19	1025	86	74	93	78	0.8	20	67	
9-22	1030	85	76	86	78	0.7	64	131	
9-23	1030	82	71	89	80	0.7	22	153	
9-24	1120	83	71	90	82	0.6	22	175	
9-25	1100	83	68	83	78	0.1	21	196	
9-26	1045	85	73	89	80	0.5	31	227	
9-29	1115	81	73	89	81	0.5	44	271	
9-30	1045	83	70	87	79	0.6	31	302	
10-1	1415	85	72	91	84	0.6	24	326	
10-2	1430	85	71	96	79	0.6	21	347	
10-3	1430	86	71	92	78	0.6	19	366	
10-6	1120	83	72	88	78	0.7	63	429	
10-7	1030	82	72	78	76	0.5	20	449	Serviced the unit
TOTAL		1176	1006	1242	1116		449		
AVG.		84	71.8	88.7	79.7				
10-8	1045	85	74	75	73	0.5	21	470	
10-9	120	72	68	78	74	0.8	23	493	
10-10	1030	83	73	77	73	0.6	19	512	
10-13	1045	80	68	79	78	0.8	28	540	
10-14	1108	65	60	80	68	0.5	25	565	
10-15	1115	82	66	72	67	0.5	22	587	
10-16	1105	79	63	68	56	0.5	22	609	
10-17	1145	80	62	75	56	0.2	21	630	
10-20	1200	81	68	75	64	0.4	64	694	
10-21	1120	80	64	75	60	0.2	20	714	
10-22	1115	83	69	73	65	0.5	21	735	
10-23	1100	82	70	75	68	0.8	21	756	
10-24	1000	82	71	76	73	0.6	20	776	
10-27	1300	83	67	74	61	0.5	65	841	
10-28	1030	81	66	79	65	0.6	19	860	
		1198	1009	1131	1001		411		
		79.8	67.2	75.4	66.7				

TABLE 7

UNIT 6

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-17	1130								Installed meter
9-18	1515	83	68	94	82		77	77	
9-19	1145	82	67	89	78		58	135	
9-22	1100	81	71	94	80		198	333	
9-23	1100	80	64	92	79		65	398	
9-24	1149	81	66	94	80		69	467	
9-25	1130	83	65	93	81		67	534	
9-26	1110	82	67	88	67		68	602	
9-29	1145	80	65	87	79		216	818	
9-30	1115	82	62	86	82		57	875	
10-1	245	85	67	94	82		80	955	
10-2	1445	84	67	95	81		69	1024	
10-3	1200	82	77	92	80		61	1085	
10-6	1145	80	64	95	78		206	1291	
10-7	1145	80	64	81	70		64	1355	Serviced the unit
TOTAL		1145	934	1274	1099		1355		
AVG.		81.7	66.7	91	78.5				
10-8	1130	78	63	78	72		59	1414	
10-9	145	78	63	78	63		68	1482	
10-10	1115	78	66	83	75		54	1536	
10-13	1115	71	61	79	79		190	1726	
10-14	1135	70	63	78	64		38	1764	
10-15	1145	77	62	79	64		55	1819	
10-16	1130	77	60	74	57		47	1866	
10-17	1200	79	60	75	62		52	1918	
10-20	1230	77	61	85	66		128	2046	
10-21	1145	76	61	76	64		38	2084	
10-22	1135	79	65	75	67		43	2127	
10-23	1200	80	68	75	70		54	2181	
10-24	1115	74	59	76	73		51	2232	
10-27	1315	76	60	82	65		158	2390	
10-28	1130	82	66	76	62		41	2431	
		1152	938	1169	1003		1076		
		76.8	62.5	77.9	66.8				

TABLE 8

UNIT 7

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb	KW	KWH DIFF	KWH TOTAL	REMARKS
9-17	1030								Installed meter
9-18	1440	82	70	94	82	1.5	30	30	
9-19	925	81	65	83	79	1.2	28	58	
9-22	135	79	63	90	82	1.5	55	113	
9-23	850	92	70	85	80	1.4	26	139	
9-24	920	82	63	86	79	1.4	11	150	
9-25	930	77	62	89	82	1.4	20	170	
9-26	940	72	60	93	83	1.7	21	191	
9-29	1100	78	62	90	79	2.9	65	256	
9-30	1050	77	61	88	80	1.4	21	277	
10-1	925	76	60	88	81	1.2	22	299	
10-2	1000								
10-3	1045	82	63	92	80	2	45	344	
10-6	400	78	61	88	73	2	69	413	
10-7	300	79	62	80	71	1.5	17	430	Serviced the unit
TOTAL		1025	822	1146	1031		430		
AVG.		78.8	63.2	88.1	79.3				
10-8	300	71	60	80	74	1.5	17	447	
10-9	330	77	61	79	75	1.5	19	466	
10-10	305	77	61	80	76	1.3	18	484	
10-13	930	80	62	79	76	1.2	54	538	
10-14	1025	78	61	69	63	1	17	555	
10-15	410	78	64	79	66	1.3	18	573	
10-16	200	80	63	74	62	1.1	13	586	
10-17	915	73	57	70	63	1	10	596	
10-20	1345	80	64	77	64	1.1	44	640	
10-21	1030	75	60	73	61	2.9	12	652	
10-22	1030	76	58	70	64	1.1	13	665	
10-23	1130	78	60	70	74	1.2	16	681	
10-24	1045	80	61	78	73	1.1	14	695	
10-27	915	74	59	77	67	1.5	56	751	
10-28	1414	74	61	81	63	1.5	8	759	
		1151	912	1136	1021		329		
		76.7	60.8	75.7	68.0				

TABLE 9

UNIT 3

DATE 1986	TIME	INSIDE db	INSIDE wb	OUTSIDE db	OUTSIDE wb		DIFF	TOTAL	REMARKS
9-16	1200								Installed meter
9-18	415	75	66	73	78	4.7	102	102	
9-19	1030	78	69	95	73	4.6	33	135	
9-22	1150	74	70	90	80	4.6	121	256	
9-23	1405	72	63	94	80	3.5	42	298	
9-24	1100	80	72	90	78	3.5	35	333	
9-25	1245	79	71	93	82	4.1	51	383	
9-26	1215	78	70	87	82		48	431	
9-29	1100	76	71	84	77		122	553	
9-30	130	79	70	92	74	4.9	50	603	
10-2	1400	81	70	92	78	3.9	49	694	
10-3	1045	80	70	91	80	4.7	42	741	
10-5	1085	78	62	90	78	4.5	87	868	
10-7	900	80	62	72	65	4.5	39	907	
TOTAL		1011	886	1164	1011		761		Serviced the unit
AVG.		77.7	68.1	89.5	78.2				
10-8	130	78	72	81	74	4.5	31	754	
10-9	1030	75	78	74	76	3.8	31	985	
10-10	210	80	68	88	75	3.8	42	1027	
10-13	150	78	67	83	77	3.6	96	1123	
10-14	1020	76	64	69	61	2.4	32	1150	
10-15	1115	82	67	78	62	2.7	20	1170	
10-16	1045	73	63	70	59	2.3	34	1212	
10-17	1115	78	62	76	61	2.5	29	1241	
10-20	1145	73	61	77	65	2.6	80	1321	
10-21	1345	70	58	81	62	2.5	33	1354	
10-22	1400	72	72	81	74	2.4	29	1383	
10-23	1330	71	64	74	70	3.4	34	1417	
10-24	1305	74	67	79	73	3	35	1452	
10-27	1100	90	65	71	62	4	95	1547	
10-28	1015	70	59	79	62	2.4	18	1565	
		1130	987	1161	1011		642		
		75.3	65.8	77.4	67.4				

Executive Summary

The effect of maintenance on electrical consumption of refrigeration and freezer units was demonstrated. Eight individual units were assigned to three groupings: Group 1, a control group, Group 2, a group which received regular maintenance by store personnel, and Group 3, a group which received no scheduled maintenance. Professional service resulted in an average savings of 35 kwh or $2.80 per unit per month for group 2 units and 334 kwh or $26.72 per unit per month for group 2 units. These results clearly demonstrate the need for and cost effectiveness of regular maintenance. Inadequate ventilation of a unit was shown to cause an increased consumption of 261 kwh or $20.88 per month. In addition it was observed that a closed freezer box had less than half the energy consumption of a similar size open freezer box.