05.31.2018

BELMONT HIGH SCHOOL HVAC SYSTEM REVIEW

AGENDA

01 / Mechanical System Review

02 / Energy Comparison

03 / Life Cycle Costing

04 / Comparrison Summary

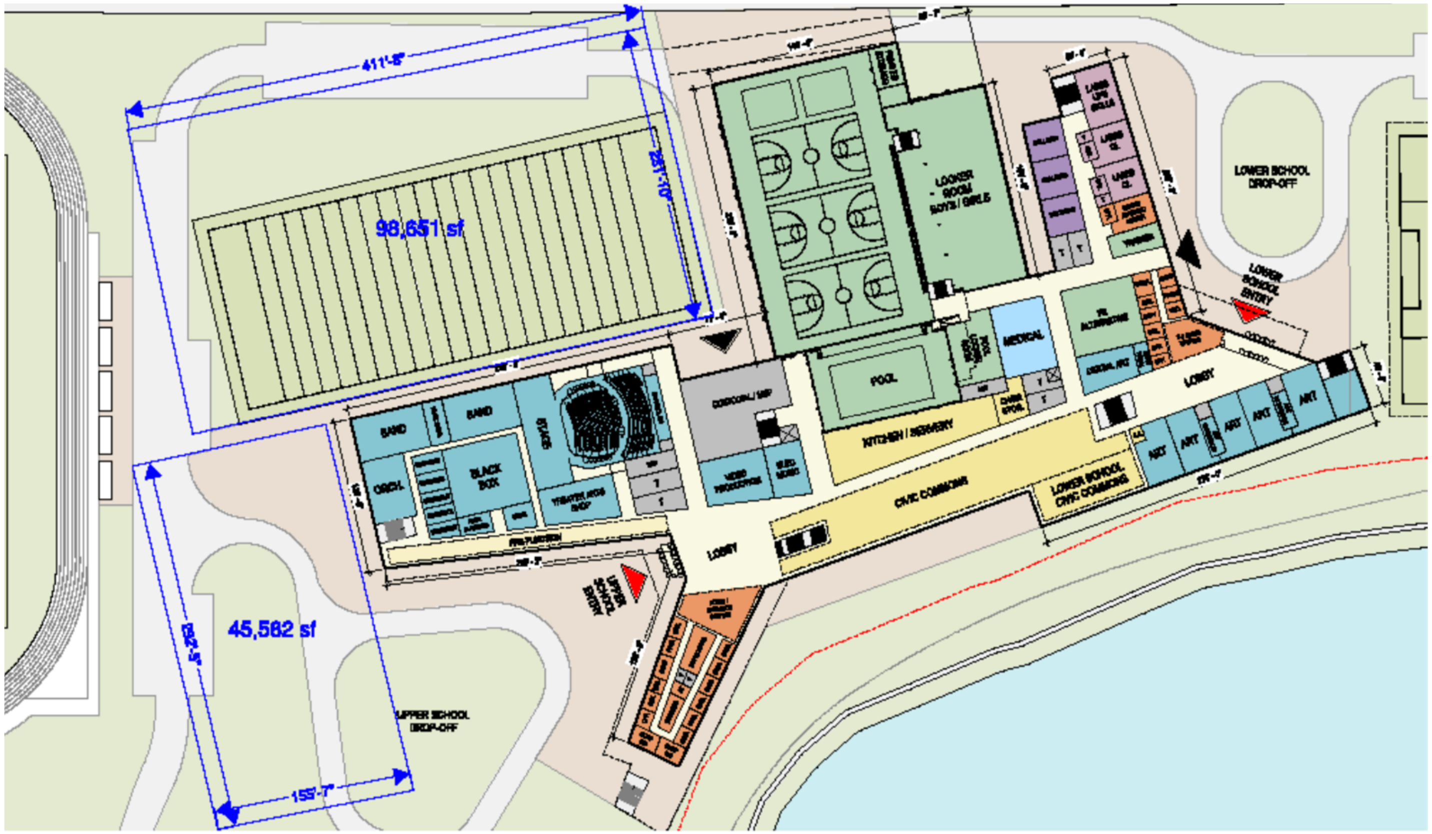
HVAC SYSTEM GOALS

- ❑ ALL SYSTEMS TO EXCEED MASS ENERGY CODE BY 20%
- ❑ MINIMIZE ANNUAL ENERGY COST & FOSSIL FUEL EMISSIONS
- ❑ EXPLORE ZERO NET ENERGY SITE

GEO-EXCHANGE SYSTEM WITH INDUCTION UNITS

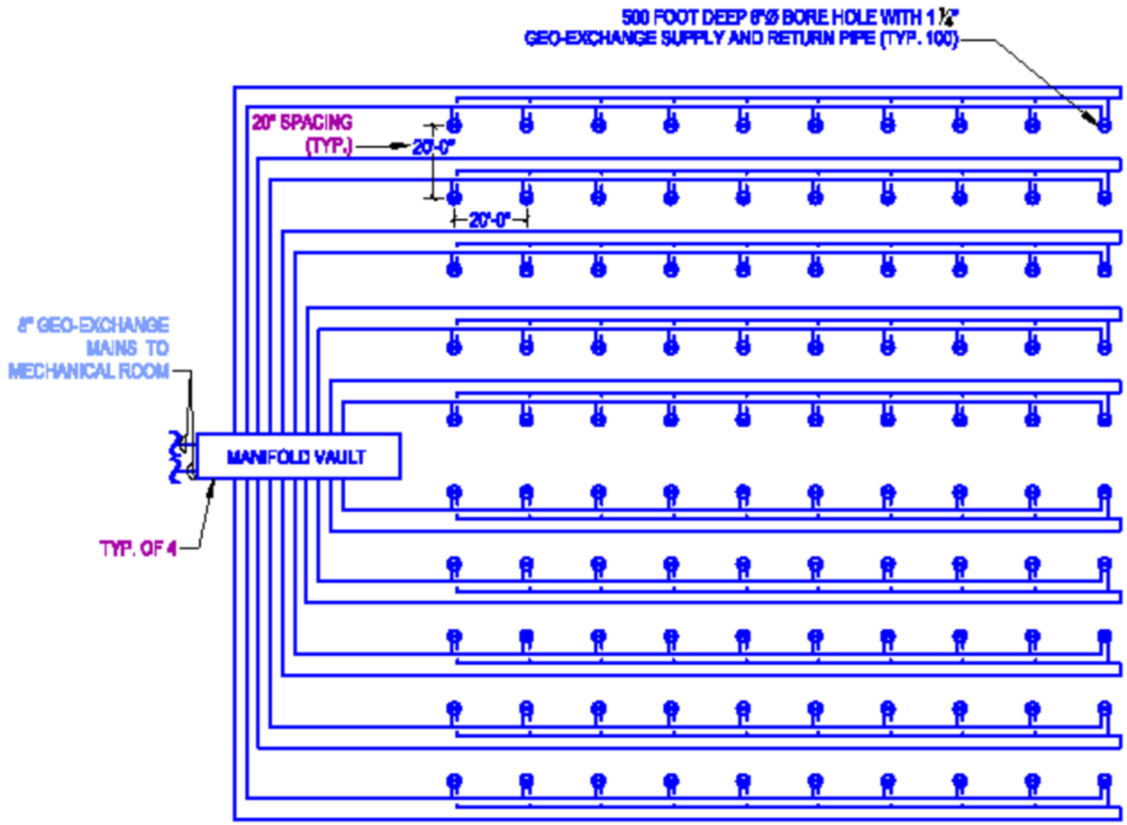
- GEO-EXCHANGE BOREHOLE FIELD
- HIGH EFFICIENCY WATER-TO-WATER CHILLER-HEATERS
- VARIABLE SPEED PUMPS
- INDUCTION UNITS IN CLASSROOMS
- RADIANT FLOOR HEATING AND COOLING
- VARIABLE AIR VOLUME SINGLE ZONE AIR HANDLING UNITS FOR AUDITORIUM, STAGE, FIELD HOUSE, BLACK BOX
- VARIABLE AIR VOLUME HEAT RECOVERY OUTSIDE AIR UNITS SERVING CLASSROOMS, MEDIA SPACES, INNOVATION SPACES
- CO_2 DEMAND CONTROL VENTILATION IN CLASSROOMS AND SPACES WITH HIGH OCCUPANT DENSITY
- OCCUPANCY SENSORS FOR DAY-TIME TEMPERATURE SET BACK AND VENTILATION REDUCTION

GEO-EXCHANGE SYSTEM WITH INDUCTION UNITS



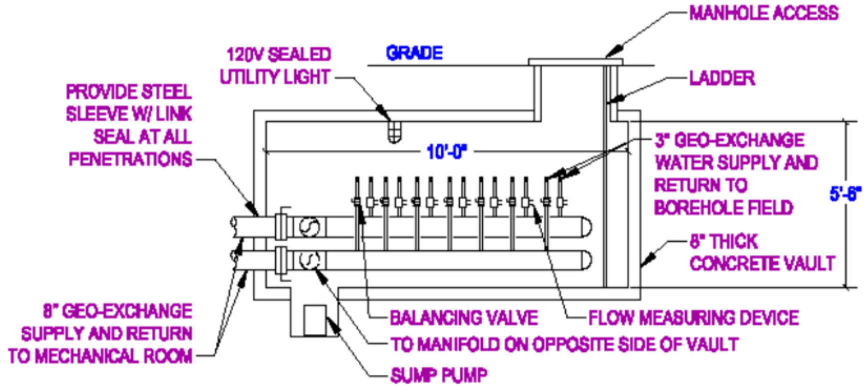
GEO-EXCHANGE BOREFIELD AREA

GEO-EXCHANGE SYSTEM WITH INDUCTION UNITS

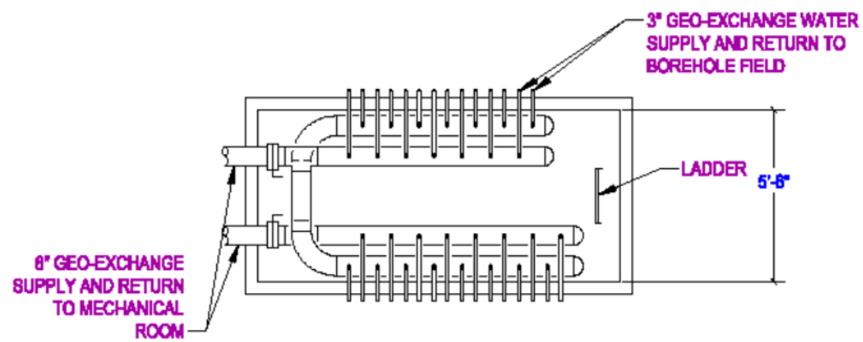


GROUND SOURCE HEAT PUMP BOREHOLE FIELD
(NOT TO SCALE): ALL PIPING BELOW FROST LINE

GEO-EXCHANGE SYSTEM WITH INDUCTION UNITS

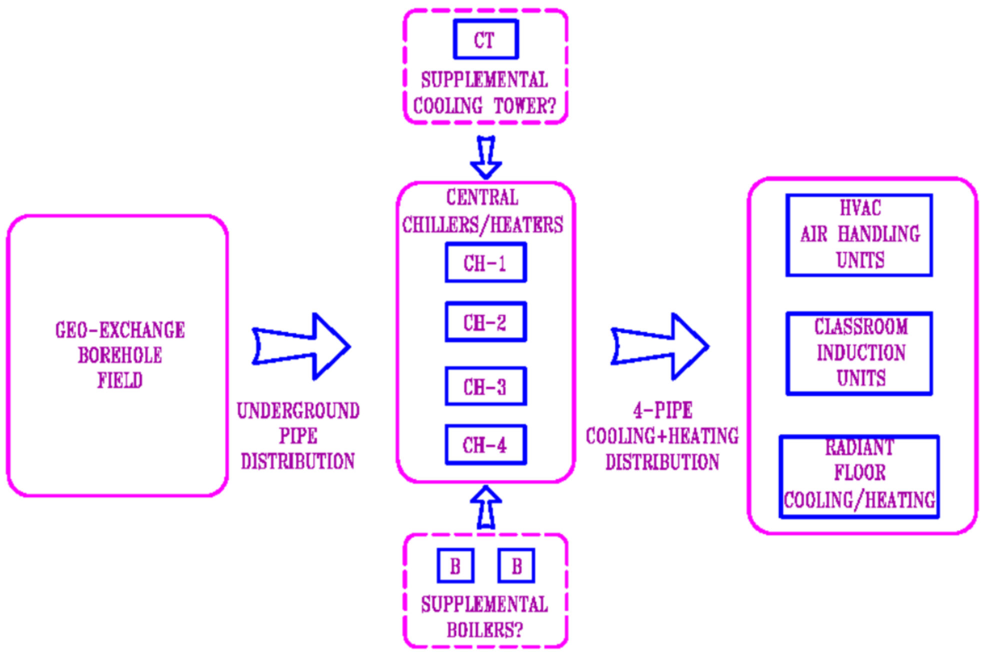


MANIFOLD VAULT WITH TWO SUPPLY AND TWO RETURN MANIFOLDS SECTION VIEW (NOT TO SCALE)



MANIFOLD VAULT WITH TWO SUPPLY AND TWO RETURN MANIFOLDS PLAN VIEW (NOT TO SCALE)

GEO-EXCHANGE SYSTEM WITH INDUCTION UNITS



GEO-EXCHANGE SYSTEM
BASE - NET ZERO OPTION

CHILLER / BOILER SYSTEM WITH INDUCTION UNITS

- HIGH EFFICIENCY WATER COOLED CHILLERS WITH COOLING TOWERS
- GAS-FIRED CONDENSING HOT WATER BOILERS
- VARIABLE SPEED PUMPS
- INDUCTION UNITS IN CLASSROOMS
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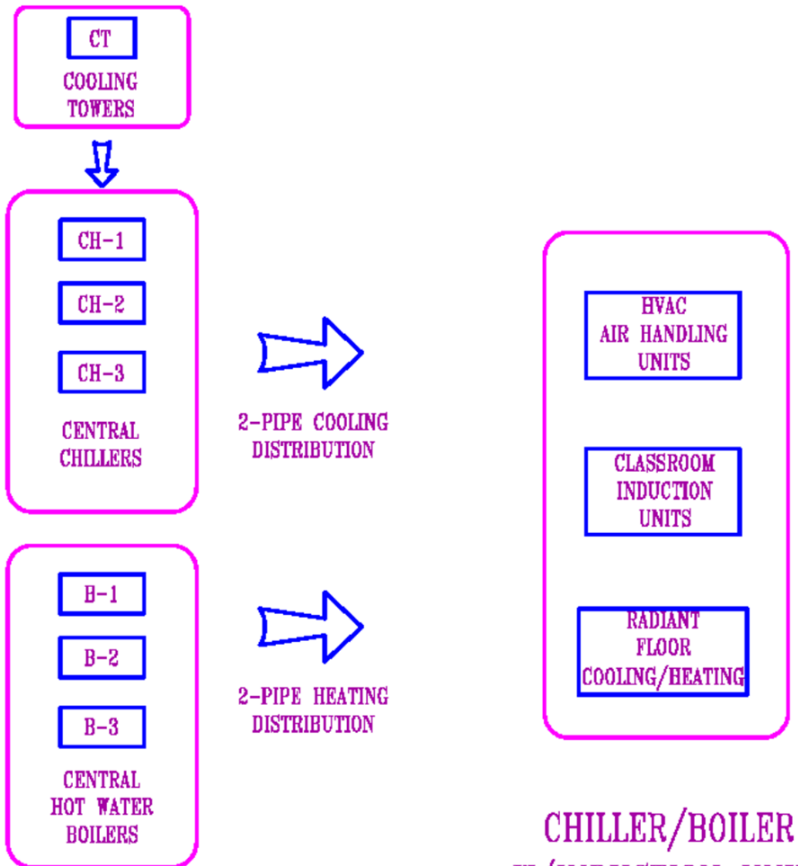
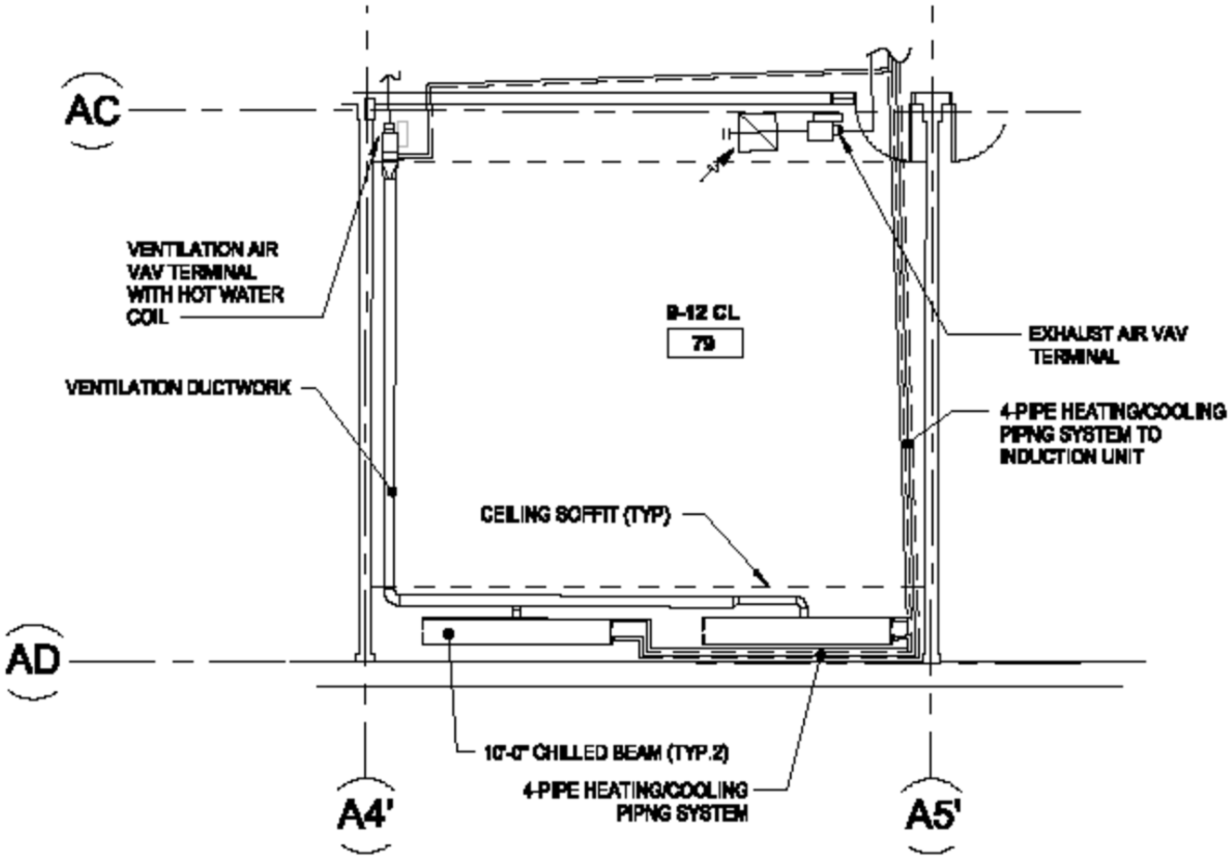


CHILLER/BOILER SYSTEM
W/INDUCTION UNITS OPTION

INDUCTION UNIT CLASSROOM LAYOUT



CHILLER / BOILER SYSTEM WITH FAN COIL UNITS

- HIGH EFFICIENCY WATER COOLED CHILLERS WITH COOLING TOWERS
- GAS-FIRED CONDENSING HOT WATER BOILERS
- VARIABLE SPEED PUMPS
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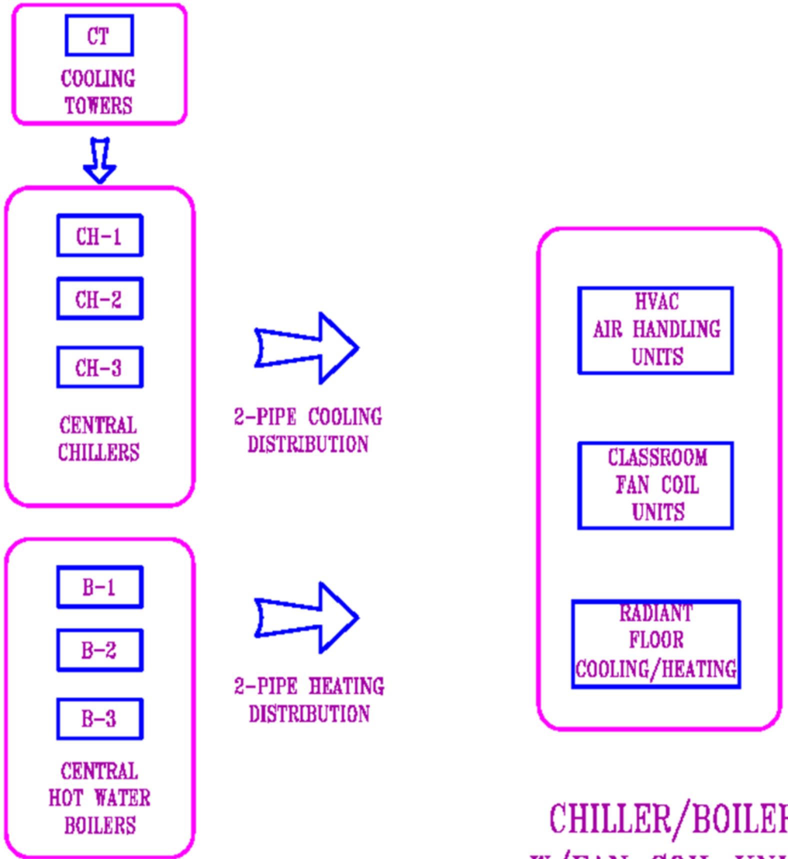
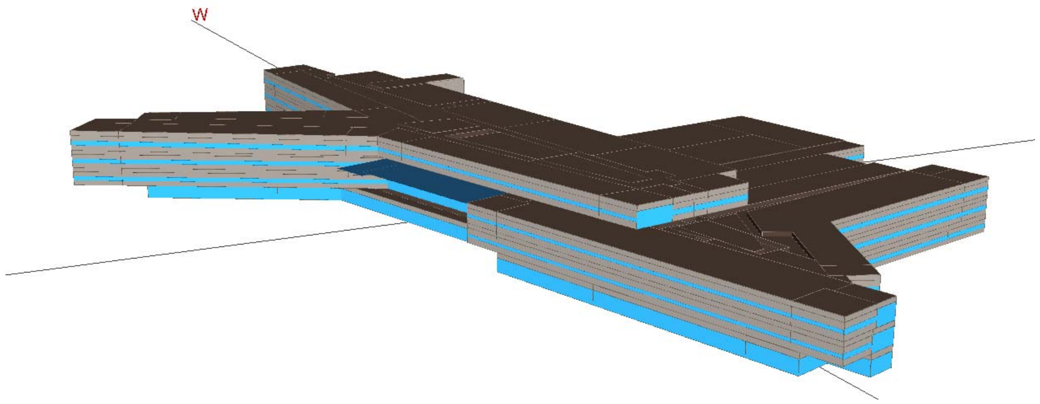


CHILLER/BOILER SYSTEM
W/FAN COIL UNITS OPTION

HVAC System Options:

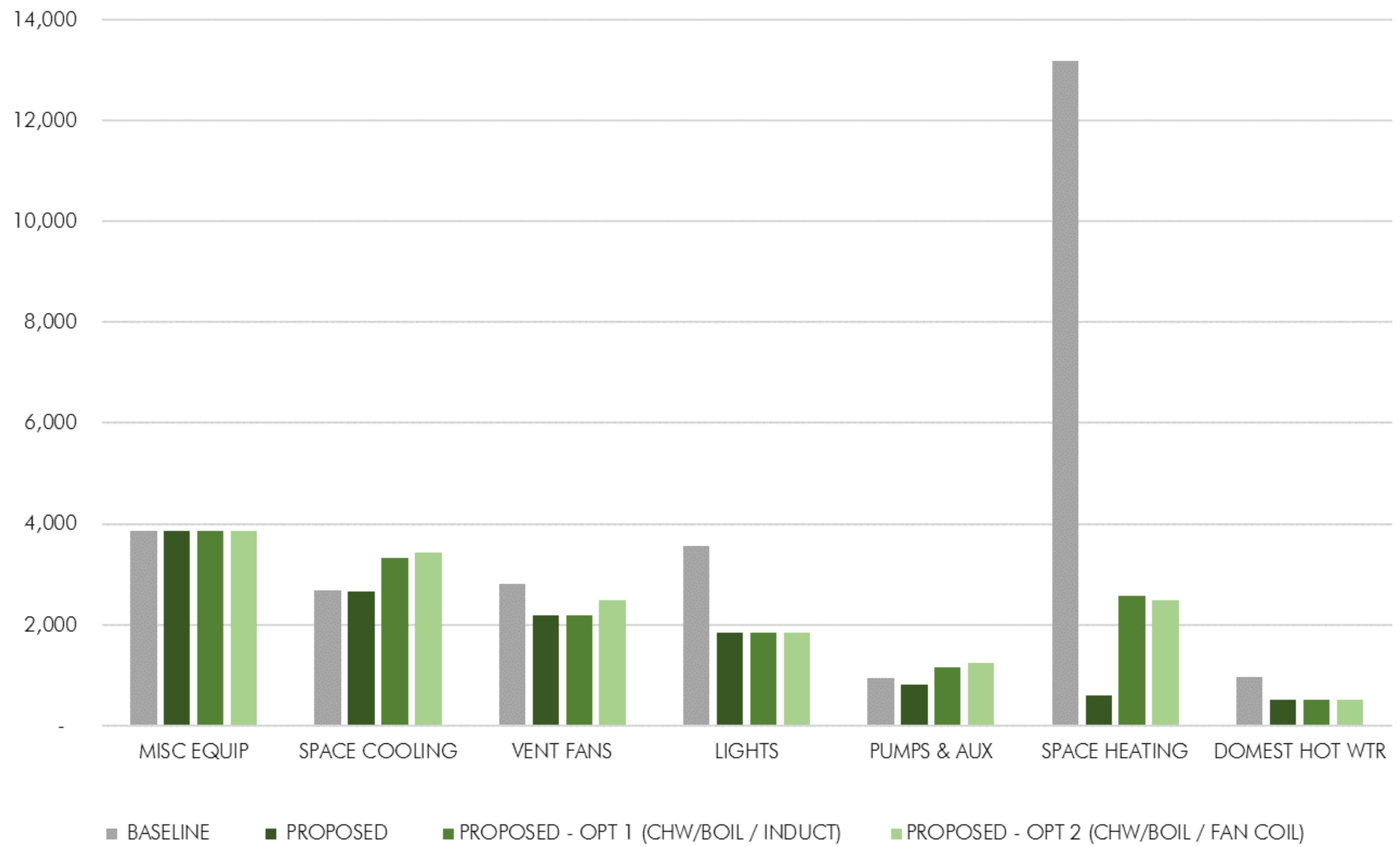
- Proposed (Geothermal & Induction Units
- Option 1 (Chiller/Boiler & Induction Units)
- Option 2 (Chiller/Boiler & Fan Coils)



ENERGY COMPARISON

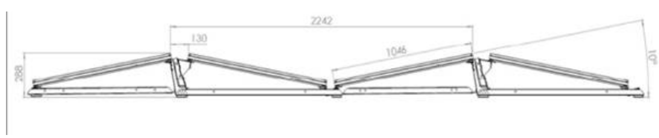
SUMMARY - ENERGY AND COST	TOTAL CONSUMPTION (MMBTU)	EUI (kbtu/sf/yr)	SITE ENERGY SAVINGS (%)	ESTIMATED ANNUAL UTILITY COST ($)	UTILITY COST SAVING (%)	ANNUAL UTILITY COST DELTA vs. PREFERRED/ PROPOSED DESIGN
ASHRAE 90.1-2013 BASELINE	28,039	58.42	-	$697,770	-	-
PROPOSED (GEOTHERMAL / INDUCTION UNITS)	12,490	26.02	55%	$539,431	23%	-
PROPOSED - OPT 1 (CHILLER/BOILER/ INDUCT)	15,494	32.28	45%	$563,248	19%	$23,817
PROPOSED - OPT 2 (CHILLER/BOILER/ FAN COIL)	15,894	33.11	43%	$582,901	16%	$43,469

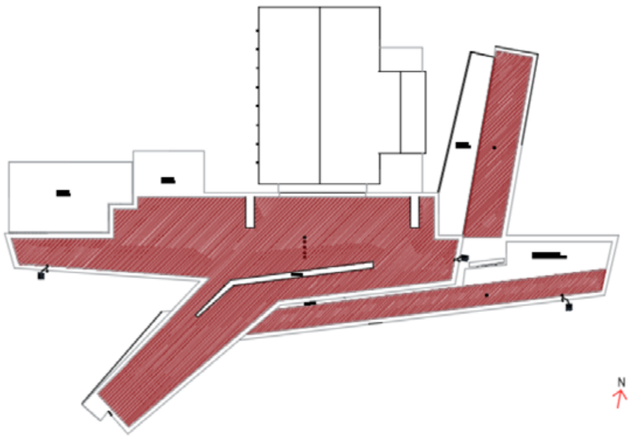
Annual Energy End-Use Breakdown (MMBtu)



PV PRODUCTION ON ROOF

- Possible PV locations have been shown in red. Approximately 3,394 Panels, 95,900 SF
- Panels would be mounted in bi-fold manner – ‘east’ & ‘west’
- SD estimated roof energy generation based on a 340W PV panel is 1,190,650 kWh



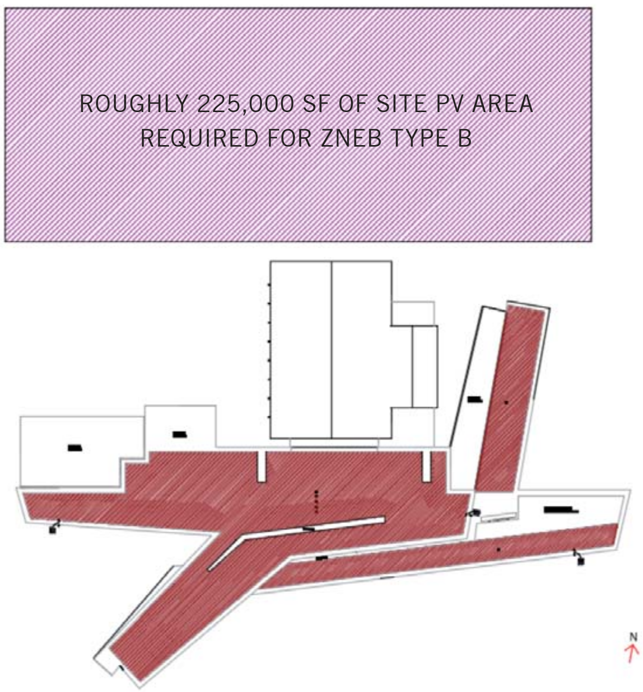


PV REQUIREMENTS

	Total Consumption (MMBTU)	Equivalent kWh	% Offset by 95,900 SF of Panels on Roof	Energy Remaining	# of Panels	Site PV Canopy Area Required (SF)
ASHRAE 90.1-2013 BASELINE	28,039	8,217,420	14%	7,026,764	17,061	482,045
PROPOSED (GEOTHERMAL / INDUCTION UNITS)	12,490	3,660,458	32%	2,469,802	5,997	169,431
PROPOSED - OPT 1 (CHILLER/BOILER/INDUCT)	15,494	4,540,843	26%	3,350,187	8,134	229,827
PROPOSED - OPT 2 (CHILLER/BOILER/ FAN COIL)	15,894	4,658,072	26%	3,467,416	8,419	237,869

PV PRODUCTION ON ROOF

- Overall, PV on the roof would offset roughly 14% of the baseline building's annual energy
- PV on the roof would offset roughly 25 - 32% of the improved HVAC cases.
- To get the Geothermal Case to Net Zero, an additional approximately 6,000 panels would need to be mounted on the site. (This does not include any contingency)
- The purple area shows how much more PV would be needed.



NET ZERO ENERGY

NZEB:A	**Renewable energy harvested within the building footprint**
NZEB:B	Renewable energy harvested within the building footprint and on the site
NZEB:C	Renewable energy harvested within the building footprint, on site or by renewable sources imported to the site
NZEB:D	Renewable energy harvested within building footprint and/or on site and supplemented by purchased renewable energy certificates

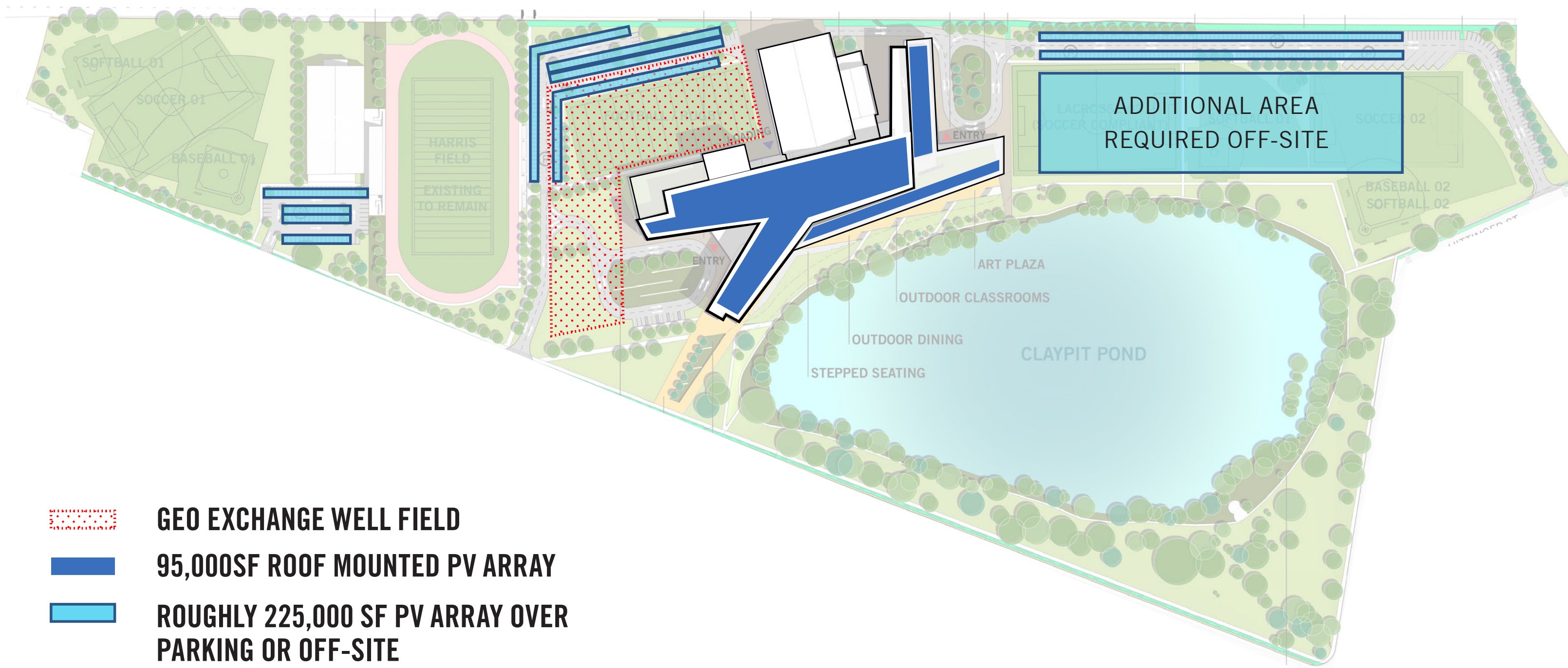
Net-Zero Energy Buildings: A Classification System Based on Renewable Energy Supply Options, NREL, June 2010

SITE PLAN

PERKINS+WILL   AKF   i:p   Nitsch Engineering   WARNER LARSON LANDSCAPE ARCHITECTS   BALA

MAY 31, 2018

SITE PLAN WITH ESTIMATED PV REQUIRED TO ACHIEVE NET ZERO ENERGY



GEO EXCHANGE WELL FIELD

95,000SF ROOF MOUNTED PV ARRAY

ROUGHLY 225,000 SF PV ARRAY OVER PARKING OR OFF-SITE

LIFE CYCLE COST SUMMARY

Life Cycle Cost Analysis for HVAC Options

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

Type of Analysis .... Public Sector Lifecycle Analysis
Type of Design Alternatives .... Independent
Length of Analysis .... 30 yrs
Discount Rate .... 2.25 %

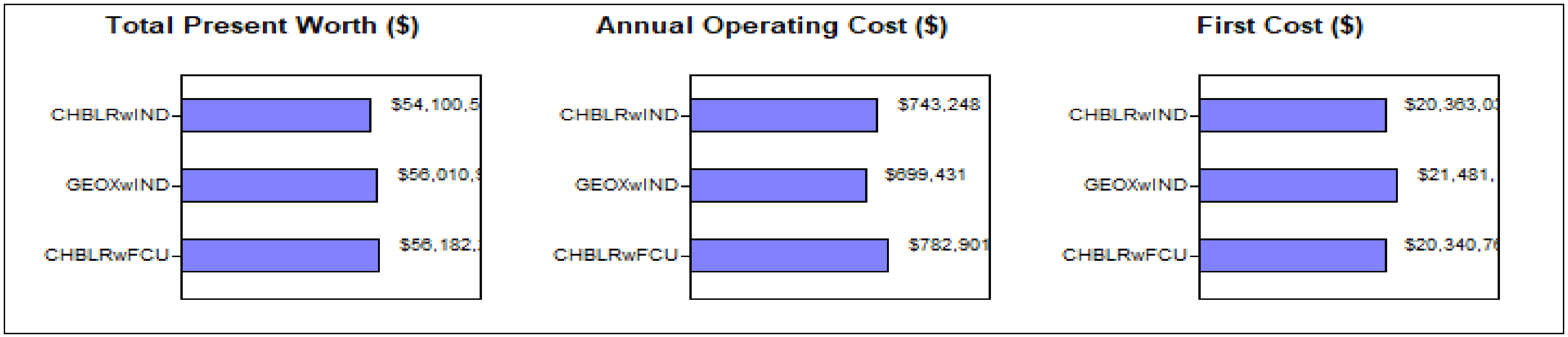


Table 1. Executive Summary

Economic Criteria	Best Design Case for Each Criteria	Value ($)
Lowest Total Present Worth	Chiller/ Boiler with Induction	$54,100,534
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 ($)
Chiller/ Boiler with Induction	CHBLRwIND	$54,100,534	$743,248	$20,363,034
Geo-Exchange with Induction	GEOXwIND	$56,010,898	$699,431	$21,481,139
Chiller/ Boiler with Fan Coil Units	CHBLRwFCU	$56,182,200	$782,901	$20,340,759

SYSTEM PROS AND CONS

SYSTEMS	GEO-EXCHANGE w/INDUCTION	CHILLER/BOILER w/INDUCTION	CHILLER/BOILER w/FAN COIL UNITS
PROS	HIGHEST EFFICIENCY COOLING AND HEATING	HIGH EFFICIENCY COOLING AND HEATING	HIGH EFFICIENCY COOLING & HEATING
	LOWEST ANNUAL OPERATING COST	CONVENTIONAL CHILLER/BOILER CENTRAL PLANT	CONVENTIONAL CHILLER/ BOILER CENTRAL PLANT
	CENTRAL PLANT PRIMARILY CHILLER AND PUMP MAINTENANCE	LOWEST 30 YR LIFE-CYCLE COST	LOW MAINTENANCE INDUCTION UNITS AND RADIANT FLOOR SYSTEMS
	CENTRAL PLANT WITH NO OUTDOOR EQUIPMENT NOISE	LOW MAINTENANCE INDUCTION UNITS AND RADIANT FLOOR SYSTEMS	
	POTENTIAL FOR NO FOSSIL FUEL		
	GREATEST POTENTIAL FOR NET ZERO		
	CENTRAL PLANT WITH HIGH LIFE EXPECTANCY		
	LOW MAINTENANCE INDUCTION UNITS AND RADIANT FLOOR SYSTEMS		
CONS	HIGHEST FIRST COST w/GEO-EXCHANGE BOREHOLES & ASSOCIATED PIPING	MODERATE FIRST COST W/INDUCTION UNITS	MODERATE FIRST COST w/FAN COIL UNITS
	HIGHEST 30 YR LIFE-CYCLE COST	HIGH LEVEL CHILLER/COOLING TOWER CENTRAL PLANT CONTROLS	HIGH LEVEL CHILLER/COOLING TOWER CENTRAL PLANT CONTROLS
	SOPHISTICATED CHILLER-HEATER CONTROLS/ TECHNICAL EXPERTISE	HIGH LEVEL COOLING TOWER MAINTENANCE (WATER TREATMENT)	HIGH LEVEL COOLING TOWER MAINTENANCE (WATER TREATMENT)
	MAY REQUIRE SUPPLEMENTAL HEAT REJECTION OR HEAT ADDITION INITIALLY OR IN THE FUTURE	LOWER LIFE EXPECTANCY CENTRAL PLANT COMPONENTS (COOLING TOWERS & BOILERS)	LOWER LIFE EXPECTANCY CENTRAL PLANT COMPONENTS (COOLING TOWERS & BOILERS)
		COOLING TOWER OUTDOOR NOISE	COOLING TOWER OUTDOOR NOISE/ FAN COIL UNITS MODERATE INDOOR NOISE
			HIGH FAN COIL UNIT MAINTENANCE (FILTERS, MOTORS, CONDENSATE)

COMMON FEATURES	
RADIANT FLOOR COOLING & HEATING	VERY LOW MAINTENANCE/ HIGHEST COOLING & HEATING EFFICIENCY/ REDUCES DUCTWORK DISTRIBUTION FOR COOLING
DEMAND CONTROL VENTILATION	REDUCES OUTSIDE VENTILATION AIR WHEN OCCUPANCY IS LOW OR SPACE IS UNOCCUPIED/ REDUCES ENERGY CONSUMPTION
HEAT RECOVERY VENTILATION UNITS	PRE-CONDITIONING OF OUTSIDE VENTILATION AIR USING EXHAUST AIR/ SIZED FOR VENTILATION/ REDUCES DUCT SIZES AND FAN ENERGY
VAV AIR HANDLING UNITS	REDUCES FAN ENERGY DURING PERIODS OF LOW DEMAND