WEST CONTRA COSTA COUNTY UNIFIED SCHOOL DISTRICT: ENERGY ANALYSIS OF OHLONE ELEMENTARY SCHOOL

FINAL Report

CONSULTANT REPORT

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PREFACE

This study was prepared as a result of West Contra Costa Unified School District's request for assistance under the Bright Schools Program. This Energy Commission Program assists public schools in identifying projects that can cut energy use and cost in existing and planned facilities. The study was conducted for the CEC by CTG Energetics, under the direction of Mike Bolger.

Additionally, West Contra Costa Unified School District plans to participate in the High Performance School Grant Program. This program is provided by the Office of Public School Construction.

West Contra Costa Unified School District will be building several new schools using the Collaborative for High Performance Schools Criteria as a guideline.

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ABSTRACT

This report documents an analysis of energy efficiency improvements to the design of the proposed Ohlone Elementary school located in Hercules, CA. The purpose of this analysis was to investigate potential energy efficient design alternatives for the school and to assist the West Contra Costa Unified School District maximize points for the Collaborative for High Performance Schools program.

The results of the analysis indicate a potential score of eight points for credit EE1.1, Superior Energy Performance, in addition to one to four points for EQ1.1 credit, daylighting. EQ1.1 is in the Indoor Environmental Quality category of the Collaborative for High Performance Schools criteria.

Keywords: energy, efficiency, analysis, Title 24, compliance, lighting, daylighting, Collaborative, High, Performance, Schools, thermal displacement ventilation, heat, recovery

EXECUTIVE SUMMARY

This report documents an analysis of energy efficiency improvements to the design of the proposed Ohlone Elementary school located in Hercules, CA. The purpose of this analysis was to investigate potential energy efficient design alternatives for the school and to assist the West Contra Costa Unified School District maximize points for the Collaborative for High Performance Schools program. The final list of recommended efficiency design alternatives was determined based on District goals and standards, and implementation costs and project paybacks calculated in the analysis.

The Ohlone School is being built in two distinct phases. Phase I is being designed by Powell & Powell Architects and includes Building A and Building B. Phase II is being designed by HMC Architects. This analysis only addresses Phase I of the Ohlone Elementary School.

The CHPS Criteria contains six main rating categories: Sustainable Sites, Water, Energy, Materials, Indoor Environmental Quality, and Policy and Operations. Considerable interaction occurred between design team members, the owner, and consultants to identify design alternatives that maximize CHPS points for the Energy Efficiency and Indoor Environmental Quality categories.

The daylighting effectiveness was analyzed for a number of different glazing options in the windows, clerestories, and skylights using the SPOT (Sensor Placement + Optimization Tool) daylighting analysis tool.

The energy consumption and demand of the Ohlone Elementary were calculated for the as-designed baseline design and for a standard design possessing 2005 Title 24 minimally compliant building characteristics using the EnergyPro (DOE-2.1e) energy analysis tool. These models were initially conducted by Chuck Clemons of Energy Calc Co with anticipated efficiency measures. CTG then altered this EnergyPro model to analyze the following energy efficiency measures:

- Measure 0: 2005 Title-24 Standard Design
- Measure 1: Baseline Prior to District Standard Design Alternatives
- Measure 2: District Standard Design Alternative – HVAC Efficiency - 14 SEER, 81% efficient
- Measure 3: District Standard Design Alternative – Window overhangs
- Measure 4: District Standard Design Alternative - R-21 walls
- Measure 5: District Standard Design Alternative - High efficiency lighting with daylighting controls
- Measure 6: High efficiency dual pane low-E windows
- Measure 7: Air-side economizer controls
- Measure 8: Demand Control Ventilation
- Measure 9: Revised Window Area
- Measure 10: Energy Recovery

Table 1 summarizes the incremental energy and cost savings and simple paybacks for each design alternative, and includes combined results for both buildings.

Table 1: Incremental Energy and Cost Savings

Incremental Energy Savings Summary - West Contra Costa - Ohlone Elementary School

		Title-24 TDV Energy Savings		Site Energy Savings			Annual Energy	Total Incremental	Simple	CHPS
		Total	EUI	Electric	N. Gas	Total	Cost Savings	Cost	Payback	E1.1
Alt	Description	(%)	(kBtu/sf/yr)	(kWh)	(Therms)	(MBtu)	($)		(yrs)	Points
Alt 1	Baseline Prior to District Std Design Alts	4.4	13.2	23,874	721	317	$4,463	$0	0.0	0
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	3.2	9.4	17,319	11	178	$4,298	$3,645	0.8	0
Alt 3	Alt 2 + Window overhangs	0.9	2.5	5,335	-29	52	$960	$13,500	14.1	0
Alt 4	Alt 3 + R-21 walls	0.0	0.1	1,339	247	38	$719	$3,234	4.5	0
Alt 5	Alt 4 + Efficient lighting with daylighting cont	7.8	23.3	46,794	-61	473	$7,407	$61,581	8.3	3
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	0.7	2.1	1,169	314	43	$1,061	$26,412	24.9	0
Alt 7	Alt 6 + Airside economizer controls	8.8	26.2	61,692	-1	632	$7,613	$23,200	3.0	4
Alt 8	Alt 7 + Demand control ventilation	0.4	1.4	4,441	-1,132	-68	$957	$20,300	21.2	1
Alt 9	*Alt 8 + Revised window area*	*-1.4*	*-5.1*	*-15,698*	*1,564*	*-4*	*($720)*	*$43,122*	*0.0*	*-1*
Alt 10	*Alt 9 + Energy recovery*	*0.0*	*0.0*	*-12,208*	*78*	*-117*	*($2,221)*	*$61,581*	*0.0*	*0*

Table 2 summarizes the cumulative energy and cost savings, and CHPS incentives, where each alternative measure is built up on the previous efficiency measure.

Table 2: Cumulative Energy and Cost Savings

Cumulative Energy Savings Summary - West Contra Costa - Ohlone Elementary School

		Title-24 TDV Energy Savings		Site Energy Savings			Annual Energy	Total Incremental	Simple	CHPS
		Total	EUI	Electric	N. Gas	Total	Cost Savings	Capital Cost	Payback	E1.1
Alt	Description	(%)	(kBtu/sf/yr)	(kWh)	(Therms)	(MBtu)	($)		(yrs)	Points
Alt 1	Baseline Prior to District Std Design Alts	4.4	13.2	23,874	721	317	$4,463	$0	0.0	0
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	7.6	22.6	41,193	732	495	$8,761	$3,645	0.4	0
Alt 3	Alt 2 + Window overhangs	8.5	25.2	46,528	703	547	$9,721	$17,145	1.8	0
Alt 4	Alt 3 + R-21 walls	8.5	25.2	47,867	950	585	$10,440	$20,379	2.0	0
Alt 5	Alt 4 + Efficient lighting with daylighting cont	16.3	48.5	94,661	889	1,058	$17,847	$81,960	4.6	3
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	17.0	50.6	95,830	1,203	1,101	$18,908	$108,372	5.7	3
Alt 7	Alt 6 + Airside economizer controls	25.8	76.8	157,522	1,202	1,733	$26,521	$131,572	5.0	7
Alt 8	Alt 7 + Demand control ventilation	26.2	78.2	161,963	70	1,665	$27,478	$151,872	5.5	8
Alt 9	*Alt 8 + Revised window area*	*24.8*	*73.1*	*146,265*	*1,634*	*1,661*	*$26,758*	*$194,994*	*7.3*	*7*
Alt 10	*Alt 9 + Energy recovery*	*24.8*	*73.1*	*134,057*	*1,712*	*1,544*	*$24,537*	*$256,575*	*10.5*	*7*

SECTION 1.0: Introduction

Improving the energy efficiency of all newly constructed schools is a goal of the West Contra Costa Unified School District (the District). The District will use the Collaborative for High Performance Schools (CHPS) Criteria, and participate in both the CHPS certification process and the Office of Public School Construction (OPSC) High Performance School (HPS) Grant Program for all new school and modernization projects.

Through the California Energy Commissions' Bright Schools program the District requested technical assistance to review the design of the new Ohlone Elementary School located in Hercules, CA. The objective of the technical assistance was to assist the District in identifying as-designed and additional energy efficiency projects that will help the school maximize the number of CHPS points related to energy efficiency and indoor environmental quality in a cost effective manner. Based on the results of an energy analysis and a daylighting analysis, this study identifies opportunities to maximize CHPS points and energy efficiency for the Ohlone Elementary School

Ohlone was originally constructed in 1979, with the last major renovation performed in 1992. The District plans to demolish and rebuild Ohlone Elementary School on the existing site. The new campus is estimated to have to be 62,000 sqft.

The Ohlone School is being built in two distinct phases. Phase I is being designed by Powell & Powell Architects and includes Building A and Building B. Phase II is being designed by HMC Architects. This analysis only addresses Phase I of the Ohlone Elementary School, which includes approximately 41,000 square feet of classroom and administration space.

The overall organization of the study is divided into six sections:

- SECTION ONE provides this introduction and project background.
- SECTION TWO discusses the analysis methodology used in the study.
- SECTION THREE discusses the various design alternatives that were evaluated in the study.
- SECTION FOUR recounts the economic assumptions that were used for the economic analysis.
- SECTION FIVE presents the analysis results and recommendations.
- SECTION SIX provides information regarding relevant Collaborative for High Performance Schools credits.

SECTION 2.0: Analysis Methodology

A detailed computer simulation of the proposed building was performed using the EnergyPro building energy analysis program (version 4.4) which is based on the DOE-2.1e simulation engine. The energy analysis program simulates yearly operation of the buildings including the heating, ventilation, and air conditioning systems and subsequent interactions with the building envelope, lighting systems, and other interior loads such as kitchen equipment. The EnergyPro program also calculates Title 24 compliance margins for the proposed project. Title 24 compliance margins are used by CHPS to score school buildings in the superior energy performance category (EE1.1). The weather file used for this analysis was the long term average weather data for California Climate Zone CZ03 (Oakland Area) as defined by the California Energy Commission.

The simulation process begins by developing a model of the building based on building plans and specifications; this is known as the as-designed model. A base case building model with minimum Title 24 prescriptive requirements is automatically generated by the software and is the base from which energy savings are calculated. The preliminay EnergyPro model was created by Chuck Clemons of Energy Calc Co. CTG used this model to analyze additional energy efficiency measures. For each of these additional measures, energy savings, cost savings, Title 24 compliance margin, initial cost, simple payback, life-cycle cost, and potential CHPS points were calculated.

SECTION 3.0: Design Alternatives

This section describes the design alternatives for Ohlone Elementary included in the energy analysis study. All alternatives starting with Alternative 1 are simulated cumulatively meaning the alternatives are built upon the previous alternative and include all previous design alternatives.

Measure 0: Reference Title-24 Design

The 2005 Title-24 Standard case was generated by EnergyPro with the same building form and orientation, and glazing percentages per façade as were reflected in the plans for the as-designed baseline design. Based on climate zone the EnergyPro rules processor automatically generates the mechanical, lighting, and envelope prescriptive requirements for the Title 24 standard design. Please note that there are slight changes in the EnergyPro Standard Case due to the fact that the Title-24 Baseline is sometimes adjusted based on proposed case inputs (such as window percentage, fan power, etc.).

Measure 1: As-Designed Prior to Implementation of District Standard

Prior to the implementation of efficiency measures, the project performs slightly better than Title-24 2005 requirements. This is due to slight improvements in envelope efficiency and HVAC systems.

Measure 2: District Standard Design Alternative – HVAC Efficiency - 14 SEER, 81% efficient

The packaged rooftop HVAC units serving each classroom building, and each zone of the administrative building are slightly more efficient than required by Title-24 2005. The units of a cooling efficiency of 14 SEER (versus 13 SEER required by code), and an AFUE of 81% (versus 80% required by code).

Measure 3: District Standard Design Alternative – Window overhangs

The glare into the space is curbed through the use of overhangs on the South-facing windows. These perforated overhangs still allow light into the space, while limiting direct sun penetration into the space, and reducing solar heat gain to the space.

Measure 4: District Standard Design Alternative - R-21 walls

The project includes 2x6 wood framed walls and R-21 batt insulation. The Title 24 prescriptive requirement is 2x4 wood framed walls with R-11 batt insulation.

Measure 5: District Standard Design Alternative - High efficiency lighting with daylighting controls

The lighting design incorporates several energy efficient design alternatives including a reduced lighting power density (LPD) and the application of automatic lighting controls. The automatic lighting controls include occupancy sensors that turn on and off lights when motion is detected and daylighting controls that automatically dim the lights when sufficient natural daylight is detected in the room. Fixtures connected to continuous daylighting controls must have dimmable ballasts for the lights to continuously dim. Title 24 2005 allows credit for lighting fixtures connected to automatic lighting controls in the form of power adjustment factors which are applied when calculating the installed lighting wattage. The fixture wattage is reduced by the power adjustment factor if it is connected to an automatic control.

The project intends to provide daylighting in all classrooms that meets the requirements of the CHPS daylighting credit (Credit 1.1).

- The computer program SPOT (Sensor Placement and Orientation Tool) was used to quantify the electric and daylighting performance of the project, and to help achieve compliance with the CHPS daylighting credit.
- Multiple glazing products were analyzed to help select one that would allow daylighting specifications to be met without jeopardizing energy efficiency.

The control types proposed for Ohlone Elementary School and their related power adjustment factors are listed below.

Table 3: Power Adjustment Factors for Automatic Lighting Controls

Automatic Lighting Control Type	Power Adjustment Factor
Occupancy Sensor, classrooms, corridors, any room < 250 sf	0.2
Occupancy Sensor >250 sf	0.1
Daylighting with Continuous Dimming, Window Wall ratio <20%, Glazing VLT >60%	0.3
Daylighting with Continuous Dimming, Window Wall ratio >20%, Glazing VLT >60%	0.4
Combined Occupancy Sensor and Daylighting, Classroom	.1 + daylighting credit (up to 0.50)

Title 24 compliance form LTG-4-C, Lighting Controls Credit Worksheet, lists the lighting fixtures that have power adjustment factors, the power adjustment factor, and the room location or name of the fixtures.

Measure 6: High efficiency dual pane low-E windows

The district standards originally required single pane windows due to maintenance issues. However, in order to improve the daylighting penetration into the space, while limiting solar gains, this measure identifies the benefit of revising the district standard to high performance dual-pane low-E windows. The following windows have been included in the project during the course of this analysis:

- Blomberg 880 series fixed windows: These windows have a framed assembly U-factor of 0.350, an SHGC of 0.39, and a visual light transmittance of 0.67.
- Blomberg 680 series single-hung windows have an assembly U-factor of 0.58, an SHGC of 0.34, and a visual light transmittance of 0.58.

Title-24 prescriptively requires a U-factor of 0.77 and an SHGC of 0.61 for North-facing glass and 0.41 for Non-north facing glass.

Measure 7: Air-side economizer controls

Significant savings are achieved through air-side economizer controls on the individual packaged rooftop units serving each classroom space and each zone of the administrative building. The air-side economizer controls provide free cooling for the building when outdoor air conditions are mild, resulting in reduced requirements for compressor cooling. The air-side economizers will require on-going maintenance to ensure the persistence of savings, but should substantially improve the energy performance of the school if maintained properly.

Measure 8: Demand Control Ventilation

Additional energy savings can be achieved by including demand control ventilation in spaces with variable occupancy that have high minimum outdoor air requirements. The minimum outside air flow for each space will be lowered during periods of reduced occupancy. CO_2 sensors located in the breathing zone served by the packaged rooftop unit will serve as an indicator of how densely occupied the space is. When the CO2 levels in the space are significantly lower than those of the outside air, and the outside air conditions are significantly hotter or colder than the room air, the minimum outside air provided to the space will be lowered. This will lead towards lower heating energy when outdoor conditions are cold, and towards lower cooling energy on hot days.

Measure 9: Revised Window Area

Window area was revised to increase the amount of daylight entering high in each classroom space. Title-24 limits the amount of credit that can be reflected for daylighting controls, so the increased window area does not improve the Title-24 energy results. However, in spite of the energy analysis showing increased energy consumption tied to the additional fenestration area,

it is anticipated that these changes will contribute towards lower lighting energy consumption, since the electric lighting in the space will be dimmed when sufficient daylighting is available.

Measure 10: Energy Recovery

A heat energy recovery ventilator that recovers heat from the exhaust stream leaving the building can save energy in many parts of the county. This equipment preheats the classroom ventilation air, leading towards lower natural gas consumption by the furnaces serving the classrooms. However, in mild climates such as this location, the increased heating energy savings is often outweighed by increased fan energy consumption associated with recovering the heat in the space.

Measure 11: Photovoltaics

The CHPS rating system awards 1, 2, or 3 points if 5%, 10%, or 15% of the buildings annual source energy use is provided through the use of on-site renewable energy systems.

A scenario was developed to show the required levels to reach each of these thresholds via the installation of photovoltaic panels on the school's roof.

SECTION 4.0: Economic Parameters

Economic assumptions used in this analysis are delineated in this section.

4.1 Electric Rate

The electric rate used in the analysis for Pacific Gas and Electric was the PG&E A-10 rate schedule. The A-10 rate schedules and cost components are built into the EnergyPro software.

4.2 Gas Rate

The natural gas rate used in the analysis for Pacific Gas and Electric was the PG&E GNR-1 rate from EnergyPro. The GNR-1 rate schedules and cost components are built into the EnergyPro software.

4.3 Incremental Costs of Efficiency Measures

Cost estimates for the analyzed measures were provided based on information from the Database of Energy Efficiency Resources (DEER) database and RS Means for all measures except the glazing. Glazing costs estimates were provided the window frame manufacturer. Not all analyzed measures have incremental costs associated with them and others were not included because the measure was analyzed to assess the impact on maximizing CHPS credits for the project. The measures without incremental cost analysis are noted in the table below. The cost estimates presented are rough estimates to assist in economic analysis for the preliminary energy analysis. More precise incremental costs should be provided by the design team for the final energy analysis to verify the estimated economic impacts of the energy efficiency alternatives. A tabular summary of the incremental cost estimates is provided below in Table 4:

Table 4: Incremental Costs of Energy Efficiency Measures

Measure	Description	# of Units / Building	$ per Unit (Incremental Costs)	Total Cumulative Measure Costs
Alt-1	Baseline Design prior to Energy Efficiency Measures	NA	NA	$0
Alt-2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	• 135 tons	• $27/ton	• $3,645
Alt-3	Alt 2 + Window overhangs	• 270 linear feet	• $50 / linear foot	• $13,500
Alt-4	Alt 3 + R-21 walls	• Total – 35,290 square feet of wall area	• $0.10 per square foot	• $3,234
Alt-5	Alt 4 + Efficient lighting with daylighting controls	• 41,054 square feet	• $1.50 per square foot	• $61,581
Alt-6	Alt 5 + High efficiency dual pane, low-E windows	• 6,603 square feet	• $4 per square foot of window area	• $26,412
Alt-7	Alt 6 + Airside economizer controls	• 29 units	• $800 / unit	• $23,200
Alt-8	Alt 7 + Demand control ventilation	• 29 units	• $700 / unit	• $20.300
Alt-9	Alt 8 + Revised window area	• 828 square feet of window area	• $52.08 per square foot of window area	• $43,122
Alt-10	Alt 9 + Energy recovery	• $5/cfm of energy recovery	• 12,316 cfm	• 61,581
Alt-11 *5%* *10%* *15%*	Photovoltaics	• $8 / Watt of installed PV (DC rated)		

SECTION 5.0: Analysis Results

5.1 Energy Impacts

This section presents the energy impacts of the design alternatives on the baseline design relative to the Title 24 baseline building.

If the project implements Measures 1 through 8, the project would perform 26.2% better than Title-24 2005 requirements, saving 161,963 kWh of electricity and 70 therms of natural gas annually.

This first table, Energy Results Summary, presents the total source and site energy consumption and peak demand as well as energy usage by end use for each alternative. In this table, each design alternative builds up on the previous design alternative, and the cumulative energy savings are reflected. The Energy Usage Intensity (EUI) column in this table provides the TDV energy consumption of the building using 2005 Title 24 prescribed operating characteristics. This value is used to compare the performance of the building with the 2005 Title-24 Standard Case building.

The second table, Energy Savings Summary - Cumulative, presents the energy savings summary including the percent better than Title 24 for the design alternatives. In this table, each design alternative builds up on the previous design alternative, and the cumulative energy savings are reflected.

The third table, Energy Savings Summary - Incremental, presents the incremental energy savings for each measure, including the incremental percent better than Title 24 for each design alternative.

The fourth table, Renewable Energy Summary, presents the photovoltaic panels (DC-rated) required to earn CHPS EE2.1 credit for each design alternative (where each design alternative is built up cumulatively on the previous design alternative). The credit assumes that the photovoltaics are lying flat.

Table 5: Energy Results Summary Ohlone Elementary School

Energy Results Summary - West Contra Costa - Ohlone Elementary School

		Title-24 TDV Energy (including process)		Site Energy			Peak	Lighting	HVAC Energy		
		Total	EUI	Electric	N. Gas	Total	Demand	Electric	Electric	N. Gas	Total
Alt	Description	(MBtu)	(kbtu/sf/yr)	(kWh)	(Therms)	(MBtu)	(kW)	(kWh)	(kWh)	(Therms)	(MBtu)
Alt 0	Title-24 Baseline	12,221.4	297.7	567,390	9,465	6,756	246	146,508	294,373	1,380	1,143
Alt 1	Baseline Prior to District Std Design Alts	11,679.9	284.5	543,516	8,744	6,439	239	146,508	270,499	729	996
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	11,293.1	275.1	526,197	8,733	6,261	222	146,508	253,180	718	936
Alt 3	Alt 2 + Window overhangs	11,186.8	272.5	520,780	8,762	6,208	220	146,508	247,763	747	920
Alt 4	Alt 3 + R-21 walls	11,186.8	272.5	519,588	8,517	6,172	217	146,508	246,571	502	892
Alt 5	Alt 4 + Efficient lighting with daylighting cont	10,241.3	249.5	473,381	8,577	5,705	203	112,567	234,305	562	856
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	10,143.2	247.1	471,560	8,262	5,654	200	112,567	232,484	247	818
Alt 7	Alt 6 + Airside economizer controls	9,068.4	220.9	409,868	8,263	5,023	199	112,567	170,792	248	608
Alt 8	Alt 7 + Demand control ventilation	9,024.1	219.8	409,307	8,169	5,008	197	112,567	170,231	154	596
Alt 9	*Alt 8 + Revised window area*	*9,091.0*	*221.4*	*412,313*	*8,170*	*5,039*	*201*	*112,567*	*173,237*	*155*	*607*
Alt 10	*Alt 9 + Energy recovery*	*9,091.0*	*221.4*	*424,521*	*8,093*	*5,156*	*201*	*112,567*	*185,445*	*78*	*641*

Table 6: Cumulative Energy Savings Summary – Ohlone Elementary School

Cumulative Energy Savings Summary - West Contra Costa - Ohlone Elementary School

		Title-24 TDV Energy		Site Energy			Peak	Lighting	HVAC Energy			CHPS E1.1 Points
		Total	EUI	Electric	N. Gas	Total	Demand	Electric	Electric	N. Gas	Total	
Alt	Description	(%)	(kBtu/sf/yr)	(kWh)	(Therms)	(MBtu)	(kW)	(kWh)	(kWh)	(Therms)	(MBtu)	
Alt 1	Baseline Prior to District Std Design Alts	4.4	13.2	23,874	721	317	7	0	23,874	651	147	0
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	7.6	22.6	41,193	732	495	24	0	41,193	662	207	0
Alt 3	Alt 2 + Window overhangs	8.5	25.2	46,528	703	547	26	0	46,528	633	222	0
Alt 4	Alt 3 + R-21 walls	8.5	25.2	47,867	950	585	31	0	47,867	880	251	0
Alt 5	Alt 4 + Efficient lighting with daylighting cont	16.3	48.5	94,661	889	1,058	43	33,941	60,720	819	289	3
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	17.0	50.6	95,830	1,203	1,101	46	33,941	61,889	1,133	325	3
Alt 7	Alt 6 + Airside economizer controls	25.8	76.8	157,522	1,202	1,733	47	33,941	123,581	1,132	535	7
Alt 8	Alt 7 + Demand control ventilation	26.2	78.2	161,963	70	1,665	48	33,941	128,022	0	437	8
Alt 9	*Alt 8 + Revised window area*	*24.8*	*73.1*	*146,265*	*1,634*	*1,661*	*43*	*33,941*	*112,324*	*1,564*	*540*	*7*
Alt 10	*Alt 9 + Energy recovery*	*24.8*	*73.1*	*134,057*	*1,712*	*1,544*	*43*	*33,941*	*100,116*	*1,642*	*506*	*7*

Table 7: Incremental Energy Savings Summary – Ohlone Elementary School

Incremental Energy Savings Summary - West Contra Costa - Ohlone Elementary School

		Title-24 TDV Energy		Site Energy			Peak	Lighting	HVAC Energy			CHPS E1.1 Points
		Total	EUI	Electric	N. Gas	Total	Demand	Electric	Electric	N. Gas	Total	
Alt	Description	(%)	(kBtu/sf/yr)	(kWh)	(Therms)	(MBtu)	(kW)	(kWh)	(kWh)	(Therms)	(MBtu)	
Alt 1	Baseline Prior to District Std Design Alts	4.4	13.2	23,874	721	317	7	0	23,874	651	147	0
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	3.2	9.4	17,319	11	178	17	0	17,319	11	60	0
Alt 3	Alt 2 + Window overhangs	0.9	2.5	5,335	-29	52	2	0	5,335	-29	15	0
Alt 4	Alt 3 + R-21 walls	0.0	0.1	1,339	247	38	5	0	1,339	247	29	0
Alt 5	Alt 4 + Efficient lighting with daylighting cont	7.8	23.3	46,794	-61	473	12	33,941	12,853	-61	38	3
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	0.7	2.1	1,169	314	43	3	0	1,169	314	35	0
Alt 7	Alt 6 + Airside economizer controls	8.8	26.2	61,692	-1	632	0	0	61,692	-1	210	4
Alt 8	Alt 7 + Demand control ventilation	0.4	1.4	4,441	-1,132	-68	1	0	4,441	-1,132	-98	1
Alt 9	*Alt 8 + Revised window area*	*-1.4*	*-5.1*	*-15,698*	*1,564*	*-4*	*-5*	*0*	*-15,698*	*1,564*	*103*	*-1*
Alt 10	*Alt 9 + Energy recovery*	*0.0*	*0.0*	*-12,208*	*78*	*-117*	*0*	*0*	*-12,208*	*78*	*-34*	*0*

Table 8: Renewable Energy Summary – Ohlone Elementary School

		Total Source Energy	Energy - PV Required (DC Rated)			Electricity Generated (kWh/year)		
			1 point	2 points	3 points	1 point	2 points	3 points
Alt	Description	(MBtu)	5%	10%	15%	5%	10%	15%
Alt 0	Title-24 Baseline	6,756	25.2	50.5	75.7	32,992	65,983	98,975
Alt 1	Baseline Prior to District Std Design Alts	6,439	24.1	48.1	72.2	31,446	62,891	94,337
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	6,261	23.4	46.8	70.2	30,574	61,149	91,723
Alt 3	Alt 2 + Window overhangs	6,208	23.2	46.4	69.6	30,318	60,635	90,953
Alt 4	Alt 3 + R-21 walls	6,172	23.1	46.1	69.2	30,138	60,277	90,415
Alt 5	Alt 4 + Efficient lighting with daylighting cont	5,705	21.3	42.6	63.9	27,857	55,715	83,572
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	5,655	21.1	42.3	63.4	27,613	55,225	82,838
Alt 7	Alt 6 + Airside economizer controls	5,023	18.8	37.5	56.3	24,528	49,057	73,585
Alt 8	Alt 7 + Demand control ventilation	5,008	18.7	37.4	56.1	24,455	48,909	73,364
Alt 9	*Alt 8 + Revised window area*	*5,039*	18.8	37.7	56.5	24,605	49,211	73,816
Alt 10	*Alt 9 + Energy recovery*	*5,156*	19.3	38.5	57.8	25,178	50,356	75,533

5.2 Cost Impacts

This section presents the economic impacts of the design alternatives on the as-designed baseline.

The table presents the cost results summary, including the estimated annual utility costs, and the incremental cost or additional capital expenditure associated with implementing each alternative. In this table, each design alternative builds up on the previous design alternative, and the cumulative cost savings, incremental cost and lifecycle cost are reflected.

The second table presents the cumulative cost savings for each measure. In this table, each design alternative builds up on the previous design alternative, and the cumulative cost savings, incremental cost, and simple payback are reflected.

The third table presents the incremental cost savings for each measure.

The fourth table presents the annual energy cost, incremental cost, and cost payback associated with achieving the CHPS renewable energy credits by installing photovoltaics.

Table 9: Cost Results Summary – Ohlone Elementary School

Cost Results Summary - West Contra Costa - Ohlone Elementary School

		Electric		Natural	Total	First	LCC
		Energy	Total	Gas	Utility	Cost	25 Yr
Alt	Description	($)	($)	($)	($)	($)	($)
Alt 0	Title-24 Baseline	$102,829	$102,829	$7,983	$110,812	$0	$2,770,300
Alt 1	Baseline Prior to District Std Design Alts	$98,991	$98,991	$7,358	$106,349	$0	$2,658,725
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	$94,703	$94,703	$7,348	$102,051	$3,645	$2,554,920
Alt 3	Alt 2 + Window overhangs	$93,717	$93,717	$7,374	$101,091	$17,145	$2,544,420
Alt 4	Alt 3 + R-21 walls	$93,212	$93,212	$7,160	$100,372	$20,379	$2,529,679
Alt 5	Alt 4 + Efficient lighting with daylighting cont	$85,752	$85,752	$7,213	$92,965	$81,960	$2,406,085
Alt 6	Alt 5 + High efficiency dual pane, low-E windo	$84,967	$84,967	$6,937	$91,904	$108,372	$2,405,972
Alt 7	Alt 6 + Airside economizer controls	$77,353	$77,353	$6,938	$84,291	$131,572	$2,238,847
Alt 8	Alt 7 + Demand control ventilation	$76,478	$76,478	$6,856	$83,334	$151,872	$2,235,222
Alt 9	Alt 8 + Revised window area	$77,197	$77,197	$6,857	$84,054	$194,994	$2,296,344
Alt 10	*Alt 9 + Energy recovery*	$79,483	$79,483	$6,792	$86,275	$256,575	$2,425,756

Table 10: Cumulative Cost Savings Summary – Ohlone Elementary School

Cumulative Cost Savings Summary - West Contra Costa - Ohlone Elementary School

		Electric		Natural	Total	Simple	LCC
		Energy	Total	Gas	Utility	Payback	25 Yr
Alt	Description	($)	($)	($)	($)	(yrs)	($)
Alt 1	Baseline Prior to District Std Design Alts	$3,838	$3,838	$625	$4,463	0.0	$111,575
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	$8,126	$8,126	$635	$8,761	0.4	$215,380
Alt 3	Alt 2 + Window overhangs	$9,112	$9,112	$609	$9,721	1.8	$225,880
Alt 4	*Alt 3 + R-21 walls*	$9,617	$9,617	$823	$10,440	2.0	$240,621
Alt 5	Alt 4 + Efficient lighting with daylighting cont	$17,077	$17,077	$770	$17,847	4.6	$364,215
Alt 6	*Alt 5 + High efficiency dual pane, low-E windo*	$17,862	$17,862	$1,046	$18,908	5.7	$364,328
Alt 7	Alt 6 + Airside economizer controls	$25,476	$25,476	$1,045	$26,521	5.0	$531,453
Alt 8	Alt 7 + Demand control ventilation	$26,351	$26,351	$1,127	$27,478	5.5	$535,078
Alt 9	Alt 8 + Revised window area	$25,632	$25,632	$1,126	$26,758	7.3	$473,956
Alt 10	*Alt 9 + Energy recovery*	$23,346	$23,346	$1,191	$24,537	10.5	$344,544

Table 11: Incremental Cost Savings Summary – Ohlone Elementary School

Incremental Cost Savings Summary - West Contra Costa - Ohlone Elementary School

		Electric		Natural	Total	Simple	LCC
		Energy	Total	Gas	Utility	Payback	25 Yr
Alt	Description	($)	($)	($)	($)	(yrs)	($)
Alt 1	Baseline Prior to District Std Design Alts	$3,838	$3,838	$625	$4,463	0.0	$111,575
Alt 2	Alt 1 + HVAC Efficiency - 14 SEER, 81%	$4,288	$4,288	$10	$4,298	0.8	$103,805
Alt 3	Alt 2 + Window overhangs	$986	$986	($26)	$960	14.1	$10,500
Alt 4	*Alt 3 + R-21 walls*	$505	$505	$214	$719	4.5	$14,741
Alt 5	Alt 4 + Efficient lighting with daylighting cont	$7,460	$7,460	($53)	$7,407	8.3	$123,594
Alt 6	*Alt 5 + High efficiency dual pane, low-E windo*	$785	$785	$276	$1,061	24.9	$113
Alt 7	Alt 6 + Airside economizer controls	$7,614	$7,614	($1)	$7,613	3.0	$167,125
Alt 8	Alt 7 + Demand control ventilation	$875	$875	$82	$957	21.2	$3,625
Alt 9	Alt 8 + Revised window area	($719)	($719)	($1)	($720)	0.0	-$61,122
Alt 10	*Alt 9 + Energy recovery*	($2,286)	($2,286)	$65	($2,221)	0.0	-$129,412

SECTION 6.0: Discussion on Design Alternatives and CHPS Criteria

Energy efficiency and equipment selection can contribute to CHPS credits in both the Energy and the Indoor Environmental Quality categories of the CHPS criteria. The design team put considerable time into identifying design alternatives that maximize both the Energy and Indoor Environmental categories. Increasing Title 24 performance came at the expense of Indoor Environmental Quality category for some alternatives. This section includes brief discussion on the impact that the design alternative may have on achieving credits using the CHPS criteria and the impact on Title 24 compliance margin.

Relevant CHPS Credits for Energy Efficiency Category

- EE1.0 Minimum Energy Performance Prerequisite: the school is designed to exceed Title 24 by at least 10% and meets the Energy Efficiency prerequisite.
- EE1.1 Superior Energy Performance: the intent of this credit is to exceed the energy performance of the buildings beyond the prerequisite 10%. If Measures 1 through 8 are all implemented, the project would perform approximately 26.2% better than Title 24-2005, earning eight EE1.1 points.
- EE2.1 Renewable Energy: renewable energy systems are currently not in the design. The tables in Section 4 indicate the required photovoltaics needed to achieve 1 point, 2 points, or 3 points for each design alternative modeled.

Relevant CHPS Credits for Indoor Environmental Quality Category

- EQ1.1 Daylighting: the intent of this credit is to provide high quality daylighting in classrooms to enhance student performance and achieve credit in one of three methods.

  In order to achieve this credit, all spaces where credit is taken may not have direct sun hitting anywhere within 4 feet of the classroom space. The SPOT analysis did not have the capability to reflect the sun check as meeting the requirements in each space. Therefore, an alternative software such as the software used for completing the drawings may be needed to verify compliance with this requirement.

  Additionally, each space where credit is taken must have the capability to turn off or dim electric lights when daylighting is available, and diffusing glazing must be located above the line of sight for the teacher and the students.

After the direct sun check requirement is met, the project can document compliance with this credit using one of the following three approaches:

- Single Point in Time: An average horizontal illumination of 25 footcandles is required on a sunny day at noon on March 21. Additional uniformity at the workplane no greater than 8:1 is required at this time.
    - 1 point – 25% of classrooms meet the requirements
    - 2 points – 50% of classrooms meet the requirements
    - 3 points – 75% of classrooms meet the requirements
    - 4 points – 100% of classrooms meet the requirements
- Daylight Saturation Percentage (DSP) Approach: The software must show an average daylight saturation percentage for all classroom spaces as follows:
    - 1 point – 30% average
    - 2 points – 45% average
    - 3 points – 60% average
    - 4 points – 75% average
- Daylight factor approach – the project must show a percentage of classrooms lit with a daylight factor of at least 2%:
    - 1 point – 25%
    - 2 points – 50%
    - 3 points – 75%
    - 4 points – 100%

A number of different glass types and window configurations were run, and additional analyses were run for the SH and mult-use classrooms to identify whether skylights or additional glazing could help meet the requirements in those classrooms.

A summary of the analysis results are shown below for the current design of the project. Other options were considered during the analysis, but have since been rejected, and therefore, are not included in the results.

Table 12: Incremental Cost Savings Summary – Ohlone Elementary School

Ohlone Elementary School - Daylighting Analysis (EQ1.1)								
Classroom	**Square Footage**	**Sun Dir.**	**Floor**	**Sun Check**	**Dylght Factor**	**Sat. %**	**PIT**	
A#1	930	North	2	Pass	3.30%	86%	4:1 - Pass	
A#2	930	North	2	Pass	3.30%	86%	4:1 - Pass	
A#3	930	North	2	Pass	3.30%	86%	4:1 - Pass	
B#1	930	North	1	Pass	2.90%	83%	5:1 - Pass	
B#2	930	North	1	Pass	2.90%	83%	5:1 - Pass	
B#3	930	North	1	Pass	2.90%	83%	5:1 - Pass	
B#4	930	North	1	Pass	2.90%	83%	5:1 - Pass	
B#5	930	North	1	Pass	2.90%	83%	5:1 - Pass	
B#6	930	North	1	Pass	2.90%	83%	5:1 - Pass	
A#4	930	South	2	Fail	2.90%	71%	4:1 - Pass	
A#5	930	South	2	**Fail**	2.90%	71%	4:1 - Pass	
A#6	930	South	2	**Fail**	2.90%	71%	4:1 - Pass	
A#7	930	South	2	**Fail**	2.90%	71%	4:1 - Pass	
B#7	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
B#8	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
B#9	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
B#10	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
B#11	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
B#12	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
B#13	930	South	1	**Fail**	2.20%	75%	4:1 - Pass	
A-SH	970	South	1	**Fail**	2.20%	71%	**10:1 - Fail**	
A-Multipurpose	971	South	1	**Fail**	2.30%	70%	**10:1 - Fail**	

							Points Available with this option (4 Maximum)	**Points available if Direct Sun Check were passing**
Requirement: Percent of classrooms passing direct sun check:					**41%**			
Option 1: Percent of classrooms meeting single point in time requiremer					**91%**		**1**	**3**
Option 2: Minimum average daylighting saturation:					**70%**		**0**	**3**
Option 3: Percent of classrooms with daylight factor > 2%					**100%**		**1**	**4**

- If no further analysis is done to show compliance with the Direct Sun Check, the maximum number of points achieved under EQ1.1 would be 1 point using either Option 1 or Option 3. If the direct sun check could be verified for all classrooms, then 4 points can be achieved using Option 3.