

# On Balance: *Heat Rejection Control* a Packaged Solution

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Echelon Americas  
Channel Partner Conference  
March 11, 2005

Presented by  
Doug Scott  
VaCom Technologies  
La Verne, California

# Opportunity

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An integrated packaged control with:

- Broad applicability
- Value to end users
- Value to integrators
- Open systems benefits

# Description

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One-box integration of:

- Variable speed drives
- Bypass controls
- Controller
- User interface
- Energy efficiency
- Communications



# Application

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Any type of heat rejection to ambient:

- Air-cooled condensers
- Evaporative-cooled condensers
- Fluid coolers (evap or air-cooled)
- Cooling towers

# Value to Owners

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- Lower installed cost
- Lower operating costs
- Reliability
- Serviceability
- Easier life-cycle cost maintenance

# Value to Integrators

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- Higher delivered value to owner
  - Differentiation with life cycle cost
- Save cost and time vs. custom build
- New business
  - Retrofit previous projects
  - First opportunity for new customers
  - Leverage utility incentives

# Add to Open Systems Value

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- Subsystem control example:
  - Integrate subsystem elements
  - Built-in energy efficiency optimization
  - Push intelligence closer to end-use
- Information = service opportunity
  - Manufacturers monitor during warranty
  - Third party service and monitoring
- Flexibility: integrate now or later

# Energy Background

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## □ Concepts

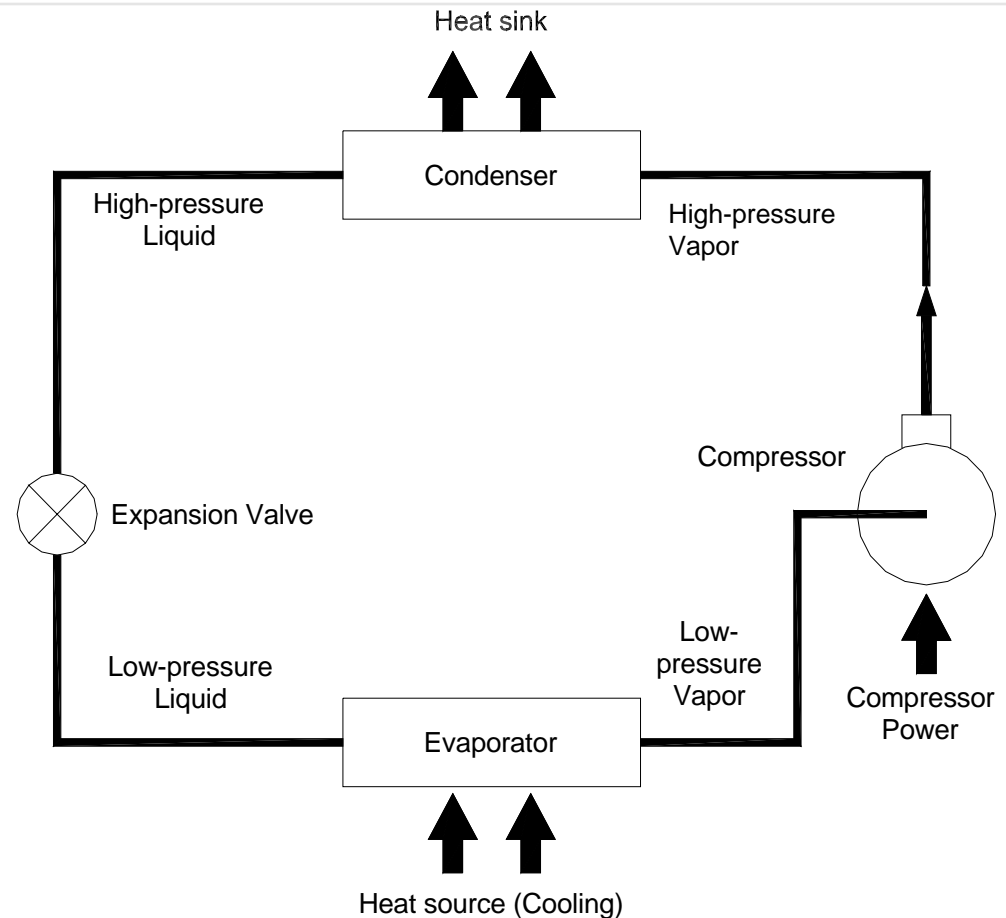
- Vapor compression cycle
- Lift and floating head pressure
- Variable speed – affinity laws
- System balance



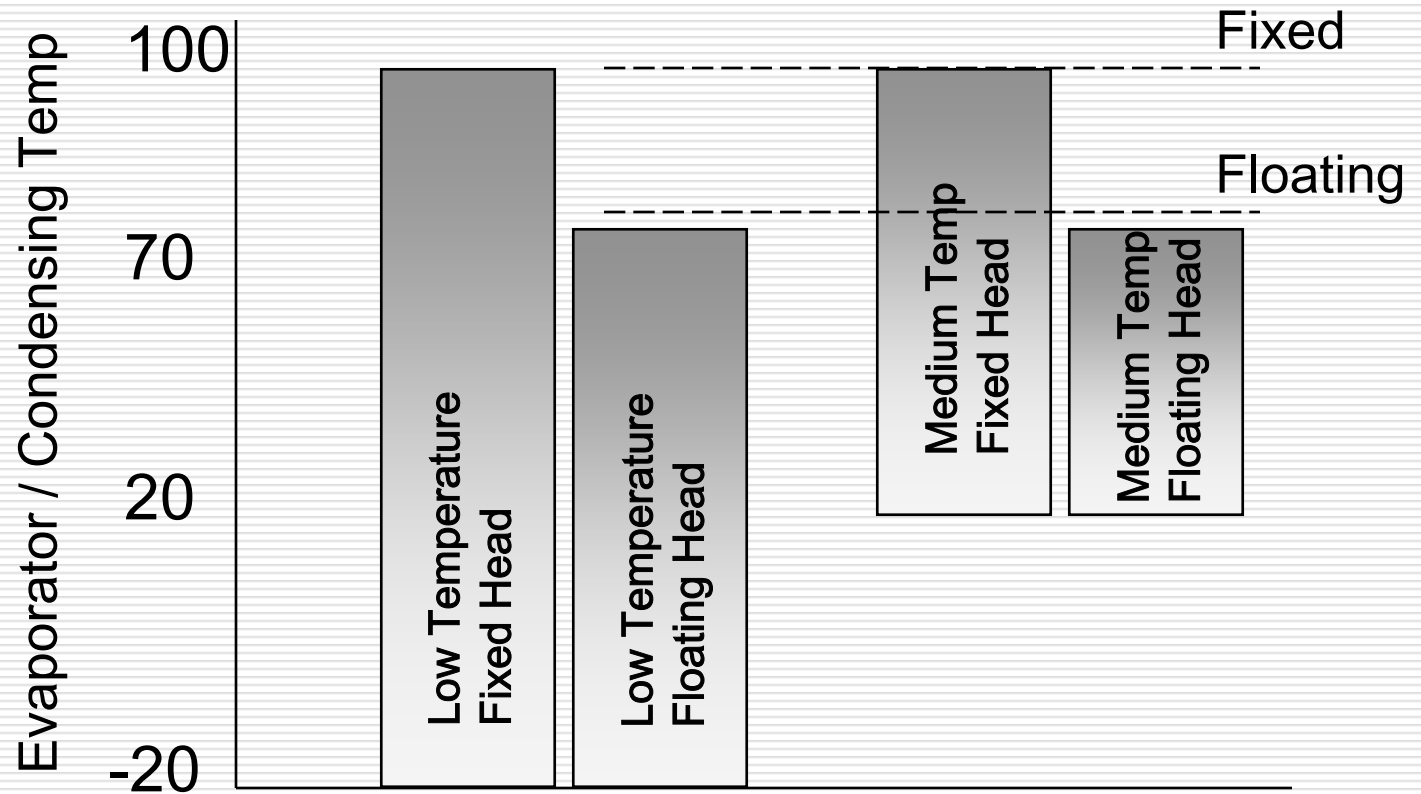
# Vapor Compression Cycle

## *BASIC CONCEPTS*

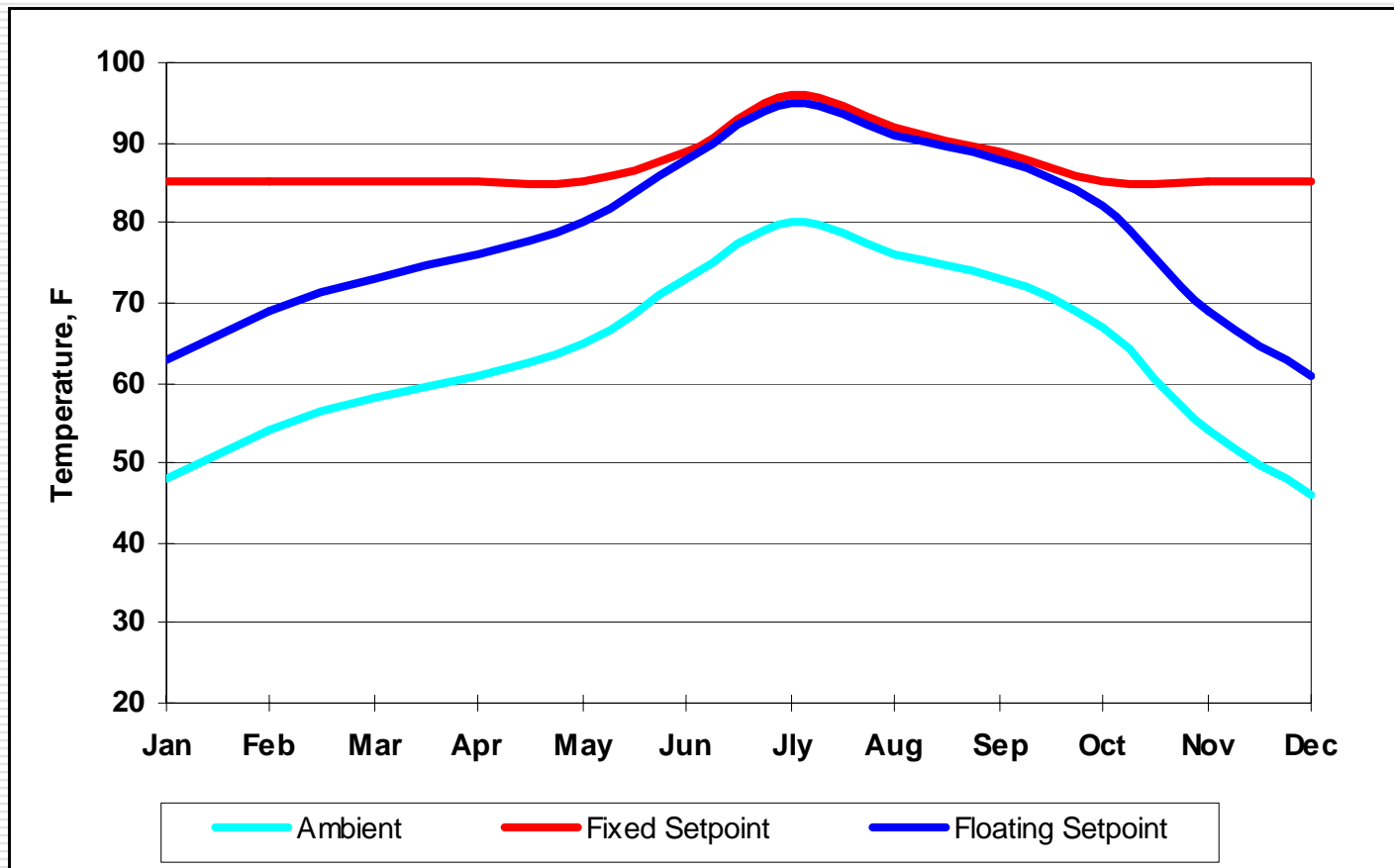
- Energy is conserved -- energy in equals energy out.
- Compressor pumps vapor; refrigerant has the cooling effect:  $\text{Lb/Hr} \times \text{BTU/Lb} = \text{BTU/Hr}$



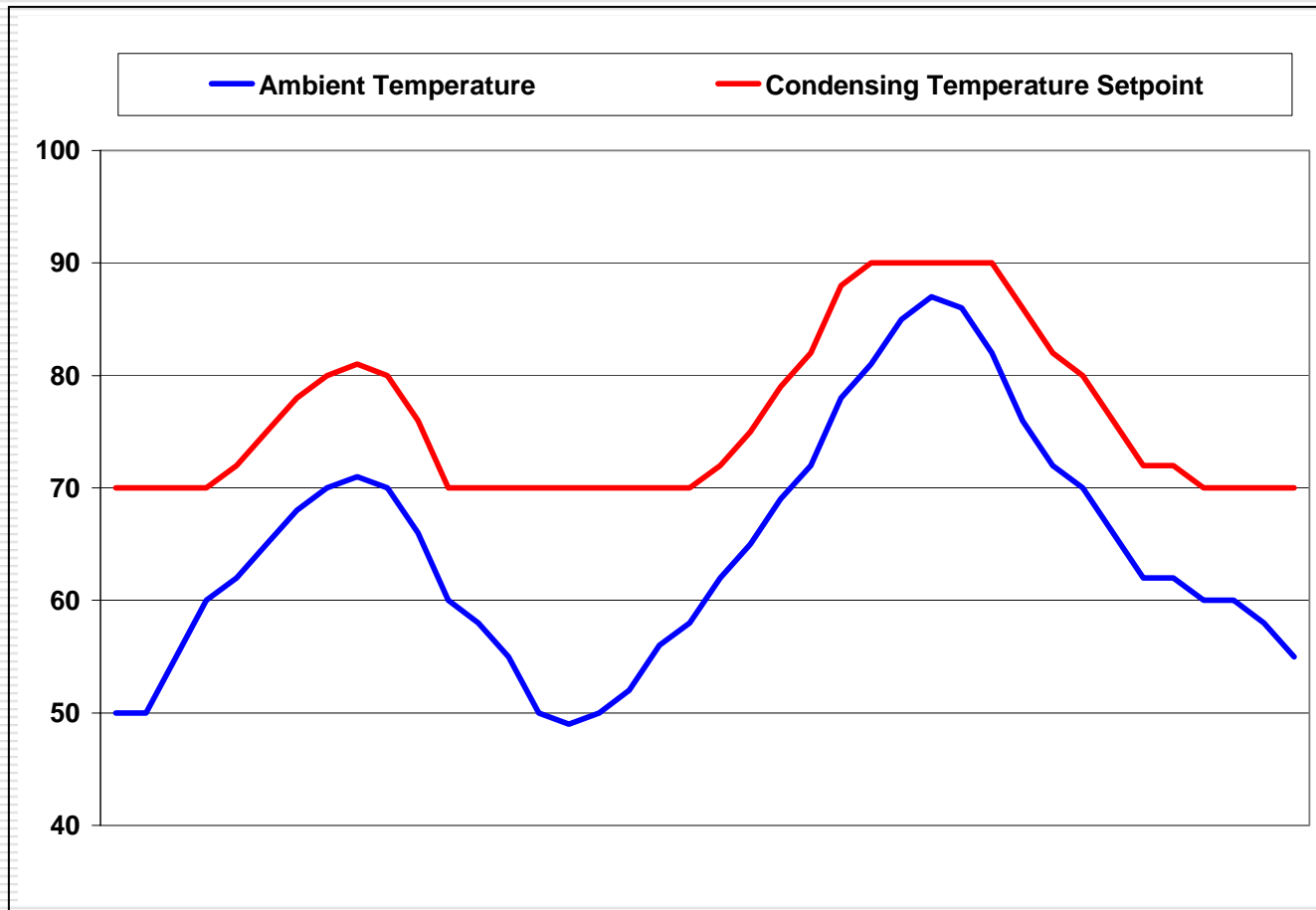
# Cooling System "Lift"



# Fixed vs. Floating Head Pressure

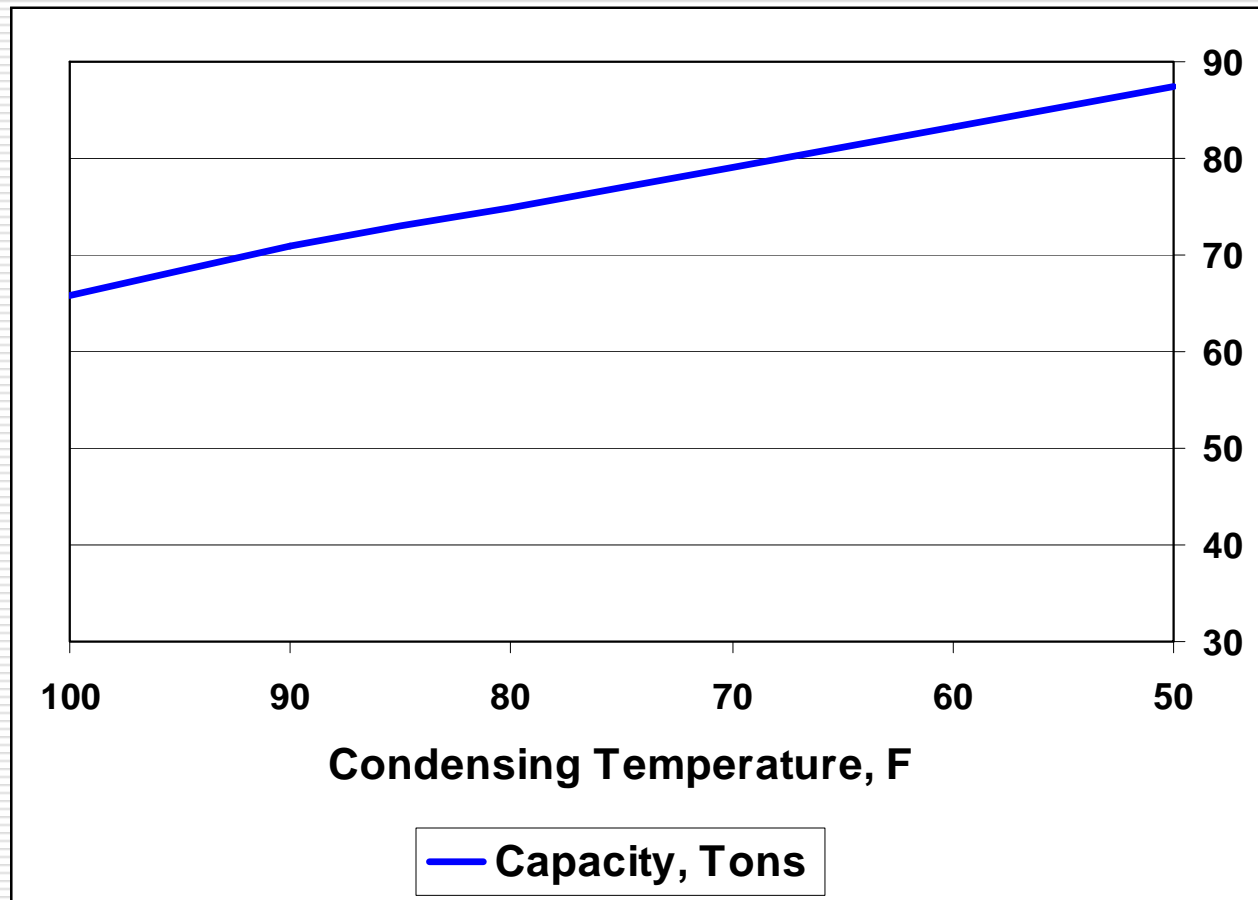


# Variable Setpoint Control



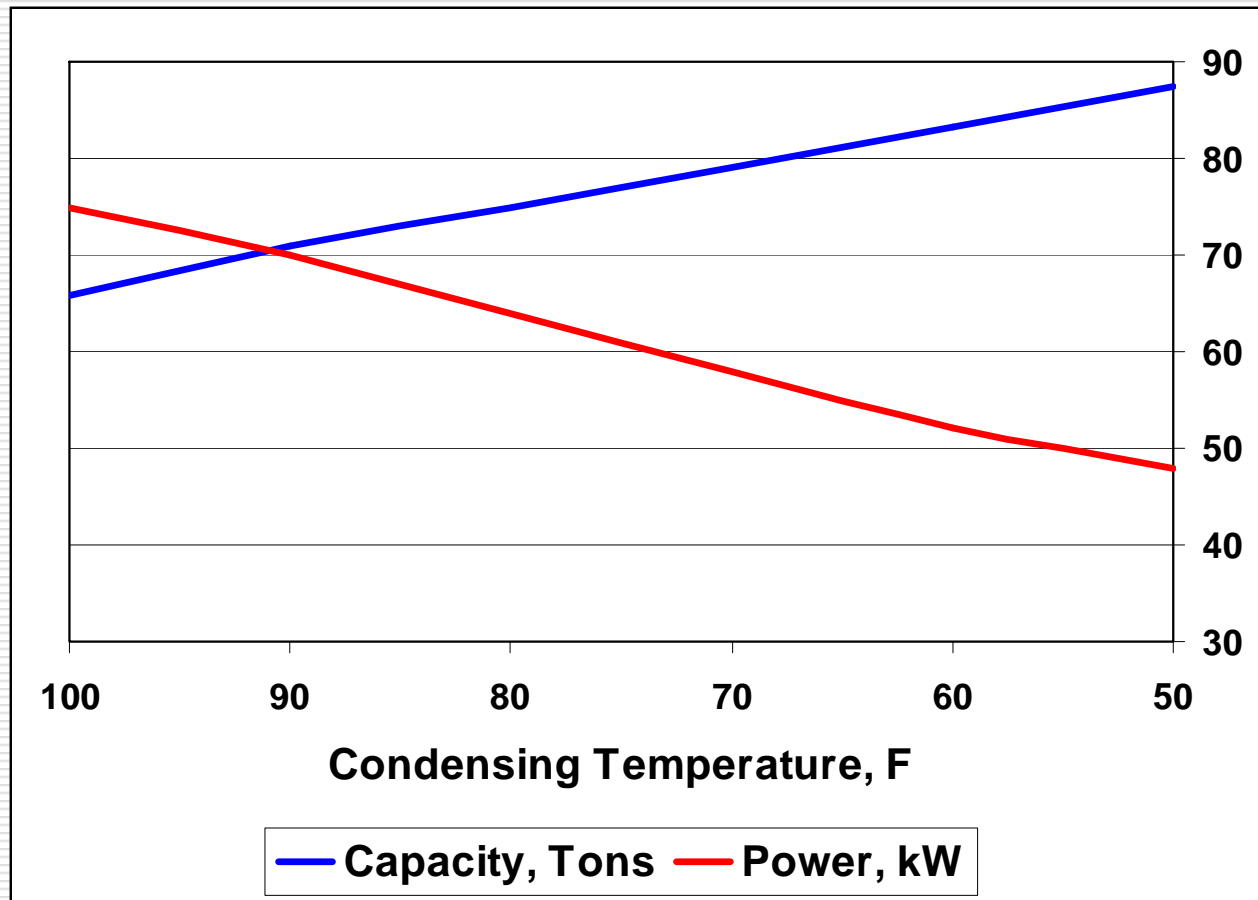
# Floating Head Pressure – Impact on capacity

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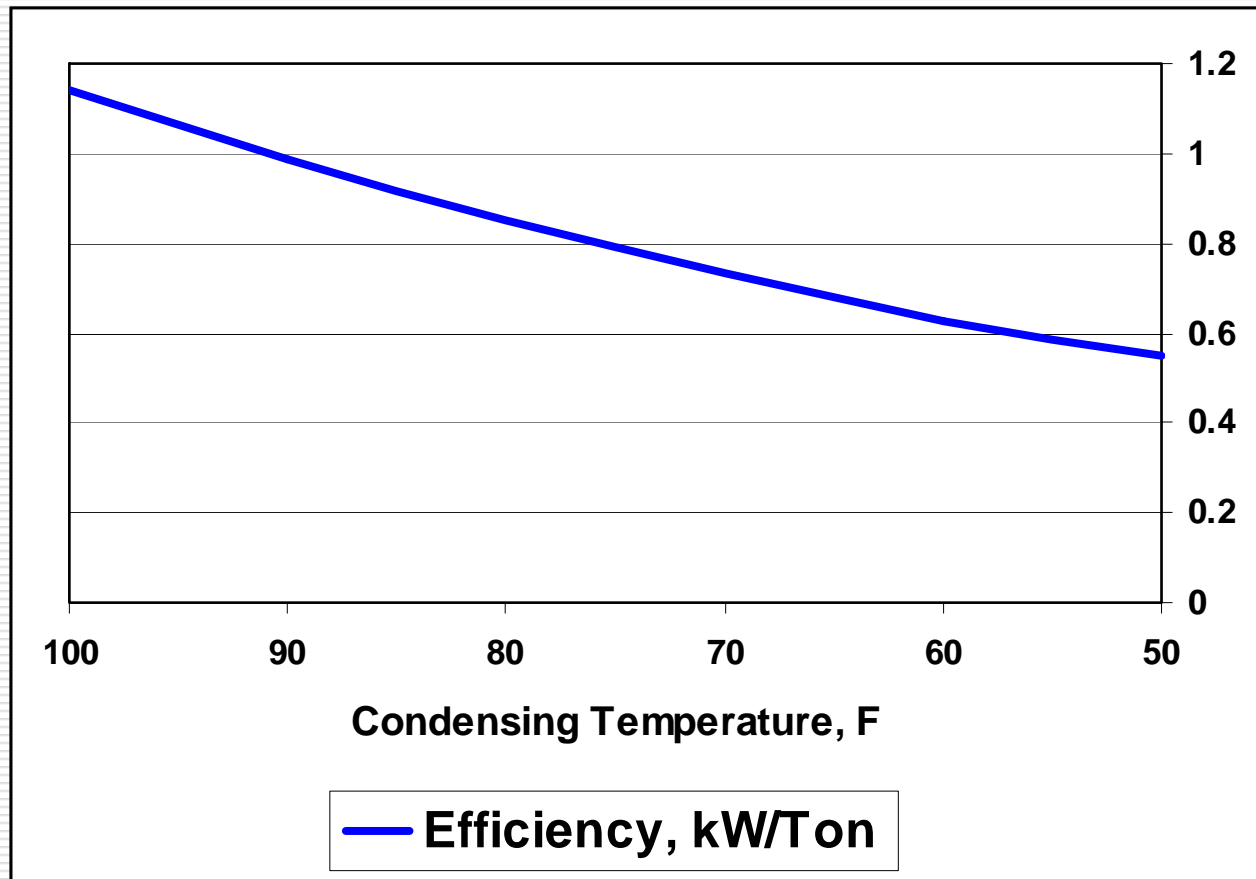
# Floating Head Pressure – Impact on capacity and power

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# Floating Head Pressure – Net effect on efficiency

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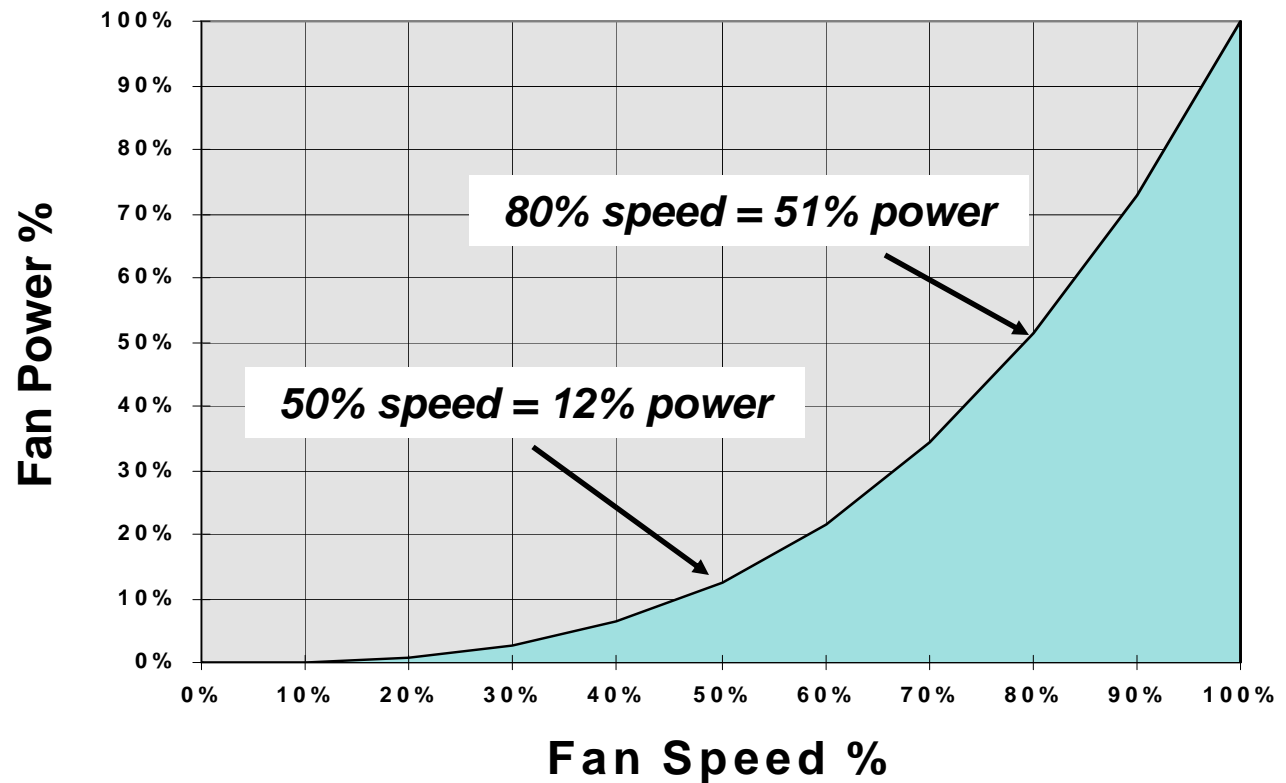
# Variable Speed Fan Control

## Third power relationship

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Capacity varies directly with change in airflow

Fan power varies with cube of change in airflow

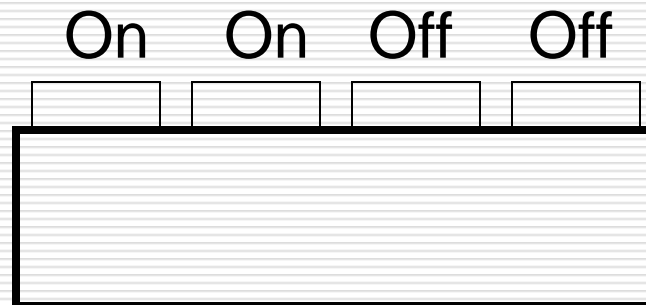




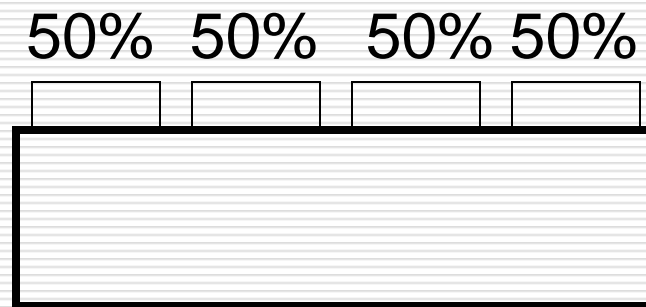
# Part Load Performance

## Variable speed vs. fan cycling

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50% capacity  
50% power  
80 BTUH/Watt



50% capacity  
12% power  
330 BTUH/Watt

Specific efficiency increased by 300% with variable speed

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# Energy Savings

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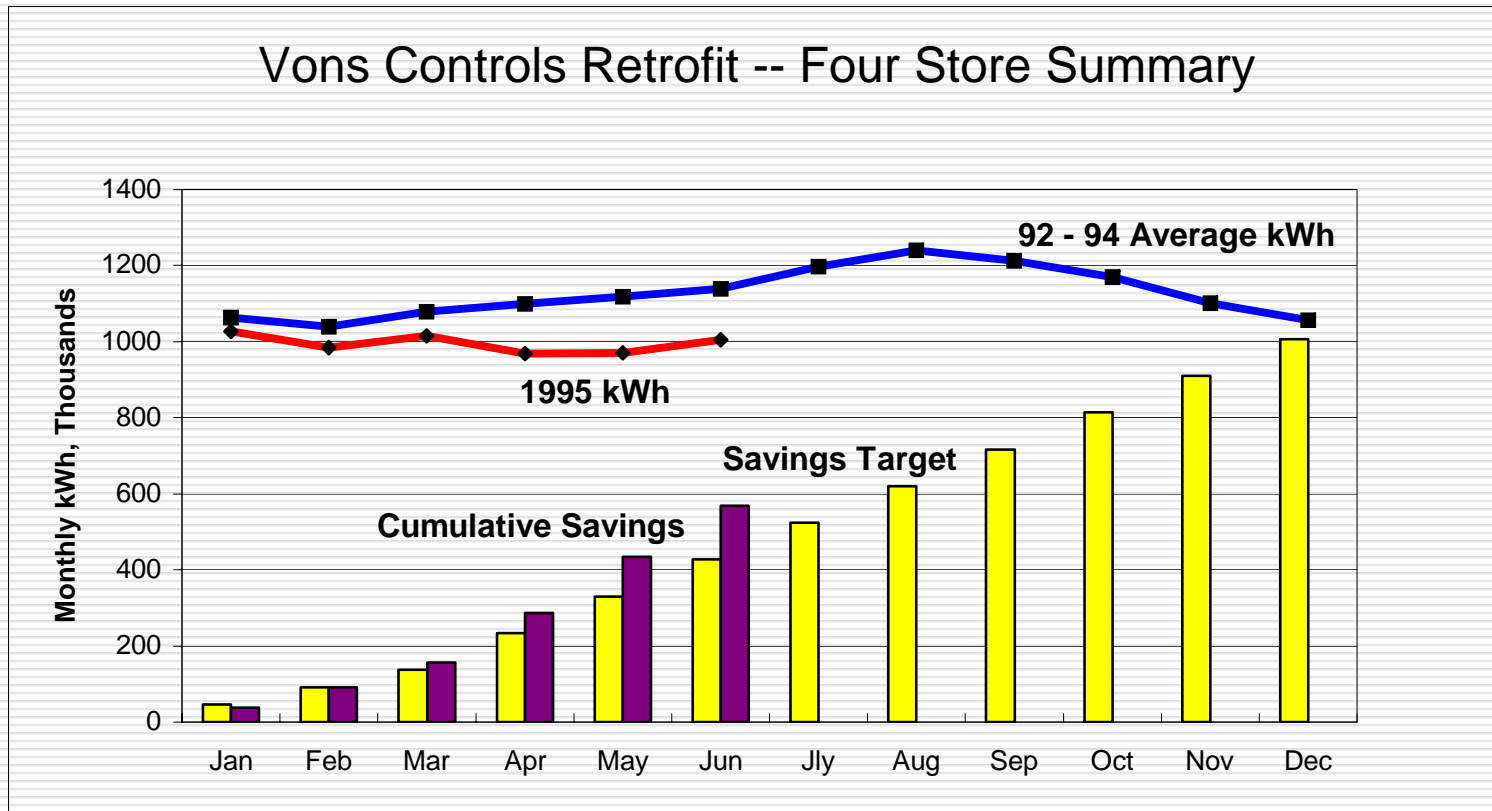
Energy Savings come from:

- Lower head pressure
- Lower fan power
  - Variable speed
  - Variable setpoint
- System stability
- Overall: optimum system balance

# Early Experience

## Successful supermarket trial

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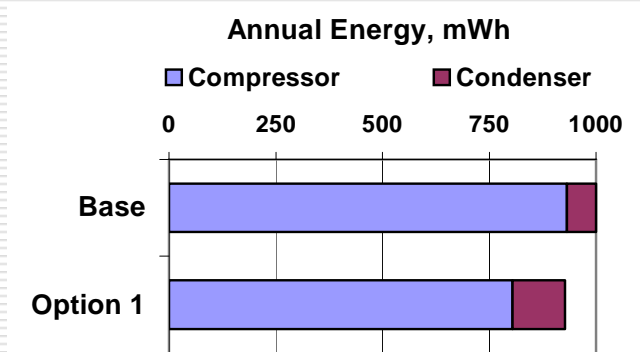


# Case Study

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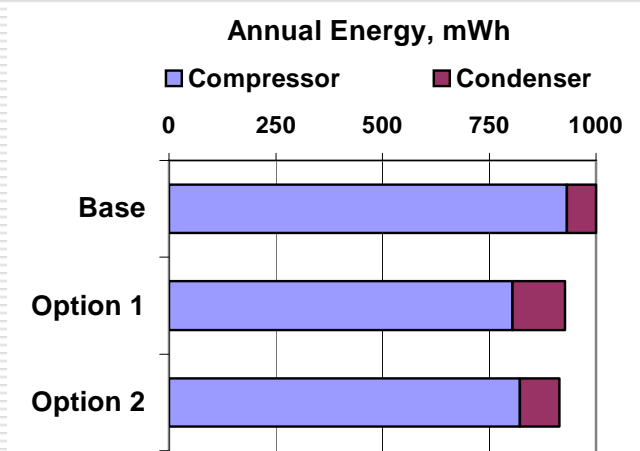
- ❑ Cold storage warehouse in Stockton
- ❑ Evaporative condenser
- ❑ Base case = fixed SCT at 85 F
- ❑ Options
  - Float SCT using fixed setpoint
  - Add variable setpoint
  - Add variable speed with fixed setpoint
  - Add variable speed with variable setpoint

# Results



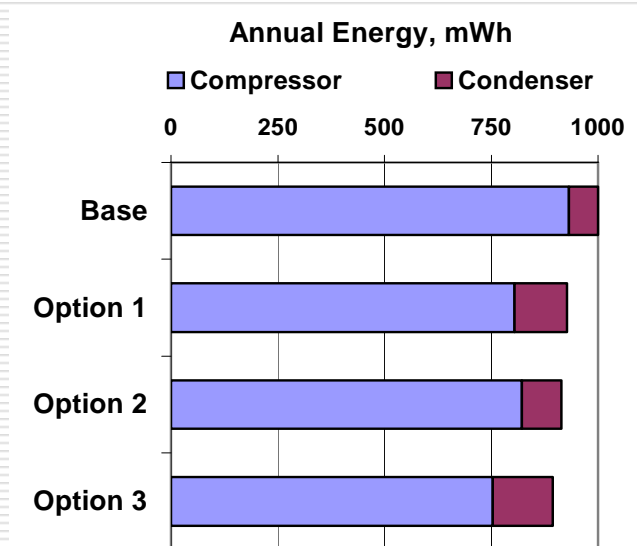
FHP	Control Options			Savings	Payback	NPV
	FSP	VSP	VFD			
X	X			\$ 6,400	0.3	\$ 63,500

# Results



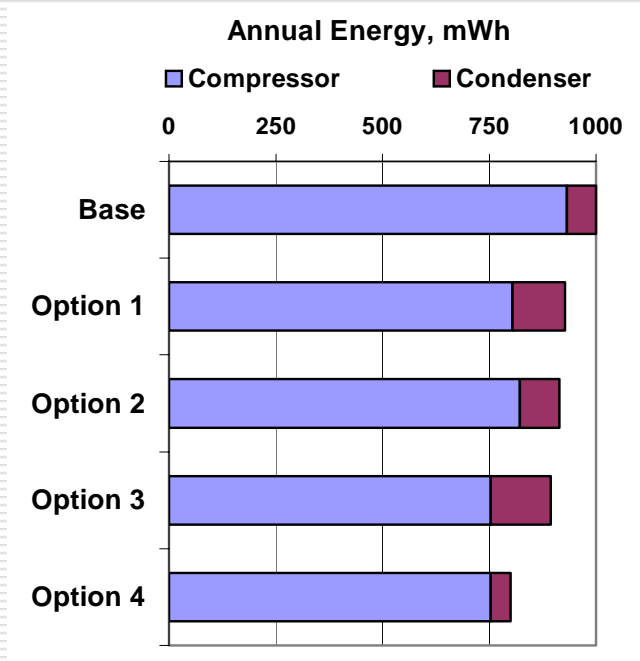
Control Options	Control Options				Savings	Payback	NPV
	FHP	FSP	VSP	VFD			
	X	X			\$ 6,400	0.3	\$ 63,500
	X		X		\$ 8,400	0.6	\$ 80,300

# Results



	Control Options				Savings	Payback	NPV
	FHP	FSP	VSP	VFD			
Base							
Option 1	X	X			\$ 6,400	0.3	\$ 63,500
Option 2	X		X		\$ 8,400	0.6	\$ 80,300
Option 3	X	X		X	\$ 9,100	4.4	\$ 52,900

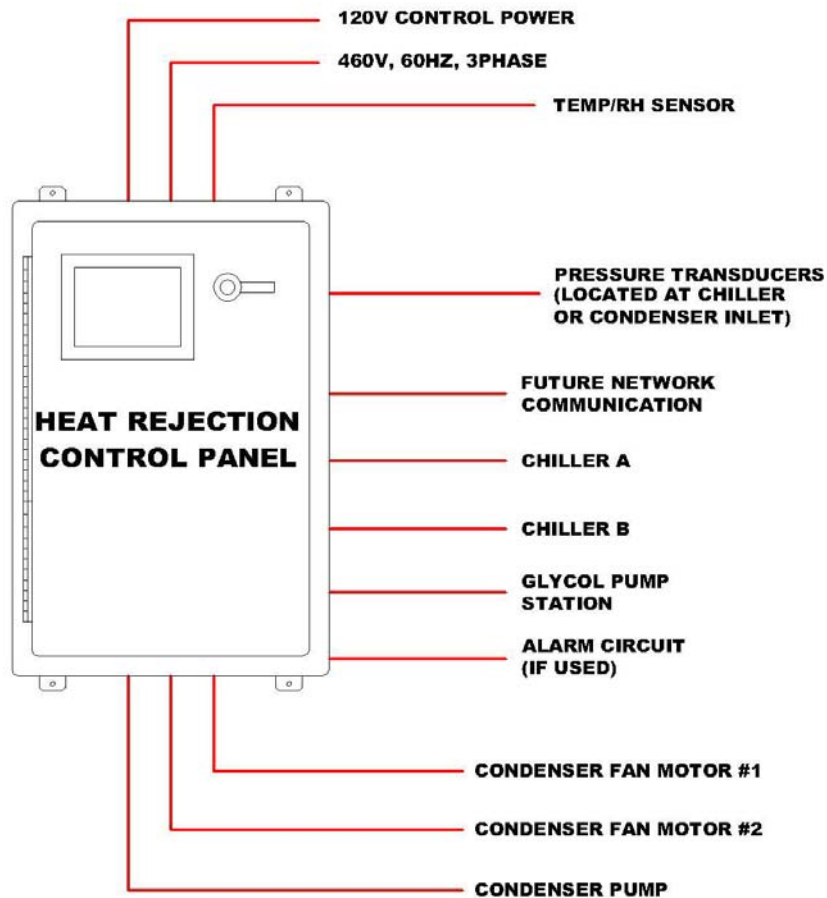
# Results



	Control Options				Savings	Payback	NPV
	FHP	FSP	VSP	VFD			
Base							
Option 1	X	X			\$ 6,400	0.3	\$ 63,500
Option 2	X		X		\$ 8,400	0.6	\$ 80,300
Option 3	X	X		X	\$ 9,100	4.4	\$ 52,900
Option 4	X		X	X	\$ 21,600	2.1	\$ 175,300



# Example System



**75 Ton condenser for two glycol chillers with four separate high sides**

*Estimated first cost savings:*

\$3,000 savings in reduced custom programming

\$2,500 savings in reduced on-site electrical installation cost and MCC hardware

# Typical Panel

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# Controller I/O

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## Analog inputs

- Ambient DBT
- Ambient RH
- Discharge pressures

## Digital inputs

- Fan enables
- VFD status
- Override status
- Pump proof
- Defrost monitor

## Digital outputs

- VFD enable
- VFD auto bypass
- Pump enable
- Emergency spray

## Analog outputs

- VFD speed

# Controller Functions

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## □ Capability

- Up to four separate pressures or temperature inputs
- Two VFDs per controller

## □ VFD control

- Auto, bypass and service modes
- Automatic restarts
- Automatic bypass

## □ Control logic

- Fixed setpoint
- Variable setpoint using DBT or WBT
- PID control
- SCT calculation for different refrigerants

## □ Other features

- Emergency spray control
- Run time and cycle monitoring

# Communications Interface

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- i.LON100 used for:
  - Initial setup
  - Current status
  - Setpoints
  - Alarms and datalogging
- Use web browser for setup, setpoint adjustments and current status

<http://63.110.57.69/forms/main.htm>

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LOWMARK ASSOCIATE

HEAT REJECTION CONTROL PANEL

EnergyDashboard™

Main

Current Status

Control Settings

System Configuration


Datalogging

Alarm History

Help

### System Information


<b>System:</b>	North Chiller Plant A
<b>Location:</b>	VaCom Technologies La Verne, California
<b>Contact:</b>	James Smith (909) 392-6704

Powered By: *i.LON* 100e2  ECHELON™

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**HEAT REJECTION CONTROL SYSTEM**

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VFD

Spray Pump

### System Status

Discharge Pressure				
<i>High Side #:</i>	#1	#2	#3	#4
Pressure (PSIG)	125.44	87.40	N/A	N/A
Refrigerant Type	R22	R134	N/A	N/A
SCT (DegF)	70.89	78.97	N/A	N/A

SCT		Ambient	
Avg. SCT (DegF):	74.93	DB Temperature (DegF):	91.00
SCT SetPoint (DegF):	68.56	RH (%):	25.00
		WB Temp (DegF):	66.00

Condenser Fans		Defrost	
Fan Speed (%):	66	Defrost Status:	OFF
VFD #1 Status:	ON		
VFD #2 Status:	ON		


  

Spray Pump	
Pump Status:	ON

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Spray Pump

### VFD Status


<b>Fan Speed:</b>	54.00 % / 32.40Hz	
<b>VFD #:</b>	<b>#1</b>	<b>#2</b>
<b>Power Switch</b>	ON	ON
<b>Mode Switch</b>	Auto	Auto
<b>Drive Status</b>	ON	ON
<b>Auto Bypass</b>	Normal	Normal
<b>Restart Count</b>	0	0
<b>Cycle Count - Current Day</b>	0	0
<b>Cycle Count - Previous Day</b>	2	4
<b>Cycle Count - Cumulative</b>	0	0
<b>Run Time - Current Day (Hr)</b>	16.3	16.3
<b>Run Time - Previous Day (Hr)</b>	24	24
<b>Run Time - Cumulative (Hr)</b>	400	400
	<input type="button" value="Reset Fault"/>	<input type="button" value="Reset Fault"/>



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Calibration


### SCT Control Settings

Max. SCT Set Point (DegF)	<input type="text" value="90"/>	Set
Min. SCT Set Point (DegF)	<input type="text" value="65"/>	Set
Fixed SCT Set Point (DegF)	<input type="text" value="70"/>	Set
Defrost SCT Set Point (DegF)	<input type="text" value="80"/>	Set
Variable Set Point T <sub>d</sub> (DegF)	<input type="text" value="14"/>	Set
Use Highest SCT Delta (DegF)	<input type="text" value="8"/>	Set
VFD Restart Differential (DegF)	<input type="text" value="5"/>	Set
Design Wet Bulb Temperature (DegF)	<input type="text" value="70"/>	Set
Wet Bulb Factor	<input type="text" value="0.28"/>	Set

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### Refrigerant & Alarm Settings

High Side #	#1	#2	#3	#4	
Refrigerant Type	R22	R134	R404	R404	Set
High Discharge Pressure Alarm Limit (PSIG)	375	225	0	0	Set
Alarm Deadband (PSIG):	450	275	0	0	Set
Alarm Notification Delay (min)	02	02	00	00	Set

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### VFD Control Settings

VFD Run Proof Delay (sec)	<input type="text" value="10"/>	Set
Restart Delay (sec)	<input type="text" value="20"/>	Set
Minimum Speed (%)	<input type="text" value="10"/>	Set
Min Run Time @ Minimum Speed (min)	<input type="text" value="15"/>	Set
VFD Sequence Interval (sec)	<input type="text" value="12"/>	Set
VFD Restart Count	<input type="text" value="2"/>	Set
<b>PID Parameters</b>		
Gain Factor (P)	<input type="text" value="50"/>	Set
Rate Factor (D)	<input type="text" value="1"/>	Set
Reset Factor (I)	<input type="text" value="1"/>	Set
PID Loop Delay(sec)	<input type="text" value="2"/>	Set



HEAT REJECTION CONTROL SYSTEM

EnergyDashboard™

Main Current Status Control Settings System Configuration Datalogging Alarm History Help

Initial Set-Up Control Configuration

Initial Set-Up

System Information:

System Type:	ECwithSPwithDEF		
# of High Sides:	2		Set
# of VFDs:	2		

Sensor Set-Up

	Max. Eng Scale Value	Min. Eng Scale Value	
High Side #1 Disch Pressure Sensor	500	0	Set
High Side #2 Disch Pressure Sensor	500	0	Set
High Side #3 Disch Pressure Sensor	300	0	Set
High Side #4 Disch Pressure Sensor	300	0	Set
Ambient DB Temperature Sensor	500	0	Set
Ambient Humidity Sensor	100	0	Set

# Performance Monitoring using EnergyDashboard™

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- Remote efficiency monitoring
  - Real time, continuous performance analysis
  - Web based results presentation
- High level performance metrics
  - Energy efficiency: kW/Ton, \$/Ton-Hr
  - Maintenance indicators
  - Trends (e.g. refriger. level, inventory)

**Refrigeration Monitoring System - Demo Site**

Select Time Period to View Data and Click on 'Process Data' Button

Start Time/Date **January 2005** End Time/Date **January 2005** Time Filter

Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat
26	27	28	29	30	31	1	26	27	28	29	30	31	1
2	3	4	5	6	7	8	2	3	4	5	6	7	8
9	10	11	12	13	14	15	9	10	11	12	13	14	15
16	17	18	19	20	21	22	16	17	18	19	20	21	22
23	24	25	26	27	28	29	23	24	25	26	27	28	29
30	31	1	2	3	4	5	30	31	1	2	3	4	5

Today: 2/27/2005  
 12:00:00 AM

Time Filter:  
 Sel. Period  
 5 Minutes  
 15 Minutes  
 Hourly  
 Daily  
 Weekly  
 Monthly

**Data Processing Results**

Selected Time Period: 1/9/2005 TO: 1/12/2005 Selected Time (Hr): 72.000

Data Processing Progress:

Collected Data (Hr): 71.750

Processed Data Start Date/Time: 9/29/2004 Data Collection Rate (%): 99.653

Processed Data End Date/Time: 2/27/2005 3:00:00 PM

Status: Data Retrieved and Processed

Process Data



Condenser: **Medium Temp EC1** Condenser VFD Speed Set Point (%)

Graph Mode  
 Cursor Mode  
 Zoom Mode

Cursor: Time/Data  
[ ]  
[ ]

Fan Speed (%): \*

32.9

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Condenser Power (kW)

Graph Mode  
 Cursor Mode  
 Zoom Mode

Cursor: Time/Data  
[ ]  
[ ]

Condenser Power (kW): \*

2.9

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High Pressure Receiver Levels

Graph Mode  
 Cursor Mode  
 Zoom Mode

Cursor: Time/Data  
[ ]  
[ ]

EC1 HP Receiver Level (%): \*

12.4

EC2 HP Receiver Level (%): \*

82.0

\* Period Average

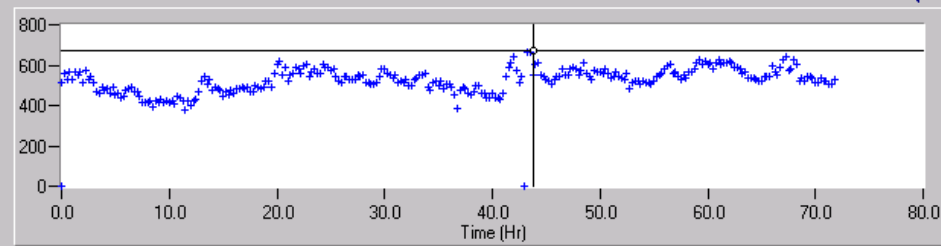
Total System	Energy Rates	Energy Consumption	Power Graphs	Reports	System Information
Data	Compressors-1	Compressors-2	<b>Suction Group</b>	Heat Rejection	Zones - Temperature

<p>Suction Group: <input type="text" value="MT"/></p> <p><b>Suction Pressure - Current (PSIG), Target (PSIG), Float</b></p> <p>Graph Mode  <input checked="" type="radio"/> Cursor Mode  <input type="radio"/> Zoom Mode</p> <p>Cursor: Time/Data  <input type="text"/>  <input type="text"/></p>	<p><b>Design SST: +15 °F</b>  <b>Design SCT: 90 °F</b></p> <p>Suction Pressure Current (PSIG): *  <input type="text" value="43.7"/></p> <p>Suction Pressure Target (PSIG): *  <input type="text" value="44.4"/></p> <p>Suction Pressure Float: *  <input type="text" value="4.5"/></p>
<p><b>Discharge Pressure (PSIG)</b></p> <p>Graph Mode  <input checked="" type="radio"/> Cursor Mode  <input type="radio"/> Zoom Mode</p> <p>Cursor: Time/Data  <input type="text"/>  <input type="text"/></p>	<p>Discharge Pressure (PSIG): *  <input type="text" value="128.5"/></p>
<p><b>SST (DegF) and SDT (DegF)</b></p> <p>Graph Mode  <input checked="" type="radio"/> Cursor Mode  <input type="radio"/> Zoom Mode</p> <p>Cursor: Time/Data  <input type="text"/>  <input type="text"/></p>	<p>SST (DegF): *  <input type="text" value="19.8"/></p> <p>SCT (DegF): *  <input type="text" value="74.7"/></p> <p>kW/Ton *  <input type="text" value="0.7"/></p> <p>Power (kW): *  <input type="text" value="28.5"/></p> <p>Refrigeration (Tons) *  <input type="text" value="42.6"/></p> <p style="text-align: right;">* Period Average</p>



Power System: Total

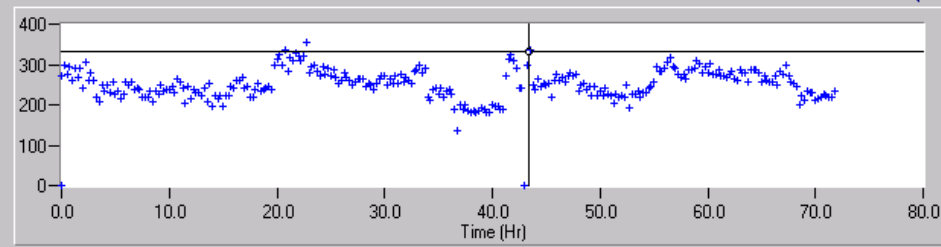


Graph Mode  
 Cursor Mode  
 Zoom Mode

Cursor: Time/Data  
 01/10/05 19:13:00  
 671.70

Demand (kW): \*  
 526.1  
 Energy (kWh):  
 37745.9

Power System: Refr



Graph Mode  
 Cursor Mode  
 Zoom Mode

Cursor: Time/Data  
 01/10/05 19:13:00  
 332.08

Demand (kW): \*  
 252.1  
 Energy (kWh)  
 18086.4

\* Period Average

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# *Questions?*

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