City and Borough of Sitka
PUBLIC WORKS
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MEMO

To:	Mayor McConnell and Assembly Jim Dinley, Administrator
From:	Michael Harmon, Public Works Director Gary Baugher, O&M Superintendent Chris Wilbur, Facilities Manager
CC:	Jay Sweeney, Finance Director
Date:	November 19, 2012
Subject:	MSC Refrigeration Controls project award

Per CBS Procurement Policy and Procedures, procurement of supplies and services, capital outlays, projects and fixed assets over $50,000 must be approved by the Department Head, Administrator and Assembly.

Background

The Marine Services Center (MSC) was built in 1991 to assist the two Seafood Processing plants in storing frozen product and shipping out as needed. The Refrigeration system in the MSC consists of two 125HP Compressors, one 100HP compressor, one 25HP Condenser, two ammonia pumps, one High Pressure Receiver, one Low Pressure Receiver and 6 unit coolers. This facility consumes an average of 1.2M kWh ($108,000) in electricity cost per year. About 85% of that energy is consumed by the refrigeration system.

Wyatt Refrigeration installed the original refrigeration equipment in the MSC in 1991. They have operated and maintained the system since 2002 and are intimately familiar with the specialized equipment and work involved in installing the Refrigeration controls. They have installed this type of control system in a number of cold storage facilities with great success, increasing energy savings with a payback as short as 1.5 years. We are recommending this contract be sole sourced to Wyatt Refrigeration as they are the refrigeration system specialists and can provide a seamless transition between the old system and the new controls while maintaining temperature in the cold room for approximately 3,000,000 lbs of product.

Financial Note

The proposed contract with Wyatt Refrigeration is $61,745. There is $83,000 in the MSC Capital Budget for this work. With a cost savings estimated at $14,300 per year (at $.09/kWh) the simple payback on this project is 4 years. The investment in this project produces a life cycle cost savings of $168,000 over 25 years.

Recommendation

Award project to Wyatt Refrigeration for $61,745. Account number: 770-600-630-5212.000 90724 2106

SCOPE OF WORK
MARINE SERVICES CENTER
INSTALLATION OF REFRIGERATION CONTROLS

The scope of work for this project is to install a fully integrated microprocessor based Logix (or equal) Refrigeration Control System, RCS, with Logix Clarity and Axiom Software for the intelligent operation, automation and monitoring of the equipment located at the Sitka Marine Services Center as described below. Contractors that wish to substitute an Or Equal controls system must have CBS approval of that substitution before bidding. If substitution is not approved bid will non compliant.

The system will be optimized (to reduce electrical energy consumption) and commissioned by the Contractor or Logix Controls subcontractor. The optimization and commissioning of the controls system will be demonstrated to the CBS Facilities Manager. CBS and Wyatt Refrigeration staff will be trained in the use of the system after commissioning. All labor and materials needed to accomplish this scope of work will be included in the bid. This Controls system is a turnkey operation.

Bidders shall have three successful installations of the specified system (or equal) within the last five (5) years. Provide references (name and phone number of owners) of these installations with your bid. Bids without three (3) references will be deemed non compliant.

The successful Bidder shall be responsible for the operation of the MSC refrigeration system while installation is ongoing. The refrigeration system will be turned off for the least amount of time practical to get the controls installed and operable. A schedule of the installation will be provided to CBS Facilities at least a month prior to commencing work. Comprehensive training of the CBS staff and Wyatt Refrigeration employee will be including in the schedule.

Submit 3 complete sets of documentation including: Equipment data cut sheets, system schematics including sequence of operation, point names and addresses wiring diagrams, panel layouts and riser diagrams and controls system shop drawings.

Upon project completion submit (2) copies Operations and Maintenance manuals consisting of Index sheet, equipment parts list, Auto-CAD disk of system schematics, description of sequence of operations, as built wiring diagrams, operators manuals, Logix Clarity software backup disk, list of connected data points including panels and input device to which they are connected, startup or testing reports and truck cable schematic showing panel locations and all trunk data.

The Logix® Refrigeration Control System shall accomplish the following:
Compressor / Engine Room
Item Logix Control Panel Axiom™ Software Equipment Monitoring / Control Description

A) **Booster Compressor Stager**: Stage a total of three (3) screw compressors on a common suction. One (1) compressor shall be controlled via manufacturer's third party data communications protocol (protocol supplied by others). Two (2) compressors shall be controlled via direct digital signals (motor starter, starter read back, load and unload solenoids) and 1K ohm pot slide position indication.

B) **Optimal Compressor Stager**: The most energy-efficient combination of available compressors necessary to maintain the current cooling load is continuously evaluated and automatically implemented while maintaining refrigeration system stability. The Optimal Stager strategy can dynamically handle the loss of a compressor due to malfunction or maintenance and does not rely on operator selection of the most efficient sequence of operation.

C) **Optimum Suction Pressure Control**: Floating suction pressure control allows the Compressor Stagers' suction pressure set-point to float higher when all associated cooling loads (e.g. evaporators) are satisfied and lower when demand increases. Each cooling load is evaluated for its cooling requirements using operator-adjustable set-points. Compressor energy is minimized as the stager suction pressure set-point gradually tracks changes in system load.

D) **Floating Condenser Pressure Control:** Using the ambient wet-bulb temperature approach for one (1) pump and one (1) Variable-speed fan, the **Floating Condenser Pressure Control** minimizes compressor horsepower by operating condenser water pumps and fans to maintain lowest condensing pressure allowable based on current ambient conditions and user-adjustable limits. An adjustable Low Limit condenser pressure set-point ensures adequate liquid pressure for other refrigeration equipment, while an operator adjustable Hot Gas Defrost pressure set-point to accommodates air unit defrosting.

E) Control liquid level on one (1) **Low Pressure Receiver** with an electronic level sensor, a HLS float, one (1) liquid feed solenoid, two (2) pumps with motor starter auxiliary contacts for failure detection and a pump discharge pressure transducer for cavitation detection and correction.

F) Provide **Engine Room Ammonia Detection** with one (1) 0-500ppm ammonia sensor. Run one (1) **Exhaust fan** upon leak detection.

G) Provide **Primary RCS Alarm/Failure indication** with three (3) 120 vac contacts (RCS Alarm, RCS Failure, RCS Operational) for field wiring to external customer-supplied strobe light/horn alarm annunciation device, fire or security alarm system.

H Monitor one (1) **Power Phase Loss** input (indication supplied by others).

I) Provide a **secondary Emergency Stop** input for field wiring to remote switch.

Temperature Zone Monitoring and Control

All Return Air temperatures have user-adjustable High and Low Alarm set points. Defrost operation and termination is set by user-defined time schedulers with manual override capability. Defrost may be optionally initiated by user-defined accumulated Liquid Feed runtime. Defrost operation may be "BLOCKED" during specified times of the day/days of the week. Limiting Maximum number of evaporators defrosting at any one time may be user-defined. All fans may cycle at operator request.

Item Logix Control Panel Axiom™ Software Equipment Monitoring / Control Description

J) **Freezer Evaporators**: Control three (3) Hot Gas defrost valve stations, each with four (4) solenoid valves and one (1) fan output per valve station. Cooling controlled by one (1) temperature sensor per valve station (3 total)

K) **Optimum Defrost Control**: Evaporator defrosts are major energy consumers in a refrigerated facility. A typical freezer requires roughly 3 minutes of compressor operation to remove defrost heat for every 2 minutes of evaporator defrost. It is therefore very desirable to both reduce the *length* of the defrost cycle and reduce the *frequency* of defrost cycles.
The frequency of defrost cycles can be reduced by intelligently initiating defrost cycles only when they are required. Simple time of day scheduling is inadequate as defrost requirements change greatly from season to season as well as from weekday to weekend and from product type to product type.
Therefore, multiple methods of defrost initiation are provided as follows:
1. Operator adjustable time accumulation (runtime) of the liquid feed solenoid valve.
2. Time of Day scheduling with a operator adjustable *minimum* time accumulation of the liquid feed solenoid valve.
3. Operator requested over-ride.

L) **Advanced Fan Cycling**: Almost *all* fan energy is placed into its cooling room in the form of heat. Typically, for every 2 fan horsepower, 1 compressor horsepower is required to remove the heat. Therefore, every 1 fan horsepower removed results in 1.5 total conserved horsepower. Each evaporator shall have the option to operate fans only during cooling periods or, remain in operation continuously. When the zone temperature is satisfied, the evaporator fans shall optionally stop after an operator adjustable time delay. After an operator adjustable time delay (45 minutes typical) the fan shall again energize to re-stir room air and thus prevent air stratification.

M) **Load Leveler™**: The Logix Air Unit Load Leveler™ routine coordinates air unit cooling demand to limit the random nature of simple thermostat-like operation. A conventional control system without a Load Leveler™ may, by pure chance, have nearly all air units cooling and, sometime later, nearly all air units satisfied (not cooling). The Logix Air Unit Load Leveler™ stabilizes evaporator loads so the entire refrigeration system operates with greater stability and lower kW demand without cooling performance compromise.

N) **Flexible Defrost Queue**: The operator can assign each evaporator to a one of ten (10) defrost queue groups (a queue is simply a waiting list, much like a line at a grocery checkout stand). All automatic evaporator defrost requests are managed by the Defrost Queue Manager. Any evaporator not assigned to a defrost queue group is allowed to defrost immediately upon request.

O) **Monitor** Room Temperature in Cold Room with two (2) temperature sensors.

P) Logix® **Clarity™** Software for two (2) Intel Pentium-class Windows XP computer location with the following features/capabilities:

1 **Two completely independent, operator-access networks** (PC Network, Dial-up Modem) ensure the control system can be accessed in the event of an onsite PC malfunction. Because Logix does not utilize remote PC access software such as "PC Anywhere", a Logix Control System is always accessible even if the on-site PC is disabled.

2 **Graphical User-Interface** displays current operating conditions of all controlled equipment and sensors using animation and color-coded on/off status and provide one-click links to setpoints and features. No special programming or computer operation skills are necessary.

3 **Trend Logging** records all system operating parameters at a user-adjustable interval and is saved to hard-disk daily (20-30 years storage is typical).

4 **Report Printing** of Trend Log Reports with optional automatic time of day/day of week printing feature. Reports may be **exported directly to Microsoft Excel**.

5 **Graphical Trend Log Plotting** provides visual analysis of up to eight (8) items on one plot.

6 **Maintenance Manager**: organizes and forecasts impending maintenance tasks based upon Runtime and Periodic time intervals. Creates works orders with description and check list, maintenance date, parts needed and personnel

assigned to the task. Includes a Maintenance History Log for recording all maintenance activity (useful for PSM).

7 **On-Line Operations Manual** instantly display on-screen "How to Use" information for all equipment set point and system features. Includes printable RCS documentation (wiring diagrams, channel assignments and system specification) and a hardware Troubleshooting section.

Q) **MODEM** communications for complete off-site control system access.

R) All digital outputs are **24VAC/120VAC capable.**

S) All Logix control panels are **UL listed** and conform to OSHA, electrical and other regulatory agency safety requirements.

T) **Fail-Safe wiring** design assures robust and accurate monitoring and control.

U) **Distributed control architecture** lowers RCS installation cost by reducing length of wiring runs. Equally suitable for centralized control system installation.

V) **Control Set point Scheduling** provides different equipment set point and lead-list parameters at different times of the day and days of the week. These set points can be user-configured to shift refrigeration electrical load to "**Off Peak**" utility rate periods or coordinate refrigeration operations with production schedules.

W) **Password Protection** provides multiple levels of access restriction to system operation and control.
A minimum of ten passwords are available for plant management authorization of control system operators. Clarity™ Access History records date, time, I.D. and authority level of all password protected operator accesses.

X) **Hand-Off-Auto switches** located inside every Logix® control panel on each digital output permit
manual operation of pumps, fans, valves and other switched equipment.

Y) **Modular "Building Block"** construction of the Logix® control system permits the flexibility to meet any site's requirements while accommodating integrated control of future equipment through simple modification or expansion to the RCS.
All Logix® control functions and parameters are accessed, monitored and modified through a display of menus and screens that easily facilitate data input and command execution. All information and commands are in straight-forward English and do not require any computer programming skills.
The **Logix® Clarity™ Software** includes a graphical user interface with icons, symbols, and buttons that permit a "point and shoot" selection of Clarity's features. The Clarity's design emphasis on ease-of-use, comprehensive data

logging, and flexible data management & reporting features greatly improve understanding of the refrigeration system and its efficient operation. These capabilities allow management to constantly detect problems or trends which need correcting. This continuous improvement enables owners to realize ongoing cost and quality improvements beyond the immediate savings provided by the Refrigeration Control System.

Z) **Automatic Alarm and Failure Dialing System** notifies personnel of a RCS alarm or failure through the use of both a pager service (service by others) and voice over phone. The dialer acts as a ***secondary refrigeration system alarm and failure notification system*** and should not be used in lieu of the primary **RCS Alarm**, **RCS Failure** and **RCS Operational** contacts intended for local on-site connection to UL-listed alarm annunciation devices such as strobe lights, horns, and fire or security alarm systems. The Automatic Dialing System allows personnel to acknowledge all alarms and failures from a Touch-tone phone.

The proposed Logix® RCS system includes the following:

Qty. Item

1 Intel-Pentium / 2.0GHz Computer with Windows XP Operating System, minimum 80 Gigabyte Hard disk, 256 Mb RAM, HP DeskJet Color printer, 19" VGA color monitor, CD-RW drive, optical mouse
2 Logix Clarity software for two Intel Pentium class Windows XP computers
1 Logix® Axiom UL® listed Control Panel in a powder-coated NEMA-4 enclosure
3 Pressure Transducers (1 Suction, 1 Condenser, 1 refrigerant pump discharge)
5 Air Temperature sensor (-50 - 125F, Precision Platinum RTD)
1 Combination Outside Air Temperature/Relative Humidity Sensor
1 Ammonia Sensors (Hansen Systems Electrochemical type)
1 LPR electronic level sensor
1 Ammonia Leak Alarm Strobe Light/Horn unit
1 56K baud MODEM for remote RCS access and control

Includes

1 One-year unlimited Normal-Business-Hours telephone support.

1 One-year Parts-only Warranty to replace components that fail due to faulty manufacture.

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Memorandum

February 19, 2010

to: **Chris Wilbur, Facilities Manager**

subject: **Wyatt Refrigeration Proposal**

project: **Marine Services Center Refrigeration Controls**

I have reviewed the proposal from Wyatt Refrigeration Co. to provide and install a Computer Control System at the Marine Services Center (MSC). I have also called Scott Wyatt of Wyatt Refrigeration to discuss the Control System, refrigeration system operation, control integration, and the projected energy savings.

For reasons outlined below, I recommend that the Control System be procured and installed. A revised proposal should be requested from Wyatt that includes the following requirements:

- Defrost Control: Provide a real-time sensor on each evaporator to monitor frost build-up and initiate defrost when needed, as well as run-time defrost scheduling.
- Sequencer: Provide lead/lag/standby operating sequences for the compressors. The sequencer should be capable of selecting different compressor configuration sequences depending upon time of year, outside temperatures, or other factors.
- Energy Savings Calculation: The calculated energy efficiency should be based on actual motor horsepower. In the calculations, the horsepower should be divided (not multiplied) by the motor efficiency to obtain energy (kWh) savings.
- The labor quote should specifically include on-site time for commissioning and optimization of the Control System to derive the greatest benefit from its installation. This work was in the original quote, but was not specifically listed as a deliverable. The quote should detail which features of the System are likely, at a minimum, to be incorporated into the controls.

Background

The MSC has three refrigeration compressors (two 125 HP and a 100HP), a rooftop condenser unit to reject heat, and 6 evaporators that absorb heat from the cold storage.

The facility consumes an average of 1,200,000 kWh per year in energy at an effective cost of 9¢ per kWh for an annual energy cost of $108,000. I estimate that 85% of the energy is consumed by the refrigeration system to cool the cold room. Annual electric data is attached.

As an aside, this level of heat rejection leads me to wonder if can be captured and used in a nearby facility?

Control System

Wyatt has installed the Logix Control System in an number of cold storage facilities with great success. The system has worked well, the energy savings has been substantial, and the payback has been as short as 1.5 years. Installing the system at the MSC will provide the capability to optimize cooling operations. The following are the primary opportunities:

- Cold Storage Temperature Control: Currently, the refrigeration system operates continuously and the temperature in the cold storage floats. Capacity is manually controlled but this control only occurs at most twice a day during operational checks. The Control System will control and modulate the compressor output based on room temperature and turn off evaporators in the cold room when the temperature is satisfied. Tighter control will result in energy savings.
- Defrost Control: The evaporators in the cold room are defrosting at set intervals based on a timer. This consumes energy to heat the evaporator coils as well as energy to transfer the defrost heat out of the cold room. The controller has the capability to initiate defrost based on actual evaporator run-times, rather than at set intervals. There is also an option for an optical sensor that monitors frost buildup on the evaporator coil and initiates defrost when needed. Optimizing defrost operation with this control will improve system efficiency.
- Compressor/Condenser Optimization: Currently, the compressors put out 130 psi gas to the rooftop condensers, year-round. This pressure ensures that the gas is hot enough so the heat can be rejected to outdoors. With Sitka's mild climate and cool winters, a lower discharge pressure would still provide amply heat rejection while reducing the energy consumption of the compressors. The Control System will control compressor discharge pressure, the condenser fan VFD and the circulation pump to optimize system operation to cool the cold room for lowest energy consumption.
- Night Cooling: The Control System is capable of being programmed to sub-cool the cold room at night so it requires less cooling during the day. This can reduce demand changes because the daytime peak load is likely to be lower.

The Control System has numerous other features, but these were the main opportunities for the MSC. It will be valuable to have Wyatt identify which features that anticipate being applicable to the MSC.

I was assured by Scott Wyatt that they have installed a number of these Control Systems, that they have a good track record, and that he will stand behind the system. I am also assured that he is motivated to optimize cooling system operation to minimize energy costs at the MSC.

Energy and Cost Analysis

I have reviewed and recalculated Wyatt's energy savings calculations. Scott based the energy savings on an average of 100 HP of compressor power. This is in close agreement with my calculated value of 101 HP which I derived from electric load data and equipment sizes.

I did discover a repetitive error where he converted from motor horsepower to electric load (kW) by multiplying by the motor efficiency rather dividing. I discussed the assumptions used in the calculations and, while I do not have direct experience to substantiate them, I feel he is comfortable that he has been reasonably conservative.

The following energy saving benefits were evaluated (calculation spreadsheet is attached):

Control Scheme	Annual Savings, kWh	Annual Savings, $
Floating Condenser Pressure Control [1]	94,000	$ 8,400
Evaporator Defrost Control [2]	19,000	1,700
Evaporator Fan Control [3]	46,000	4,100
Totals	156,000	$ 14,300

1. Based on Wyatt's estimate that condenser pressure can be reduced from 130 psig to 1110 psig year-round.
2. Based on Wyatt's estimate that evaporator defrost will be reduced 33% from current defrost time.
3. Based on Wyatt's estimate that the evaporator fan operation will reduced to 33% of the current continuous operation.

It is likely that the predicted energy savings is conservative because he did not include the savings associated with controlling the cooling system from a room thermostat and integrating control of the compressors, condensers, and evaporators. On-site commissioning and optimization as an essential component of this procurement is needed to ensure the maximum benefit from the system

The cost of the Control System is quoted at $56,000, which includes an automatic alarm dialer. The simple payback for the system is $56,000 / $14,300 = 3.9 years. This payback is reasonable short given the remaining service life of the refrigeration system and the facility.

On a life cycle cost basis—includes $1,000 annual control system monitoring and optimization and electric inflation of 1.5% per year—the investment provides a life cycle savings of $168,000 over 25-years. This has a savings to cost ratio of 2.3, which would make this a high priority ECO as part of an energy audit. Life cycle cost spreadsheet is attached.

Conclusion

The MSC refrigeration system is operating inefficiently due to a low level of control. Control technology has improved and matured to be a desirable and beneficial component of the refrigeration systems. Since Wyatt Refrigeration also maintains the refrigeration system, any complexity associated with the control system can be seamlessly incorporated into that contract. The anticipated energy savings is likely to provide a payback of less than four years on investment. It is recommended that a Refrigeration Control System be installed in the MSC.

by: [signature]

Jim Rehfeldt, P.E.

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Electric Use Data

February 19, 2010

Marine Services Center

ELECTRIC RATE

Sitka Electric General Schedule

Electricity Charge	$/kWh	Demand Charge	$/kW
0 to 500 kWh	$0.1417	0 to 25 kW	$0.00
501 to 10,000 kWh	$0.0903	Over 25 kW	$3.90
10,000 to 100,000 kWh	$0.0850	Tax Rate	0%
> 100,000 kWh	$0.0750	Customer Charge ($ / mo)	$21.25

ELECTRICAL CONSUMPTION AND DEMAND

Month	2006		2007		2008		2009		Average
	kWh	kW	kWh	kW	kWh	kW	kWh	kW	
Jan			82,800	144.0	95,520	146.4	93,360	148.8	271,680
Feb			89,280	146.4	84,480	146.4	90,240	165.6	264,000
Mar			88,560	158.4	90,480	160.8	91,200	163.2	270,240
Apr			93,120	163.2	113,280	165.6	108,480	165.6	314,880
May			97,200	153.6	94,080	168.0	96,240	156.0	287,520
Jun			93,600	153.6	109,440	172.8	110,400	163.2	313,440
Jul			112,560	175.2	113,760	168.0	101,040	180.0	327,360
Aug			107,520	182.4	115,920	180.0	103,680	180.0	327,120
Sep			104,160	180.0	113,520	175.2	113,280	172.8	330,960
Oct			104,880	165.6	94,800	165.6	92,880	168.0	292,560
Nov			83,760	153.6	94,800	156.0	83,520	141.6	262,080
Dec			68,640	165.6	99,360	148.8	90,480	141.6	258,480
Total			1,126,080		1,219,440		1,174,800		1,173,440
Average			93,840	162	101,620	163	97,900	162	97,787
Load Factor			79.4%		85.5%		82.7%		162

ELECTRIC BILLING DETAILS

Electrical costs are based on the current electric rates.

Month	2008				2009				% Change
	Energy	Demand	Cust & Tax	Total	Energy	Demand	Cust & Tax	Total	
Jan	$8,198	$473	$21	$8,693	$8,014	$483	$21	$8,518	-2.0%
Feb	$7,260	$473	$21	$7,754	$7,749	$548	$21	$8,319	7.3%
Mar	$7,770	$530	$21	$8,320	$7,831	$539	$21	$8,391	0.8%
Apr	$9,575	$548	$21	$10,144	$9,215	$548	$21	$9,784	-3.5%
May	$8,076	$558	$21	$8,654	$8,259	$511	$21	$8,791	1.6%
Jun	$9,287	$576	$21	$9,884	$9,359	$539	$21	$9,919	0.3%
Jul	$9,611	$558	$21	$10,190	$8,657	$605	$21	$9,282	-8.9%
Aug	$9,773	$605	$21	$10,398	$8,855	$605	$21	$9,480	-8.8%
Sep	$9,593	$586	$21	$10,200	$9,575	$576	$21	$10,172	-0.3%
Oct	$8,137	$548	$21	$8,706	$7,974	$558	$21	$8,552	-1.8%
Nov	$8,137	$511	$21	$8,669	$7,178	$455	$21	$7,654	-11.7%
Dec	$8,524	$483	$21	$9,028	$7,770	$455	$21	$8,245	-8.7%
Total	$ 103,938	$ 6,449	$ 255	$ 110,642	$ 100,434	$ 6,421	$ 255	$ 107,110	-3.2%
Average	$ 8,661	$ 537	$ 21	$ 9,220	$ 8,369	$ 535	$ 21	$ 8,926	-3.2%
Cost ($/kWh)				0.0907	94%	6%	0%	0.0912	0.5%

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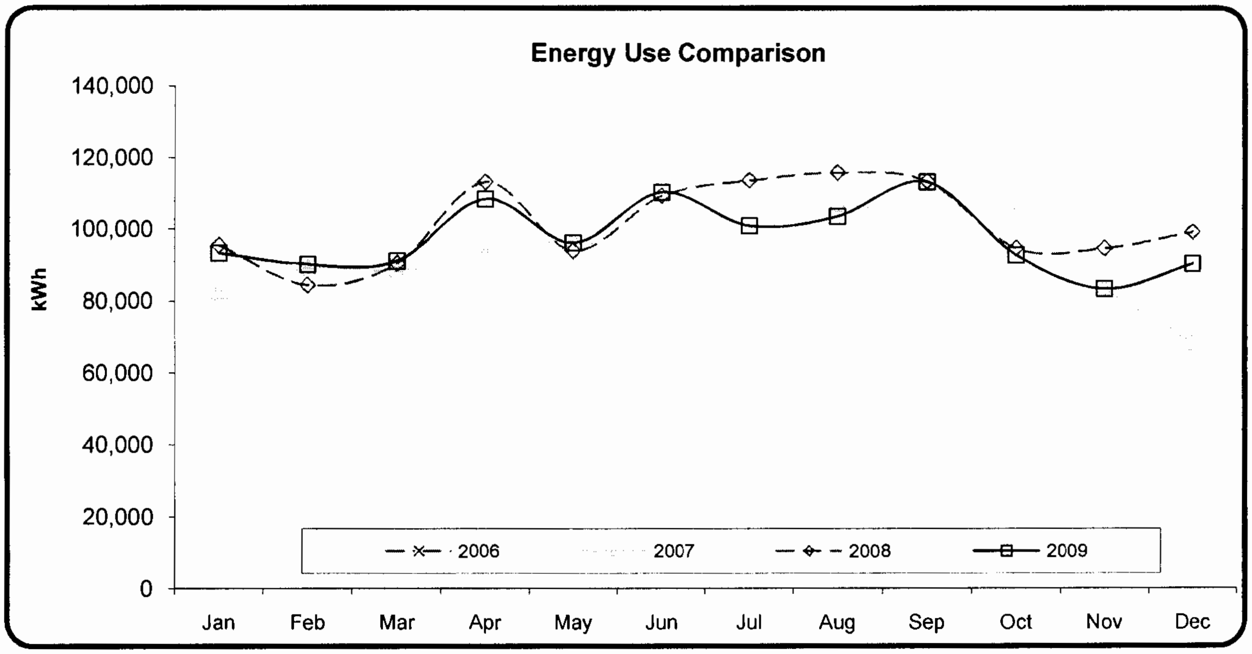
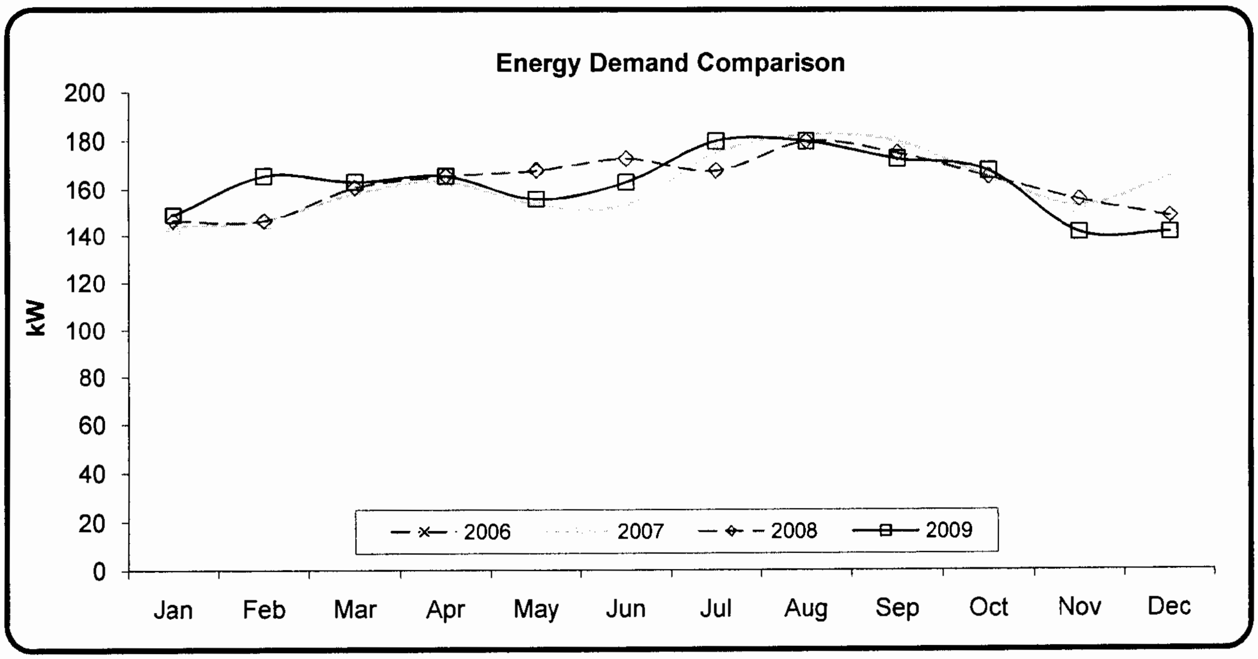
Marine Services Center





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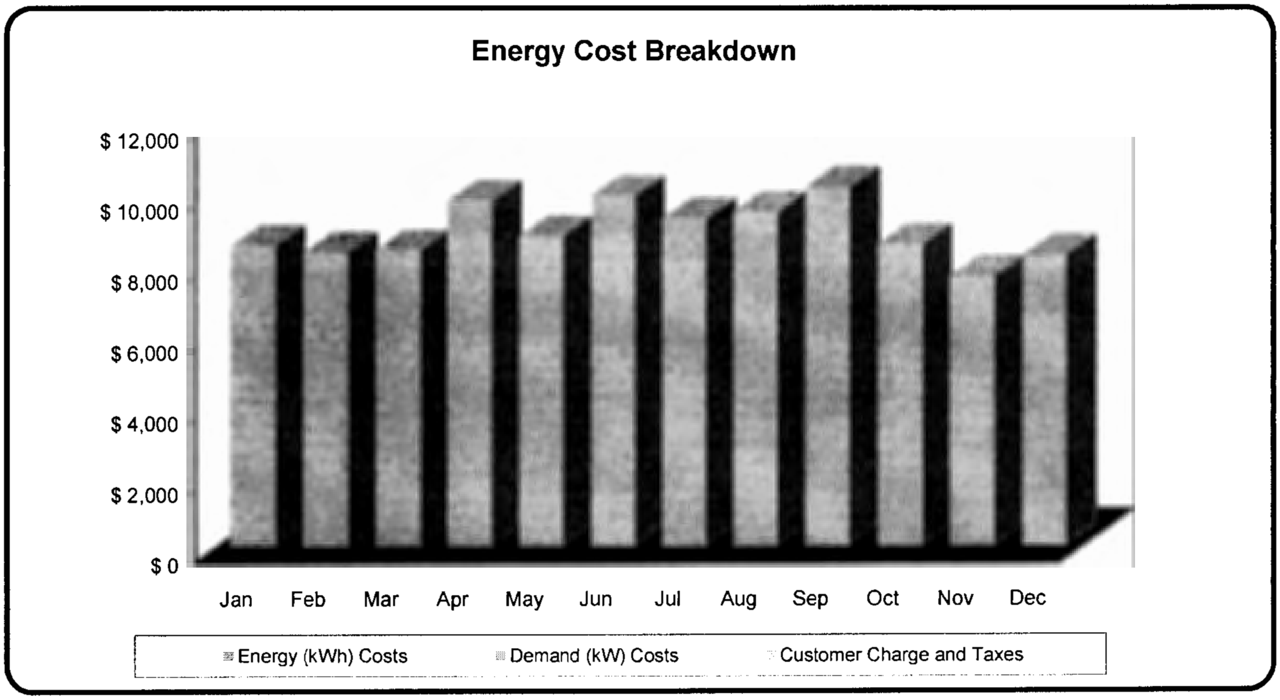
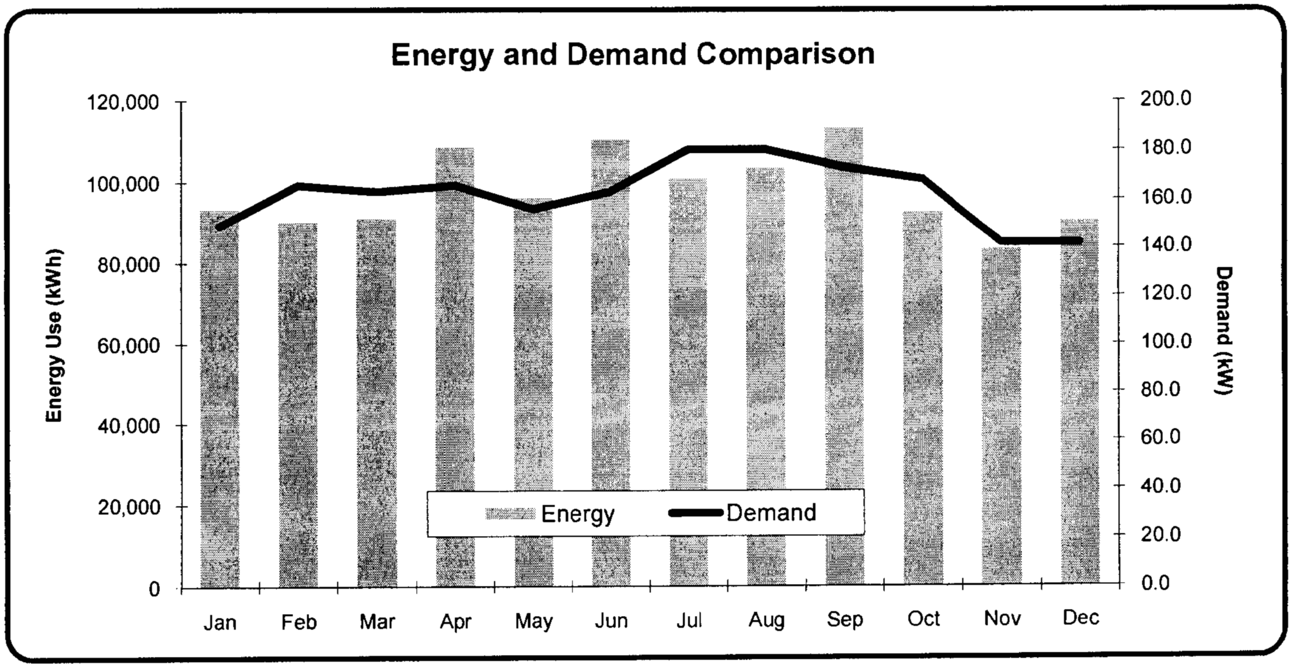
Annual Comparison
February 19, 2010

Marine Services Center





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CALCULATIONS
February 19, 2010

Marine Services Center

Control System Energy Savings

Baseline Energy Use

Total kWh	Refrig	Refrig kWh	Ave kW	Ave HP
1,170,000	85%	995,715	114	152

Electric Loads

Load, kW	Summer	Winter	Average
Peak kW	180	145	162
Lighting	20	20	20
Truck	17	17	17
Others	22	21	22
Refrig, kW	121	87	103
Refrig, HP	162	117	138

Refrigeration Loads

Equip	Summer, HP	Winter, HP	Average, HP	η, motor	Average, kW	Energy, kWh
Comp	125	100	101	94%	80	702,161
Cond	25	5	25	90%	21	181,527
Evap	12	12	12	70%	13	112,028
	162	117	138		114	995,715

1. Floating Condenser Pressure Control

P, exist	P, new	ΔP	% save / psi	% savings	
130	110	-20	0.667%	-13.3%	-93,668

2. Evaporator Defrost Control

kW	Hrs, day	Savings	
80	2	-33%	-19,309

3. Evaporator Fan Control

kW	Hrs, day	Savings	Refrig Effect	
13	22	-67%	1.5	-45,869

Savings	-16%	-158,847
	$/kWh	$0.09
	$	($14,296)

Cost	Materials	$38,070
	Dialer	$3,575
	Labor	$14,299
		$55,944

Payback 3.9 years

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Life Cycle Cost Analysis

February 19, 2010

Marine Services Center

Refrigeration Control System

Basis

25	Study Period (years)	3.0%	General Inflation
4.13%	Nominal Discount Rate	6.0%	Fuel Inflation
1.10%	Real Discount Rate	1.5%	Electricity Inflation

Construction Costs	Year	Qty	Unit	Base Cost	Year 0 Cost
Install and commission control system	0	1	ea	$65,000.00	$65,000
Project management	0			10%	$6,500
				Total Construction Costs	$71,500

Annual Costs	Years	Qty	Unit	Base Cost	Present Value
Annual Maintenance	1 - 25	1	LS	$1,000.00	$21,517
				Total Annual Costs	$21,500

Energy Costs	Years	Qty	Unit	Base Cost	Present Value
Fuel Oil	1 - 25				$0
Electricity	1 - 25	-159,000	kWh	$0.09	($260,838)
				Total Energy Costs	($260,800)

Present Worth	($167,800)