AIRCUITY®

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

Aircuity Cash Flow Savings Analysis

October 21, 2010

Customer Name	**Anywhere State University**
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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

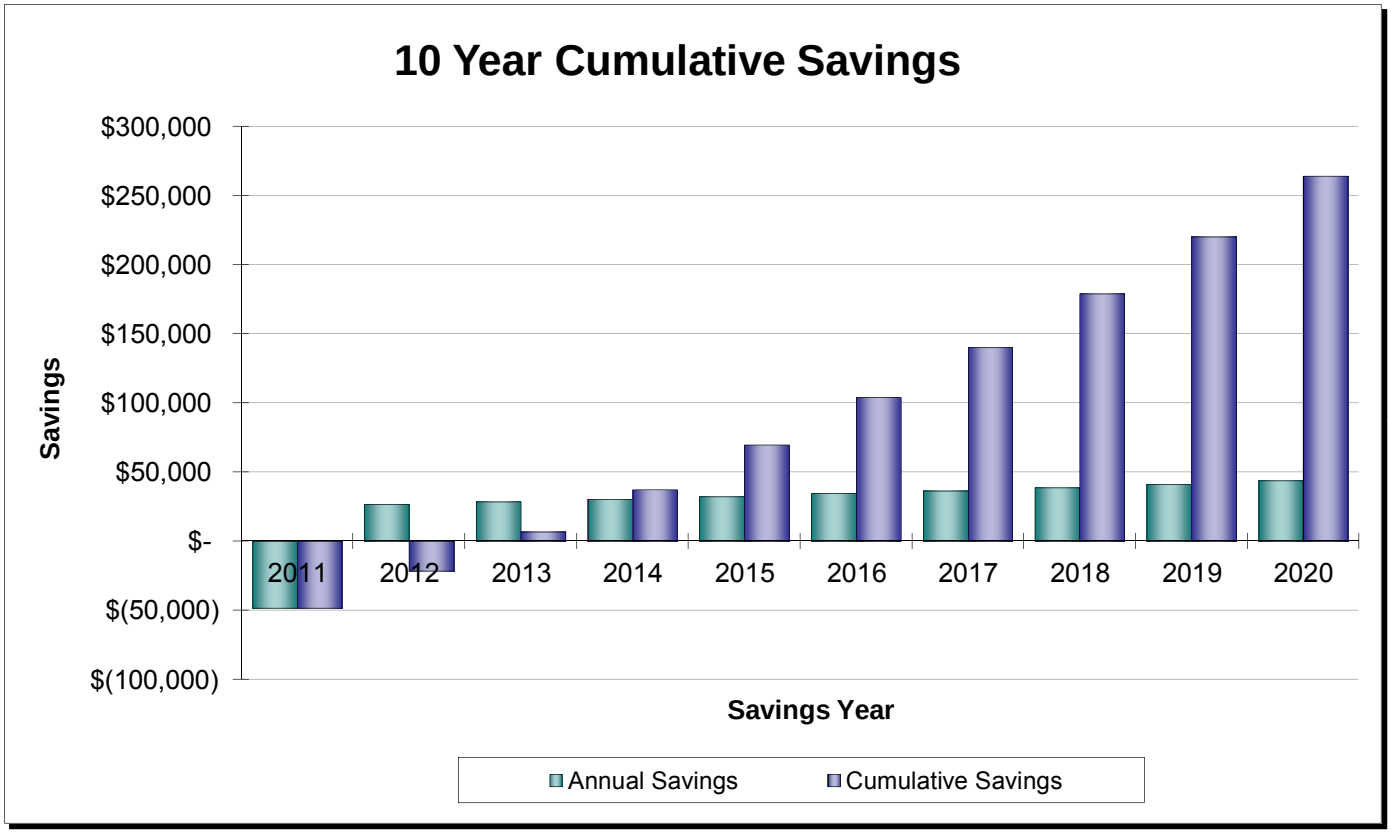
Capital Cost	$ 76,800
Utility Rebates	$ -
Net Capital Cost	$ 76,800
1st Year Savings	$ 28,306
Payback	**2.8 years**

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%



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Massachusetts Statewide Average Annual Output Emission Rates*		US National Average
CO_2 (lb/MWh)	1,226.147	1,363.001
NOx (lb/MWh)	1.316	2.103
SO_2 (lb/MWh)	3.506	5.436
Hg (Mercury) (lb/GWh)	0.0141	0.0269

Fossil Fuel	lb CO_2/ MMBtu
Coal	208.39
Gas	116.39
LP Gas	138.75
Oil	159.66

Dry-Bulb Economizer Annual Emissions

Annual Energy Units		Equivalent MMBTUs	Equivalent MBTUs	CO_2 Lbs	CO_2 Short Tons	CO_2 Metric Tons	NOx Lbs	SO_2 Lbs	Hg 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 Lbs	CO_2 Short Tons	CO_2 Metric Tons	NOx Lbs	SO_2 Lbs	Hg 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 Lbs**	**CO_2 Short Tons**	**CO_2 Metric Tons**	**NOx Lbs**	**SO_2 Lbs**	**Hg 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

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Annual Energy Costs

Strategy	Mode	Cooling $	Heating $	Supply/ Exhaust Fan $	Total Energy $	$/ft^2
DCV DOAS - Traditional Sensors	Day	$ 8,127	$ 11,367	$ 11,854	$ 31,348	$0.313
(OA used only for ventilation)	Night	$ 1,234	$ 3,076	$ 3,578	$ 7,888	$0.079
	Total	**$ 9,361**	**$ 14,443**	**$ 15,432**	**$ 39,236**	**$0.392**
CV DOAS	Day	$ 9,995	$ 13,981	$ 17,676	$ 41,651	$0.417
(OA used only for ventilation)	Night	$ 5,463	$ 13,619	$ 14,434	$ 33,516	$0.335
	Total	**$ 15,458**	**$ 27,599**	**$ 32,109**	**$ 75,166**	**$0.752**
DCV DOAS - Aircuity	Day	$ 4,997	$ 6,990	$ 6,282	$ 18,270	$0.183
(OA used only for ventilation)	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 (Aircuity)	Day	$ 13,633	$ 10,531	$ 17,196	$ 41,360	$0.414
(Aircuity)	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	Day	$ 13,854	$ 6,212	$ 17,196	$ 37,262	$0.373
(Traditional Sensors)	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 (Aircuity)	Day	$ 13,557	$ 919	$ 17,196	$ 31,672	$0.317
(Aircuity)	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 (Aircuity)	Day	$ 12,683	$ 919	$ 17,196	$ 30,798	$0.308
(Aircuity)	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	Day	67,722	11,367	98,785	166,506	183
(OA used only for ventilation)	Night	10,283	3,076	29,814	40,097	54
	Total	**78,004**	**14,443**	**128,599**	**206,603**	**183**
CV DOAS	Day	83,290	13,981	147,296	230,586	234
(OA used only for ventilation)	Night	45,528	13,619	120,280	165,807	234
	Total	**128,817**	**27,599**	**267,576**	**396,393**	**234**
DCV DOAS - Aircuity	Day	41,645	6,990	52,351	93,996	109
(OA used only for ventilation)	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	Day	113,609	10,531	143,298	256,906	282
(Aircuity)	Night	45,528	13,619	96,170	141,698	224
	Total	**159,136**	**24,150**	**239,468**	**398,604**	**282**
DCV & Dry-Bulb Economizer	Day	115,449	6,212	143,298	258,747	263
(Traditional Sensors)	Night	22,351	1,715	77,971	100,322	105
	Total	**137,800**	**7,928**	**221,269**	**359,069**	**263**
DCV & Dry-Bulb Economizer	Day	112,974	919	143,298	256,271	232
(Aircuity)	Night	22,158	387	77,971	100,129	96
	Total	**135,132**	**1,306**	**221,269**	**356,400**	**232**
DCV & Diff Enthalpy Economizer	Day	105,694	919	143,298	248,992	232
(Aircuity)	Night	20,533	387	77,971	98,504	96
	Total	**126,227**	**1,306**	**221,269**	**347,496**	**232**

Aircuity Savings Analysis Assumptions

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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			
Night Design Min Vent OA (20 CFM/person)	10,000	CFM	Dry-bulb Economizer Changeover	67° F	
			Max OA as % of Design CFM	100%	
Base Case Min OA Set Point	36,000	CFM			
			Day/Occ Max Watts/ft^2	6.0	watts
Average Day Occupancy As % of Design	50%		Day Average Plug & Lights Watts/ft^2	2.50	watts
Average Day Occupancy	900	people	People Load in Sensible Watts/ft2	0.63	watts
Average Day Min DCV OA (20 CFM/person)	18,000	CFM	Total Day Average Watts/ft2	3.13	watts
			Night Average Watts/ft^2	1.25	watts
Average Night Occupancy As % of Design	50%		Skin effect on Cooling Load	0.30	watts
Average Night Occupancy	250	people			
Average Night Min DCV OA (20 CFM/person)	5,000	CFM	Exhaust Fan Discharge Static	3.0	in. w.c.
			Supply Fan Discharge Static	4.0	in. w.c.
24-Hour Operation	☐		Fan Efficiency	70%	
			COP of Refrigeration System	3.5	
Cooling Method	Electricity		Heating Efficiency	80%	
Heating Method	Gas				
			CV DOAS Enthalpy Wheel Eff.	0%	
Electricity $/kWh	$ 0.1200		DCV DOAS (Trad.) Enth Wheel Eff.	0%	
Chilled Water $/Ton-Hour	$ 0.2000	*(Not used)*	DCV DOAS (Aircuity) Enth Wheel Eff.	0%	
Gas/Oil $/Therm	$ 1.0000				
Steam $/1,000#	$ 6.0000	*(Not used)*	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	$ -

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

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

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	

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

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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

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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 ft²	-	CFM	CO2 Generation/person	0.01	CFM of CO2/person
OA CFM	36,000	CFM	Differential Set point	500	PPM
OA CFM	20.0	CFM/Person	Differential Measurement Error	32%	(=160 PPM / 500 PPM)
			Max Clamped % Error	454%	

Differential Sensing Error

CO2 Sensors: 32% Differential Measurement Error

	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%**

Over-Ventilation

Aircuity: 0% Differential Measurement Error

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

No 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%

Aircuity O&M Savings Analysis

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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**

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**

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	$ -

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**	

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

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**	

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