4

Energy Conservation Measures:

During the development of this report, CMS Viron Energy Services identified 28 potential Energy Conservation Measures (ECM's) which were applicable to the San Mateo County Community College District (SMCCCD). These ECM's range from traditional high-efficiency lighting retrofits to repair and refurbishment of existing air handling systems to on-site generation of electricity. The following table shows all of the ECMs investigated.

Table 4-1: Energy Conservation Measures Investigated

ECM No.	Description	Application			
		CSM	Cañada	Skyline	Dist. HQ
M1	Boiler Tune-Up & Preventative Maintenance	x	x	x	
M2	Boiler Tube Replacement	x		x	
M3	HW Piping Loop Repair	x			
M4	Pipe Insulation Repair		x		
M5	Expansion Compensator Replacement	x	x		
M6	Nighttime Boiler Shutdown	x	x	x	
M7	AH System Refurbishment	x	x	x	x
M8	Air & Water Balance	x	x	x	x
M9	High-Efficiency Motors	x	x	x	x
M10	HHW Primary/Secondary Pumping	x	x	x	x
M11	Boiler Replacement				x
M12	Chiller Replacement				x
M13	Cooling Tower Replacement				x
M14	Utility Vision^{SM}	x	x	x	x
M15A	Central CHW Plant - Cañada College		x		
M15B	Central CHW Plant - CSM	x			
M16	CAV to VAV	x	x		x
L1	T8 Lamps & Electronic Ballasts	x	x	x	x
L2	Incandescent to Screw-In Fluorescent	x	x	x	x
L3	LED Exit Signs	x	x	x	x
L4	MV/HPS to Metal Halide		x		
L5	HPS/MV to T5 High-Bay	x		x	
L6	Occupancy Sensor Lighting Controls	x	x	x	
L7	Multi-Circuit Switching	x	x	x	
L8	Incandescent to Tungsten Halogen	x	x		
C1	Install New DDC EMS for all Core Equip.	x	x	x	x
C2	Install New DDC EMS for all Zone Level Equip.	x	x	x	x
DG1	Combined Heat & Power System	x		x	
DG2	Solar Photovoltaic System		x		
FLP	Fall 2001 Lighting Project	x	x	x	x

To take advantage of substantial one-time electricity rebates available in 2001, the SMCCCD and CMS Viron completed a lighting retrofit project. This is referred to as the Fall 2001 Lighting Project in the attached tables.

A thorough analysis of the individual ECM's led to the development of a "short list" of recommended ECM's based on input from the SMCCCD staff. The following table shows the recommended ECM's along with their relative electric or natural gas savings.

Table 4-2: Recommended Energy Conservation Measures

ECM No.	Description	Savings			
		Elect (kWh)	**Elect ($$)**	**Gas (Therms)**	**Gas ($$)**
M1	Boiler Tune-Up & Preventative Maintenance	0	$0	13,061	$6,530
M2	Boiler Tube Replacement	Incl w/M1	Incl w/M1	Incl w/M1	Incl w/M1
M3	HW Piping Loop Repair	0	$0	11,056	$5,528
M4	Pipe Insulation Repair	Incl w/M3	Incl w/M3	Incl w/M3	Incl w/M3
M7	AH System Refurbishment	546,300	$70,505	45,826	$22,913
M8	Air & Water Balance	Incl w/M7	Incl w/M7	Incl w/M7	Incl w/M7
M10	HHW Primary/Secondary Pumping	398,477	$51,653	0	$0
M14	Utility Vision^{SM}	0	$0	0	$0
M15A	Central CHW Plant – Cañada College	(372,286)	($49,142)	0	$0
L1	T8 Lamps & Electronic Ballasts	596,498	$76,991	(20,341)	($10,171)
L2	Incandescent to Screw-In Fluorescent	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
L3	LED Exit Signs	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
L4	MV/HPS to Metal Halide	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
L5	HPS/MV to T5 High-Bay	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
L6	Occupancy Sensor Lighting Controls	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
L7	Multi-Circuit Switching	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
L8	Incandescent to Tungsten Halogen	Incl w/L1	Incl w/L1	Incl w/L1	Incl w/L1
C1	Install New DDC EMS for all Core Equip.	647,043	$83,994	89,259	$44,630
DG1	Combined Heat & Power System	4,365,498	$659,881	(315,618)	($157,809)
FLP	Fall 2001 Lighting Project	534,992	$69,055	(22,522)	($11,261)
		6,716,522	$962,937	(199,279)	($99,640)

Note: Negative numbers (###) reflect additional usage

The following tables show the application of the recommended ECM's at each campus and in each building.

Table 4-3: Recommended ECM Application Chart – CSM Buildings 1-17

		T8 Retrofit	Compact Fluor	LED Exit Signs	Metal Halide	T5	Occupancy Sensors	Switching Cicuits	Tungsten - Halogen	DDC EMS (Core)	Boiler Tune-up	Boiler Re-tube	HHW Pipe Repair	HHW Insulation Repair	AHU Refurbishment	Air & Water Balance	HHW Variable Flow	UtilityVision	Cogen
Campus	**Building Number & Name**	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**C1**	**M1**	**M2**	**M3**	**M4**	**M7**	**M8**	**M10**	**M14**	**DG1**
CSM	Campus-wide										x	x	x				x	x	x
CSM	1 - Admin	x	x	x			x		x	x					x	x			
CSM	2 - Music	x	x	x			x	x	x	x					x	x			
CSM	3 - Theater	x	x	x			x	x	x	x					x	x			
CSM	4 - Art	x	x	x			x	x	x	x					x	x			
CSM	5 - Student Center	x	x	x			x		x	x					x	x			
CSM	6 - Museum	x	x	x			x	x	x	x					x	x			
CSM	7 - Maint Bldg	x	x	x			x		x	x									
CSM	8 - Phys Education	C	C	C		P				x					x	x			
CSM	9 - Library/KCSM	x	x	x			x		x	x					x	x			
CSM	10 - Life Science	x	x	x			x	x		x					x	x			
CSM	11 - Science Lecture	x	x	x			x	x		x					x	x			
CSM	12 - Phys Science	x	x	x			x			x					x	x			
CSM	13 - Planetarium		x	x															
CSM	14 - South Hall	C	C	C			C	C		x					x	x			
CSM	15 - Faculty Offices	C	C	C			C			x					x	x			
CSM	16 - Central Hall	C	C	C			C	C		x					x	x			
CSM	17 - Faculty Offices	C	C	C			C			x					x	x			

Note: X denotes ECM recommended for building
C denotes ECM completed during Fall 2001 Lighting Project
P denotes ECM completion postponed due to asbestos

Table 4-4: Recommended ECM Application Chart – CSM Buildings 18-Dist HQ

		T8 Retrofit	Compact Fluor	LED Exit Signs	Metal Halide	T5	Occupancy Sensors	Switching Cicuits	Tungsten - Halogen	DDC EMS (Core)	Boiler Tune-up	Boiler Re-tube	HHW Pipe Repair	HHW Insulation Repair	AHU Refurbishment	Air & Water Balance	HHW Variable Flow	UtilityVision	Cogen
Campus	**Building Number & Name**	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**C1**	**M1**	**M2**	**M3**	**M4**	**M7**	**M8**	**M10**	**M14**	**DG1**
CSM	18 - North Hall	**C**	**C**	**C**			**C**	**C**		**x**					**x**	**x**			
CSM	19 - Engineering	**x**	**x**	**x**			**x**	**x**		**x**					**x**	**x**			
CSM	20 - Horticulture	**x**	**x**	**x**			**x**			**x**					**x**	**x**			
CSM	21 - Cosmotology	**x**	**x**	**x**						**x**					**x**	**x**			
CSM	22 - Dental Asst	**x**	**x**	**x**						**x**					**x**	**x**			
CSM	23 - Nursing	**x**	**x**	**x**						**x**					**x**	**x**			
CSM	24 - Lockers	**x**	**x**	**x**						**x**					**x**	**x**			
CSM	25 - East Wing - Aero	**No Retrofit - Building will be demolished**																	
CSM	26 - Academic Bldg	**No Retrofit - Building will be demolished**																	
CSM	27 - West Wing - Voc	**No Retrofit - Building will be demolished**																	
CSM	28 - Test Cell	**No Retrofit - Building will be demolished**																	
CSM	29 - Classrooms	**No Retrofit - Building will be demolished**																	
CSM	30 – Team House	**x**	**x**				**x**												
CSM	31 – Ticket Booth																		
CSM	32 – Tennis Bldg																		
CSM	33 – Childcare	**x**	**x**				**x**												
CSM	34 – KCSM																		
HQ	Dist HQ	**C**	**C**	**C**					**C**	**x**								**x**	

Note: X denotes ECM recommended for building
C denotes ECM completed during Fall 2001 Lighting Project
P denotes ECM completion postponed due to asbestos

Table 4-5: Recommended ECM Application Chart – Cañada College

		T8 Retrofit	Compact Fluor	LED Exit Signs	Metal Halide	T5	Occupancy Sensors	Switching Cicuits	Tungsten - Halogen	DDC EMS (Core)	Boiler Tune-up	Boiler Re-tube	HHW Pipe Repair	HHW Insulation Repair	AHU Refurbishment	Air & Water Balance	HHW Variable Flow	UtilityVision	Central CHW Plant
Campus	**Building Number & Name**	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**C1**	**M1**	**M2**	**M3**	**M4**	**M7**	**M8**	**M10**	**M14**	**M15A**
Cañada	Campus-wide										x			x			x	x	x
Cañada	1 - Phys Education	x	x	x	C		x			x					x	x			
Cañada	2 - Bookstore	x	x	x			x	x		x					x	x			
Cañada	3 - Fine Arts	x	x	x			x	x		x					x	x			x
Cañada	5 - Student Center	x	x	x			x			x					x	x			
Cañada	6 - Library	x	x	x			x	x		x					x	x			
Cañada	8 - Admin	x	x	x			x			x					x	x			
Cañada	13 - Academic Bldg	C	C	C			C	C		x					x	x			x
Cañada	16 - Science Bldg	C	C	C			C	C		x					x	x			
Cañada	17 - Science Bldg	C	C	C			C	C		x					x	x			
Cañada	18 - Science Bldg	C	C	C			C	C		x					x	x			
Cañada	19 - Childcare	**No Retrofit - New Building**																	
Cañada	20 – West Ed.																		
Cañada	99 – Port Childcare	**No Retrofit - Building will be demolished**																	

Note: X denotes ECM recommended for building
C denotes ECM completed during Fall 2001 Lighting Project
P denotes ECM completion postponed due to asbestos

Table 4-6: Recommended ECM Application Chart – Skyline College

		T8 Retrofit	Compact Fluor	LED Exit Signs	Metal Halide	T5	Occupancy Sensors	Switching Cicuits	Tungsten - Halogen	DDC EMS (Core)	Boiler Tune-up	Boiler Re-tube	HHW Pipe Repair	HHW Insulation Repair	AHU Refurbishment	Air & Water Balance	HHW Variable Flow	UtilityVision	Cogen
Campus	**Building Number & Name**	**L1**	**L2**	**L3**	**L4**	**L5**	**L6**	**L7**	**L8**	**C1**	**M1**	**M2**	**M3**	**M4**	**M7**	**M8**	**M10**	**M14**	**DG1**
Skyline	Campus-wide										x	x					x	x	x
Skyline	1 - Fine Arts	x					x	x		x					x	x			
Skyline	2 - Campus Center						x			x					x	x			
Skyline	3 - Phys Education					C				x					x	x			
Skyline	4 - Bookstore	**No Retrofit - Building will be demolished**																	
Skyline	5 - Library/LRC		x																
Skyline	7 - Science Bldg	x					x	x		x					x	x			
Skyline	8 - Academic Bldg	x					x	x		x					x	x			
Skyline	9 - Auto Lab	x	x																
Skyline	10 - Auto Shop	x	x				x												
Skyline	11 - Warehouse	**No Retrofit - Building will be demolished**																	
Skyline	12 - Maint Office	**No Retrofit - Building will be demolished**																	
Skyline	13 - Maint Garage	**No Retrofit - Building will be demolished**																	
Skyline	16 - Port Childcare	x	x																
Skyline	99 - Portables	**No Retrofit - Building will be demolished**																	

Note: X denotes ECM recommended for building
C denotes ECM completed during Fall 2001 Lighting Project
P denotes ECM completion postponed due to asbestos

ECM Number: M1

ECM Title: Boiler Tune-Up & Preventative Maintenance

Description:

The original boilers, installed around 1967, remain at all three main campuses. The boilers at Cañada College and CSM have been de-rated to meet the current air quality standards. The boilers at Skyline College have been retrofitted with Low-NOX burners to meet the current air quality standards. These hot water heating boilers consume 90% of all the natural gas supplied to the campuses. Therefore, maintaining these boilers in peak operating condition is key to any energy savings strategy. This ECM would be applied to the following boilers:

Location	Tag	Make	Model
CSM	B-7-1	Cleaver Brooks	CR 266-300
CSM	B-7-2	Cleaver Brooks	CR 266-300
CSM	B-7-3	Cleaver Brooks	CR 266-300
Cañada College	B-1	Cleaver Brooks	CB 282-300
Cañada College	B-2	Cleaver Brooks	CB 282-300
Skyline College	B-1B	Cleaver Brooks	CB 282-400
Skyline College	B-2B	Cleaver Brooks	CB 282-400

Scope of Work

The scope of work associated with this ECM is as follows:

- Inspection of all brickwork and refractory (point up included)
- Washing coat refractory with refractory coating
- Cleaning fireside with power equipment as necessary
- Draining waterside for inspection
- Removing the manhole and hand hole plates and installing new gaskets
- Inspecting drum and shell for scale and pitting
- Flushing waterside with water
- Removing plugs in all crosses and water column
- Inspecting water column and housings
- Flushing water column and housing with water
- Replacing gauge glass and gaskets
- Sealing and closing the waterside and filling the system
- Testing and start-up of the boilers
- Combustion adjustment & testing

ECM Number: M2

ECM Title: Boiler Tube Replacement

Description:

Based on an inspection by a local boiler service company, Viron is recommending the replacement of the lower tube bundles in the boilers at Skyline and CSM. This recommendation is being made because a boiler at Skyline is actively leaking, and the remaining Skyline and CSM boilers appear vulnerable to leaking in the near term. One of the existing boilers at CSM was retubed in January 2000 and appears to be in good condition. The following boilers would receive new lower tube bundles as part of this ECM:

Location	Tag	Make	Model
CSM	B-7-1	Cleaver Brooks	CR 266-300
CSM	B-7-3	Cleaver Brooks	CR 266-300
Skyline College	B-1B	Cleaver Brooks	CB 282-400
Skyline College	B-2B	Cleaver Brooks	CB 282-400

Scope of Work

The scope of work for this ECM is as follows:

- Opening the fire and the waterside of the boiler
- Removal of all 175 of 2-1/2" diameter tubes
- Installing new tubes and performing hydraulic boiler testing
- Installation of new fireside gaskets

ECM Number: M3

ECM Title: Hot Water Piping Loop Repair

Description:

Based on discussions with the maintenance staff at CSM, it is estimated that over 100,000 gallons of heated water leaks out of the underground heating hot water piping system every year. To maintain system pressurization, an equal amount of fresh water is being introduced into the hot water piping system. The induction of fresh water into the system requires replenishment of the chemicals lost during treatment in the hot water system, which have to be added, and waste of heating energy that has to be provided by the boilers. The chemical treatment in the hot water system is essential to prevent piping corrosion by removing corrosive elements from the fresh water.

Viron is recommending this ECM to ensure that precious heated water reaches the buildings rather than being leached into the soil.

Scope of Work

The scope of work associated with this ECM is as follows:

- Visually inspect exposed piping and expansion joints at all accessible manholes
- Visually inspect piping at the maintenance/boiler room and outlying buildings
- Five days of pressure testing
- Provide a written report of findings and recommendations
- Provide a written budget estimate for the piping repair

ECM Number: M4

ECM Title: Pipe Insulation Repair

Description:

The insulation on approximately 320 feet of the underground hot water piping loop at the northern end (near Building 18) of the Cañada College campus has deteriorated such that heat is rapidly being dissipated to the surrounding soil and groundwater. During the winter months, the manholes near Building 18 regularly fill with water from an underground spring. The facility staff is forced to pump-out these manholes so that water does not backflow into the surrounding buildings.

Viron is recommending that the utility trench be opened and the affected insulation repaired. The SMCCCD should evaluate measures to mitigate the encroachment of the groundwater into the underground systems.

Scope of Work

Based on our site evaluation, Viron proposes the following scope of work to determine the extent of the insulation repairs for Cañada College campus:

- Visually inspect all insulation at the accessible manholes
- Visually inspect piping insulation at building connections where accessible
- Provide written report of findings and recommendations

ECM Number: M5

ECM Title: Expansion Compensator Replacement

Description:

The existing underground hot water piping loops at the Cañada College and CSM campuses have several pipe expansion compensators, which leak if the temperature of the water within the pipe drops substantially. This prevents the boiler plant from being shut down when there is no call for heating. The underground piping loop is rigidly anchored at many points including changes in direction, manholes, etc. Piping expansion compensators prevent the metal pipes from breaking due to thermal stress associated with expansion and contraction of metallic elements.

ECM Number: M6

ECM Title: Nighttime Boiler Shutdown

Description:

After the expansion joints have been replaced, the energy management system (EMS) will be used to shut down the central boiler plants at all three main campuses when there is no call for heat at night. The flexibility of the programming available through the EMS will allow for various methods of determining the need for hot water. Over time, the program parameters will be developed for optimum savings and performance.

One of the biggest challenges associate with this ECM is the mitigation of the thermal shock experienced by the existing boilers. Frequent exposure to wide ranges of operating temperatures could leave the boilers susceptible to stress fractures between the boiler tubes and the tube manifold.

ECM Number: M7 & M8

ECM Title: Air Handling System Refurbishment & Air/Water Balance

Description:

As discussed in Section 3, many of the existing mechanical system at the SMCCCD are showing their age, and most are in some state of disrepair. This ECM proposes to refurbish the existing heating and cooling air-handling systems and to make them fully functional. CMS Viron investigated the wholesale replacement of the equipment but found the cost to be three times that of refurbishment without substantive energy savings.

The existing air handling systems waste energy and sacrifice comfort in many ways:

- Clogged coils, filters, louvers, and grilles restricting airflow
- Conditioned air leaking from ductwork
- Inoperable dampers unable to control fresh air intake
- Improper distribution of conditioned air
- Improper distribution of hydronic systems
- Heat transfer to uninsulated ducts and pipes
- Leaking control valves

Scope of Work

1) Replace heating hot water circulating pump and pump trim (strainers, flex connectors, isolation/balancing valves, etc.)
2) Repair/replace economizer dampers (outside air, exhaust air, and return air)
3) Refurbish and clean heating and air conditioning fan systems shown in the tabulation on the page after next including:
    a) Belts
    b) Sheaves
    c) Bearings
    d) Filters
    e) Coils
4) Clean louvers and mechanical plenums
5) Patch duct and piping insulation as required in mechanical/fan rooms
6) Inspect operation of all dampers (fire, smoke, balancing, etc.) in mechanical/fan rooms. Repair/replace non-functional dampers
7) Patch ductwork in mechanical/fan rooms to minimize air leaks
8) Inspect, clean, and recommission wall mounted unit ventilators including:

  a) Coils
  b) Filters
  c) Fresh air dampers
  d) Valves

9) Replace all hot water and chilled water control valves (except for reheat zone valves)

10) Clean and flush HHW piping system, clean strainers at air handling units

11) Perform post-retrofit air flow measurements, electrical measurements and water balance on equipment listed in tables below.

College of San Mateo	
Tag	**Location (Bldg-Rm)**
HV-1-1	1-Basement
HV-2-3	2-181
HV-2-4	2-181
HV-2-6	4-258
HV-2-5	3-262
HV-2-1	2-201
HV-2-2	3-283
HV-5-6	5-209
HV-5-2	5-202
HV-5-1	5-22A
HV-6-1	6-110
HV-5-3	5-Ceiling
HV-5-4	5-Ceiling
HV-5-5	5-Ceiling
HV-5-7	5-Ceiling
HV-8-2	8-158
HV-8-1	8-Mezz
HV-8-3A-F	8- Roof
F-9-1	9-1st Flr
F-9-2	9-1st Flr
HV-10-5	11-46
HV-10-1	10-5
HV-10-7C	10-11
HV-10-7D	10-11
HV-10-4	12-184
F-14-1A	14-Bsmt
F-14-2A	14-Bsmt
SF-18	18-Bsmt
Rf-18	18-Bsmt
HV-19-1	19-35
HV-20-2	20-110
HV-20-3	20-Roof
HV-20-1B	20-103
HV-20-1A	20-102
HV-21-3	21-111
HV-21-2	22-145
HV-21-1	23-153
HV-21-4	24-183
SF-DA-1	DA-Mech Rm
SF-DA-2	DA-Mech Rm
SF-DA-3	DA-Mech Rm

Skyline College	
Tag	**Location (Bldg-Rm)**
HV-1B	1-316A Corr.
HV-2B	1-Roof
HV-3B	1-203C
HV-4B	1-203C
HV-5B	1-207
HV-6B	1-Sceneshop
HV-7B	1-Sceneshop
HV-8B	1-103
HV-9B	1-360
HV-10B	1-360
HV-11B	1-Stage
HV-12B	Basement
HV-1C	2-PH
HV-2C	2-PH
HV-3C	2-PH
HV-4C	2-110
HV-5C	2-107F
AH-1C	3-302A
HV-1D	3-302A
HV-2D	3-302A
HV-3D	3-Roof
HV-4D	3-Roof
HV-5D	3-Roof
HV-6D	3-108A
AH-1F	5-Mech Rm
HV-1A	7-323 Corr,
HV-2A	7-304 Corr.
HV-3A	7-217A
HV-4A	7-200A
HV-5A	7-119 corr.
HV-6A	7-102 corr.
HV-7A	8-213A
HV-8A	8-Autoshop
HV-9A	8-Roof

Cañada College	
Tag	**Location (Bldg-Rm)**
HV-1A	1-102
AC-1A	1-102
AC-2A	1-309
AC-3A	1-309
AC-4A	1-203
AC-5A	1-203
AC-6A	1-203
AC-7A	1-203
AC-1B	2-Roof
AC-2B	2-Roof
AC-1C	3-123
AC-2C	3-123
AC-3C	3-244
AC-4C	3-244
AC-5C	3-166
AC-6C	3-166
AC-7C	3-258
AC-1F	6-30
AC-2F	6-143A
AC-3F	6-202
AC-1H	6-143A
AC-1G	8-212
AC-2G	8-212
AC-1K	13-9
AC-1Q	16-9
AC-1R	17-Roof
AC-1N	18-105

ECM Number: M9

ECM Title: High-Efficiency Motors

Description:

Electric motors are available in varying degrees of efficiency. Some of the existing motors in the district are old and have a standard rated efficiency. This ECM involves replacing various standard efficiency motors over 5 horsepower (HP) in size with premium efficiency motors that use significantly less power to perform the same amount of work. This ECM would be applied to the following motors that have significant operating hours:

CSM / Dist HQ		
TAG	**LOCATION (Bldg-Rm)**	**HP**
HV-5-2	5-202	5
HV-5-1	5-22A	5
HV-10-5	11-46	8
HV-10-1	10-5	10
HV-19-1	19-35	15
RE-DA-1	DA Mech Rm	5
P-7-1	7	10
P-7-2	7	10
P-7-3	7	10
P-7-4	7	30
P-7-5	7	30
P-7-6	7	50
P-9-1A	9-Outside	10
P-0-1	East Pool	5
P-DA-4	DA Mech Rm	5
P-DA-2	DA Outside	5
F-8-3	8-B-4	7.5
F-8-2	8 - Mezz	15
F-9-3	9-B-3	30
F-9-6	9-B-4	15
F-14-1A	14 - Bsmt	7
F-14-1B	16 - Bsmt	7.5
F-18-M	18-87	15
F-18-M	18-87	7.5
F-19-1	19-35	5
F-25-1C	27-110	15
AC-9-2	9-B-5	5
FCC-1	DA Mech Rm	7 1/2
FCC-2	DA-Rm-02	7 1/2
FCC-3	DA Mech Rm	7 1/2

Cañada College		
TAG	**LOCATION (Bldg-Rm)**	**HP**
HV-1A	1-102	7.5
AC-2A	1-309	10
AC-1B	2-Roof	5
AC-1C	3-123	15
AC-2C	3-123	10
AC-7C	3-258	15
AC-1F	6-30	10
AC-2F	6-143A	15
AC-1H	6-143A	15
AC-1G	8-212	5
AC-1K	13-9	20
AC-1Q	16-9	10
AC-1R	17-Roof	7.5
AC-1N	18-105	20
P-1A	1-102	5
P-3C	Boiler Rm	25
P-4C	Boiler Rm	25
P-5C	Boiler Rm	10
P-6C	Boiler Rm	10
P-1F	6-202	5
EF-3A	1-207	5
EF-4A	Roof	5
EF-5A	Roof	5
EF-6A	Roof	5
EF-7A	Roof	5
EF-1C	3-236	5
EF-1F	6-Roof	5

Skyline College		
TAG	**LOCATION (Bldg-Rm)**	**HP**
HV-3B	1-203C	10
HV-4B	1-203C	8
HV-5B	1-207	8
HV-9B	1-360	5
HV-10B	1-360	5
HV-1C	2-PH	5
HV-2C	2-PH	5
HV-3C	2-PH	5
HV-4C	2-110	15
HV-5C	2-107F	15
AH-1D	3-302A	5
HV-2D	3-302A	5
HV-3D	3-Roof	10
HV-6D	3-108A	8
HV-7A	8-213A	5
P-1B	1-103A	5
P-5B	1-103A	30
P-6B	1-103A	30
P-4C	2-Roof	5
EF-16B	1-202C	5
EF-5D	3-Roof	10
EF-9A	7-Roof	5
EF-10A	7-Roof	5
EF-11	7-Tunnel	10
EF-18A	8-Roof	5
AC-1C	2-Roof	25
SF 1-4	5-Roof	25
AC-1	5-Roof	25

ECM Number: M10

ECM Title: Heating Hot Water Primary/Secondary Pumping Conversion

Description:

Currently, heating hot water is pumped continuously at a constant flow rate to the heating coils in the heating loops of most buildings. This pumping arrangement is identical at all three campuses. At times, much of this water is bypassed to the return water line and returned to the heat exchanger or passes through the heating coil without giving up all of its heat content. Pumping continuously at a constant flow rate throughout the heating season is a waste of energy because the greatest pumping rate is only needed at design conditions. Lower pumping flow rates will be adequate at all other conditions during the large majority of the season.

Converting the existing constant volume system to primary/secondary pumping will save pump energy. This conversion is achieved by replacing the existing constant volume pumps that circulate the water only through the boilers and installing secondary pumps with variable frequency drives to distribute the exact required flow throughout the campus. Installing variable frequency drives (VFD's) on these pumps and installing two-way control valves (where needed) will permit less water to be pumped, thus, saving pump energy. Further, variable frequency drives will be used to "soft-start" pump motors which will significantly reduce stress on the motors, bearings, and the coupling to the pumps. By restricting the water flow to only what is needed to maintain loop pressure, energy requirements to pump water through the loop is reduced. In addition, the installation of the VFD will greatly reduce the amount of power required to operate the pumps at part-load conditions.

This retrofit is considered for pumps that are large enough and have running hours long enough to realize significant energy savings. The new VFD will act as a new motor starter; and the new valves, in most cases, will be replacing current valves. Any additional maintenance costs due to the increased number of valves should be offset by the reduction of pneumatic controls, which have a higher maintenance cost than electronic controls.

Scope of Work

The scope of the work for this ECM for three campuses consists of the following:

1. New primary and secondary pumps with high-efficiency motors
2. New decoupler piping, valves at the pumps, gauges, and pipefittings
3. Replacement of existing 3-way control valves
4. Installation of new VFD's at the secondary pumps
5. Installation of pressure transducer in the distribution piping
6. Installation of control devices and connection to the campus EMS

ECM Number: M11

ECM Title: Boiler Replacement

Description:

This ECM includes replacing the existing natural gas boiler at District Administration with a new induced-draft natural gas boiler that has higher efficiency and improved performance. Due to the age of the existing boiler and lack of water treatment, it is likely that fouling of heat transfer surfaces has resulted in serious performance degradation. A new water treatment system will be included in this measure to assure performance. Replacement of this boiler will reduce maintenance costs and increase energy efficiency.

ECM Number: M12

ECM Title: Chiller Replacement

Description:

This ECM involves replacing the existing semi-hermetic chiller at District Administration. The design information and current measurements indicate that this chiller runs at APVL of around .7 to .8 kW per ton. New chillers are available which operate with an APVL of .6 kW per ton. This lower APVL translates to lower cooling costs of 18.3%. The current CFC refrigerant (R-12) is no longer manufactured, and is becoming scarce. In addition, the price of R-12 continues to escalate as stockpiles of this refrigerant diminish. A new water treatment system will be included in this measure to assure future performance. Replacement of this chiller will reduce maintenance costs and increase energy efficiency.

ECM Number: M13

ECM Title: Cooling Tower Replacement

Description:

This ECM considers replacing the existing condenser cooling tower at District Administration. The current tower has exceeded its average useful life and is extremely inefficient due to lack of water treatment. Draw-through cooling towers are available which use approximately 50% of the electrical energy and electrical demand that the current tower requires. A new water treatment system will be included in this measure to assure future performance. Replacement of this cooling tower will reduce maintenance costs and increase energy efficiency.

ECM Number: M14

ECM Title: UtilityVision^{SM}

Description:

UtilityVision is an energy management data analysis tool that lets the end-user track energy usage with the click of a mouse. It is an ideal solution in monitoring electricity and gas consumption in multi-building facilities such as campuses. UtilityVision is a web-based energy tracking system that collects and reports energy consumption data to customers over the Internet. UtilityVision allows customers to become more self-sufficient in analyzing energy consumption for energy management purposes. Collected data is password protected and stored securely at CMS Viron's UtilityVision site. The SMCCCD will be responsible to provide the necessary IT support as outlined in Section 5 of this report. The three components of CMS Viron UtilityVision service, which are currently available, are:

Load Profiling: Web-based reports profile electric consumption and demand data by day, week, month, and year for individual meters. UtilityVision accumulates data in 15-minute intervals for each meter, and reports contain energy information for up to 13 months and graph up to a year's worth of data. UtilityVision also monitors other properties such as power factor, amps, and voltage as necessary.

Meter Aggregation Analysis: The aggregation of consumer data from various meters into a single analysis report provides a cumulative profile of electric consumption and demand data by day or day of week for a month. A cumulative report more accurately represents the overall peak demand for the requested reporting units.

Sub-metering: Sub-metering allows the accumulation of data for energy analysis, cost allocations, or troubleshooting by reporting unit. For example, the customer could sub-meter a building, a floor, or a piece of equipment and obtain usage data by day of week and/or year.

The SMCCCD meters which would be connected to the UtilityVision platform are shown in the following tabulation.

Campus	Existing Electric Meters			Existing Gas Meters		
	Meter No.	Account	Location	Meter No.	Account	Location
CSM	9280R4	KRNT590001	Bldg 7	42061261	FRNA300171	Adjacent to Bldg 7
Cañada	6686R2	QRNT131001	Bldg 3	452325V	QRN0983301	Adjacent to Bldg 3
Skyline	6692R7	MRBT231261	Bldg 1	4849349X	MRBA200211	Adjacent to Bldg 1
Dist HQ	C22100	LRNT257001	HQ Bldg	47240457	LRN3355701	Adjacent to HQ Bldg

ECM Number: M15A – Cañada College
M15B – College of San Mateo

ECM Title: New Central Chilled Water Plant

Description:

The SMCCCD asked CMS Viron to investigate the installation cost and energy usage impact of adding a central chilled water plant at two of the main campuses.

Cañada College

The existing chilled water plant in the Fine Art Building (#3) would be expanded to handle the existing Academic Building (#13) and the new Learning Resource Center (LRC). A new 200 Ton high-efficiency chiller would be added to the existing 180 Ton plant as well as a new 400 Ton cooling tower and new chilled water pumps. It appears that the new equipment can be added to the existing mechanical room without substantial structural or architectural modifications. The capacity of the chilled water plant is based on the following building areas:

- Fine Arts Building – 63,300 square feet (gross)
- Academic Building – 31,470 square feet (gross)
- Learning Resource Center – 51,000 square feet (gross)

Approximately 685 feet of new underground chilled water piping would be installed to distribute water to the buildings listed above. A point of connection would be installed for the new LRC, complete with isolation valves and blind flanges.

The work within Building #13 and the new LRC to add air conditioning is not part of this scope of work but would be included as part of the overall modernization contract. The Fine Art Building is already air conditioned and should not require any additional modifications.

CMS Viron is estimating that the cost to the SMCCCD for the added electricity consumed by the additional plant capacity will be approximately $50,000 annually.

College of San Mateo

The new central chilled water plant would serve the Administration Building (#1), the Student Center/Museum (Buildings #5 & #6), the future location of the KCSM studios (Building #10), the North Academic Hall (Building #18), and the new Integrated Science Center. The plant is tentatively sized for 525 Tons and would include new high-efficiency chillers, cooling tower, and pumps. The chilled water plant capacity is based on the following building area:

- Administration Building – 24,930 square feet (gross)
- Student Center / Museum – 66,138 square feet (gross)

- Future KCSM Studio – 21,882 square feet (gross)
- North Academic Hall – 27,640 square feet (gross)
- Integrated Science Center – 65,000 square feet (gross)

A network of approximately 2,200 feet of underground piping would be installed to serve the existing buildings with a point of connection installed at Building #18 for the new Integrated Science Center. The CSM Maintenance Center (Building #7) would be expanded to accommodate the new equipment.

The work within the new and existing buildings to add air conditioning is not included in this scope of work but would be included in the overall modernization project.

CMS Viron is estimating that the cost to the SMCCCD for the added electricity to run the central chilled water plant will be approximately $88,000 annually.

ECM Number: M16

ECM Title: Constant Volume to Variable Air Volume (Air Conditioned Buildings Only)

Description:

In constant volume (CV) reheat systems, air delivered from the fan is cooled to a set temperature and then reheated by a hot water coil in the ductwork. A room thermostat normally controls a reheat coil valve to obtain the desired room temperature. The temperature of the air handler supply air is usually set by the cooling requirement of the hottest space served by the air handler. Variable air volume (VAV) systems use less thermal and electrical energy than used by a constant volume reheat system.

This ECM concerns converting the current constant volume reheat system to a VAV reheat system. The conversion would be accomplished by installing a VAV box in series with reheat coils, installing a variable frequency drive, and modifying the air handler controls. The controls would use the VAV box first and then bring reheat coils in play when control temperatures cannot be reached with the VAV box. A duct pressure sensor installed about 2/3 of the way to the end of the longest duct run would control the air handler fan speed.

ECM Number: L1

ECM Title: T8 Lamps and Electronic Ballasts

Description:

SMCCCD buildings utilize fluorescent fixtures containing a combination of standard and energy saving T12 lamps with standard magnetic core and coil ballasts and a limited number of electronic T12 ballasts. This ECM considers replacing the existing T12 lamps and ballasts with T8 lamps and electronic ballasts.

The T8 system, which consists of T8 lamps and electronic ballasts, is the most technologically advanced fluorescent lighting system available and also has a proven track record. The T8 fluorescent light system is approximately 40 percent more energy efficient than conventional cool white fluorescent lamps and standard magnetic core and coil ballasts. The T8 lamps fit in the existing standard T12 bi-pin sockets without luminaire modification. The electronic ballasts specifically developed for the T8 lamps replace the old core and coil ballasts. Electronic ballasts operate at high frequencies, which reduces the power requirements to produce the same amount of light as the existing T12 lighting system. Electronic ballasts also reduce the tendency of fluorescent lamps to flicker or ballasts to hum. T8 lamps also use rare earth phosphor minerals, which provide superior color rendition similar to the familiar energy saver or warm white lamps.

Viron recommends retrofitting nearly all of the existing T12 fluorescent luminaires with the T8 system. This retrofit includes the removal of all the existing lamps and ballasts and the installation of new high-frequency electronic ballasts and T8 lamps. Recommended replacement lamps are as follows: 20 watt 2’ T12 lamps replaced with 17 watt T8 lamps, 34 watt and 40 watt 4' T12 lamps replaced with 32 watt T8 lamps, 60 watt and 96 watt 8’ T12 lamps with two 32 watt T8 lamps mounted end-to-end. These retrofits will reduce the energy consumption of these luminaires while maintaining the appropriate lighting level and improve upon the quality of light.

Electronic ballasts are available that can control up to 4 lamps. Some areas that have luminaires mounted end-to-end can be tandem-ballasted. That is, one fixture will house the ballast; and it will operate lamps in one (or more) of the nearby luminaires. The luminaires with ballasts will be indicated with a small stick-on dot so that the ballast can be easily found. Tandem-wiring of fixtures reduces the number of ballasts purchased.

In addition to energy savings, this lighting ECM creates maintenance savings as well. The proposed new T8 lamps and electronic ballasts will replace existing older lamps and ballasts. The new lamps and electronic ballasts have expected lives of approximately 24,000 hours and 25 years respectively, and are 100 percent guaranteed by the manufacturer for 5 years (lamps) and 7 years (ballasts).

This ECM would be installed in the buildings indicated in the ECM Application Tables shown earlier in this section.

ECM Number: L2

ECM Title: Incandescent to Screw-In Fluorescent

Description:

The SMCCCD facilities currently utilize one- and two-lamp incandescent luminaires in common areas. Incandescent sources provide such desirable qualities as instant light, good color rendition, low replacement cost, and ease of control in dimming situations. However, they are the least efficient types of light source currently existing. The typical life of an incandescent bulb ranges between 750 and 900 hours, and the typical efficacy of the incandescent source is 20 lumens per watt. Of the total input power, only 10 percent emerges as visible light.

Compact fluorescent lamps are a much more efficient light source with a typical efficacy of 50 to 70 lumens per watt having an average rated lamp life of 10,000 hours. Long lamp life results in reduced maintenance cost required for lamp replacements. The higher efficiency, lower wattage compact fluorescent lamp can provide light levels of the same intensity as a higher wattage incandescent lamp. This ECM considers replacing incandescent luminaires with new one- and two-lamp compact fluorescent luminaires.

This ECM can be applied to those buildings indicated in the ECM Application Table shown earlier in this section.

ECM Number: L3

ECM Title: LED Exit Signs

Description:

SMCCCD currently utilizes exit signs that are illuminated by various wattage incandescent lamps. Incandescent sources provide such desirable qualities as instant light, good color rendition, and low replacement cost. However, they are the least efficient types of luminaire on the market. The typical lamp life of an incandescent exit light bulb ranges from 2,000 to 3,000 hours with an efficacy light source rating of 20 lumens per watt. Of the total input power, only 10 percent emerges as visible light in an incandescent lamp.

Viron recommends replacing these fixtures with a Light Emitting Diode (LED) type exit fixture. LED fixtures meet or exceed IES standards for exit lighting levels, while using only 2 watts of energy. The LED exit fixtures recommended as a replacement have a five-year warranty and a twenty-five year projected life that will reduce nearly all maintenance labor and material costs associated with replacing bulbs.

This ECM would be installed in the buildings indicated in the ECM Application Tables shown earlier in this section.

ECM Number: L4

ECM Title: Mercury Vapor/HPS to Metal Halide

Description:

Some areas at SMCCCD currently utilize Mercury Vapor (MV) lamps and fixtures to illuminate the interior, as well as the exterior of some buildings. Most of these MV lamps are well past their useful rated lives. This ECM considers retrofitting these existing MV fixtures with new ballasts and lamps.

Mercury vapor sources provide such desirable qualities as good color rendition, high quality light, and long lamp life. However, MV lamps significantly degrade over time by supplying lower light at the same energy levels. MV lamps rarely go out; however, the light output reduces with old lamps by as much as 90%.

Metal Halide (MH) lamps are much more efficient light sources than MV lamps. The efficacy of a high output MH lamp is 100 lumens per watt compared to 30 to 50 lumens per watt for MV lamps. With its higher efficacy, MH lamps can provide higher light levels with less wattage. The life of an MH lamp is 20,000 hours, compared to 16,000 hours for the MV lamps. Viron recommends removing the existing MV lamps and installing new ballasts and MH lamps into the existing luminaires.

This ECM would be applied in the buildings listed in the ECM Application Table shown earlier in this section.

ECM Number: L5

ECM Title: High Pressure Sodium/MV to T5 High-Bay

Description:

The gyms at Skyline (Bldg 3) and CSM (Bldg 8) currently utilize high pressure sodium (HPS)/mercury vapor (MV) fixtures containing a combination of standard and pulse-start lamps. This ECM considers replacing the High Intensity Discharge (HID) fixtures with T5HO fixtures mounted with either 4 or 6 new T5 lamps. As an electric demand-saving lighting retrofit that allows for instant on/off and enhanced control, the F54T5HO fixture application has enough punch for high mountings like those found at the gyms. They are thin enough to be considered almost a line source, so luminaire efficiency can be very high. These linear sources in well-designed hibays provide excellent vertical foot-candles. A high bay with four (4) - F54T5HO's, consuming 234 maximum Watts can usually replace a 400W standard MH or 450W HPS. With electronic ballasts, the rated lamp life is 20,000 hours compared with 8,000 to 15,000 hours for HID lamps. Installation labor is kept to a minimum since hook, cord, and plug options are available.

ECM Number: L6

ECM Title: Occupancy Sensor Lighting Controls

Description:

Viron has identified several areas at the campuses where the use of an occupancy sensor will significantly reduce the operating hours of the lighting system by automatically turning it off during non-occupied periods. This ECM evaluates the installation of Occupancy Sensors (Infrared, Ultrasonic, and Dual Technology) for all the locations shown. Typical energy savings for some locations are described below.

APPLICATION	ENERGY SAVINGS
Offices (Private)	25-50%
Offices (Open spaces)	20-25%
Rest Rooms	30-75%
Corridors	30-40%
Storage Areas	45-65%
Conference Room	45-65%

There are three types of motion sensing technologies: Infrared, Ultrasonic, and Dual Technology. A description of each follows.

1. **Infrared-Motion Sensors**. These sensors respond to motion between horizontal and vertical cones of vision defined by the faceted lens surrounding the sensor. They emit infrared wave patterns, which react only to energy sources such as the human body. Infrared sensors detect occupancy by sensing the difference between the heat emitted from a person and the background space. Infrared sensors must “see” the covered area in order to sense occupancy.

2. **Ultrasonic (Sound) Sensors.** Ultrasonic sensors emit and receive high-frequency sound waves in the range of 25-40 kHz, well above the range of human hearing. These waves bounce off objects and room surfaces in a controlled area, and the sensor measures the frequency of the waves that return to the receiver. If there is motion within this area, the frequency of the reflected wave will shift slightly resulting in occupancy detection. One disadvantage of this type of sensor is that they don’t work very well in areas with sound-absorbing surfaces like partitions and ceiling tiles.

3. **Dual Technology (D/T) Sensors.** D/T sensors combine infrared and ultrasonic technologies to provide lighting control in areas where it is difficult to apply a single technology. In standard mode, the D/T sensor turns lighting on only when both technologies sense occupancy. Then, motion detection by either technology will hold lighting on. D/T sensors combine the best of both technologies and eliminate their weaknesses.

This ECM would be applied to those buildings listed in the ECM Application chart shown earlier in this section.

ECM Number: L7

ECM Title: Multi-Circuit Switching

Description:

The SMCCCD facilities were originally designed with single circuit switching in lecture and classrooms. Over time, and with the advent of modern projection devices, the educational mission has adapted technology for use in the classroom to facilitate learning with visual and graphical aids. Due to these changing requirements, an improvement in the lighting circuitry has been established. The new lighting circuitry enables dual-switching to separately control the lighting in the front third of the lecture/classroom and the back two-thirds to enable presentations without having added glare due to direct lighting. Other configurations may also be applied to best suit the individual room lighting requirements.

This ECM would be installed in the buildings indicated in the ECM Application Table shown earlier in this section.

ECM Number: L8

ECM Title: Incandescent to Tungsten Halogen

Description:

Incandescent PAR lamps are currently being used in various fixtures located throughout SMCCCD. While incandescent sources provide such desirable qualities as instant light, good color rendition, low replacement cost, and ease of control in dimming situations, they are the least efficient and shortest-lived type of light source now on the market. The typical life of an incandescent lamp ranges between 750-2500 hours, and the typical efficacy of the incandescent source is 20 lumens per watt.

Tungsten halogen par lamps are a more efficient light source, with an efficacy of as high as 50 lumens per watt. The typical lamp life of a tungsten halogen par lamp is from 2,000 to 4,000 hours. With a higher efficacy, a lower wattage tungsten halogen lamp can provide light levels of the same intensity as a higher wattage incandescent lamp, while the increased life span reduces maintenance costs. Another benefit of the tungsten halogen retrofit is that these lamps are available in the same sizes and shapes as incandescent par lamps, reducing installation costs normally associated with fixture adjustments. This ECM considers retrofitting selected existing incandescent luminaires with tungsten halogen par lamps in areas where the desired lighting levels cannot be achieved through current compact fluorescent technology.

This ECM would be applied to those buildings listed in the ECM Application Tables shown earlier in this section.

ECM Number: C1

ECM Title: Install New Direct Digital Control Energy Management System for all Core Equipment

Description:

This ECM outlines the installation of an Energy Management System (EMS), which is comprised of hardware devices that utilize Direct Digital Control (DDC) to control the core heating, ventilation, air conditioning (HVAC), and lighting equipment at specified buildings included in this study for San Mateo County Community College District. Core equipment is defined as all heating-ventilating units, supply fans, heat pumps, air conditioning fans, return fans, exhaust fans (5 HP or above), fan coil units, unit ventilators, pumps, boilers chillers, cooling towers, condensing units, heat exchangers, and outdoor lighting. Unit ventilators and fan coil units will receive supervisory controls only (start/stop for scheduling purposes).

Excluded from this ECM are all reheat coils, defined as “zone level controls” (except those associated with the VAV’s in Building 9, CSM, which will receive new DDC controls). All reheat coils will remain under control of existing pneumatic thermostats and will not be available for monitoring or adjustment from the EMS user interface. The effectiveness of all control strategies designed to use zone level data (morning warm-up, optimal start, discharge air temp reset and load shedding) will be forced to use return air temperature, which is not accurate when the fan system is not running.

All equipment included and points associated with them are detailed in the points list provided in Appendix A.

Sites included in this proposal, which presently do not have (or have partial) EMS control, are:

1. College of San Mateo (Buildings 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24)

2. District Administration Office

3. Skyline College (Buildings 1, 2, 3, 7, 8)

4. Cañada College (Buildings 1, 2, 3, 5, 6, 8, 13, 16, 17, 18)

The DDC systems will be a continuation of those that were installed at the Skyline Campus Library upgrade (Building #5) last year and the Skyline Campus Center upgrade (Building #2) this year.

Most buildings currently have pneumatic control systems that are functioning at various levels of reliability. With the DDC system, all identified equipment will be electronically controlled and monitored by the EMS. Some existing systems will remain under pneumatic control, but any new HVAC equipment installed as part of the energy program will have electronic DDC controls (no pneumatics).

This system will also allow the user to interface with all equipment controlled in these buildings via standard web browser from any designated location with a user I.D. made available by the District.

The following paragraphs describe the types of HVAC systems found at the SMCCD sites and the proposed scopes of work. The abbreviations at the beginning of each section are in reference to the points list provided in Appendix A. The EMS strategies are defined at the end of this section:

1. **HV** - Heating-Ventilating Units
   Generally located in ceilings or mechanical rooms, these fan systems provide fresh and/or recycled air (if unit has economizer) for cooling and heated air (hot water coil) for heating. We propose that all HV units be recommissioned for full functionality and, at a minimum:
   - Install new DDC damper actuators (if unit has existing economizer) *
   - Install new heating valve and DDC actuator *
   - Install DDC controls with start/stop, status, supply air temp, zone temp, damper control, and heating valve control
   - EMS strategies will include scheduling, outside air lockout, economizer control, morning warm-up, optimal start, load shedding, and discharge air temp reset

2. **SF** – Supply Fans
   Similar to HV units, and generally located in mechanical rooms, these fan systems provide cooling through the use of fresh and/or recycled air (in some cases a chilled water coil is used) and heating through the use of a hot water coil. We propose that all SF units be recommissioned for full functionality and, at a minimum:
   - Install new DDC damper actuators (if unit has existing economizer) *
   - Install new heating valve and DDC actuator *
   - Install new cooling valve and DDC actuator (if present) *
   - Install DDC controls with start/stop, status, supply air temp, zone temp, damper control, heating valve control, and cooling valve control (if present)
   - EMS strategies will include scheduling, outside air lockout, economizer control, morning warm-up, optimal start, load shedding, and discharge air temp reset

3. **HP** – Heat Pumps
   Generally located outside or on rooftops, these fan systems provide cooling and heating through the use of their compressors. Fresh and/or recycled air is used. We propose that all HP units be recommissioned for full functionality and, at a minimum:
   - Install new DDC damper actuators (if unit has existing economizer) *
   - Install DDC controls with start/stop, status, supply air temp, zone temp, damper control, compressor control, and reversing relay control

- EMS strategies will include scheduling, outside air lockout, economizer control, morning warm-up, optimal start, load shedding, and discharge air temp reset

4. **AC** – Air Conditioning Fans
   Generally located in mechanical rooms or on rooftops, these fan systems provide cooling through the use of their compressors and heating through the use of a hot water coil. Fresh and/or recycled air is used. We propose that all AC units be recommissioned for full functionality and, at a minimum:
   - Install new DDC damper actuators (if unit has existing economizer) *
   - Install new heating valve and DDC actuator *
   - Install DDC controls with start/stop, status, supply air temp, zone temp, compressor control, and heating control
   - EMS strategies will include scheduling, outside air lockout, economizer control, morning warm-up, optimal start, load shedding, and discharge air temp reset

5. **FCU or UV** – Fan Coil Units or Unit Ventilators
   Generally located in classrooms or offices and mounted on the wall or in the ceiling, these small fan systems provide ventilation through the use of fresh and/or recycled air and heating through the use of a hot water coil. We propose that all FCU and UV units be recommissioned for full functionality and, at a minimum:
   - Install new damper actuators compatible with existing controls *
   - Install new heating valve and actuator compatible with existing controls (as needed) *
   - Install DDC controls with start/stop, status for scheduling purposes. Temperature control will be maintained by existing standalone pneumatic controls
   - EMS strategies will include scheduling, outside air lockout, economizer control, morning warm-up, optimal start, load shedding, and discharge air temp reset

6. **RF**– Return Fans
   Generally located in mechanical rooms or inside rooftop units, these fans remove air from the spaces supplied by their associated SF or AC units and either return the air to the supply fan for reintroduction to the building or exhaust it out of the building. We propose that all RF units be recommissioned for full functionality and, at a minimum:
   - Install DDC controls with start/stop, status for scheduling purposes. Fan operation will be interlocked via hardwire and/or software with any associated SF, HV, or AC system
   - EMS strategies will include scheduling, optimal start, load shedding, and morning warm-up

7. **F** or **EF** – Exhaust Fans
   Generally located in mechanical rooms or on rooftops, these fans remove air from the building to compensate for minimum ventilation air being supplied to the building. We propose that all F and EF units be recommissioned for full functionality and, at a minimum:

- Install DDC controls with start/stop, status for scheduling purposes. Fan operation will be interlocked via hardwire and/or software with any associated SF, HV, or AC system.
- EMS strategies will include scheduling, optimal start, load shedding, and morning warm-up

8. **CU** – Condensing Unit
   Generally located outside or on rooftops, these systems provide remote operation of cooling for a supply fan system. They consist of a compressor and a fan system to cool the compressor. We propose all CU units be recommissioned for full functionality and, at a minimum:
   - Install DDC controls with start/stop, status for scheduling purposes. CU operation will be interlocked via hardwire and/or software with any associated SF or AC system
   - EMS strategies will include scheduling, optimal start, load shedding and outside air lockout

9. **HX** – Heat Exchanger
   These systems provide individual building control of heating water temperature. We propose that all HX units be recommissioned for full functionality and, at a minimum:
   - Install DDC controls with enable/disable, valve or pump control, and hot water supply temp. HX operation will be locked out and reset by outside air temp and building demand
   - EMS strategies will include scheduling, outside air lockout, optimal start, morning warm-up, and hot water reset

10. **P** – Pump
    Pumps provide heating, cooling and domestic hot water to the buildings. Most domestic pumps (for sinks, showers, etc) will be left as standalone systems, but we propose that all building heating and cooling pump systems be recommissioned for full functionality and, at a minimum:
    - Install DDC controls with start/stop, status for scheduling purposes. Pump operation will be interlocked via hardwire and/or software with any associated system's call for heat. Heating and cooling systems will be locked out when there is no demand.
    - EMS strategies will include scheduling, outside air lockout, optimal start, load shedding, and morning warm-up

    Additionally, ECM M-10 proposes that all of the pumps associated with heating at the central boiler plants of the three campuses be retrofitted with variable speed drives (primary/secondary conversion). Implementation of this measure will require, at a minimum:
    - Install DDC controls with start/stop, status, loop pressure inputs, and speed control. Pump operation will be interlocked with any associated system's call for heat. Heating systems will be locked out when there is no demand

- EMS strategies will include scheduling, outside air lockout, optimal start, load shedding, and morning warm-up

11. **B** – Boiler

    Boilers provide heating water and, in some cases, domestic hot water to the buildings. Domestic hot water heaters (for sinks, showers, etc) will be left as standalone systems, but we propose that all boilers will require, at a minimum:
    - Install DDC controls with start/stop, status, alarm, supply water temp, and return water temp. Boiler operation will be interlocked with primary pumps. Heating systems will be locked out when there is no demand
    - EMS strategies will include scheduling, outside air lockout, morning warm-up, optimal start, load shedding, and hot water reset

12. **CH** – Chiller

    Chillers provide cooling water. We propose that all chillers will require, at a minimum:
    - Install DDC controls with start/stop, status, alarm, supply water temp, and return water temp. Chiller operation will be interlocked with demand from associated air handling systems. Cooling systems will be locked out when there is no demand
    - EMS strategies will include scheduling, outside air lockout, morning warm-up, optimal start, load shedding, and chilled water reset

13. **CT** – Cooling Tower

    Cooling towers provide rejection of heat from a chiller or compressor. We propose that all cooling towers will require, at a minimum:
    - Install DDC controls with start/stop (possibly multi-speed or variable speed), status, supply water temp, and return water temp. Cooling tower operation will be interlocked with chiller (or compressor) and condenser pump
    - EMS strategies will include scheduling, outside air lockout, optimal start, and load shedding

14. **CG** – Cogeneration

    Cogenerators provide heat and electricity and are proposed in ECM DG-1. If implemented, we propose that all cogenerator systems will require, at minimum:
    - Install DDC controls with status, kW output, alarm, supply water temp, and return water temp
    - EMS strategies will include load shedding
    -

*** Note: The actual installation of new control valves and damper actuators will take place under ECM – M7.**

Definitions of EMS Control Strategies

1. Scheduling

   The proposed EMS will include time-based start/stop control of the designated equipment. It will include control of the economizer air dampers, hot water and chilled water coil valves, and/or stages of direct heating or cooling.

2. Outside Air Lockout

   The heating hot water pumps and the heating systems should be completely shut off when the outside air temperature is greater than 64°F, or a temperature determined to be appropriate by the District. This concept also applies to the cooling systems. The cooling water pumps and cooling systems would be off until the outside air temperature reaches 68°F. These temperature set points will be adjustable, and cooling and heating will occur simultaneously on few occasions. This will save gas and electricity, and can help to minimize overheating in crowded areas and overcooling in unoccupied areas of the buildings.

3. Economizer Control

   Our local climate provides “free cooling” for many hours of the year, using outside air to augment air conditioning or to ventilate a building when the enthalpy (total heat content) of the outside air is less than the enthalpy of the internal air and there is a desire to cool the building environment. This will save energy and improve indoor air quality.

4. Morning Warm-up

   Once all economizers are active and reliable, the “free cooling” benefits will be augmented by “free heating”, wherein the dampers are overridden to full recirculation on cold mornings, enabling the heating system to bring the zone temperature up to the desired setpoint by occupancy time without having to warm up the outside air. Once occupancy time and setpoint are achieved, the dampers are released to normal operation and provide fresh air requirements. Without zone level control, the need for warm-up will be determined by outside air and return temp.

5. Optimal Start

   Each building will utilize an Optimal Start routine that will determine the time to start the equipment in order to bring the occupied portion of the building up to the setpoint temperature before the occupied period begins. This type of control can be replaced with operator-determined start/stop schedules where deemed appropriate. Without zone level control (ECM C-2), this strategy will be difficult and relatively ineffective. The software will be forced to use the return temperature sensors (which are inaccurate when the fans are off) to "learn" when to start the equipment based on the outside air temperature.

6. Load Shedding

   Designated equipment will be turned off when conditions for load shedding are met. Conditions will be determined by user, custom programming, or input from Viron UtilityVision^{SM} panel. This strategy will reduce the peak demand element of the energy bill. Without zone level control (ECM C-2), this strategy will be less effective, due to the inability to change setpoints at the zone level.

7. Discharge Air Temp Reset

   This strategy will reset the temperature of air being discharged by the air handler based on the demands of the zones served by the fan. Energy is saved, and areas are less likely to be overcooled or overheated. Without zone level control (ECM C-2), this strategy will be less effective. The software will be forced to use the return temperature sensors to reset the setpoint and will be unable to react to differences in zones.

8. Hot Water Reset

   These are controls that reset the temperature of hot water supplied to space heating coils as a function of load or outside air temperature. Eliminating overheating, reducing piping heat loss, and improving boiler and heat exchanger performance saves energy.

9. Chilled Water Reset

   These controls will reset the temperature of chilled water supplied to the cooling coils from the chiller as a function of load or outside air temperature. As with hot water reset controls, chilled water reset controls save energy by reducing piping thermal losses. Also, by increasing the exiting water temperatures, suction pressure is increased and chiller performance is improved. While the primary savings for hot water reset is due to the reduction in piping thermal losses, the primary savings for chilled water reset is a result of the chiller efficiency improvement.

All HVAC equipment will be scheduled according to the occupancy schedule of the spaces and the times agreed upon in the contract. It is imperative that district personnel verify the equipment schedules with the occupied schedules at least once a year. Failing to maintain these schedules will prevent a large portion of the energy savings from materializing. All of the schedules will be adjustable from the central location or from an authorized user's workstation. In areas that require 24 hour per day operation, the equipment will operate 24 hours per day.

Another important step related to the implementation of the EMS is training for the facility staff. Included in the initial cost of the EMS is scheduled training for the appropriate district personnel. Basic trouble-shooting and component replacement will be discussed. This will give the maintenance staff the ability to repair most basic future EMS problems (i.e., fewer outside contractor service calls and expenses). In addition, the occupants of the building will be informed on the new temperature controls; and a procedure for permanent schedule changes and adjusting temperature set points will be established.

- New low voltage control and communication wire for the EMS will be plenum rated when installed above drop ceilings.
- When ceiling access is not possible, wire will be run in conduit.
- Wire mold will be allowed only when pre-authorized by Viron and District.
- New wire in mechanical rooms shall be in EMT conduit.
- Smoke detector repair/installation/testing in air handling units is not included.

The installation contractor will provide a complete 1-year material and labor warranty for all EMS components. Viron will perform a point-by-point commissioning during the installation to ensure that the EMS works properly.

San Mateo County Community College will be responsible for the following items:

1. Maintaining temperatures and operating schedules as detailed. If changes in these values are required, Viron will need to be notified so that the impact of energy usage can be accounted for.

2. For maintaining and repairing the EMS after the 1-year material and labor warranty expires.

3. For installing (if extra lines are currently not available) and maintaining a dedicated phone line or a VPN connection for the EMS to have remote monitoring capability from our Kansas City or Oakland office.

All electrical installations for the EMS will comply with the National Electric Code, the equipment shall be UL or ETL (or other approved insurance organization) listed, and the overall installation will conform to all Uniform Building Codes.

ECM Number: C2

ECM Title: Install New Direct Digital Control Energy Management System for all Zone Level Equipment

Description:

This ECM outlines the installation of an Energy Management System (EMS), which is comprised of hardware devices that utilize Direct Digital Control (DDC) to control the zone level heating equipment at specified buildings included in this study for San Mateo County Community College District. Zone level equipment is defined as all reheat coils controlled by room thermostats.

All equipment included and points associated with them are detailed in the points list provided in Appendix A.

Sites included in this proposal, which presently do not have (or have partial) EMS control, are:

1. College of San Mateo (Buildings 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 18, 19, 21, 22, 23, 24)

2. District Administration Office

3. Skyline College (Buildings 1, 2, 3, 7, 8)

4. Cañada College (Buildings 1, 2, 3, 5, 6, 8, 13, 16, 17, 18)

The DDC systems will be a continuation of those that were installed at the Skyline Campus Library upgrade (Building #5) last year and the Skyline Campus Center upgrade (Building #2) this year.

Most buildings currently have pneumatic control systems that are functioning at various levels of reliability. With the DDC system, all identified equipment will be electronically controlled and monitored by the EMS. Any new HVAC equipment installed as part of the energy program will have electronic DDC controls (no pneumatics).

This system will also allow the user to interface with all equipment controlled in these buildings via standard web browser from any designated location with a user I.D. made available by the District.

RHC – Reheat Coils

> Generally located in ceilings or mechanical rooms, these systems provide heat by controlling the amount of hot water passing through the coil. Heat is transferred to the air as it passes through the coil. A pneumatic thermostat in the room directly controls the hot water valve. We propose that all RHC units be recommissioned for full functionality and, at a minimum:

- Install new DDC valve and actuator
- Install new room temperature sensor
- Install DDC controls with supply air temp, zone temp, and heating valve control
- EMS strategies will include scheduling, morning warm-up, optimal start, and load shedding

Definitions of EMS Control Strategies

1. Scheduling

   The proposed EMS will include time-based start/stop control of the designated hot water coil valves.

2. Morning Warm-up

   Once all economizers are active and reliable, the “free cooling” benefits will be augmented by “free heating”, wherein the dampers are overridden to full recirculation on cold mornings, enabling the heating system to bring the zone temperature up to the desired setpoint by occupancy time without having to warm up the outside air. Once occupancy time and setpoint are achieved, the dampers are released to normal operation and provide fresh air requirements.

3. Optimal Start

   Each building will utilize an Optimal Start routine that will determine the time to start the equipment in order to bring the occupied portion of the building up to the setpoint temperature before the occupied period begins. The software will use the zone temperature sensors to "learn" when to start the equipment based on the outside air temperature. This type of control can be replaced with operator-determined start/stop schedules where deemed appropriate.

4. Load Shedding

   Designated equipment will be turned off and/or setpoints will be raised/lowered when conditions for load shedding are met. Conditions will be determined by user, custom programming, or input from Viron UtilityVision^{SM} panel. This strategy will reduce the peak demand element of energy bill.

All HVAC equipment will be scheduled according to the occupancy schedule of the spaces and the times agreed upon in the contract. It is imperative that district personnel verify the equipment schedules with the occupied schedules at least once a year. Failing to maintain these schedules will prevent a large portion of the energy savings from materializing. All of the schedules will be adjustable from the central location or from an authorized user’s workstation. In areas that require 24 hour per day operation, the equipment will operate 24 hours per day.

Another important step related to the implementation of the EMS is training for the facility staff. Included in the initial cost of the EMS is scheduled training for the appropriate district personnel. Basic trouble-shooting and component replacement will be discussed. This will give the maintenance staff the ability to repair most basic future EMS problems (i.e., fewer outside contractor service calls and expenses). In addition, the occupants of the building will be informed on the new temperature controls; and a procedure for permanent schedule changes and adjusting temperature set points will be established.

- New low voltage control and communication wire for the EMS will be plenum rated when installed above drop ceilings.
- When ceiling access is not possible, wire will be run in conduit.
- Wire mold will be allowed only when pre-authorized by Viron and District.
- New wire in mechanical rooms shall be in EMT conduit.
- Smoke detector repair/installation/testing in air handling units is not included.

The installation contractor will provide a complete 1-year material and labor warranty for all EMS components. Viron will perform a point-by-point commissioning during the installation to ensure that the EMS works properly.

San Mateo County Community College will be responsible for the following items:

1. Maintaining temperatures and operating schedules as detailed. If changes in these values are required, Viron will need to be notified so that the impact of energy usage can be accounted for.

2. For maintaining and repairing the EMS after the 1-year material and labor warranty expires.

3. For installing (if extra lines are currently not available) and maintaining a dedicated phone line or a VPN connection for the EMS to have remote monitoring capability from our Kansas City or Oakland office.

All electrical installations for the EMS will comply with the National Electric Code, the equipment shall be UL or ETL (or other approved insurance organization) listed, and the overall installation will conform to all Uniform Building Codes.

ECM Number: DG1

ECM Title: Combined Heat and Power System

Description:

As part of our analysis of campus energy savings, combined heat and power systems were analyzed for connection to the College of San Mateo central plant and swimming pool complex and to the Skyline College central plant. Their purpose is to offset facility electrical demand and usage, and to provide heat at a lower aggregate expense. We found that cogeneration at these facilities represents a very good value. CSM would profit from a natural gas-powered reciprocating engine generator unit of 525 kW, while Skyline would benefit from a similar system of 375 kW.

Background

A combined heat and power or cogeneration ("cogen") system typically consists of an engine and an electric generator, with associated controls, fuel system, electric switchgear, thermal systems, and emissions control systems. Possible engines include reciprocating engines, turbines, microturbines, etc. The generator output offsets a portion of the electric load of the facility, while engine waste heat offsets some of the facility's thermal requirement. Because much of the energy output of the system is applied to loads, cogeneration can be a financially effective tactic and an efficient use of natural resources.

The main strategy of the system at CSM would be to offset PG&E power when it is economically advantageous to do so. Depending upon the size of the cogen plant, operation may require some automatic modulation of output through the day, in order to not exceed the facility's instantaneous electric demand. Scheduling would be based on both the value of electricity being offset (i.e. at the off-peak, part-peak, or on-peak rates), and on the price of natural gas.

Analysis of CSM's and Skyline's historic electric and thermal loads have suggested that an appropriate cogeneration system would be approximately 500 – 600 kilowatts for CSM and 300 – 400 kilowatts for Skyline. Our analysis explored several options to find the most appropriate system types, and included extensive computer modelling of the cogen systems. In subsequent sections, we discuss several approaches to cogeneration generally, and finally the opportunities at CSM and Skyline.

Gas Turbines

Gas turbine engines are similar in principle to jet engines. Many, in fact, are redesigned aero engines, either turbo-prop or helicopter, fitted for stationary use. They are commonly fueled by natural gas or diesel oil. In a cogeneration application, they are connected through a gearbox to an electric generator. Gas turbines, in the smaller size range, tend to have significantly higher capital costs as well as lower efficiencies than similar-sized reciprocating engines. However, they also tend to generate less air pollution and require somewhat less operator attention, including less frequent overhauls.

Performance Characteristics: Specific fuel consumption (the fuel-to-power conversion rate, also called "heat rate") for gas turbines in this size range varies from 17,000 to 19,000 Btu/kWh-higher heating value (HHV). Heat can be recovered from the exhaust in a large boiler known as a heat recovery steam generator (HRSG). Heat recovery as a percentage of fuel input ranges from 20% to 50%. Small turbines in the under-one megawatt class tend to suffer severe efficiency losses at reduced output ("turn-down") and cannot generally "load-follow"; however, about 10% turndown is usually tolerable. Operational life is a function of both accumulated hours and the number of "starts". Thus, turbines generally do not perform well in applications requiring variations in output or intermittent operation.

Operation and Maintenance Requirements: Gas turbine cogeneration systems are well-suited for automatic control. Routine maintenance includes lubricating oil changes (usually on a three-month schedule) and periodic overhauls (usually no more frequently than once every three years). Specialized personnel are generally required for anything more than minor maintenance. Small "aero-derivative" engines can often be "swapped out" for major maintenance or overhauls, reducing downtime to a few hours.

Air Pollution Controls: Air pollutants of concern from the exhaust of natural gas engines of any type include nitrous oxide (NOx), carbon monoxide (CO), unburned hydrocarbons (UHC and other categories), and particulates (PM10, PM2.5). Air pollutant emissions levels from gas turbines fueled by natural gas are natively lower than those from reciprocating engines. Air pollution control systems for engines are principally aimed at NO_X levels, and include water or steam injection systems, catalytic combustion (e.g. SoLoNox or Xonon), or selective catalytic reduction (SCR), usually with ammonia injection, from either anhydrous ammonia or urea.

Natural Gas Reciprocating Engines

Natural gas reciprocating engines are spark-ignited, internal combustion engines that are fueled by natural gas. There are two main technologies: lean burn and stoichiometric, or rich burn. The difference is that lean burn engines use a stratified charge combustion system to improve efficiency and reduce emissions. Lean burn engines are more complex and more expensive, and the exhaust tends to be cooler with a greater flowrate than that of rich burn engines.

Performance Characteristics: Lean burn engines can achieve a specific fuel consumption of slightly less than 10,000 Btu/kWh HHV for the largest, newest designs available. Smaller engines (less than 1 MW) and older designs tend to have slightly lower efficiencies, with specific fuel consumption (SFC) above 11,000 Btu/kWh HHV. Stoichiometric engines have slightly lower efficiencies, with SFC above 12,000 Btu/kWh HHV.

Heat can be recovered from the exhaust, jacket water, lubricating oil, and (for turbocharged machines) the intercooler cooling water on the engine. Exhaust heat can be used to generate hot water or high pressure steam; but on lean burn engines, the lower exhaust temperature reduces the amount of steam that can be generated and adds to the cost of heat recovery. Through "ebullient cooling" jacket water heat can be used to generate low pressure (15 psig) steam; but this approach adds considerable cost and complexity, and reduced reliability. The conventional application of jacket water heat is as a low temperature (170-200 degree F) thermal source. Lubricating oil generally provides only low temperature heat, and intercooler heat is most often not recovered, as it is available only at the lowest temperatures (85 to 130 degrees F, depending on system design). Reciprocating engines generally maintain good efficiency and operating life at reduced output ("turn-down") and, thus, are better able than small turbines to follow a varying load.

Operation and Maintenance Requirements: A cogeneration system based on a natural gas reciprocating engine can be operated almost entirely under automatic control, although an operator should check the system periodically to ensure proper function.

Routine maintenance also includes monthly oil changes, monthly or bi-monthly spark-plug replacement and valve adjustment, and overhauls every two to eight years, depending on the engine. The air pollution system requires periodic catalyst cleaning and replacement and, depending on type, an ammonia or urea supply.

Air Pollution Controls: While all pollutants must be dealt with, the primary air pollutant of concern with natural gas engines is nitrous oxide (NO_X). Basic levels of NO_X are higher with a gas engine than with a turbine, and in most circumstances are addressed with exhaust treatment. Stoichiometric engines are usually provided with a passive 3-way catalytic reactor. The exhaust from lean burn engines is too lean and too cool to support a simple reactor, and requires a selective catalytic reactor (SCR) at somewhat greater expense, complexity, and maintenance. (The state-of-the-art in catalytic reactors is quite advanced. After passing through the catalytic reactor, exhaust from a natural gas engine typically has extremely low remaining pollutants, on the order of a few parts per million.)

Dual Fuel and Diesel Engines

Diesel engines are reciprocating "compression ignition" engines, which use the temperature of compression to ignite a charge of liquid fuel injected directly into the combustion chamber at the appropriate time. Dual fuel engines are reciprocating engines that use a pilot diesel oil injector to ignite by compression a main charge of natural gas. There are no spark plugs present in either of these types. Often dual fuel units can also operate on 100% diesel oil as a backup fuel; but since natural gas is typically less expensive and considerably lower in emissions than diesel fuel, normal operation is on 1% to 10 % diesel fuel, with the remainder being fueled by natural gas. Diesels are available in all sizes, though dual fuel engines are mainly large, from about three to twenty megawatts.

Performance Characteristics: Straight diesel engines have air quality issues and are usually employed only as backup units, permitted for operation less than 200 hours per year; therefore, they are rarely used in small cogeneration installations in the United States. Dual fuel engines use so little diesel that air quality can usually be addressed. Compression ignition makes dual fuel engines more efficient than lean burn natural gas engines. Dual fuel engines achieve efficiencies of 8,000 to 11,000 Btu/kWh HHV generated. Heat can be recovered from the exhaust, jacket water, and lubricating oil. Typical heat recovery as a proportion of fuel input ranges from 16% to 23%. The low heat recovery value reflects the low temperature of the exhaust.

Operation and Maintenance Requirements: Operation and maintenance requirements for dual fuel engines are similar to those for lean burn engines. However, it should be noted that dual fuel engines are more complicated because of the two fuel systems that must operate in tandem, the need to maintain diesel oil injectors, and the controls that permit operation in either dual fuel or 100% diesel oil modes.

Air Pollution Controls: Air pollutant emissions from dual fuel engines tend to contain larger amounts of NO_X than lean burn engines, as well as small amounts of fine particulates (sub-10 micron, PM10). Catalytic emissions reactors with particulate traps are available and have been used successfully, although these increase capital cost and maintenance as well.

Microturbines

Microturbines have been under development for four or five years and have lately caught the public “fancy.” Initial developers met with uneven success; and at this time, there is only one American manufacturer of a commercial product (Capstone).

A microturbine is distinguished from a conventional gas turbine by its size, its simplicity, and the method by which it creates a sinusoidal alternating current. The typical size range is from 20 kW to perhaps 200 kW. The compressor, turbine, and electric generator are mounted along a single shaft, forming a single-piece rotating element, which is supported in the engine by air-lubricated journal bearings. Thus, there is no gearbox, couplings, oil system, etc. The generator rotor contains permanent magnets and spins at turbine speed, some 90,000 rpm, producing a high frequency alternating current output. This is fed through a solid-state circuit consisting of a rectifier and inverter, which creates the useful 60 Hz sine-wave output. Solid-state controls complete the system. Microturbines are new and rather expensive on a cost per kW basis. As R&D is paid off, other competitors appear, and economies of scale develop, future prices should be lower.

Performance Characteristics: Small turbines are inherently inefficient, so thermal recouperators are usually part of the design, improving base heat rate to about 15,000 Btu/kWh HHV. Microturbines require high-pressure gas; if not available at the site, a gas compressor is required, with its cost and parasitic power. Also, as with all turbines, microturbines suffer sharp performance loss with increased inlet air temperatures. However, unlike large turbines, microturbines perform well at part-load, and are good for load-following. Thermal output is all contained in the 600ºF exhaust stream, which, unless there is a local need for copious hot air, will usually require a heat recovery steam generator to capture. Because the exhaust temperature of a microturbine is lower than that of other DG technologies, thermal recovery is limited.

Operation and Maintenance Requirements: O&M costs and frequency are probably not great – the units are designed to be an appliance and run for several years without attention. Since there is no oil-based lubrication system, periodic maintenance should consist mostly be changing air filters, fuel filters, and igniters. However, since they are very new, O&M has little historical record.

Air Pollution Controls: Since microturbines have low compression ratios and low combustion temperatures, NO_X emissions are very low, on the order of nine parts per million. For this reason, microturbines require no exhaust treatment for emissions, although they are still required to be "permitted" by the governing air quality district.

System Locations and Selection

Locations: Both campuses are fundamentally similar from the cogeneration standpoint, with similar schedules and with campus heating loops. The central plant for CSM houses three 10,000,000 Btu/h natural gas boilers which supply heat to the hot water campus heating system. The main gas supply for the campus is here also. Additionally, there is a 480 volt distribution switchgear. Skyline College's central plant has two 400 horsepower boilers supplying the campus heating loop, distribution switchgear available nearby, and a supply of natural gas.

The central plants appear to be the best location for the cogen because of the intesection of all of the connections needed by the system – electric load, thermal load, water, fuel, and maintenance access.

The generator sets could probably be placed inside the central plants: for instance, the CSM package is approximately 6' wide × 8' high × 18' long, while the Skyline unit is about 5' wide × 7 ' high × 10' long. A far better alternative in both cases, though, is to install the units on poured concrete slabs adjacent to the plant buildings, each contained in its own sound-attenuating enclosure. This has a number of advantages: maintenance access is good, installation is direct, much pre-assembly work can be completed at the factory, and running noise levels are quite low. We assume this alternative.

System Selection: The selection of the type and size of a cogeneration system depends upon characteristics of a particular application. In both these cases, the limited daily full-load schedule (not 24 hours per day), the need for relatively low temperature hot water for the heating loop, and the relatively small size of the system, recommend a reciprocating engine, rather than a turbine or a cluster of microturbines. Computer modeling of the various systems connected to CSM's and Skyline's thermal and electrical loads verify this conclusion. Microturbines, in fact, had simple payback periods over twice as long as similar-sized reciprocating systems, as well as poorgeneral efficiency.

From the analyses, we recommend a reciprocating stoichiometric engine cogeneration system of 500 – 600 kW for CSM and 300 – 400 kW for Skyline College. As further discussed below, we selected a 525 kW and a 375 kW Waukesha system for the two campuses. They will each employ heat recovery from the water jacket and from the exhaust, and utilize a three-way catalyst in the exhaust to control emissions. The recovered heat in both cases will be applied to the campus heating loop, offsetting the boilers and reducing their gas consumption.

Installation: A site adjacent to each central plant will be dug out to allow the pouring of a reinforced concrete "inertia block" slab on which the system will be placed. At CSM, it will occupy the site of the existing but disused incinerator, while at Skyline it will be poured in the landscaped area next to the boiler room in Building 1. Also, a slab for a dump radiator and exhaust heat recovery unit and pads for the switchgear and added motor control center will be poured as appropriate. Existing water piping will be fitted with suitable flanges and valves to allow connection, control, or isolation of the new systems. Wall coring will be done as necessary, and coolant piping, conduit for 480 volt electric cabling, and conduit for controls/monitoring connections will be run to required connection points inside the central plant. Conduit for the 480 volt cabling will be run from the generator switchgear to the existing 480 volt switchgear, and to the new motor control center associated with the genset.

The skid-mounted generator unit will be placed and bolted to the slab, in compliance with seismic regulations. The dump radiator and associated water and electrical connections will be installed next to the generator unit. Generator switchgear will be installed on the raised curb where convenient. The main heat exchanger will be connected to the campus heating loop. Electrical cabling will connect the generator to the switchgear, and the switchgear to the existing switchgear. Natural gas will be connected from its present station to a filter and metering station and to the engine. A weatherproof, sound-attenuating enclosure manufactured specifically for the unit will be installed over the generator unit. The engine exhaust system will be connected to its three-way catalyst and exhaust heat recovery unit – it will be critically silenced. The last of the coolant connections will then be made up. Control and monitoring, small electrical such as lighting, etc., will be connected. Coolant will be filled and tested for leaks, oil filled, and the system started, set up, and commissioned. Air quality testing will commence about 60 days later, and final setup will occur then to assure compliance.

Since the heat output represents only a fractional "baseload" of the total facility heat load most of the time, the cogen control system need not interface with the boiler control system, although remote monitoring and control will be part of the cogen control system.

Interface to Existing Utilities

This section describes the existing utilities at the sites that the cogeneration equipment would tie into. These utilities include the electrical system, natural gas, and hot water campus heating system.

Electrical: There are 480 volt switchgear in both CSM's and Skyline College's central plants, providing an easy place to connect the generator. At CSM, the generator switchgear, with a breaker, protective relaying, paralleling equipment, and a disconnect switch, will be located in the central plant; while at Skyline, it may be an outdoor unit. Cable in conduit will run from the generator to the generator switchgear to the existing switchgear. Smaller conduit, as required, will carry service power to fans, pumps, controls, etc. on the cogen unit and its ancillary parts. Separate conduit will carry control wiring.

Natural Gas: The natural gas systems at both CSM and Skyline College were designed to accommodate future expansion. At both campuses, the existing central plant gas systems have sufficient capacity to supply the cogeneration systems and the existing boilers.

Thermal Loads: CSM's boilers currently supply the hot water loop at 190-200ºF for 24 hours per day, with a varying load. A group of circulating pumps and a campus-wide heating loop delivers the hot water to each of the buildings on the campus, where it provides space heating, domestic hot water for bathrooms, heating for showers in the gymnasium, and heat for the swimming pools. Skyline College's heating loop is similar in temperature and schedule, but is smaller.

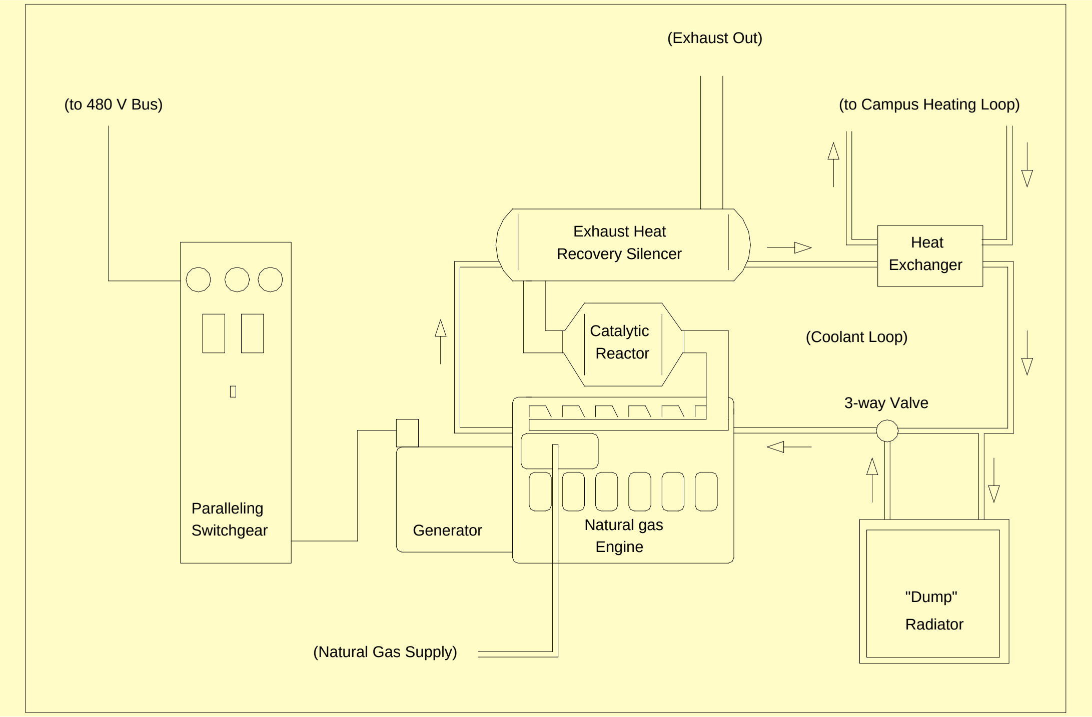
Since the pumps, control valves, and control system are in the central plant, connection of the cogeneration system will not be difficult here. From the heating system's point of view, the cogen will become, in effect, the "lead" boiler, with the other existing boilers operated as necessary to make up additional heat. At both campuses, the thermal load is larger than the cogen's thermal output most of the time, so that the cogen will operate in an efficient mode, using most of its available heat. At the occasional times that the cogen's heat output exceeds the campus load, a "dump" radiator will automatically reject the excess, allowing the cogen to continue to address the electrical load as required.

Piping and Electrical Connections

The system will be connected to the existing facilities in the central plants by the following:

Natural gas line
Insulated hot water pipes
Electrical conduits for 480 volt cables and ground
Electrical conduit with 480/277 100 Amp service for auxiliaries
Electrical conduit for communication and control

These pipes and electrical conduits will be carried underground from the slabs to the buildings, or will be carried overhead on a bridge structure. The electric connections will lead to dedicated generator switchgear and disconnect switch to be located in each central plant, and then landed on the service bus in the existing switchgear. Generation at both campuses will be at 480 volts. The engine hot coolant loop will pass through a heat exchanger onboard the generator skid. Campus heating loop water will pass through the other side of this heat exchanger, providing heat to each campus heating loop. The heat exchanger will be tapped in "upstream" of the existing boilers. The dedicated motor control centers will provide power for various cogen-related fans, pumps, lights, and other ancillary equipment.



Savings Estimate

The cogen systems will operate at a varying rate, sensing facility load at the utility connection. During the school day, when electric loads are high, the cogens will operate at 100% output; but during evenings and weekends, they will automatically reduce output to not exceed the loads. No generation "into the grid" is anticipated.

The savings estimate computes the net value of cogenerated power as the sum of the following:

- ❑ Value of generated electricity – usage and demand
- ❑ Value of generated heat
- ❑ Cost of fuel
- ❑ Cost of operation and maintenance

Value of generated electricity: As discussed in Section 2, the SMCCCD has had a price contract with Enron to provide electricity for a price about 33% less than PG&E's E20P rate, which would otherwise apply. Skyline's power arrangement was similar, but based on the E19P rate. The District's contract with Enron expires in March of 2003. At that time, the District will most likely be forced to revert to PG&E's full market rate structure.

The value of electricity is, therefore, based on PG&E's latest E20P rate for CSM and E19P rate for Skyline College. Added to both the E19P and E20P rate tables are several "surcharges" to recover lost revenue, including the 1/5/01 and the 6/1/01 surcharges. A comparison of the noncogen versus cogen situation realistically uses these surcharged rates for both. The E19P & E20P rate structures are shown in Section 2 of this report.

Value of generated heat: The value of cogen heat is found from its usable heat generation, the efficiency of the boilers being offset, and the cost of natural gas for the boilers.

Cost of fuel: The cost of fuel is based on the cost of natural gas for cogeneration systems. This cost has two components: the cogeneration gas rate, which is available for up to 9,683 Btu of fuel per kWh generated, and the otherwise applicable rate (boiler gas rate), which applies to the remainder, and also applies to the boiler fuel. Please refer to Section 2 of this report for a detailed discussion of the natural gas rates.

Cost of operation and maintenance: Maintenance cost is typically calculated on a cents/kWh or dollar/hour basis. For this analysis, it includes the cost of the periodic minor and major overhauls as well as routine service. The maintenance and overhaul costs are shown in the financial proformas in Section 1.

Modeling

The cogeneration modeling used a two-hourly interval through a characteristic weekday and weekend day each month. It calculated loads, production, costs, and savings for the two-hour periods through the year. All loads were based on Baseline values found for each campus. The model includes scheduled downtime, unscheduled downtime (and failure to make demand savings), off-, part- and on-peak electric demand and usage rates, surcharges, monthly gas rate variations, etc. Attached at the end of this discussion are summary data from solutions using several different systems, presented without regard for incentives or rebates.

Discussion of Recommended Installations

The intermediate-sized Waukesha VHP3600GSI unit is the most economic for CSM. It would have a 525 kW output at the present location, including auxiliary pumping and other losses. Skyline's optimum unit is the somewhat smaller Waukesha VGF24GSID, rated at 375 kW. Preliminary modeling indicates that the cogen units provide the most economic benefit at 5,423 run hours per year based on the PG&E electric and natural gas rate structures outlined in Section 2. This corresponds to the operating schedule of the two campuses. We may find that the selected cogen units may be able to be run continuously once the District completes construction of the planned new buildings. A lesser number of run hours may be more economic if the SMCCCD opts not to secure long-term gas contracts and is subject to the fluctuations of the natural gas spot market.

Although Waukesha engines were used for the modeling, it may be that another brand of engine having slightly different characteristics proves better in this installation. Detailed engineering will discover the optimum engine makers and engine sizes for the campuses.

In the modeled configurations, water jacket and exhaust heat were applied to the heating loop; and intercooler and oil heat were wasted. However, it may be possible to use these heat streams to, for instance, preheat makeup water, gaining a further small efficiency. All efficiencies are presented on a higher heat value (HHV) basis.

Emissions control in both cases will be through the use of a three-way catalytic reactor in the exhaust. This type needs no reactants, such as ammonia or urea, with their attendant costs and dangers. The exhaust from a natural gas-fueled engine, after treatment with the catalytic reactor, is typically very clean. NO_X levels are often in the single digits of parts per million, which is near the threshold of measurement.

Maintenance will be contracted, directly by the SMCCCD, with the equipment manufacturer or with a factory-approved third party. Sometimes "Level-one" maintenance is performed by the system owner, and includes the small and frequent operations, such as periodic oil and filter changes. In any case the maintenance contractor will be responsible for higher level maintenance, including periodic inspections, spark plug changes, valve adjustments, system testing and adjustment, and periodic minor and major overhauls.

ECM Number: DG2

ECM Title: Solar Photovoltaic System

Description:

One method of generating electricity on-site is by the installation of solar photovoltaic panels also known as a PV system. PV panels convert sunlight into DC electrical current, which is then converted to AC current by an invertor and fed into the facility's electrical distribution system. PV panels can be mounted on any external surface and can be mounted in a fixed position or made to track the sun's position.

Proposed System

CMS Viron worked with the PowerLight Corporation to develop a proposal for a 272 kWp (DC Kilowatt-Peak) PowerGuard installation at the San Mateo CCCD on three buildings at the Cañada College campus. PowerLight's PV proposal called for the installation of PV panel on the roofs of the Fine Arts (3), Gymnasium (1) and Academic (13) Buildings. The PV panels would lie on top of the flat roofs and would not be visible from the ground. PowerLight's patented PowerGuard system mounts raw PV panels on top of insulating, interlocking pads, which do not require anchorage to the roof in any way. In addition to generating electricity, the PV panels will also provide an additional level of roof insulation and extend the useful life of the roofing membrane.