ERIP DE-FG01-96EE15670
Final Technical Progress Report
Report Date: 2/11/98
Prepared By: David J. Kimber

Final Project Summary
In order to gauge the effectiveness of the ERIP Project #670, Nevada Energy Control Systems, Inc., Grant Number DE-FG01-96EE15670, the Statement of Work must be compared to the achievements by NECSI during the grant period. The following report reflects the aforementioned statement and is coordinated directly with it.

Project Aim:
To gather data and test in order to validate earlier tests of energy savings, safety, reliability and practicality of the NECSI Evaporator Fan Controller in order to fully commercialize and market the product.

Project Objectives:
1. Test for overall safety of the NECSI Controller.

The Controller was issued CSA and NRTL/C certification #107113.

2. Test for performance and reliability of the NECSI Controller in maintaining appropriate temperature in the refrigerated chamber in which it is installed.

After analyzing the "real world" requirements for validation testing in relation to commercialization of the NECSI Evaporator Fan Controller, the necessary test equipment, as specified in our Cost Proposal, was purchased. During the following months, five separate tests of the NECSI Controller were completed by NECSI in different commercial walk-in refrigerators, each of which was of a different size and conformation. Additionally, tests in two other walk-in refrigerators were conducted by SDG&E. All of these tests showed that the introduction of the NECSI Controller maintained the appropriate temperature within the refrigerated chambers. Additionally, the decreased air flow attributed to the NECSI Controller actually decreased air temperature stratification within the refrigerated chambers. Copies of the results from the NECSI-conducted tests are included in the addenda to this report. The data from the SDG&E tests is only available from the utility itself.

3. Test for any adverse effects of reduced voltage on the life of evaporator fan motors and for optimum speed of the fans in low-speed mode.

Various manufacturers' evaporator fan motors were both bench and field tested. Run tests were completed while monitoring RPM characteristics, motor temperature and ambient temperature. This was done to determine the optimum low voltage and low motor speed characteristics of both shaded pole and PSC motors. These tests in conjunction with beta site installations show that the reduction in voltage and RPM was not detrimental to the motors. Copies of these test results are also included with this report.

DISCLAIMER

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4. Verify any questions of warranty coverage involved with installing the NECSI Controller in refrigerated chambers and/or equipment covered by manufacturers' warranties.

Evaporator and fan motor manufacturers will not warrant or endorse the NECSI Controller, unless they individually test the technology in conjunction with their products. Since at this time there is no financial incentive for them to do such testing, this has not happened. The field testing completed to date shows no adverse conditions; however, our data is insufficient at this time for other manufacturers to draw a positive conclusion about this technology.

5. Gather data and calculate energy savings, cost estimates and payback periods for installations of the NECSI Controller in various sizes of refrigerated chambers.

The aforementioned tests were completed in different walk-in refrigerators, each of which varied in size and equipment. Each test showed a decrease in the total power consumed by the refrigeration system. As noted, copies of these test results are included with this report.

6. Share our technology and learn more about other relevant technologies at industry conferences and educational expositions.

During the grant period, we attended the following conferences in order to share our technology, and to solicit input from many different sources in order to advance the technology from the commercialization phase to the deployment phase:

California Grocers Association Retail Food Industry Conference (10/96)
S.P.I.E. Commercialization Seminar (2/97)
California Central Valley Plant Engineers Annual Conference (3/97)
International Hotel and Restaurant Conference (6/97)
Southwestern Food Service and Restaurant Conference (6/97)
The Food Marketing Institute's Energy and Technical Conference (8/97)
World Energy Efficiency Congress (11/97)

By attending the above conferences and seminars we were able to disseminate the results of our ongoing validation testing results to various equipment manufacturers, end users, refrigeration service companies and energy service companies. Especially with the latter, talks are continuing to discover the best ways to assist in energy management and efficiency in medium temperature walk-in refrigerated boxes for commercial and institutional uses

Conclusion

Through our validation testing in conjunction with the constant input that we have solicited from various outside sources involved in energy management, it has been determined that the NECSI Evaporator Fan Controller is a commercially viable and safe energy management technology.

NECSI greatly appreciates the help received from the ERIP program. For this technology to take the next step from commercialization to deployment, it would be very helpful if the federal government would apply this proven technology in their facilities. This would further validate the federal government's position of being at the forefront of energy efficiency.

Nevada Energy Control Systems Inc.

Refrigeration Monitoring Test Results

Safeway Store #309
Fremont Hub, Fremont, California

Completed in conjunction with

The United States
Department of Energy
(ERIP DE-FG01-96EE15670)

NECSI Nevada Energy Control Systems, Inc.
P. O. Box 6689, Incline Village, Nevada 89450 (702) 831-7728 FAX (702) 831-7731

March 28, 1997

Mr. Atma Advani
Mr. Robert C. Uhl
Safeway Inc.
5918 Stoneridge Mall Road
Pleasanton, California 94588-3229

Dear Messrs. Advani and Uhl:

We at NECSI would like to thank you for your participation and cooperation in our refrigeration monitoring and testing project. The following report contains a description of the test, with the results and summaries of the data sets.

As you will see, the results are very positive in relationship to both energy savings and equipment performance. The installation of the NECSI Evaporator Fan Controller in this application will save Safeway approximately $229 per year in electrical energy costs and approximately $140 per year in equipment costs for a total combined estimated annual savings of $369. Please note that these savings estimates do not include a quantified maintenance savings.

It must be noted that the subject refrigeration system is equipped with energy efficient PSC evaporator fan motors. Since these motors have low amperage draws, any future motor replacement should be done with like type motors.

Thank you again.

David J. Kimber
Director of Marketing, NECSI

Test Description

Location:	Safeway Store # 309, Fremont Hub, Fremont, CA
Refrigeration Equipment:	
Box Size	5,695 cubic feet
Doors	1 Personnel, 13 Reach-in
Compressors/Condensing Unit	Hussman HICA0494PSMFG
Evaporators	2 Hussman SK6
Evaporator Fan Motors Type	Energy-efficient PSC
BTU Per Cubic Foot	9.90
Test Equipment:	
Data Recording Equipment	Fluke Hydra DataBucket Model 2635
Temperature Input Sensing Equipment	K-Temperature Wire Probes
	Omega Relative Humidity and Temperature Probe
Temperature Inputs Monitored	By K-Wire Probes: Box Temperature (4 inputs): low, mid and high elevations for stratification, mid-main door area temperature for open time Product Temperature Ambient Air Temperature External of Box Ambient Air Temperature External of Compressor Condenser Outlet Evaporator Inlet and Outlet
	By Omega Probe: Relative Humidity and Temperature of Box
Electrical Input Sensing Equipment	Fluke DC/AC Current Probes Model 80i-410
Electrical Inputs Monitored	Compressor/Condensing Unit Voltage Compressor/Condensing Unit Amperage Evaporator Voltage Evaporator Amperage
Input Monitoring Interval	Two minutes, 24 hours per day
Door Monitor	Gnosis Model 2I-CH
Days monitored without NECSI Evaporator Fan Controller installed	Phase 1---9 days, 2/11-2/19/97 Phase 3---8 days, 3/03-3/10/97
Days monitored with NECSI Evaporator Fan Controller installed	Phase 2---9 days, 2/21-3/1/97 Phase 4---10 days, 3/12-3/21/97

NOTE: Data from days of change of mode were deleted from computations.

Test Objectives

The objectives of this test are to determine the effects of the introduction of a NECSI Evaporator Fan Controller on the subject walk-in refrigerated box. The effects to be monitored and analyzed are as follows:

The energy consumption of the subject refrigeration system.
Thermal dynamic characteristics and differentials of the subject box and stored product.
Humidity differentials.
Equipment load differentials.
Personnel door monitoring.

Test Procedures

This test was run in four phases as detailed below, with the Fluke Hydra datalogger recording power consumption, temperatures and humidity every two minutes 24 hours a day. Data is not used from days in which switching from mode to mode occurs. Each "day" runs from midnight to midnight. Door monitoring was continuous.

Phase One: Began on 2/11/97 at midnight, after maintenance on the refrigerated dairy box had been completed the previous day. This phase consisted of nine days without the NECSI Evaporator Fan Controller installed, concluding at midnight on 2/19/97. During the day of 2/20/97, the NECSI controller was enabled, to begin the second phase of the test.

Phase Two: Began on 2/21/97 at midnight. This phase consisted of nine days with the NECSI Evaporator Fan Controller installed. This phase concluded on 3/01/97 at midnight. During the day of 3/02/97, the NECSI controller was disconnected, to start the third phase.

Phase Three: Began on 3/03/97 at midnight. This phase consisted of eight days without the NECSI Evaporator Fan Controller installed, concluding on 3/10/97 at midnight. During the day of 3/11/97, the NECSI controller was enabled, to begin the fourth phase.

Phase 4: Began on 3/12/97 at midnight. This phase consisted of ten days with the NECSI Evaporator Fan Controller installed. This phase concluded on 3/21/97 at midnight. During the day of 3/22/97, the NECSI Evaporator Fan Controller and the monitoring equipment were removed from the box.

Results

The energy consumption of the subject refrigeration system:
In order to determine the comparative energy consumption of the subject system, this analysis was completed in four phases: two phases which were baseline phases (control), and two test phases which included the introduction of the NECSI Evaporator Fan Controller. By segregating the test phases in this manner, sufficient data was obtained to create a matched-pairs analysis of energy consumption based on similar ambient external air temperatures at the condensing unit. From the total data set, eighteen comparable days (nine pairs) were found and utilized in this analysis. This

was done in order to eliminate, as much as possible, the external ambient air temperature variable which was a major concern of the Safeway engineering staff. Other variables which could not be controlled include: box loading and the personnel door being left open. After reviewing the electrical consumption and temperature data combined with general discussions with store personnel, it is concluded that the product loading variable appears to be relatively consistent and is therefore not considered as a major data influence. After reviewing the personnel door monitoring data relative to temperature variations and compressor duty cycle data, it has been determined that this variable has a major effect on system performance. This will be discussed as it relates to energy consumption with further details in the personnel door monitoring section of this report.

The baseline matched pairs data indicates that the subject compressor/condensing unit consumes an average of 30.3 KwH per day and the evaporator units consume an average of 20.6 KwH per day. This yields a total average consumption of 50.9 KwH per day without the NECSI Evaporator Fan Controller introduced to the system.

The test phase matched pairs data indicates that the subject compressor/condensing unit consumes an average of 30.8 KwH per day and the evaporator units consume an average of 12.7 KwH per day. This yields a total average consumption of 43.5 KwH per day with the NECSI Evaporator Fan Controller introduced to the system. (See Table 1 and Figures 1 and 2.) The minimal increase in the compressor/condensing unit average power consumption is directly related to the hours per day that the main door is left open. This correlation is shown in Table 7 and Figure 11.

This equates to an average daily system savings of 7.4 KwH per day, which represents a 14.5% system savings. On an annualized basis, the introduction of the NECSI Evaporator Fan Controller in this application would save 2,701 KwH. At Safeway's present average cost for electricity ($0.085/KwH), this equals an annualized savings of $229.

Thermal dynamic characteristics and differentials of the subject box and stored product:
A variety of temperature monitoring inputs were utilized for this analysis. They include three separate monitoring points located near the floor, middle and ceiling elevations within the subject box. These monitors are used to determine the effect of the NECSI Evaporator Fan Controller on temperature stratification. The average of these temperatures is utilized to determine the effect of the NECSI Evaporator Fan Controller on overall box temperature. Additional monitoring points include evaporator inlet and outlet temperature sensing and actual product temperature.

The baseline temperature stratification monitoring showed stratification differentials of slightly over .5 degree F. up to 1 degree F. This is considered to be an acceptable stratification range.

The test phase temperature stratification monitoring showed stratification differentials ranging from nil to .5 degree F. (See Table 3 and Figure 4.) Although the baseline stratification is within an acceptable range, the introduction of the NECSI Evaporator Fan Controller has improved the subject box's stratification range. This improvement is attributable to a decrease in fan motor heat combined with decreased air velocity which creates a decreased air exchange through the reach-in doors.

The subject box had an average baseline internal temperature of 39.4 degrees F. and an average test phase internal temperature of 38.1 degrees F. This equates to 1.3 degree (3.3%) temperature decrease, attributable to the introduction of the NECSI Evaporator Fan Controller. The reasons for this decrease are the combined effect of lowered air velocity and decreased fan motor heat. The decreased air velocity causes a reduction in warm air exchange through the thirteen reach-in doors which are located directly in front of the forced air flow path from the evaporator. The decreased fan motor heat reduces the overall thermal load on the system, thereby increasing its efficiency. These two factors, coupled with the normal thermal lag of the thermostat, create an overall decrease in average internal box temperature and an increase in system efficiency. (See Figure 5.)

The average daily baseline evaporator inlet and outlet temperatures and the average daily test phase evaporator inlet and outlet temperatures reflect a decrease in temperature similar to the overall decrease in average internal box temperature. This is attributable to the aforementioned increase in system performance due to the introduction of the NECSI Evaporator Fan Controller. (See Table 4, Figures 6 and 7.)

The average daily baseline product temperature and the average daily test phase product temperature also reflect a similar decrease in temperature to the overall decrease in average internal box temperature. This is attributable to the aforementioned increase in system performance due to the introduction of the NECSI Evaporator Fan Controller. This decrease in product temperature will create increased product shelf life, reduced "shrink" and improved customer satisfaction. (See Table 5, Figures 8 and 9.)

The overall decrease in average internal box temperature attributed to increased system efficiency creates an opportunity to further decrease the system's power consumption by a simple thermostat adjustment to raise the internal box temperature to the original higher baseline temperature after the NECSI Evaporator Fan Controller is installed.

Humidity Differentials:
After the NECSI Evaporator Fan Controller was installed, the internal box humidity decreased, on average, 3.4 per cent. This is attributed to the decrease in external air exchange through the reach-in doors. This decrease is due to the lowered air velocity within the walk-in box combined with the overall decrease in average internal box temperature. (See Table 6 and Figure 10.)

Equipment Load Differentials:
The amount of time that equipment runs during any twenty-four hour period is called its duty cycle. This is measured to determine any differential in equipment run time attributable to the installation of the NECSI Evaporator Fan Controller.

Without the fan controller installed, the evaporators run at their full speed 100% of the time. After the installation of the NECSI Evaporator Fan Controller in the subject system, the evaporator fans ran at a decreased speed/load 61% of the time (at full speed 39%). During this time, the fan motors are subjected to 64% less wear (this directly correlates to the voltage drop created by the NECSI Evaporator Fan Controller). The combination of these two factors equates

to a 39% overall decrease in fan motor wear, which can be directly translated into an increase in fan motor longevity. Assuming a five-year physical and economic life and an average installed replacement cost of $150[1] per PSC evaporator fan motor ($1,800 for twelve motors), this equates to an annual equipment savings of $140. This estimated annual equipment savings does not include decreased maintenance costs attributable to increased system efficiency.

Personnel Door Monitoring:
The opening and closing of the personnel door was monitored utilizing two methods. The first of these was a dedicated electronic metering system (Gnosis Model 2I-CH) which was installed on 1/18/97 at 12:00 noon and removed on 3/22/97 at 12:00 noon. This test equipment continuously monitored the total number of door openings and the total open time.

During the sixty-three day (1,512 hours) test period, the personnel door was opened 4,589 times with a total open time of 404.0 hours. This equates to an average of 72.84 openings per day with an average open time of 6.4 hours per day (26.72% total open time).

The second method of personnel door monitoring was achieved by sensing temperature changes adjacent to the personnel door inside the box. By monitoring the temperature changes inside the subject box adjacent to the personnel door, the number of open hours and the frequency of door opening can be estimated. These inputs can also be used to determine approximate time of day and duration of door openings.

As shown in Figure 11, there is a direct correlation between compressor duty cycle and the amount of time that the personnel door is left open. This is attributed to the location of the evaporator fan inlets in relation to the personnel door. Since the door is behind the evaporator inlets, when the door is open the evaporator fans draw warm air in through the door from outside of the box. This decreases the system's cooling efficiency and increases the compressor's duty cycle. Note: Some door open periods lasted upwards of fifty minutes.

Financial Savings Summary

The estimated annual energy savings attributable to the installation of the NECSI Evaporator Fan Controller is $229. The estimated annual equipment savings attributable to the installation of the NECSI Evaporator Fan Controller is $140. This yields a total combined estimated annual savings on the order of $369.

[1] Cost estimates taken from survey of local refrigeration contractors; minimum costs only.

Table 1.

Daily Averaged Energy Consumption (KwH)
Paired Data Sets ReflectingComparable Condenser Ambient Temperature
Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver.°F	AmbExtBox Aver.°F	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
9	5766 - 6485	02/19/97	56.2	72.0	29.58%	100.00%	29.2	20.6	49.8
2	726 - 1445	03/04/97	56.3	70.0	28.61%	100.00%	25.7	20.8	46.5
4	2166 - 2885	03/06/97	56.9	70.0	29.31%	100.00%	27.1	20.7	47.8
5	2886 - 3605	03/07/97	57.4	68.2	29.03%	100.00%	26.8	20.6	47.4
1	6 - 725	02/11/97	57.8	68.6	36.67%	100.00%	36.2	20.5	56.7
2	726 - 1445	02/12/97	58.8	69.2	32.78%	100.00%	32.9	20.5	53.4
7	4326 - 5045	03/09/97	61.2	68.4	31.94%	100.00%	29.7	20.6	50.3
6	3606 - 4325	02/16/97	61.4	70.6	31.25%	100.00%	31.7	20.4	52.0
8	5046 - 5765	03/10/97	63.6	69.2	32.78%	100.00%	33.0	20.6	53.6
		Averages	58.9	69.6	31.33%	100.00%	30.3	20.6	50.9

With NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver.°F	AmbExtBox Aver.°F	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
7	4326 - 5045	02/27/97	56.2	68.2	29.86%	32.36%	28.5	12.1	40.7
1	6 - 725	03/12/97	56.3	68.6	31.11%	35.42%	29.7	12.5	42.2
1	6 - 725	02/21/97	57.0	71.3	32.78%	39.03%	31.4	12.9	44.4
2	726 - 1445	02/22/97	57.5	68.7	30.69%	36.11%	29.2	12.6	41.9
6	3606 - 4325	02/26/97	57.9	70.2	31.25%	34.86%	29.7	12.5	42.2
5	2886 - 3605	02/25/97	58.9	70.4	31.25%	35.56%	30.4	12.7	43.1
3	1446 - 2165	02/23/97	61.2	67.6	31.53%	37.36%	32.6	12.8	45.4
3	1446 - 2165	03/14/97	61.6	70.9	32.92%	39.44%	32.3	13.0	45.3
4	2166 - 2885	02/24/97	64.0	67.4	32.92%	39.03%	33.7	13.2	46.9
		Averages	58.9	69.2	31.59%	36.57%	30.8	12.7	43.5

Figure 1.

Daily Averaged Energy Consumption (KwH)
Paired Data Sets Reflecting Comparable Condenser Ambient Temperature
Without and With the NECSI Evaporator Fan Controller

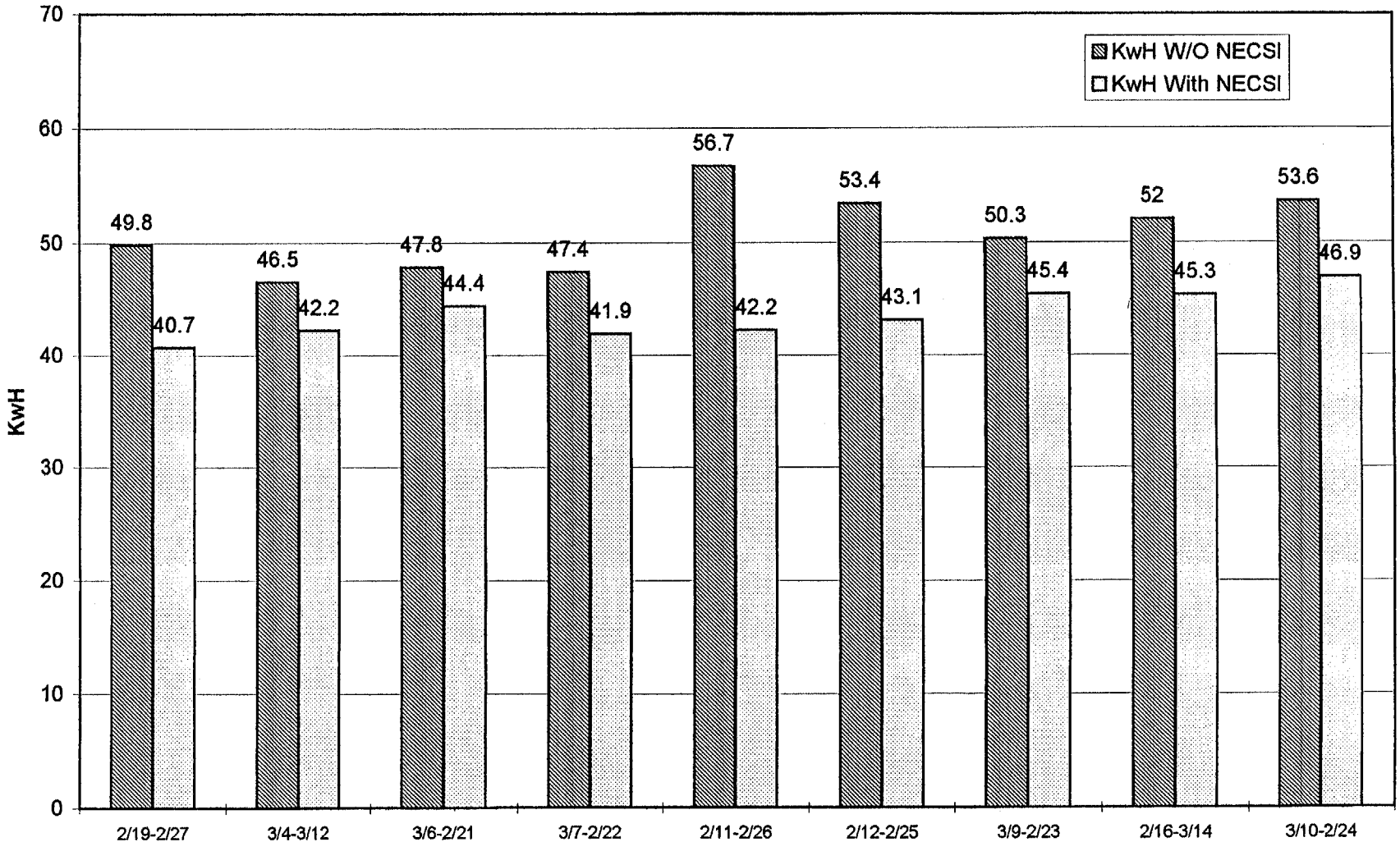


Figure 2.

Average Daily Energy Consumption (KwH) on Days of Comparable Condenser Ambient Temperature, Derived From Paired Data Sets, Without and With the NECSI Evaporator Fan Controller

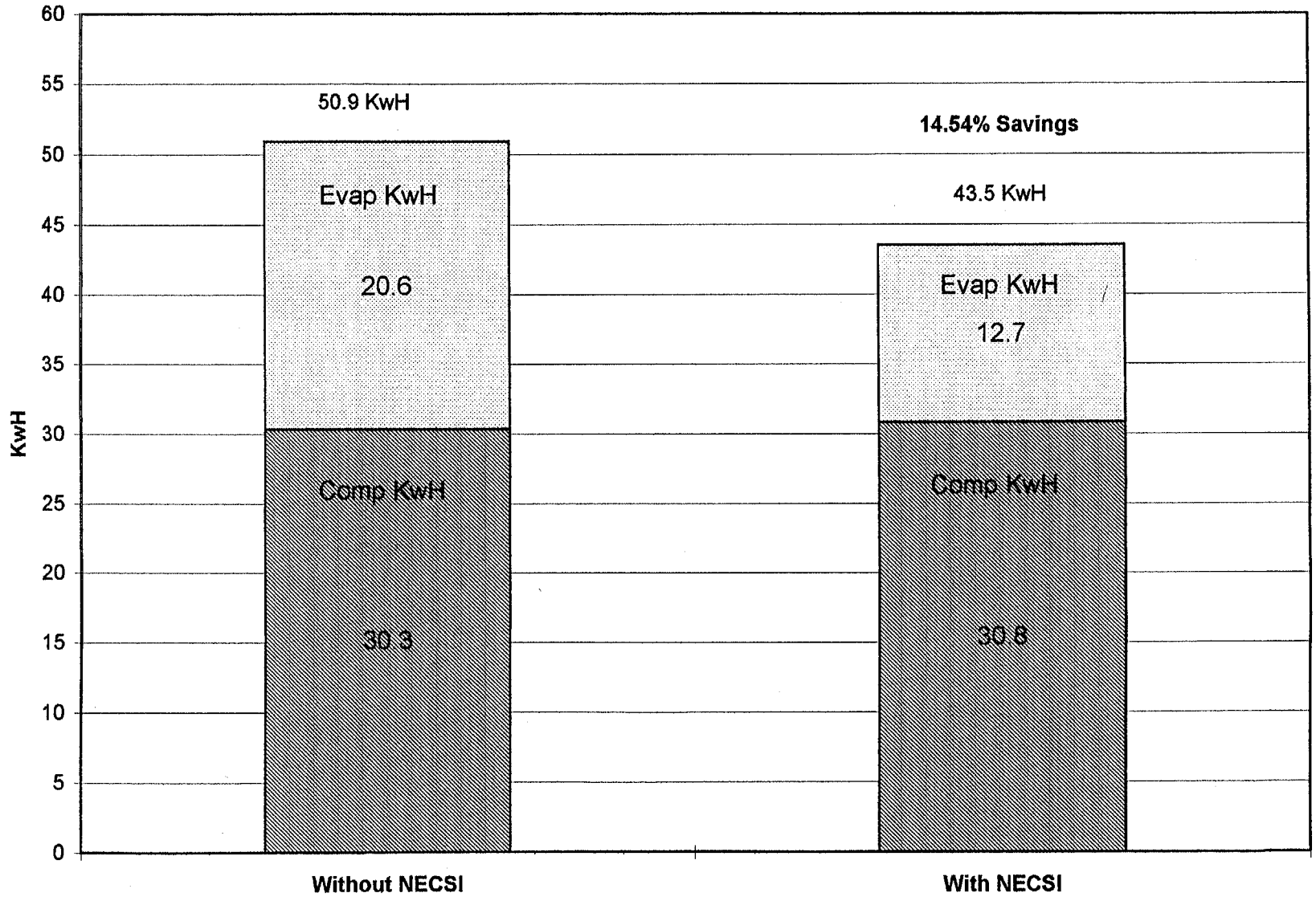


Table 2.

Daily Averaged Energy Consumption (KwH), Non-Paired Data Set, Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
1	6 - 725	02/11/97	57.8	68.6	36.67%	100.00%	36.2	20.5	56.7
2	726 - 1445	02/12/97	58.8	69.2	32.78%	100.00%	32.9	20.5	53.4
3	1446 - 2165	02/13/97	61.0	70.3	31.81%	100.00%	32.2	20.5	52.7
4	2166 - 2885	02/14/97	65.0	71.3	33.89%	100.00%	35.6	20.4	56.1
5	2886 - 3605	02/15/97	64.5	70.7	32.50%	100.00%	33.0	20.4	53.4
6	3606 - 4325	02/16/97	61.4	70.6	31.25%	100.00%	31.7	20.4	52.0
7	4326 - 5045	02/17/97	58.2	72.2	30.00%	100.00%	30.7	20.5	51.1
8	5046 - 5765	02/18/97	57.2	71.8	33.61%	100.00%	32.3	20.5	52.8
9	5766 - 6485	02/19/97	56.2	72.0	29.58%	100.00%	29.2	20.6	49.8
1	6 - 725	03/03/97	54.1	67.2	26.67%	100.00%	24.2	20.7	45.0
2	726 - 1445	03/04/97	56.3	70.0	28.61%	100.00%	25.7	20.8	46.5
3	1446 - 2165	03/05/97	55.9	70.7	28.33%	100.00%	26.3	20.8	47.1
4	2166 - 2885	03/06/97	56.9	70.0	29.31%	100.00%	27.1	20.7	47.8
5	2886 - 3605	03/07/97	57.4	68.2	29.03%	100.00%	26.8	20.6	47.4
6	3606 - 4325	03/08/97	57.4	67.8	29.17%	100.00%	27.1	20.0	47.1
7	4326 - 5045	03/09/97	61.2	68.4	31.94%	100.00%	29.7	20.6	50.3

Data from starting and ending days, and days of change of mode not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
1	6 - 725	02/21/97	57.0	71.3	32.78%	39.03%	31.4	12.9	44.4
2	726 - 1445	02/22/97	57.5	68.7	30.69%	36.11%	29.2	12.6	41.9
3	1446 - 2165	02/23/97	61.2	67.6	31.53%	37.36%	32.6	12.8	45.4
4	2166 - 2885	02/24/97	64.0	67.4	32.92%	39.03%	33.7	13.2	46.9
5	2886 - 3605	02/25/97	58.9	70.4	31.25%	35.56%	30.4	12.7	43.1
6	3606 - 4325	02/26/97	57.9	70.2	31.25%	34.86%	29.7	12.5	42.2
7	4326 - 5045	02/27/97	56.2	68.2	29.86%	32.36%	28.5	12.1	40.7
8	5046 - 5765	02/28/97	56.6	69.5	30.56%	34.86%	29.5	12.5	41.9
9	5766 - 6485	03/01/97	55.4	74.5	34.72%	37.78%	33.0	12.8	45.8
1	6 - 725	03/12/97	56.3	68.6	31.11%	35.42%	29.7	12.5	42.2
2	726 - 1445	03/13/97	59.7	69.6	29.58%	34.58%	28.8	12.4	41.2
3	1446 - 2165	03/14/97	61.6	70.9	32.92%	39.44%	32.3	13.0	45.3
4	2166 - 2885	03/15/97	60.3	69.7	31.25%	36.25%	30.1	12.6	42.7
5	2886 - 3605	03/16/97	58.9	69.1	32.64%	35.28%	31.7	12.5	44.2
6	3606 - 4325	03/17/97	64.0	68.5	33.33%	41.94%	33.0	13.2	46.2
7	4326 - 5045	03/18/97	67.6	69.3	32.92%	45.69%	32.9	13.7	46.6

Data from starting and ending days, and days of change of mode not included in computations.

Figure 3.

Daily Averaged Energy Consumption (KwH), Non-Paired Data Set, Without and With the NECSI Evaporator Fan Controller

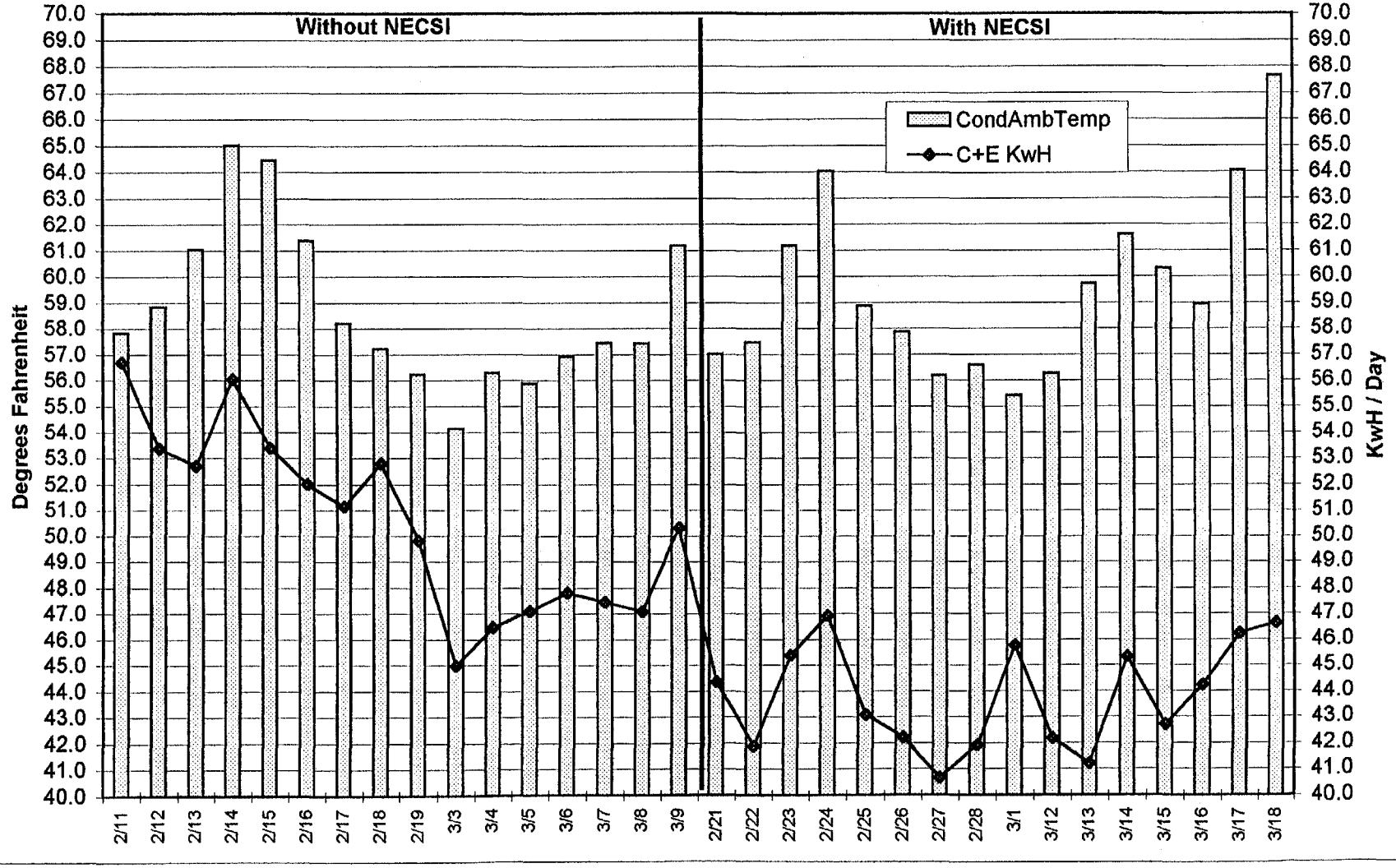


Table 3.

Daily Averaged Internal Box Temperatures
Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	Ceiling Aver."°F"	Midpoint Aver."°F"	Floor Aver."°F"	Average
1	6 - 725	02/11/97	38.2	38.6	38.5	38.4
2	726 - 1445	02/12/97	38.6	39.5	39.8	39.3
3	1446 - 2165	02/13/97	38.9	39.7	39.6	39.4
4	2166 - 2885	02/14/97	38.7	39.4	39.3	39.1
5	2886 - 3605	02/15/97	38.7	39.2	39.2	39.0
6	3606 - 4325	02/16/97	38.7	39.6	39.3	39.2
7	4326 - 5045	02/17/97	38.6	39.1	39.3	39.0
8	5046 - 5765	02/18/97	38.6	39.2	39.0	38.9
9	5766 - 6485	02/19/97	38.9	39.5	39.4	39.2
1	6 - 725	03/03/97	39.2	39.7	40.0	39.7
2	726 - 1445	03/04/97	39.2	40.0	40.3	39.8
3	1446 - 2165	03/05/97	39.0	39.7	40.1	39.6
4	2166 - 2885	03/06/97	39.3	39.9	40.1	39.8
5	2886 - 3605	03/07/97	39.5	40.4	40.5	40.1
6	3606 - 4325	03/08/97	39.7	40.3	40.3	40.1
7	4326 - 5045	03/09/97	39.7	40.1	40.4	40.1
8	5046 - 5765	03/10/97	39.3	39.3	39.8	39.5
	Average for both phases		39.0	39.6	39.7	39.4

Data from starting and ending days, and days of change of mode not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	Ceiling Aver."°F"	Midpoint Aver."°F"	Floor Aver."°F"	Average
1	6 - 725	02/21/97	37.9	37.9	37.8	37.9
2	726 - 1445	02/22/97	38.4	38.1	37.9	38.2
3	1446 - 2165	02/23/97	37.9	38.0	37.8	37.9
4	2166 - 2885	02/24/97	38.1	37.8	38.0	37.9
5	2886 - 3605	02/25/97	37.7	37.6	37.6	37.6
6	3606 - 4325	02/26/97	37.9	37.5	37.7	37.7
7	4326 - 5045	02/27/97	37.6	37.4	37.5	37.5
8	5046 - 5765	02/28/97	38.8	38.5	38.5	38.6
9	5766 - 6485	03/01/97	38.4	37.9	37.9	38.1
1	6 - 725	03/12/97	38.3	38.1	38.0	38.1
2	726 - 1445	03/13/97	38.4	38.2	38.3	38.3
3	1446 - 2165	03/14/97	38.4	38.0	38.1	38.2
4	2166 - 2885	03/15/97	38.9	38.3	38.2	38.5
5	2886 - 3605	03/16/97	38.2	38.0	37.9	38.0
6	3606 - 4325	03/17/97	39.0	38.8	38.7	38.8
7	4326 - 5045	03/18/97	38.2	38.1	38.0	38.1
8	5046 - 5765	03/19/97	38.1	38.1	38.1	38.1
9	5766 - 6485	03/20/97	38.3	38.3	38.3	38.3
10	6486 - 7205	03/21/97	38.3	38.2	38.3	38.3
	Average for both phases		38.3	38.1	38.0	38.1

Data from starting and ending days, and days of change of mode not included in computations.

Figure 4.

Daily Averaged Internal Box Stratification Analysis (Ceiling, Midpoint of Wall, Floor) Without and With the NECSI Evaporator Fan Controller

Figure 5.

Average Daily Internal Box Temperatures
Without and With the NECSI Evaporator Fan Controller

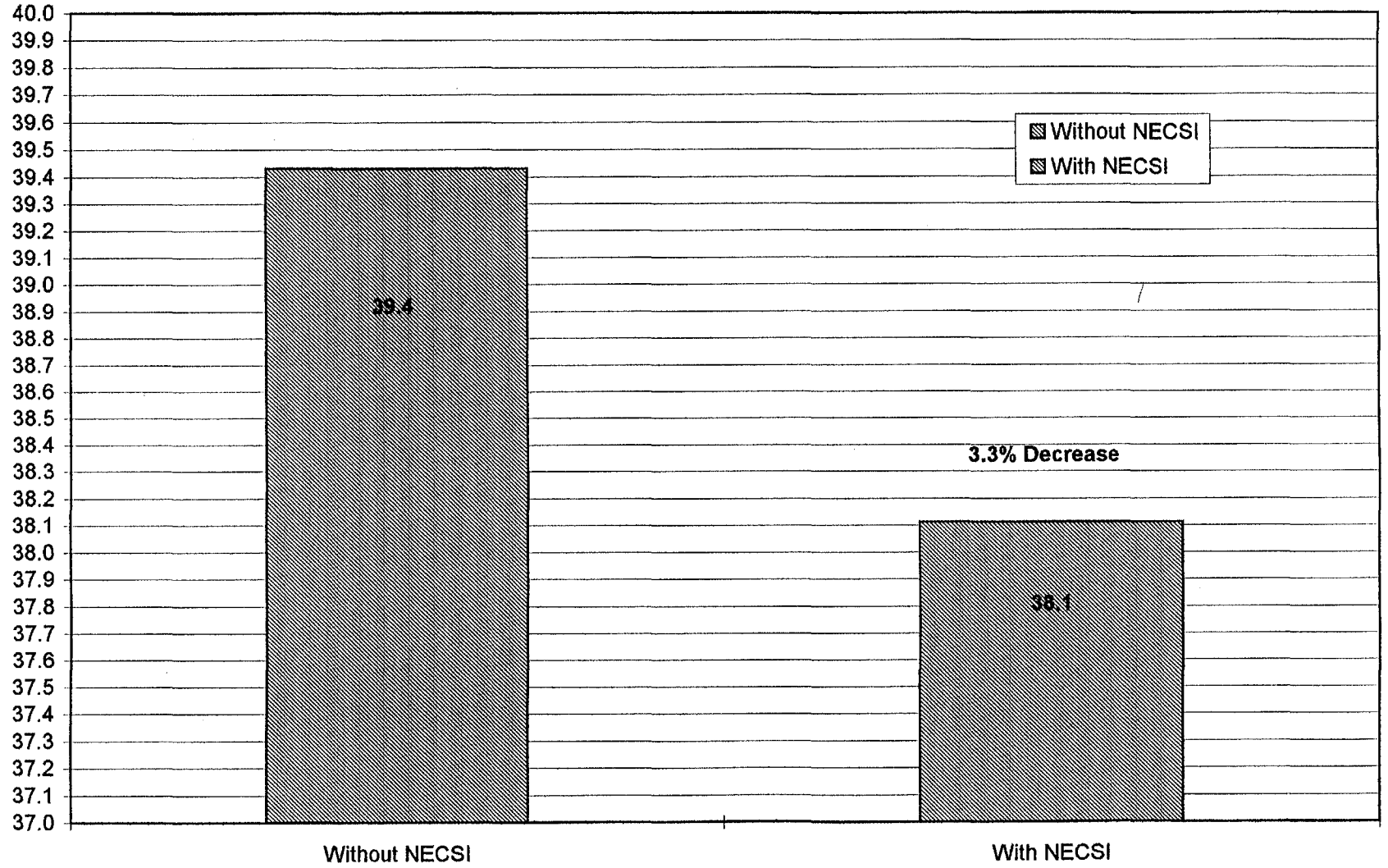


Table 4.

Daily Averaged Evaporator Inlet and Outlet Temperature Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Ev InletTemp Aver."°F"	Ev Outlet Temp Aver."°F"
1	6 - 725	02/11/97	57.8	68.6	38.5	36.6
2	726 - 1445	02/12/97	58.8	69.2	39.2	37.4
3	1446 - 2165	02/13/97	61.0	70.3	39.2	37.3
4	2166 - 2885	02/14/97	65.0	71.3	39.0	37.1
5	2886 - 3605	02/15/97	64.5	70.7	39.1	37.2
6	3606 - 4325	02/16/97	61.4	70.6	39.1	37.3
7	4326 - 5045	02/17/97	58.2	72.2	39.0	37.2
8	5046 - 5765	02/18/97	57.2	71.8	39.0	37.1
9	5766 - 6485	02/19/97	56.2	72.0	39.3	37.5
1	6 - 725	03/03/97	54.1	67.2	39.7	38.0
2	726 - 1445	03/04/97	56.3	70.0	39.7	37.8
3	1446 - 2165	03/05/97	55.9	70.7	39.5	37.8
4	2166 - 2885	03/06/97	56.9	70.0	39.8	37.9
5	2886 - 3605	03/07/97	57.4	68.2	40.1	38.4
6	3606 - 4325	03/08/97	57.4	67.8	40.3	38.6
7	4326 - 5045	03/09/97	61.2	68.4	40.2	38.2
8	5046 - 5765	03/10/97	63.6	69.2	39.7	37.6
	Average for both phases		59.0	69.9	39.4	37.6

Data from starting and ending days, and days of change of mode not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Ev InletTemp Aver."°F"	Ev Outlet Temp Aver."°F"
1	6 - 725	02/21/97	57.0	71.3	38.5	35.2
2	726 - 1445	02/22/97	57.5	68.7	38.7	35.5
3	1446 - 2165	02/23/97	61.2	67.6	38.3	35.5
4	2166 - 2885	02/24/97	64.0	67.4	38.4	35.5
5	2886 - 3605	02/25/97	58.9	70.4	38.3	35.3
6	3606 - 4325	02/26/97	57.9	70.2	38.4	35.1
7	4326 - 5045	02/27/97	56.2	68.2	38.3	35.2
8	5046 - 5765	02/28/97	56.6	69.5	39.4	36.4
9	5766 - 6485	03/01/97	55.4	74.5	38.8	35.6
1	6 - 725	03/12/97	56.3	68.6	39.0	35.6
2	726 - 1445	03/13/97	59.7	69.6	39.1	36.0
3	1446 - 2165	03/14/97	61.6	70.9	39.0	35.7
4	2166 - 2885	03/15/97	60.3	69.7	39.2	36.0
5	2886 - 3605	03/16/97	58.9	69.1	38.9	35.5
6	3606 - 4325	03/17/97	64.0	68.5	39.4	36.4
7	4326 - 5045	03/18/97	67.6	69.3	38.6	36.0
8	5046 - 5765	03/19/97	68.5	70.1	38.6	35.5
9	5766 - 6485	03/20/97	66.9	71.1	38.9	35.9
10	6486 - 7205	03/21/97	72.3	71.8	38.7	35.9
	Average for both phases		61.1	69.8	38.8	35.7

Data from starting and ending days, and days of change of mode not included in computations.

Figure 6.

Daily Averaged Evaporator Inlet and Outlet Temperatures Without and With the NECSI Evaporator Fan Controller

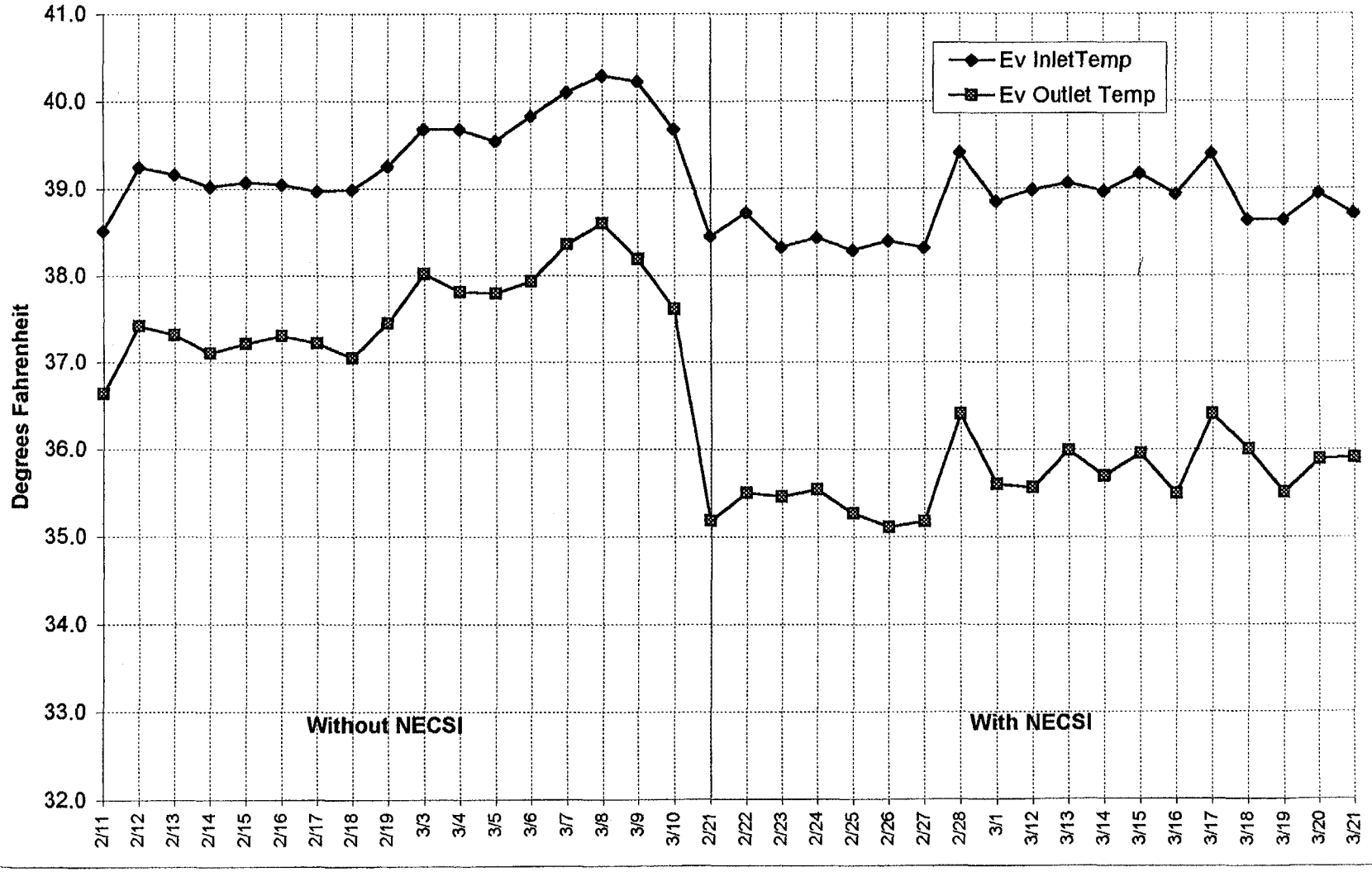


Figure 7.

Average Daily Evaporator Inlet and Outlet Temperature Without and With the NECSI Evaporator Fan Controller

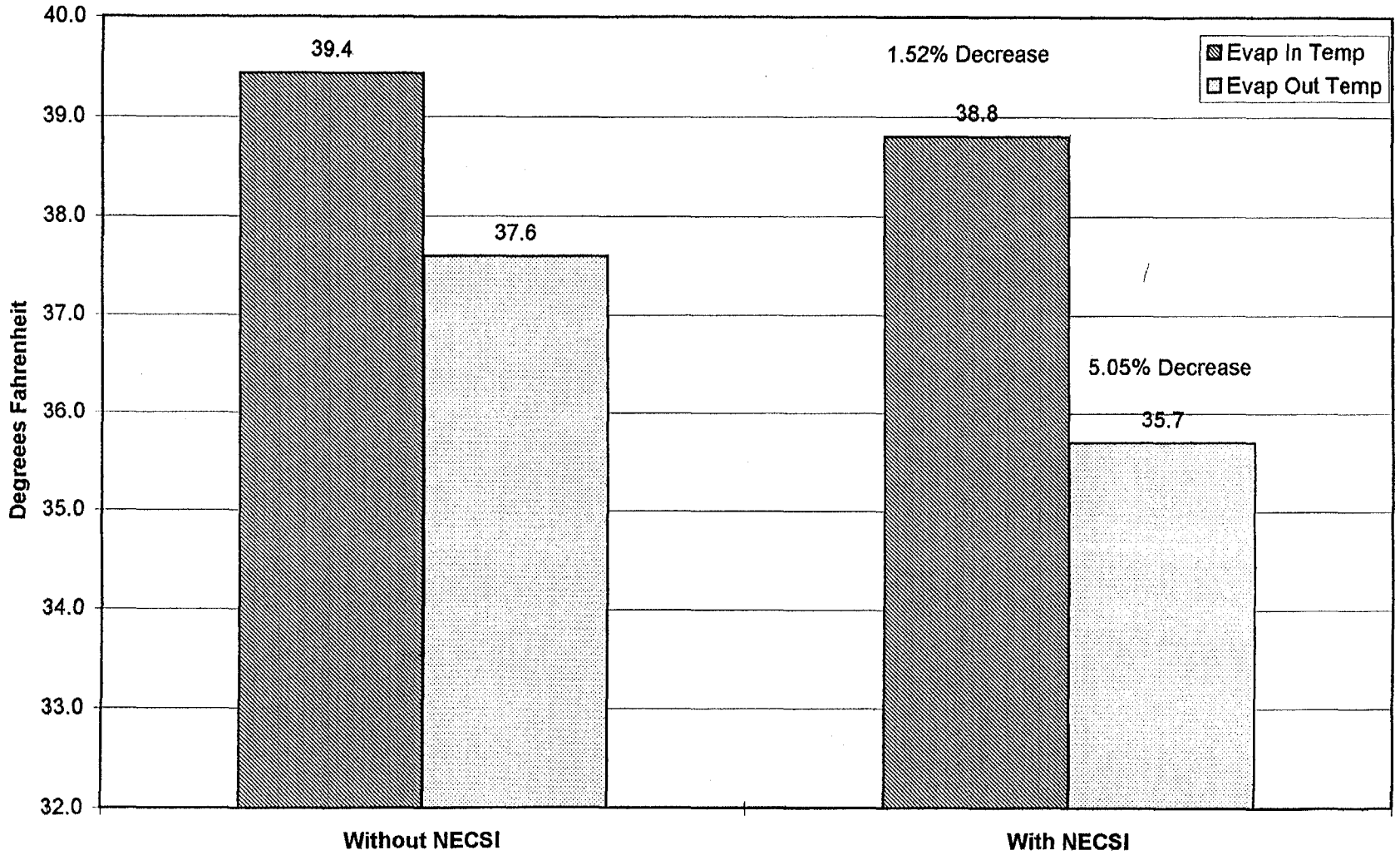


Table 5.

Daily Averaged Product Temperature
Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Product Aver."°F"
1	6 - 725	02/11/97	57.8	68.6	39.1
2	726 - 1445	02/12/97	58.8	69.2	39.6
3	1446 - 2165	02/13/97	61.0	70.3	39.8
4	2166 - 2885	02/14/97	65.0	71.3	39.7
5	2886 - 3605	02/15/97	64.5	70.7	39.6
6	3606 - 4325	02/16/97	61.4	70.6	39.7
7	4326 - 5045	02/17/97	58.2	72.2	39.6
8	5046 - 5765	02/18/97	57.2	71.8	39.7
9	5766 - 6485	02/19/97	56.2	72.0	39.8
1	6 - 725	03/03/97	54.1	67.2	40.1
2	726 - 1445	03/04/97	56.3	70.0	40.2
3	1446 - 2165	03/05/97	55.9	70.7	40.0
4	2166 - 2885	03/06/97	56.9	70.0	40.2
5	2886 - 3605	03/07/97	57.4	68.2	40.6
6	3606 - 4325	03/08/97	57.4	67.8	40.9
7	4326 - 5045	03/09/97	61.2	68.4	40.7
8	5046 - 5765	03/10/97	63.6	69.2	40.0
	Average for both phases		59.0	69.9	39.9

Data from starting and ending days, and days of change of mode not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Product Aver."°F"
1	6 - 725	02/21/97	57.0	71.3	38.5
2	726 - 1445	02/22/97	57.5	68.7	38.9
3	1446 - 2165	02/23/97	61.2	67.6	38.7
4	2166 - 2885	02/24/97	64.0	67.4	38.7
5	2886 - 3605	02/25/97	58.9	70.4	38.5
6	3606 - 4325	02/26/97	57.9	70.2	38.3
7	4326 - 5045	02/27/97	56.2	68.2	38.4
8	5046 - 5765	02/28/97	56.6	69.5	39.5
9	5766 - 6485	03/01/97	55.4	74.5	39.1
1	6 - 725	03/12/97	56.3	68.6	39.2
2	726 - 1445	03/13/97	59.7	69.6	39.2
3	1446 - 2165	03/14/97	61.6	70.9	39.2
4	2166 - 2885	03/15/97	60.3	69.7	39.5
5	2886 - 3605	03/16/97	58.9	69.1	39.1
6	3606 - 4325	03/17/97	64.0	68.5	39.7
7	4326 - 5045	03/18/97	67.6	69.3	39.0
8	5046 - 5765	03/19/97	68.5	70.1	38.8
9	5766 - 6485	03/20/97	66.9	71.1	38.9
10	6486 - 7205	03/21/97	72.3	71.8	38.9
	Average for both phases		61.1	69.8	39.0

Data from starting and ending days, and days of change of mode not included in computations.

Figure 8.

Daily Averaged Product Temperature
Without and With the NECSI Evaporator Fan Controller

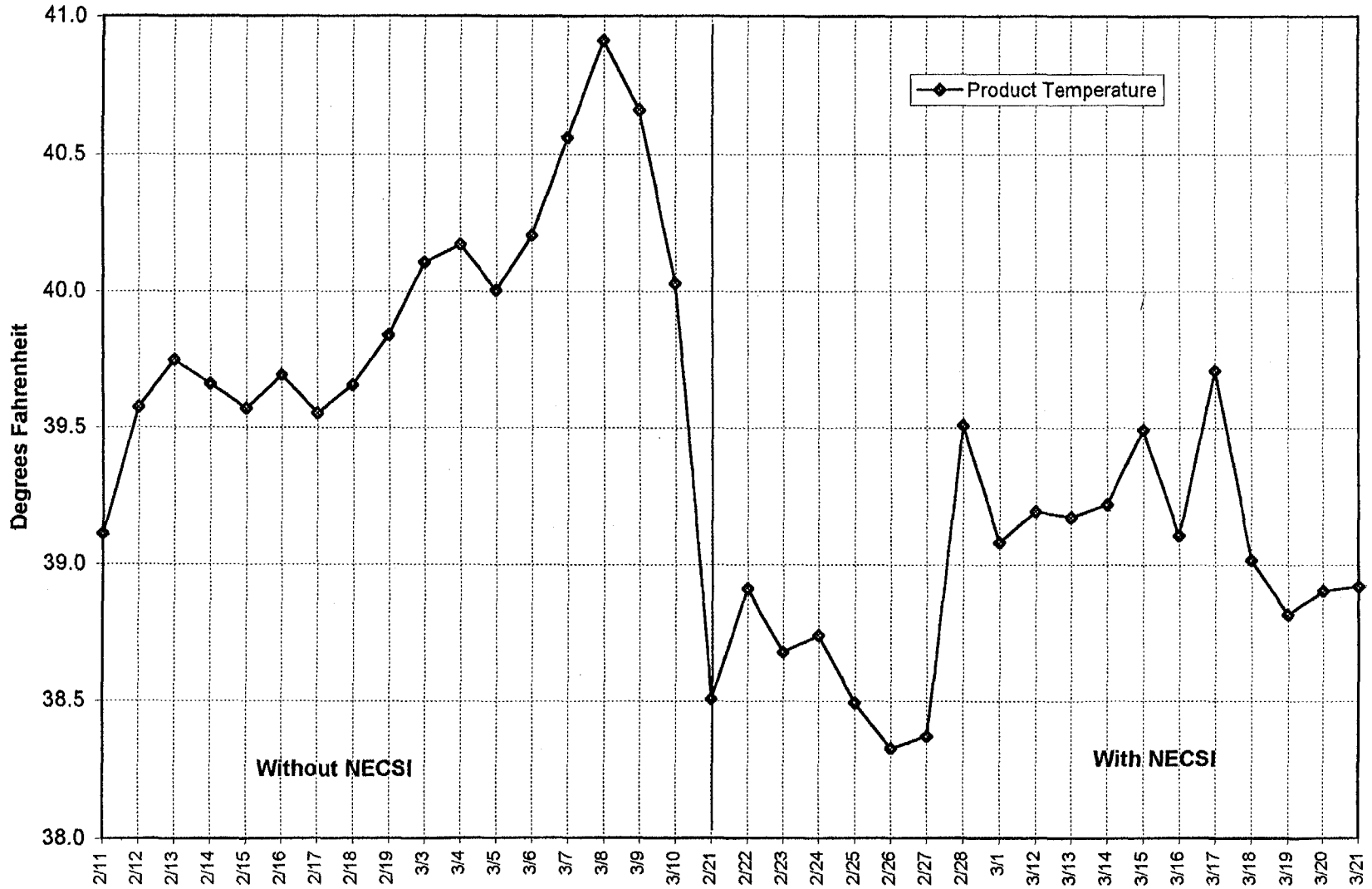


Figure 9.

Average Daily Product Temperature
Without and With NECSI Evaporator Fan Controller

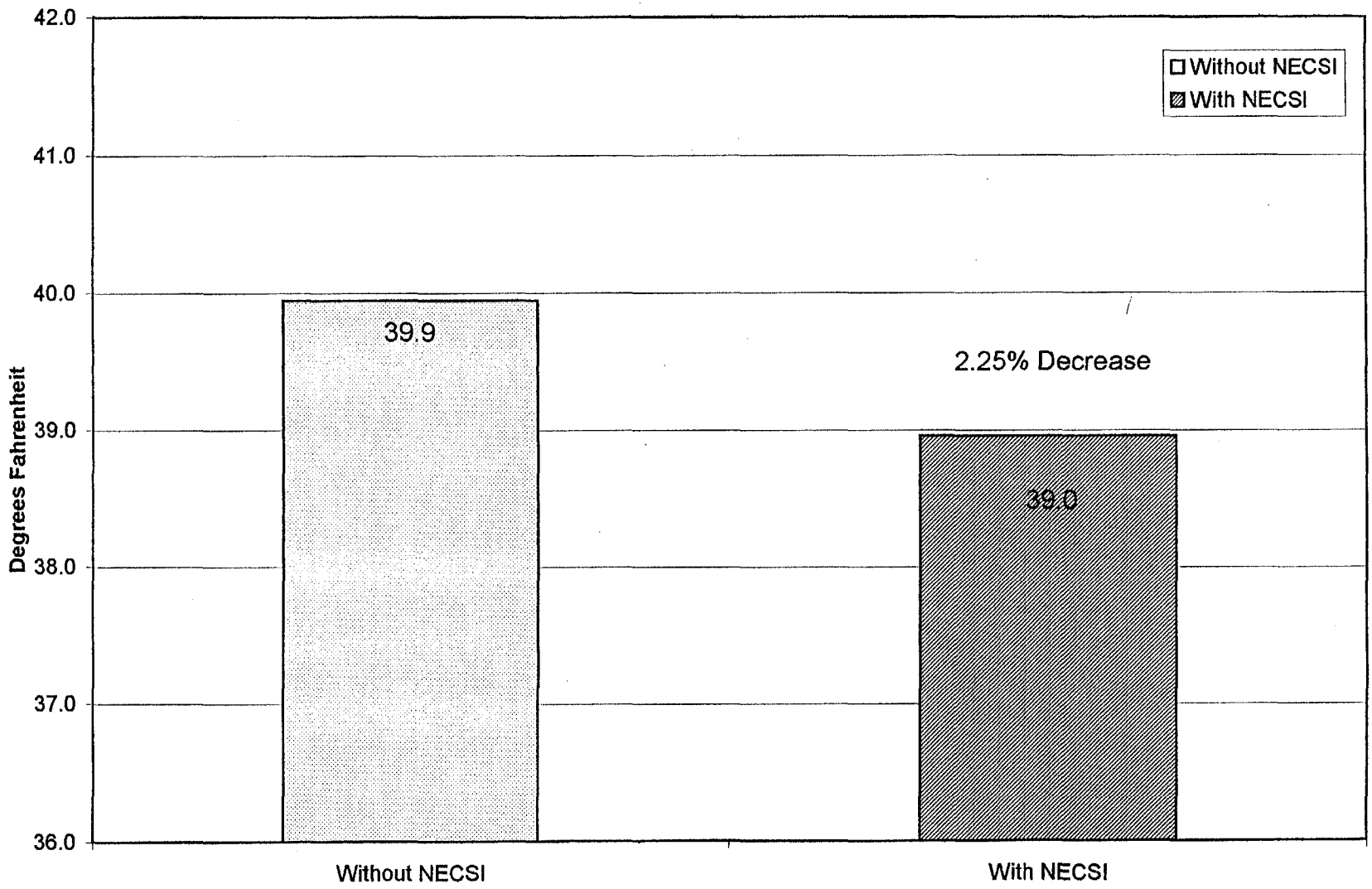


Table 6.

Daily Averaged Relative Humidity Inside Box
Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Humidity "%"	Average Box Temp.
1	6 - 725	02/11/97	57.8	68.6	82.6	38.4
2	726 - 1445	02/12/97	58.8	69.2	82.6	39.3
3	1446 - 2165	02/13/97	61.0	70.3	82.4	39.4
4	2166 - 2885	02/14/97	65.0	71.3	82.7	39.1
5	2886 - 3605	02/15/97	64.5	70.7	83.8	39.0
6	3606 - 4325	02/16/97	61.4	70.6	83.0	39.2
7	4326 - 5045	02/17/97	58.2	72.2	83.4	39.0
8	5046 - 5765	02/18/97	57.2	71.8	82.1	38.9
9	5766 - 6485	02/19/97	56.2	72.0	82.3	39.2
1	6 - 725	03/03/97	54.1	67.2	80.9	39.7
2	726 - 1445	03/04/97	56.3	70.0	80.5	39.8
3	1446 - 2165	03/05/97	55.9	70.7	80.5	39.6
4	2166 - 2885	03/06/97	56.9	70.0	80.5	39.8
5	2886 - 3605	03/07/97	57.4	68.2	80.7	40.1
6	3606 - 4325	03/08/97	57.4	67.8	81.0	40.1
7	4326 - 5045	03/09/97	61.2	68.4	80.3	40.1
8	5046 - 5765	03/10/97	63.6	69.2	81.2	39.5
	Average for both phases		59.0	69.9	81.8	39.4

Data from starting and ending days, and days of change of mode not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	CondAmbTemp Aver."°F"	AmbExtBox Aver."°F"	Humidity "%"	Average Box Temp.
1	6 - 725	02/21/97	57.0	71.3	80.13	37.9
2	726 - 1445	02/22/97	57.5	68.7	80.08	38.2
3	1446 - 2165	02/23/97	61.2	67.6	79.37	37.9
4	2166 - 2885	02/24/97	64.0	67.4	78.37	37.9
5	2886 - 3605	02/25/97	58.9	70.4	79.84	37.6
6	3606 - 4325	02/26/97	57.9	70.2	80.08	37.7
7	4326 - 5045	02/27/97	56.2	68.2	79.80	37.5
8	5046 - 5765	02/28/97	56.6	69.5	77.99	38.6
9	5766 - 6485	03/01/97	55.4	74.5	79.13	38.1
1	6 - 725	03/12/97	56.3	68.6	77.16	38.1
2	726 - 1445	03/13/97	59.7	69.6	77.98	38.3
3	1446 - 2165	03/14/97	61.6	70.9	77.38	38.2
4	2166 - 2885	03/15/97	60.3	69.7	77.90	38.5
5	2886 - 3605	03/16/97	58.9	69.1	76.48	38.0
6	3606 - 4325	03/17/97	64.0	68.5	77.21	38.8
7	4326 - 5045	03/18/97	67.6	69.3	78.13	38.1
8	5046 - 5765	03/19/97	68.5	70.1	77.98	38.1
9	5766 - 6485	03/20/97	66.9	71.1	77.01	38.3
10	6486 - 7205	03/21/97	72.3	71.8	77.13	38.3
	Average for both phases		61.1	69.8	78.4	38.1

Data from starting and ending days, and days of change of mode not included in computations.

Figure 10.

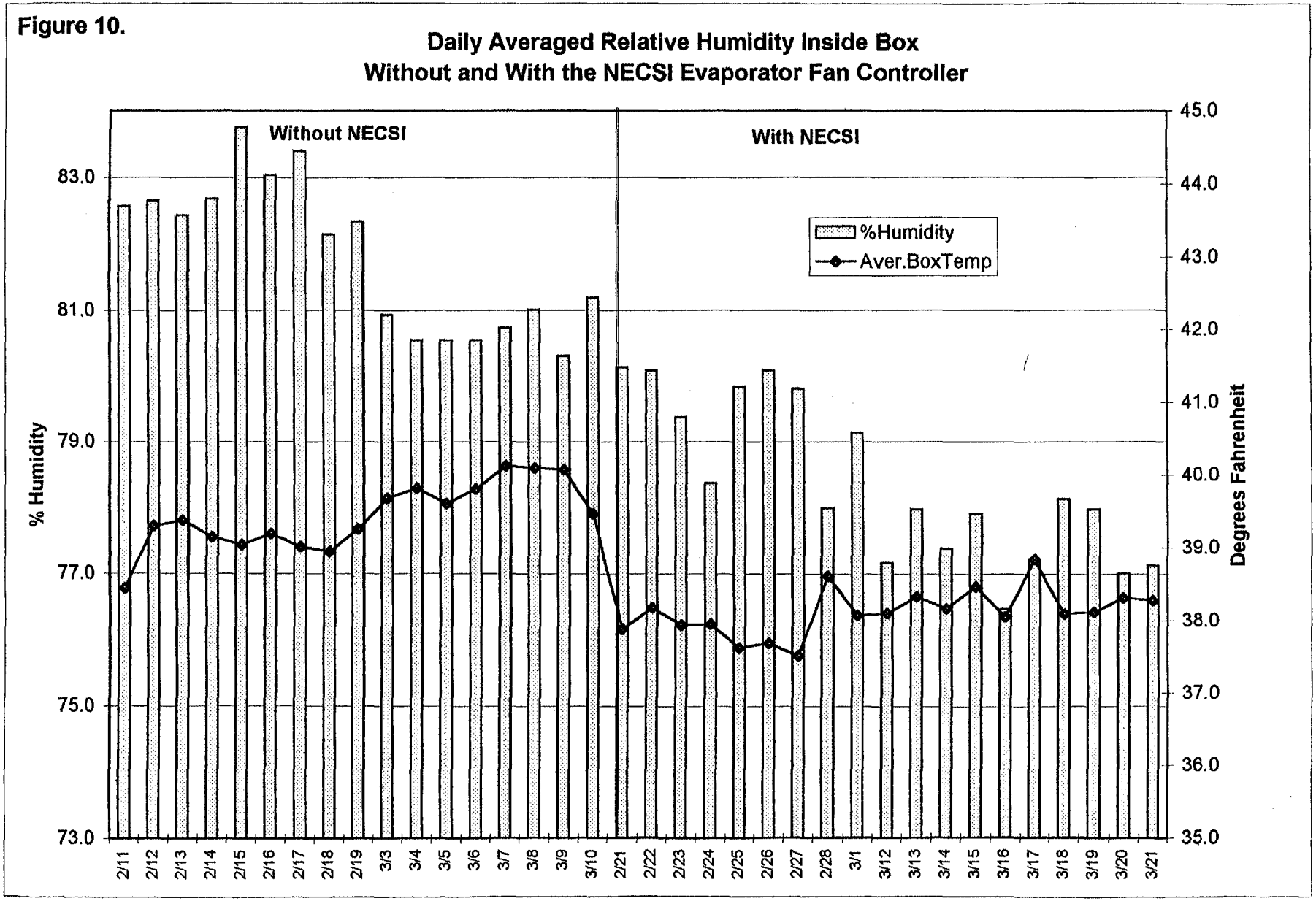

Daily Averaged Relative Humidity Inside Box
Without and With the NECSI Evaporator Fan Controller
Without NECSI
With NECSI
%Humidity
Aver.BoxTemp
% Humidity
Degrees Fahrenheit
83.0
81.0
79.0
77.0
75.0
73.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
38.0
37.0
36.0
35.0
2/11
2/12
2/13
2/14
2/15
2/16
2/17
2/18
2/19
3/3
3/4
3/5
3/6
3/7
3/8
3/9
3/10
2/21
2/22
2/23
2/24
2/25
2/26
2/27
2/28
3/1
3/12
3/13
3/14
3/15
3/16
3/17
3/18
3/19
3/20
3/21

Table 7

Compressor Duty Cycle Correlated to Hours Per Day Main Door is Open

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	Compressor Duty Cycle	MidMainDoor Open Count	MidMainDoor Hours Open
1	6 - 725	02/11/97	36.67%	32	1.1
2	726 - 1445	02/12/97	32.78%	198	6.6
3	1446 - 2165	02/13/97	31.81%	158	5.3
4	2166 - 2885	02/14/97	33.89%	289	9.6
5	2886 - 3605	02/15/97	32.50%	250	8.3
6	3606 - 4325	02/16/97	31.25%	233	7.8
7	4326 - 5045	02/17/97	30.00%	185	6.2
8	5046 - 5765	02/18/97	33.61%	225	7.5
9	5766 - 6485	02/19/97	29.58%	214	7.1
1	6 - 725	03/03/97	26.67%	104	3.5
2	726 - 1445	03/04/97	28.61%	112	3.7
3	1446 - 2165	03/05/97	28.33%	165	5.5
4	2166 - 2885	03/06/97	29.31%	95	3.2
5	2886 - 3605	03/07/97	29.03%	180	6.0
6	3606 - 4325	03/08/97	29.17%	103	3.4
7	4326 - 5045	03/09/97	31.94%	113	3.8
8	5046 - 5765	03/10/97	32.78%	175	5.8
	Average for both phases		31.05%	166.5	5.6

Data from starting and ending days, and days of change of mode not included in computations.

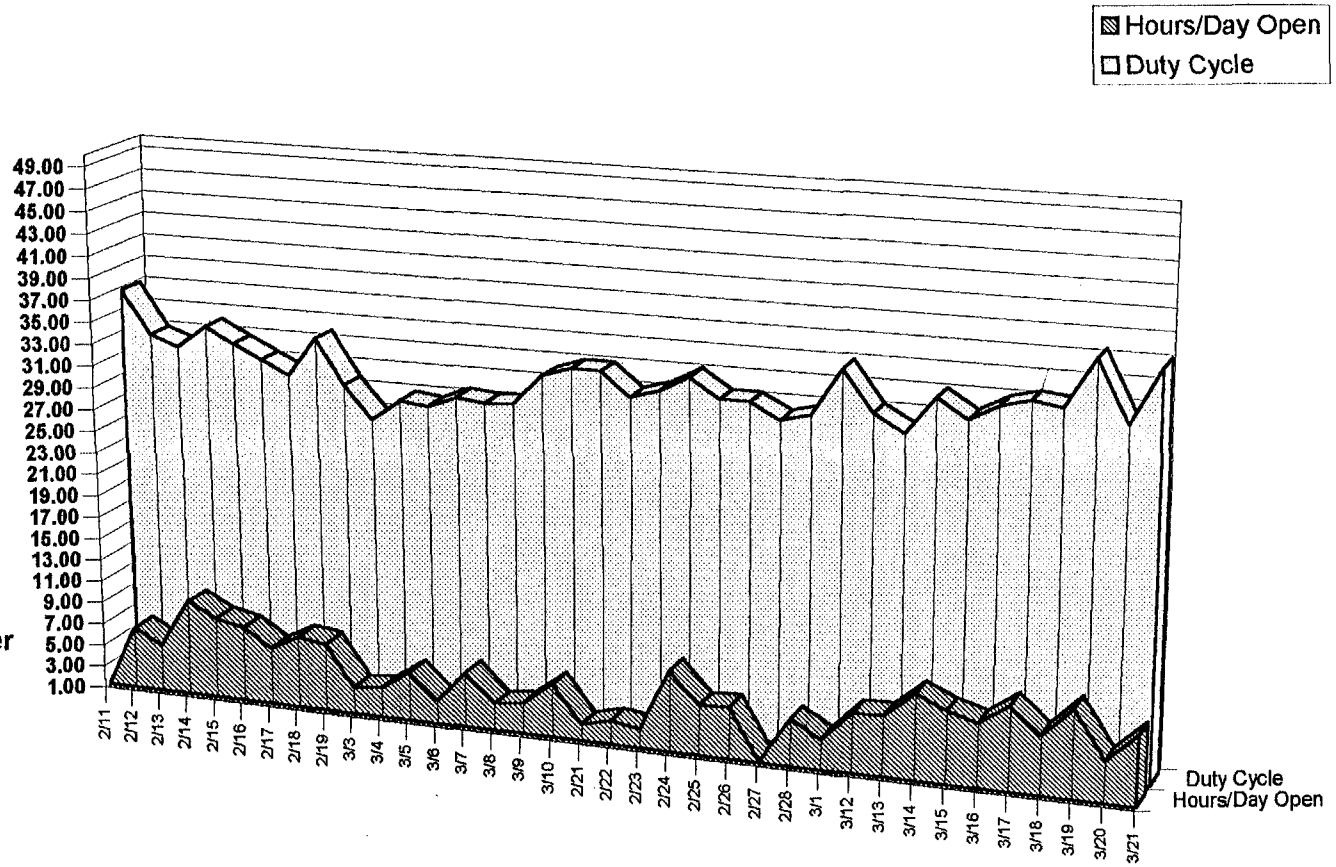
With NECSI Evaporator Fan Controller

Day	Readings #	Date	Compressor Duty Cycle	MidMainDoor Open Count	MidMainDoor Hours Open
1	6 - 725	02/21/97	32.78%	74	2.5
2	726 - 1445	02/22/97	30.69%	94	3.1
3	1446 - 2165	02/23/97	31.53%	82	2.7
4	2166 - 2885	02/24/97	32.92%	249	8.3
5	2886 - 3605	02/25/97	31.25%	165	5.5
6	3606 - 4325	02/26/97	31.25%	170	5.7
7	4326 - 5045	02/27/97	29.86%	32	1.1
8	5046 - 5765	02/28/97	30.56%	158	5.3
9	5766 - 6485	03/01/97	34.72%	112	3.7
1	6 - 725	03/12/97	31.11%	190	6.3
2	726 - 1445	03/13/97	29.58%	193	6.4
3	1446 - 2165	03/14/97	32.92%	262	8.7
4	2166 - 2885	03/15/97	31.25%	225	7.5
5	2886 - 3605	03/16/97	32.64%	202	6.7
6	3606 - 4325	03/17/97	33.33%	257	8.6
7	4326 - 5045	03/18/97	32.92%	188	6.3
8	5046 - 5765	03/19/97	37.36%	268	8.9
9	5766 - 6485	03/20/97	31.94%	142	4.7
10	6486 - 7205	03/21/97	36.94%	218	7.3
	Average for both phases		32.40%	173	5.8

Data from starting and ending days, and days of change of mode not included in computations.

Figure 11.

Compressor Duty Cycle Correlated to Hours Per Day Main Door is Open



Values: Duty Cycle=%, Hours/Day Open=Number of hours

Nevada Energy Control Systems Inc.

Refrigeration Monitoring Test Results

Trader Joe's Store #70
2601 Marconi Avenue
Sacramento, California

Completed in conjunction with

The United States
Department of Energy
(ERIP DE-FG01-96EE15670)

NECSI Nevada Energy Control Systems, Inc.
3197 Boeing Road, Cameron Park, CA 95682 (916) 677-3233 FAX (916) 677-3293

September 3, 1997

Mr. David Hetzel
Trader Joe's
Director of Construction and Maintenance
P. O. Box 3270
South Pasadena, California 91031

Dear Mr. Hetzel:

We at NECSI would like to thank you for your participation and cooperation in our refrigeration monitoring and testing project. The following report contains a description of the test, with the results and summaries of the data sets.

As you will see, the results are very positive in relationship to both energy savings and equipment performance. The installation of the NECSI Evaporator Fan Controller in this application will save Trader Joe's approximately $560 per year in electrical energy costs and approximately $97 per year in equipment costs for a total combined estimated annual savings of $657. Please note that these savings estimates do not include a quantified maintenance savings.

Thank you again.

David J. Kimber
Director of Marketing, NECSI

Test Description

Location:	Trader Joe's, Store #70 2601 Marconi Avenue, Sacramento, California
Refrigeration Equipment:	
Box Size	28.33' x 9.5' x 8.5' = 2287.65 cu.ft.
Doors	9 reach-in doors, 1 personnel door
Compressors/Condensing Unit	5.5 hp Copeland Copelematic 2DD3-0500-UC
Evaporators	2 Tyler MMA-124
Evaporator Fan Motors Type	3 per evaporator, shaded pole
Test Equipment:	
Data Recording Equipment	Fluke Hydra DataBucket Model 2635
Electrical Input Sensing Equipment	Fluke DC/AC Current Probes Model 80i-410
Electrical Inputs Monitored	Compressor/Condensing Unit Voltage Compressor/Condensing Unit Amperage Evaporator Voltage Evaporator Amperage
Input Monitoring Interval	Two minutes, 24 hours per day
Days monitored without NECSI Evaporator Fan Controller installed	14 days---7/20-7/26/97 and 8/05-8/11/97
Days monitored with NECSI Evaporator Fan Controller installed	14 days---7/28-8/03/97 and 8/13-8/19/97

NOTE: Data from days of change of mode were deleted from computations.

Test Objectives

The objectives of this test are to determine the effect of the introduction of a NECSI Evaporator Fan Controller on the subject walk-in refrigerated box in relation to energy consumption and equipment load differentials.

Test Procedures

This test was run in four phases as detailed below, with a Fluke Hydra datalogger recording power consumption every two minutes 24 hours a day. Data is not used from days in which switching from mode to mode occurs. Each "day" runs from midnight to midnight.

Phase One: Began on Sunday, 7/20/97 at midnight. This phase consisted of seven days without the NECSI Evaporator Fan Controller installed, concluding at midnight on Saturday, 7/26/97. During the day of Sunday, 7/27/97, the NECSI controller was enabled, to begin the second phase of the test.

Phase Two: Began on Monday,7/28/97 at midnight. This phase consisted of seven days with the NECSI Evaporator Fan Controller installed. This phase concluded on Sunday, 8/03/97 at midnight. During the day of Monday, 8/04/97, the NECSI controller was disconnected, to begin the third phase of the test

Phase Three: Began on Tuesday, 8/05/97 at midnight. This phase consisted of seven days without the NECSI Evaporator Fan Controller enabled, concluding at midnight on Monday, 8/11/97. During the day of Tuesday, 8/12/97, the NECSI controller was enabled, to begin the fourth phase of the test.

Phase Four: Began on Wednesday, 8/13/97 at midnight. This phase consisted of seven days with the NECSI Evaporator Fan Controller enabled. This phase concluded on Tuesday, 8/19/97 at midnight. On 8/21/97, the monitoring equipment was disconnected. The NECSI controller was left installed and enabled in the subject refrigerated box.

Results

The energy consumption of the subject refrigeration system:
In order to determine the comparative energy consumption of the subject system, this analysis was completed in four phases: the first and third of these were baseline phases (control), and the second and fourth were test phases which included the introduction of the NECSI Evaporator Fan Controller. By segregating the phases in this manner, sufficient data was obtained to complete an analysis of energy consumption.

The baseline data indicates that the subject compressor/condensing unit consumes an average of 119.3 KwH per day and the evaporator units consume an average of 24.5 KwH per day. This yields a total average consumption of 143.8 KwH per day without the NECSI Evaporator Fan Controller introduced to the system.

The test phase data indicates that the subject compressor/condensing unit consumes an average of 108.6 KwH per day and the evaporator units consume an average of 16.0 KwH per day. This yields a total average consumption of 124.6 KwH per day with the NECSI Evaporator Fan Controller introduced to the system. (See Data Table and Graph.)

This equates to an average daily system savings of 19.2 KwH per day, which represents a 13.4% system savings. On an annualized basis, the introduction of the NECSI Evaporator Fan Controller in this application would save 7,008 KwH. At a typical average cost for electricity ($0.08/KwH), this equals an annualized savings of $560.

Equipment load differentials:
The amount of time that equipment runs during any twenty-four hour period is called its duty cycle. This is measured to determine any differential in equipment run time attributable to the installation of the NECSI Evaporator Fan Controller.

Compressor: Without the fan controller installed, the subject compressor has a duty cycle of 69.5%. After the installation of the NECSI Evaporator Fan Controller, this duty cycle was decreased to 65.0%. This equates to a 6.5% decrease in operating time. This is attributed to the decrease in fan motor heat introduced into the box when the fan motors are running at decreased voltage.

This directly translates into an increase in compressor life of 6.5% and a similar decrease in maintenance costs over the life of the refrigeration unit. Assuming a five-year life and an average installed replacement cost of $5,000, this equates to an annual savings of $65.

Evaporator: Without the fan controller installed, the evaporators run at their full speed 100% of the time. After the installation of the NECSI Evaporator Fan Controller in the subject system, the evaporator fans ran at a decreased speed/load 42.3% of the time (at full speed 57.7%). During this time, the fan motors are subjected to 64% less wear (this directly correlates to the voltage drop created by the NECSI Evaporator Fan Controller). The combination of these two factors equates to a 27.1% overall decrease in fan motor wear, which can be directly translated into an increase in fan motor longevity. Assuming a five-year physical and economic life and an average installed replacement cost of $100[1] per evaporator fan motor ($600 for six motors), this equates to an annual equipment savings of $32. This estimated annual equipment savings does not include decreased maintenance costs attributable to increased system efficiency

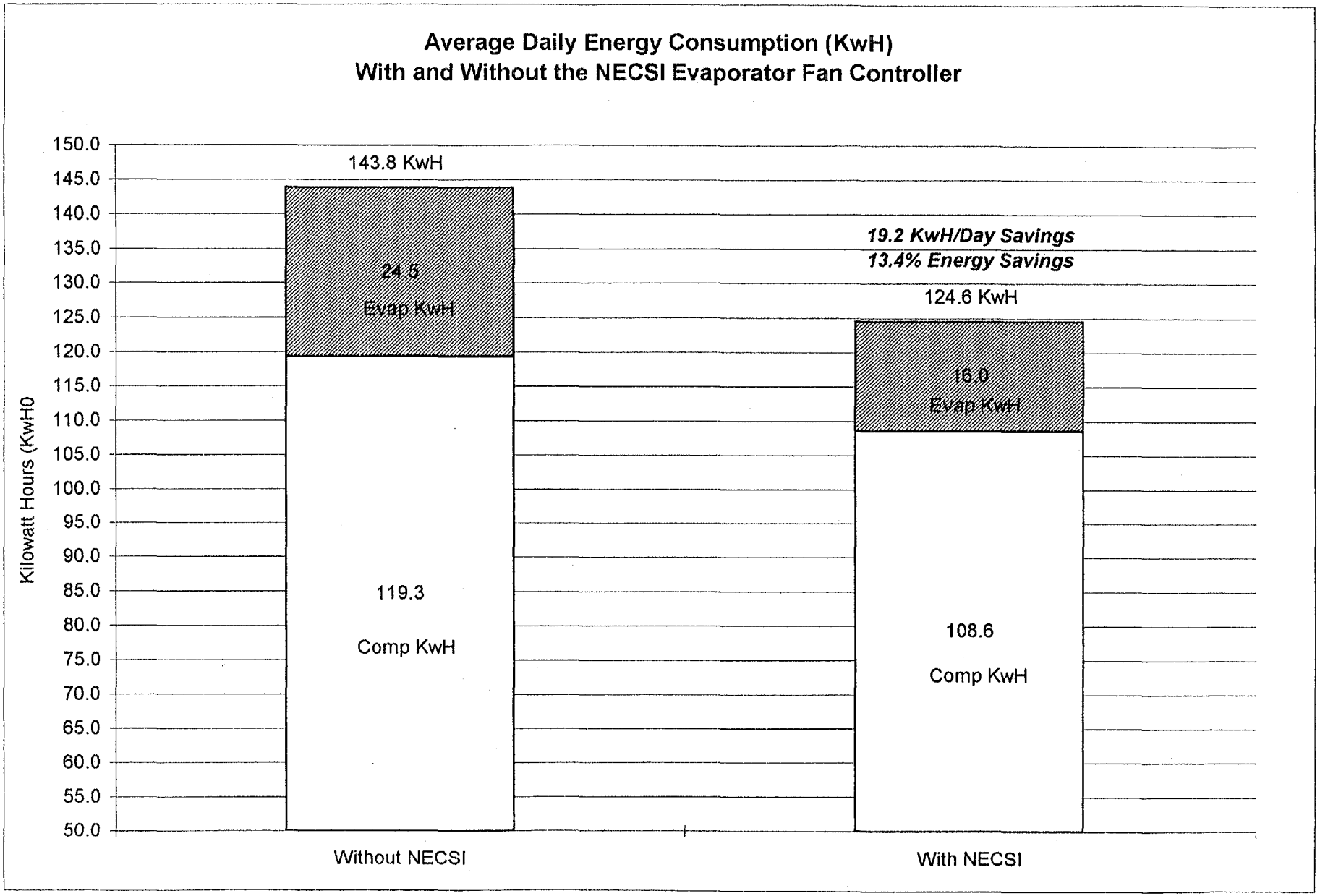
Financial Savings Summary

The estimated annual energy savings attributable to the installation of the NECSI Evaporator Fan Controller is $560. The estimated annual equipment savings attributable to the installation of the NECSI Evaporator Fan Controller is $97. This yields a total combined estimated annual savings on the order of $657.

[1] Cost estimates taken from survey of local refrigeration contractors; minimum costs only.

Trader Joe's, Store #70
2601 Marconi Avenue, Sacramento, CA

July - August 1997



Trader Joe's, Store #70
2601 Marconi Avenue, Sacramento, CA

July - August, 1997

Daily Averaged Energy Consumption (KwH) and Compressor and Evaporator Duty Cycles, Without and With the NECSI Evaporator Fan Controller

Day	Date	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
Without NECSI Evaporator Fan Controller:						
1	07/20/97	72.1%	99.6%	121.3	23.9	145.2
2	07/21/97	70.4%	100.0%	120.7	23.5	144.2
3	07/22/97	71.4%	100.0%	119.7	24.9	144.6
4	07/23/97	64.9%	100.0%	107.6	24.9	132.4
5	07/24/97	67.2%	100.0%	119.3	24.8	144.2
6	07/25/97	75.8%	99.9%	131.4	24.2	155.6
7	07/26/97	68.6%	100.0%	117.8	24.6	142.4
With NECSI Evaporator Fan Controller:						
9	07/28/97	66.5%	59.3%	112.9	16.8	129.8
10	07/29/97	70.6%	61.3%	116.5	17.1	133.6
11	07/30/97	60.8%	51.8%	98.2	15.4	113.6
12	07/31/97	61.9%	53.9%	104.1	15.8	120.0
13	08/01/97	67.5%	64.4%	114.0	17.7	131.7
14	08/02/97	67.5%	63.6%	117.0	17.8	134.8
15	08/03/97	61.9%	54.2%	106.9	15.9	122.8
Averaged readings, first and second weeks						
Without NECSI		70.1%	99.9%	119.7	24.4	144.1
With NECSI		65.3%	58.4%	109.9	16.6	126.6

Day	Date	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
Without NECSI Evaporator Fan Controller:						
1	08/05/97	66.9%	100.0%	119.5	23.8	143.3
2	08/06/97	69.3%	100.0%	123.1	24.8	147.9
3	08/07/97	74.9%	100.0%	134.3	24.7	159.0
4	08/08/97	66.9%	100.0%	117.5	24.9	142.5
5	08/09/97	65.4%	99.9%	109.4	24.2	133.7
6	08/10/97	64.6%	100.0%	106.6	25.3	131.8
7	08/11/97	74.4%	100.0%	122.6	23.9	146.5
With NECSI Evaporator Fan Controller:						
9	08/13/97	67.2%	60.1%	113.8	16.8	130.6
10	08/14/97	65.7%	58.6%	111.0	15.0	126.0
11	08/15/97	69.2%	64.3%	110.9	14.4	125.3
12	08/16/97	67.2%	61.0%	109.5	16.3	125.8
13	08/17/97	58.8%	49.2%	95.7	14.8	110.5
14	08/18/97	62.6%	52.8%	104.4	14.4	118.8
15	08/19/97	62.4%	53.3%	105.2	15.4	120.5
Averaged readings, third and fourth weeks						
Without NECSI		68.9%	100.0%	119.0	24.5	143.5
With NECSI		64.7%	57.0%	107.2	15.3	122.5
Averaged readings for complete test period:						
Without NECSI		**69.5%**	**100.0%**	**119.3**	**24.5**	**143.8**
With NECSI		**65.0%**	**57.7%**	**108.6**	**16.0**	**124.6**

Average daily savings attributed to NECSI Controller: 19.2 KwH

Data from starting and ending days, and days of change of mode, not included in computations.

Nevada Energy Control Systems Inc.

Refrigeration Monitoring Test Results

McDonald's Restaurant
4515 Pacific Avenue, Stockton, California
for Redarhcs Management Company

Completed in conjunction with

The United States
Department of Energy
(ERIP DE-FG01-96EE15670)

NECSI Nevada Energy Control Systems, Inc.
P. O. Box 6689, Incline Village, Nevada 89450 (702) 831-7728 FAX (702) 831-7731

March 19, 1997

Mr. Bob Hancock
Redarhcs Management Company
4502 Georgetown Place, Suite 202
Stockton, California 95207

Dear Mr. Hancock:

We at NECSI would like to thank you for your participation and cooperation in our refrigeration monitoring and testing project. The following report contains a description of the test, with the results and a summary of the data sets.

As you will see, the results are quite positive in relationship to energy savings and equipment performance. There is a 43.5% reduction in average overall daily electrical consumption for the refrigeration system. The installation of the NECSI Evaporator Fan Controllers will save you approximately $294 per year in combined electrical and equipment costs. This savings does not include a dollar figure attributable to decreased maintenance labor expenses since you have your own in-house maintenance staff.

Thank you again.

David J. Kimber
Director of Marketing, NECSI

Test Description:

Location:	McDonald's Restaurant
	4515 Pacific Avenue, Stockton, CA
Management:	Redarhcs Management Company
Refrigeration Equipment:	
Box size	12' x 9' x 8' = 864 cubic feet
Doors	one 3' wide door
Compressor	Copeland KAKI-0100-TAC
Condenser	Bohn MAC-6
Evaporators	Bohn MCN 1321D
Evaporator Fan Motor Type	Energy Efficient PSC
Test Equipment:	
Data Recording Equipment	Fluke Hydra DataBucket Model 2635
Temperature Input Sensing Equipment	Omega Relative Humidity and Temperature Probes
	K-Temperature Wire Probes
Temperature Inputs Monitored:	By K-Wire Probes: Box Temperature (3 inputs): low, mid and high elevations for stratification Ambient Air Temperature External of Compressor Air Temperature at Evaporator Inlet and Outlet
	By Omega Probes: Relative Humidity and Temperature of box
Electrical Input Sensing Equipment	Fluke DC/AC Current Probes Model 80i-410
Electrical Inputs Monitored:	Compressor/Condensing Unit Voltage Compressor/Condensing Unit Amperage Evaporator Voltage Evaporator Amperage
Input Monitoring Interval:	Two minutes, 24 hours per day
Number of days monitored with NECSI Evaporator Fan Controller installed:	For temperature readings: 7 days, 2/02-2/08/97 For power consumption readings: 8 days, 2/14-2/21/97
Number of days monitored without NECSI Evaporator Fan Controller installed:	For temperature readings: 10 days, 1/13-1/22/97 For power consumption readings: 7 days, 2/23-3/1/97

Note: Days of change of mode, or other partial days of monitoring, are not used in computations. Each "day" runs from midnight to midnight.

Test Objectives

The primary objective of this test is to determine the energy consumption characteristics of the subject walk-in refrigerated box, in both its existing state and with the NECSI Evaporator Fan Controller installed. Secondly, temperatures will be monitored in order to determine if there is any significant temperature differential in relationship to the introduction of the NECSI Evaporator Fan Controller to the system. Thirdly, equipment run times will also be monitored to determine significant compressor and evaporator load differentials.

Test Procedures and Treatment of Data

This test was run in two stages as detailed below, with the Fluke Hydra datalogger recording temperatures and humidity every two minutes 24 hours a day during the first, temperature recording stage, and then power consumption in the same manner during the power monitoring stage. The data from the days in which switching from mode to mode of a testing stage occurred were not used in computing the results or in averaging the data sets because they were not full 24-hour days of data. Each "day" runs from midnight to midnight.

Stage One - Temperature and Humidity Monitoring: This was begun on 1/13/97, running through 1/22/97, without the NECSI Evaporator Fan Controller installed. The second half of this stage ran from 2/02/97 through 2/08/97, with the NECSI Evaporator Fan Controller enabled.

Stage Two - Power Consumption Monitoring: This was begun 2/14/97 through 2/21/97, with the NECSI Evaporator Fan Controller enabled. The second half of this stage began on 2/23/97, running through 3/01/97, without the NECSI Evaporator Fan Controller installed.

Results

The results are divided into four categories: temperature, humidity, electrical consumption and equipment load differentials.

Temperature:

The purpose of the temperature monitoring within the walk-in refrigerated box is to determine the effect, if any, that the NECSI Evaporator Fan Controller has on overall temperature and on temperature stratification. After the NECSI Evaporator Fan Controller was installed, the internal box temperature decreased, on average, 1.8 degrees. This decrease is attributed to the diminished air velocity from the evaporator fans. By decreasing the air velocity, the warm air exchange through the door is decreased. The temperature decrease is also attributed to the increased efficiency of the refrigeration equipment, coupled with a decrease in fan motor heat introduced into the walk-in box when the NECSI Evaporator Fan Controller is installed. The aforementioned factors, coupled with the normal thermal lag of the thermostat, create this temperature decrease.

Humidity:

After the NECSI Evaporator Fan Controller was installed, the internal box humidity increased, on average, 3.7 per cent. This increase is attributed to the lower temperature and diminished air velocity from the evaporator fans, in a box with open product. With lowered air velocity and less fan motor heat being discharged into the box when the NECSI Evaporator Fan Controller is

installed, more of the natural product moisture remains in the box, keeping the air surrounding the product more moist and less drying to the product. The product thus is able to maintain its natural freshness and moistness for a longer period of time. This will aid in the reduction of "shrink."

Electrical Consumption:
The average daily electrical consumption was reduced by an average of 6.0 Kilowatt hours (KwH) per day with the introduction of the NECSI Evaporator Fan Controller. This equates to a 43.5% reduction in average daily electrical consumption. On an annualized basis, the use of the NECSI Evaporator Fan Controller in this application would save 2,190 KwH.

At McDonald's average present cost of electricity ($0.08/KwH), this equals an annualized savings of $175.20.

Equipment Load Differential:
The amount of time that the equipment runs during any given twenty-four hour period is called its duty cycle. This is measured to determine any differential in compressor and evaporator run time attributable to the installation of the NECSI Evaporator Fan Controller.

Compressor: Without the fan controller installed, the subject compressor has a duty cycle of 21.23%. After the installation of the NECSI Evaporator Fan Controller, this duty cycle was decreased to 13.96%. This equates to 34.24% decrease in operating time. This is attributed to the decrease in fan motor heat introduced into the walk-in box when the fan motors are running at decreased voltage.

This directly translates into an increase in compressor life of 34.24% and a similar decrease in maintenance costs over the life of the refrigeration unit. Assuming a five-year life and an average installed replacement cost of $1,100.00, this equates to an annual savings of $75.24.*

Evaporator: Without the fan controller installed, an evaporator runs at its normal full speed all the time. After the installation of the NECSI Evaporator Fan Controller in this system, the evaporator fans ran at a decreased speed/load for 77% of the time. During this time, the fan motors are subjected to 64% less wear (this directly correlates to the voltage drop created by the NECSI Evaporator Fan Controller). The combination of these two factors equates to a 49% overall decrease in evaporator fan motor wear, which can be directly translated into an increase in fan motor longevity. Assuming a five-year life and an average installed replacement cost of $150.00 per PSC evaporator fan motor ($450 for three motors), this equates to an annual savings of $44.10.*

The total estimated annual equipment savings, not including decreased maintenance costs, is on the order of $119.00.

Savings Summary

The total estimated combined savings attributable to the installation of the NECSI Evaporator Fan Controller is $294 annually.

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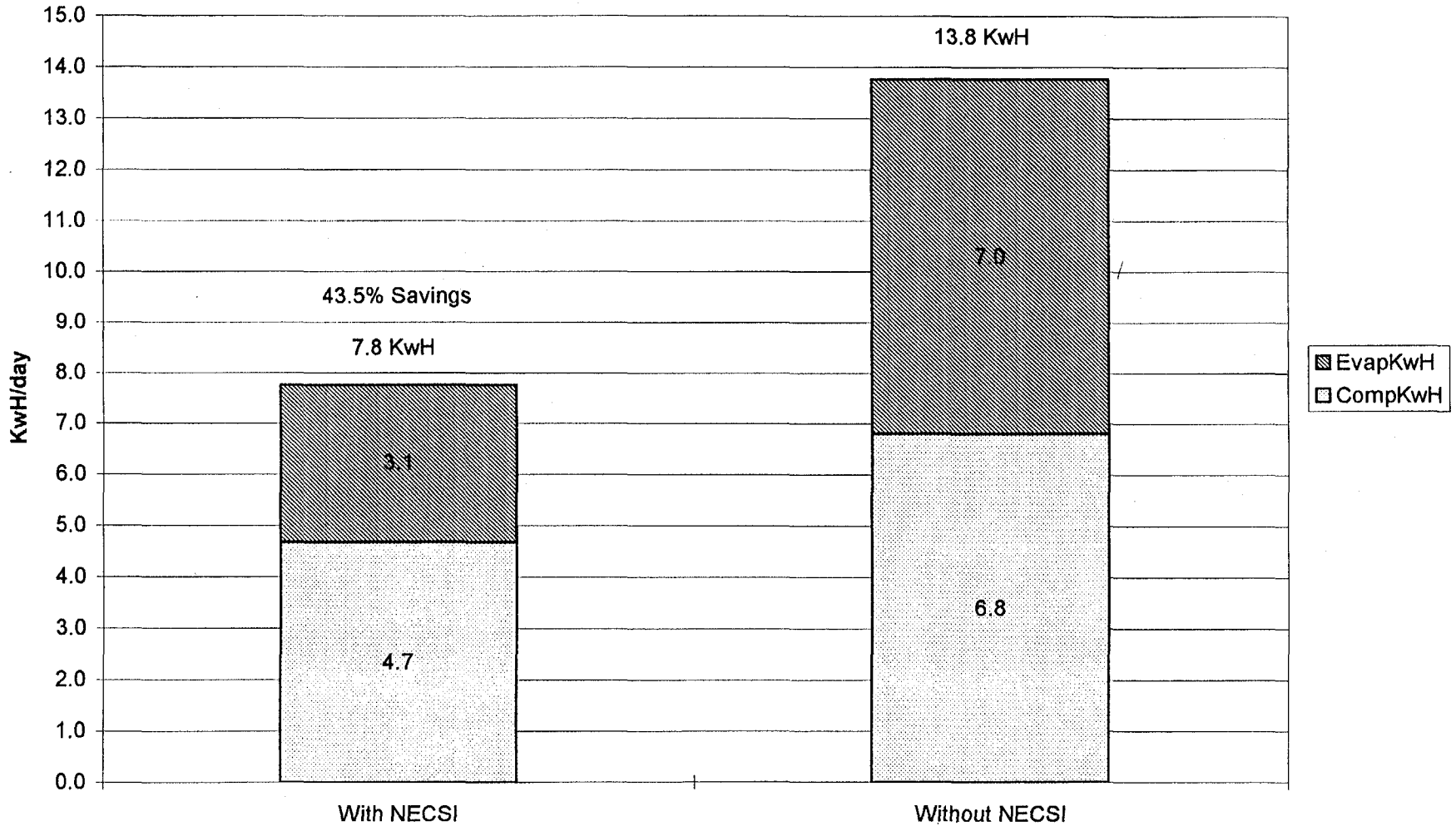
* Cost estimates taken from survey of local refrigeration contractors; minimum costs only.

Average Daily Energy Consumption (KwH)
With and Without the NECSI Evaporator Fan Controller



With NECSI Evaporator Fan Controller							
		CondAmbTemp	Compressor	Evaporator			Comp +
Day	Date	Aver."°F"	Duty Cycle	Duty Cycle	Comp KwH	Evap KwH	Evap KwH
1	02/14/97	57.7	13.75%	19.03%	4.6	2.9	7.5
2	02/15/97	59.3	15.00%	25.00%	5.0	3.2	8.3
3	02/16/97	59.9	13.61%	23.33%	4.6	3.1	7.6
4	02/17/97	55.9	11.25%	20.14%	4.0	2.9	6.9
5	02/18/97	59.0	13.61%	19.58%	4.5	2.9	7.4
6	02/19/97	58.8	15.83%	25.28%	5.3	3.2	8.6
7	02/20/97	56.5	14.58%	25.69%	4.7	3.2	7.9
8	02/21/97	58.3	14.03%	23.47%	4.6	3.2	7.8
Average of days 1 - 8:		58.2	13.96%	22.69%	4.7	3.1	7.8
Without NECSI Evaporator Fan Controller							
		CondAmbTemp	Compressor	Evaporator			Comp +
Day	Date	Aver."°F"	Duty Cycle	Duty Cycle	Comp KwH	Evap KwH	Evap KwH
9	02/23/97	58.1	19.31%	100.00%	6.3	7.0	13.3
10	02/24/97	58.9	18.75%	100.00%	6.1	7.0	13.1
11	02/25/97	58.9	24.72%	100.00%	7.9	7.0	14.9
12	02/01/56	59.0	24.58%	100.00%	7.9	6.9	14.8
13	02/27/97	56.5	17.36%	100.00%	5.7	6.9	12.5
14	02/28/97	56.5	18.89%	100.00%	5.9	6.9	12.9
15	03/01/97	55.9	25.00%	100.00%	7.9	7.0	14.8
Average of days 9 - 15:		57.7	21.23%	100.00%	6.8	7.0	13.8
		NECSI EFC ON (days 1-8)			**NECSI EFC OFF (days 9-15)**		
Average KwH/day		7.8	KwH/day		13.8	KwH/day	
Average Duty Cycle - Comp. ON time		13.96%	ON time		21.23%	ON time	
Average Duty Cycle - Evap .ON time		22.92%	ON time		100.00%	ON time	
Average Ambient(Outside)Temp.		58.2	F.		57.7	F.	

With NECSI Evaporator Fan Controller									
Day	Date	Outside F		Omega °F	High °F	Mid °F	Low °F		Humidity
		Aver."°F"		Aver."°F"	Aver."°F"	Aver."°F"	Aver."°F"		"%"
11	02/02/97	54.4		36.4	41.9	42.0	41.6		84.1
12	02/03/97	53.2		37.6	42.8	42.3	41.4		81.4
13	02/04/97	54.6		37.7	42.7	42.4	41.8		82.8
14	02/05/97	51.9		34.2	38.5	38.6	38.3		81.9
15	02/06/97	50.9		32.2	36.7	36.7	36.5		79.3
16	02/07/97	53.8		32.6	37.3	36.9	36.4		74.9
17	02/08/97	51.0		33.0	37.5	37.5	37.2		75.6
Average of days 11 - 17		52.8		34.8	39.6	39.5	39.0		80.0
Without NECSI Evaporator Fan Controller									
		Outside F		Omega °F	High °F	Mid °F	Low °F		Humidity
Day	Date	Aver."°F"		Aver."°F"	Aver."°F"	Aver."°F"	Aver."°F"		"%"
1	01/13/97	40.2		39.3	40.0	40.5	40.3		73.0
2	01/14/97	41.8		39.0	40.2	40.5	40.4		66.7
3	01/15/97	44.9		38.9	40.6	40.8	40.6		74.2
4	01/16/97	49.3		38.5	40.9	41.0	40.7		74.9
5	01/17/97	49.1		38.5	40.7	40.5	40.1		74.4
6	01/18/97	49.4		38.1	40.7	40.4	40.1		73.0
7	01/19/97	49.5		38.2	41.0	40.6	40.3		75.5
8	01/20/97	51.5		37.9	40.8	40.5	40.4		80.4
9	01/21/97	51.7		37.9	40.8	40.5	40.2		83.8
10	01/22/97	51.6		37.4	40.3	40.3	40.1		86.9
Average of days 1 - 10		47.9		38.4	40.6	40.6	40.3		76.3
				NECSI EFC ON (days 11 - 17)			NECSI EFC OFF (days 1 - 10)		
Average of all box interior temperatures									
(Omega monitor, high, mid and low monitors)					38.2			40.0	
Average humidity					80.0			76.3	

Nevada Energy Control Systems Inc.

Refrigeration Monitoring Test Results

Walnut Creek School District
Walnut Creek, California

Completed in conjunction with

The United States
Department of Energy
(ERIP DE-FG01-96EE15670)

NECSI Nevada Energy Control Systems, Inc.
P. O. Box 6689, Incline Village, Nevada 89450 (702) 831-7728 FAX (702) 831-7731

April 15, 1997

Ms. Gail Tomei
Walnut Creek School District
2425 Walnut Boulevard
Walnut Creek, California 94596

Dear Ms. Tomei:

We at NECSI would like to thank you for your participation and cooperation in our refrigeration monitoring and testing project. The following report contains a description of the test, with the results and summaries of the data sets.

As you will see, the results are very positive in relationship to both energy savings and equipment performance. The installation of the NECSI Evaporator Fan Controller in this application will save Walnut Creek School District approximately $569 per year in electrical energy costs and approximately $100 per year in equipment costs for a total combined estimated annual savings of $669. Please note that these savings estimates do not include a quantified maintenance savings.

Thank you again.

David J. Kimber
Director of Marketing, NECSI

Test Description

Location:	Walnut Creek School District Main Cafeteria Facility, 2425 Walnut Blvd., Walnut Creek, California, 94596
Refrigeration Equipment:	
Box Size	24.33' x 13.0' x 8.66'= 2,739 cu.ft.
Doors	2 personnel doors
Compressors/Condensing Unit	MLH300
Evaporators	2 AA28122B, 14,600 BTUH each
Evaporator Fan Motors Type	2 per evaporator, shaded pole
BTU Per Cubic Foot	10.66
Test Equipment:	
Data Recording Equipment	Fluke Hydra DataBucket Model 2635
Temperature Input Sensing Equipment	K-Temperature Wire Probes
	Omega Relative Humidity and Temperature Probe
Temperature Inputs Monitored	By K-Wire Probes: Box Temperature (3 inputs): low, mid and high elevations for stratification, Ambient Air Temperature External of Compressor Condenser Outlet Evaporator Inlet and Outlet
	By Omega Probe: Relative Humidity and Temperature of Box
Electrical Input Sensing Equipment	Fluke DC/AC Current Probes Model 80i-410
Electrical Inputs Monitored	Compressor/Condensing Unit Voltage Compressor/Condensing Unit Amperage Evaporator Voltage Evaporator Amperage
Input Monitoring Interval	Two minutes, 24 hours per day
Days monitored without NECSI Evaporator Fan Controller installed	7 days---3/9-3/15/97
Days monitored with NECSI Evaporator Fan Controller installed	7 days---3/18-3/24/97

NOTE: Data from days of change of mode were deleted from computations.

Test Objectives

The objectives of this test are to determine the effects of the introduction of a NECSI Evaporator Fan Controller on the subject walk-in refrigerated box. The effects to be monitored and analyzed are as follows:

The energy consumption of the subject refrigeration system.
Temperature stratification differentials.
Equipment load differentials.

Test Procedures

This test was run in two phases as detailed below, with the Fluke Hydra datalogger recording power consumption, temperatures and humidity every two minutes 24 hours a day. Data is not used from days in which switching from mode to mode occurs. Each "day" runs from midnight to midnight.

Phase One: Began on Sunday, 3/09/97 at midnight. This phase consisted of seven days without the NECSI Evaporator Fan Controller installed, concluding at midnight on Saturday, 3/15/97. During the day of Monday, 3/17/97, the NECSI controller was enabled, to begin the second phase of the test.

Phase Two: Began on Tuesday, 3/18/97 at midnight. This phase consisted of seven days with the NECSI Evaporator Fan Controller installed. This phase concluded on Monday, 3/24/97 at midnight. During the day of 3/25/97, all the monitoring equipment was removed. The NECSI controller was left installed and connected in the subject refrigerated box.

Results

The energy consumption of the subject refrigeration system:
In order to determine the comparative energy consumption of the subject system, this analysis was completed in two phases: the first of these was a baseline phase (control), and the second was a test phase which included the introduction of the NECSI Evaporator Fan Controller. By segregating the phases in this manner, sufficient data was obtained to complete an analysis of energy consumption.

The baseline data indicates that the subject compressor/condensing unit consumes an average of 8.9 KwH per day and the evaporator units consume an average of 23.1 KwH per day. This yields a total average consumption of 32.0 KwH per day without the NECSI Evaporator Fan Controller introduced to the system.

The test phase data indicates that the subject compressor/condensing unit consumes an average of 7.0 KwH per day and the evaporator units consume an average of 6.2 KwH per day. This yields a total average consumption of 13.2 KwH per day with the NECSI Evaporator Fan Controller introduced to the system. (See Table 1 and Figures 1 and 2.)

This equates to an average daily system savings of 18.8 KwH per day, which represents a 58.75% system savings. On an annualized basis, the introduction of the NECSI Evaporator Fan Controller in this application would save 6,862 KwH. At Walnut Creek School District's present average cost for electricity ($0.083/KwH), this equals an annualized savings of $569.

Temperature stratification differentials:
In order to determine the effect of the NECSI Evaporator Fan Controller in relation to temperature stratification within the subject box, three separate temperature monitoring points were utilized. These were located near the floor, middle and ceiling elevations within the subject box.

The baseline temperature stratification monitoring showed an average stratification differential of .69 degrees F. This is considered to be an acceptable stratification.

The test phase temperature stratification monitoring showed an average stratification differential of .61 degrees F. (See Table 2.) Even though this is a decrease, and thus an improvement, in the average stratification differential, it is considered to be negligible.

Equipment load differentials:
The amount of time that equipment runs during any twenty-four hour period is called its duty cycle. This is measured to determine any differential in equipment run time attributable to the installation of the NECSI Evaporator Fan Controller.

Compressor: Without the fan controller installed, the subject compressor has a duty cycle of 16.17%. After the installation of the NECSI Evaporator Fan Controller, this duty cycle was decreased to 12.12%. This equates to a 25% decrease in operating time. This is attributed to the decrease in fan motor heat introduced into the box when the fan motors are running at decreased voltage. (See Table 3 and Figure 3.)

This directly translates into an increase in compressor life of 25% and a similar decrease in maintenance costs over the life of the refrigeration unit. Assuming a five-year life and an average installed replacement cost of $1,100.00, this equates to an annual savings of $55.00

Evaporator: Without the fan controller installed, the evaporators run at their full speed 100% of the time. After the installation of the NECSI Evaporator Fan Controller in the subject system, the evaporator fans ran at a decreased speed/load 87% of the time (at full speed 13%). During this time, the fan motors are subjected to 64% less wear (this directly correlates to the voltage drop created by the NECSI Evaporator Fan Controller). The combination of these two factors equates to a 56% overall decrease in fan motor wear, which can be directly translated into an increase in fan motor longevity. Assuming a five-year physical and economic life and an average installed replacement cost of $100[1] per evaporator fan motor ($400 for four motors), this equates to an annual equipment savings of $45. This estimated annual equipment savings does not include decreased maintenance costs attributable to increased system efficiency. (See Table 3, Figure 3.)

[1] Cost estimates taken from survey of local refrigeration contractors; minimum costs only.

Financial Savings Summary

The estimated annual energy savings attributable to the installation of the NECSI Evaporator Fan Controller is $569. The estimated annual equipment savings attributable to the installation of the NECSI Evaporator Fan Controller is $100. This yields a total combined estimated annual savings on the order of $669.

Table 1.

Daily Averaged Energy Consumption (KwH), Reflecting Ambient Temperature Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	Weekday	Amb. Temp Aver."°F"	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
1	6 - 725	03/09/97	Sunday	62.6	11.81%	100.00%	6.7	23.4	30.1
2	726 - 1445	03/10/97	Monday	65.0	19.72%	100.00%	10.9	22.9	33.8
3	1446 - 2165	03/11/97	Tuesday	62.5	20.00%	100.00%	10.9	22.8	33.7
4	2166 - 2885	03/12/97	Wednesday	57.7	18.19%	100.00%	9.8	23.0	32.9
5	2886 - 3605	03/13/97	Thursday	58.1	18.75%	100.00%	10.2	23.0	33.1
6	3606 - 4325	03/14/97	Friday	63.1	14.17%	100.00%	8.0	23.2	31.1
7	4326 - 5045	03/15/97	Saturday	60.4	10.56%	100.00%	6.0	23.4	29.4
		Averages		61.3	16.17%	100.00%	8.9	23.1	32.0

Data from starting and ending days, and days of change of mode, not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	Weekday	Amb. Temp Aver."°F"	Compressor Duty Cycle	Evaporator Duty Cycle	Comp KwH	Evap KwH	C+E KwH
1	6 - 725	03/18/97	Tuesday	63.1	12.08%	12.92%	7.0	6.1	13.1
2	726 - 1445	03/19/97	Wednesday	65.4	13.19%	13.89%	7.6	6.3	13.9
3	1446 - 2165	03/20/97	Thursday	66.5	15.69%	16.81%	8.8	6.9	15.7
4	2166 - 2885	03/21/97	Friday	68.4	15.14%	16.53%	8.6	6.8	15.4
5	2886 - 3605	03/22/97	Saturday	65.9	5.56%	6.11%	3.5	4.9	8.4
6	3606 - 4325	03/23/97	Sunday	65.7	5.69%	6.67%	3.6	5.0	8.6
7	4326 - 5045	03/24/97	Monday	68.5	17.50%	19.44%	9.8	7.4	17.2
		Averages		66.2	12.12%	13.19%	7.0	6.2	13.2

Data from starting and ending days, and days of change of mode, not included in computations.

Figure 1.

Average Daily Energy Consumption (KwH)
Without and With the NECSI Evaporator Fan Controller

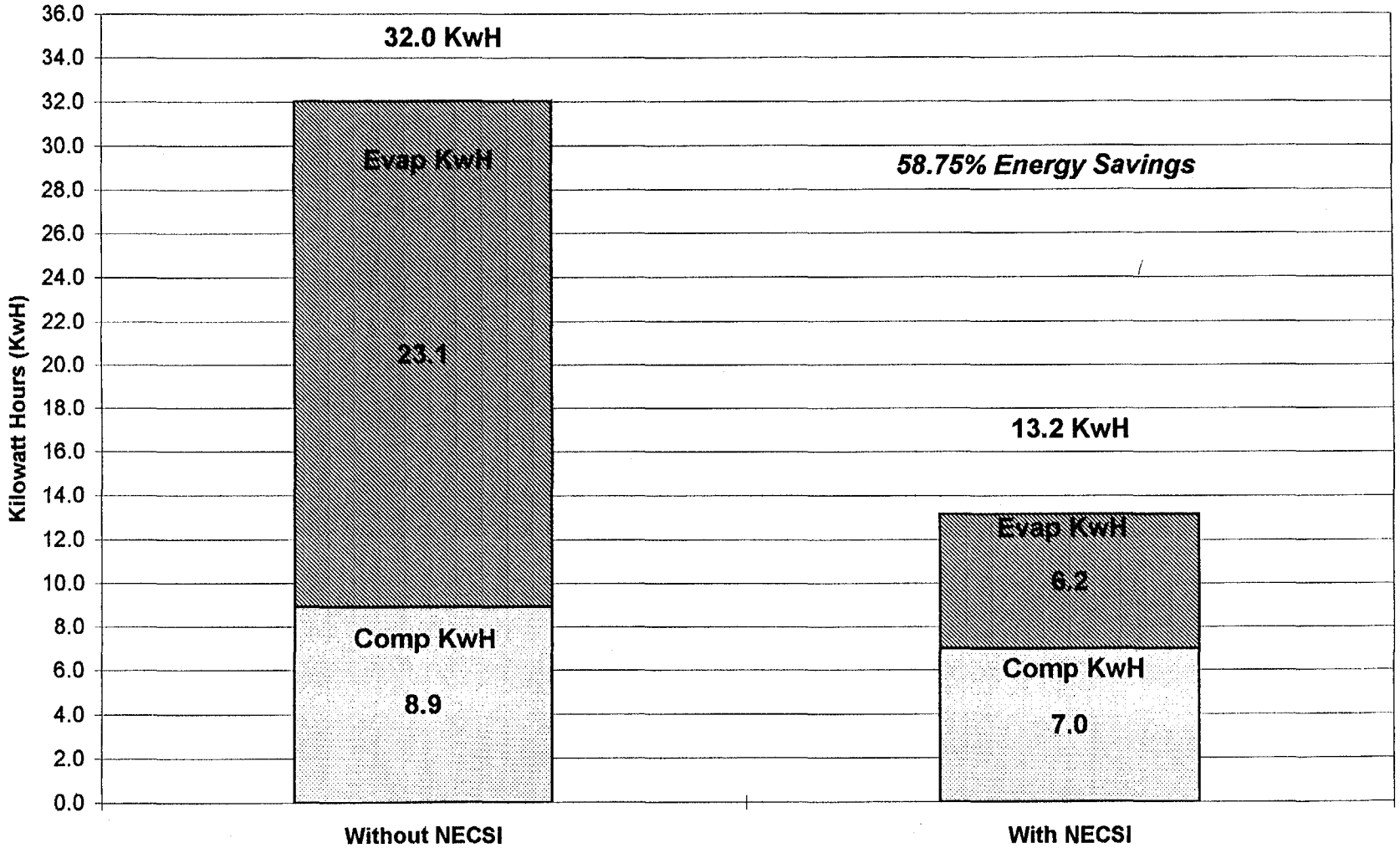


Figure 2.

Daily Averaged Energy Consumption (KwH), Correlated With the Ambient Temperature, Without and With the NECSI Evaporator Fan Controller

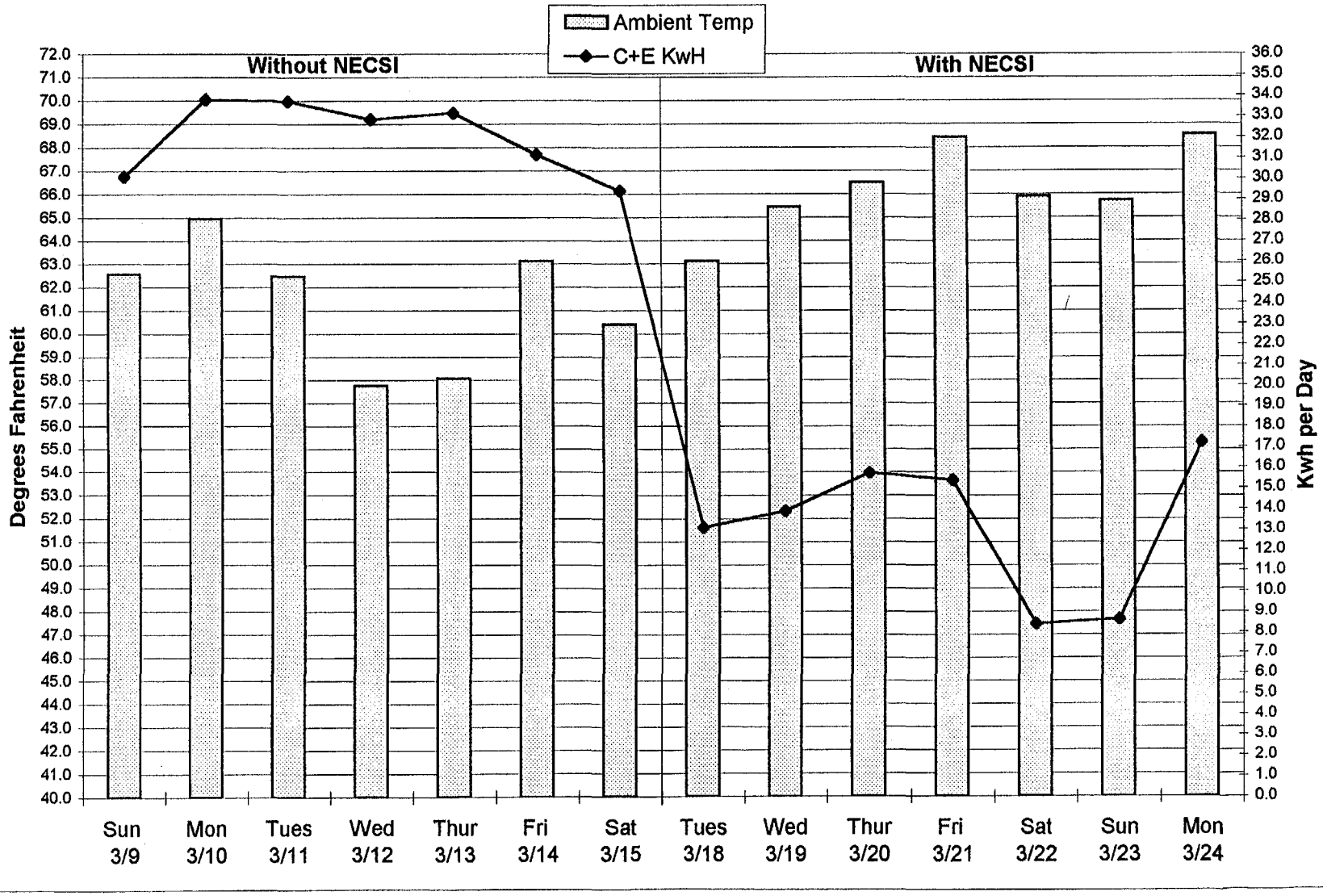


Table 2.

Daily Averaged Stratification Data
Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	Weekday	Amb. Temp Aver."°F"	Ceiling Aver."°F"	Midpoint Aver."°F"	Floor Aver."°F"	Average	AvgStratDiff
1	6 - 725	03/09/97	Sunday	62.6	37.1	37.4	37.9	37.5	0.8
2	726 - 1445	03/10/97	Monday	65.0	37.2	36.9	37.6	37.2	0.7
3	1446 - 2165	03/11/97	Tuesday	62.5	37.0	37.0	37.7	37.2	0.7
4	2166 - 2885	03/12/97	Wednesday	57.7	37.0	36.9	37.5	37.1	0.6
5	2886 - 3605	03/13/97	Thursday	58.1	37.1	36.7	37.5	37.1	0.8
6	3606 - 4325	03/14/97	Friday	63.1	37.0	36.9	37.5	37.1	0.6
7	4326 - 5045	03/15/97	Saturday	60.4	37.1	37.2	37.7	37.3	0.6
		Averages		61.3	37.1	37.0	37.6	37.2	0.69

Data from starting and ending days, and days of change of mode, not included in computations.

With NECSI Evaporator Fan Controller

Day	Readings #	Date	Weekday	Amb. Temp Aver."°F"	Ceiling Aver."°F"	Midpoint Aver."°F"	Floor Aver."°F"	Average	AvgStratDiff
1	6 - 725	03/18/97	Tuesday	63.1	38.2	37.9	38.4	38.2	0.5
2	726 - 1445	03/19/97	Wednesday	65.4	38.1	37.9	38.1	38.0	0.2
3	1446 - 2165	03/20/97	Thursday	66.5	37.8	37.6	38.2	37.9	0.6
4	2166 - 2885	03/21/97	Friday	68.4	38.1	37.8	38.5	38.1	0.7
5	2886 - 3605	03/22/97	Saturday	65.9	38.8	38.1	39.1	38.7	1.0
6	3606 - 4325	03/23/97	Sunday	65.7	38.6	38.2	39.3	38.7	1.1
7	4326 - 5045	03/24/97	Monday	68.5	38.0	37.8	38.0	37.9	0.2
		Averages		66.2	38.2	37.9	38.5	38.2	0.61

Data from starting and ending days, and days of change of mode, not included in computations.

Table 3.

Compressor and Evaporator Duty Cycles
Without and With the NECSI Evaporator Fan Controller

Without NECSI Evaporator Fan Controller

Day	Readings #	Date	Weekday	Compressor Duty Cycle	Evaporator Duty Cycle
1	6 - 725	03/09/97	Sunday	11.81%	100.00%
2	726 - 1445	03/10/97	Monday	19.72%	100.00%
3	1446 - 2165	03/11/97	Tuesday	20.00%	100.00%
4	2166 - 2885	03/12/97	Wednesday	18.19%	100.00%
5	2886 - 3605	03/13/97	Thursday	18.75%	100.00%
6	3606 - 4325	03/14/97	Friday	14.17%	100.00%
7	4326 - 5045	03/15/97	Saturday	10.56%	100.00%
		Averages		16.17%	100.00%

Data from starting and ending days, and days of change of mode, not included in computations.

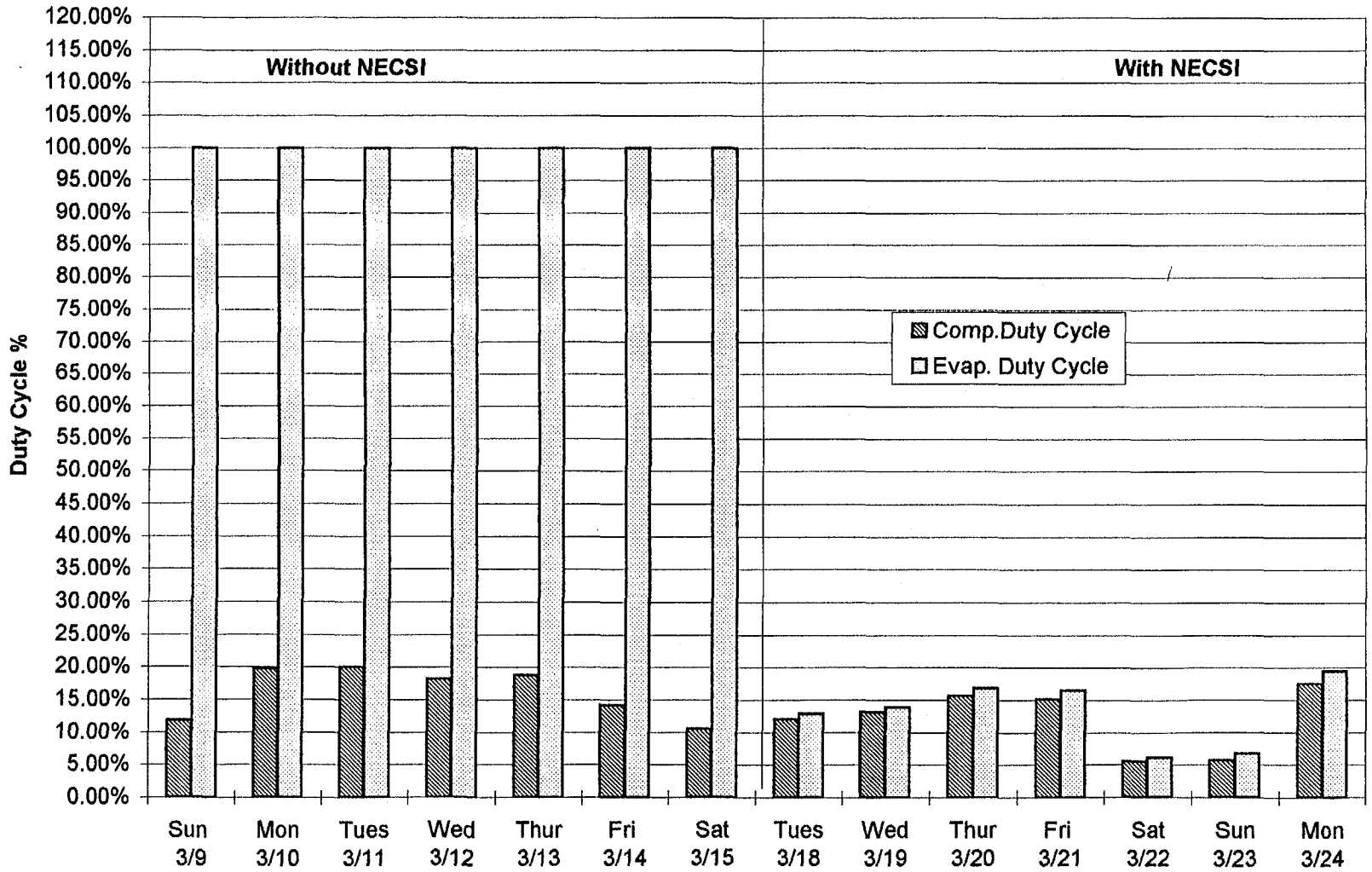
With NECSI Evaporator Fan Controller

Day	Readings #	Date	Weekday	Compressor Duty Cycle	Evaporator Duty Cycle
1	6 - 725	03/18/97	Tuesday	12.08%	12.92%
2	726 - 1445	03/19/97	Wednesday	13.19%	13.89%
3	1446 - 2165	03/20/97	Thursday	15.69%	16.81%
4	2166 - 2885	03/21/97	Friday	15.14%	16.53%
5	2886 - 3605	03/22/97	Saturday	5.56%	6.11%
6	3606 - 4325	03/23/97	Sunday	5.69%	6.67%
7	4326 - 5045	03/24/97	Monday	17.50%	19.44%
		Averages		12.12%	13.19%

Data from starting and ending days, and days of change of mode, not included in computations.

Figure 3.

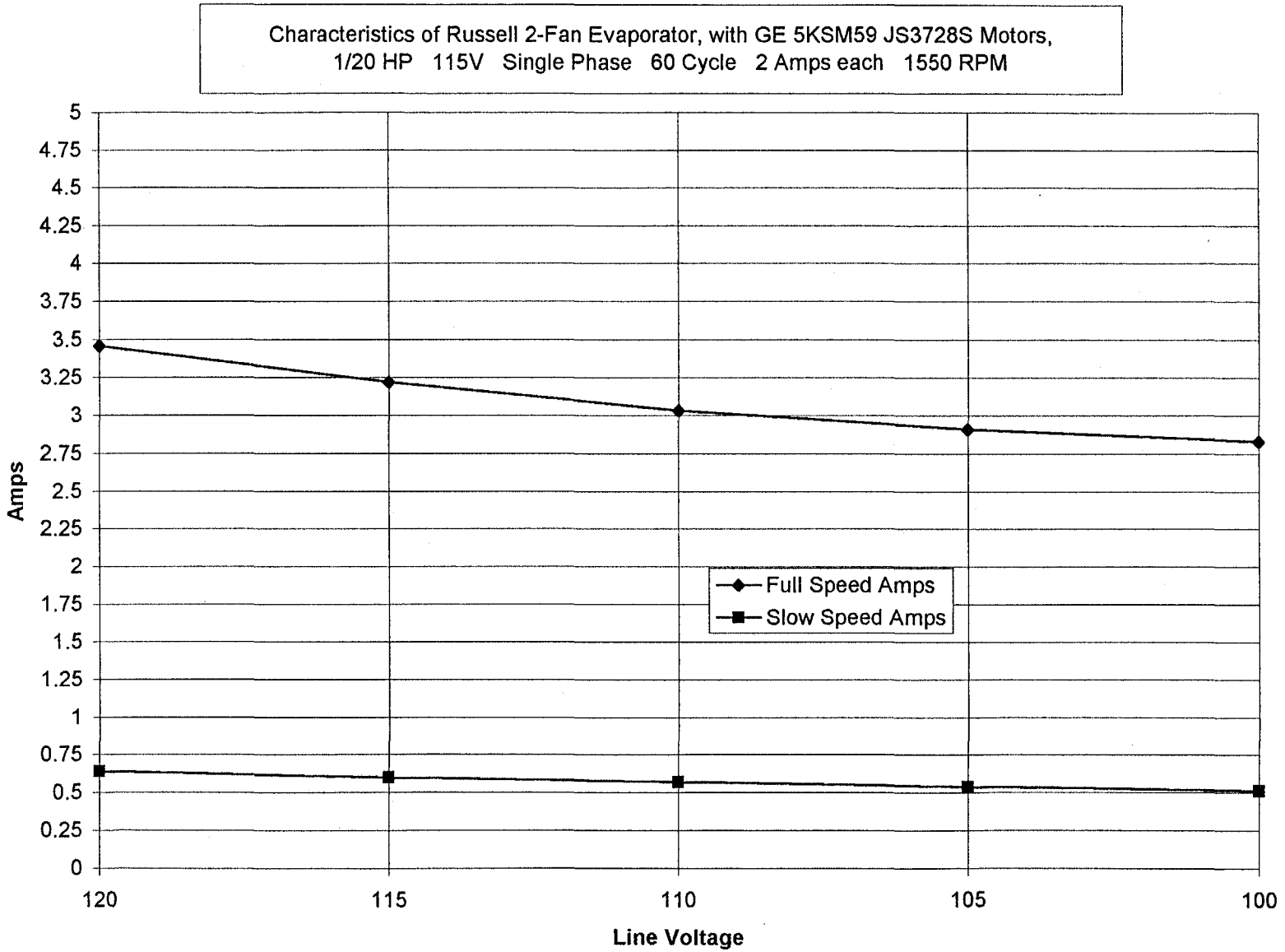
Compressor and Evaporator Duty Cycles
Without and With the NECSI Evaporator Fan Controller



NECSI-Nevada Energy Control Systems, Inc.

	Characteristics of Russell 2-Fan Evaporator, with GE 5KSM59 JS3728S motors,						
	1/20 HP 115V Single Phase 60 Cycle 2 Amps each 1550 RPM						
Line	Full Speed	Slow Speed	Lo Spd Amps %	Full Speed	Slow Speed	% RPM	Slow Speed
Voltage	Amps	Amps	of Full Spd Amps	RPM	RPM	Reduction	Volts
Line Voltage	Full Speed Amps	Slow Speed Amps					
120	3.46	0.64	18.5%	1666	444	26.7%	41.90
115	3.22	0.60	18.6%	1666	416	25.0%	39.64
110	3.03	0.57	18.8%	1666	394	23.6%	37.82
105	2.91	0.54	18.6%	1600	365	22.8%	36.00
100	2.83	0.51	18.0%	1590	340	21.4%	34.48

NECSI-Nevada Energy Control Systems, Inc.



FAN MOTOR TESTS

General Electric Model 5K8M59USK148-S 115 VOLTS 60 HZ 1.6 AMPS					9" Six Blade Fan 1/20 HP		
VOLTS 60Hz	**AMPS**	**RPM**	**OAT °C**	**MOTOR °C**	**MOTOR VA**	**AUTOFORMER * VA**	**TOTAL VA**
120	1.40	1,724	22.6	47.6	168.0	Insertion loss 1.2	169.2
110	1.35	1,666	22.6	44.6	148.5	14.7	163.2
100	1.25	1,587	22.6	43.9	125.0	26.2	151.2
90	1.30	1,379	22.6	46.8	117.0	40.2	157.2
****80**	1.25	909	22.6	54.0	100.0	51.2	151.2
70	1.20	704	22.6	51.7	84.0	61.2	145.2
60	0.95	588	22.6	46.6	57.0	58.2	115.2
50	0.81	500	22.6	42.9	40.5	57.9	98.4
40	0.75	384	22.6	38.2	30.0	61.2	91.2

* The autotransformer's insertion loss is added into the VA shown.

** This motor exhibited cogging, slip, and erratic RPM at this voltage. It also reached its maximum temperature at this voltage.

A normal 5 fan motor evaporator with the above motor would use 845 VA at 120 volts and 456 VA at our low speed voltage of 40 volts. Projecting this power consumption to the maximum our controller can handle (10 amps, ≅ 13 motors) would be 2,028 VA at 120 volts and 1,094 VA at 40 volts. All of this includes the autotransformer's heat generation.

General Electric Model 5KSP51GL453HS 115 Volts 60 Hz 1.1 Amps					10" Four Blade Fan Not rated HP		
VOLTS 60Hz	**AMPS**	**RPM**	**OAT °C**	**MOTOR °C**	**MOTOR VA**	**AUTOFORMER * VA**	**TOTAL VA**
120	1.00	1,648	22.6	49.6	120.0	Insertion loss 1.2	121.2
110	0.90	1,630	22.6	45.7	99.0	10.2	109.2
100	0.87	1,530	22.6	43.1	87.0	18.6	105.6
90	0.85	1,456	22.6	40.4	76.5	26.7	103.2
80	0.90	1,250	22.6	40.3	72.0	37.2	109.2
****70**	0.75	937	22.6	41.1	52.5	38.7	91.2
60	0.75	681	22.6	39.2	45.0	46.2	91.2
50	0.60	600	22.6	35.6	30.0	43.2	73.2
40	0.50	454	22.6	33.4	20.0	41.2	61.2

* The autotransformer's insertion loss is added into the VA shown.

** This motor exhibited cogging at this voltage.

A normal 5 fan motor evaporator with the above motor would use 606 VA at 120 volts and 306 VA at our low speed voltage of 40 volts. Projecting this power consumption to the maximum our controller can handle (10 amps, ≅ 20 motors) would be 2420 VA at 120 volts and 1224 VA at 40 volts. All of this includes the autotransformer's heat generation.

NOTE: The above tests were conducted with the fan motors in open air.

Nevada Energy Control Systems Inc.

Refrigeration Monitoring Test Results

Cameron Park Liquors
Cameron Park, California

Completed in conjunction with

The United States
Department of Energy
(ERIP DE-FG01-96EE15670)

NECSI Nevada Energy Control Systems, Inc.
P. O. Box 6689, Incline Village, Nevada 89450 (702) 831-7728 FAX (702) 831-7731

December 17, 1996

Mr. S. Khabra and Mr. S. Sandhu
Cameron Park Liquors
3326 Coach Lane
Cameron Park, California 95682

Dear Sirs:

We at NECSI would like to thank you for your participation and cooperation in our refrigeration monitoring and testing project. The following report contains a description of the test, with the results and a summary of the data sets.

As you will see, the results are very positive in relationship to energy savings and equipment performance. The installation of the NECSI Evaporator Fan Controllers will save you approximately $676 per year in electrical energy costs.

During the installation of our monitoring equipment, we noticed that the wiring and circuit breakers for your evaporators are insufficient for the amperage used by this equipment. We would highly recommend that you contact an electrician to remedy this situation.

Thank you again.

David J. Kimber
Director of Marketing, NECSI

Test Description:

Location:	Cameron Park Liquors, 3326 Coach Lane, Cameron Park, California 95682
Owners:	S. Khabra and S. Sandhu
Refrigeration Equipment:	
Box size	1880 Cubic Feet
Doors	13 Reach in, 1 personnel
Compressors/Condensing Units	Copeland Semi-Hermetic LAL1 0300 TAC 3 Hp Copeland Semi-Hermetic LAH1 0310 TAC 3 Hp
Evaporators	2 Kramer C130 (13,400 BTU/HR) 2 McQuay RLC-150B (15,000 BTU/HR) Total BTU/HR= 56,800
BTU Per Cubic Foot	30.21
Test Equipment:	
Data Recording Equipment	Fluke Hydra DataBucket Model 2635
Input Sensing Equipment	Omega Relative Temperature and Humidity Probe J-Temperature Wire Probes
Inputs Monitored:	Box Temperature (4 inputs): low, mid and high elevations for stratification, mid-box temperature Relative Humidity Ambient Air Temperature External of Box Electrical: Compressor/Condensing Unit Voltage Compressor/Condensing Unit Amperage Evaporator Voltage Evaporator Amperage
Input Monitoring Interval:	Two minutes, 24 hours per day
Number of days monitored without NECSI Evaporator Fan Controller installed	7 days, 11/16-23/96
Number of days monitored with NECSI Evaporator Fan Controller installed	6 days, 11/23-29/96

Test Objectives

The primary objective of this test is to determine the energy consumption characteristics of the subject walk-in refrigerated box, both in its existing state and with the NECSI Evaporator Fan Controller installed. Additionally, temperatures will be monitored in order to determine if any significant temperature stratification differentials exist in relationship to the introduction of the NECSI Evaporator Fan Controller to the system.

Test Procedures

The test was run in two stages as detailed below, with the Fluke Hydra datalogger recording power consumption, temperatures and humidity every two minutes 24 hours a day for thirteen days.

Stage One: Began on 11/16/96 at 12:44 P.M. This stage consisted of seven days without the NECSI Evaporator Fan Controllers installed.

Stage Two: Began on 11/23/96 at 12:50 P.M. This stage consisted of six days with the NECSI Evaporator Fan Controllers installed.

The test concluded on 11/29/96 at 9:34 A.M., at which time the test equipment was removed and the NECSI Evaporator Fan Controllers were disconnected.

Results

The results are divided into three categories: electrical consumption, temperature and humidity.

Temperature:
After the NECSI Evaporator Fan Controller was installed, the internal box temperature decreased, on average, 3.9 degrees. This decrease is attributed to the diminished air velocity from the evaporator fans. The subject box is designed with the evaporator air flow moving toward the reach-in doors. By decreasing this air velocity, the warm air exchange through these doors is decreased. The 3.9 degree temperature decrease is also attributed to the increased refrigeration equipment efficiency with the NECSI Evaporator Fan Controller installed, and the normal thermal lag of the thermostat.

Humidity:
There was no significant differential between the test stages.

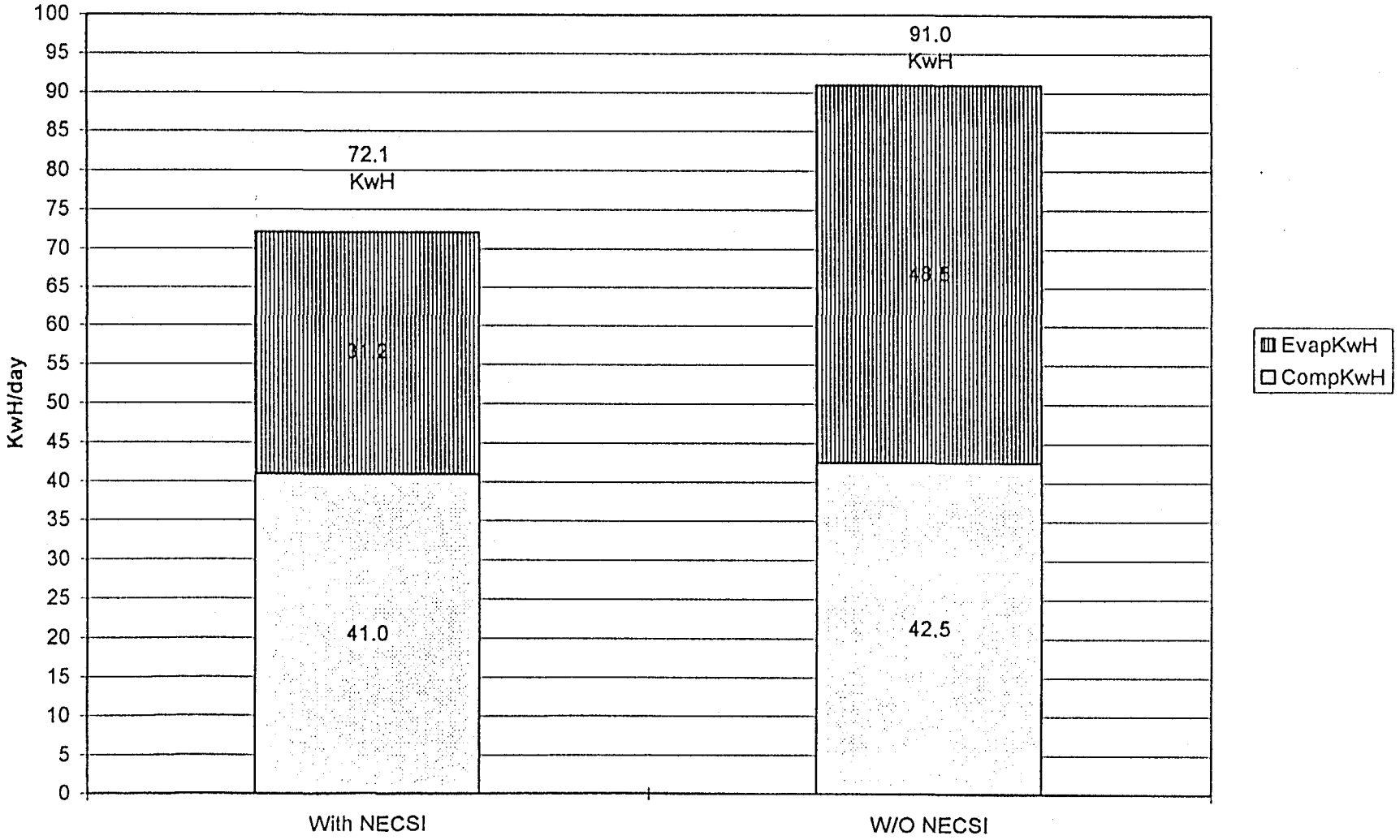
Electrical consumption:
The average daily electrical consumption was reduced by 18.9 Kilowatt hours (KwH) per day with the introduction of the NECSI Evaporator Fan Controllers. This equates to a 20.76% reduction in daily electrical consumption. On an annualized basis, the use of the NECSI Evaporator Fan Controllers in this application would save 6,898 KwH.

At the present average cost of electricity for this business ($0.098/KwH), this equals an annualized savings of **$676.05.**

Treatment of Data:

The data from the first and last days of each testing stage were not used in figuring the results or in averaging the data sets because they were not full 24-hour days of data. Additionally, in order to make the comparison of days as accurate as possible, days with similar ambient temperatures were chosen to be averaged, since ambient temperature, according to PG&E, can be used as an estimator of refrigerator load.

Average Daily Energy Consumption (KwH)
With and Without the NECSI Evaporator Fan Controller



Cameron Park Liquors 11/16-29/96

Day #	Date	Amb Temp*	CompKwH	EvapKwH	C+E KwH	Box High °F	Box Mid °F	Box Low °F
Without NECSI Evaporator Fan Controller								
1	11/16-17	57	110.7	41.5	152.2	46.7	47.0	48.0
2	11/17-18	61	70.6	45.9	116.4	47.0	47.3	48.3
3	11/18-19	66	41.3	48.6	89.9	46.8	47.4	48.2
4	11/19-20	60	41.9	48.6	90.5	46.3	47.1	47.7
5	11/20-21	64	43.7	48.6	92.3	45.5	46.3	47.1
6	11/21-22	64	43.1	48.1	91.2	45.5	46.3	47.2
7	11/22-23	60	37.3	46.6	83.9	45.6	46.7	46.5
	average of days 3-6		42.5	48.5	91.0	46.0	46.8	47.6
With NECSI Evaporator Fan Controller								
8	11/23-24	63	46.2	33.0	79.2	44.3	44.9	43.9
9	11/24-25	65	40.9	30.2	71.1	43.5	44.0	43.1
10	11/25-26	63	41.3	31.0	72.3	42.6	43.0	42.4
11	11/26-27	69	43.3	29.6	72.9	43.5	43.8	43.2
12	11/27-28	63	38.3	33.9	72.2	42.0	42.4	41.5
13	11/28-29	59	30.5	26.1	56.7	42.5	42.4	41.0
	average of days 9-12		41.0	31.2	72.1	42.9	43.3	42.5

*Average noon-5PM outside temp.