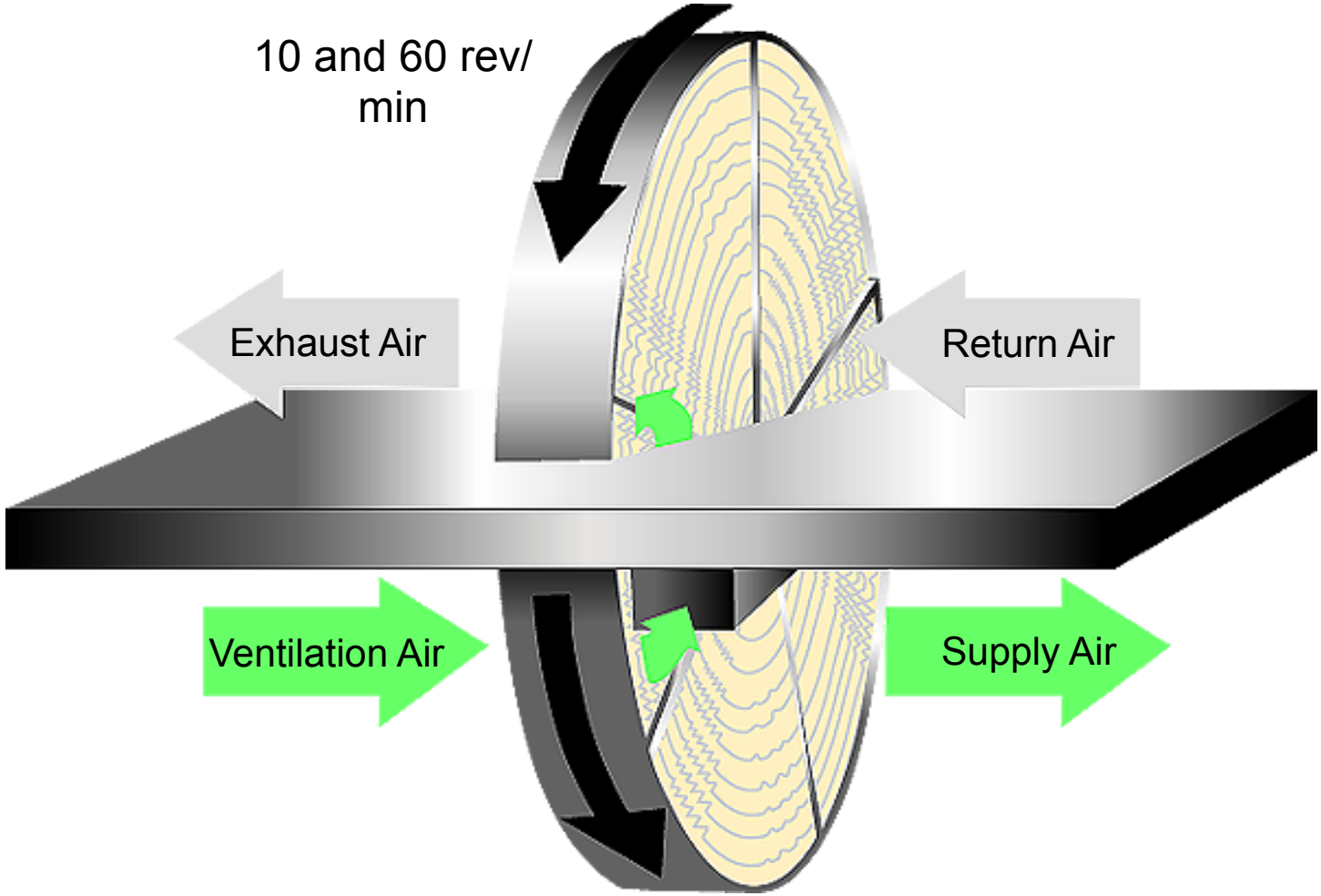
Energy Wheel Operation

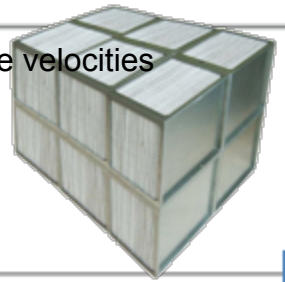
55 to 90% **total** (sensible + latent) effectiveness



Technology Comparison

5000 CFM and equal face velocities

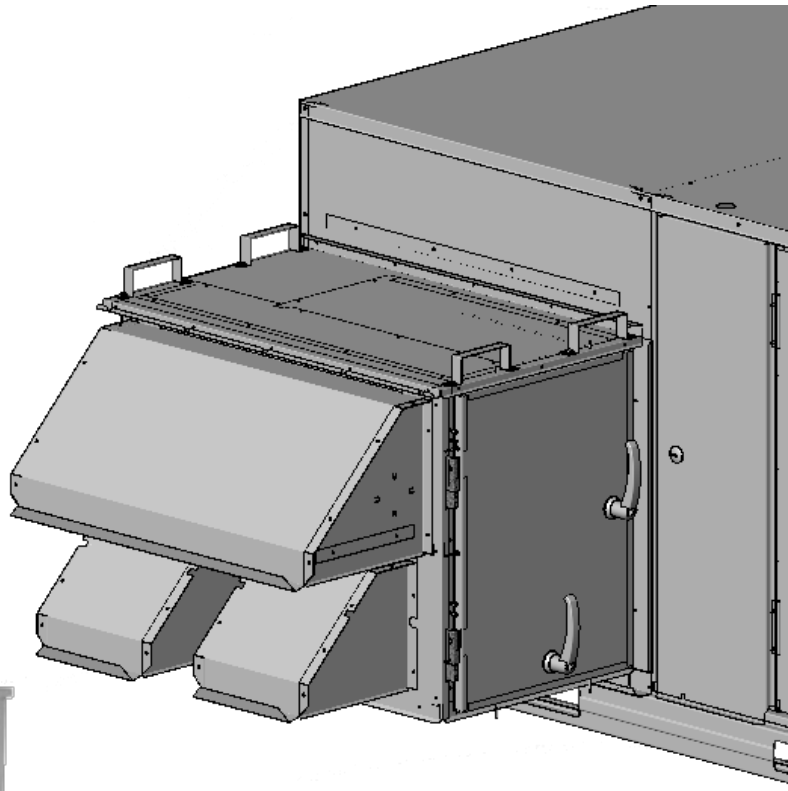





	Heat Pipe	Sensible Plate	Membrane Core	Mem.@ 450 FPM	Heat Wheel
MBHTotal	57.4	59	95.2	104.7	207.6
EffectivenessTotal	19.8	20.4	32.9	36.1	71.7
RERTotal	33.03	35.75	24.14	37.58	119.10

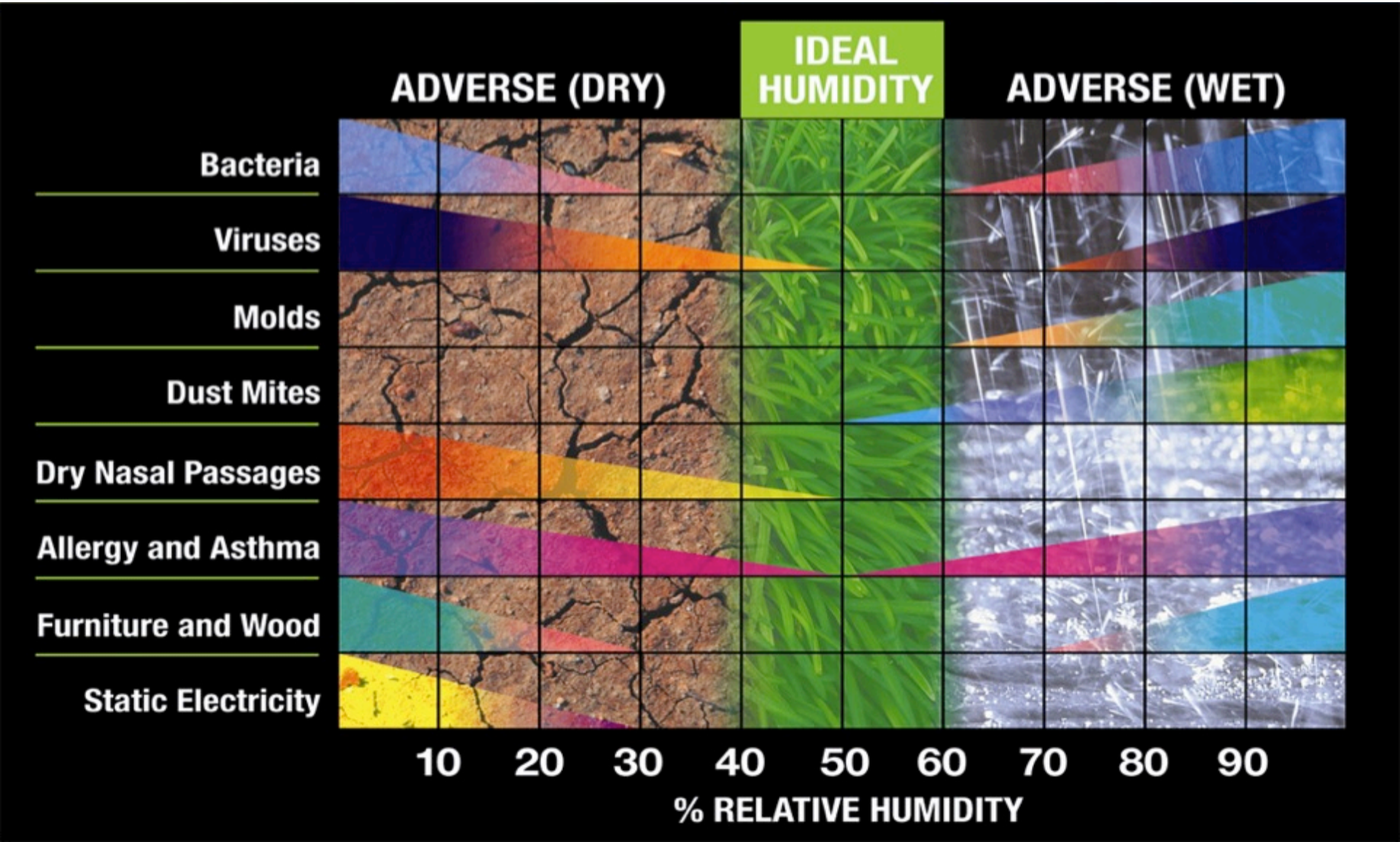
RTU Integrated ERV

- Cost effective method of providing a RTU with an ERV
- Retro-fit or factory install
- Optional economizer and power exhaust function



RTU Combination Curb

Why Correct Humidity Is Important



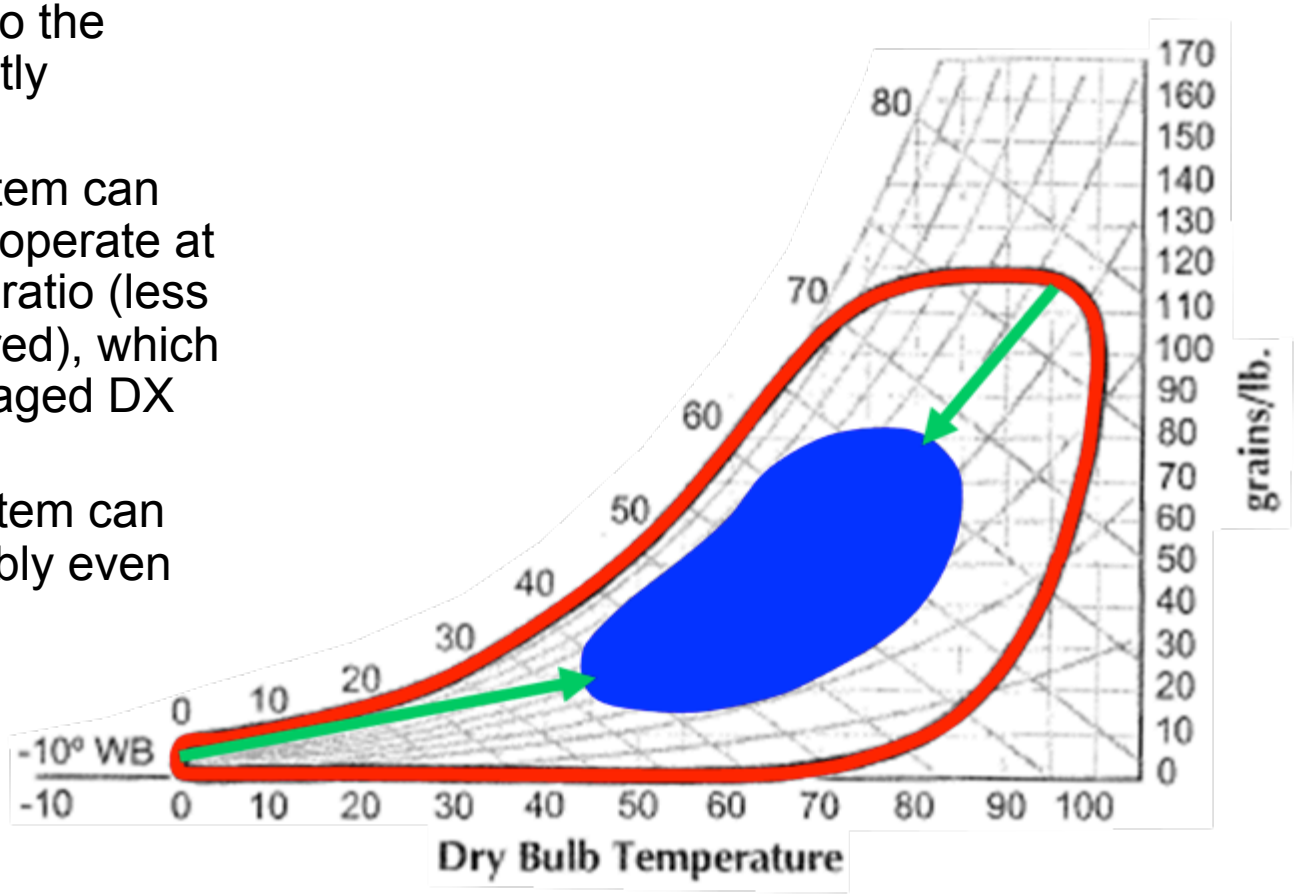
Humidity Buildup at Part Load

Load Condition	Design Load Sunny Day	Part-Load Condition
Occupancy	100%	20%
Outdoor Air Condition	95 db, 76 wb	80 db, 71 wb
Supply Air Cfm Cooling Coil Dewpoint	15,000 53.5 °F	15,000 65.5 °F
Room Conditions	*75 db* *48% rh*	*75 db* *71% rh*

Reduced Operating Range

- Range of ventilation air conditions introduced to the HVAC unit is significantly reduced
- HVAC unit cooling system can be downsized and will operate at a higher sensible heat ratio (less dehumidification required), which is typical of most packaged DX rooftop units
- HVAC unit heating system can be downsized or possibly even eliminated

"Weather Compressor"



Airxchange catalog, January 2006

IECC 2012: Requirement for Energy Recovery

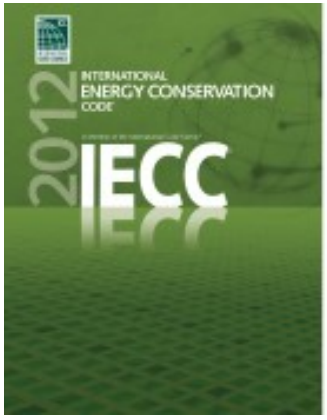
Required in many high population areas (gyms, theaters, etc.)

Check map for climate zone

Look up supply fan CFM and OA fraction

Note: IECC 2006 and 2009 only required ERVs above 70% OA on a 5,000 supply CFM system (regardless of climate)

C403.2.6 Energy recovery ventilation systems. Where the supply airflow rate of a fan system exceeds the values specified in Table C403.2.6, the system shall include an energy recovery system. The energy recovery system shall have the capability to provide a change in the enthalpy of the outdoor air supply of not less than 50 percent of the difference between the outdoor air and return air enthalpies, at design conditions. Where an air economizer is required, the energy recovery system shall include a bypass or controls which permit operation of the economizer as required by Section C403.4



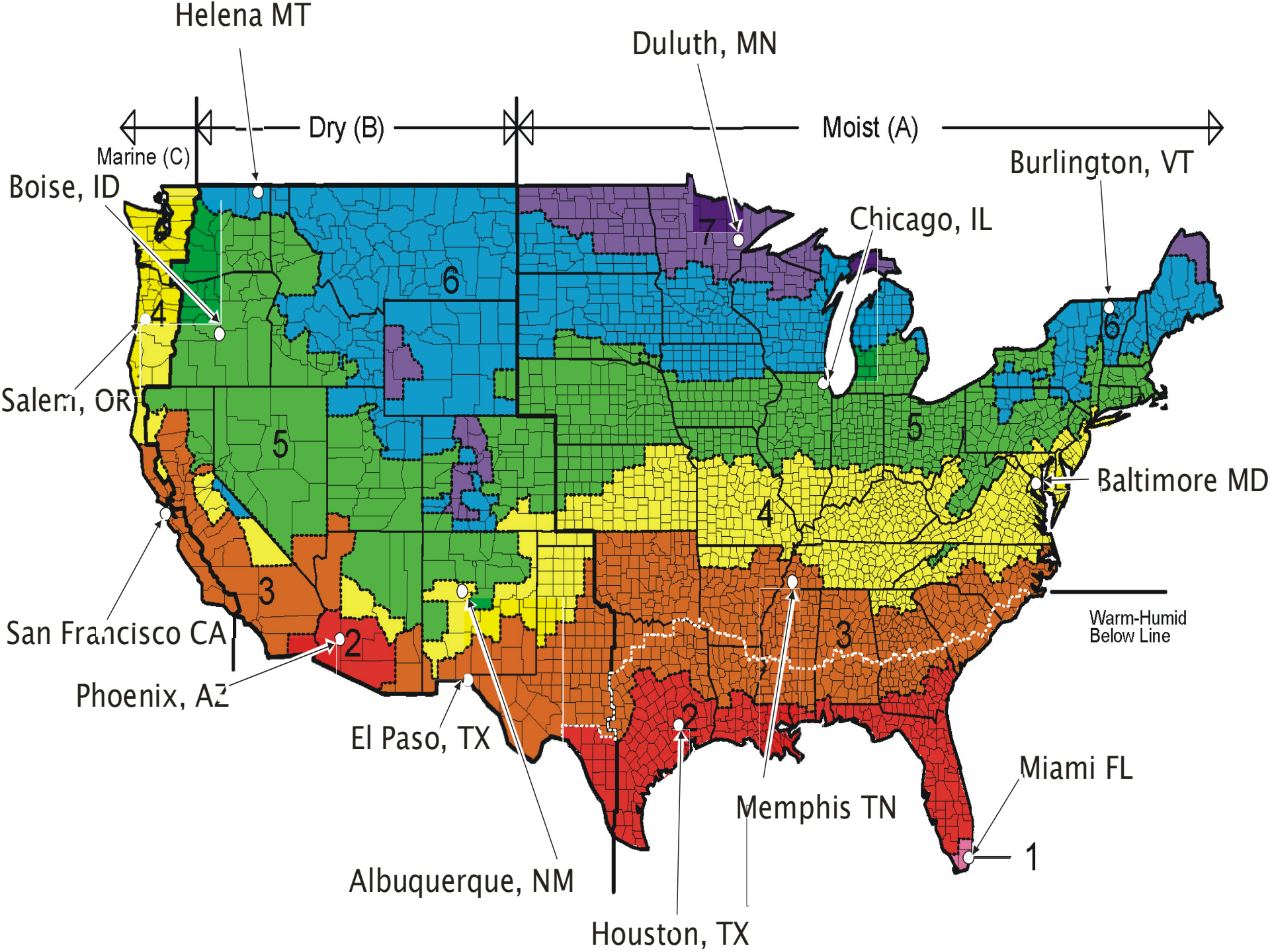

Helena MT
Duluth, MN
Dry (B)
Moist (A)
Marine (C)
Boise, ID
Burlington, VT
Chicago, IL
Salem, OR
Baltimore MD
San Francisco CA
Warm-Humid
Below Line
Phoenix, AZ
El Paso, TX
Miami FL
Memphis TN
Albuquerque, NM
Houston, TX
1
2
3
4
5
6
7

TABLE C403.2.6
ENERGY RECOVERY REQUIREMENT

CLIMATE ZONE	PERCENT (%) OUTDOOR AIR AT FULL DESIGN AIRFLOW RATE					
	≥ 30% and < 40%	≥ 40% and < 50%	≥ 50% and < 60%	≥ 60% and < 70%	≥ 70% and < 80%	≥ 80%
	DESIGN SUPPLY FAN AIRFLOW RATE (cfm)					
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥ 5000	≥ 5000
1B, 2B, 5C	NR	NR	≥ 26000	≥ 12000	≥ 5000	≥ 4000
6B	≥ 11000	≥ 5500	≥ 4500	≥ 3500	≥ 2500	≥ 1500
1A, 2A, 3A, 4A, 5A, 6A	≥ 5500	≥ 4500	≥ 3500	≥ 2000	≥ 1000	> 0
7, 8	≥ 2500	≥ 1000	> 0	> 0	> 0	> 0

Exception: An energy recovery ventilation system shall not be required in any of the following conditions:

1. Where energy recovery systems are prohibited by the *International Mechanical Code*.
2. Laboratory fume hood systems that include at least one of the following features:
   - 2.1. Variable-air-volume hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to 50 percent or less of design values.
   - 2.2. Direct makeup (auxiliary) air supply equal to at least 75 percent of the exhaust rate, heated no warmer than 2°F (1.1°C) above room setpoint, cooled to no cooler than 3°F (1.7°C) below room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control.
3. Systems serving spaces that are heated to less than 60°F (15.5°C) and are not cooled.
4. Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
5. Heating energy recovery in Climate Zones 1 and 2.
6. Cooling energy recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7 and 8.
7. Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
8. Where the largest source of air exhausted at a single location at the building exterior is less than 75 percent of the design *outdoor air* flow rate.
9. Systems expected to operate less than 20 hours per week at the *outdoor air* percentage covered by Table C403.2.6

OUTSIDE AIR (CFM)	ERV MODEL	VENTILATION LOAD A/C REDUCTION (TONS)	VENTILATION LOAD HEAT REDUCTION (BTU/h)	NEW O/A CONDITIONS SUMMER (DB / WB)	NEW O/A CONDITIONS WINTER (DB / WB)	ECONOMIC ANALYSIS PAYBACK (YEARS)	ECONOMIC ANALYSIS ROI %	ECONOMIC ANALYSIS ANNUAL SAVINGS
500	EVAA bolt-on	1.0	31,367	82.2 / 68.7	41.0 / 33.8			$400
500	EVCC	1.4	43,961	78.4 / 65.7	56.1 / 44.6	4.6	22	$550
1000	EVCD	2.6	80,611	79.7 / 66.4	50.4 / 41.2	3.1	32	$940
1500	EVDD	3.9	120,367	79.8 / 66.5	49.9 / 40.9	1.6	63	$1,400
2000	EVED	5.3	163,748	79.5 / 66.3	50.9 / 41.6	1.6	63	$1,940
2500	EVED	6.2	194,161	80.3 / 66.8	47.6 / 39.3	1.1	91	$2,100
3000	EVHF	7.9	245,774	79.4 / 66.4	51.5 / 41.7	1.1	91	$3,270
4000	EVHD	10.8	331,501	79.4 / 66.2	51.7 / 42.1	0.6	157	$4,160
5000	EVKG	13.3	409,900	79.5 / 66.3	51.1 / 41.7	0.6	167	$5,550
6000	EVLD	16.5	505,827	79.1 / 66.0	53.0 / 42.9	0.9	111	$6,570
7000	EVKD	18.0	554,912	80.0 / 66.6	49.0 / 40.3	0.4	250	$6,570
8000	EVLD	20.6	635,832	79.9 / 66.6	49.1 / 40.4	0.3	333	$7,580
9000	EVND	24.8	755,867	79.2 / 66.0	52.6 / 42.8	0.4	250	$9,750
10000	EVMD	25.4	783,645	80.1 / 66.8	48.2 / 39.8	0.4	250	$9,150
12,000	EVND	31.0	943,255	80.2 / 66.6	48.0 / 40.0	0.1	1000	$11,100
14,000	EVRD	36.9	1,121,163	79.9 / 66.4	49.3 / 40.8	0.5	200	$13,600
16,000	EVSD	42.6	1,295,721	79.7 / 66.3	50.0 / 41.3	0.4	250	$16,000
18,000	EVSD	46.5	1,414,388	80.2 / 66.6	48.0 / 40.0	0.3	333	$16,700
20,000	EVTD	51.4	1,560,067	80.3 / 66.6	47.5 / 39.7	0.1	1000	$18,300

Project Name: Fitness Gym 4/10/2009

MicroMetl Corporation AIRX ERC DESIGN POINT ANALYSIS

DESIGN CONDITIONS	Dry Bulb, F	Wet Bulb, F	Enthalpy, Btu/lb
SUMMER, Outdoor	95.00	75.00	38.80
SUMMER, Indoor	75.00	63.00	28.74
WINTER, Outdoor	-10.00	-10.00	-1.90
WINTER, Indoor	72.00	54.00	22.71

Project Unit: ERV-5	**Model Number:** EVDD	
SUPPLY AIR FLOW RATE, cfm	1440	1440
EXHAUST AIR FLOW RATE, cfm	1440	1440
Latent Effectiveness	70.47%	70.78%
Sensible Effectiveness	76.26%	76.68%
Measured Effectiveness (S/W)	73.7%	75.7%

SUPPLY AIR CONDITIONS	**Summer**	**Winter**
Dry Bulb Temperature, F	79.68	51.64
Wet Bulb Temperature, F	66.44	41.88
Enthalpy, Btu/lb	31.38	16.23
Relative Humidity, %	50.5	42.9

DESIGN LOADS, Btu/h	**Summer**	**Winter**
Outside Air, Sensible	29,620	129,055
Outside Air, Latent	32,431	32,330
Outside Air, Total	62,051	161,385

RECOVERED LOADS, Btu/h	**Summer**	**Winter**
Sensible Recovered	22,588	90,015
Latent Recovered	22,945	21,752
Total Recovered	45,532	111,767

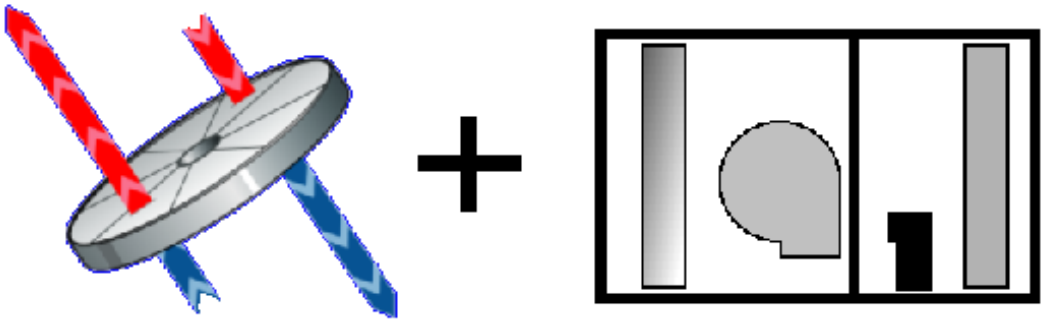
Net OA Load	16,519	42,164
INSTALLED HVAC REDUCTION		
COOLING, Tons	3.79	
HEATING, Btu/h		119,220

Project Name: Fitness Gym

4/10/2009

MicroMetl Corporation AIRX ERC SystemEER ANALYSIS

Airxchange Component Unitary Equipment



Model Unit	ERV RER	Unitary Name	Unitary Capacity	Unitary EER	ERV Cap. (Y), %	SystemEER
EVDD						
1 : ERV-5	64.66	48HJE012	120000.0	11.0	28	14.25

Project Name: Fitness Gym 4/10/2009

MicroMetl Corporation AIRX ERC ECONOMIC SUMMARY

Model Unit	Supply cfm	Exhaust cfm	Coolg Saved MBtu	Cooling $ Saved	Heatg Saved MBtu	Heating $ Saved	Fan kWh Used	Fan $ Spent	Net $ Savings
EVEF 1 : ERV-1	2280	2500	26,633	511	370,306	4,747	9,179	797	4,461
EVEF 2 : ERV-2	2280	2500	26,633	511	370,306	4,747	9,179	797	4,461
EVDD 3 : ERV-4	1320	1320	17,574	337	238,252	3,054	4,550	395	2,996
EVDD 4 : ERV-5	1440	1440	18,784	361	255,372	3,274	5,292	460	3,175
EVAA 5 : ERV-6	430	400	4,503	86	64,796	831	1,088	95	823
EVDD 6 : ERV-8	1440	1440	18,784	361	255,372	3,274	5,292	460	3,175
EVAA 7 : ERV-9	240	240	3,167	61	43,649	560	475	41	579
EVEF 8 : ERV-10	1720	1720	21,436	411	296,576	3,802	5,006	435	3,778
EVEF 9 : ERV-11	2300	2300	26,130	501	363,351	4,658	8,534	741	4,418
EVCC 10 : ERV-3	550	600	7,832	150	107,044	1,373	1,995	173	1,350
EVCC 11 : ERV-7	730	730	9,597	184	131,458	1,686	2,833	246	1,624
SUMMARY All Units	14730	15190	181,072	3,474	2,496,482	32,005	53,425	4,640	30,839

Fitness Gym

Net Present Value — [ERV]

4/10/2009

Capital & Operational Costs	Value	
ERV Cost	$ 54,000	End user cost
ERV Combo Curb Cost	$ 23,000	End user cost
Original RTU Curb Cost	$ 10,000	End user cost, this backs out original curb cost because you now have combo curbs instead
RTU Cost Savings	$ 2,500	End user cost, how much are they saving by purchasing the smaller RTUs
Additional Install Labor	$ 1,000	End user cost, this is just the extra cost to install the ERVs and should not include any regular RTU install costs
Annual Maintenance	$ 500	Today's dollars, regular filter changes, annual wheel cleaning, general inspection
Expected Annual Inflation	2.5%	US averaged 2.6% for past 15 years (1992 to 2007)
Annual Energy Savings	$ 30,800	Today's dollars
Expected Annual Energy Increase	5.0%	Use best guess for average increase over next 15 years (good luck!) - 2008 industry predications of 15-40% for natural gas, EIA/DOE says NG and LP pretty flat in 2009, EIA/DOE estimates electric to increase 2.3% in 2009 and 2.0% in 2010
Discount Rate	4.0%	Discount Rate is the rate you could get if this money was invested elsewhere

Simple Payback = 2.1 years

Gray cells will be calculated for you and do not require any entry

	Expenses			Income		
Term in years	Annual Costs	Other Costs	Total	Energy Costs	Cash flow	Cumulative Cash Flow
0	$ 65,500		$ 65,500		$ (65,500)	$ (65,500)
1	$ 500	$ 1	$ 501	$ 30,800	$ 30,299	$ (35,201)
2	$ 513	$ 1	$ 514	$ 32,340	$ 31,827	$ (3,375)
3	$ 525	$ 1	$ 526	$ 33,957	$ 33,431	$ 30,056
4	$ 538	$ 1	$ 539	$ 35,655	$ 35,115	$ 65,172
5	$ 552	$ 1	$ 553	$ 37,438	$ 36,885	$ 102,056
6	$ 566	$ 1	$ 567	$ 39,309	$ 38,743	$ 140,799
7	$ 580	$ 1	$ 581	$ 41,275	$ 40,694	$ 181,493
8	$ 594	$ 1	$ 595	$ 43,339	$ 42,743	$ 224,236
9	$ 609	$ 1	$ 610	$ 45,506	$ 44,895	$ 269,132
10	$ 624	$ 1	$ 625	$ 47,781	$ 47,155	$ 316,287
11	$ 640	$ 1	$ 641	$ 50,170	$ 49,529	$ 365,816
12	$ 656	$ 1	$ 657	$ 52,678	$ 52,021	$ 417,838
13	$ 672	$ 1	$ 673	$ 55,312	$ 54,639	$ 472,477
14	$ 689	$ 1	$ 690	$ 58,078	$ 57,388	$ 529,864
15	$ 706	$ 1	$ 707	$ 60,982	$ 60,274	$ 590,139
				NPV =	$ 403,375	
				IRR =	51%	

Example Rebates for ERVs

- Minnesota Power
  - $0.75 per CFM
- Focus on Energy in Wisconsin
  - $0.75 per CFM
- Minnesota Xcel
  - $1.00 per CFM
- Peoples Gas and North Shore Gas in Illinois
  - $0.75 per CFM
- All other Midwestern utilities use custom rebate programs

Please read all rules and qualifications for each incentive.

Staged Air Volume (SAV)

…or Single Zone VAV

…or Multi-stage Air Volume (MSAV)

…or Adaptive Fan Control

SAV™ System Overview

Industry Acronym	Definition	Application Need
VAV	**V**ariable **A**ir **V**olume	Typically multi-zone, large applied systems
SAV	**S**taged **A**ir **V**olume	Single zone VAV, simple, saves energy!
CAV	**C**onstant **A**ir **V**olume	Traditional System

Standard and High Efficiency units

Electro-mechanical or Digital Controls

VFD: pre-configured and adjustable

Adaptive Integrated Economizer Control:

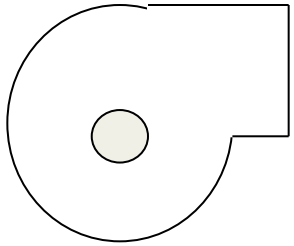
Prevents over/under ventilation

(VFD)
Speed Controller

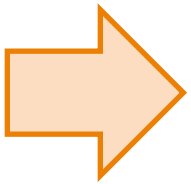
Fan Automatically Adjusts To Unit Operation Per New Standard

- 1st Stage Cooling = Fan at 67%
- 1st and 2nd Stage Cooling = Fan at 100%
- Any Heating = Fan at 100%
- Ventilation Only = Fan at 67%

Indoor Fan Motor
Belt Drive 2 Speed



Why Two Speed Fan Control?



SAV™ SYSTEM DESIGN
Why a VFD?

- A two speed (two winding) indoor fan motor would require the next size motor frame in order to achieve the same CFM. The VFD system can use the smaller standard motor frame.

- VFDs can also provide advanced options for special application including soft start capabilities, higher power factors, and lower full load KVA values

- VFDs also allow programming to meet very specific applications, and to adjust the speed of the powered motor.

Variable Frequency Drives (VFDs)

- Retro-fit to fans
- Varies the power input to motor
- On average building fan systems in the US are oversized by 60%*
- If a motor running at 100% speed costs $1,000/month, what about:
  - Running at 75% speed = $420
  - Running at 50% speed = $125
  - Due to the Affinity Laws
- Soft start means less wear & tear on couplings, belts, and motors
- Payback less than 18 months

*John Hopkins Univ. AICGS Policy Report

FAN LAW BASICS

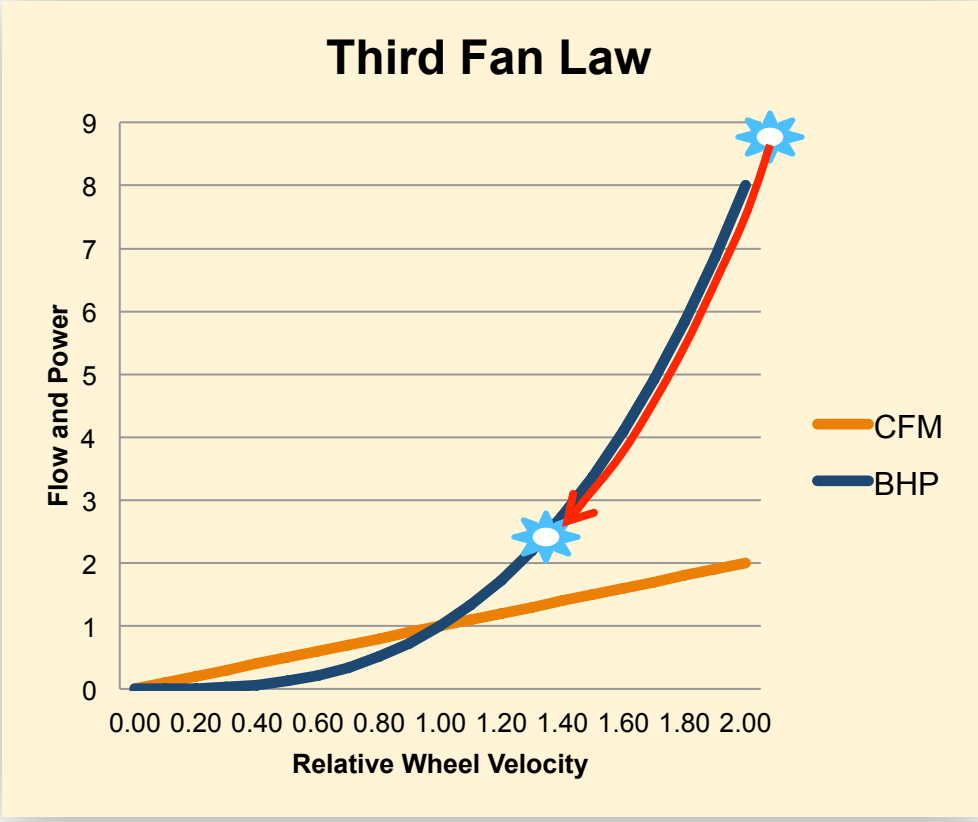
Energy saved...

Let's quickly re-visit the third fan law:

Brake horsepower (BHP) varies as the cube of the fan speed:

$$\frac{BHP_1}{BHP_2} = \left[\frac{RPM_1}{RPM_2}\right]^3$$

For simplicity, if we assume $RPM_1 = 1000$, $BHP_1 = 2.0$, and then decrease fan speed to 677 RPM (or 67%)



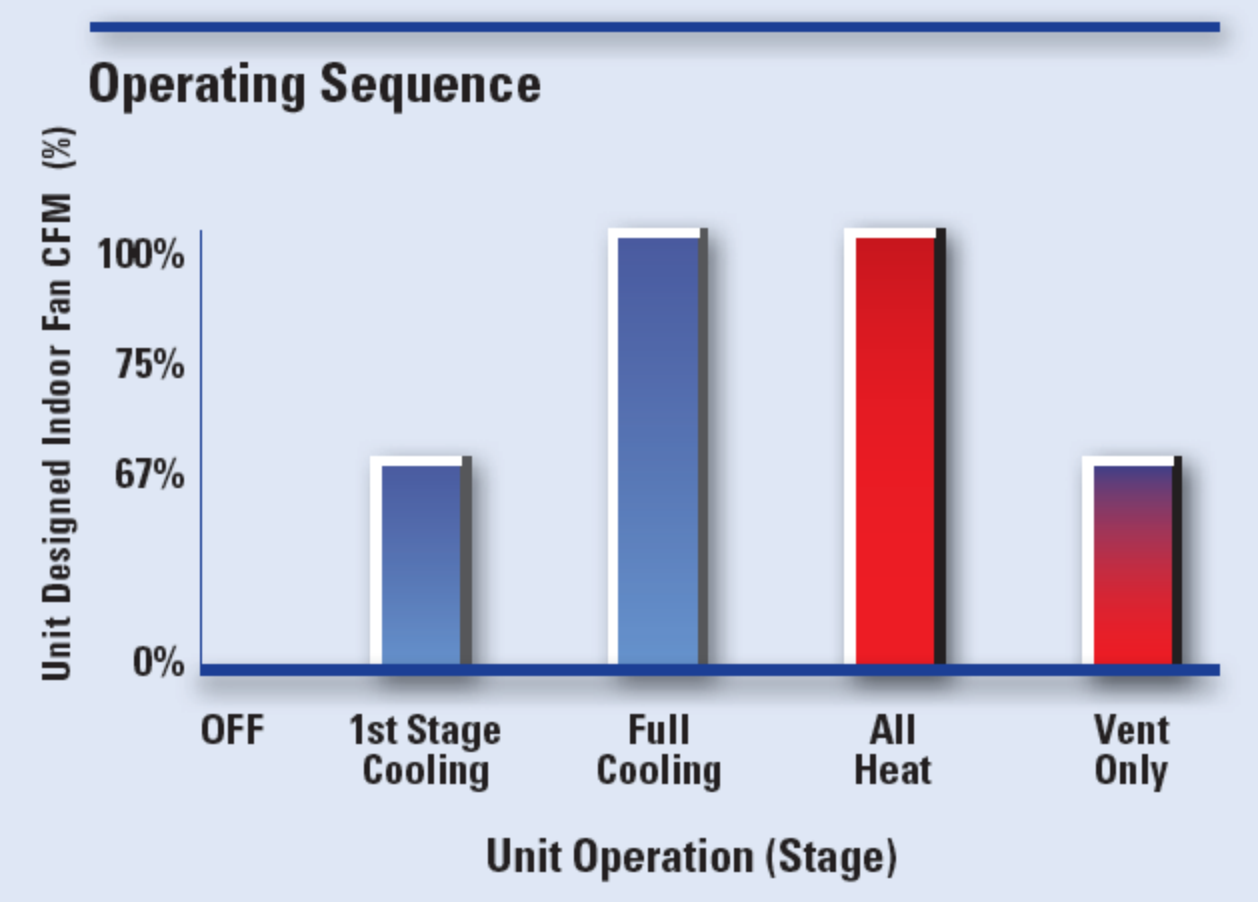
$$BHP_2 = BHP_1 \left[\frac{RPM_2}{RPM_1}\right]^3$$

$$BHP_2 = 2.0 \left[\frac{677}{1000}\right]^3$$

$$BHP_2 = .62$$

33% speed decrease, delivers 69% energy savings!

Staged Air Volume (SAV)



- Improves humidity control and saves energy
- Saves about 25-30% electrical energy in Midwest climate
- Minimum OA needs means of automatic adjustment when fan slows
- Similar logic could potentially be applied to heating mode if RTU has multiple stage heat, but pay attention to heat exchanger airflow needs

ASHRAE 90.1-2010 Fan Power Limitation

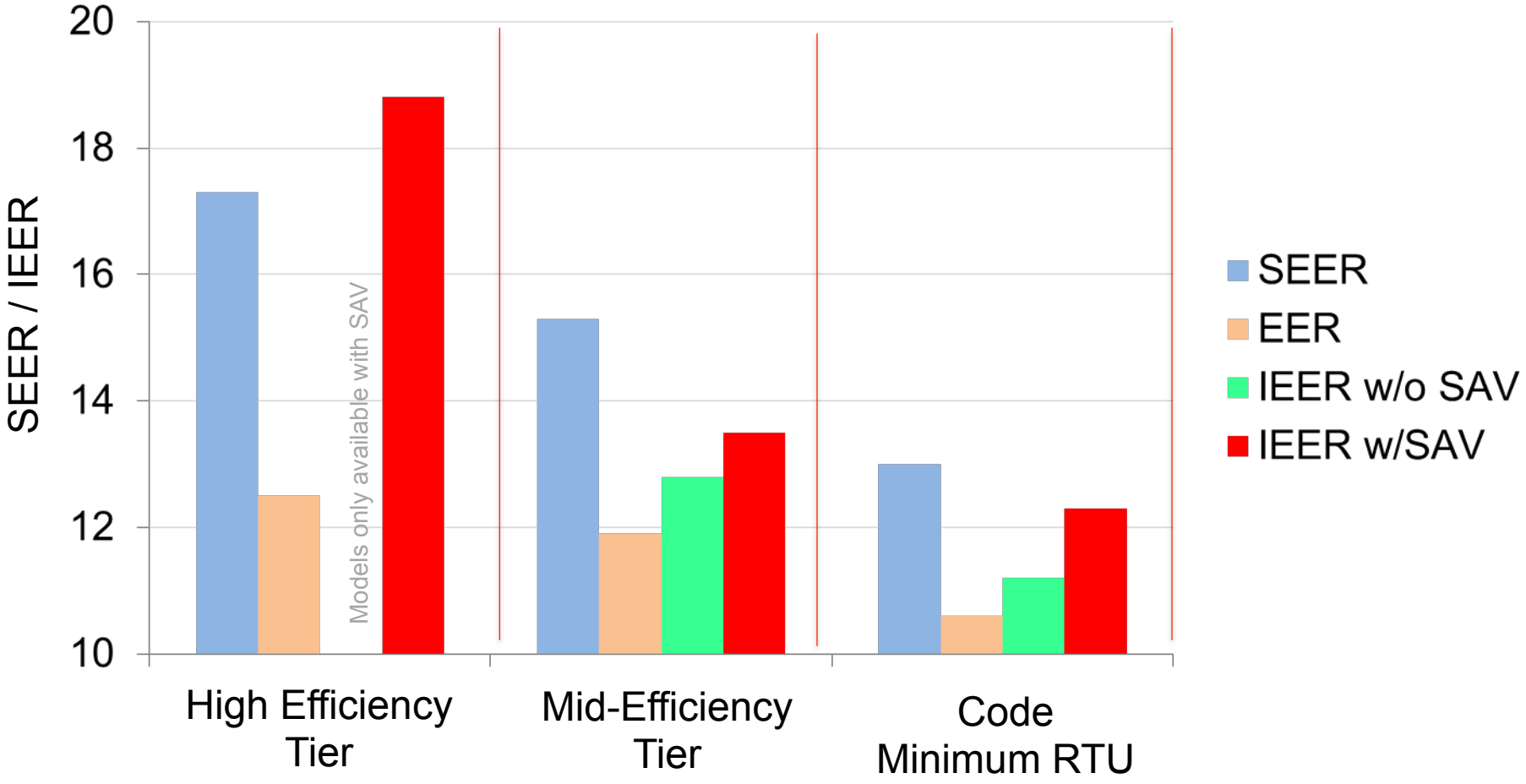
6.4.3.10 Single Zone Variable-Air-Volume Controls. HVAC systems shall have variable airflow controls as follows:

b. Effective January 1, 2012, all air-conditioning equipment and air-handling units with direct expansion cooling and a cooling capacity at AHRI conditions greater than or equal to 110,000 Btu/h that serve single zones shall have their supply fans controlled by two-speed motors or variable-speed drives. At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:

1. Two-thirds of the full fan speed, or
2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

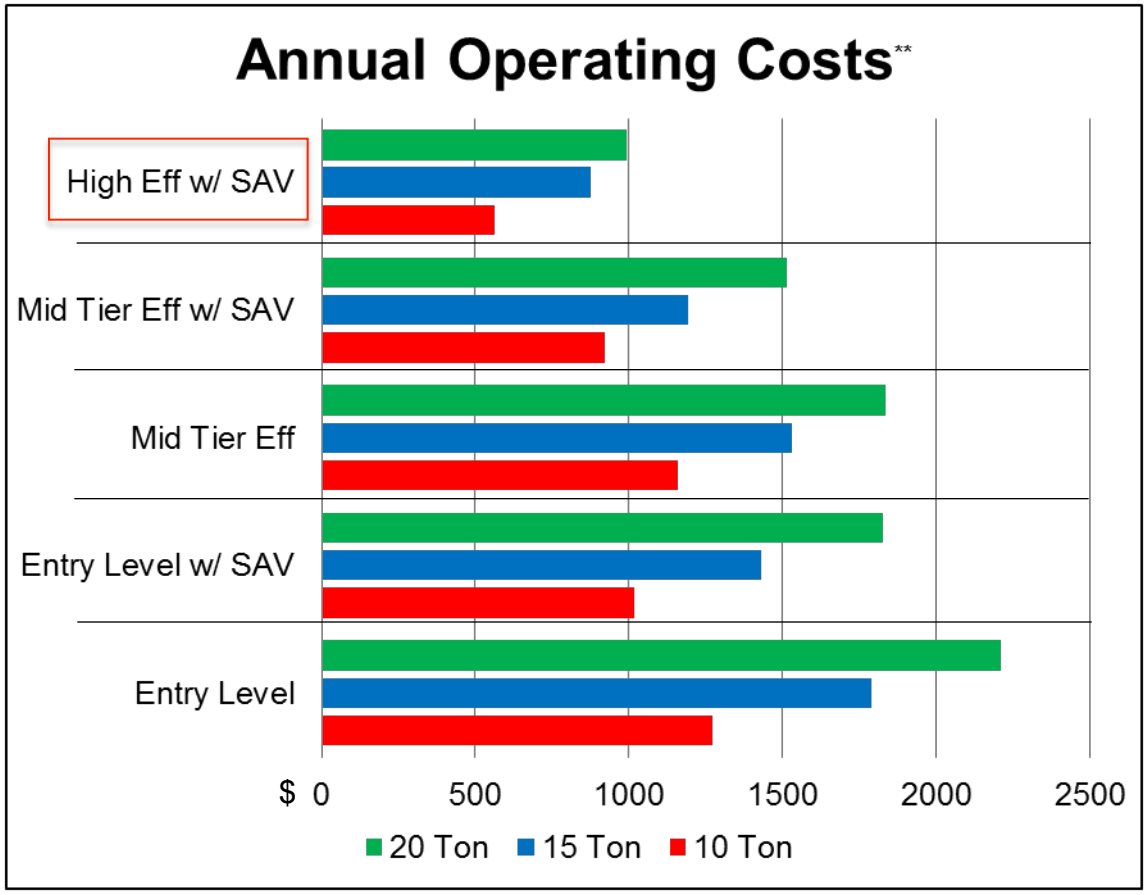
- All manufacturers offer (or will) SAV on 10 ton RTUs and up…several offer on smaller sizes also
- Note: this is a requirement of ASHRAE 90.1-2010 and 2013, but is not currently included in IECC 2012 (probable for IECC 2015 when published)

Example Manufacture Product Offering w/ SAV Option



Values are averaged

Operating Cooling Cost Comparison



Savings between 27% to 56% - WOW!

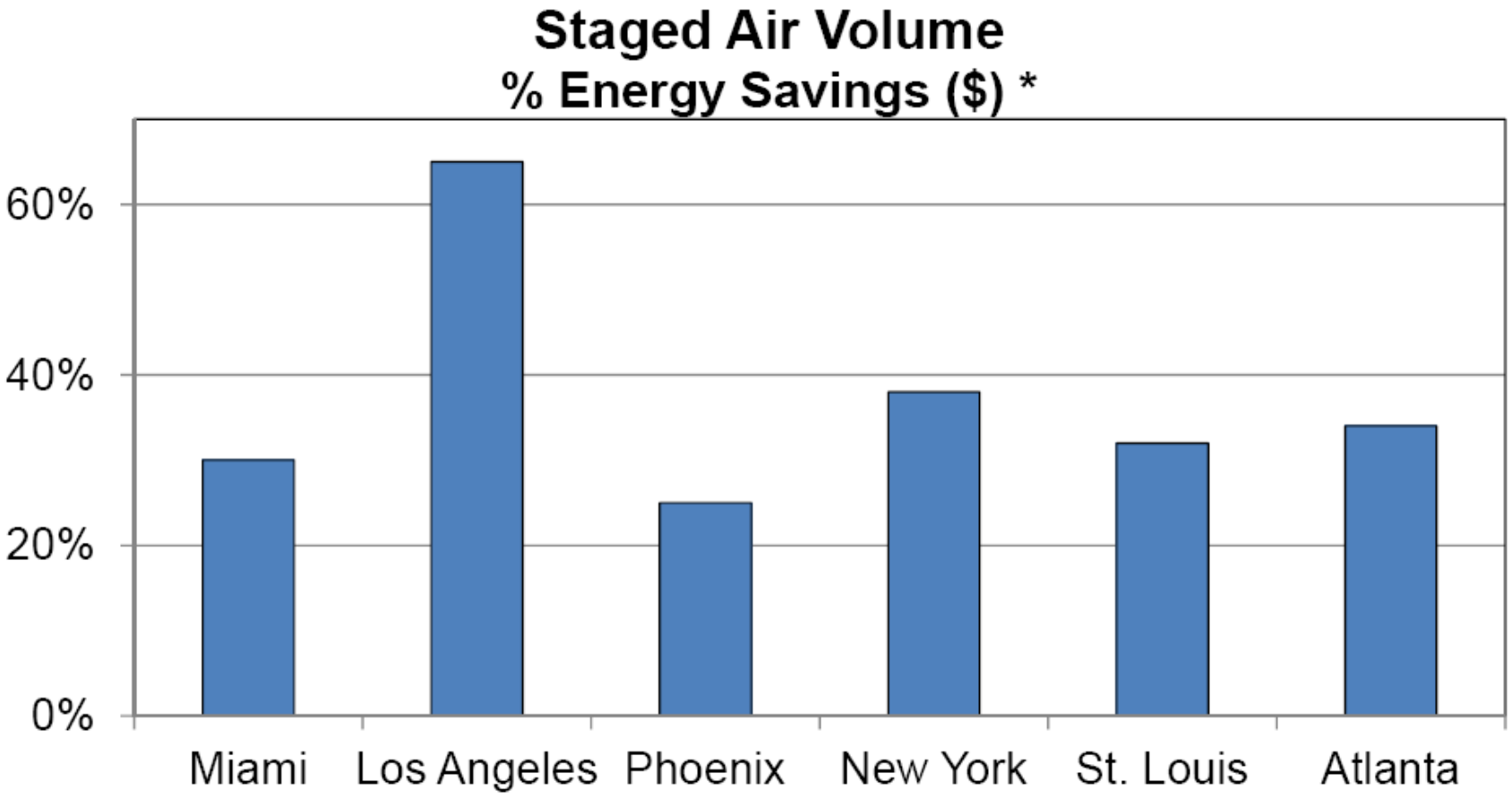
Annual Energy Savings ($, %) In Using High Efficiency RTUs*

	10 Ton	15 Ton	20 Ton
Mid Tier w/ SAV	$ 359 39%	$ 320 27%	$ 523 35%
Mid Tier	$ 596 51%	$ 655 43%	$ 842 46%
Entry Level w/ SAV	$ 454 45%	$ 558 39%	$ 834 46%
Entry Level	$ 709 56%	$ 916 51%	$ 1,217 55%

* These models use three stages of cooling capacity control and matching fan speed controls

**Building Profile:
Memphis, TN (Single Story Office Building
Simulated 10, 15 and 20 ton Models
Using DOE Energy Plus software
.10 kWh

Operating Cooling Cost Comparison



* Annual estimated electric energy savings utilizing Carrier's Hourly Analysis (HAP) Program v4.6. Based on cooling and ventilation fan runtime hours using ASHRAE 90.1 office application, default schedule, weather and building data. Carrier model 48/50TC 12 at .10 ($/kWh) energy rate.

Chicago Cooling Cost Comparison

Job Information

Job Title:	Illinois Example
Job Type:	Replacement
Notes:	

Location Information

Region:	U.S.A.
Location:	Illinois
City:	Chicago IAP

Building Information

Building Type:	Office
Unit Peak Clg Load:	10.0 Tons

Energy Prices

Input Data:	Illinois - EIA
Electric Price (Avg):	0.08640 $/kWh
Gas Price (Avg):	8.14000 $/MCF

Equipment Information

	Baseline	Proposed
Unit Description:	Unit 1	Unit 2
Equipment Type:	Cooling with Gas Heat	Cooling with Gas Heat
Model:	48TC	48TC
Size:	ED12 (Medium Heat)	ED12 (Medium Heat)
Refrigerant:	R-410a	R-410a
Age (yrs):	0 Years	
Nominal Cooling Capacity:	10.0 Tons	10.0 Tons
AHRI Cooling Rating:	11.10 EER	11.10 EER
Capacity Control:	2-Stage	2-Stage
Heating Capacity:	184.0 MBH	184.0 MBH
AHRI Heating Rating:	COP	COP
Heating Efficiency:	82 %	82 %
Indoor Fan Power:	Med. Static, 3Ph 3.70 BHP	Med. Static, 3Ph 3.70 BHP
Indoor Fan Control:	1-Speed	2-Speed
Economizer:	☑	☑
Energy Recovery:	☐	☐
DCV (CO2) Control:	☐	☐
Purchase Cost ($):	0	0
Installation Cost ($):	0	0
Ann. Maint. + Repair ($/yr):	0	0
Downtime Loss ($/yr.)	0	

Chicago Cooling Cost Comparison

Job Information

Job Title: Illinois Example

Job Type: Replacement

Notes:

Key Results

Energy Cost Savings over 5 years:	$2,885
Maintenance, Repair, Downtime, Refrig. Savings over 5 years:	$0
Total Savings over 5 years:	$2,885
Annual Energy Cost Savings:	$577 (30%)

Energy Cost Savings

Criteria	Unit 1 ($)	Unit 2 ($)	Energy Savings ($)	Percent Savings (%)
Indoor Fan	$1,379	$752	$627	45%
Cooling Electric	$268	$256	$13	5%
Heating Electric	na	na	na	na
Heating Natural Gas	$275	$337	$-62	na
Annual Energy Costs	**$1,922**	**$1,345**	**$577**	**30%**

Madison Cooling Cost Comparison

Job Information

Job Title:	Madison Example
Job Type:	Replacement
Notes:	

Location Information

Region:	U.S.A.
Location:	Wisconsin
City:	Madison

Building Information

Building Type:	Office
Unit Peak Clg Load:	10.0 Tons

Energy Prices

Input Data:	Wisconsin - EIA
Electric Price (Avg):	0.10420 $/kWh
Gas Price (Avg):	8.03000 $/MCF

Equipment Information

	Baseline	Proposed
Unit Description:	Unit 1	Unit 2
Equipment Type:	Cooling with Gas Heat	Cooling with Gas Heat
Model:	48TC	48TC
Size:	ED12 (Medium Heat)	ED12 (Medium Heat)
Refrigerant:	R-410a	R-410a
Age (yrs):	0 Years	
Nominal Cooling Capacity:	10.0 Tons	10.0 Tons
AHRI Cooling Rating:	11.10 EER	11.10 EER
Capacity Control:	2-Stage	2-Stage
Heating Capacity:	184.0 MBH	184.0 MBH
AHRI Heating Rating:	COP	COP
Heating Efficiency:	82 %	82 %
Indoor Fan Power:	Med. Static, 3Ph 3.70 BHP	Med. Static, 3Ph 3.70 BHP
Indoor Fan Control:	1-Speed	2-Speed
Economizer:	☑	☑
Energy Recovery:	☐	☐
DCV (CO_2) Control:	☐	☐
Purchase Cost ($):	0	0
Installation Cost ($):	0	0
Ann. Maint. + Repair ($/yr):	0	0
Downtime Loss ($/yr.)	0	

Madison Cooling Cost Comparison

Job Title: **Madison Example**

Job Type: **Replacement**

Notes:

Key Results

Energy Cost Savings over 5 years:	**$3,395**
Maintenance, Repair, Downtime, Refrig. Savings over 5 years:	**$0**
Total Savings over 5 years:	**$3,395**
Annual Energy Cost Savings:	**$679 (29%)**

Energy Cost Savings

Criteria	Unit 1 ($)	Unit 2 ($)	Energy Savings ($)	Percent Savings (%)
Indoor Fan	$1,665	$927	$739	44%
Cooling Electric	$277	$268	$9	3%
Heating Electric	na	na	na	na
Heating Natural Gas	$382	$451	$-69	na
Annual Energy Costs	**$2,325**	**$1,646**	**$679**	**29%**

Eau Claire Cooling Cost Comparison

Job Information

Job Title:	Eau Claire Example
Job Type:	Replacement
Notes:	

Location Information

Region:	U.S.A.
Location:	Wisconsin
City:	Eau Claire

Building Information

Building Type:	Office
Unit Peak Clg Load:	10.0 Tons

Energy Prices

Input Data:	Wisconsin - EIA
Electric Price (Avg):	0.10420 $/kWh
Gas Price (Avg):	8.03000 $/MCF

Equipment Information

	Baseline	Proposed
Unit Description:	Unit 1	Unit 2
Equipment Type:	Cooling with Gas Heat	Cooling with Gas Heat
Model:	48TC	48TC
Size:	ED12 (Medium Heat)	ED12 (Medium Heat)
Refrigerant:	R-410a	R-410a
Age (yrs):	0 Years	
Nominal Cooling Capacity:	10.0 Tons	10.0 Tons
AHRI Cooling Rating:	11.10 EER	11.10 EER
Capacity Control:	2-Stage	2-Stage
Heating Capacity:	184.0 MBH	184.0 MBH
AHRI Heating Rating:	COP	COP
Heating Efficiency:	82 %	82 %
Indoor Fan Power:	Med. Static, 3Ph 3.70 BHP	Med. Static, 3Ph 3.70 BHP
Indoor Fan Control:	1-Speed	2-Speed
Economizer:	☑	☑
Energy Recovery:	☐	☐
DCV (CO2) Control:	☐	☐
Purchase Cost ($):	0	0
Installation Cost ($):	0	0
Ann. Maint. + Repair ($/yr):	0	0
Downtime Loss ($/yr.)	0	

Eau Claire Cooling Cost Comparison

Job Title: Eau Claire Example

Job Type: Replacement

Notes:

Key Results

Energy Cost Savings over 5 years:	**$3,064**
Maintenance, Repair, Downtime, Refrig. Savings over 5 years:	**$0**
Total Savings over 5 years:	**$3,064**
Annual Energy Cost Savings:	**$613 (24%)**

Energy Cost Savings

Criteria	Unit 1 ($)	Unit 2 ($)	Energy Savings ($)	Percent Savings (%)
Indoor Fan	$1,670	$989	$681	41%
Cooling Electric	$280	$274	$6	2%
Heating Electric	na	na	na	na
Heating Natural Gas	$611	$684	$-74	na
Annual Energy Costs	**$2,561**	**$1,948**	**$613**	**24%**

Duluth Cooling Cost Comparison

Job Information

Job Title:	Duluth Example
Job Type:	Replacement
Notes:	

Location Information

Region:	U.S.A.
Location:	Minnesota
City:	Duluth

Building Information

Building Type:	Office
Unit Peak Clg Load:	10.0 Tons

Energy Prices

Input Data:	Minnesota - EIA
Electric Price (Avg):	0.08630 $/kWh
Gas Price (Avg):	7.43000 $/MCF

Equipment Information

	Baseline	Proposed
Unit Description:	Unit 1	Unit 2
Equipment Type:	Cooling with Gas Heat	Cooling with Gas Heat
Model:	48TC	48TC
Size:	ED12 (Medium Heat)	ED12 (Medium Heat)
Refrigerant:	R-410a	R-410a
Age (yrs):	0 Years	
Nominal Cooling Capacity:	10.0 Tons	10.0 Tons
AHRI Cooling Rating:	11.10 EER	11.10 EER
Capacity Control:	2-Stage	2-Stage
Heating Capacity:	184.0 MBH	184.0 MBH
AHRI Heating Rating:	COP	COP
Heating Efficiency:	82 %	82 %
Indoor Fan Power:	Med. Static, 3Ph 3.70 BHP	Med. Static, 3Ph 3.70 BHP
Indoor Fan Control:	1-Speed	2-Speed
Economizer:	☑	☑
Energy Recovery:	☐	☐
DCV (CO2) Control:	☐	☐
Purchase Cost ($):	0	0
Installation Cost ($):	0	0
Ann. Maint. + Repair ($/yr):	0	0
Downtime Loss ($/yr.)	0	

Duluth Cooling Cost Comparison

Job Title: **Duluth Example**

Job Type: **Replacement**

Notes:

Key Results

Energy Cost Savings over 5 years:	**$2,220**
Maintenance, Repair, Downtime, Refrig. Savings over 5 years:	**$0**
Total Savings over 5 years:	**$2,220**
Annual Energy Cost Savings:	**$444 (19%)**

Energy Cost Savings

Criteria	Unit 1 ($)	Unit 2 ($)	Energy Savings ($)	Percent Savings (%)
Indoor Fan	$1,384	$834	$549	40%
Cooling Electric	$121	$128	$-7	na
Heating Electric	na	na	na	na
Heating Natural Gas	$863	$962	$-98	na
Annual Energy Costs	**$2,368**	**$1,924**	**$444**	**19%**

South Bend Cooling Cost Comparison

Job Information

Job Title:	Indiana Example
Job Type:	Replacement
Notes:	

Location Information

Region:	U.S.A.
Location:	Indiana
City:	South Bend

Building Information

Building Type:	Office
Unit Peak Clg Load:	10.0 Tons

Energy Prices

Input Data:	Indiana - EIA
Electric Price (Avg):	0.08770 $/kWh
Gas Price (Avg):	8.11000 $/MCF

Equipment Information

	Baseline	Proposed
Unit Description:	Unit 1	Unit 2
Equipment Type:	Cooling with Gas Heat	Cooling with Gas Heat
Model:	48TC	48TC
Size:	ED12 (Medium Heat)	ED12 (Medium Heat)
Refrigerant:	R-410a	R-410a
Age (yrs):	0 Years	
Nominal Cooling Capacity:	10.0 Tons	10.0 Tons
AHRI Cooling Rating:	11.10 EER	11.10 EER
Capacity Control:	2-Stage	2-Stage
Heating Capacity:	184.0 MBH	184.0 MBH
AHRI Heating Rating:	COP	COP
Heating Efficiency:	82 %	82 %
Indoor Fan Power:	Med. Static, 3Ph 3.70 BHP	Med. Static, 3Ph 3.70 BHP
Indoor Fan Control:	1-Speed	2-Speed
Economizer:	☑	☑
Energy Recovery:	☐	☐
DCV (CO2) Control:	☐	☐
Purchase Cost ($):	0	0
Installation Cost ($):	0	0
Ann. Maint. + Repair ($/yr):	0	0
Downtime Loss ($/yr.)	0	

South Bend Cooling Cost Comparison

Job Title: Indiana Example

Job Type: Replacement

Notes:

Key Results

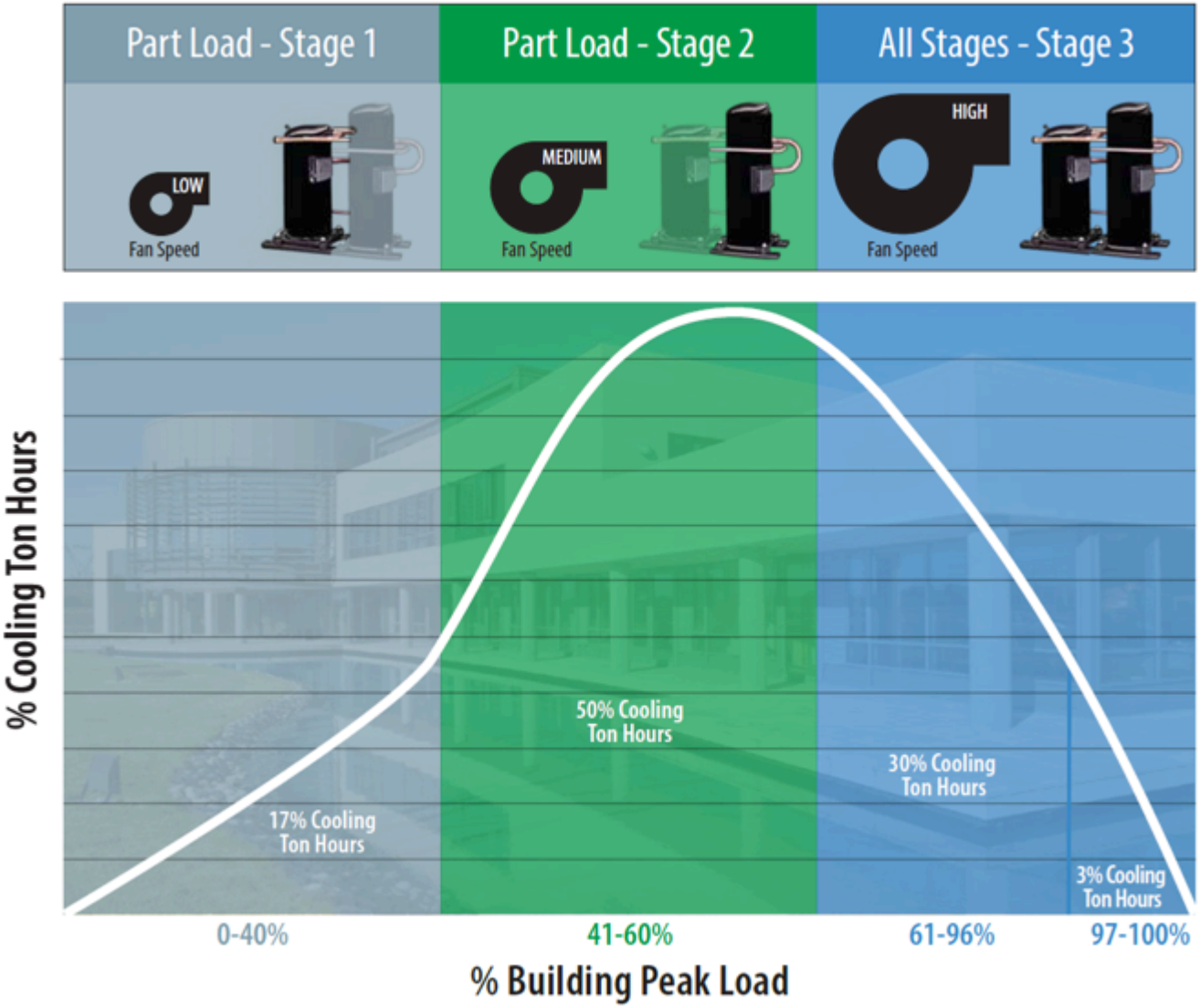
Energy Cost Savings over 5 years:	$2,888
Maintenance, Repair, Downtime, Refrig. Savings over 5 years:	$0
Total Savings over 5 years:	$2,888
Annual Energy Cost Savings:	$578 (28%)

Energy Cost Savings

Criteria	Unit 1 ($)	Unit 2 ($)	Energy Savings ($)	Percent Savings (%)
Indoor Fan	$1,397	$757	$640	46%
Cooling Electric	$304	$296	$8	3%
Heating Electric	na	na	na	na
Heating Natural Gas	$326	$397	$-70	na
Annual Energy Costs	**$2,027**	**$1,449**	**$578**	**28%**

High Efficiency RTU w/ SAV

Product Design Strategy



Benefits

- **Saves Energy**
- **Greater Comfort**
- **Better Match, Typical Building Profiles**
- **Greater IEER's**
- **Simple Design**

Typical office – Memphis TN
Sizes 07-09 use two speed indoor fan motor, all other use three speed

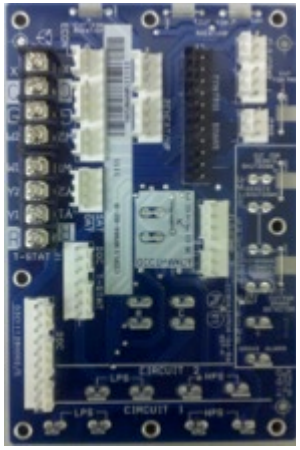
SAV™ SYSTEM DESIGN
Key components (DDC Controls)

Unit Internal Components

Space Sensor (Field Provided)

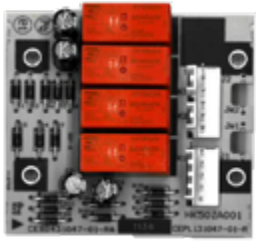
RTU Open Controller

Central Terminal Board (CTB)



Belimo Economizer Actuator (if installed)

Fan Relay Board



Variable Frequency Drive (VFD)

Inverter Duty Rated Motor

Designed factory logic automatically adjusts fan speed

VFD is factory programmed for 67% and 100%

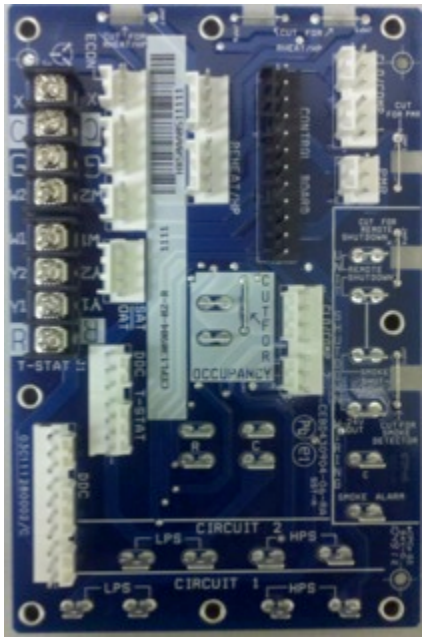
SAV™ SYSTEM DESIGN

Key components (electro-mechanical unit)

Unit Internal Components

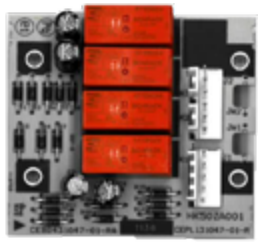
Thermostat (Field Provided)

Central Terminal Board (CTB)



Honeywell W7220 Economizer Controller (if installed)

Honeywell MS3103 Economizer Actuator (if installed)



Fan Relay Board

Variable Frequency Drive (VFD)

Inverter Duty Rated Motor

Designed factory logic automatically adjusts fan speed

VFD is factory programmed for 67% and 100%

Compatible Economizer for SAV

New W7220 Economizer controller provides the needed 2-speed operation plus new set up and diagnostic capabilities.

- Large 2-line LCD interface screen for setup, configuration and troubleshooting
- On board fault detection and diagnostics
- Automatic recognized sensor detection
- Incorporates multiple economizer damper set point capabilities for use with multi speed indoor fan motor system
- Demand control ventilation capability

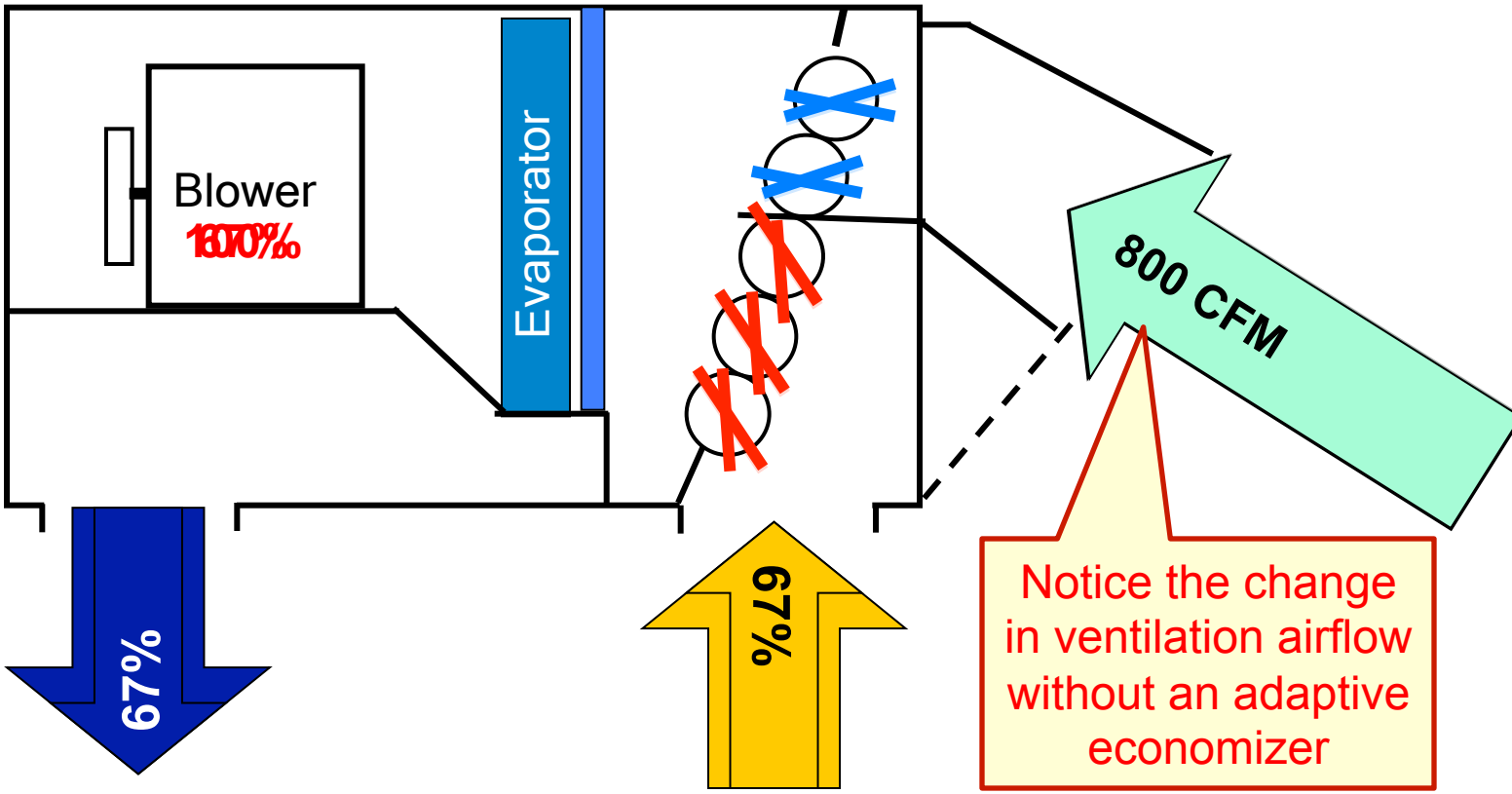
Learn more>>> http://customer.honeywell.com/Business/Cultures/en-US/Products/Demo/JADE+Economizer+Demo.htm

ECONOMIZER IMPACT

Why TWO minimum economizer positions?

Low Speed (67%) Blower with adaptive economizer operation:

2680 CFM SA (67%) 800 CFM OA ventilation (30% SA) 520 CFM



Entering Assumptions:

10 ton 2-speed fan unit with 400 CFM/ton (4000 CFM SA)

800 CFM ventilation requirement (20% SA)

Example Rebates for VFDs

- Minnesota Power
  - $40-60 per HP
- Focus on Energy in Wisconsin
  - $50 per HP
- Minnesota Xcel
  - $400+ … see side >>>
- ComEd Electric in Illinois
  - $60 per HP
  - Or as part of new ARC
  - $92 per HP (DCEO for public bldgs)
- Energizing Indiana
  - $40 per HP
- Efficiency United in Michigan
  - $60 per HP

Motor HP	Prescriptive Rebate Levels
1	$400
1.5	$400
2	$400
3	$400
5	$600
7.5	$750
10	$1,000
15	$1,250
20	$1,600
25	$2,000
30	$2,400
40	$3,000
50	$3,500
60	$4,000
75	$5,000
100	$6,000
125	$7,000
150	$7,000
200	$8,000
Larger than 200	Requires custom evaluation and preapproval.

Please read all rules and qualifications for each incentive.

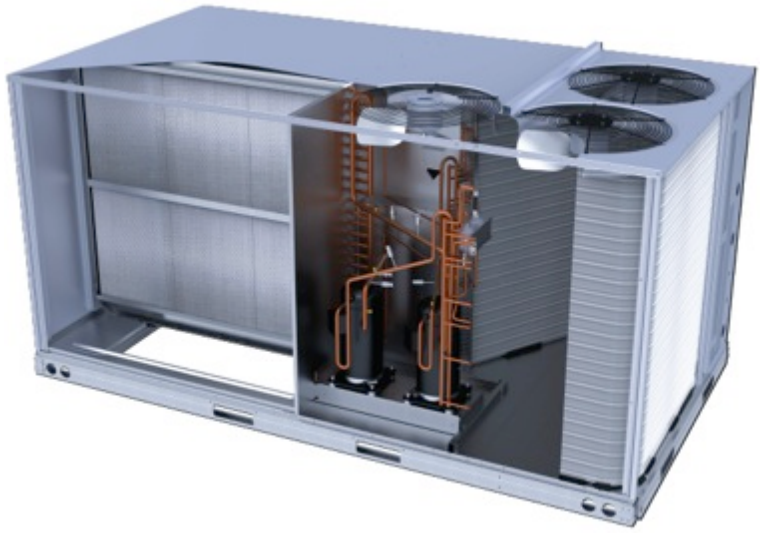
Choices for SAV

New RTUs

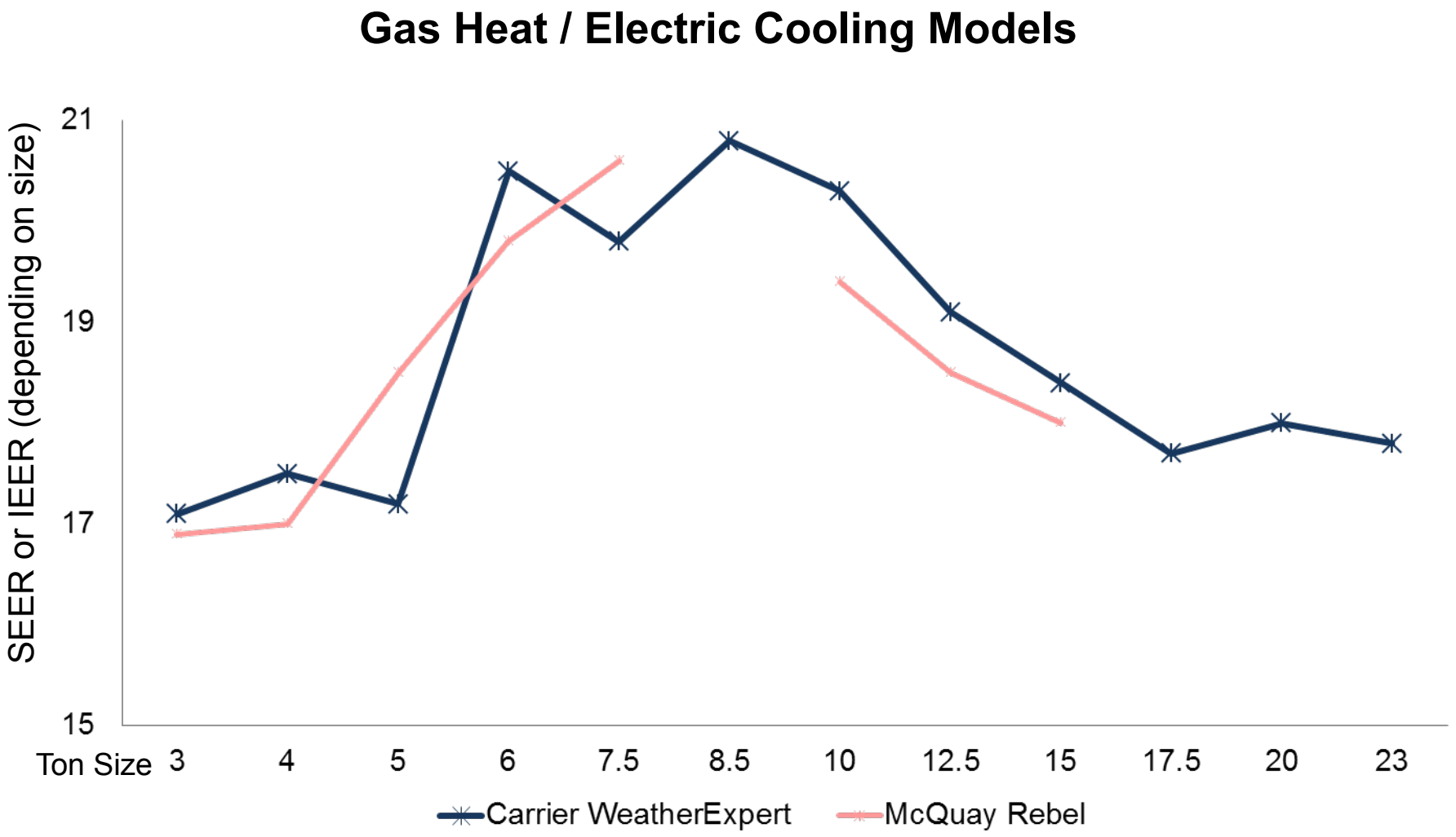
- Carrier/Bryant
- Daikin/McQuay
- Lennox
- Trane

Retro-fit Kits

- CATALYST
- Enerfit
- Digi-RTU
- Honeywell ???



Carrier WeatherExpert vs McQuay Rebel™ - Efficiency



Carrier from product catalogs (April 2012 and March 2013)
McQuay from catalog 256-6 (March 2013) and website (Jan 2014)
Lennox data not published with SAV included in IEER
Trane data not available

Items to Consider When Choosing

- Is the RTU or Retrofit kit available with adaptive integrated economizer control (aka dual minimum setpoints) to ensure minimum ventilation rate is not impacted?
- Is knowledge of a specific brand of DDC controls required?
- Is the SAV option available on their high-end and entry level units or must you get all the bells and whistles just to get SAV?
- Are other advanced options, such as ERV or dehumidification systems available on the same RTU?
- Is VFD field programming required or is it factory set?

The CATALYST is a complete retrofit solution for existing RTUs

transformativewave

catalyst

- Adds 4-5 new sensors and a variable frequency drive.
- Provides CO2-based demand control ventilation
- Advanced economization control sequence.
- Variable speed supply fan control
- Remote web-based communications via smart phone, tablet, or browser.

The CATALYST is a complete retrofit solution for existing RTUs

transformativewave

catalyst

- Proven track record of reducing overall energy use by 25%-50%
- Maintains comfort & IAQ
- Automatic air flow adjustments to protect equipment.
- Solves Power Exhaust problem
- Upgrade option replaces thermostats with Tridium BMS control via the web.
- Demand-Response capable

Constant Volume RTUs

The Most Potential:

- Units 5-tons and up
- 1 hp fan motors and up
- All brands and ages
- Fan-only = OK

The CATALYST is delivered as a complete retrofit "kit"

Pre-engineered, pre-programmed, and can be installed in only a few hours.
Produces a repeatable and scalable process with predictable results.

Energy Savings Strategies

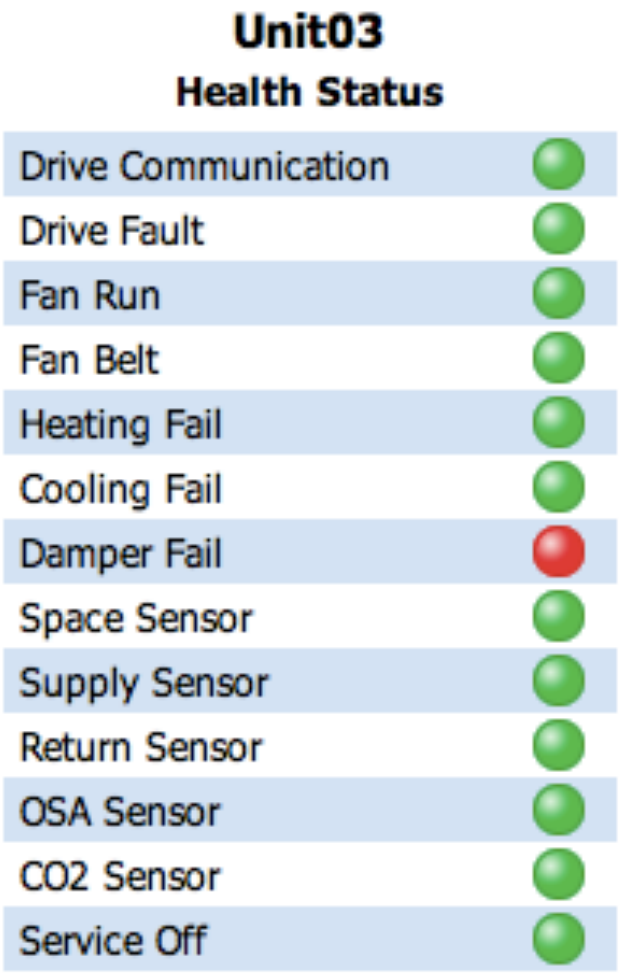
Integrated Economizer with Differential Changeover Control

Variable Speed Fan Control to Match the Needs of the Space Served

Elimination of Over-Ventilation via Demand Control Ventilation (DCV)

Remediation of Service and Operational Issues

ECONOMIZER PERFORMANCE VERIFICATION



Fault detection monitors for numerous conditions including economizer damper failure and sensor failures.

CATALYST Service Switch

- A multi-position selectable switch for service personnel use. This will enable techs to operate the system in any mode of operation for maintenance purposes.
- The use of the service switch will suppress data collection by the eIQ Platform to avoid negative impact on fault detection and analytics.

Empowers contractors to easily perform preventative maintenance and verify economizer functions without undermining the CATALYST installation.

Department of Energy

New study by PNNL shows CATALYST saved an average energy savings of 57% on 66 RTUs across 4 US climate zones.

U.S. DEPARTMENT OF ENERGY

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by **Battelle** *Since 1965*

Department of Energy

The DOE chose to work with Transformative Wave's CATALYST based on "its features & product maturity"

U.S. DEPARTMENT OF ENERGY

Pacific Northwest NATIONAL LABORATORY

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RTU EFFICIENCY STRATEGY

Performance Monitoring

Visual Fault Reporting

Perpetual Trending

Fault Prioritization

Icon-based Status Indications

Demand Management

Unit sub-metering

Remote Troubleshooting

Outlier Identification

Predictive Maintenance

Life Cycle Extension

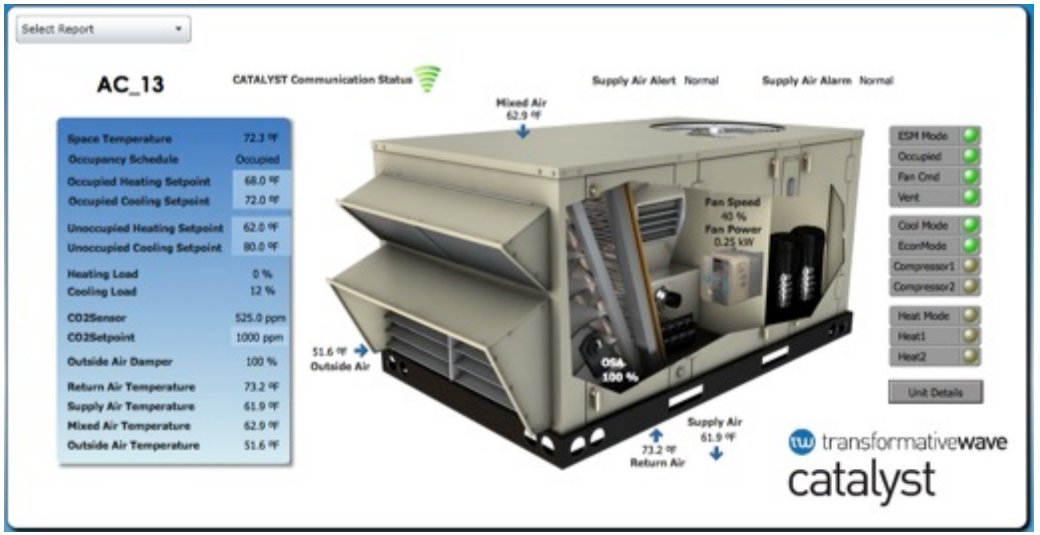
Advanced Fault Detection and Diagnostic Routines

Portfolio Energy & Performance Management

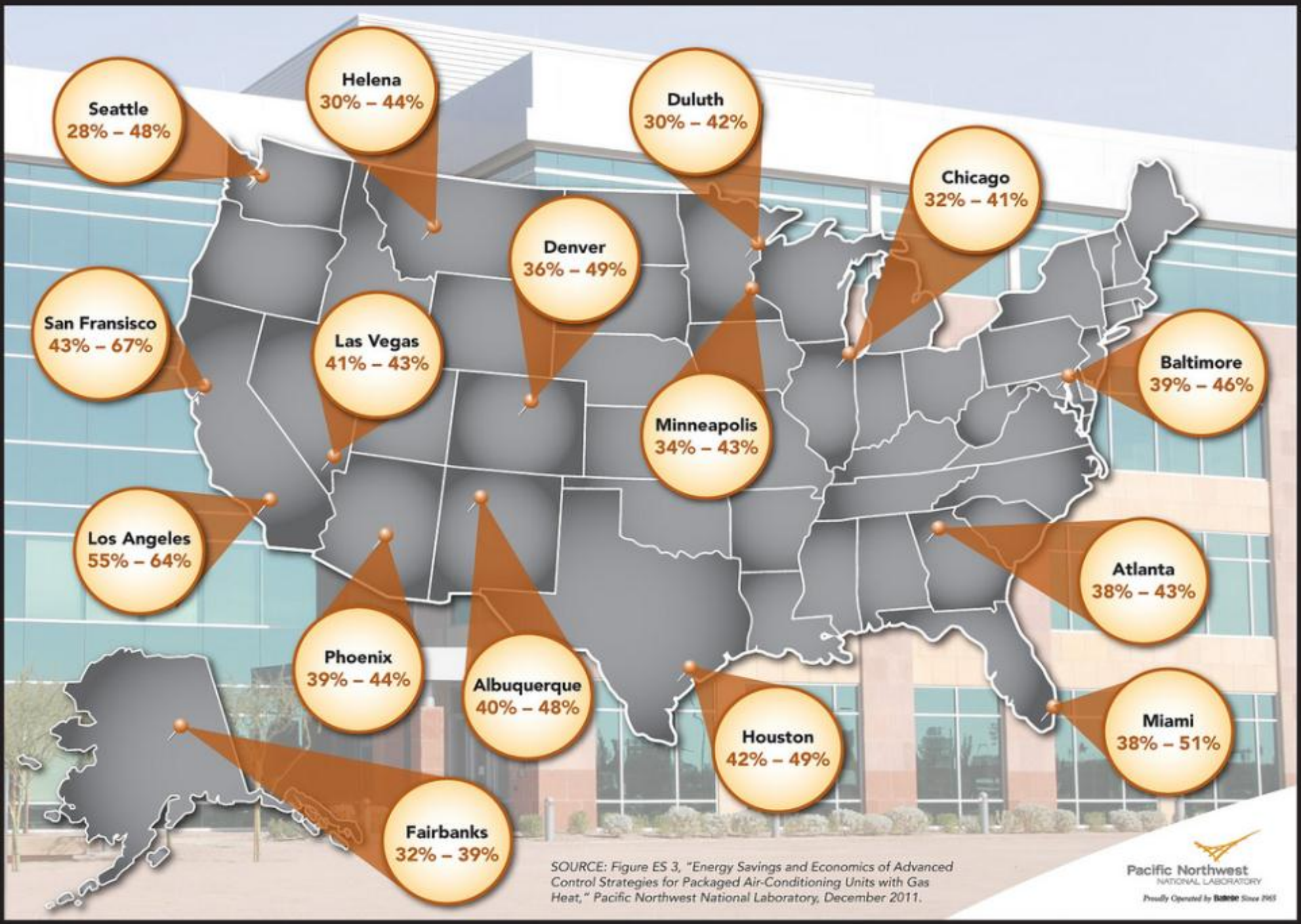
HVAC Asset Management Tools

energy intelligence platform

Powered by Niagara AX FRAMEWORK



ESTIMATED COST SAVING RANGES FOR U.S. COMMERCIAL BUILDING HVACS WITH EFFICIENCY CONTROLS



SOURCE: Figure ES 3, "Energy Savings and Economics of Advanced Control Strategies for Packaged Air-Conditioning Units with Gas Heat," Pacific Northwest National Laboratory, December 2011.

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

Case Study

Install Date: March 2010

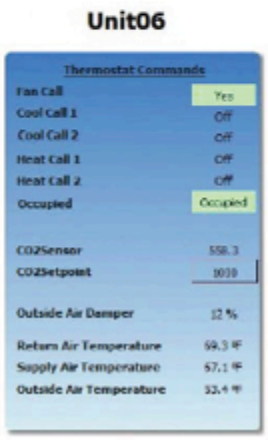
Location Type: Retail - Showroom

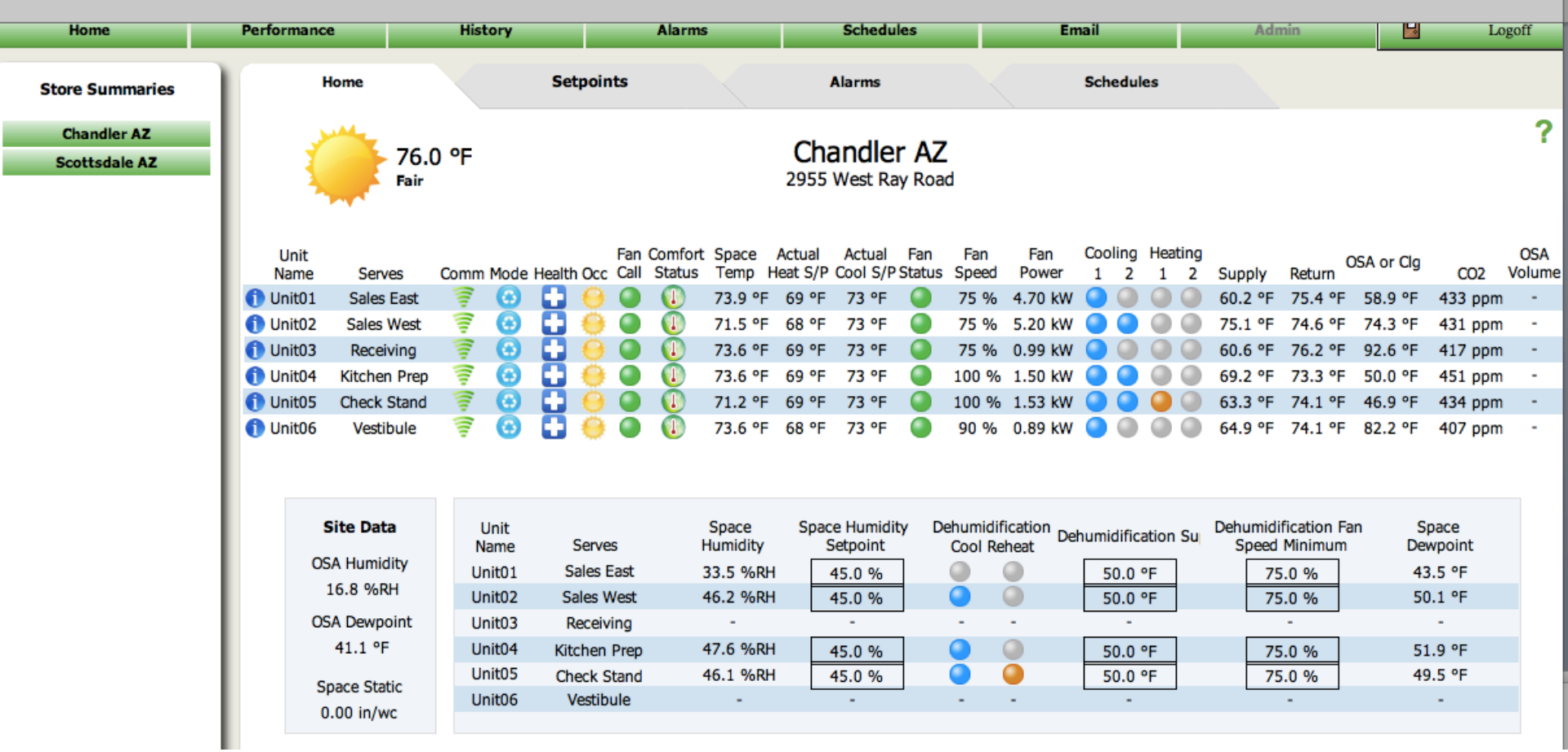
Project Details:

HVAC Equipment:	**(40) Gas/Electric units, Average Size 12.5 Tons**
Projected Savings:	**327,000 kWh/year**

Savings Summary

Projected Payback:	**1.8 Years**
ROI:	**56%**
HVAC Fan Energy:	**69% Savings in Fan Energy Usage**
Utility Bill Analysis:	**9% Reduction in Total Building Energy Use**





This screenshot from the eIQ summary view of the store shows the various aspects of the eIQ web interface that can be customized for each client. Humidity is controlled based on dew point. Lower fan speed allows for more effective dehumidification by the HVAC system.

72.0 °F
Clear

Scottsdale
7111 E. Mayo Blvd.

Unit Name	Serves	Comm	Mode	Health	Occ	Fan Call	Comfort Status	Space Temp	Actual Heat S/P	Actual Cool S/P	Fan Status	Fan Speed	Fan Power	Cooling 1	Cooling 2	Heating 1	Heating 2	Supply	Return	OSA	CO2	OSA Volume
Unit01	Sales Seafood							71.6 °F	70 °F	73 °F		40 %	0.34 kW					80.3 °F	77.5 °F	87.9 °F	446 ppm	-
Unit02	Main Sales Cntr							72.3 °F	70 °F	73 °F		40 %	0.33 kW					80.7 °F	77.8 °F	88.7 °F	450 ppm	-
Unit03	Sales Tapas							72.8 °F	70 °F	73 °F		40 %	0.36 kW					79.7 °F	76.7 °F	88.0 °F	473 ppm	-
Unit04	Loading Dock							70.3 °F	68 °F	71 °F		90 %	1.80 kW					53.0 °F	72.1 °F	84.2 °F	412 ppm	-
Unit05	Food Prep							71.0 °F	68 °F	71 °F		40 %	0.13 kW					82.7 °F	77.8 °F	82.7 °F	392 ppm	-
Unit06	Checkstands							70.6 °F	68 °F	73 °F		40 %	0.14 kW					82.8 °F	78.1 °F	80.3 °F	442 ppm	-
Unit07	Bakery							71.5 °F	68 °F	71 °F		40 %	0.14 kW					81.4 °F	77.6 °F	80.6 °F	472 ppm	-
Unit08	Vestibule							74.0 °F	68 °F	71 °F		90 %	0.84 kW					45.2 °F	74.0 °F	82.4 °F	-	-
Unit09	Produce							72.3 °F	68 °F	71 °F		90 %	0.46 kW					46.3 °F	76.8 °F	47.6 °F	443 ppm	-

Site Data

OSA Humidity
20.5 %RH

OSA Dewpoint
39.4 °F

Space Static
0.02 in/wc

	Space Humidity	Space Humidity Setpoint	Dehumidification Cool	Dehumidification Reheat	Dehumidification Su	Dehumidification Fan Speed Setpoint	Space Dewpoint
Unit01	31.3 %RH	50.0 %				80.0 %	39.7 °F
Unit02	28.8 %RH	50.0 %			-	80.0 %	38.1 °F
Unit03	35.7 %RH	50.0 %			-	80.0 %	44.7 °F
Unit04	-	-	-	-	-	-	-
Unit05	-	-	-	-	-	-	-
Unit06	34.4 %RH	50.0 %			55.0 °F	75.0 %	41.3 °F
Unit07	34.9 %RH	50.0 %			55.0 °F	75.0 %	42.5 °F
Unit08	-	-	-	-	-	-	-
Unit09	32.7 %RH	50.0 %			55.0 °F	75.0 %	41.4 °F

transformativewave catalyst

Fault Detection has identified fan belts slipping on Units 1-3. Humidity has historically been an issue at this store during the "monsoon" season. The CATALYST supermarket control sequence has enabled us to get the store humidity issues under control.

transformativewave
catalyst

The CATALYST has a four-year track record of proven results.

The product is mature and fully commercialized with almost 1,000 installations.