



Savings Analysis
for
Anywhere State University
New Office and Classroom Building
Newton, MA (Using weather data from Boston, MA)

Submitted by
Your Aircuity Rep

This analysis compares the following Ventilation and Economizer Strategies:
Dry-Bulb Economizer - Base Case
and DCV & Dry-Bulb Economizer (Aircuity) - Proposed Case

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Aircuity Cash Flow Savings Analysis



October 21, 2010

Customer Name	Anywhere State University
Project Name	New Office and Classroom Building
City	Newton, MA (Using weather data from Boston, MA)
Submitted by	Your Aircuity Rep

This Payback Compares:

Base Case	2 Dry-Bulb Economizer
Proposed	7 DCV & Dry-Bulb Economizer (Aircuity)

Energy Units Saved:

45,522 kWh saved annually
22,844 Therms saved annually
50 kW peak reduction

Capital Cost	\$ 76,800
Utility Rebates	\$ -
Net Capital Cost	\$ 76,800
1st Year Savings	\$ 28,306
Payback	2.8 years

Cash Flow Analysis

Year	Energy Savings	Net Recurring Costs Savings	Annual Savings	Net Capital Costs	Annual Savings	Cumulative Savings
2011	\$ 28,306	\$ -	\$ 28,306	\$ (76,800)	\$ (48,494)	\$ (48,494)
2012	\$ 30,005	\$ (3,164)	\$ 26,841		\$ 26,841	\$ (21,653)
2013	\$ 31,805	\$ (3,259)	\$ 28,546		\$ 28,546	\$ 6,893
2014	\$ 33,713	\$ (3,357)	\$ 30,356		\$ 30,356	\$ 37,249
2015	\$ 35,736	\$ (3,458)	\$ 32,279		\$ 32,279	\$ 69,528
2016	\$ 37,880	\$ (3,561)	\$ 34,319		\$ 34,319	\$ 103,847
2017	\$ 40,153	\$ (3,668)	\$ 36,485		\$ 36,485	\$ 140,332
2018	\$ 42,562	\$ (3,778)	\$ 38,784		\$ 38,784	\$ 179,116
2019	\$ 45,116	\$ (3,892)	\$ 41,224		\$ 41,224	\$ 220,340
2020	\$ 47,823	\$ (4,008)	\$ 43,815		\$ 43,815	\$ 264,155
Totals	\$ 373,100	\$ (32,145)	\$ 340,955	\$ (76,800)	\$ 264,155	\$ 264,155

First year energy savings represent a 39.1% reduction.

NPV =	\$ 180,689
IRR =	37.6%

10 Year Cumulative Savings



Customer	Anywhere State University
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Massachusetts Statewide Average Annual Output Emission Rates*		US National Average	Fossil Fuel	lb CO ₂ /MMBtu
CO ₂ (lb/MWh)	1,226.147	1,363.001	Coal	208.39
NO _x (lb/MWh)	1.316	2.103	Gas	116.39
SO ₂ (lb/MWh)	3.506	5.436	LP Gas	138.75
Hg (Mercury) (lb/GWh)	0.0141	0.0269	Oil	159.66

Dry-Bulb Economizer Annual Emissions

Annual Energy Units	Equivalent MMBTUs	Equivalent MBTUs	CO ₂			NO _x	SO ₂	Hg	
			Lbs	Short Tons	Metric Tons	Lbs	Lbs	Lbs	
Total kWh	401,923	1,372	1,371,762	492,816	246.4	223.5	529	1,409	0.0057
Total Therms	24,150	2,415	2,414,950	281,076	140.54	127.47			
Total Units		3,787	3,786,713	773,892	386.9	351.0	529	1,409	0.0057

DCV & Dry-Bulb Economizer (Aircuity) Annual Emissions

Annual Energy Units	Equivalent MMBTUs	Equivalent MBTUs	CO ₂			NO _x	SO ₂	Hg	
			Lbs	Short Tons	Metric Tons	Lbs	Lbs	Lbs	
Total kWh	356,400	1,216	1,216,394	436,999	218.5	198.2	469	1,250	0.0050
Total Therms	1,306	131	130,587	15,199	7.60	6.89			
Total Units		1,347	1,346,981	452,198	226.1	205.1	469	1,250	0.0050

DCV & Dry-Bulb Economizer (Aircuity) Annual Emissions Savings

Annual Energy Units Saved	Equivalent MMBTUs	Equivalent MBTUs	CO ₂			NO _x	SO ₂	Hg	
			Lbs	Short Tons	Metric Tons	Lbs	Lbs	Lbs	
Total kWh	45,522	155	155,368	55,817	27.9	25.3	60	160	0.0006
Total Therms	22,844	2,284	2,284,363	265,877	132.94	120.58			
Total Units		2,440	2,439,731	321,694	160.8	145.9	60	160	0.0006

Saving 146 metric tons of CO₂ emissions is equivalent to:

- ✓ 17,795 gallons of gasoline burned (28 average cars).
- ✓ 40 metric tons of carbon.
- ✓ the annual CO₂ emissions from 12 average american households.

* Source: eGRID v2.1: <http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html>

Annual Energy Use by Strategy



October 21, 2010

Customer Name	Anywhere State University
Project Name	New Office and Classroom Building
City	Newton, MA (Using weather data from Boston, MA)
Submitted by	Your Aircurity Rep

Annual Energy Costs

Strategy	Mode	Cooling \$	Heating \$	Supply/ Exhaust Fan \$	Total Energy \$	\$/ft ²
DCV DOAS - Traditional Sensors (OA used only for ventilation)	Day	\$ 8,127	\$ 11,367	\$ 11,854	\$ 31,348	\$0.313
	Night	\$ 1,234	\$ 3,076	\$ 3,578	\$ 7,888	\$0.079
	Total	\$ 9,361	\$ 14,443	\$ 15,432	\$ 39,236	\$0.392
CV DOAS (OA used only for ventilation)	Day	\$ 9,995	\$ 13,981	\$ 17,676	\$ 41,651	\$0.417
	Night	\$ 5,463	\$ 13,619	\$ 14,434	\$ 33,516	\$0.335
	Total	\$ 15,458	\$ 27,599	\$ 32,109	\$ 75,166	\$0.752
DCV DOAS - Aircurity (OA used only for ventilation)	Day	\$ 4,997	\$ 6,990	\$ 6,282	\$ 18,270	\$0.183
	Night	\$ 759	\$ 1,891	\$ 3,329	\$ 5,979	\$0.060
	Total	\$ 5,756	\$ 8,882	\$ 9,611	\$ 24,249	\$0.242
Fixed OA Damper	Day	\$ 15,406	\$ 10,531	\$ 17,196	\$ 43,133	\$0.431
	Night	\$ 5,463	\$ 13,619	\$ 11,540	\$ 30,622	\$0.306
	Total	\$ 20,870	\$ 24,150	\$ 28,736	\$ 73,755	\$0.738
Dry-Bulb Economizer	Day	\$ 14,031	\$ 10,531	\$ 17,196	\$ 41,758	\$0.418
	Night	\$ 5,463	\$ 13,619	\$ 11,540	\$ 30,622	\$0.306
	Total	\$ 19,495	\$ 24,150	\$ 28,736	\$ 72,380	\$0.724
Differential Enthalpy Economizer (Aircurity) (Aircurity)	Day	\$ 13,633	\$ 10,531	\$ 17,196	\$ 41,360	\$0.414
	Night	\$ 5,463	\$ 13,619	\$ 11,540	\$ 30,622	\$0.306
	Total	\$ 19,096	\$ 24,150	\$ 28,736	\$ 71,982	\$0.720
DCV & Dry-Bulb Economizer (Traditional) (Traditional Sensors)	Day	\$ 13,854	\$ 6,212	\$ 17,196	\$ 37,262	\$0.373
	Night	\$ 2,682	\$ 1,715	\$ 9,357	\$ 13,754	\$0.138
	Total	\$ 16,536	\$ 7,928	\$ 26,552	\$ 51,016	\$0.510
DCV & Dry-Bulb Economizer (Aircurity) (Aircurity)	Day	\$ 13,557	\$ 919	\$ 17,196	\$ 31,672	\$0.317
	Night	\$ 2,659	\$ 387	\$ 9,357	\$ 12,402	\$0.124
	Total	\$ 16,216	\$ 1,306	\$ 26,552	\$ 44,074	\$0.441
DCV & Diff Enthalpy Economizer (Aircurity) (Aircurity)	Day	\$ 12,683	\$ 919	\$ 17,196	\$ 30,798	\$0.308
	Night	\$ 2,464	\$ 387	\$ 9,357	\$ 12,207	\$0.122
	Total	\$ 15,147	\$ 1,306	\$ 26,552	\$ 43,005	\$0.430

Annual Energy Units Used

Strategy	Mode	Cooling Kwh	Heating Therms	Supply/ Exhaust Fan Kwh	Total Kwh	Peak kW
DCV DOAS - Traditional Sensors (OA used only for ventilation)	Day	67,722	11,367	98,785	166,506	183
	Night	10,283	3,076	29,814	40,097	54
	Total	78,004	14,443	128,599	206,603	183
CV DOAS (OA used only for ventilation)	Day	83,290	13,981	147,296	230,586	234
	Night	45,528	13,619	120,280	165,807	234
	Total	128,817	27,599	267,576	396,393	234
DCV DOAS - Aircurity (OA used only for ventilation)	Day	41,645	6,990	52,351	93,996	109
	Night	6,323	1,891	27,739	34,062	37
	Total	47,968	8,882	80,090	128,058	109
Fixed OA Damper	Day	128,387	10,531	143,298	271,685	282
	Night	45,528	13,619	96,170	141,698	224
	Total	173,915	24,150	239,468	413,383	282
Dry-Bulb Economizer	Day	116,928	10,531	143,298	260,225	282
	Night	45,528	13,619	96,170	141,698	224
	Total	162,455	24,150	239,468	401,923	282
Differential Enthalpy Economizer (Aircurity)	Day	113,609	10,531	143,298	256,906	282
	Night	45,528	13,619	96,170	141,698	224
	Total	159,136	24,150	239,468	398,604	282
DCV & Dry-Bulb Economizer (Traditional Sensors)	Day	115,449	6,212	143,298	258,747	263
	Night	22,351	1,715	77,971	100,322	105
	Total	137,800	7,928	221,269	359,069	263
DCV & Dry-Bulb Economizer (Aircurity)	Day	112,974	919	143,298	256,271	232
	Night	22,158	387	77,971	100,129	96
	Total	135,132	1,306	221,269	356,400	232
DCV & Diff Enthalpy Economizer (Aircurity)	Day	105,694	919	143,298	248,922	232
	Night	20,533	387	77,971	98,504	96
	Total	126,227	1,306	221,269	347,496	232

Customer Name	Anywhere State University		
Project Name	New Office and Classroom Building		
City	Newton, MA	Weather Station	Boston, MA
Submitted by	Your Aircuity Rep		

Bldg sq ft	100,000	ft ²	Day Zone Heating Set Point	70° F
Max People/1,000ft ² (Day)	18.0		Day Zone Cooling Set Point	74° F
Day Design Occupancy	1,800	people	Night Zone Heating Set Point	68° F
Max People/1,000ft ² (Night/Shoulder)	5.0		Night Zone Cooling Set Point	76° F
Night Design Occupancy	500		Day Supply Air Temp	55° F
Occ OA CFM/person	20	CFM	Night Supply Air Temp	55° F
Occ Design Min Vent OA (20 CFM/person)	36,000	CFM	Dry-bulb Economizer Changeover	67° F
Night Design Min Vent OA (20 CFM/person)	10,000	CFM	Max OA as % of Design CFM	100%
Base Case Min OA Set Point	36,000	CFM	Day/Occ Max Watts/ft ²	6.0
Average Day Occupancy As % of Design	50%		Day Average Plug & Lights Watts/ft ²	2.50
Average Day Occupancy	900	people	People Load in Sensible Watts/ft ²	0.63
Average Day Min DCV OA (20 CFM/person)	18,000	CFM	Total Day Average Watts/ft ²	3.13
Average Night Occupancy As % of Design	50%		Night Average Watts/ft ²	1.25
Average Night Occupancy	250	people	Skin effect on Cooling Load	0.30
Average Night Min DCV OA (20 CFM/person)	5,000	CFM	Exhaust Fan Discharge Static	3.0
24-Hour Operation	<input type="checkbox"/>		Supply Fan Discharge Static	4.0
Cooling Method	Electricity		Fan Efficiency	70%
Heating Method	Gas		COP of Refrigeration System	3.5
Electricity \$/kWh	\$ 0.1200		Heating Efficiency	80%
Chilled Water \$/Ton-Hour	\$ 0.2000	(Not used)	CV DOAS Enthalpy Wheel Eff.	0%
Gas/Oil \$/Therm	\$ 1.0000		DCV DOAS (Trad.) Enth Wheel Eff.	0%
Steam \$/1,000#	\$ 6.0000	(Not used)	DCV DOAS (Aircuity) Enth Wheel Eff.	0%
			Annual Inflation Rate	3%
			Energy Inflation Rate	6%
			Hurdle Rate	5%

Capital and Operating Cost Data

Traditional Sensors		
Type	Qty	Installed Unit Price
CO2	32	\$ 1,000
TVOC	0	\$ 1,000
CO	0	\$ 1,000
Particles	0	\$ 1,000
RH/Dew point	0	\$ 1,000
Other	0	\$ -

Aircuity	
Type	# of Locations
CO2	32
TVOC	0
CO	0
Particles	0
RH/Dew point	0
Other	0

Traditional Sensor Calibration	
Calibration Labor Minutes/Sensor	60 minutes
Calibrations per year	2 (per ASHRAE)
Daily Travel Hours (one way)	1 hour
Labor \$/Hour price	\$ 105
Annual Calibration Gas Price (per sensor per year)	\$ 30

Installed Price	\$ 76,800
Annual Services Price	\$ 3,072

Customer has sensor maintenance program

Traditional Sensor Replacement	
Annual Replacement Interval	4 years
Labor Minutes per Sensor	90 minutes
Replacement Sensor Unit Price	\$ 400

Incentive and Rebate Assumptions	
Incentive/Rebate \$/kWh	\$ -
Incentive/Rebate \$/Therm	\$ -
Incentive/Rebate \$/kW	\$ -

[Find Utility Rebates and Tax Incentives](#)

Traditional CO2 Sensor Error	
CO2 Sensor Error	80 PPM
CO2 Generation/person	0.01 CFM of CO2/person

OA Airflow Measuring Stations	
# of AHUs	-
\$/AHU for AFMS	\$ 9,980

About Aircuity DCV & Economizer Analysis	
Version #	2.6
Release Date	11/24/2009

Occupancy Schedule



October 21, 2010

Customer Name	Anywhere State University
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City	Newton, MA (Using weather data from Boston, MA)
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Hour	Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2
2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2
3	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2
4	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2
5	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2
6	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1
7	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1
8	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
9	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
10	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
11	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
Noon	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
1	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
2	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc1
3	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc2
4	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc2
5	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc2
6	UnOcc2	Occ	Occ	Occ	Occ	Occ	UnOcc2
7	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc2
8	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc2
9	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc2
10	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc2
11	UnOcc2	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc1	UnOcc2
Midnight	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2	UnOcc2

	Occ Hours	Operating UnOcc Hours	Shutdown UnOcc Hours	Occ Hours Percent	UnOcc Hours Percent	Shutdown UnOcc Percent
0-8	5	13	38	9%	23%	68%
9-16	40	6	10	71%	11%	18%
17-24	10	25	21	18%	45%	38%
Total	55	44	69	33%	26%	41%

Traditional CO2 Sensor Error Analysis

October 21, 2010

Customer Name	Anywhere State University
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City	Newton, MA (Using weather data from Boston, MA)
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Square Feet	100,000	CO2 Sensor Error	80	PPM
Design Occupancy	1,800	Differential System Error	160	PPM
OA CFM/person	20	CFM		
OA CFM per 1,000 ft ²	-	CFM		
OA CFM	36,000	CFM		
OA CFM	20.0	CFM/Person		
		CO2 Generation/person	0.01	CFM of CO2/person
		Differential Set point	500	PPM
		Differential Measurement Error	32%	(=160 PPM / 500 PPM)
		Max Clamped % Error	454%	

Differential Sensing Error

CO2 Sensors: 32% Differential Measurement Error	Aircuity: 0% Differential Measurement Error
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	CO2 PPM	CFM/Person	% Error w/ Clamp
+160 PPM Error	500	20.0	0%
	468	21.4	7%
	436	22.9	15%
	404	24.8	24%
	372	26.9	34%
Set Point	340	29.4	47%
	308	32.5	62%
	276	36.2	81%
	244	41.0	105%
	212	47.2	136%
-160 PPM Error	180	55.6	178%
	Averages	32.5	63%

	CO2 PPM	CFM/Person	% Error
Set Point	500	20.0	0%
	Averages	20.0	0%

No Over-Ventilation

Over-Ventilation

Calibration Error

Based on independent data from Lawrence Berkeley National Laboratories, funded by the U.S. Department of Energy:

Assumptions:

Commercial grade CO2 sensors	
No sensor maintenance program	
Average sensor error based on LBNL study	51%
Differential CO2 set point	500 PPM
CO2 background level	400 PPM
Min OA %	36%

Expected Results:

The average over-ventilation (excess OA) is expected to be 157%

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City	Newton, MA (Using weather data from Boston, MA)
Submitted by	Your Aircuity Rep

Traditional Sensor(s)

Installed Cost

Type	Qty	Installed Unit Price	Total Price
CO2	32	\$ 1,000	\$ 32,000
TVOC	0	\$ 1,000	\$ -
CO	0	\$ 1,000	\$ -
Particles	0	\$ 1,000	\$ -
RH/Dew point	0	\$ 1,000	\$ -
Other			
Total Sensors	32		\$ 32,000
OA AFMS	0	\$ 9,980	\$ -
Total Installed Price			\$ 32,000

Calibration & Maintenance

Sensor Qty	32
Labor Minutes per Sensor	60
Calibrations per year	2 (per ASHRAE)
Total Annual Calibration Hours	64 (~ 8 days)
Daily Travel Hours (one way)	1
\$/Hour	\$ 105
Annual Calibration Gas Price	\$ 960
Annual Sensor Calibration Labor Price	\$ 9,360
Annual Calibration Price per Sensor	\$ 293

Traditional sensors will cost \$6,288 or 205% more per year.

Data Services

Not Included

Sensor Replacement

Annual Replacement Interval	4 years
Sensor Qty	32
Labor Minutes per Sensor	90
Total Replacement Labor Hours	48 (~6 days)
Daily Travel Hours (one way)	1
\$/Hour	\$ 105
Sensor Replacement Labor Price	\$ 6,300
Replacement Sensor Unit Price	\$ 400
Total Material Price	\$ 12,800
Total Sensor Replacement Price	\$ 19,100

3 Year O&M Costs

Year	Sensor Calibration	Sensor Replacement	Total O&M Costs
Year 1	\$ 9,360	\$ -	\$ 9,360
Year 2	\$ 9,641	\$ -	\$ 9,641
Year 3	\$ 9,930	\$ -	\$ 9,930
3 Year Totals	\$ 28,931	\$ -	\$ 28,931

Over 3 years, traditional sensors will cost \$22,508 or 350% more than Aircuity.

5 Year O&M Costs

Year	Sensor Calibration	Sensor Replacement	Total O&M Costs
Year 1	\$ 9,360	\$ -	\$ 9,360
Year 2	\$ 9,641	\$ -	\$ 9,641
Year 3	\$ 9,930	\$ -	\$ 9,930
Year 4	\$ 5,114	\$ 20,871	\$ 25,985
Year 5	\$ 10,535	\$ -	\$ 10,535
5 Year Totals	\$ 44,580	\$ 20,871	\$ 65,451

Over 10 years, traditional sensors will cost \$52,213 or 394% more than Aircuity.

* Year 1 Service Costs are included with the base price of the Aircuity system

Aircuity

Installed Cost

Type	# of Locations	Total Price
CO2	32	
TVOC	0	
CO	0	
Particles	0	
RH/Dew point	0	
Other	0	
Total Locations	32	\$ 76,800
OA AFMS	0	\$ -
Total Installed Price		\$ 76,800

Calibration & Maintenance

Sensors Replaced at Least Twice Annually.

Annual price	\$ 3,072
Annual Calibration Price per Zone	\$ 96

Data Services

Included in Calibration & Maintenance

Sensor Replacement

Included in Aircuity Calibration & Maintenance

Total Sensor Replacement Price	\$ -
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3 Year O&M Costs

Year	Total O&M Costs
Year 1	\$ - *
Year 2	\$ 3,164
Year 3	\$ 3,259
3 Year Totals	\$ 6,423

5 Year O&M Costs

Year	Total O&M Costs
Year 1	\$ - *
Year 2	\$ 3,164
Year 3	\$ 3,259
Year 4	\$ 3,357
Year 5	\$ 3,458
5 Year Totals	\$ 13,238