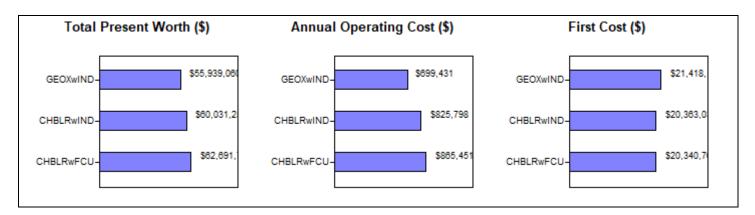
## Lifecycle Summary

### Life Cycle Cost Analysis for HVAC Options

30 year life-cycle cost analysis for thre	e HVAC system options.	
Type of Analysis	Public Sector Lifecycle Analysis	
Type of Design Alternatives	Independent	
Length of Analysis		yrs
Discount Rate	2.25	%



### Table 1. Executive Summary

Economic Criteria	Best Design Case for Each Criteria	Value (\$)
Lowest Total Present Worth	Geo-Exchange with Induction	\$55,939,058
Lowest Annual Operating Cost	Geo-Exchange with Induction	\$699,431
Lowest First Cost	Chiller/ Boiler with Fan Coil Units	\$20,340,759

## Table 2. Design Cases Ranked by Total Present Worth

Design Case Name	Design Case Short Name	Total Present Worth (\$)	Annual Operating Cost (\$/yr)	First Cost (\$)
Geo-Exchange with Induction	GEOXwIND	\$55,939,058	\$699,431	\$21,418,139
Chiller/ Boiler with Induction	CHBLRwIND	\$60,031,253	\$825,798	\$20,363,034
Chiller/ Boiler with Fan Coil Units	CHBLRwFCU	\$62,691,737	\$865,451	\$20,340,759

Type of Analysis	Public Sector Lifecycle Analysis	
Length of Analysis Income Taxes		yrs

### **General Information :**

Design Case NameGeo-Exchange with InductionDesign Case Short NameGEOXwINDDescription :Case Short Name

Geo-exchange system with central chiller-heaters and induction terminal units. \$21,481,139 total system cost.

#### Investment Costs :

Cost Item	Cost (\$)	Year Incurred	Esc Rate	Salvage Value	Useful Life
			(%/yr)	(\$)	(yrs)
Geo-Exchange System Part 1	\$ 9,000,000	0	0.00	\$ 0	30
Geo-Exchange System Part 2	\$ 3,418,139	0	0.00	\$ 0	30
Partial Replacement Cost	\$ 5,000,000	20	3.00	\$ 0	10
Geo-Exchange System Part 3	\$ 9,000,000	0	0.00	\$ 0	0

### Loans :

Loan Item	Start Year	Investment In Start Year (\$)		Term Of Loan (Years)		Payment Method
Municipal Bond Financing for HVAC	0	\$ 26,418,139	100	30	3.25	Equal Payments
Replacement Cost Financing	20	\$ 26,418,139	100	10	4.50	Equal Payments

#### Annual Operating Costs :

Cost Item	Cost (\$)	Start Year	Number Of Years	Esc Rate (%/yr)
Annual Energy Cost	\$ 539,431	1	30	3.50
Annual Maintenance Cost	\$ 160,000	1	30	3.00

There are no non-annual operating cost inputs

Type of Analysis Length of Analysis	, , , , , , , , , , , , , , , , , , ,	vrs
Income Taxes	Not Considered	,.0

### **General Information :**

Design Case Name \_\_\_\_\_\_ Chiller/ Boiler with Induction Design Case Short Name \_\_\_\_\_ CHBLRwIND Description : Central chiller with cooling tower, gas-fired hot water boilers and induction terminal units. \$19,993,034 total system cost. \$370k Additional Costs: cooling tower suport and screening plus gas service. Annual Cooling Tower Water Consum: 5920 CCF

#### Investment Costs :

Cost Item	Cost (\$)	Year Incurred	Esc Rate	Salvage Value	Useful Life
			(%/yr)	(\$)	(yrs)
Chiller Boiler Induction Part 1	\$ 9,370,000	0	0.00	\$ 0	30
Chiller Boiler Induction Part 2	\$ 1,993,034	0	0.00	\$ 0	30
Partial System Replacement Cost	\$ 6,000,000	20	3.00	\$ 0	10
Chiller Boiler Induction Part 3	\$ 9,000,000	0	0.00	\$ 0	30

#### Loans :

Loan Item	Start Year	Investment In Start Year (\$)		Term Of Loan (Years)		Payment Method
Municipal Bond Financing for HVAC	0	\$ 26,363,034	100	30	3.25	Equal Payments
Replacement Cost Financing	20	\$ 26,363,034	100	10	4.50	Equal Payments

### Annual Operating Costs :

Cost Item	Cost (\$)	Start Year	Number Of Years	Esc Rate (%/yr)
Annual Energy Costs	\$ 563,248	1	30	3.50
Annual Maintenance Costs	\$ 180,000	1	30	3.00
Cooling Tower - Water & Sewer	\$ 82,550	1	30	2.20

There are no non-annual operating cost inputs

Type of Analysis	, , , , , , , , , , , , , , , , , , ,	
Length of Analysis		yrs
Income Taxes	Not Considered	

### **General Information :**

Design Case Name ...... Chiller/ Boiler with Fan Coil Units Design Case Short Name ..... CHBLRwFCU Description : Central chiller with cooling tower, gas-fired hot water boilers and fan coil terminal units. \$19,970,759 total system cost.. \$370k Additional Costs: cooling tower suport and screening plus gas service. Annual Cooling Tower Water Consum; 5,920 CCF

#### Investment Costs :

Cost Item	Cost (\$)	Year Incurred	Esc Rate	Salvage Value	Useful Life
			(%/yr)	(\$)	(yrs)
Chiller Boiler Fan Coil Part 1	\$ 9,370,000	0	0.00	\$ 0	30
Chiller Boiler Fan Coil Part 2	\$ 1,970,759	0	0.00	\$ 0	30
Partial System Replacement Cost	\$ 7,000,000	20	3.00	\$ 0	10
Chiller Boiler Fan Coil Part 3	\$ 9,000,000	0	0.00	\$ 0	30

#### Loans :

Loan Item	Start Year	Investment In Start Year (\$)		Term Of Loan (Years)		Payment Method
Municipal Bond Financing for HVAC	0	\$ 27,340,759	100	30	3.25	Equal Payments
Replacement Cost Financing	20	\$ 27,340,759	100	10	4.50	Equal Payments

### Annual Operating Costs :

Cost Item	Cost (\$)	Start Year	Number Of Years	Esc Rate (%/yr)
Annual Energy Costs	\$ 582,901	1	30	3.50
Annual Maintenance Costs	\$ 200,000	1	30	3.00
Cooling Tower Water & Sewer	\$ 82,550	1	30	2.20

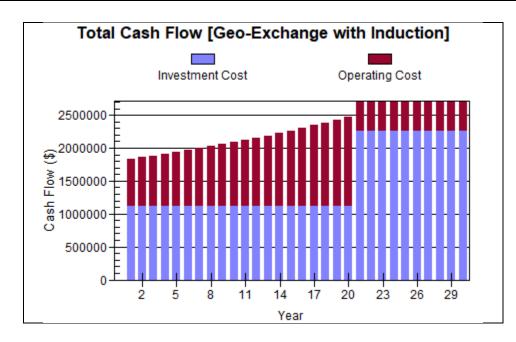
There are no non-annual operating cost inputs

Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

### Life Cycle Cost Analysis for HVAC Options

30 year life-cycle cost analysis for three HVAC system options.

Ту	pe of Analysis	Public Sector Lifecycle Analysis	
T	pe of Design Alternatives	Independent	
Le	ngth of Analysis		yrs
Di	scount Rate		%



### 1A. Component Cash Flows [Geo-Exchange with Induction], Actual Value

Year	Date	Cash	Loan	Loan Interest	Total	Annual	Non-Annual	Total	Total Cash
		Investment (\$)	Principal (\$)	(\$)	Investment	Operating	Operating	Operating	Flow (\$)
					Cost (\$)	Cost (\$)	Cost (\$)	Cost (\$)	
0	Initial	0	0	0	0	0	0	0	0
1	1	0	432,255	696,089	1,128,344	723,111	0	723,111	1,851,455
2	2	0	446,303	682,041	1,128,344	747,596	0	747,596	1,875,940
3	3	0	460,808	667,536	1,128,344	772,913	0	772,913	1,901,257
4	4	0	475,784	652,560	1,128,344	799,091	0	799,091	1,927,435
5	5	0	491,247	637,097	1,128,344	826,159	0	826,159	1,954,503

### Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

6/8/2018								
1:13:15 PM								

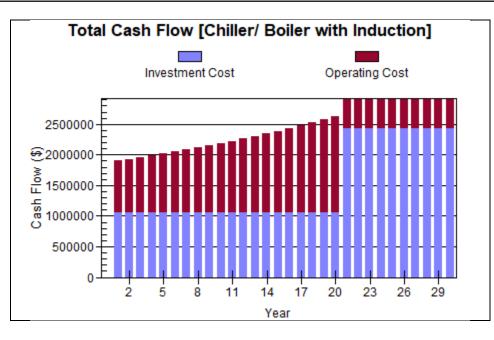
Year	Date	Cash	Loan	Loan Interest	Total	Annual	Non-Annual	Total	Total Cash
		Investment (\$)	Principal (\$)	(\$)	Investment	Operating	Operating	Operating	Flow (\$)
					Cost (\$)	Cost (\$)	Cost (\$)	Cost (\$)	
6	6	0	507,213	621,132	1,128,344	854,147	0	854,147	1,982,491
7	7	0	523,697	604,647	1,128,344	883,087	0	883,087	2,011,431
8	8	0	540,717	587,627	1,128,344	913,011	0	913,011	2,041,355
9	9	0	558,291	570,054	1,128,344	943,953	0	943,953	2,072,297
10	10	0	576,435	551,909	1,128,344	975,947	0	975,947	2,104,292
11	11	0	595,169	533,175	1,128,344	1,009,030	0	1,009,030	2,137,375
12	12	0	614,512	513,832	1,128,344	1,043,239	0	1,043,239	2,171,583
13	13	0	634,484	493,860	1,128,344	1,078,612	0	1,078,612	2,206,956
14	14	0	655,105	473,240	1,128,344	1,115,188	0	1,115,188	2,243,533
15	15	0	676,395	451,949	1,128,344	1,153,010	0	1,153,010	2,281,354
16	16	0	698,378	429,966	1,128,344	1,192,119	0	1,192,119	2,320,463
17	17	0	721,076	407,269	1,128,344	1,232,559	0	1,232,559	2,360,904
18	18	0	744,511	383,834	1,128,344	1,274,377	0	1,274,377	2,402,721
19	19	0	768,707	359,637	1,128,344	1,317,618	0	1,317,618	2,445,962
20	20	0	793,690	334,654	1,128,344	1,362,332	0	1,362,332	2,490,676
21	21	0	1,554,381	715,234	2,269,615	1,408,568	0	1,408,568	3,678,184
22	22	0	1,614,085	655,531	2,269,615	1,456,380	0	1,456,380	3,725,995
23	23	0	1,676,142	593,473	2,269,615	1,505,820	0	1,505,820	3,775,436
24	24	0	1,740,648	528,967	2,269,615	1,556,945	0	1,556,945	3,826,561
25	25	0	1,807,702	461,913	2,269,615	1,609,812	0	1,609,812	3,879,427
26	26	0	1,877,407	392,208	2,269,615	1,664,480	0	1,664,480	3,934,096
27	27	0	1,949,871	319,745	2,269,615	1,721,012	0	1,721,012	3,990,627
28	28	0	2,025,204	244,411	2,269,615	1,779,470	0	1,779,470	4,049,086
29	29	0	2,103,525	166,091	2,269,615	1,839,922	0	1,839,922	4,109,537
30	30	0	2,184,953	84,663	2,269,615	1,902,434	0	1,902,434	4,172,049
Totals		0	30,448,695	14,814,344	45,263,030	36,661,942	0	36,661,942	81,924,981

## 1B. Present Worth Cash Flows [Geo-Exchange with Induction]

Year	Date	Total Investment Cost	Total Investment Cost Total Operating Cost	
		(\$)	(\$)	(\$)
0	Initial	0	0	0
1	1	1,103,515	707,199	1,810,714
2	2	1,079,232	715,056	1,794,289
3	3	1,055,484	723,004	1,778,488
4	4	1,032,258	731,043	1,763,301
5	5	1,009,544	739,174	1,748,718
6	6	987,329	747,399	1,734,728

## Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

Year	Date	<b>Total Investment Cost</b>	<b>Total Operating Cost</b>	<b>Total Present Worth</b>
		(\$)	(\$)	(\$)
7	7	965,603	755,719	1,721,321
8	8	944,355	764,134	1,708,488
9	9	923,574	772,646	1,696,220
10	10	903,251	781,256	1,684,507
11	11	883,375	789,965	1,673,340
12	12	863,937	798,774	1,662,711
13	13	844,926	807,685	1,652,611
14	14	826,333	816,699	1,643,032
15	15	808,150	825,816	1,633,966
16	16	790,367	835,038	1,625,405
17	17	772,975	844,367	1,617,342
18	18	755,965	853,804	1,609,769
19	19	739,331	863,349	1,602,680
20	20	723,062	873,005	1,596,066
21	21	1,422,403	882,771	2,305,174
22	22	1,391,103	892,651	2,283,754
23	23	1,360,492	902,645	2,263,137
24	24	1,330,554	912,754	2,243,308
25	25	1,301,276	922,980	2,224,256
26	26	1,272,641	933,324	2,205,965
27	27	1,244,637	943,788	2,188,425
28	28	1,217,249	954,372	2,171,621
29	29	1,190,463	965,080	2,155,543
30	30	1,164,267	975,911	2,140,178
Totals		30,907,651	25,031,408	55,939,057



### 2A. Component Cash Flows [Chiller/ Boiler with Induction], Actual Value

Year	Date	Cash	Loan	Loan Interest	Total	Annual	Non-Annual	Total	Total Cash
		Investment (\$)	Principal (\$)	(\$)	Investment	Operating	Operating	Operating	Flow (\$)
					Cost (\$)	Cost (\$)	Cost (\$)	Cost (\$)	
0	Initial	0	0	0	0	0	0	0	0
1	1	0	410,961	661,799	1,072,760	852,728	0	852,728	1,925,487
2	2	0	424,317	648,442	1,072,760	880,549	0	880,549	1,953,309
3	3	0	438,108	634,652	1,072,760	909,293	0	909,293	1,982,053
4	4	0	452,346	620,414	1,072,760	938,989	0	938,989	2,011,749
5	5	0	467,047	605,712	1,072,760	969,670	0	969,670	2,042,430
6	6	0	482,226	590,533	1,072,760	1,001,369	0	1,001,369	2,074,128
7	7	0	497,899	574,861	1,072,760	1,034,119	0	1,034,119	2,106,879
8	8	0	514,080	558,679	1,072,760	1,067,957	0	1,067,957	2,140,716
9	9	0	530,788	541,972	1,072,760	1,102,918	0	1,102,918	2,175,678
10	10	0	548,039	524,721	1,072,760	1,139,040	0	1,139,040	2,211,800
11	11	0	565,850	506,910	1,072,760	1,176,363	0	1,176,363	2,249,123
12	12	0	584,240	488,520	1,072,760	1,214,927	0	1,214,927	2,287,686
13	13	0	603,228	469,532	1,072,760	1,254,773	0	1,254,773	2,327,532

### Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

6/8/2018
1:13:15 PM

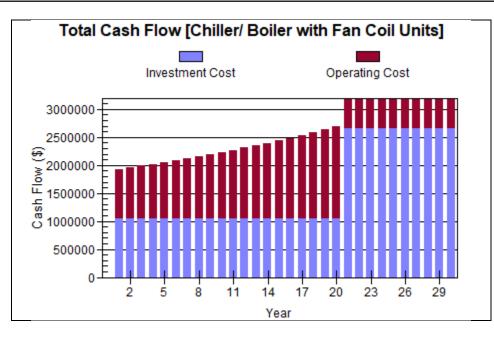
Year	Date	Cash	Loan	Loan Interest	Total	Annual	Non-Annual	Total	Total Cash
		Investment (\$)	Principal (\$)	(\$)	Investment	Operating	Operating	Operating	Flow (\$)
					Cost (\$)	Cost (\$)	Cost (\$)	Cost (\$)	
14	14	0	622,833	449,927	1,072,760	1,295,944	0	1,295,944	2,368,704
15	15	0	643,075	429,685	1,072,760	1,338,485	0	1,338,485	2,411,245
16	16	0	663,975	408,785	1,072,760	1,382,443	0	1,382,443	2,455,202
17	17	0	685,554	387,206	1,072,760	1,427,864	0	1,427,864	2,500,624
18	18	0	707,834	364,925	1,072,760	1,474,798	0	1,474,798	2,547,558
19	19	0	730,839	341,921	1,072,760	1,523,296	0	1,523,296	2,596,056
20	20	0	754,591	318,168	1,072,760	1,573,411	0	1,573,411	2,646,170
21	21	0	1,660,991	781,294	2,442,285	1,625,196	0	1,625,196	4,067,481
22	22	0	1,725,996	716,289	2,442,285	1,678,709	0	1,678,709	4,120,994
23	23	0	1,793,611	648,674	2,442,285	1,734,007	0	1,734,007	4,176,292
24	24	0	1,863,941	578,344	2,442,285	1,791,151	0	1,791,151	4,233,436
25	25	0	1,937,099	505,186	2,442,285	1,850,202	0	1,850,202	4,292,487
26	26	0	2,013,200	429,085	2,442,285	1,911,226	0	1,911,226	4,353,511
27	27	0	2,092,366	349,919	2,442,285	1,974,288	0	1,974,288	4,416,573
28	28	0	2,174,723	267,561	2,442,285	2,039,458	0	2,039,458	4,481,743
29	29	0	2,260,403	181,882	2,442,285	2,106,806	0	2,106,806	4,549,091
30	30	0	2,349,543	92,742	2,442,285	2,176,407	0	2,176,407	4,618,691
Totals		0	31,199,703	14,678,340	45,878,050	42,446,386	0	42,446,386	88,324,428

### 2B. Present Worth Cash Flows [Chiller/ Boiler with Induction]

Year	Date	Total Investment Cost	Total Operating Cost	Total Present Worth
		(\$)	(\$)	(\$)
0	Initial	0	0	0
1	1	1,049,154	833,964	1,883,117
2	2	1,026,067	842,223	1,868,290
3	3	1,003,489	850,578	1,854,066
4	4	981,407	859,028	1,840,435
5	5	959,811	867,576	1,827,387
6	6	938,691	876,222	1,814,913
7	7	918,035	884,968	1,803,003
8	8	897,834	893,814	1,791,648
9	9	878,077	902,762	1,780,839
10	10	858,755	911,813	1,770,568
11	11	839,858	920,969	1,760,827
12	12	821,377	930,230	1,751,607
13	13	803,303	939,598	1,742,901
14	14	785,626	949,073	1,734,700

## Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

Year	Date	<b>Total Investment Cost</b>	<b>Total Operating Cost</b>	<b>Total Present Worth</b>	
		(\$)	(\$)	(\$)	
15	15	768,339	958,658	1,726,997	
16	16	751,431	968,354	1,719,785	
17	17	734,896	978,161	1,713,057	
18	18	718,725	988,082	1,706,807	
19	19	702,909	998,117	1,701,026	
20	20	687,442	1,008,267	1,695,709	
21	21	1,530,617	1,018,535	2,549,153	
22	22	1,496,936	1,028,922	2,525,858	
23	23	1,463,996	1,039,428	2,503,425	
24	24	1,431,781	1,050,056	2,481,838	
25	25	1,400,275	1,060,807	2,461,082	
26	26	1,369,462	1,071,682	2,441,144	
27	27	1,339,327	1,082,682	2,422,010	
28	28	1,309,856	1,093,810	2,403,666	
29	29	1,281,032	1,105,067	2,386,099	
30	30	1,252,843	1,116,453	2,369,297	
Totals		31,001,351	29,029,899	60,031,254	



### 3A. Component Cash Flows [Chiller/ Boiler with Fan Coil Units], Actual Value

Year	Date	Cash	Loan	Loan Interest	Total	Annual	Non-Annual	Total	Total Cash
		Investment (\$)	Principal (\$)	(\$)	Investment	Operating	Operating	Operating	Flow (\$)
					Cost (\$)	Cost (\$)	Cost (\$)	Cost (\$)	
0	Initial	0	0	0	0	0	0	0	0
1	1	0	410,511	661,075	1,071,586	893,669	0	893,669	1,965,255
2	2	0	423,853	647,733	1,071,586	922,820	0	922,820	1,994,406
3	3	0	437,628	633,958	1,071,586	952,937	0	952,937	2,024,523
4	4	0	451,851	619,735	1,071,586	984,052	0	984,052	2,055,638
5	5	0	466,536	605,050	1,071,586	1,016,197	0	1,016,197	2,087,783
6	6	0	481,699	589,887	1,071,586	1,049,408	0	1,049,408	2,120,994
7	7	0	497,354	574,232	1,071,586	1,083,721	0	1,083,721	2,155,307
8	8	0	513,518	558,068	1,071,586	1,119,171	0	1,119,171	2,190,758
9	9	0	530,207	541,379	1,071,586	1,155,798	0	1,155,798	2,227,385
10	10	0	547,439	524,147	1,071,586	1,193,641	0	1,193,641	2,265,227
11	11	0	565,231	506,355	1,071,586	1,232,741	0	1,232,741	2,304,327
12	12	0	583,601	487,985	1,071,586	1,273,139	0	1,273,139	2,344,725
13	13	0	602,568	469,018	1,071,586	1,314,880	0	1,314,880	2,386,466

### Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

6/8/2018				
1:13:15 PM				

Year	Date	Cash	Loan	Loan Interest	Total	Annual	Non-Annual	Total	Total Cash
		Investment (\$)	Principal (\$)	(\$)	Investment	Operating	Operating	Operating	Flow (\$)
					Cost (\$)	Cost (\$)	Cost (\$)	Cost (\$)	
14	14	0	622,151	449,435	1,071,586	1,358,008	0	1,358,008	2,429,594
15	15	0	642,371	429,215	1,071,586	1,402,570	0	1,402,570	2,474,156
16	16	0	663,248	408,338	1,071,586	1,448,615	0	1,448,615	2,520,201
17	17	0	684,804	386,782	1,071,586	1,496,192	0	1,496,192	2,567,778
18	18	0	707,060	364,526	1,071,586	1,545,352	0	1,545,352	2,616,938
19	19	0	730,039	341,547	1,071,586	1,596,149	0	1,596,149	2,667,735
20	20	0	753,766	317,820	1,071,586	1,648,638	0	1,648,638	2,720,224
21	21	0	1,807,118	862,248	2,669,366	1,702,876	0	1,702,876	4,372,242
22	22	0	1,878,710	790,656	2,669,366	1,758,922	0	1,758,922	4,428,287
23	23	0	1,953,207	716,159	2,669,366	1,816,836	0	1,816,836	4,486,201
24	24	0	2,030,730	638,635	2,669,366	1,876,681	0	1,876,681	4,546,047
25	25	0	2,111,405	557,960	2,669,366	1,938,523	0	1,938,523	4,607,888
26	26	0	2,195,363	474,003	2,669,366	2,002,428	0	2,002,428	4,671,794
27	27	0	2,282,739	386,627	2,669,366	2,068,467	0	2,068,467	4,737,833
28	28	0	2,373,676	295,690	2,669,366	2,136,711	0	2,136,711	4,806,077
29	29	0	2,468,322	201,044	2,669,366	2,207,234	0	2,207,234	4,876,600
30	30	0	2,566,831	102,534	2,669,366	2,280,114	0	2,280,114	4,949,479
Totals		0	32,983,536	15,141,841	48,125,380	44,476,490	0	44,476,490	92,601,868

### 3B. Present Worth Cash Flows [Chiller/ Boiler with Fan Coil Units]

Year	Date	Total Investment Cost	<b>Total Operating Cost</b>	Total Present Worth
		(\$)	(\$)	(\$)
0	Initial	0	0	0
1	1	1,048,006	874,004	1,922,010
2	2	1,024,945	882,654	1,907,599
3	3	1,002,391	891,403	1,893,794
4	4	980,333	900,253	1,880,587
5	5	958,761	909,204	1,867,965
6	6	937,664	918,258	1,855,922
7	7	917,031	927,415	1,844,446
8	8	896,851	936,677	1,833,529
9	9	877,116	946,046	1,823,162
10	10	857,816	955,522	1,813,337
11	11	838,939	965,107	1,804,046
12	12	820,479	974,801	1,795,280
13	13	802,424	984,607	1,787,031
14	14	784,767	994,525	1,779,292

## Project: 60-17-427 Belmont High School - HVAC\_180608 Prepared By: BALA

Year	Date	<b>Total Investment Cost</b>	<b>Total Operating Cost</b>	<b>Total Present Worth</b>
		(\$)	(\$)	(\$)
15	15	767,498	1,004,558	1,772,056
16	16	750,609	1,014,705	1,765,315
17	17	734,092	1,024,969	1,759,062
18	18	717,939	1,035,351	1,753,290
19	19	702,141	1,045,853	1,747,993
20	20	686,690	1,056,475	1,743,165
21	21	1,672,932	1,067,219	2,740,151
22	22	1,636,120	1,078,086	2,714,206
23	23	1,600,117	1,089,079	2,689,196
24	24	1,564,907	1,100,198	2,665,105
25	25	1,530,471	1,111,445	2,641,916
26	26	1,496,793	1,122,822	2,619,615
27	27	1,463,856	1,134,329	2,598,186
28	28	1,431,644	1,145,969	2,577,614
29	29	1,400,141	1,157,743	2,557,885
30	30	1,369,331	1,169,653	2,538,984
Totals		32,272,804	30,418,930	62,691,739