Final Investment Grade Audit Sample

Siemens Building Technologies, Inc. presented Crafton Hills College (CHC) with the attached Comprehensive Energy Assessment (CEA) Report. The analysis and proposal provided CHC with a comprehensive plan to reduce utility costs, replace aging equipment, improve comfort, enhance the appearance, and improve security at the campus through the use of available bond money in conjunction with a performance contract. The report was a result of an on-site audit and technical analyses and was reflective of Siemens desire to deliver the most cost effective, state-of-the-art, and reliable energy and operational savings solutions possible.

The overall objectives of this detailed evaluation were to identify facility improvement measures (FIMs), develop firm implementation costs and guaranteeable savings from those measures, and move the projects toward implementation. The level of analysis in this report provided an assessment of the potential for energy-efficiency financing opportunities at the college. As a first step, an understanding of the operations of the facilities, including the condition and scheduling of the buildings and systems, and the intent and focus of the facility use in the future were necessary. Based on this information, a broad-based yet comprehensive evaluation was conducted which addressed not only energy saving measures, but also the functionality of the space.

Based on the results of this evaluation, it was evident that opportunities did exist at Crafton Hills College to implement measures that reduced both energy usage and costs while maintaining or improving the comfort of the occupants. A list of these measures is provided in Table E-1.

Table E.1 Identified Measures Crafton Hills College

FIM Number	Measure Name
1	Interior Lighting Upgrade
2	Exterior Lighting Upgrade
3	Chiller Plant Upgrades
4	Conversion of Multizone Units to Variable Volume
5	Replacement of Boilers at Gymnasium
6	Upgrades to the Restrooms on Campus
7	Addition of a Building Access Control and Security System
8	Repair Economizer Dampers
9	Addition of Skylights to the Gymnasium
10	Addition of Photovoltaic Solar Panels to Gym Roof
11	Addition of a Natural Gas Refueling Station

Many of the measures also resulted in additional maintenance cost savings and reduced future capital costs for renovation and equipment replacement. The turnkey installation of the identified measures cost $6.3 million (less rebates and avoided capital estimated at $510,000) and saved $167,000 in annual utility energy costs. The project involved: detailed design, equipment selection, permitting, bonding, decommissioning, equipment removal, installation of new equipment, and commissioning.

The energy services program discussed in this study was a guaranteed program. This means that Siemens guaranteed the energy cost savings presented in this report. The guarantee was an annual reconciliation of the energy and operational savings presented versus the actual savings.

The project was developed, analyzed, implemented and measured by members of the Siemens team identified in Section 5.0.

COMPREHENSIVE ENERGY AUDIT

Crafton Hills College

Prepared by:

SIEMENS

December 2003

COMPREHENSIVE ENERGY ASSESSMENT FOR CRAFTON HILLS COLLEGE

Prepared for:

Crafton Hills College
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December 2003

Confidentiality of Information

This Comprehensive Energy Assessment Report package includes data that is proprietary and confidential and shall not be disclosed outside its recipient and shall not be duplicated, used, or disclosed, either in whole or in part, for any purpose other than it's evaluation. This restriction does not limit in any way the recipient's right to use information contained in this data if it is obtained from another source. The data subject to the restriction are contained in all sheets that are marked with the following legend: "Proprietary and confidential property of Siemens. Not to be reproduced or distributed without prior written Siemens approval."

EXECUTIVE SUMMARY

Siemens Building Technologies, Inc. (Siemens) is pleased to present Crafton Hills College (CHC) with this Comprehensive Energy Assessment (CEA) Report. This analysis and proposal provides CHC with a comprehensive plan to reduce utility costs, replace aging equipment, improve comfort, enhance the appearance, and improve security at the campus through the use of available bond money in conjunction with a performance contract. The report is a result of an on-site audit and technical analyses and is reflective of Siemens desire to deliver the most cost effective, state-of-the-art, and reliable energy and operational savings solutions possible.

The overall objectives of this detailed evaluation are to identify facility improvement measures (FIMs), develop firm implementation costs and guarantee able savings from those measures, and move the projects toward implementation. The level of analysis in this report provides an assessment of the potential for energy-efficiency financing opportunities at the college. As a first step, an understanding of the operations of the facilities, including the condition and scheduling of the buildings and systems, and the intent and focus of the facility use in the future are necessary. Based on this information, a broad-based yet comprehensive evaluation was conducted which addresses not only energy saving measures, but also the functionality of the space.

Based on the results of this evaluation, it is evident that opportunities exist at Crafton Hills College to implement measures that will reduce both energy usage and costs while maintaining or improving the comfort of the occupants. A list of these measures is provided in Table E-1.

Table E.1
Identified Measures
Crafton Hills College

FIM Number	Measure Name
1	Interior Lighting Upgrade
2	Exterior Lighting Upgrade
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4	Conversion of Multizone Units to Variable Volume
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9	Addition of Skylights to the Gymnasium
10	Addition of Photovoltaic Solar Panels to Gym Roof
11	Addition of a Natural Gas Refueling Station

Many of the measures will also result in additional maintenance cost savings and will reduce future capital costs for renovation and equipment replacement. The turnkey installation of the identified measures will cost $6.3 million (less rebates and avoided capital estimated at $510,000) and save $167,000 in annual utility energy costs. The project involves: detailed design, equipment selection, permitting, bonding, decommissioning, equipment removal, installation of new equipment, and commissioning.

The energy services program discussed in this study is a guaranteed program. This means that Siemens guarantees the energy cost savings presented in this report. The guarantee will be an annual reconciliation of the energy and operational savings presented versus the actual savings. If the energy services program exceeds the estimated savings, Crafton Hills College will get to keep the additional savings. If the energy services program does not meet the savings guaranteed, Siemens will make up the difference between the actual operational and energy savings, and the guaranteed amount. This reconciliation would be in form of a direct payment to the college from Siemens. **Therefore, the economics presented are a "worst case scenario" for the college since the savings may exceed those predicted but cannot be lower than projected – the money will come from either the utility reductions or from Siemens**. On behalf of college, Siemens can also apply for any available rebates from the utility.

If the recommendations made, project costs, and scopes of work are acceptable Crafton Hills College and Siemens should next enter into a construction agreement.

Key Features of Siemens Solution are:

1. **No Up-Front Capital**. All costs related to the implementation of the recommended solution such as a feasibility study, design and engineering fees, project management, construction cost, operations and maintenance training, monitoring of results, and verification of savings are included in Siemens integrated solution.

2. **Long-Term Comprehensive Perspective**. Siemens solution evaluates and considers all cost-effective measures and is not limited to short-term paybacks.

3. **Hassle-Free Implementation.** Since Siemens is an integrated arrangement, CHC does not have to allocate existing personnel to micro-manage the various steps involved in performing energy efficiency improvements such as feasibility studies, design and installing equipment, training personnel, and monitoring the systems' performance.

4. **Partners in Process**. Siemens will always include CHC personnel in key milestone decisions throughout the project.

5. **Performance Standards.** Siemens will address the quality of service provided and will ensure that vendors follow specific performance standards.

6. **Wrap-Around Warranty**. Siemens will provide an overall warranty coverage for a period of twelve months from the date of substantial completion for each end-use measure.

7. **Follow-Up Reports**. Siemens will provide CHC with a summary of the project's performance on a periodic basis.

TABLE OF CONTENTS

1.0 INTRODUCTION

Siemens is pleased to provide the San Bernardino Community College District (SBCCD) this evaluation of Crafton Hills College located at 11711 Sand Canyon Road, Yucaipa, California. The purpose of this evaluation is to:

- Aid SBCCD in reducing their energy expenditures at Crafton Hills College
- Maintain or improving occupant comfort
- Increase the esthetics of the campus through improvements to the lighting systems
- Improve the security on the campus

This energy and infrastructure evaluation included an in-depth analysis of utility billing rates; a room-by-room inventory of the lighting systems, an on-site survey to inspect building automation and HVAC systems; short-term monitoring and spot measurements of equipment performance; and interviews with the facility personnel.

For each identified opportunity, conceptual designs and project scopes of works were developed to develop firm turnkey implementation cost and guarantee able utility costs savings for each recommendation. The pricing presented herein represents a tentative scope for each capital improvement project with appropriate adjustments after review and comments from the college and district.

2.0 THE SIEMENS COMPANY

Founded in 1850, today The Siemens Company is one of the largest companies in the world employing almost 500,000 people world-wide in over 190 countries. Siemens has seven main business groups, which include:

Information and Communication

Power Generation and Distribution

Automation and Control

Transportation

Medical

Lighting

Financing and Real Estate

SIEMENS USA

For 280 million Americans - and for people around the globe - the 70,000 employees of Siemens USA are working together to change the world. With a wide array of products, systems and services, Siemens is a world leader in information and communications, automation and control, power, medical solutions, transportation and lighting. As Siemens' largest market in the world, with 11 of Siemens' worldwide businesses headquartered here, Siemens USA offers customers access to a strong global network of innovation.

SIEMENS BUILDING TECHNOLOGIES

With U.S. headquarters in Buffalo Grove, Illinois Siemens Building Technologies is part of Siemens Automation and Control division, which is the largest supplier of products, systems, solutions and services for industrial automation and building technology in the world. Through superior applications expertise combined with cutting-edge technology, the six divisions of Siemens Building Technologies create added value and outstanding benefits for customers. The result is higher productivity in buildings through comfort, life safety and security, eco-efficiency and programmed utilization. The six divisions include:

Building Automation

Systems and services for building and energy management, including integrated solutions

HVAC Products

Manufacture and distribution of products for controlling and operating heating, ventilating and air-conditioning systems

Fire Safety

Systems and services for fire detection, fire extinguishing systems, gas alarm devices and the evacuation of buildings

Security Systems

Systems and services for access control, surveillance systems and intrusion detection

Security & Fire Products

Development, manufacture and distribution of products for security systems and fire detection for use in-house, for OEM customers and for selected distribution partners.

Facility Management

Services for the efficient operation and programmed utilization of buildings throughout the lifecycle of the infrastructure

SIEMENS BUILDING TECHNOLOGIES - CALIFORNIA

Siemens Building Technologies maintains offices in the Bay area, Sacramento, San Diego, and Los Angeles. Combined, these offices employee over 500 people, 60 energy professionals, and have over 300 service trucks on the road. This presence makes Siemens one of, if not, the largest local building technology company in California. With this presence, Siemens annually provides over $30 million dollars of facility performance solutions to its customers. These projects are funded through savings captured from existing operating budgets and are guaranteed annually by Siemens.

3.0 ANALYSIS METHODOLOGY

This section presents a description of the analysis methodology used to estimate the potential savings available to Crafton Hills College from implementing the identified facility improvement measures (FIMs). For this project, Siemens developed a computer model of the campus based on monitored data, available prints, size of existing equipment, operating schedules, building occupancy schedules, typical outdoor temperatures, and conversations with facility operators. Room-by-room cooling load calculations were not performed. Lighting energy use for the model was estimated based on a room-by-room inventory of the existing fixtures with schedules based both upon conversations with facility operators and short term monitoring of representative fixtures. This model was then calibrated to the previous years utility data with energy usage (electrical consumption, electrical demand, and natural gas usage) and then converted to utility costs using the actual electric and natural gas rates. The purpose of this section is to authenticate, to all parties, the accuracy of the computer model, because an accurate model of the existing systems is paramount to projecting potential energy savings that can be realized

SHORT TERM MONITORING AND SPOT READINGS

To enhance the accuracy of the model and the calibration process, monitoring of various HVAC components and lighting systems were performed. To determine the power consumption of the various motors in the building, spot-measurements were conducted for motors. In addition, short-term monitoring was conducted for the air-handler fans and lighting operation in representative spaces to verify the operating schedules. Table 1 below provides a list of data monitored and spot measurements taken.

Table 1
Monitored Data and Spot Measurements

Item	Spot Measure	Short-Term Monitoring	Item	Spot Measure	Short-Term Monitoring
LADM Chilled Water Pump-1	x	x	LADM 3rd Floor Lighting		x
LADM Chilled Water Pump-2	x	x	LADM Rm 216 Lighting		x
LADM Condenser Water Pump-1	x		Library Rm 348 Lighting		x
AHU Café Fan	x	x	Library 3rd Flr Lobby Lighting		x
AHU Classroom Bldg Fan	x	x	PAC Rm 225 Lighting		x
AHU Library 2nd Floor Fan	x	x	Class Bldg Rm 111 Lighting		x
AHU PAC Fan	x	x	SSB Rm 110 Lighting		x
AHU LADM North Fan	x	x	Class Bldg Rm 106 Lighting		x
AHU LADM Biology 1 Fan	x	x	SSA Rm 213 Lighting		x
AHU LADM Biology 2 Fan	x	x	Class Bldg Rm 215 Lighting		x
AHU CHC - 1 Fan	x	x	SSA Fac Office Hall Lighting		x
AHU CHC - 2 Fan	x	x	Class Bldg Rm 218 Lighting		x
LADM Air Comp		x	Class Bldg Rm 219 Lighting		x
SSA 30 Ton Chiller		x	LADM Rm 201 Lighting		x
SSA Chilled Water Pump		x	LADM Rm 211 Lighting		x
SSA AHU by Admin		x			

COMPUTER MODELING

A detailed computer simulation was performed for entire Crafton Hills College using the Trace 700 building energy analysis program. Trace 700 was developed specifically for determining heating and cooling loads, and evaluating the energy performance of commercial buildings. It has been widely reviewed and validated in the public domain.

Trace 700 calculates hourly building energy consumption over an entire year using 30-year average weather data for the location under consideration (San Bernardino). Input to Trace 700 consists of a detailed description of the building being analyzed including hourly scheduling of occupants, lighting, equipment, and thermostat settings. Trace 700 provides very accurate simulation of such building features as shading, fenestration, interior building mass, envelope building mass, and the dynamic response of differing heating and air conditioning system types and controls.

The characteristics of the facility used to generate the simulation model were gathered from building plans and verified by on-site visits. Interviews with maintenance personnel were performed to determine central plant operation, control methods, and to detail any other operational characteristics that would effect energy consumption.

The simulation process begins by developing a baseline model of the building then fine-tuning the model using the monitored data to reflect actual building operation. Once the computer model results reflect monitored and utility data within acceptable limits, the base model can then be modified to reflect the proposed FIMs. These alternate models created can then be simulated to predict the annual energy and utility cost savings for each of the FIMs.

RESULTS FROM THE COMPUTER MODEL

Figure 1, shows a comparison between the monthly, metered electric demand (kW) and the monthly electric demand calculated by the computer model.

Figure 1
Comparison of Actual to Modeled Electric Demand (kW)

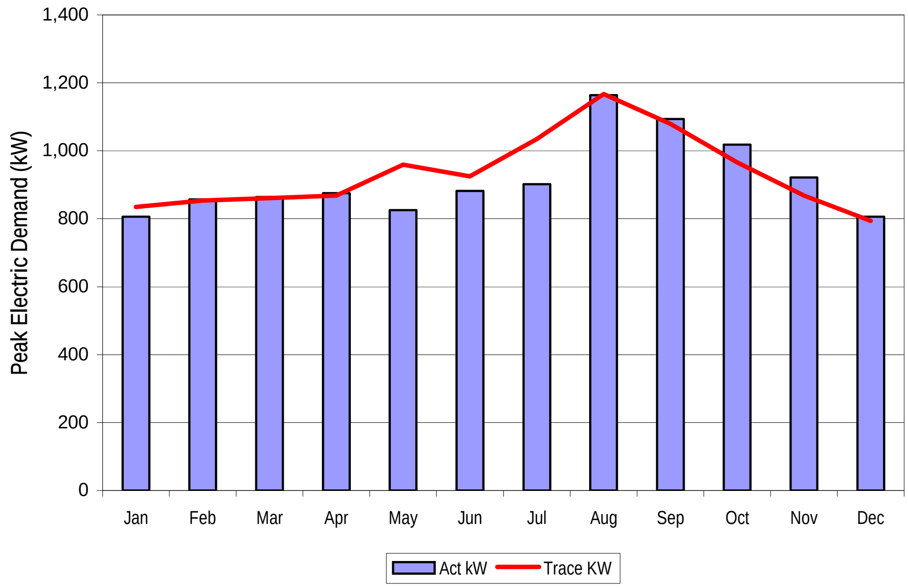


Figure 2, shows a comparison between the monthly, metered electric consumption (kWh) and the monthly electric consumption calculated by the computer model.

Figure 2
Comparison of Actual to Modeled Electric Consumption (kWh)

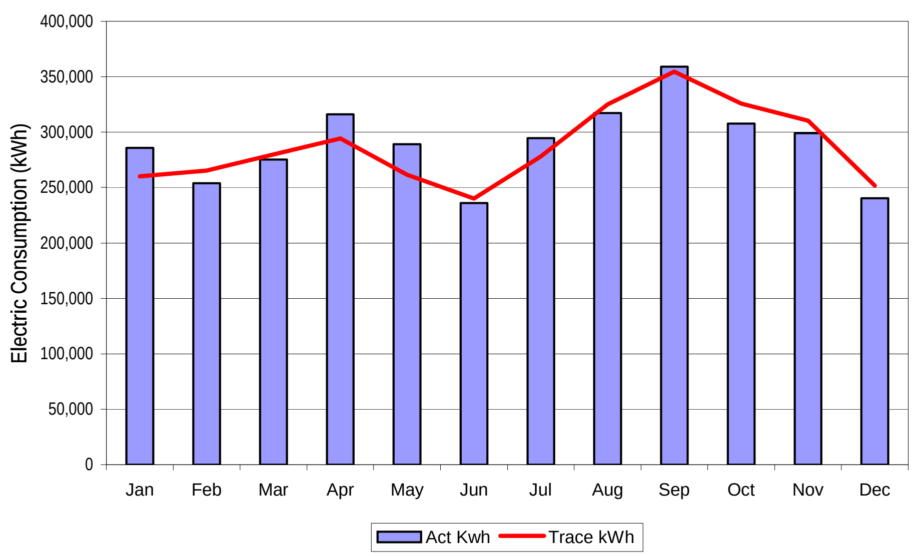


Figure 3 through Figure 14 show a comparison between the actual 15-minute demand data and the hourly-calculated demand from the computer model for the weekdays of each month.

Figure 3
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for January

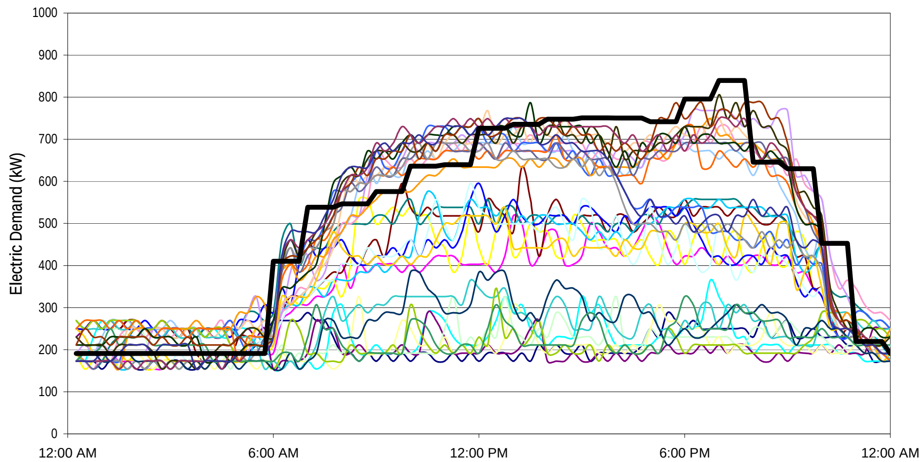


Figure 4
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for February

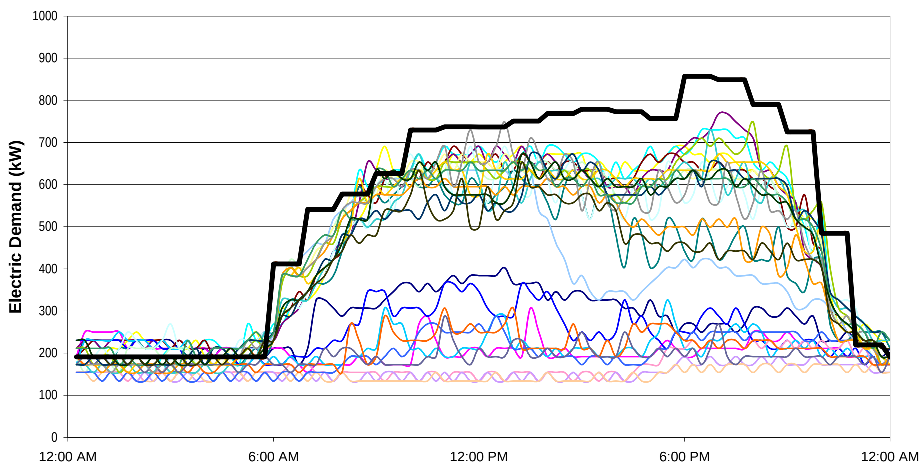


Figure 5
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for March

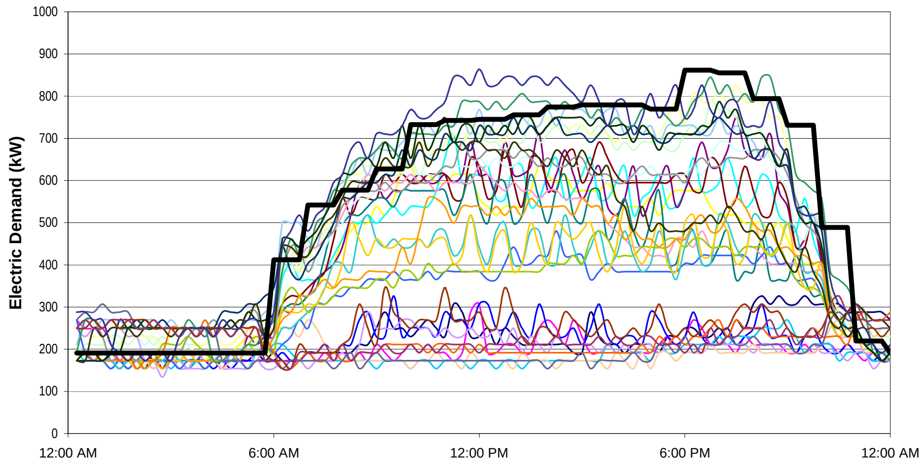


Figure 6
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for April

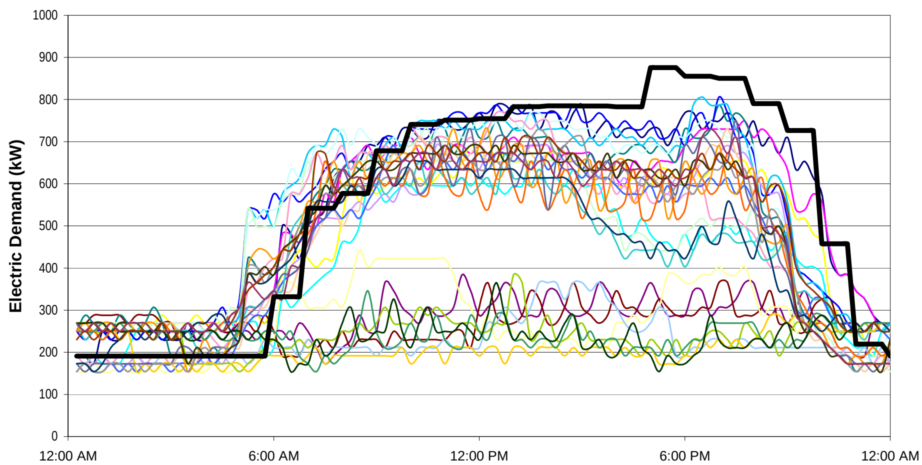


Figure 7
Comparison of Actual 15-minute Demand Data (kW) to Hourly Modeled Demand Data for May

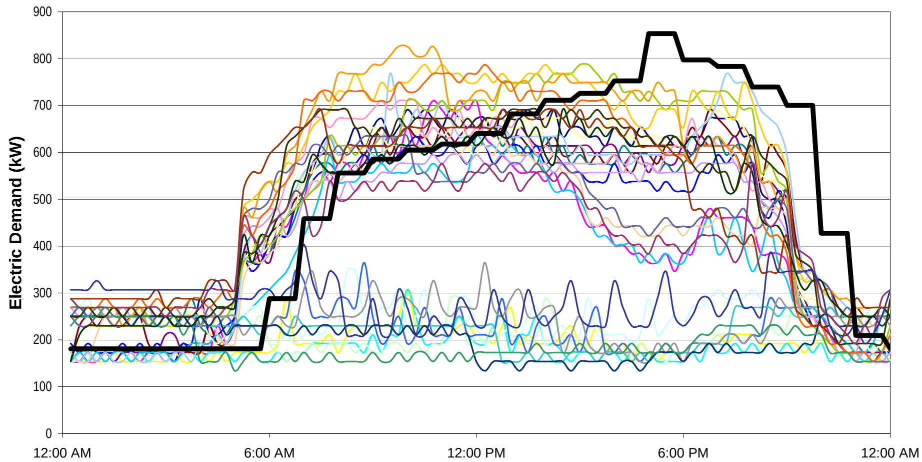


Figure 8
Comparison of Actual 15-minute Demand Data (kW) to Hourly Modeled Demand Data for June

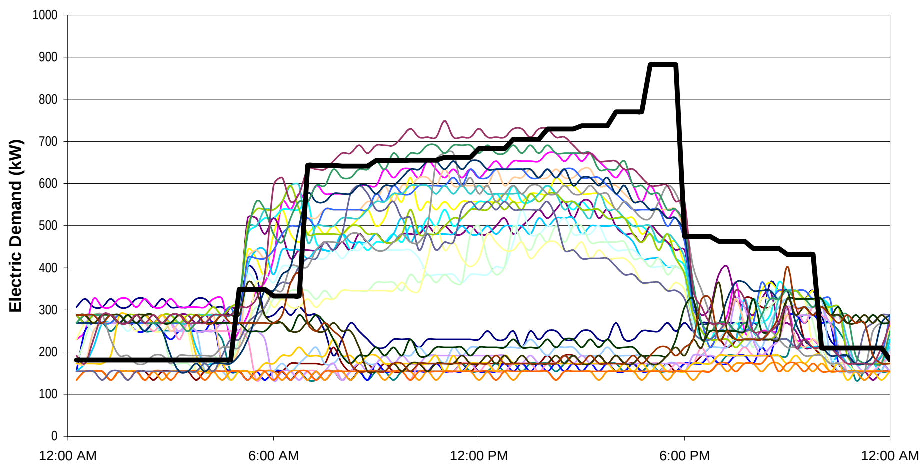


Figure 9
Comparison of Actual 15-minute Demand Data (kW) to Hourly Modeled Demand Data for July

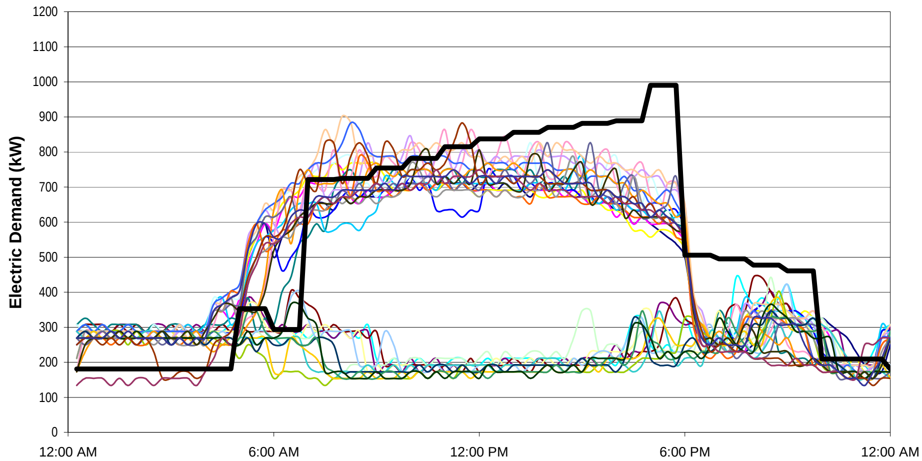


Figure 10
Comparison of Actual 15-minute Demand Data (kW) to Hourly Modeled Demand Data for August

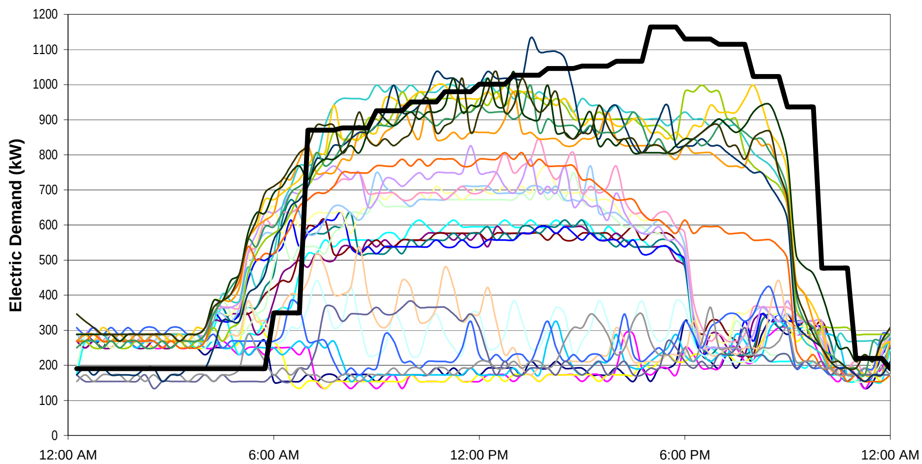


Figure 11
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for September

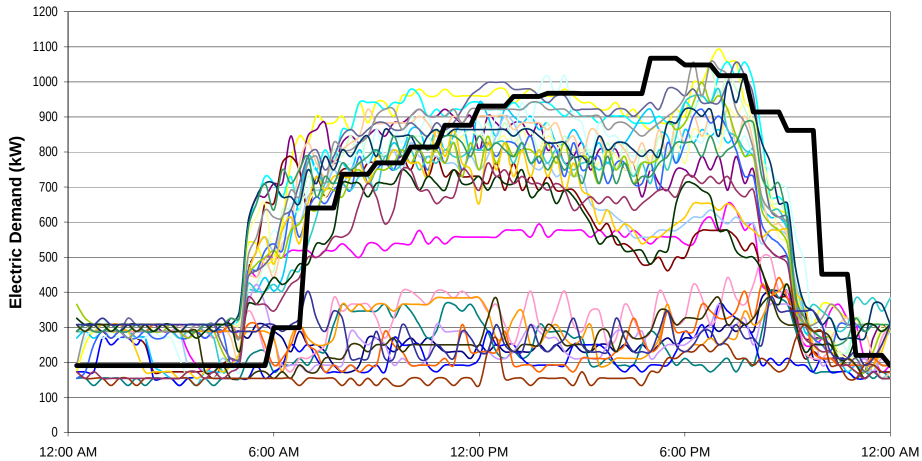


Figure 12
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for October

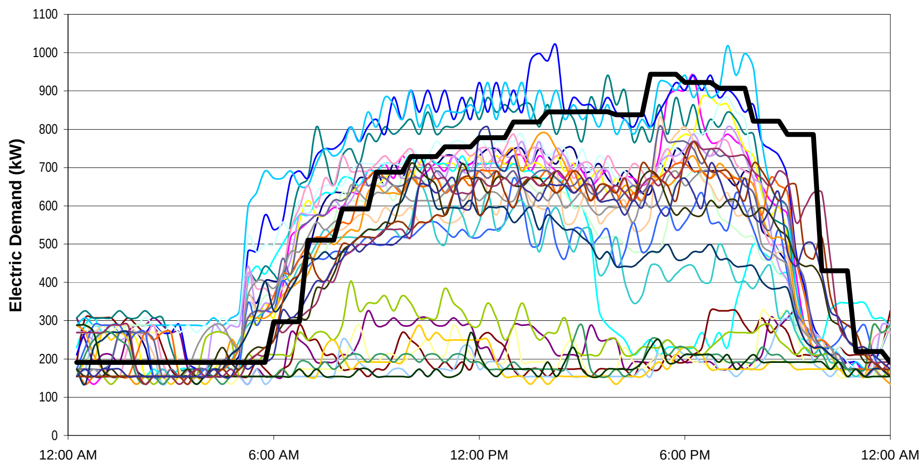


Figure 13
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for November

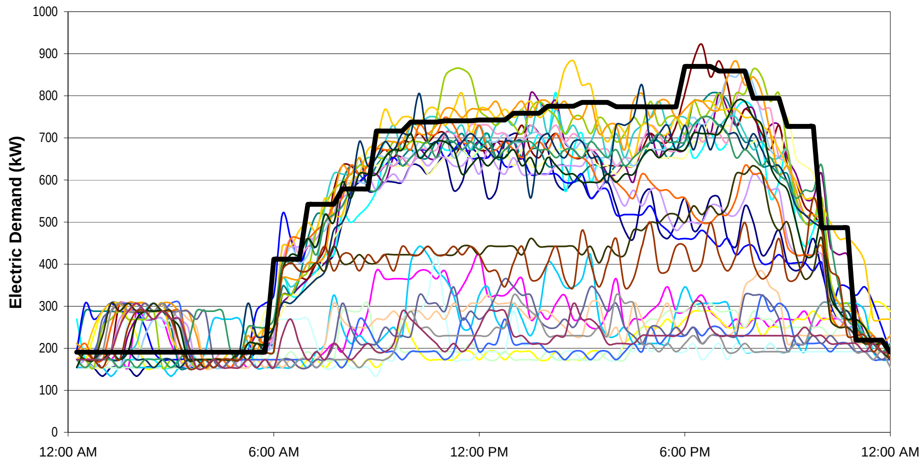


Figure 14
Comparison of Actual 15-minute Demand Data (kW) to
Hourly Modeled Demand Data for November

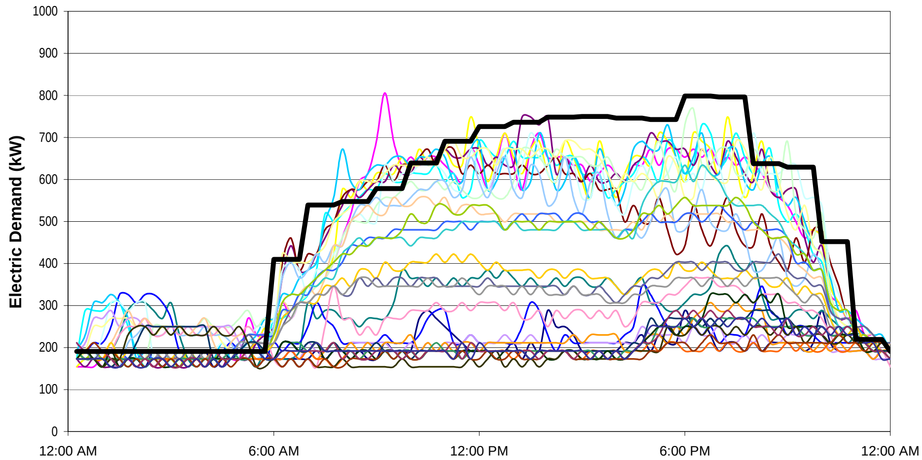


Figure 15, shows a breakdown of the electric consumption by end-use.

Figure 15
Break Down of Electric Consumption (kWh) by End-Use

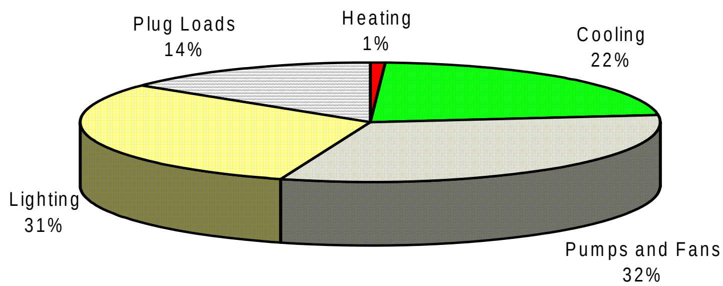


Figure 16, shows a comparison of the actual monthly electric cost and the monthly electric cost predicted from the computer model.

Figure 16
Comparison of Actual Electric Cost to Computer Model

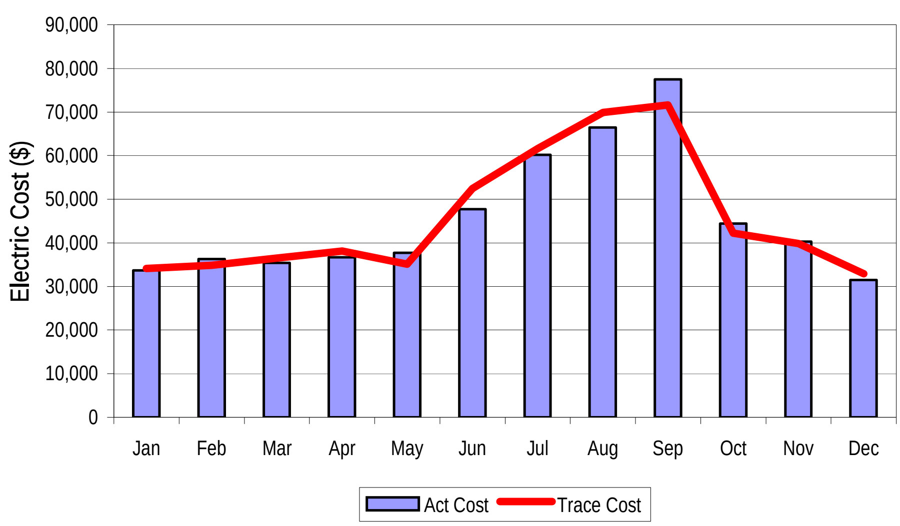


Figure 17, shows a comparison of the actual monthly natural gas usage and the monthly natural gas usage predicted by the computer model.

Figure 17
Comparison of Actual to Modeled Natural Gas Consumption (therms)

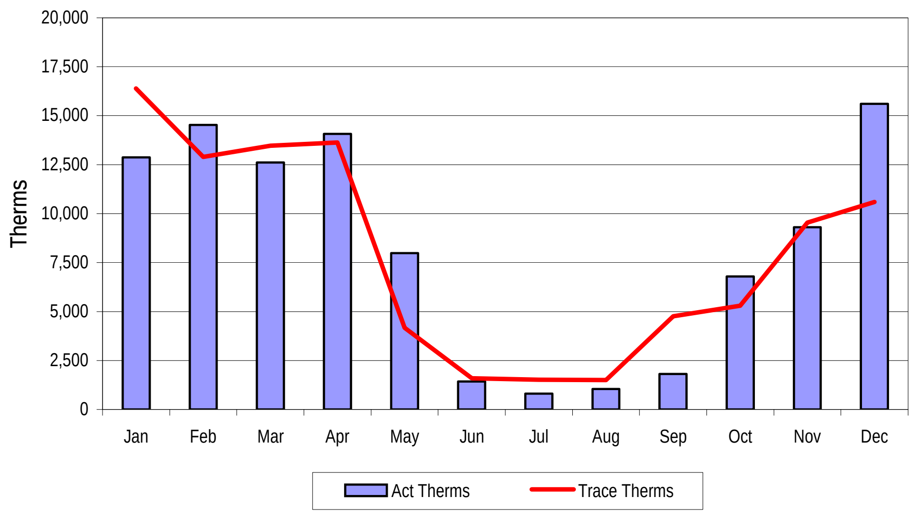
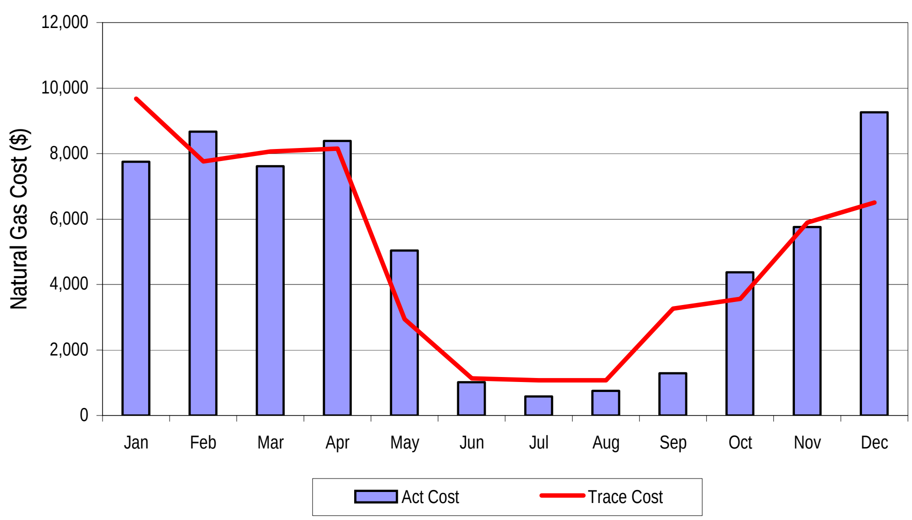


Figure 18, shows a comparison of the actual monthly natural gas cost and the monthly natural gas cost predicted by the computer model.

Figure 18
Comparison of Actual to Modeled Natural Gas Cost ($)



SUMMARY OF ANALYSIS METHODOLOGY

Results presented from the computer model show a close correlation to the actual utility monitored data. This close correlation indicates that the computer model provides an accurate representation of the energy using equipment, heating and cooling loads, and operating schedules; and can be used to predict energy savings at the campus.

4.0 IDENTIFIED MEASURES

Facility improvement measures (FIMs) were identified to reduce operational cost, improve comfort conditions, and address operational and maintenance concerns at the college. Estimates for total project costs, energy savings, and project economics were determined for each of the identified measures. Appendix A provides a detailed scope of work for each of the facility improvement measures listed. The identified measures, are presented in Table 2

Table 2
Identified Measures
Crafton Hills College

FIM Number	Measure Name
1	Interior Lighting Upgrade
2	Exterior Lighting Upgrade
3	Chiller Plant Upgrades
4	Conversion of Multizone Units to Variable Volume
5	Replacement of Boilers at Gymnasium
6	Upgrades to the Restrooms on Campus
7	Addition of a Building Access Control and Security System
8	Repair Economizer Dampers
9	Addition of Skylights to the Gymnasium
10	Addition of Photovoltaic Solar Panels to Gym Roof
11	Addition of a Natural Gas Refueling Station

FIM-1, INTERIOR LIGHTING UPGRADE

This FIM addresses retrofit strategies for fluorescent lighting systems using T12 lamps, first generation T8 lamps, lighting controls, exit sign lighting, and the incandescent lighting. Fixture quantities and types are based on a detailed room-by-room lighting audit.

Fluorescent Lighting Systems. The existing fluorescent lighting systems will be upgraded to utilize third generation T8 lamps and programmable electronic ballasts. The new third generation T8 lamps and ballasts use 19 percent less energy and have rated lamp lives 50 percent longer than the first generation T8 lamps currently used by the campus. As part of the space-by-space assessment the lighting retrofit was selected to provide lighting levels in accordance with IES recommendations to ensure proper lighting levels while minimizing energy consumption.

Incandescent Lighting. Incandescent light bulbs are an inefficient lighting source when compared to other means of illuminating a space. The incandescent bulbs use excessive amounts of energy, and require extensive maintenance to ensure fixtures are operational. The remaining incandescent fixtures will be retrofitted to utilize compact fluorescent lamps.

Metal Halide Lighting. The gymnasium is illuminated with 400 watt metal halide lighting. These fixtures will be replaced with surface mounted fluorescent T-8 fixtures with a wire cage and the lighting system will be re-circuited to enable the college to illuminate portions of the gym floor. The T-8 fluorescent lighting will dramatically improve the quality of light in the gymnasiums while reducing the energy usage of the lighting systems.

Exit Sign Lighting. The existing exit signs not illuminated with light-emitting diodes (LEDs) will be replaced with new signs using LEDs. LEDs are ideal for exit signs because they use very little energy, as low as 1.0 watt per illuminated face, and maintenance free life expectancies are over twenty years. LED exit signs compliant with the U.S. EPA's Energy Star Exit Sign Program use 5 watts or less per illuminated face. Traditional incandescent exit signs use 40 watts per illuminated face and require annual maintenance to replace the bulbs. The compact fluorescent lamps (CFLs) with screw-in bases are available to retrofit exit signs that use incandescent lamps. CFLs use 7 to 9 watts per sign and last about 15 months. While retrofit kits are available to convert the existing exit signs from to LED, Siemens will replace the existing exit signs with new signs to ensure that the signs illumination meets local fire codes.

Lighting Controls. Interior lighting is controlled by manual wall switches and by old single technology occupancy sensors that are reported by the occupants and staff to be non-functional in many spaces. This measure includes installing dual technology occupancy sensors that utilize both passive infrared and ultrasonic occupancy sensors to turn off the lights when the spaces are vacant.

FIM 2, EXTERIOR LIGHTING UPGRADE

This measure recommends upgrades to the exterior lighting on the campus. The campus was originally designed with exterior lighting provided by low-pressure sodium fixtures. Due to the poor lighting around the campus, metal halide wall packs were added around the campus to improve the lighting. The campus has a desire to upgrade all exterior lighting on the campus and add additional lighting – the primary focus of the exterior lighting upgrade is not to reduce energy use, but rather to efficiently increase the quantity and quality of light. Existing pole mounted flood fixtures will be replaced with new fixtures that contain induction fluorescent lamps. These lamps do not contain electrodes. Current is induced inside the lamp through a magnetic field, and since the electrodes are normally the point of failure in a fluorescent lamp, the rated life on these induction lamps is 100,000 hours of use. These will be used to replace existing Low Pressure Sodium, High Pressure Sodium, and Metal Halide pole fixtures with rated lives of 24,000 hours and 20,000 hours. Replacing lamps five times less often at the top of 30' poles saves significant maintenance dollars. Additionally, fluorescent sources have higher color rendering indices than low pressure sodium, high pressure sodium, or metal halide sources which provides much better visual acuity, especially at night.

Walkway bollards will be retrofitted with lower wattage PL type lamps and removing ballasts to capture energy savings. Building mounted decorative fixtures will be replaced with lower wattage PL type lamps to capture energy savings and improve the aesthetics of the campus. Pole mounted sports lighting at the tennis courts will be replaced with new 1,000 watt Metal Halide sports lighting fixtures. All of these outdoor lighting upgrade measures will result in clean outdoor lighting fixtures in top working order with new lamps.

FIM 3, CHILLER PLANT UPGRADES

Improvements to the SSA central plant include:

- Converting the two primary only pumping systems to a combined primary-secondary.
- Converting the chilled water distribution system from constant volume pumping to variable volume.
- Converting the 70-ton water-cooled screw chiller to a centrifugal chiller with a variable frequency drive.
- Interconnection with the LADM Plant

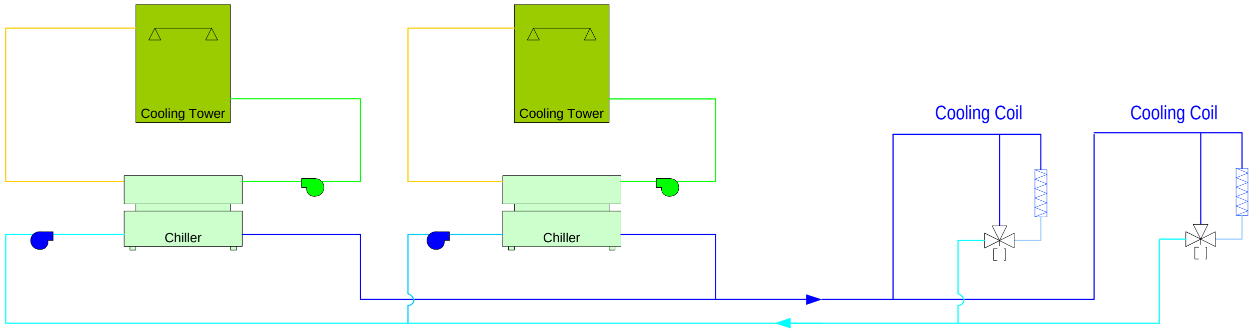
Improvements to the LADM central plant include:

- Converting the primary only pumping system to primary-secondary system.
- Converting the chilled water distribution system from constant volume pumping to variable volume.
- Addition of a cogeneration system with an absorption chiller.
- Interconnection with the SSA Plant

Conversion to Primary-Secondary

Currently, both the SSA and LADM chiller plants use a parallel primary only chiller chilled water distribution system similar to what is shown in Figure 19.

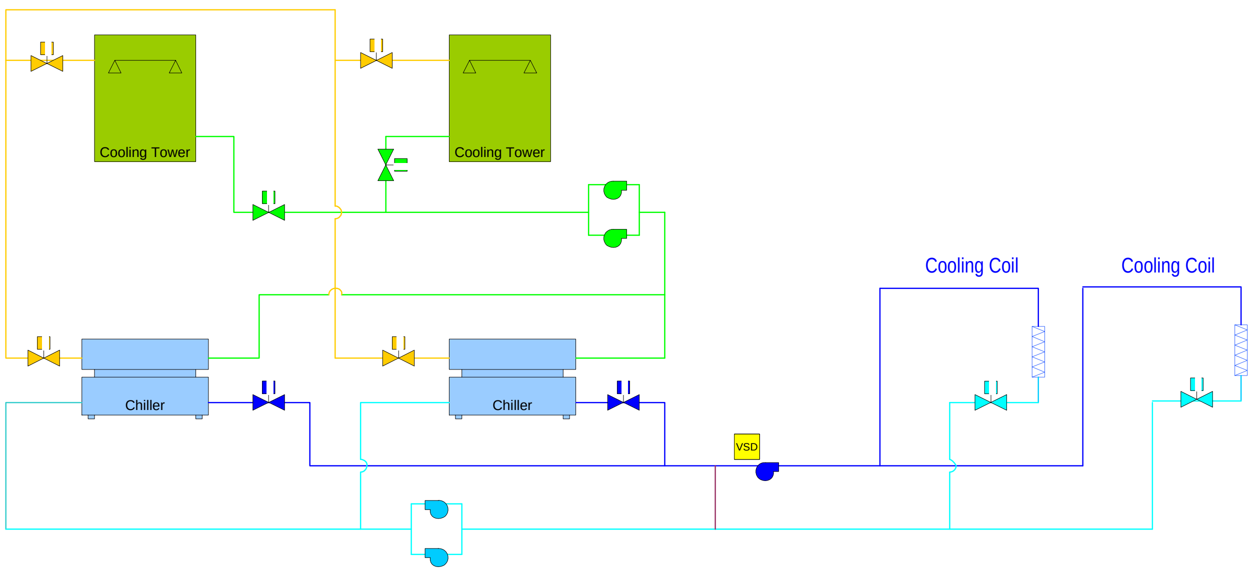
Figure 19
Schematic of Existing Chilled Water Distribution



With this configuration, if the control sequence cycles the pumps with the chillers, the total system flow will decrease significantly, according to the pump-system curve relationship when only one chiller is operating. With only one pump operating, all the cooling coils will receive less water, regardless of their need. Consequently, it is possible to starve some loads that are still high, or to starve the loads farthest from the pump.

The conversion to a primary-secondary pumping system overcomes the problems associated with the fixed relationship between the chiller and the system flow rates. The primary-secondary pumping configuration decouples the production of chilled water from the distribution of chilled water. Figure 20 shows a schematic of a decoupled system. Separate pumps are dedicated to the production and distribution. While the same water is pumped twice, there is no duplication of pumping energy because the production pumps overcome only the chiller and production-side pressure drop while the distribution pumps overcome only the distribution system pressure drops.

Figure 20
Schematic of Primary Secondary System

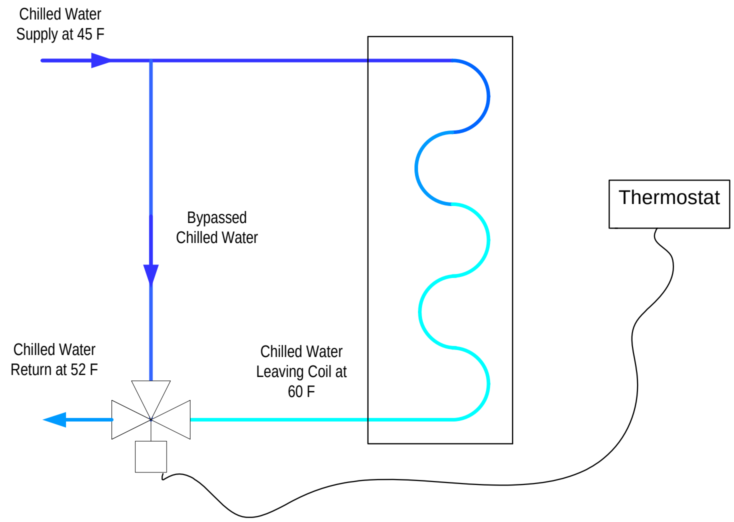


The biggest advantage of converting the system to primary secondary is the ability to easily convert the chilled water in the distribution system to variable flow since the restrictions of constant flow through the chiller are not an issue in a decoupled system.

Convert Constant Volume Pumping to Variable Volume

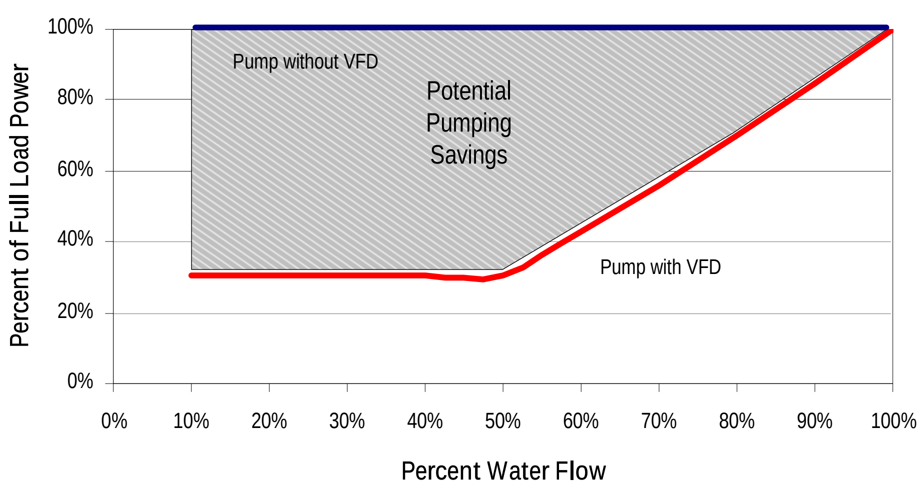
This measure recommends upgrading the chilled water distribution system to variable flow. Currently, the chilled water system distributes a constant volume of water to the air-handling units. At the air-handler, a 3-way automatic valve that modulates to control the temperature of the supply air. Figure 21 shows a schematic of a typical the 3-way valve and coil arrangement. The water that bypasses the coil is unnecessarily pumped to the coil.

Figure 21
Schematic of Cooling Coil with 3-Way Valve



As part of the conversion to variable flow, the 3-way chilled water valves will be replaced with 2-way modulating chilled water valves. The conversion of the chilled water distribution from constant volume will dramatically reduce the amount of pumping energy used by the college. The power required to pump the chilled water varies as a cubic function to the amount of water distributed. Figure 22, shows a graph of the pumping power required versus the amount of flow delivered. As can be seen, the ability to reduce the amount of chilled water pumped to the air-handlers during off-peak conditions will dramatically reduce the pumping energy.

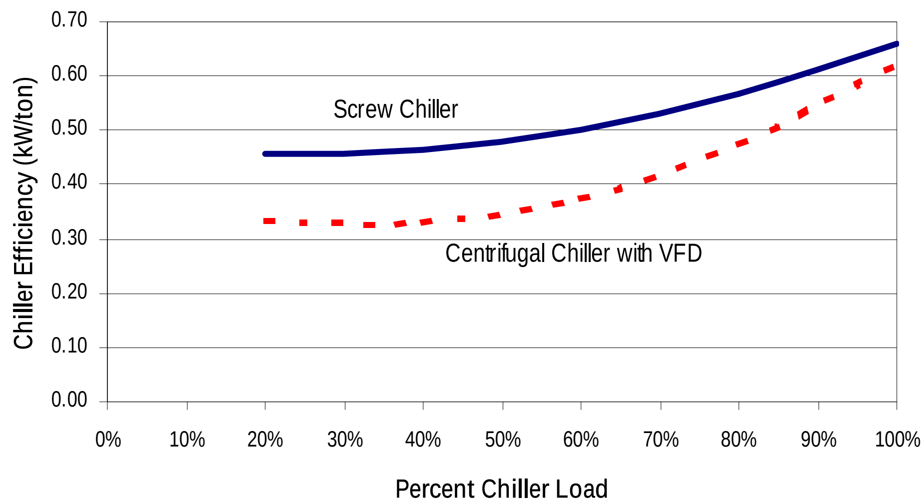
Figure 22
Percent of Pumping Power versus Percent of Water Flow



Converting the 75-ton Reciprocating Chiller to a Centrifugal Chiller with a VFD

This measure recommends retrofitting the existing 75-ton reciprocating chiller at the SSA Plant to a centrifugal chiller equipped with a variable frequency drive. This conversion will include replacing the existing compressor with a new frictionless, oil-less compressor. This new centrifugal compressor retrofit proposed is a relatively new product, which offers efficiencies previously not available in chillers in this size range. Figure 23 shows a comparison of the manufacturers test data for the centrifugal chiller retrofit compared to a water-cooled screw chiller – like the other chiller in the SSA Plant. As can be seen, the centrifugal chiller with the VFD offers better performance than the screw chiller at part-load conditions.

Figure 23
Comparison of VFD Centrifugal Chiller to Screw Chiller



The VFD chiller at the SSA plant is anticipated to operate as the lead chiller, and have substantial operating hours at part-load conditions when cooler condenser water temperatures are available due to the lack of air-side economizers on the systems served.

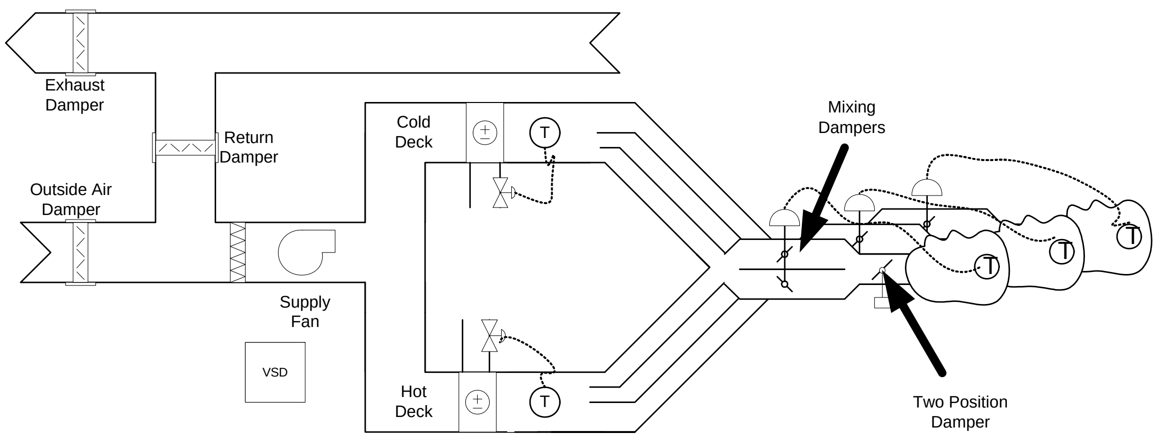
Interconnection of Central Plants

Like many other campus environments, Crafton Hills College has multiple chilled water plants. During much of the summer, the spring, fall, and winter months both chilled water plants have extra capacity. During these periods, operating a single plant at full load or near full load conditions is more economical than operating both cooling plants at low-loads. Interconnecting the chilled water plants will enable the campus to minimize the cost associated with cooling the campus. The connection of the SSA and LADM central plants will be through an interconnection of the new, secondary loops in each system through an underground piping connection between the Library and the Classroom Building.

FIM 4, CONVERSION OF MULTIZONE UNITS TO VARIABLE AIR VOLUME

A well-designed multizone system provides a substantial degree of individual temperature control throughout the areas served. A multizone unit can concurrently distribute either warm air or cold air to each space based on a signal from the thermostat. The temperature of the air distributed is controlled based on a set of mixing dampers. The multizone units at Crafton Hills College were retrofitted in the early 90s to include variable frequency drives and two-position dampers on each zone. This retrofit was intended to reduce fan energy, but since the college does not schedule each zone independently, the two-position zone dampers are always open when the unit is operational. A schematic of a multizone air-handling unit is provided in Figure 25.

Figure 25
Schematic of a Multizone Unit



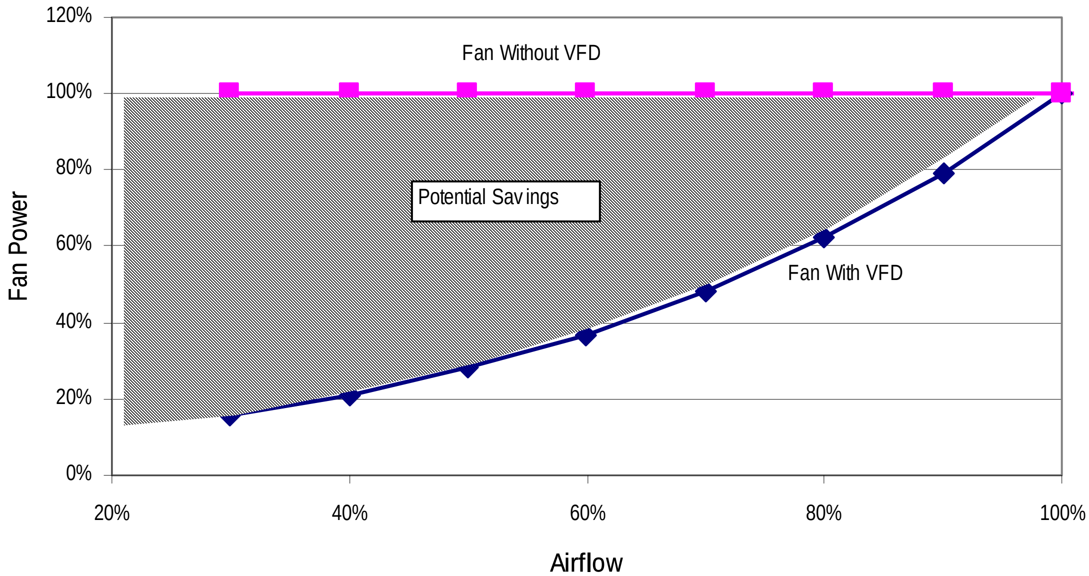
Conversion to Variable Volume

Like a multizone system, a well-designed variable air volume (VAV) system provides a substantial degree of individual temperature control throughout the areas served. Additionally, VAV systems enable fan energy savings by reducing the amount of air supplied during low load conditions and decrease both the heating and cooling loads by reducing the total amount of air that is conditioned. The conversion from constant volume to variable volume will include the addition of air flow stations to each zone duct and replacing the two-position damper actuator with a modulating damper actuator and upgrading the control sequence.

When a zone needs cooling, the hot-deck damper will be closed, and the cold deck damper will be open with the modulating damper controlling the amount of air entering the zone based on the thermostat. When a zone needs heat, VAV damper will be at its minimum position and the mixing damper will modulate to adjust the supply air temperature based on the needs of the space.

This modification to a true variable air volume unit enables fan savings. The variable speed drive on the fans will modulate the speed of the fan based on the amount of air needed by the air-handling unit. The theoretical fan power savings varies as a cubic function of the airflow delivered by the fan. Figure 26 below provides a visual representation of the fan energy savings potential versus airflow.

Figure 26
Example of VAV Conversion Savings



FIM 5, REPLACEMENT OF THE BOILERS AT THE GYMNASIUM

Currently, the gymnasium is heated by two Bryan natural gas hot water boilers with rated capacities of 792 MBH each. The boilers are both 30 years old, and no longer meet the emission guidelines established by the Air Quality Management District. The measure includes the removal of the two existing boilers and the installation of new high efficient natural gas boilers. The improved efficiency of the new boilers will reduce the amount of natural gas used to heat the gym and the improved emissions will reduce the pollution generated.

FIM 6, UPGRADES TO THE RESTROOMS ON CAMPUS

This FIM address upgrading the restrooms on the campus by replacing the existing faucets and flush valves with new infrared touch-less fixtures. This measure also includes replacing the partitions between the toilets and urinals. Replacing the existing fixtures with the touch less variety will aid in reducing the spread of bacteria between occupants. These upgrades will enhance and modernize the feel of the campus to the students and staff.

FIM 7, ADDITION OF A BUILDING ACCESS CONTROL AND SECURITY SYSTEMS

This measure recommends the installation of smart card readers on selected doors and the installation of closed circuit television cameras to enhance campus security. The campus has budgeted to replace the existing door hardware and re-key the entire campus do to the condition of the existing locks and the number of keys that have been issued but never returned or have been lost. This presents an opportune time to install a building access control system. Smart cards can control access to a building, be required to log on to a computer, used to check-out library books, or make a purchase at a vending machine. The main advantage over the traditional brass-key system is that keys, including master keys, are occasionally lost or unknown copies of the keys are made. If (when) an employee loses their keys, and the College wishes to maintain security it may be difficult to know which doors would need to be re-keyed. Especially when dealing with a master key, or a key that opens multiple doors. A Card Access Control system secures an area using an electronic door-locking mechanism that requires a card reader and valid cards to access the area. Only persons who are permitted to access the area and who have been issued valid cards may gain entry. If a Smart Card is lost, the owner of the card can alert the campus police, and the card can be removed from the database preventing its use. The Card Access Control system records who has entered each area, at what time and through which entry and stores this information to a file.

FIM 8, REPAIR ECONOMIZER DAMPERS

This measure recommends repairing and replacing the economizer dampers on the units at the gymnasium and modification to the economizer system at the CHS building. The economizer dampers at the gym are no-longer functioning. The economizer system at CHS does not currently enable the system to utilize 100 percent outside air. The CHS system mixes outside air and return air from one zone while closing the return air from another zone this will lead to pressurization problems throughout the building. Properly functioning economizer dampers enable the HVAC systems to cool the facility with outside air when conditions permit, reducing the number of hours the chiller must operate

FIM 9, ADDITION OF SKYLIGHTS TO THE GYMNASIUM

This measure includes the installation of skylights in the gymnasium to reduce the dependency of using artificial light sources. Figure 27 provides a photograph of a similar gymnasium that is illuminated using skylighting.

Figure 27
Photograph of Gym with Skylighting

FIM-10, ADDITION OF PHOTOVOLTAIC SOLAR PANELS TO GYM ROOF

This measure includes the addition of 30 kW of solar photovoltaic (PV) panels to the roof of the gymnasium. Photovoltaic power is one of the most benign forms of electrical power available. It produces no emissions, uses no fuel, and, PV system components are all solid-state, with no hazardous materials involved. The photovoltaic panels come with 20-25 year warranties on their rated power output, and require no maintenance during that time.

FIM 11, ADDITION OF A NATURAL GAS REFUELING STATION

This measure recommends the installation of a natural gas refueling station and the replacement of four (4) of the existing campus maintenance vehicles with duel fuel (gasoline/natural gas) vehicles.

The benefits of natural gas vehicles (NGVs) are most pronounced in congested urban areas that have air quality concerns, and federal, state and local organizations have recognized the potential benefits of NGVs in these areas. Promotional federal initiatives include the Clean Air Act, the Clean Cities Program, the Congestion Mitigation Air Quality Program, the Energy Policy Act and the Advanced Natural Gas Vehicle Program.

Natural gas is one of the cleanest burning alternative fuels available and offers a number of advantages over gasoline. According to the Alternative Fuels Data Center, in light-duty applications, air exhaust emissions from natural gas vehicles are much lower than those from gasoline-powered vehicles. In addition, smog-producing gases, such as carbon monoxide and nitrogen oxides, are reduced by over 90 percent and 60 percent, respectively and carbon dioxide, a greenhouse gas, is reduced by 30-40 percent. NGVs produce only a tiny fraction of these types of emissions and emit virtually no particulate matter, which has been known to harm the human respiratory and cardiovascular systems and cause 'haze,' or visibility impairment. In addition to being cleaner than conventional vehicles, NGVs reduce the nation's extreme dependence on imported oil, and the fuel cost is generally less than the cost of gasoline or diesel fuel.

According to the Natural Gas Vehicle Coalition: NGVs are the first vehicles certified to meet California's low-emission vehicle standards. They also are the only vehicles to officially meet California's strict ultra-low and super ultra-low emission standards. Even with reformulated gasoline, the evaporative, running loss, and refueling hydrocarbon emissions still exist, and in new vehicles, these so called 'off-cycle' emissions are as significant as the exhaust hydrocarbon emissions.

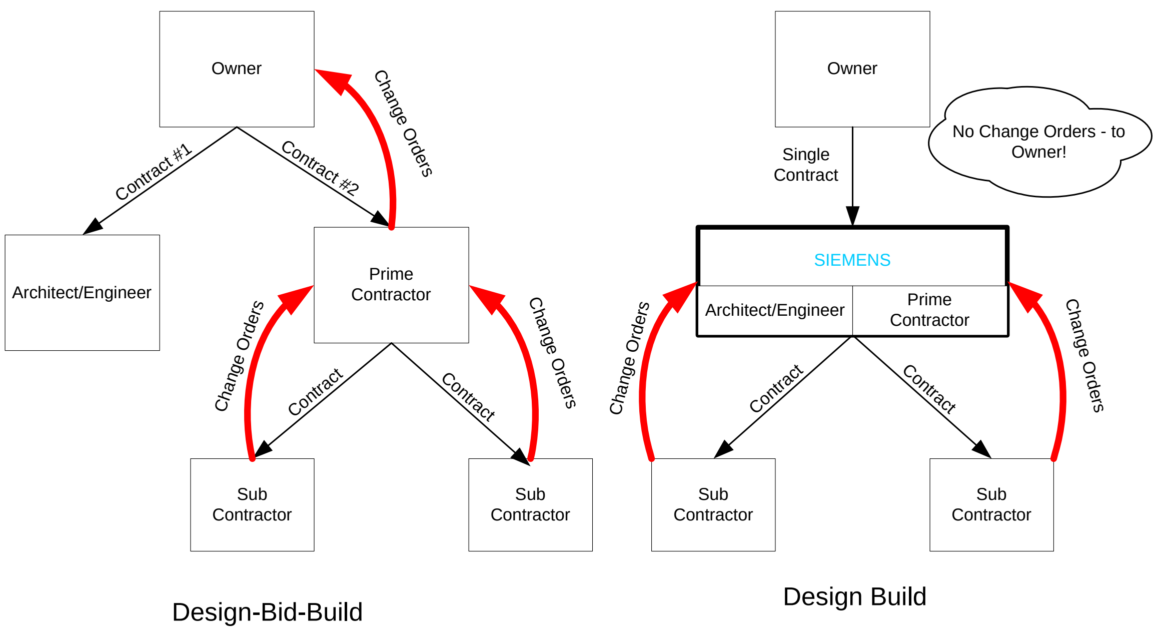
- NGVs are here now, an indication that the industry has moved beyond the developmental stage into commercialization and expanded applications.
- Public access to NGV fueling stations is increasing daily. Of the more than 1,300 fueling stations, half are available to the public.
- NGV fueling systems are safe. The NGV industry standards have been adopted by various federal agencies, and are continually upgraded to make natural gas the safest vehicular fuel.
- There are almost 130,000 NGVs on the road in the United States today and more than 2 million worldwide.
- NGVs are ideal for fleet operations. The industry is concentrating on high fuel-use commercial fleets such as public transit buses, refuse haulers, airport shuttles and taxis, and over-the road trucks.

5.0 IMPLEMENTATION APPROACH

At this point in the process, there is confidence that an acceptable scope, guarantee able savings and turnkey implementation budgets have been established. The objective of this study is to identify energy and cost-saving projects and assist the college in moving these projects towards implementation. This section was written to assist all parties involved understand the implementation approach commonly used by Siemens Building Technologies to implement capital improvement projects. This implementation approach balances the use of internal resources, and takes full advantage of external resources to control the completion of the overall project.

Performance contracting is in essence a design-build implementation approach where one entity provides the owner with both the design services and the construction needed to meet the owner's program. The owner gets both the design and construction under one contract from a single source rather than the traditional method of separate contracts with the architect/engineer and with the contractor.

Figure 28
Schematic of Contract Paths



Its advantages over traditional contracting methods include an early and firm establishment of the construction cost, speed of construction and, most importantly, for the owner, a single point of responsibility, as compared to the "finger-point" responsibility often encountered with a traditional design-bid-build.

Figure 29
Schematic of Disputes

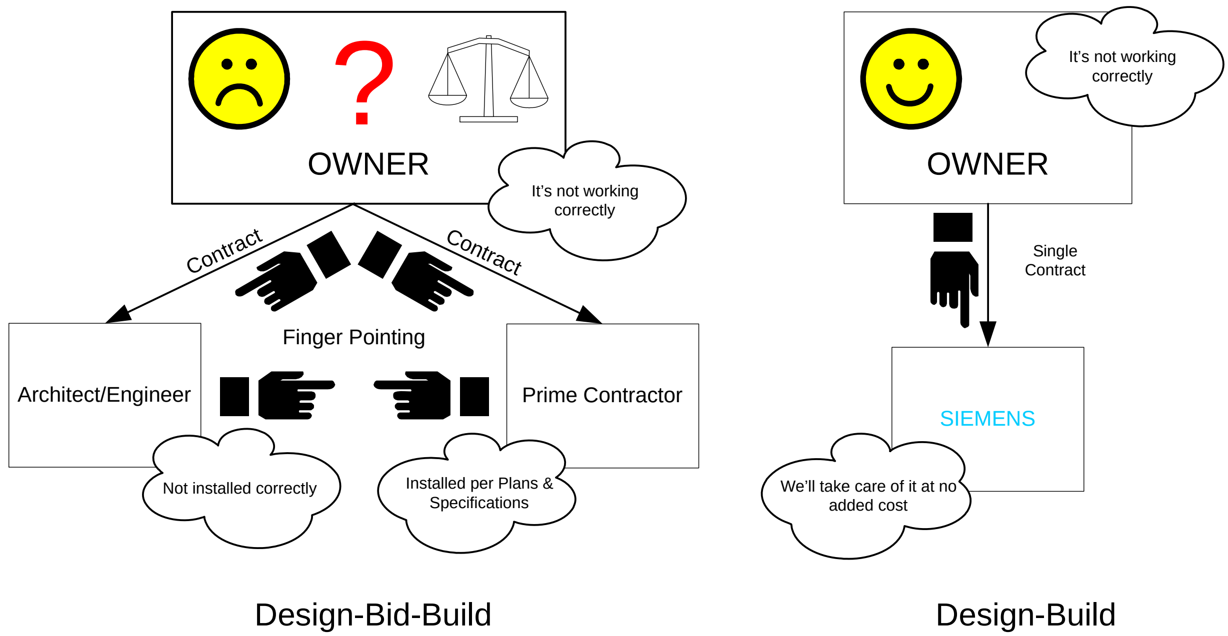
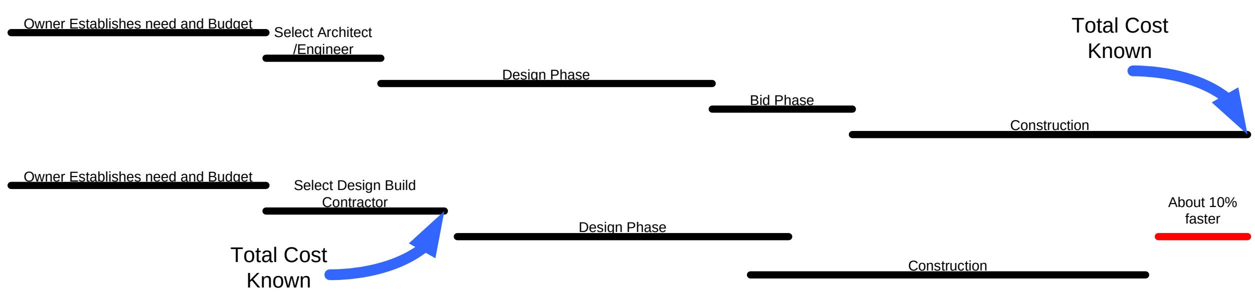


Figure 30
Schematic of Construction Time-Line



The performance-contracting firm assists the owner in securing a lease purchase agreement for the modifications. After project completion, the owner or management then pays the loan through the utility savings generated. If the utility savings are not realized, the performance contractor pays the difference between the actual savings and the projected savings. Therefore, in addition to the responsibilities of a design-build firm, the performance contractor is responsible for identifying energy saving projects and calculating the savings. This implementation approach offers the speed and cost reduction benefits associated with design-build, but also offer the additional benefits of no up-front capital cost, and guaranteed project economics.

With this approach, Siemens has stipulated the minimum amount the college will save in terms of energy costs savings and operational cost savings. The guarantee will be an annual reconciliation of the energy and operational savings presented versus the actual savings. If the energy services program exceeds the estimated savings, the college will get to keep the additional savings. If the energy services program does not meet the savings guaranteed, Siemens will make up the difference between the actual operational and energy savings, and the guaranteed amount. This reconciliation would be in form of a direct payment to the college from Siemens.

6.0 NEXT STEPS

Based on the results of this evaluation, it is evident that opportunities exist at Crafton Hills College to implement measures that will reduce both energy usage and costs while maintaining or improving the comfort of the occupants. Many of the measures will also result in additional maintenance cost savings and will reduce future capital costs for renovation and equipment replacement. The turnkey installation of the identified measures will cost $6.3 million (less rebates and avoided capital estimated at $510,000) and save $167,000 in annual utility energy costs. The project involves: detailed design, equipment selection, permitting, bonding, decommissioning, equipment removal, installation of new equipment, and commissioning. It should be noted that the current designs have been completed only to the point necessary to establish the design thrust and cost. On this basis, the contracting information and design contained in this proposal are schematic in nature. The detailed design and coordination drawings will be completed and submitted as the project advances. Appendix A provides, a detailed technical statement of the proposed work and additional detail into system components, configurations and explanations of the proposed improvements are provided. All work performed and material shall conform to all local codes.

Siemens stands ready to support Crafton Hills College in implementing any or all of the recommended measures. With the bonding capabilities, financial strength, and reserves that come from being a public company listed on the New York Stock Exchange, Siemens has the backing and the ability to assist CHC in moving forward. Siemens provides turnkey implementation services, project financing and guaranteed savings.

If the recommendations made, project costs, and scopes of work are acceptable Crafton Hills College and Siemens should next enter into a construction agreement. A sample performance contract agreement is provided in Appendix B.

Remember that the Key Features of Siemens Solution are:

1. **No Up-Front Capital**. All costs related to the implementation of the recommended solution such as a feasibility study, design and engineering fees, project management, construction cost, operations and maintenance training, monitoring of results, and verification of savings are included in Siemens integrated solution. Therefore, there are no capital requirements from the college at any time in the development or installation of the project.

2. **Hassle-Free Implementation.** Since Siemens is an integrated arrangement, the college does not have to allocate existing personnel to micro-manage the various steps involved in performing energy efficiency improvements such as feasibility studies, design and installing equipment, training personnel, and monitoring the systems' performance.

3. **Partners in Process**. Siemens will always include the college personnel in key milestone decisions throughout the project.

4. **Performance Standards.** Siemens will address the quality of service provided and will ensure that vendors follow specific performance standards.

5. **Wrap-Around Warranty**. Siemens will provide an overall warranty coverage for a period of twelve months from the date of substantial completion for each end-use measure.

6. **Follow-Up Reports**. Siemens will provide the college with a summary of the project's performance on a periodic basis.