MOTORS USED FOR REFRIGERATION AND HVAC: HOW TO IDENTIFY RETROFITS WITH GREAT ROI'S

BOSTON GREEN TOURISM

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AGENDA

- Introduction
- Objective of this presentation
- Review of energy used by motors
- Identifying or finding good opportunities
- Benefits of Continuous Performance Monitoring

- Live demo of how users work with Remote Management
- Questions

Objectives and Consideration

- How to find opportunities to save money and improve performance
  - High annual run time (refrigeration evaporator fan motors)
  - Lightly loaded motors waste energy
  - Measure characteristics of the load or equipment, volts, amps, power factor, watts
- Determine benefits and operational impact of solution options
  - How will it affect customers?
  - Is it easy to implement and who will do it?
  - Life of the retrofit--2 years? 15 years?
  - How will it impact maintenance time and costs?
- Consider adding other features to a proposed retrofit that could yield reduced maintenance or early warning of possible failure.

Research on System Performance

- Hotels have cut their fractional HP motor electricity cost by 65% by replacing shaded pole fan motors with ECM motors in cold rooms, fan coils and powered VAV boxes
- A recent research study revealed the following
  - Of 164 systems studied 87% (144) had faults
  - On average, the systems operated at 9.7% reduced COP (performance), 8.7% reduced capacity (longer run times)—boosting energy bills by 15.8%
  - Most problems found required simple fixes; only 2% were compressor problems. Biggest problems were expansion valve adjustments (36%) and improper refrigerant charge (54%).
- Poor maintenance can cost up to 50% or more in energy costs. You should already know this but what are the indicators that prompt action? …most rely on their contractor to keep system tuned.
- Need to educate operations and maintenance… Your utility has excellent training workshops that in most cases are free to customers.

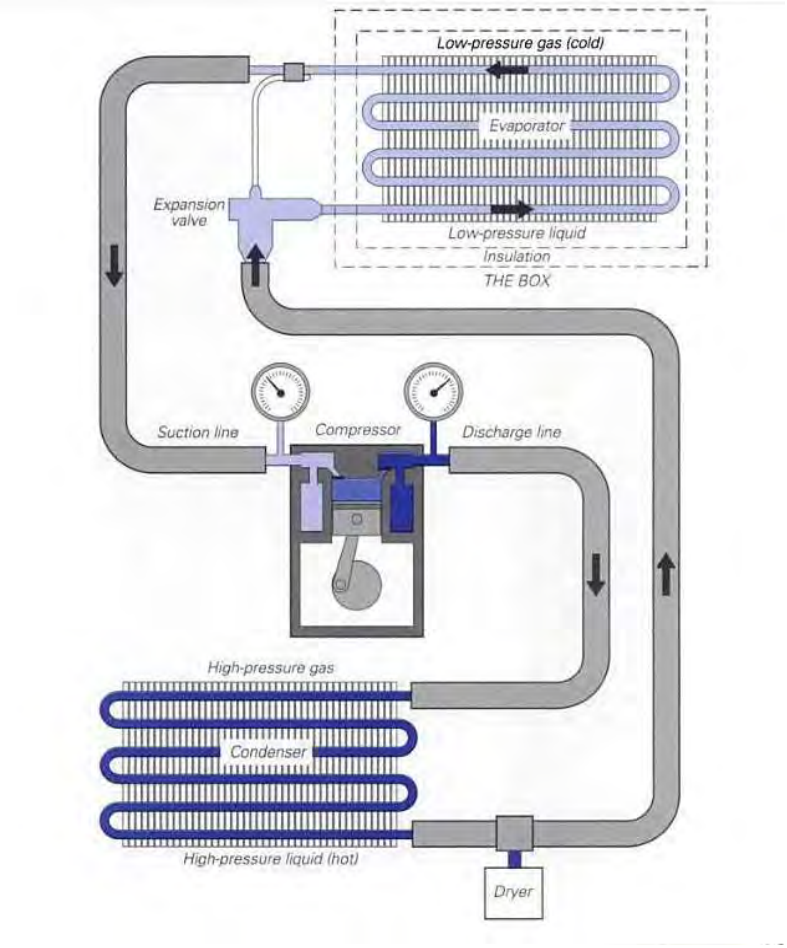
The BIG Opportunity in Refrigeration

- Why is there such a great opportunity for energy savings?
  - It is the GAP between Capacity and Load
  - Systems are designed to maintain temperature on the hottest day of the year. There are probably only 10-20 days per year like that.
  - When it is not the hottest day, there are many opportunities for energy saving … seasonal + cool days and nights. Sensors, sensors, sensors and controls.
- Why NOW, What has changed?
  - Greater focus on going green along with generous incentives from state mandated programs.
  - Innovation – Internet, new technologies and available upgrades
  - Refrigeration fan motor savings is very predictable because they run 24/7.
    - Payback – ROI in under 2 years (depends on size of the load)
  - Guest room fan motors are much more difficult to predict since run time is not easy to estimate and monitoring should be done in order to calculate

Other factors that drive this Opportunity

- Some reasons for the big energy savings opportunity
  - Poor or unknown operating performance of refrigeration or HVAC system since there is usually no simple means to track history or run time. For example a cooler may be maintaining temperature but run time is higher than normal.
  - There is no means to watch them 24 hours per day – no dashboard – automation can help if there are means to connect to the circuits
  - Refrigeration operates 24/7 – savings are relatively easy to predict (no one plays with the thermostat)
  - Historical operating information unavailable – inability to benchmark
  - Stuck in old thinking – "We have done it this way for 20+ years"
- What can you do right away
  - Education – find out what others in your industry are doing – send techs to school
  - Rethink your operation, some of the waste could be scheduling, leaving heat sources on, behavioral issues, doors left open, preventive maint.
  - Set up a process for monitoring and tracking KPI's key performance indicators
  - Are cooler temperatures set too low? Each degree costs 3-5% more in energy.

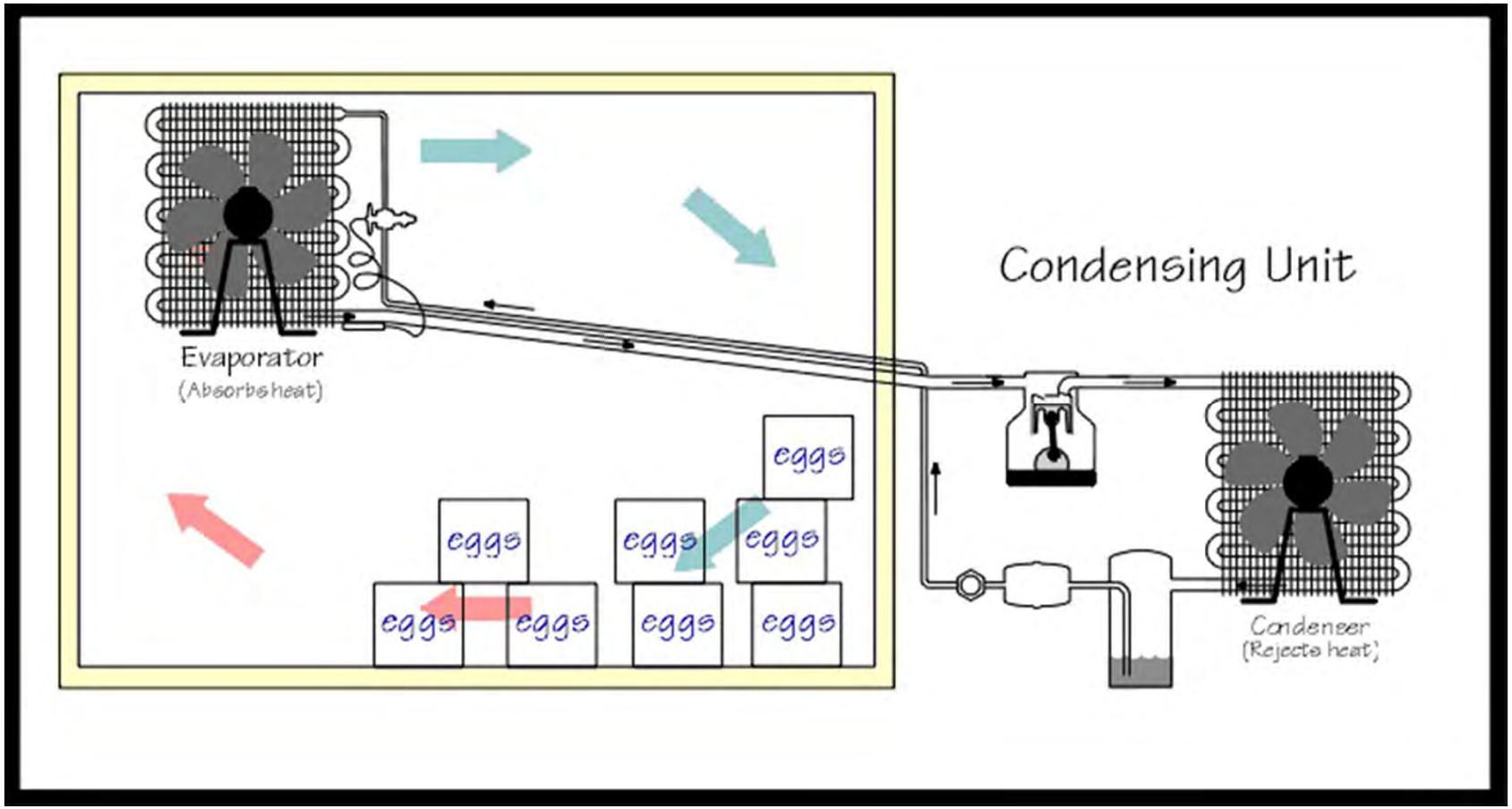
Refrigeration 101: Refrigeration is Simply the Moving of Heat from One place to another



Here's How It Works

- Refrigerant gas is sucked into the compressor
- The compressor pressurizes gas and in the process, raises temperature heat of compression
- The hot compressed gas flows through the discharge line into a condenser (heat exchanger) where it is cooled below its condensing temperature and changes to pressurized liquid ready for another cooling cycle
- Through a controlled release, the liquid refrigerant is sprayed into the evaporator coil through the expansion valve
- Fluid emerges from the expansion valve, the dramatic drop back to near atmospheric pressure causes the refrigerant to boil, absorbing heat from the air flowing over the evaporator coil
- From the evaporator coil, the cool gas is sucked into the compressor and the cycle is repeated

Air is the Medium Used to Move Heat from One Place to Another



Fan Motor Efficiencies

- Motor efficiency is defined as a % from

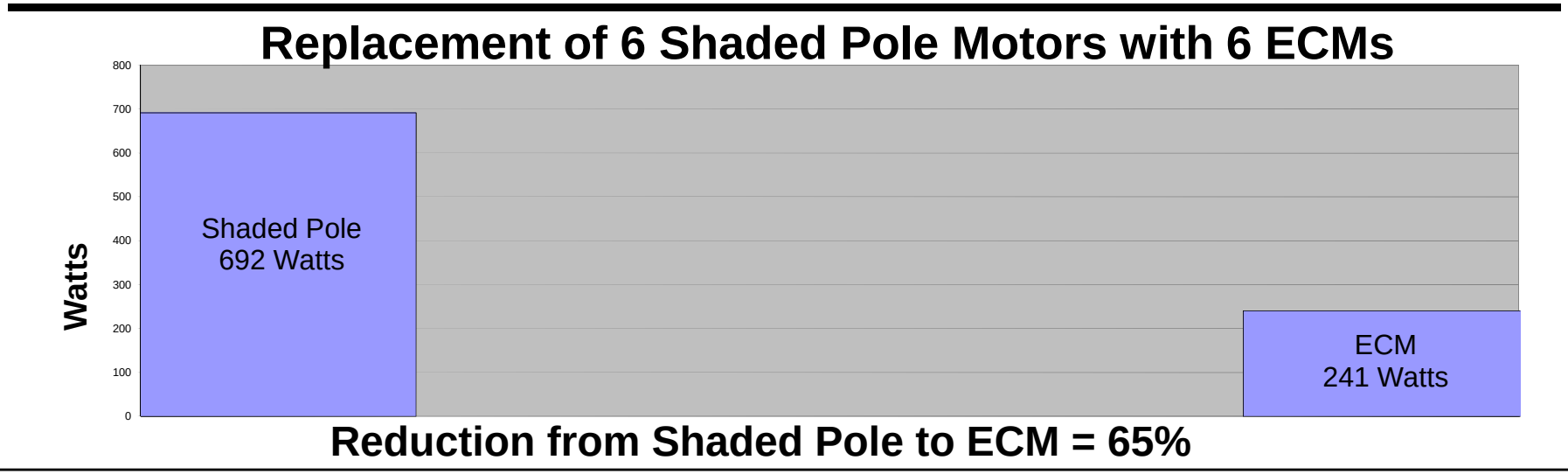
  $$\frac{\text{the power out}}{\text{the power in}}$$

- Shaded pole motors – older technology operate at 20-30% efficiency
- PSC (permanent split capacitor) motors more efficient 40-60% efficient
- EC (electronically commutated) Motors use rare earth super strong permanent magnets are 70-80% efficient

Metered Data from Converting Shaded Pole Motors to ECM in Walk-in Cooler

Before

After

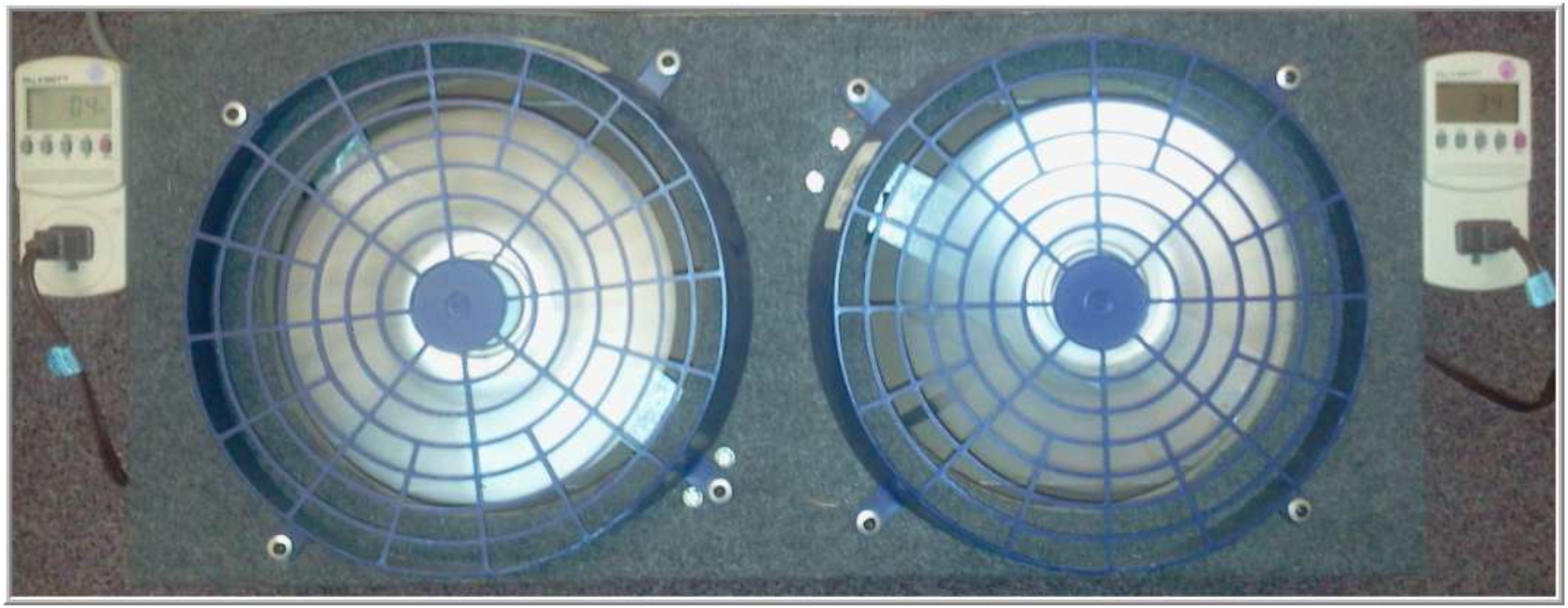


Example of ECM Savings

Both Fans at same speed
30 Watts less saving 88%

New ECM at 4 Watts

Old fan at 34 Watts



Calculate Usage

Example calculation for evaporator fans.

Say you have 8 fans at 115V and 2 amps each

8 x 115 x 2 x .55pf = 1,012 watts or 1.012 kW

At 24 hrs energy use = 8,760 x 1.29 = 8,865 kWh

At $.15/kWh cost = 8,865 x $0.15 = $1,329

What if you could save 65% of that? $864

What if your load is bigger… savings are bigger

Case Studies of from 2 projects detailed.

Hidden Energy – Interactive Effect

From previous example where fan motors used 8,865 kWh

- Usually overlooked hidden energy - refrigeration load from fan motor heat
  - A 3,413 Btu/kWh
  - B 12,000 Btu/Ton
  - C COP (coefficient of performance) 1.6 kW/Ton
  - D 8,865 kWh usage of evaporator fans in cooler
  - Formula D x (A ÷ B) x C = kWh needed by compressor to remove fan heat
  - 8,865 x (3,413 ÷ 12,000) x 1.6 = 4,034 kWh making total savings 12,899 kWh
  - This is 45% over and above the total fan energy.
  - We can conclude that for every $1.00 of fan energy there is an added cost of $.45 to remove the heat that the fans dump into a cooled space
  - This means the compressor has to run longer to remove evaporator fan heat
- **The fan heat effect is 12% of the total refrigeration system usage.**

ROI for This Refrigeration Example

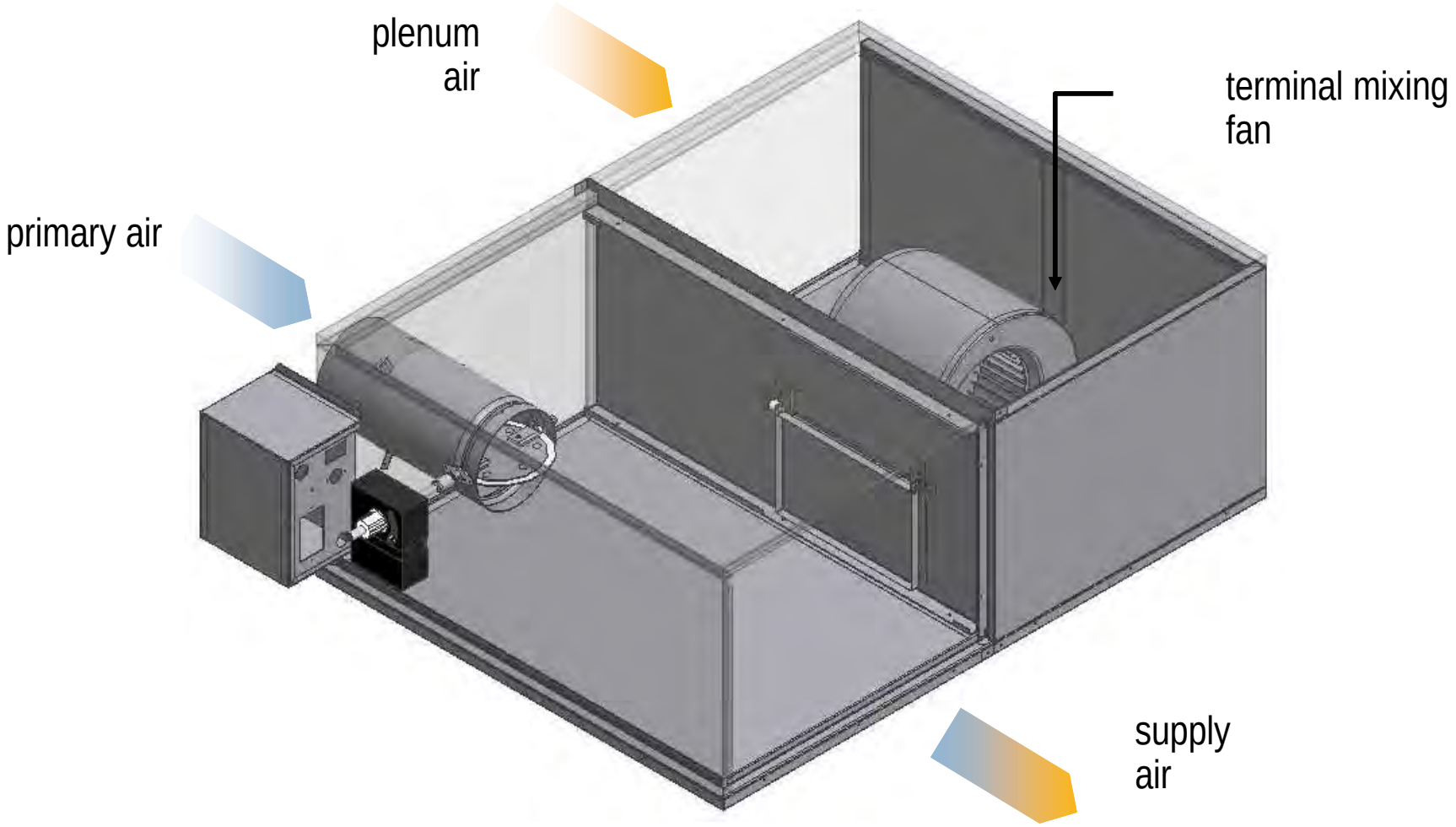
- Savings of 12,899 kWh
- Approximate retrofit cost for 8 motors $2,400.00
- Annual saving @ $0.15/kWh $1,934.00
- Simple Payback 15 months
- Potential NSTAR incentive ? $1,200.00
- Net Cost $1,200.00
- Payback with incentive 7.5 months

- We have no data for guest room fan coils

Power Formula

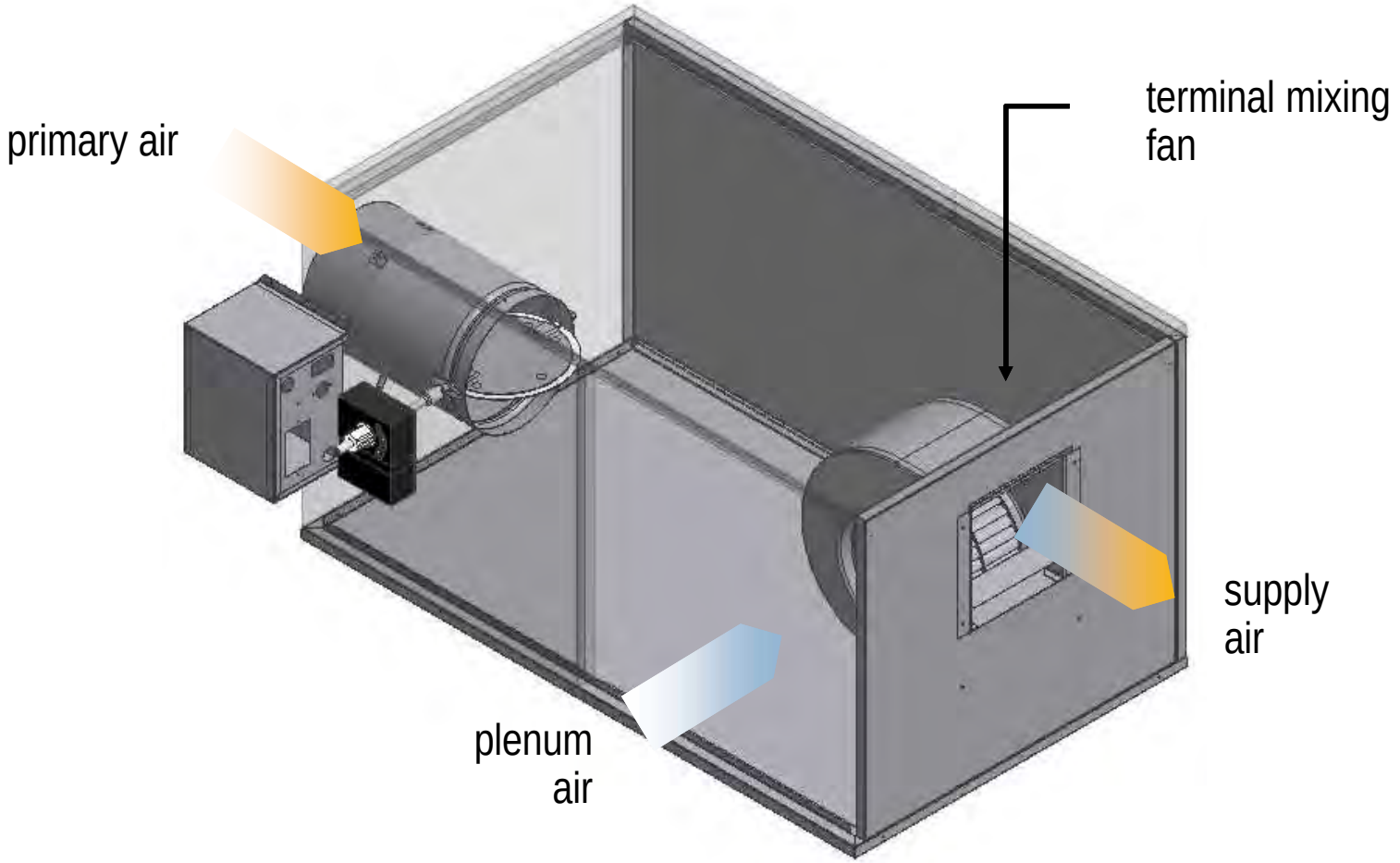
- Calculating electrical load of motors
  - Volts x Amps x √(phases) x Power Factor = Watts
  - $Load = V\ x\ A\ x\ \sqrt{phase}\ x\ PF$
  - V = 208
  - A = 4
  - Phases = 3
  - PF = .6
  - $Load = 208\ x\ 4\ x\ \sqrt{3}\ x\ .6 = 865\ Watts$
  - For resistive load PF = 1

VAV Parallel, Fan-Powered



VAV Series, Fan-Powered

(Electrically Commutated Motors – ECM's)



Parallel vs. Series – Motor Retrofit
Key to Energy Savings is Fan Run Time

- Intermittent fan
  - Fan only runs in the heat mode (Variable Volume to the space)
  - Fan is the first stage of heat
  - Fan CFM < Max Cooling
  - Most energy efficient design
  - Sound in space will vary
- Continuous fan
  - Fan runs continuously in the occupied mode (constant volume to the space)
  - Fan CFM = Max Cooling
  - Less energy efficient system design
  - Smaller main supply fan?
  - ECM Motors
  - Sound remains same

Harvard Dining Example

- Bob Leandro, Harvard Dining Manager, came to NRM for a monitoring solution (see case study available on NRM web site)
  - NRM designed and installed enhanced networked control system
  - Installed new ECM motors
  - Installed a web-based monitoring solution that provides alarms and access to viewing refrigeration by all of the dining area managers.
- The following is a summary of the results:
  - The project cost $140,000. NSTAR contributed $41,000.
  - NRM improvements generate 216,676 kWh/year
  - Approximately $35,000 in annual electric savings. The ROI is 2.8 years.
  - Real time monitoring provides an early warning system for failure or potential failure to prevent product loss
  - Harvard Dining now has access to historical record of temperatures for every cooler & freezer. Improves food safety and provides peace of mind for chefs.
  - Harvard Dining can generate performance trends at any time, enabling technicians to keep equipment tuned in each cold room
  - Dining managers get alarms for their respective areas on their smart phones as email with trend or text messages. Example later

Harvard Dining Coolers & Freezers

Harvard Dining 80 JFK Main
80 JFK St., Cambridge Ma 02138
Tel: 617-496-6751

Boston, Logan International Airport, MA
Last Updated on Apr 25 2012, 8:54 am EDT - Partly Cloudy
Temperature 50°F, Humidity 50%, Dewpoint 32°F

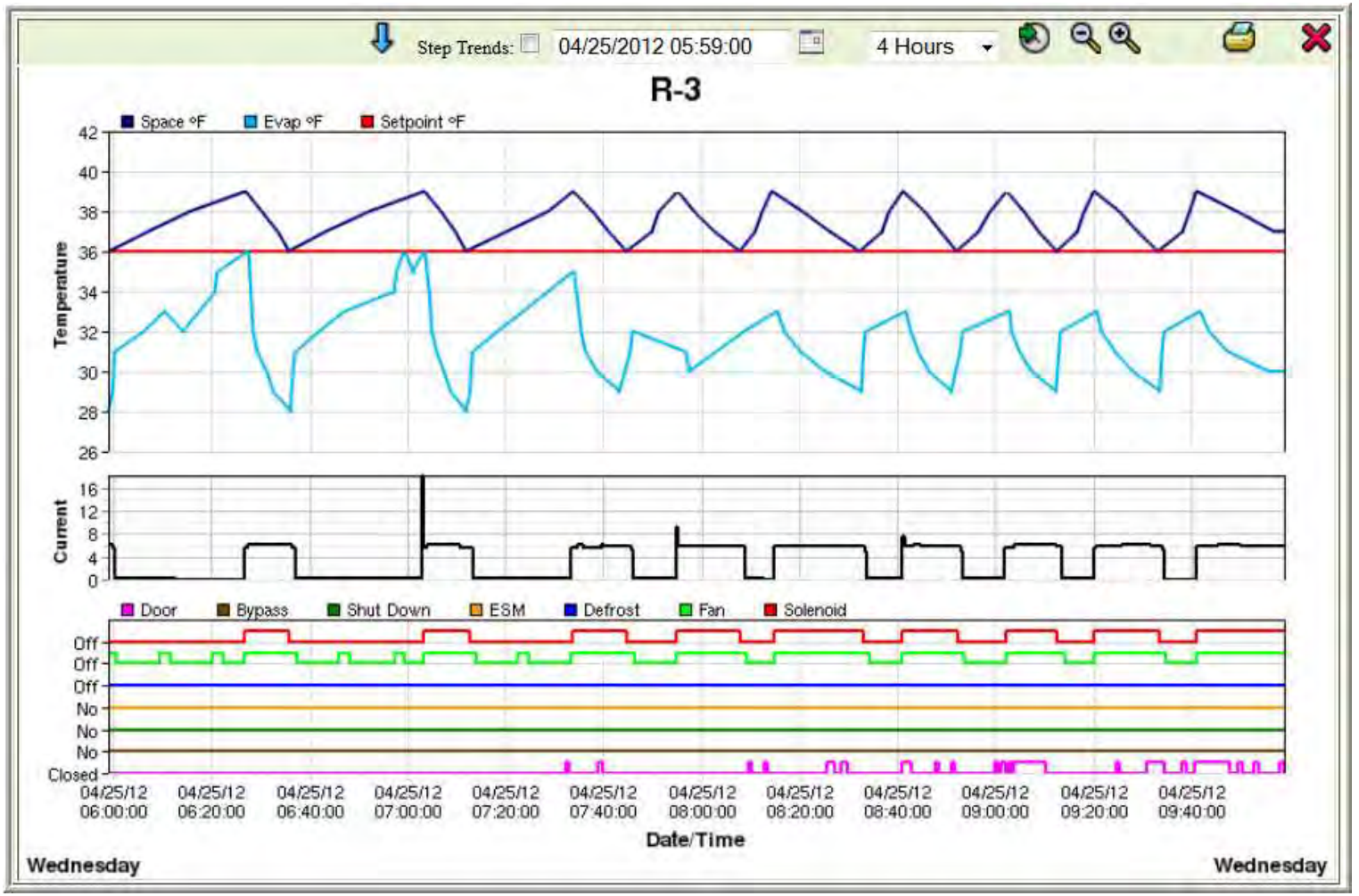
Log Out: emrejs5

Fans used to run 100% before installing controls

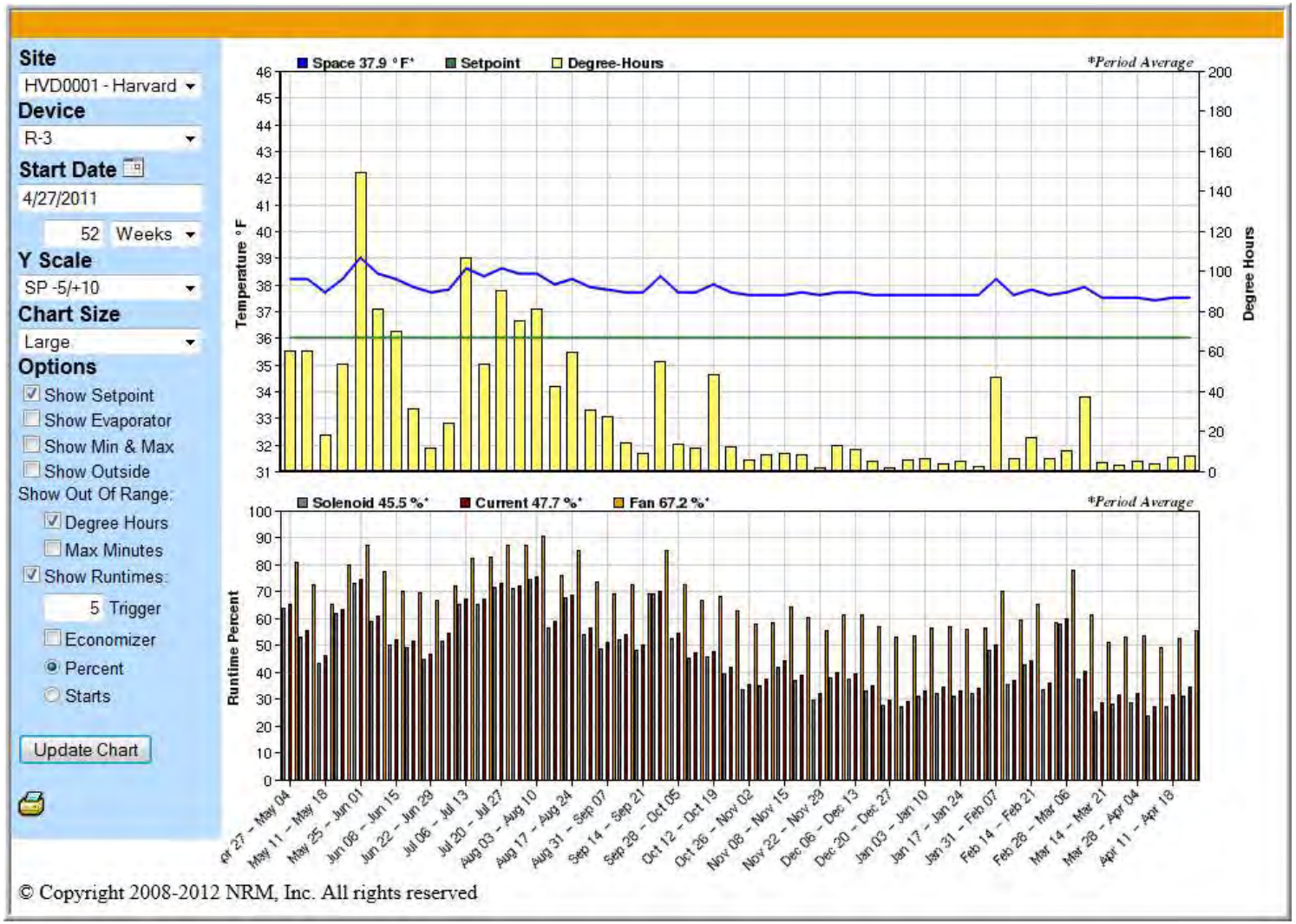
Energy Trend

NRM CoolTrol MC Series 4			Temperature °F				Status						Starts 24 Hr.			% Run 24 Hr.			% Run 7 Days		
Description	Content	Status	Space	Evap	SP	24hr	Mode	Dfrst	Sol	Fan	Door	Amps	Sol	Comp	Fan	Sol	Comp	Fan	Sol	Comp	Fan
CF-1	_		1	-2	0	2.9	Run	Off	On	On	Closed	13.7	56	68	85	44.4	45.1	58	45.3	45.9	57.4
CR-1	_		37	36	36	36.6	Run	Off	Off	Off	Closed	0.3	27	28	111	7.1	8.1	32.6	6.6	7.3	32.5
F-1	_		7	4	5	8.2	Run	Off	On	On	Closed	20.3	44	57	69	52.8	53.3	63.4	58.1	58.4	67.1
F-2	_		-2	-8	-4	1.9	Run	Off	On	On	Open	28.7	80	80	82	53.6	55.5	66.8	55	56.7	67.2
R-3	_		39	32	36	37.5	Run	Off	On	On	Closed	5.7	41	41	86	27.8	30.9	53	31.1	34.6	55.6
R-4	_		39	34	36	37.6	Run	Off	On	On	Closed	5.4	55	55	95	26.1	28.7	53.9	19.8	21.8	47.7
R-5	_		35	32	34	34.7	Run	Off	Off	Off	Open	0.5	50	50	113	16	17.7	41.9	19.4	21.2	44.6
R-6	_		33	29	33	34.2	Run	Off	Off	On	Closed	5.7	56	56	77	37.5	39.7	61.5	38.2	40.6	62.1
R-9	_		37	37	38	38.6	Run	Off	Off	Off	Closed	0.3	39	39	115	11	12.3	36.9	14.5	15.8	40.4
T-1	Kettle Station		36	34	33	35.6	Run	Off	On	On	Open	9.8	37	42	61	52.5	55	70.5	48.5	51	67.2
T-7	Cook Chill Storage		30	30	30	31.3	Run	Off	Off	Off	Open	0.5	80	82	83	49.8	53.6	63.4	49.1	52.7	62.1

Typical Refrigeration Trend



Cooler Performance – Run Time Chart



Email Alarm Message to Users

Harvard Dining 80 JFK Main HiT 49F T-7 Start

rsm@remotesitemanager.net

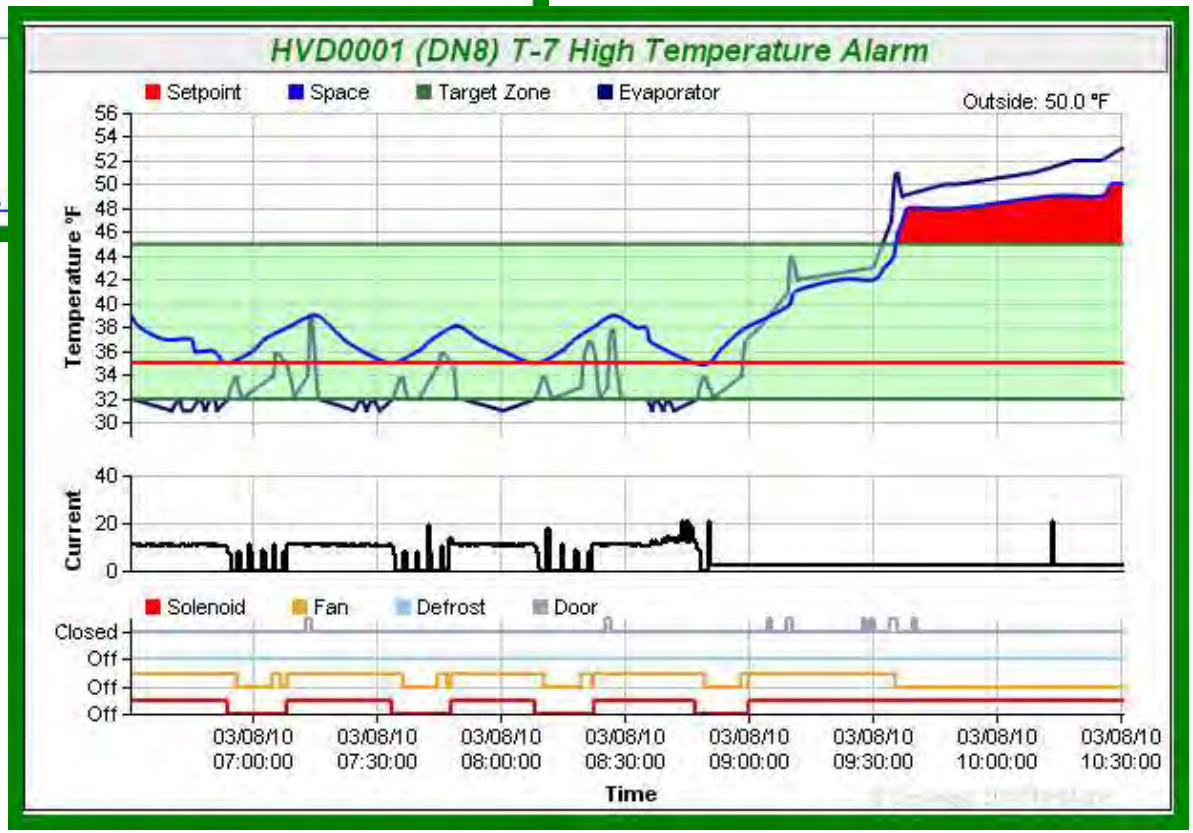
Sent: Mon 3/8/2010 10:30 AM

To: richie_spingel@harvard.edu; martin_breslin@harvard.edu; esalarms@nrminc.com; 6172126587@vtext.com

Message | chart.png (22 KB)

HVD0001 T-7 High Temperature 49 F
Started: 3/8/2010 10:30:12

http://www.remotesitemanager.com/sy.

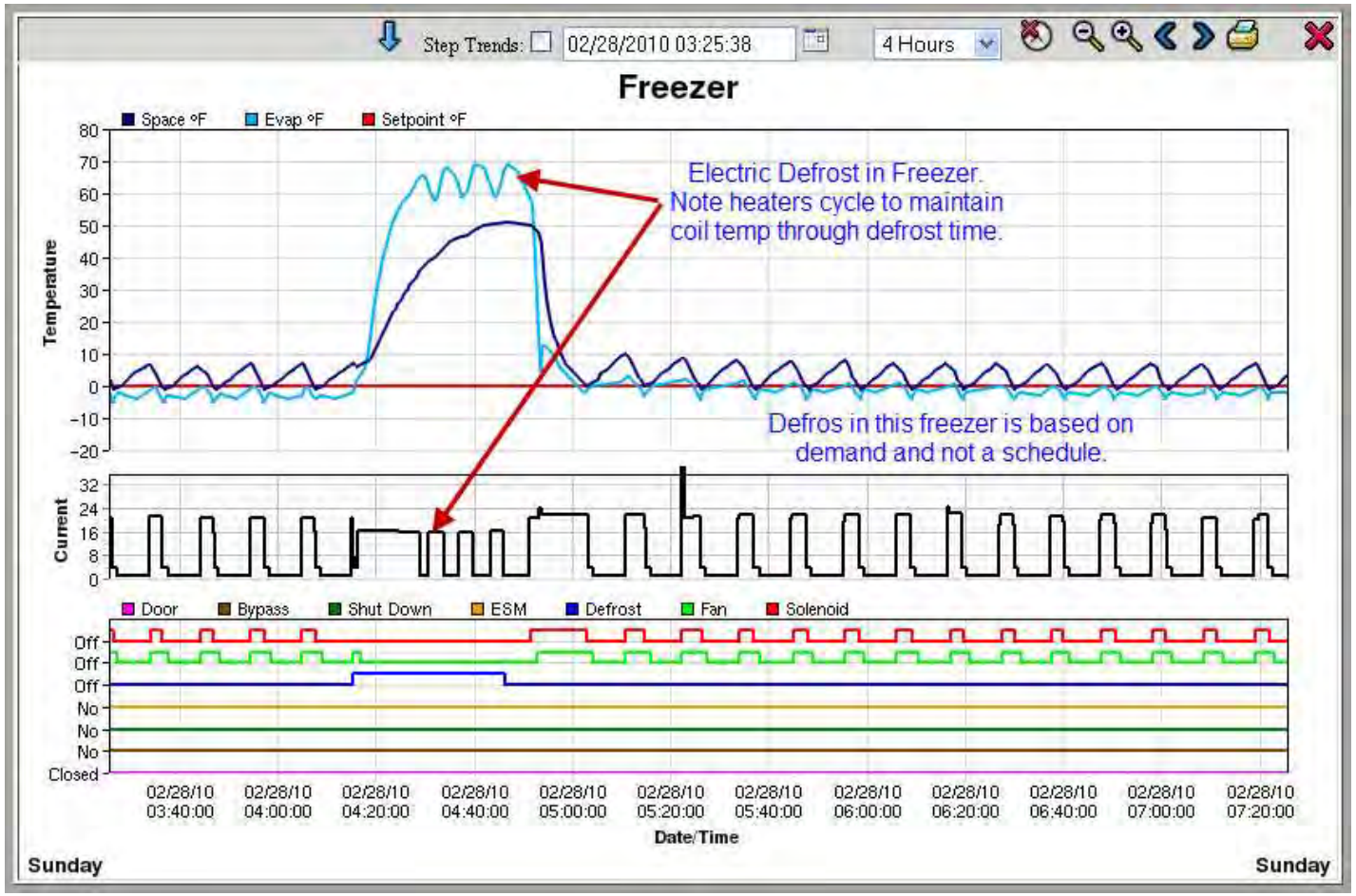


In addition to the email message alarms can be configured to be sent as a text message to users. With smart phones you get trend as well.

Harvard Equipment Failure & Repair

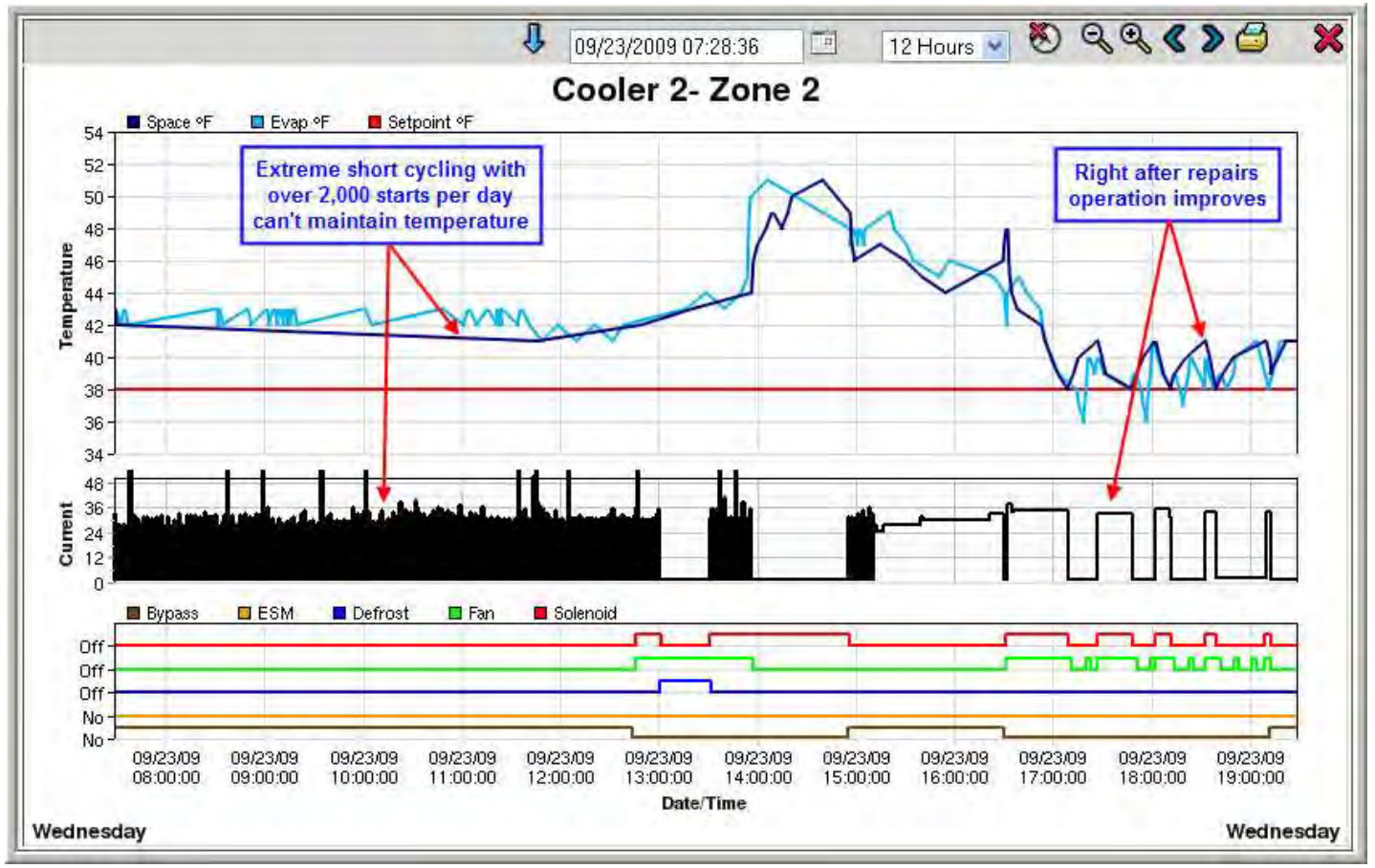
Electric Defrost Trend – Thermostat Mode

- Trend for freezer showing thermostatic defrost



Trend showing Short-cycling Problem

- Equipment issues revealed in trends with data 7-20 seconds
  - Short cycling due to low refrigerant and dirty filter



Freezer High Temp Alarm (Harvard)

Cooler Low Temp Alarm (Harvard)

Time Permitting - Real Time Live Demo - Internet

- See how clients and their technicians use Remote Management to reduce their energy, operating and maintenance costs by staying on top of their refrigeration system's performance.

- To be followed by question and answer session.

Review and Questions - Reference

Equipment issues

- Compressor
  - Short cycling
  - Improper charge
  - Improper pressure settings
  - Poor maintenance
  - Dirty coils
  - Expansion valve adjustment
  - Leaky doors
  - Dirty filters

Savings

- Reducing run times results in savings
  - Evaporator fan motors are heaters; should be off or cycled with comp.
  - Oversized system means greater savings possible and predictable
  - Replace inefficient fan motors
  - Diagnose often (check dashboard daily)
  - Be proactive to make repairs before poor performance slowly eats away your profits.
  - There is no check engine light pay for motors—so pay attention to increase system life

Top Questions

Typical user questions

- How much does it cost
- How much will I save
- How long to install
- How do I know if it will work for me
- Is there training
- Is there a monthly fee

What one should be asking

- What is the process for performing an evaluation
- What is typical payback
- Who does the installation
- How does it save time + $
- How reliable is it and will it last.

Contact NRM for assistance with identifying cost effective saving opportunities. Audits of refrigeration and fan coils are free from NRM

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