Fermilab

DZERO HVAC SYSTEM CONTROLS EVALUATION OF UPGRADE OPTIONS

ENGINEERING NOTE
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I. ABSTRACT

This engineering note documents three different options for upgrading the Dzero HVAC control system. All three options leave the current field hardware and field devices intact and upgrade the computer control hardware and software.

II. INTRODUCTION

Dzero will be heading into a physics run starting in 2000. This physics run could last several years. The Dzero HVAC system is an integral part of climate control and electronics cooling. The current HVAC control system is based upon a 1985 Johnson Controls System. In order to enter the next long-term physics run with a solid HVAC control system, the current control system needs to be upgraded for the following reasons.

- Some replacement parts are no longer available.
- System is critical to operation and gathering of physics data.
- System uses 1985 computer technology.
- The system is difficult, and understood by only a few people.
- Johnson Controls does not effectively support this system.
- The current shutdown at D-Zero provides a window of opportunity.
- The control system should be more user friendly, allowing better coverage by knowledgeable persons.
- The System should be more dynamic with 2 modes for AHU 1 & 2.
- There are a few systems on the North side of Dzero that could, and maybe should be added to a control system, such as, the WAMUS power supply, Dzero power monitoring equipment, instrument air compressor systems, etc.

This proposal investigates three options:

1. Replacement to the next generation of Johnson Controls Hardware and Software with the Johnson Controls operator interface. FESS
2. Replacement to the next generation of Johnson Controls Hardware and Software with the FIX32 Operator Interface. FESS/Dzero
3. Replacement with a commercially available Programmable Logic Controller (PLC) WITH THE FIX 32 Operator Interface. Dzero

III. FUNCTIONS OF THE DZERO HVAC SYSTEM

This system provides climate control for the majority of the D-Zero Assembly Bldg. The most important function is to provide temperature controlled water to electronics while maintaining a dew point in the area that is less than the water temperature. This function is critical to the operation of the D-Zero detector.

Functions of the current system. *Listed in order of importance.*

* = *Items critical to experiment performance*

* Provide 58 degree DCW to platform.
* Provide 57 degree DCW to MCH.
* Provide <57-degree water to MCH Liebert air conditioning units.
* Provide temperature controlled LCW to magnets and their Power Supplies.
* Provide controlled CHW temp via PW control to HX-1.
* Provide Collision Hall temp control via AHU-1.
* Provide Collision Hall temp control via Fan Coils-1 & 2.
* Provide trend logs of temperature & humidity.
* Provide Assembly Hall temp control via AHU-2.

Provide clean room temperature & humidity control via AHU-5

Provide rm. 109 & 209 temp control via AHU-4.

Provide rm. 309, 502, & 602 temp control via AHU-3.

Provide rm. 309, 502, & 602 temp control via heat pump water loop control.

Provide rm. 309, 502, & 602 temp control via pond water loop control.

	Acronym Key
DCW	De-ionized Chilled Water
MCH	Movable Counting House
LCW	Low Conductivity Water
CHW	Chilled Water
PW	Pond Water
AHU	Air Handler Unit

IV. **OPTION 1**- Replacement to the next generation of Johnson Controls Hardware and Software with the Johnson Controls operator interface. FESS.

A. Description

This option would allow FESS and Johnson Controls to install the next generation of Johnson Controls known as Metasys. The computer hardware and operator interface is all referred to as Metasys. The three Johnson Controls DSC's would be replaced while most of the field devices would remain intact. The new Johnson Control operator interface would be installed. The new Metasys operator interface would require it's own workstation, with some limited networking capabilities.

B. Budget

The Johnson Controls upgrade estimate is $227K. The estimate was produced by Al Schmitt and the FESS controls group. This budget figure includes all the engineering and programming time necessary to complete the job.

See Appendix B FESS COST SPREADSHEET.

C. Programming

FESS and Johnson Controls would be responsible for all programming. Dzero would have very little obligation here.

D. Advantages

- Requires the fewest of Dzero resources.
- FESS is responsible for future support.
- Uses typical lab HVAC support staff, FESS.

E. Disadvantages

- Cost, $227K.
- Future flexibility is questionable.
- Future Modifications done by outside people.
- Operator Interface not networked to operator view nodes.
- Outside Spares.
- No Remote control offered for Dzero personnel.
- Future upgrades just as costly.

F. Timetable

FESS believes that the entire project from engineering through bidding, to installation to operation could be accomplished by Oct 1, 1999.

G. Manpower

FESS has adequate manpower for the engineering, design and drafting. FESS would contract out all or parts of the installation, so manpower is not an issue.

V. **OPTION 2**- Replacement to the next generation of Johnson Controls Hardware and Software with the FIX32 Operator Interface. FESS/Dzero

A. Description

This option is essentially the same as option one with the difference being that Dzero would use the Fix 32 operator interface instead of the Metasys operator interface. The advantage to this is that Fix32 is used throughout the lab and has excellent networking capabilities. This would allow Dzero HVAC view screens to be displayed on any typical Fix32 view node. Fix32 nodes are currently located at the Dzero main control room, Dzero cryo control room, some Dzero offices, CDF, KTEV, PS1, PS4, CHL, etc. Fix32 is also Internet capable with live data.

B. Budget

The Johnson Controls upgrade estimate is $227K. The estimate was produced by Al Schmitt and the FESS controls group. This budget figure includes all the engineering and programming time necessary to complete the job. There would be some expense for the FIX32 operator interface, but that expense should be offset by the Metasys Operator interface savings.

See Appendix B FESS COST SPREADSHEET.

C. Programming

FESS and Johnson Controls would be responsible for all programming. Dzero would have about 2 MM of graphics, database, and general configuration work.

D. Advantages

- Most effort is outside of Dzero.
- Common operator interface with other process control systems.

E. Disadvantages

- Cost, $227K.
- Install and use a new I/O driver for FIX32 to Johnson Controls.
- Will require some minor Dzero resources.
- Future flexibility is questionable.
- Most Future Modifications done by outside people.
- Some Outside Spares.
- Future upgrades just as costly.

F. Timetable

FESS believes that the entire project from engineering through bidding, to installation to operation could be accomplished by Oct 1, 1999. Dzero could easily meet the Oct 1, 1999 date for its part of this option's installation.

G. Manpower

FESS has adequate manpower for the engineering, design and drafting. FESS would contract out all or parts of the installation, so manpower is not an issue.

Dzero would have to provide some manpower for the operator interface programming, graphics design and I/O driver research.

Dzero's share of the manpower:

Engineering	.2MM/DSC x 3 DSC = .6MM
Programming	.5MM/DSC x 3 DSC = 1.5MM

VI. **OPTION 3**-Replacement with a commercially available Programmable Logic Controller (PLC) with the FIX 32 Operator Interface. The chosen PLC is a Siemens TI545. Dzero

A. Description

Dzero personnel would replace the three Johnson Controls DSC's with one Siemens TI545 PLC and three remote bases. One remote base would be in the immediate area of each current DSC. The field wiring and devices would stay in place.

The PLC under consideration is a Siemens product and is used throughout DZero for Cryo/Gas System controls, Solenoid DC Circuit controls, and at other Fermilab locations including KTEV.

B. Budget

DSCII was accurately accounted for since it will be the first DSC replaced. DSCI and DSCIII were estimated, they should closely approximate DSCII in I/O points.

	QTY	DESCRIPTION	MODEL #	COST		
PLC (Central Processor)						
	1	545-1101 PLC	545-1101		0.00	
	1	16 SLOT BASE	505-6516	575.20	575.20	
	1	BASE PS	505-6660	362.40	362.40	
	1	ETHERNET MODULE	505-CP2572	2870.00	2870.00	
	1	4 PORT COM MODULE			0.00	
	1	PENTIUM COMPUTER		2000.00	2000.00	
	1	21' MONITOR		1500.00	1500.00	
	1	FIX32 SCADA		10000.00	10000.00	
	1	MISC CABLE/CONNECTORS		1000.00	1000.00	
	1	POWER SUPPLIES		300.00	300.00	
	1	FESS Engineering and Consultation		5000	5000	
	1	UPS		2000.00	2000.00	25607.40
DSC I		SUBTOTAL ESTIMATED				11776.50
DSC II	1	16 SLOT BASE	505-6516	575.20	575.20	
	1	BASE PS	505-6660	362.40	362.40	
	3	8 PT ANALOG INPUT MODULE	505-6108A	575.2	1725.60	
	3	8 PT RTD INPUT MODULE	505-7038	1300.00	3900.00	
	1	8 PT ANALOG OUTPUT MODULE	505-6208A	1130.4	1130.40	
	1	16 PT DISCRETE INPUT MODULE	505-4316-A	358.40	358.40	
	2	16 PT DISCRETE OUTPUT MODULE	2591	799.00	1598.00	
	1	8 PT RELAY OUTPUT	505-4908	277.60	277.60	
	1	UPS		1000.00	1000.00	
	1	REMOTE BASE CONTROLLER	505-6851-A	848.80	848.80	11776.40
DSC III		SUBTOTAL ESTIMATED				11776.40
					TOTAL	60936.80

C. Programming

Dzero Personnel would do all the programming with consultation from FESS engineering. Dzero Personnel would also complete all graphics, communication setups, historical trending, and security.

D. Advantages

- Cost $60K + Dzero in house Engineering and Technicians.
- Upgrades would be naturally done with other similar systems.
- It would be part of a larger control system, processes viewed and controlled from any view node.
- In house expertise for modifications and troubleshooting.
- Complete networking capability including Internet WebPages.

E. Disadvantages

- Will use significant Dzero personnel resources.
- Deviates from normal lab FESS controls.

F. Timetable

There are 3 Johnson Controllers at Dzero, DSCI, DSCII, and DSCIII. DSCII would be completed by Oct 1, 1998. DSCI and DSCIII would be completed by Oct 1, 1999.

G. Manpower

Option 3's manpower will come primarily from the Dzero staff. This manpower is not accounted for in the budget for option 3, however there is $5k in the budget for FESS consultation expenses.

Dzero manpower breakdown for HVAC control upgrade:

Engineering	1MM/DSC x 3 DSC = 3MM
Technician	1MM/DSC x 3 DSC = 3MM
Programming	1MM/DSC x 3 DSC = 3MM
Shakedown and Calibration	.5MM/DSC x 3 DSC = 1.5MM

VII. SUMMARY TABLE

Option #	Cost	Pros	Cons
1 Johnson Controls Hardware Johnson Controls Interface FESS installation	$227K No Dzero Time	No Dzero Resources FESS Support	Cost Future Modifications Local Operations Out of House Support Out of House Spares
2 Johnson Controls Hardware FIX32 Interface FESS/Dzero Installation	$227K Little Dzero Time	Little Dzero Resources Distributed Operations Some In House Support	Cost Future Modifications Test New Drivers Some Out of House Support
3 Siemens PLC Hardware FIX32 Interface Dzero Installation	$61K 10.5 MM Dzero	Cost Future Modifications Distributed Operations In House Support Common Spares Automatic Upgrades	Significant Dzero Resources

VIII. CONCLUSION

We believe that option #3 has the most favorable advantages with the most tolerable disadvantages. The Dzero HVAC system would benefit from having a commercial control system that has the same advantages as other Dzero systems using the same commercial controls. Clearly though, there are several questions which the Dzero management should consider.

The first question is, can an experiment install and maintain it's own environmental controls? This work is typically, but not always, performed by FESS. It is somewhat uncommon, but not unprecedented, for an experiment or building to install and maintain it's own environmental controls. It's possible that there are enough advantages for Dzero, including cost, that may justify this investment by Dzero.

The second question is can Dzero commit the personnel resources needed to complete this effort, namely the 10.5 MM of Dzero personnel? It's possible that given the long timeframe (over one year), that it could be worked into key personnel's schedule, with the proper support.

Appendix A TABLE OF ABRIEVIATIONS

PLC	Programmable Logic Controller
DSC	Digital System Controller
HVAC	Heating, Ventilation and Air Conditioning
DCW	De-ionized Chilled Water
MCH	Movable Counting House
LCW	Low Conductivity Water
CHW	Chilled Water
PW	Pond Water
MM	Man Months
AHU	Air Handler Unit
EF	Exhaust Fan
FESS	Facilities Engineering Support Services
AH	Assembly Hall
CH	Collision Hall
TA	Technician Areas
CR	Counting Room
CLR	Clean Room

Appendix B FESS COST SPREADSHEET

D-0 DDC Conversion to Metasys

Estimate ($000)

System	Material Cost	Electrical Installation	Technician Cost	Engineer Cost	Total
Network Hub	$5		$2	$1	$8
AHU-1 AHU-2 AHU-3 AHU-4 FC-1 FC-2	12		9	2	23
AHU-5	3		2	0	6
LCW PW CHW RW GCHW	9		5	1	15
Heat Pumps CONTROLLERS	8	1	17	9	36
Workstation	10			2	11
Wiring & Tubing	4	15		1	20
Engineering Coordination Commissioning	2		23	38	62
TOTAL	$52	$16	$59	$54	**$182**

Contingency (~25%) 45

TOTAL $227 K

Description	Part Number	List Price	Fermilab Cost	Quantity	Material Lab Cost	Technician Time	Engineer Time	Labor Lab Cost	Total Lab Cost
Network Control Module	NU-NCM350-1	$6,000.00	$2,565.00	1	$2,565.00	2	4	$294.00	$2,859.00
Memory - 4mb x 9bits - 30pin, 70ns SIMM		$50.00	$50.00	2	$100.00		0.5	$49.00	$149.00
Enclosure	EN-EWC22-0	$298.00	$127.40	1	$127.40	4		$196.00	$323.40
Network Card - TC6242 Thom	NU-NET101-0	$420.00	$179.55	1	$179.55		1	$49.00	$228.55
Surge Suppresser - Transtect	ACP100BW3R	$220.00	$114.40	1	$114.40	1		$49.00	$163.40
Fiber Optic IHX Card	IHX	$625.00	$625.00	1	$625.00	4	0.5	$220.50	$845.50
Network Connection				1		16		$784.00	$784.00
Demolition				1		16		$784.00	$784.00
Misc.			$1,000.00	1	$1,000.00		8	$392.00	$1,392.00
Total NCM Parts:					$4,711.35	43	14	$2,817.50	$7,528.85
AHU-1-4, FC-1/2 Unit Parts:									
DX Controller	DX-9100-8454	$1,512.00	$646.38	5	$3,231.90	0.5	0.5	$245.00	$3,476.90
Mounting Base	DX-9100-8990	$177.00	$75.67	5	$378.34	0.5		$122.50	$500.84
Wiring Protect Kit	DX-9100-8991	$14.00	$5.99	5	$29.93	0.1		$24.50	$54.43
Extension Module	XT-9100-8204	$247.00	$105.59	0	$0.00	0.5	0.1	$0.00	$0.00
Expansion Module 6AI, 2AO	XP-9102-8204	$283.00	$120.98	0	$0.00	0.5		$0.00	$0.00
Expansion Module 4DI, 4DO	XP-9104-8004	$167.00	$71.39	0	$0.00	0.5		$0.00	$0.00
Unitary Controller,6BO,2AO	AS-UNT111-1	$532.00	$227.43	1	$227.43	2	0.5	$122.50	$349.93
Temp/Humidity Sensor - OA	Triad HD-3-2-1000	$467.60	$467.60	1	$467.60	2	0.1	$102.90	$570.50
Duct Temp/Humidity sensor	HMD 40Y - Vaisala	$250.00	$250.00	4	$1,000.00	2	0.1	$411.60	$1,411.60
Analog Actuator Board	R81GAA-2	$208.03	$88.93	11	$978.26	2	0.1	$1,131.90	$2,110.16
Triac Replacement board		$300.00	$300.00	1	$300.00	2	0.1	$102.90	$402.90
I/P Module	EP-8000-2	$246.40	$105.34	11	$1,158.70	2	0.1	$1,131.90	$2,290.60
Transformer 24VAC 40VA	Y65AS-1C	$37.14	$15.88	5	$79.39	2		$490.00	$569.39
Power Supply	Sola SLS-24-012	$41.82	$41.82	5	$209.10	2		$490.00	$699.10
Enclosure - 30"x42"	M-8101-3042	$703.12	$300.58	5	$1,502.92	4		$980.00	$2,482.92
Relays		$25.00	$25.00	25	$625.00	1		$1,225.00	$1,850.00
Surge Suppresser - Transtect	ACP100BW3R	$220.00	$114.40	5	$572.00	1		$245.00	$817.00
Demolition				5		12		$2,940.00	$2,940.00
Misc.			$200.00	5	$1,000.00		8	$1,960.00	$2,960.00
Total AHU-1-4, FC-1/2 Unit Parts:					$11,760.56			$11,725.70	$23,486.26
AHU-5 Unit Parts:									
DX Controller	DX-9100-8454	$1,512.00	$646.38	1	$646.38	0.5	0.5	$49.00	$695.38
Mounting Base	DX-9100-8990	$177.00	$75.67	1	$75.67	0.5		$24.50	$100.17
Wiring Protect Kit	DX-9100-8991	$14.00	$5.99	1	$5.99	0.1		$4.90	$10.89
Unitary Controller,6BO,2AO	AS-UNT111-1	$532.00	$227.43	1	$227.43	2	0.5	$122.50	$349.93
Wall Temp/Humidity sensor	HMD 40W - Vaisala	$250.00	$250.00	2	$500.00	2	0.1	$205.80	$705.80
Duct Temp/Humidity sensor	HMD 40Y - Vaisala	$250.00	$250.00	2	$500.00	2	0.1	$205.80	$705.80
Analog Actuator Board	R81GAA-2	$208.03	$88.93	2	$177.87	2	0.1	$205.80	$383.67
Triac Replacement board		$300.00	$300.00	1	$300.00	2	0.1	$102.90	$402.90
I/P Module	EP-8000-2	$246.40	$105.34	3	$316.01	2	0.1	$308.70	$624.71
Transformer 24VAC 40VA	Y65AS-1C	$37.14	$15.88	1	$15.88	2		$98.00	$113.88
Power Supply	Sola SLS-24-012	$41.82	$41.82	1	$41.82	2		$98.00	$139.82
Enclosure - 24"x30"	M-8101-2430	$453.24	$193.76	1	$193.76	4		$196.00	$389.76
Relays		$25.00	$25.00	3	$75.00	1		$147.00	$222.00

Description	Part Number	List Price	Fermilab Cost	Quantity	Material Lab Cost	Technician Time	Engineer Time	Labor Lab Cost	Total Lab Cost
Surge Suppresse - Transtectc	ACP100BW3R	$220.00	$114.40	1	$114.40	1		$49.00	$163.40
Demolition				1		12		$588.00	$588.00
Misc.			$200.00	1	$200.00		8	$392.00	$592.00
Total AHU-5 Unit Parts:					$3,390.19			$2,797.90	$6,188.09
LCW,PW,CHW,RW,GCHW Unit Parts:									
DX Controller	DX-9100-8454	$1,512.00	$646.38	3	$1,939.14	0.5	0.5	$147.00	$2,086.14
Mounting Base	DX-9100-8990	$177.00	$75.67	3	$227.00	0.5		$73.50	$300.50
Wiring Protect Kit	DX-9100-8991	$14.00	$5.99	3	$17.96	0.1		$14.70	$32.66
Unitary Controller,6BO,2AO	AS-UNT111-1	$532.00	$227.43	1	$227.43	2	0.5	$122.50	$349.93
Analog Actuator Board	R81GAA-2	$208.03	$88.93	0	$0.00	2	0.1	$0.00	$0.00
Positioner I/P upgrade	Bailey	$300.00	$300.00	2	$600.00	2	0.1	$205.80	$805.80
Triac Replacement board		$300.00	$300.00	12	$3,600.00	2	0.1	$1,234.80	$4,834.80
I/P Module	EP-8000-2	$246.40	$105.34	2	$210.67	2	0.1	$205.80	$416.47
Transformer 24VAC 40VA	Y65AS-1C	$37.14	$15.88	3	$47.63	2		$294.00	$341.63
Power Supply	Sola SLS-24-012	$41.82	$41.82	3	$125.46	2		$294.00	$419.46
Enclosure - 24"x30"	M-8101-2430	$453.24	$193.76	3	$581.28	4		$588.00	$1,169.28
Relays		$25.00	$25.00	7	$175.00	1		$343.00	$518.00
Surge Suppresse - Transtectc	ACP100BW3R	$220.00	$114.40	3	$343.20	1		$147.00	$490.20
Demolition				3		12		$1,764.00	$1,764.00
Misc.			$200.00	3	$600.00		8	$1,176.00	$1,776.00
Total LCW,PW,CHW,RW,GCHW Unit Parts:					$8,694.77			$6,610.10	$15,304.87
Heat Pump Unit Parts:									
Integrator	AS-MIG202-0	$4,800.00	$2,052.00	1	$2,052.00	2	4	$294.00	$2,346.00
Enclosure - 24"x30"	M-8101-2430	$453.24	$193.76	1	$193.76	4		$196.00	$389.76
Transformer 24VAC 40VA	Y65AS-1C	$37.14	$15.88	1	$15.88	2		$98.00	$113.88
Programming				20			3	$2,940.00	$2,940.00
Repeater	Y500A-1	$500.00	$213.75	1	$213.75	2		$98.00	$311.75
JC Technician Time	Per Hour	$95.00	$95.00	24	$2,280.00		4	$196.00	$2,476.00
Surge Suppresser - Transtect	ACP100BW3R	$220.00	$114.40	1	$114.40	1		$49.00	$163.40
Misc.			$1,000.00	1	$1,000.00		8	$392.00	$1,392.00
Total Heat Pump Unit Parts:					$5,869.79			$4,263.00	$10,132.79
Workstation Parts:									
Computer - PC, Win95		$2,000.00	$2,000.00	1	$2,000.00		16	$784.00	$2,784.00
Monitor - 15"		$500.00	$500.00	1	$500.00		1	$49.00	$549.00
Network Card - TC6242 Thomas	NU-NET101-0	$420.00	$179.55	1	$179.55		2	$98.00	$277.55
PMI - Workstation Software	WS-SWOPMI-0		$3,591.00	1	$3,591.00		1	$49.00	$3,640.00
GPL - Programming Language	WS-SWOGPL-0		$2,821.50	1	$2,821.50		1	$49.00	$2,870.50
HVACPro Controller Programmi	WS-WINPRO-0	$500.00	$213.75	1	$213.75		1	$49.00	$262.75
Demolition				1			4	$196.00	$196.00
Misc.			$500.00	1	$500.00		8	$392.00	$892.00
Total Workstation Parts:					$9,805.80			$1,666.00	$11,471.80
Design				12			8	$4,704.00	$4,704.00
Drawings				12			16	$9,408.00	$9,408.00

Description	Part Number	List Price	Fermilab Cost	Quantity	Material Lab Cost	Technician Time	Engineer Time	Labor Lab Cost	Total Lab Cost
Demolition - Panels				3		24		$3,528.00	$3,528.00
Programming				12			24	$14,112.00	$14,112.00
Terminations				500		0.5		$12,250.00	$12,250.00
Fiber Optic Terminations		$26.25	$26.25	8	$210.00	1		$392.00	$602.00
Project Coord ,Checkout, and Debug				1		80		$3,920.00	$3,920.00
Testing & Commissioning				1		60	60	$5,880.00	$5,880.00
Graphics				13			6	$3,822.00	$3,822.00
Training				1			40	$1,960.00	$1,960.00
Misc.			$1,000.00	1	$1,000.00		16	$784.00	$1,784.00
Power Cable - #12/2	(in feet)		$0.05	500	$31.25	$0.34		$255.00	$286.25
Control Cable - #18/2	(in feet)		$0.16	3000	$600.00	$0.50		$2,250.00	$2,850.00
N1 Cable - RG-62	(in feet)		$0.18	500	$112.50	$0.57		$427.50	$540.00
N2 Cable - #14/3	(in feet)		$0.23	1000	$287.50	$0.56		$840.00	$1,127.50
Conduit - 1/2" EMT	(in feet)		$0.67	500	$418.75	$3.60		$2,700.00	$3,118.75
Copper Pneumatic Tubing - 1/	(in feet)		$0.89	0	$0.00	$5.48		$0.00	$0.00
Poly Tubing	(in feet)		$0.70	1000	$875.00	$3.82		$5,730.00	$6,605.00
Misc.			$500.00	1	$500.00		16	$784.00	$1,284.00
TOTALS					$48,267.45			$103,626.70	$151,894.15
				Not on Pre-Purchased Material ---->				OH&P (25%):	$3,952.88
								Subtotal:	$155,847.03
FESS Hours:	2307	58%	$20,291.41					Contingency (25%):	$38,961.76
Construction Cost:	$81,753.54							TOTAL:	$194,808.79
	Above values include contingency								
						T&M	Time $	hrs	weeks
							19066.41	454	11.35
Replace C260A for New UNT's									
Heat Pump Unit Parts:									
UNT Controller	AS-UNT111-1	$532.00	$227.43	20	$4,548.60	4	4	$7,840.00	$12,388.60
Enclosure - 24"x30"	AS-ENC100-0	$63.00	$26.93	20	$538.65	1		$980.00	$1,518.65
Transformer 24VAC 40VA	Y65AS-1C	$37.14	$15.88	20	$317.55	2		$1,960.00	$2,277.55
Metastat (replace old sensor	TE-6400	$63.00	$26.93	20	$538.65	3	0.5	$3,430.00	$3,968.65
Programming				20			4	$3,920.00	$3,920.00
Terminations				200		0.25		$2,450.00	$2,450.00
Demo C260A		$50.00	$50.00	20	$1,000.00	4		$3,920.00	$4,920.00
N2 Cable - #14/3	(in feet)		$0.23	1000	$287.50	$0.56	$560.00	$840.00	$1,127.50
Misc		$50.00	$50.00	20	$1,000.00	1	1	$1,960.00	$2,960.00
Total Heat Pump Unit Parts:					$8,230.95			$27,300.00	$35,530.95
								Integrator HP Price:	$10,132.79
								TOTAL DIFFERENCE:	$25,398.16
				Not on Pre-Purchased Material ---->				OH&P (25%):	$281.88
								Subtotal:	$25,680.03
								Contingency (25%):	$6,420.01
								TOTAL HP PRICE:	$32,100.04
								FINAL JOB COST:	$226,908.83