ChevronTexaco

Feasibility Energy Analysis

Arapahoe County

Littleton, Colorado

September 2004

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Prepared by

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of

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by:

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Section 1

Executive Summary

Chevron Energy Solutions is delighted to have this opportunity to provide Arapahoe County with the enclosed Feasibility Energy Analysis (FEA). The purpose for performance contracting is to fund needed facility upgrades and improvements through guaranteed energy and operational savings. Our intent in this analysis is to evaluate the viability of performance contracting on campus. The Administration I building was the only facility surveyed for this study. Energy usage, construction costs, and energy savings were extrapolated to encompass all 21 facilities (1,243,193 square feet) to project opportunities.

Our confidence in performance contracting is based on extensive experience in developing, implementing, and monitoring/maintaining energy performance contracts. Our 30+ years of experience — coupled with the fact that we have helped to improve hundreds of government institutions across the country — will provide a successful partnership with Arapahoe County.

The enclosed study outlines the opportunities that the County can utilize to upgrade the facilities funded through energy and operational savings. As a base program, we have identified approximately $400,000 in facility improvements in the Admin I building funded through energy and operational savings. Projected throughout the other facilities, this project could expand facility improvements to almost $4,000,000 funded purely through energy savings. Additionally, these savings can fund additional capital projects, such as a new cooling plant in the Admin I building, that provide little or no savings. These funds can be used to eliminate operational problems as well as provide significant upgrades to the County, further improving the infrastructure.

The proforma found on page 1-3 details the cost and savings analysis completed for just the Admin I Building. Incorporating the remainder of the County facilities will achieve greater facility improvement opportunities and savings as shown on the next page.

If the analysis proves that there is an opportunity, as this one does, then the next step is to enter into a Comprehensive Energy Analysis (CEA) to develop a comprehensive performance contract for the Complex. The process of implementing the performance contract is outlined in four distinctive steps:

1. Feasibility Energy Analysis: Determines if performance contracting is a viable solution.
2. Comprehensive Energy Analysis: Detailed energy audit that develops comprehensive performance contracting solution.
3. Implement Facility Improvements: Design and implementation project developed under the CEA.
4. Ongoing Energy Savings & Guarantee: Contractual guarantee of energy savings that fund the performance contracting project.

We are enthusiastic about the benefits Performance Contracting can offer Arapahoe County. Chevron Energy Solutions feels this program will compliment the County's goals by improving the facilities while easing the need for capital funding. We look forward to the opportunity to develop, implement, and guarantee a successful project with you.

Sincerely,

Jim Knutson
Business Development Manager

Bret Thomas, PE, CEM
Senior Project Director

Scott Shulda, CEM
Project Manager

Table 1.1
Financial Aspects of Performance Based Energy Program for
Administration I Building, Arapahoe County
Littleton, CO

Implementation Cost	$413,347
CEA Fee	$8,598
Total Project Fee	$421,945
Financed amount of Project	**$421,945**
Construction Period Interest	$ -
Financing Fees	$ -
Total Financing Costs during Construction	**$ -**
Total Amount Financed	**$421,945**

1	2	3	4	5	6	7	8
Year	**Total Energy Savings**	**Operational and Maintenance Savings**	**Total Program Savings**	**Payment to Lessor**	**Monitoring and Verification**	**Total Program Costs**	**Net Savings**
1	$41,584	$4,800	$46,384	$38,096	$7,000	$45,096	$1,288
2	$42,623	$4,320	$46,943	$38,446	$7,210	$45,656	$1,288
3	$43,689	$3,888	$47,577	$38,863	$7,426	$46,289	$1,288
4	$44,781	$3,499	$48,280	$39,344	$7,649	$46,993	$1,288
5	$45,901	$3,149	$49,050	$47,762	$0	$47,762	$1,288
6	$47,048	$2,834	$49,882	$48,595	$0	$48,595	$1,288
7	$48,224	$2,834	$51,059	$49,771	$0	$49,771	$1,288
8	$49,430	$2,834	$52,264	$50,977	$0	$50,977	$1,288
9	$50,666	$2,834	$53,500	$52,212	$0	$52,212	$1,288
10	$51,932	$2,834	$54,767	$53,479	$0	$53,479	$1,288
11	$53,231	$2,834	$56,065	$54,777	$0	$54,777	$1,288
12	$54,561	$2,834	$57,396	$56,108	$0	$56,108	$1,288
Totals	$573,669	$39,497	$613,166	$568,430	$29,285	$597,715	$15,451

Notes By Column:

(1) Years after implementing retrofit changes

(2) Energy Savings are escalated by 2.5% to account for inflation.

(3) Operational and Maintenance Savings are stipulated, and are escalated by 0% to account for inflation.

(4) Total Program Savings are the sum of Columns (2) and (3)

(5) Payment to Lessor is based on an annual interest rate of 4.8%, 12 year term. Actual rate will be determined at closing.

(6) Monitoring Services are included for the entire term of the project as listed in Column 1 and are required for guaranteed programs. Monitoring and Verification services are escalated by 3% to account for inflation.

(7) Total Program Costs are the sum of Columns (5) and (6)

(8) Net Savings equals Total Program Savings less Total Program Costs, Columns (4) - (7).

Table 1.2
Financial Aspects of Performance Based Energy Program for
All Facilities, Arapahoe County
Littleton, CO

Implementation Cost	$3,721,217
CEA Fee	$87,024
Total Project Fee	$3,808,241
Financed amount of Project	**$3,808,241**
Construction Period Interest	$ -
Financing Fees	$ -
Total Financing Costs during Construction	**$ -**
Total Amount Financed	**$3,808,241**

1	2	3	4	5	6	7	8
Year	**Total Energy Savings**	**Operational and Maintenance Savings**	**Total Program Savings**	**Payment to Lessor**	**Monitoring and Verification**	**Total Program Costs**	**Net Savings**
1	$361,946	$31,500	$393,446	$362,671	$28,000	$390,671	$2,775
2	$370,995	$28,350	$399,345	$367,729	$28,840	$396,569	$2,775
3	$380,270	$25,515	$405,785	$373,304	$29,705	$403,009	$2,775
4	$389,776	$22,964	$412,740	$379,368	$30,596	$409,965	$2,775
5	$399,521	$20,667	$420,188	$417,413	$0	$417,413	$2,775
6	$409,509	$18,600	$428,109	$425,334	$0	$425,334	$2,775
7	$419,747	$18,600	$438,347	$435,572	$0	$435,572	$2,775
8	$430,240	$18,600	$448,841	$446,065	$0	$446,065	$2,775
9	$440,996	$18,600	$459,597	$456,821	$0	$456,821	$2,775
10	$452,021	$18,600	$470,622	$467,846	$0	$467,846	$2,775
11	$463,322	$18,600	$481,922	$479,147	$0	$479,147	$2,775
12	$474,905	$18,600	$493,505	$490,730	$0	$490,730	$2,775
Totals	$4,993,248	$259,199	$5,252,447	$5,102,000	$117,142	$5,219,142	$33,305

Notes By Column:

(1) Years after implementing retrofit changes
(2) Energy Savings are escalated by 2.5% to account for inflation.
(3) Operational and Maintenance Savings are stipulated, and are escalated by 0% to account for inflation.
(4) Total Program Savings are the sum of Columns (2) and (3)
(5) Payment to Lessor is based on an annual interest rate of 4.8%, 12 year term. Actual rate will be determined at closing.
(6) Monitoring Services are included for the entire term of the project as listed in Column 1 and are required for guaranteed programs. Monitoring and Verification services are escalated by 3% to account for inflation.
(7) Total Program Costs are the sum of Columns (5) and (6)
(8) Net Savings equals Total Program Savings less Total Program Costs, Columns (4) - (7).

Section 2

Overview of Chevron Energy Solutions Company

Chevron Energy Solutions (Chevron ES) is an engineering, design, and build company, formed in 1974 to meet the needs of a budding energy conservation industry. Chevron ES has performed energy analysis, design, construction, commissioning, and monitoring for buildings throughout the United States. Since its inception, Chevron ES has performed energy conservation work at more than 9,000 buildings, totaling over 300 million square feet.

Chevron ES was first to introduce a Performance Based Guaranteed Energy Savings Program (Performance Contract) in 1981. The customer was Adrian College in Michigan. Performance contracts are unique among contracting methods because they allow for the creation of "win-win" rather than adversarial relationships between the customer and contractor. Both parties involved in a performance contract share a common goal: *to save energy*. Chevron ES' program offered the College a reduction in energy expenditures. The savings generated from these reductions were then used to pay for all program costs. Since that first guaranteed savings performance contracting project at Adrian College, Chevron ES has performed over 300 energy performance contracts.

Cycle of Performance Contracting

What is performance contracting? Performance contracting allows a building owner to make *capital improvements* to a facility, *finance* all associated costs, and have a *guarantee* that the resulting *energy and operational savings* will cover the debt service.

Chevron ES provides traditional energy services such as audits/analysis, engineering design, project and construction management, commissioning, measurement & verification, and monitoring. We also have state-of-the-art services such as UtilityVision®. UtilityVision is a web-based monitoring tool that allows our clients track energy usage with the click of a mouse. It is the ideal solution for monitoring electricity consumption in educational institutions, manufacturing facilities, housing developments, and multi-building commercial developments — conveniently, from your computer.

Performance contracting requires a long-term commitment to projects. Our performance contracting projects typically last from five to twenty-five years. We rely on the continued performance of the installed efficiency measures throughout these project terms. Our guarantee is simple.

Chevron ES currently guarantees over thirty-five million dollars in annual energy savings. With this number of annual energy savings, Chevron ES has one of the lowest ratios of pay-out (less than 1%) in the industry. We monitor over 1,000 buildings across the United States. Chevron ES has successfully implemented a broad range of energy conservation

measures (ECM's) in many different facility types which include school districts, colleges, universities, state/city/county, hospitals, commercial/retail, housing authorities, and federal government. Examples of some of these projects are the City and County of Los Angeles, the State of Michigan, the University of Utah, and Offutt AFB.

Chevron ES is pre-qualified by the Department of Defense (DoD) and Department of Energy (DOE) as providers of energy services and has been a long-standing accreditated member of the National Association of Energy Services Companies (NAESCO), the industry's trade organization.

Chevron ES' objective in implementing a **successful** energy savings performance contract is to first and foremost identify the specific goals and needs of the client, and then customize a program to meet these goals and needs. Chevron ES' program results will be tailored to positively impact these common goals and any goals specific to the client. Some of these common goals are listed below with examples of how the Chevron ES performance contract program will help obtain them.

1. ***Create an environment of excellence…***

   Our comprehensive approach will determine specific issues with comfort conditions and then provide solutions that meet these needs in the most effective and efficient manner. New lighting systems have been proven to provide better quality lighting that reduces eyestrain (and related illnesses – headaches etc.) and increases productivity of workers. The HVAC retrofits will provide much better control of temperature, humidity, and indoor air quality (IAQ).

   The economic benefits of creating a high-quality environment can rapidly repay the capital investment required. Recent research on the impact of poor environmental quality on workers' productivity, health, performance, and absenteeism rates strongly supports the economic value of a high-quality environment.

2. ***Earn greater good will and heighten public participation through communication with community…***

   The energy saving performance contract will allow the client to obtain facility improvements without requesting additional funds, because improvements are paid from the existing utility budget. This demonstrates fiscal responsibility and could, in incidences of the client being a state/city/county institution, earn the good will of the community. Improved energy efficiency reduces the demand for burning fossil fuels, which reduces air pollution. Chevron ES can also facilitate the client pursuing the Energy Star label for facilities meeting the criteria. This partnership can produce many positive "green" PR opportunities.

3. ***Assess availability/adequacy of facilities to meet the demand of current and future programs…***

   The Comprehensive Energy Analysis will include in-depth review of all significant energy consuming systems and recommendations for improving systems that are inadequate. In addition, Chevron ES will work with client's personnel to determine what

improvements are needed and how technology needs may be addressed through the performance contract program.

Guaranteed energy savings not only pay for energy related upgrades but past performance contracts have addressed physical needs such as renovating space to create new classrooms or the purchase of logistics/routing software to improve the efficiency of the bus routes — all paid for from energy savings.

4. ***Maintain commitment to quality standards by ensuring adequate/on-going funding…***

   There are several ways a Chevron ES performance contract program would assist the client to ensure adequate funding. First, by stretching existing utility/operational budgets to cover cost of facility improvements-future funding that would have been allocated for upgrades may now be directed elsewhere. Secondly, the vast majority of our programs generate excess savings (i.e., more savings than is required to pay for the program); and Chevron ES' policy is to give 100% of these savings to the client for their discretionary use. Finally, once the program is paid off, the client retains 100% of all savings for discretionary spending.

5. ***Shifting maintenance efforts from responding to crisis situations to preventive maintenance…***

   Through the installation of new and efficient equipment, coupled with training and scheduling development, the client's maintenance and operations staff will begin to shift from responding to crisis situations and repair maintenance to an organized and coordinated preventive maintenance program that will ensure long-term operations savings.

Industry Participation

Chevron ES' dedication to the industry goes beyond implementing projects. The commitment is shown in the involvement with the industry's organizations. As a Charter Member of ***NAESCO***, Chevron ES has played an active role in the development of the organization and the energy services industry. John Mahoney, Chief Operating Officer of Chevron ES, is and has been a member of the Board of Directors. During the NAESCO conferences, John Mahoney participates as a moderator for panel discussions. Some of Chevron ES' employees are active committee members on some of NAESCO's committees such as International, Measurement & Verification, Model Legislation, Membership, Restructuring, State Affiliates, and Federal Market.

Rebuild America is a program of the Department of Energy (DOE) that focuses on energy solutions as community solutions. Rebuild America "partners" with small towns, large metropolitan areas and Native American tribes, creating a large network of peers. Rebuild America supports communities with access to DOE Regional Offices, State Energy Offices, National Laboratories, utilities, colleges and universities, and non-profit agencies. This network of partnerships can help communities be more environmentally and economically sound through smarter energy use in buildings by helping communities identify problems, prioritize them and help solve them. Chevron ES is an active member of Rebuild America. Chevron ES employees are continually requested by Rebuild America to speak/present on performance contracting with case studies at regional meetings/conferences.

In October 2000 John Mahoney, Chevron ES Chief Operating Officer, was awarded the 2000 Association of Energy Engineers (AEE) ***Energy Executive of the Year*** due to the company's significant growth in the industry. He spoke at the 1998 World Energy Congress on "The Energy Engineers – the Common Thread in Performance Contracting" and also, was the keynote speaker at the 2000 World Energy Congress in Atlanta, Georgia where he presented his paper on "The State of the Energy Industry: The User's Perspective".

Project Awards

Most recent awards for our performance contracting projects have been:

- *The University of Utah* was honored with a 2001 Rebuild America Energy Champion Award at the Rebuild America National Forum in Atlanta for making sweeping improvements to buildings campus-wide in an effort to save energy and dollars.
- The DOE, Ohio Department of Development's Office of Energy Efficiency and the Foundation honored the Springfield Local School District in Ohio in 2000 for Environmental Education for the retrofit of more than one-half million square feet of school space and reduction of energy costs.
- *Offutt AFB* in Nebraska (home of the 55th Wing of the Air Force's Air Combat Command, U.S. Strategic Command, Air Force Weather Agency) was awarded the 2000 Omaha Public Power District's J. M. Harding Award for demonstrating a smart approach to using energy.

- In 2000 *Portsmouth Housing Authority* in Ohio received recognition from Rebuild America for its energy conservation measures through performance contracting.

Chevron ES Support

As part of Chevron ES' comprehensive energy savings performance contracts, we work with our clients to reduce their energy consumption as well as provide programs that will enhance the mission of their organization. Our programs are partnerships that can focus on the following:

- Environment
- Education
- Skills
- Financial Strength
- Employment Opportunities

Environment

Chevron ES will provide responsible energy conservation measures that will improve the administrative environment of the Arapahoe County facilities. The measures we recommend will not only reduce energy consumption but will provide for the proper environmental conditions for purpose of the facilities. Lighting levels, temperature control, indoor air-quality, and life-safety will be addressed as part of our program.

Education

A major component of all of our programs is education. Chevron ES includes education at all levels of an organization. Administration, staff, and the facilities department will be trained on the energy conservation measures installed within the County facilities. An energy awareness program will be implemented that will provide a forum for the County to learn more about energy and energy conservation.

Skills

Comprehensive skills are required to deliver successful projects. Chevron ES has developed the needed skills in-house, including energy auditing, engineering, construction management, energy management system commissioning, and performance monitoring. We have over 300 engineering, construction professionals, and support staff. Nearly sixty of these are registered professional engineers. Our average engineer has over ten years experience in the energy conservation industry. Our project teams have the skills needed to provide our clients with a great success.

Financial Strength

Performance Contracting requires a long-term commitment to projects, with the financial resources to support these efforts. Our performance contracting projects typically last from five to twenty years. We rely on the continued performance of the installed efficiency measures throughout these project terms. Our guarantee is simple. If we fail to achieve the guaranteed savings, we pay the client 100% of any shortfall.

Chevron ES is a wholly owned subsidiary of ChevronTexaco, the second-largest U.S.-based energy company. More than 300 professional in over two dozen offices nationwide serve hundreds of institutional and business clients.

Section 3

Data on Present Facilities

Utility Use

The total annual cost for gas and electricity in the Admin I Building is:

Admin. I Building Electricity:	$166,193
Admin. I Building Natural Gas:	$ 21,725
Total	$187,918

The Administration Building is on an Xcel Energy secondary general (SG) electric account that encompasses both energy and demand into the billing structure.

The Energy Charge: The Energy Charge is $0.01645/kWh.

The Demand Charge: The Demand Charge is $12.55/kW.

The following table illustrates the average usage for the Administration I Building over the seventeen months of utility data collected. This indicates an average energy cost of $0.06 per kWh.

Arapahoe County Admin I Building
Electric Utility Usage

Month:	Demand KW:	Usage kWh:	Total Cost:	Blended $/kWh:
January	487	216,872	12,310	$0.0568
February	498	201,955	11,397	$0.0564
March	541	229,074	13,590	$0.0593
April	536	222,444	12,627	$0.0568
May	549	243,147	14,691	$0.0604
June	598	252,982	15,764	$0.0623
July	594	274,686	15,987	$0.0582
August	563	259,128	15,716	$0.0606
September	536	237,786	14,351	$0.0604
October	538	232,026	14,494	$0.0625
November	529	201,981	12,796	$0.0634
December	510	201,977	12,470	$0.0617
Totals:	**6,479**	**2,774,058**	**$166,193**	**$0.0599**

Natural gas is supplied by contract through Seminole Energy Services. The actual price of gas appears to fluctuate with market prices. An additional transport charge is applied by the local utility.

The following table illustrates the average usage for the Administration I Building over the eighteen months of utility data collected. This indicates an average energy cost of $0.62 per Therm. Gas prices are expected to increase between 15% and 20% this winter, correlating to a rate increase of $0.10 to $0.15 per Therm.

Arapahoe County Admin I Building
Natural Gas Utility Usage

Month:	Usage Therm:	Total Cost:	Blended $/Therm:
January	5,080	$3,278	$0.6453
February	4,650	$3,036	$0.6529
March	3,710	$2,322	$0.6259
April	3,140	$1,680	$0.5350
May	1,950	$1,263	$0.6477
June	1,650	$1,242	$0.7527
July	700	$638	$0.9114
August	590	$510	$0.8644
September	1,960	$1,223	$0.6240
October	2,750	$1,559	$0.5669
November	4,090	$2,177	$0.5323
December	4,810	$2,797	$0.5815
Totals:	**35,080**	**$21,725**	**$0.6193**

Data on Present Facilities

ADMINISTRATION I BUILDING

The Administration I Building is a four story, 122,833 square foot building built in 1977. There have been several renovations, the most recent in 1986. The building is constructed of reinforced concrete frame with glass and steel curtain wall. The exterior glass is typically single pane. The windows on the east side of the building have recently been retrofitted to double pane tinted windows.

The building is in relatively good shape. Major mechanical equipment is past its useful life and is showing signs of deterioration. Most equipment is controlled through a time clock and has experienced problems with hot and cold spots.

Heating

Heat is provided from two Peerless (Model #211-8-WT G) atmospheric hot water boilers. Each boiler is rated at 1,470 MBH input (1,178 MBH out). The boilers are used for heating hot water through reheat coils and domestic hot water. A third electric boiler has been abandoned in place. Two 7.5 HP hot water pumps circulate a constant volume of heating hot water to all reheat zones throughout the facility.

The boilers are used to heat domestic hot water. A shell and tube heat exchanger can either receive heat from the boilers or heat recovery from the chillers. The heat recovery is either not working properly or not used as the boilers had been fried at the time of the survey.

Cooling

The building is equipped with two 210-ton water-cooled reciprocating chillers and two 15 HP chilled water pumps. Both chillers serve the two penthouse air handlers and both were operating at a six degree temperature difference at the time of the survey. Each chiller utilizes four air compressors. The chillers are 1976 vintage and have required a lot of maintenance in the past few years. The cooling tower is deteriorating as well and is scheduled for replacement this winter.

Both chillers were on at the time of the survey. After reviewing the utility data, it appears the chillers are operated throughout the year. This could be a result of the air-side economizers not working properly in the penthouse AHU's.

Both chillers have heat recovery systems that appear to be not in use. The heat recovery for each chiller is piped to a shell and tube heat exchanger that can be used for heating hot water or domestic hot water. Both chillers were operating at the time of the survey; however, the heat recovery valve was in the off position.

Air Handlers

The building is equipped with two air handlers residing in two penthouses. Each unit is an identical variable volume reheat unit with a chilled water coil at the unit. Each unit has an economizer but their effectiveness is in question as the need for cooling from the chillers is needed year-round. The interior zones of the building are cooling only variable volume. The

perimeter zones use constant air but vary temperature through reheat coils. Each unit uses a constant volume exhaust fan for building pressure control.

Each unit is controlled through a time clock to operate between the hours of 7:00 am and 10:00 pm Monday through Friday. The units are in the unoccupied mode at night and throughout the weekends.

Controls

The major equipment is controlled via time clock. The following are the general sequences of operation currently in use:

Air Handling Unit Control:

Penthouse Air Handling Units: Variable air volume boxes and reheat coils are controlled via local pneumatics. The units are scheduled 7:00 am to 9:00 pm. M-F. The VFD was found operating at 40 Hz in the North Penthouse and at 34 Hz in the South Penthouse. The units are scheduled off during the unoccupied period.

Heating System Control:

Hot water is provided to the VAV box reheat coils for the AHU's. The boiler is locked out when the outside air is greater than 50 deg. F unless there is a call for heat from the domestic hot water system.

Cooling Systems Control:

Chilled water is provided to the cooling coils in the AHU's from the chillers located in the basement mechanical room.

Exhaust Fan Control:

Exhaust fans serving the restrooms and elevator equipment are operated twenty-four hours per day.

Lighting

The majority of the lighting utilizes T12 lamps and magnetic ballasts. Many of the canned incandescent fixtures have been retrofitted with compact fluorescents and exit signs converted to LED fixtures. Most of the lighting is controlled locally by the occupants; however, there are large areas of lights controlled through breaker switches.

Section 4

Energy Conservation Measures

This report summarizes the Feasibility Energy Analysis conducted by Chevron Energy Solutions. The purpose of this report is to determine if a viable energy conservation project exists. While not intended to be inclusive, this report relies on the experience of Chevron's engineers to identify viable savings opportunities. Based on this cursory review, the following Recommended Energy Conservation Measures (ECM's) have been identified as likely viable ECM's, meaning that the cost to implement them will be paid for in a reasonable time period from the resulting energy savings.

Many other ECM's were identified. Some of these will have a long payback period and, if implemented, will be done so due to reasons other than energy savings. Other ECM's may or may not be viable. In order to determine the viability of these ECM's, more analysis must be performed. Once this project moves to the Comprehensive Energy Analysis phase, the ECM's will be evaluated in detail. These ECM's are described in the last section entitled "Energy Conservation Measures to be Evaluated in More Detail".

Recommended Energy Conservation Measures

ECM Number: L-1

ECM Title: Electronic Ballasts and T8 Lamps

Description:

The Administration I Building utilizes fluorescent fixtures containing a combination of standard and energy saving T12 lamps with standard magnetic core and coil ballasts. This ECM considers replacing the existing T12 lamps and ballasts with T8 lamps and electronic ballasts.

The combination of T8 lamps and electronic ballasts is the most technologically advanced fluorescent lighting system available. It has been proven to be approximately 40% more energy efficient than the conventional T12 lamps and magnetic ballasts. The electronic ballasts operate at high frequencies to reduce the power requirements, while maintaining the appropriate light level. Electronic ballasts 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.

Electronic ballasts can control up to 4 lamps, instead of just 2. This reduces the number of ballasts purchased, by allowing a ballast to operate more than 2 lamps. Some areas that have luminaires mounted end-to-end can be tandem ballasted. Tandem-ballasted fixtures house the ballast in one luminaire, while operating lamps in one, or more, of the nearby luminaires.

In addition to energy savings, this lighting ECM creates maintenance savings as well. The proposed 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. They are 100% guaranteed by the manufacturer for 3 years (lamps) and 5 years (ballasts).

Chevron Energy Solutions recommends retrofitting T12 fluorescent luminaires with the T8 system. The T8 lamps fit in the existing standard T12 bi-pin sockets without luminaire modification. Recommended replacement lamps are as follows:

- 20-watt, 2-foot, T12 lamps replaced with 17 watt T8 lamps
- 34-watt and 40-watt, 4-foot, T12 lamps replaced with 32 watt T8 lamps
- 60-watt and 96-watt, 8-foot, 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 light level and quality.

ECM Number: L-2

ECM Title: Specular Reflectors, Electronic Ballasts, and T8 Lamps

Description:

The Admin I Building utilizes recessed luminaires that contain fluorescent T12 lamps, either linear or U-tube. Magnetic core and coil ballasts operate these lamps. The most common recessed luminaire contains 4 standard, 4-foot, T12 lamps, with two magnetic ballasts.

The lighting industry has seen continued advances in the field of light reflection, which has resulted in the introduction of specular reflectors. With the specular reflector system, up to half of the lamps and ballasts can be removed without reducing the light level at the work surface. A reflective surface is installed in the fixture to make up for the loss of illumination, due to lamp removal. This reflects more of the remaining light back into the room.

Each specular reflector is custom designed using sophisticated optical engineering and computer-aided design. The reflector is bent at optimum angles for each fixture type. The enhanced aluminum material optimizes reflectivity and overall performance. The reflector produces uniform lighting that is comfortable and aesthetically pleasing without changing the appearance of existing fixtures. Trapped light is redirected in such a way that the fixture actually appears to still have all bulbs active. Use of this reflector causes almost all of the light energy within a fixture to be transmitted as usable light. Resulting light levels are less diverse because of the reflector's geometric design. This induces even distribution of light and reduces glare.

This ECM considers retrofitting luminaires with specular reflectors, T8 lamps, and electronic ballasts. Experience shows that fixture wattages may be reduced by half with little or no noticeable loss of light intensity at the working level. Listed below are the typical lighting fixtures and the proposed retrofit for each:

- The existing 2' x 4' luminaires containing three to four standard, 4-foot, T12 lamps and two ballasts, will be retrofitted with two 4-foot T8 lamps, an enhanced aluminum reflector, and one 2-lamp electronic ballast.
- The existing 2' x 4' luminaires located in an end-to-end configuration, and containing three to four standard, 4-foot, T12 lamps and two ballasts, will be retrofitted with each fixture containing two, 4-foot, T8 lamps, and an enhanced aluminum reflector, with one 4-lamp electronic ballast installed in one luminaire and tandem wired to the second luminaire.
- The existing 2' x 2' luminaires containing two, T12, U-tube lamps and one ballast will be retrofitted with two, 2-foot, T8 lamps, an enhanced aluminum reflector, and one 2-lamp electronic ballast.

This ECM considers retrofitting existing three, four lamp, and two lamp U-tube fluorescent fixtures with specular reflectors, electronic ballasts, and T8 lamps. This retrofit will reduce the energy consumption of these lighting fixtures by 50% or more while maintaining or improve the existing lighting levels.

ECM Number: L-3

ECM Title: New Fluorescent Fixtures with Electronic Ballasts and T8 Lamps or Compact Fluorescent Lamps

Description:

This ECM considers replacing selected high wattage incandescent fixtures, which have significant operating hours, with new fluorescent fixtures containing new T8 or compact fluorescent lamps and electronic ballasts. .

Standard 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 type of light source currently available. The typical life of an incandescent bulb ranges between 750 and 1,000 hours, and the typical efficacy of the incandescent source is 20 lumens per watt. Of the total input power, only 10% emerges as visible light. The typical efficacy of a T8 fluorescent luminaire is 80 to 100 lumens per watt, and lamps have an average life of 20,000 hours, which results in reduced maintenance cost.

With this higher efficacy, a lower wattage fluorescent fixture can provide light levels of the same or greater intensity as a higher wattage incandescent fixture. Due to advanced technology, the new T8 system is an excellent replacement in almost all circumstances because it is the most efficient fluorescent system available. Electronic ballasts operating at high frequencies reduce the power needed to produce the same or greater amount of light, and more efficient T8 lamps allow more usable light to exit the fixture.

Compact fluorescent lamps are also a much more efficient light source than standard incandescent lamps, with a typical efficacy of 50 to 70 lumens per watt, and having an average rated lamp life of 10,000 hours. Long lamp life results in reduced maintenance costs associated with lamp replacements. The higher efficiency, lower-wattage compact fluorescent lamps can provide light levels of the same intensity as a higher wattage incandescent lamp.

The implementation of this ECM will also generate maintenance savings due to the longer life of the fluorescent lamps as compared to the incandescent lamps.

ECM Number: L-4

ECM Title: Incandescent to Compact Fluorescent Retrofit Kits

Description:

Many of the existing incandescent fixtures in the Administration I Building have been converted to compact fluorescents. However, a few fixtures remain in the facility that can produce great energy savings. This ECM considers replacing all incandescent lamps, which have significant operating hours, with screw-in or hard-wired compact fluorescent retrofit kits with lamps and ballasts into the existing luminaire.

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 type of light source currently available. The typical life of an incandescent bulb ranges between 750 and 1,000 hours, and the typical efficacy of the incandescent source is 20 lumens per watt. Of the total input power, only 10% emerges as visible light.

Compact fluorescent lamps are a much more efficient light source with the typical efficacy of 50 to 70 lumens per watt, and having an average rated lamp life of 10,000 hours. Long lamp life results in reduced maintenance costs associated with lamp replacements. The higher efficiency, lower wattage compact fluorescent lamp can provide light levels of the same intensity as a higher wattage incandescent lamp without sacrificing lighting quality.

The implementation of this ECM will also generate maintenance savings due to the longer life of the fluorescent lamps as compared to the incandescent lamps.

ECM Number: L-5

ECM Title: New L.E.D. Exit Fixtures

Description:

Many of the existing incandescent fixtures in the Administration I Building have been converted to compact fluorescents. However, a few fixtures remain in the facility that can produce great energy savings.

The 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. Only 10% of the total input power emerges as visible light in an incandescent lamp.

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

ECM Number: M-1

ECM Title: Expand/Upgrade Energy Management System

Description:

This ECM involves expanding and upgrading the existing energy management systems. The Administration I Building is controlled through local pneumatics and time clock controls on major equipment.

Typical methods for achieving energy savings with an EMS are described below. Specific items that were observed during the site survey to permit greater energy savings include:

Administration Building

1. Chilled water reset. The chilled water temperature is currently controlled by a manual controller on the chiller. During many hours per year, the chilled water temperature can be raised while maintaining complete comfort throughout the building. By making warmer chilled water, the chiller efficiency is increased. Additional points will be added to automatically reset the chilled water temperature based on actual load conditions. This must be done carefully to ensure the VAV air handlers do not speed up due to warmer chilled water.
2. Improve VAV modulation. Many of the existing VAV zones are not working properly or have not been calibrated recently. It is common for variable speed drives to go out of calibration or to have never been properly calibrated in the first place, thereby increasing air flow needlessly. The systems will be serviced and calibrated to permit proper modulation.
3. Tighten air handler schedules. The air handlers are scheduled to run for worst-case occupancy conditions. This results in many meaningless run hours for the air handlers. Selectively located override buttons will be installed to permit after-hours operation of the air handlers on an as-needed basis.
4. Adjust night setback temperatures. The night setback temperatures are currently programmed for 65 degrees in the heating mode and 78 degrees in the cooling mode. These setback temperatures will be adjusted to 55 degrees in the heating mode and 85 degrees in the cooling mode.
5. Recommission the entire system. The entire system will be recommissioned to ensure sensors are reading properly, temperature reset strategies, and lockout strategies are working properly, etc.

With the DDC system, all existing controllers will be controlled by the EMCS. The EMCS will provide the control movement and modulation. Any new HVAC equipment installed as part of the energy program will have DDC control with electronic controls (no pneumatics).

Features and criteria associated with the implementation of this ECM are as follows:

- Review the needs for a new host computer with color monitor, modem, and printer.
- Review the possibility of Ethernet communications between building controllers and host computer.
- AutoCAD floor plans of each site.
- All air handling units (AHU's) will have the capability of being enabled/disabled by the EMCS. The pumps, heating, cooling, and exhaust systems should be shut off in the buildings when they are not occupied. The space temperature will be allowed to drop as low as 55ºF in the heating season and rise as high as 85ºF in the cooling season. Specific areas of each building should be set back whenever they are not occupied.
- Chilled water pumps will be enabled/disabled by the EMCS and the chilled water supply and return temperatures monitored. Actual control of the chilled water from chillers will be controlled by the existing/new chiller controls.
- Loop pumps and hot water pumps will be enabled/disabled by the EMCS, and the water supply and return temperatures monitored. Actual control of the water temperature will be controlled by the new EMCS based upon the existing load and/or the outside air temperature.
- Use sensor wells provided by others.
- The EMCS will provide outside air lockout temperatures for pumps and equipment. The heating hot water pumps should be completely shut off when the outside air temperature is greater than 60ºF. This will save natural gas and electricity, and can help to minimize overheating in crowded areas of the buildings. This concept also applies to the cooling systems. The chilled water pumps would be off until the outside air temperature reaches 45ºF. These temperature set points will be adjustable, and cooling and heating will occur simultaneously on few occasions.
- Where there are no existing coil valves, new electric valves will be installed and controlled.
- Existing dampers and valves and their associated operators are assumed functional. The new EMCS will control these valves; and if the DDC system is installed, it will also control all the dampers.
- Each building will utilize an Optimal Start routine that will determine the time to start the equipment in order to bring the building up to the set-point temperature before the occupied period. The software will use the space temperature sensors to "learn" when to start the equipment based on the outside air temperature.
- New low voltage, control and communication wire for the EMCS will be plenum rated when installed above drop ceilings. When ceiling access is not possible, wire will be run in conduit. New wire in mechanical rooms shall be in EMT.
- Any asbestos abatement is excluded.
- Smoke detector repair/installation in AHU's is not included.

The HVAC equipment will be scheduled according to the occupancy schedule of the spaces. It is imperative that the owner’s 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. Because occupant overrides will be available, the scheduled “OFF” time for most

HVAC equipment will coincide with the occupied schedule for the area served by each piece of equipment. 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 EMCS is training for the facility staff. Included in the initial cost of the EMCS is scheduled training for the appropriate personnel. Basic trouble-shooting and component replacement will be discussed. This will give the maintenance staff the ability to repair most future EMCS 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.

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

Arapahoe County will be responsible for the following items:

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

2. For maintaining and repairing the EMCS 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 in each building for the EMCS to have remote monitoring capability.

All electrical installations 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.

The installation of this ECM may increase future maintenance costs due to additional control points being added to the HVAC systems. The inevitable repair on these control points will obviously increase future maintenance costs. However, these points and the proper operation of the EMCS will allow the maintenance department to troubleshoot HVAC problems and reduce on-site troubleshooting labor.

ECM Number: M-2

ECM Title: Variable Speed Chilled Water Pumping

Description:

Currently, chilled water is pumped continuously to the coils in the air handling units (AHU's) in the Admin I Building. At times, much of this water is bypassed to the return water line (if a 3-way valve is installed) or returns to the chiller with a low delta T (6 degrees at the time of the survey), thus, not giving up all its useful cooling energy. Installing variable frequency drives on the main supply pump motors and installing a secondary loop to keep constant flow through the chiller will permit less water to be pumped to the coils, thus, saving pump energy. Further, the variable frequency drive will be used to "soft-start" pump motors which significantly reduces stress on the motors, bearings, and the coupling to the pumps.

By restricting the water flow to only what is needed to cool the space, energy requirements to cool the water are also reduced. The supply water, which has been cooled to the specified supply temperature, is not mixed with warmer return water. This change greatly reduces the amount of power required to operate the system. This ECM will require the installation of 2-way valves on the chilled water coils located throughout the building.

The installation of this ECM will reduce short-term maintenance costs and, over the years, will not increase maintenance costs above the current level. 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 increase number of valves should be offset by the reduction of pneumatic controls which have a higher maintenance cost than electronic controls.

Pumps included in this ECM are as follows:

Pump ID	Location	Motor Hp
CHWP P-1	Basement Mechanical	15
CHWP P-2	Basement Mechanical	15

ECM Number: M-3

ECM Title: Install Variable Frequency Drives on Exhaust Fans

Description:

The penthouse AHU's in the Admin I Building are served by a variable volume supply fan and a constant volume exhaust fan. The supply fan speed is modulated by a variable frequency drive (VFD), but no VFD was installed on the exhaust fan. This forces the AHU to operate more like a constant volume system. With a constant volume exhaust fan, the volume of air removed from the building must remain constant which can cause pressurization problems. During periods when the space requires less supply air, the amount of exhaust air required may also be reduced. Energy is wasted both in conditioning higher volumes of outdoor air and in higher usage of fan power. This ECM concerns installing a variable frequency drive on the exhaust fan, space pressure sensors, and programming to permit the AHU to operate as a true VAV system.

ECM Number: M-4

ECM Title: Install Water Meters for Sewer Credits

Description:

A substantial amount of water is used for irrigation of the grounds at the Arapahoe County buildings. This water is either absorbed by the plant life that is being irrigated or it evaporates into the atmosphere. The irrigation water does not go to the sewer. The County, however, is charged for both the water consumption and the sewer usage.

This ECM concerns the installation of additional water meters on the irrigation water lines at the Arapahoe County facilities. The new irrigation meters will be able to show exactly how much water is being used for irrigation. The water utility company will then give the County a sewer credit, or refund, for the amount of the irrigation water usage since it is not going to the sewer.

Install Cooling Tower Makeup and Blow Down Meters

A substantial amount of water is also used as makeup water for the cooling towers at the County buildings. This water is used to makeup the water that has been evaporated into the atmosphere and the water that has been sent to the sewer due to the blow down, or flushing out, of the cooling tower. The County, however, is charged for both the water consumption and the sewer usage, even though the blow down water goes to the sewer but the evaporated water does not.

This ECM also includes the installation of a water meter on both the makeup water line and the blow down water line of the cooling towers. The new meters will be able to show exactly how much water is being used for makeup water and blow down water. The water utility company will then give Arapahoe County a sewer credit, or refund, for the amount of the makeup water usage that is not being sent to the sewer, which can be calculated by subtracting the blow down water usage from the makeup water usage.

ECM Number: M-5

ECM Title: Water End Use Fixture Replacements/Retrofits

Description:

The use of water at commercial and governmental facilities has become more of a concern in recent years. In Denver, this is even more of a concern due to the drought conditions that exist in the area.

Utility charges for potable water and sewage are now increasing at a rate greater than other utilities (electricity and natural gas). Consequently, retrofits have been developed for toilets to reduce the water required for each flush. These devices can reduce water usage by up to 50% per flush. Flush toilets and urinals are a major potable water user in the County facilities.

Toilets and Urinals

The scope of work involves replacing or retrofitting the existing toilets and urinals to reduce their water consumption. Water savings will be achieved while also providing adequate wash-down action.

- When possible, the existing flushometer valve will be retrofitted and the china will remain. This can be done on toilets that utilize flush valves that were installed after 1971. This provides for excellent water savings opportunities while minimizing the cost of the installation by avoiding china replacement.
- On toilets that are equipped with flush valves manufactured prior to 1971, the china and valve will be replaced. This will ensure proper operation of the systems.

Sinks

Flow restrictors have been developed for faucets to reduce the rate of flow from the faucets. These devices can reduce water usage from sinks by over 50%. Since a portion of the water saved will have been heated, thermal energy will also be saved.

The scope of work involves installing faucet flow restrictors or in-line flow restrictors on lavatory sinks in all buildings. The moderators will be 0.5 gpm vandal-proof spray type moderators so that they may not be removed except by maintenance personnel. Kitchen and utility sinks will be reduced to 1.5 gpm when appropriate. These moderators will also be vandal proof but will produce a laminar flow stream.

Generally speaking, most urinals found in the Admin I Building are an older generation type, rated at 3.0 gallons per flush (gpf). The majority of faucet aerators are rated between 2.0 and 2.5 gallons per minute (gpm). While a variety of toilet ratings were seen in the survey, nearly all units are a flush valve type; very few tank type toilets were observed.

To optimize this water conservation measure, the following replacements are proposed:

- **Toilets**: Replace all toilets with 1.6 gpf models. Install new porcelain/china and a flush valve (when appropriate in a particular model) for each proposed replacement toilet.
- **Faucets**: All non-kitchen faucets will have aerator replacements rated at 0.5 gpm. Applicable kitchen type faucets will be retrofitted with aerators rated at 1.5 gpm. Note that the proposed replacements are aerator-only upgrades; full faucet replacements are not proposed for this measure. Replacements are not proposed for certain types of faucets, including specialty kitchen sinks, faucets that are traditionally used for fixed volume purposes (i.e., janitorial closets) and any faucets specially set up for cleaning purposes.
- **Urinals**: Replace all urinals with 1.0 gpf models.
- **Showers (if applicable)**: Replace all showers with 1.5 gpm models.

Energy Conservation Measures to be Evaluated in More Detail at the Admin I Facility

1. Admin I Chilled Water System – Install Water Side Economizer. Due to a lack of air side economizers, the chilled water system must run year-round. A heat exchanger can be installed to transfer heat from the chilled water system to the condenser water system. This would permit the chillers to be shut off during the winter, producing significant energy savings.
2. Replace Chillers with High Efficiency Centrifugal Chillers: Chillers are now made which require about half the electrical energy as their old counter parts. In addition, these new energy efficient chillers do not use CFC refrigerants. This ECM saves cooling energy costs and removes CFC's from the premises.

   The new chillers at the Admin I Building can be included in the performance contract if more buildings are included increasing the level of savings to leverage against this large expenditure.
3. Optimize Boiler Control: Both hot water boilers in the basement of the Admin I Building were hot at the time of the survey, indicating operation by both simultaneously. Each boiler should have an isolation valves installed so each can operate independently. Both boilers should be tuned before each heating season, and sometimes more often. As with any piece of machinery, age and operation cause parts to wear and get out of alignment or adjustment. This ECM would involve tune-ups and adjustments to all boiler equipment. This measure will reduce run times on the boilers as well as save energy.
4. Revise Heat Recovery System. Both of the chillers in the Admin I Building have a heat recovery system, which is intended to salvage heat from the refrigeration cycle. However, it appears the heat recovery system is not being utilized as both boilers were fired at the time of the survey for domestic hot water. The system should be evaluated for potential heat reclaim for domestic and heating hot water.
5. Isolation Dampers. The air handlers in this building have extensive evening run hours. There are likely large areas that are vacant during evening hours. Isolation dampers could be installed in ducts that serve large areas that are unoccupied during evening hours. This would significantly unload the fan motors, and yield significant savings from reduced fan, cooling, heating, and outside air loads.
6. Replace Old Boilers with New High Efficiency Boilers: Boiler efficiency deteriorates with age and current designs are usually more efficient than the old boiler designs. Benefits of replacing the old boilers include: using less fuel, greater reliability, reduced maintenance costs, and require less space.
7. Electric to Natural Gas Domestic Hot Water Heaters: Buildings heated with electrical energy also have electric domestic hot water heaters. When the heating system for these buildings are converted to natural gas fired hot water boilers, the electric domestic hot water heaters should be replaced by natural gas fired units to take advantage of the lower cost natural gas.
8. Replace VAV Boxes: Many of the existing VAV terminal boxes in the Admin I Building have deteriorated. Temperature control is difficult to maintain throughout the facility as many hot and cold calls are sent to the maintenance office each day.

All Building/County-Wide Energy Conservation Measures

Building Envelope

- Caulking: Caulking around window frames and at the foundation to wall interface areas prevents cold air infiltration. Foundation wall interface applies for wood frame type structures having a heated basement. Reducing the quantity of infiltrating air will save heating energy.
- Double Pane Windows: Replacing existing single pane windows with double pane windows.
- Install Insulated Overhead Doors: Existing overhead doors are constructed with low resistance to heat transfer. Replacing these doors with insulated overhead doors will increase the thermal resistance and reduce the heat lost from the building.
- Insulate Window Panels: When buildings have large expanses of single pane windows, many of these windows could be replaced with insulated panels which would greatly reduce the heat lost through these windows. Some window areas would be left in each room to provide a reasonable quantity of outside light and allow windows to be opened for ventilation.
- Roof Insulation: Installing additional roof insulation at the time building roof membranes are replaced will reduce heat loss or heat gain through the roof.
- Sealing Air Ducts & Pipe Chases: In many buildings, air ducts and pipe chases pass from heated to unheated areas. Clearances between the ducts and the chases allows heat to escape through the clearance around the ducts and pipes. Sealing the openings around the ducts and pipes will prevent this heat loss. Other openings between heated and unheated spaces should also be sealed. Sealing these openings will save thermal energy.
- Storm Windows: Adding storm windows over single pane windows or replacing the windows with double pane windows would save substantial quantities of energy. These two measures are costly, and simple payback time is usually long.
- Weatherstripping: Weatherstripping on walk-in and overhead doors degrades with use leaving a crack that will allow cold outside air to infiltrate into the building during the heating season. This outside air must be heated to room temperature. Reducing the quantity of infiltrating air by installing or replacing degraded weatherstripping will save heating energy. Weatherstripping will also save cooling energy, but the magnitude of the saving is normally much smaller than for heating.

DHW

- Domestic Hot Water Pump Timer: At present, the domestic hot water circulating pump runs continuously to provide hot water as soon as a hot water tap is turned on. The pump runs numerous hours while the building is unoccupied. Installation of a timer to schedule hot water pump running time will save electrical energy.
- Install Domestic Hot Water Heater (DHWH) Flue Dampers: In order to minimize the heat lost by the residential domestic hot water heater during its off cycle an actuated butterfly type valve situated in the flue pipe will close the flue pipe preventing loss. The flue damper opens during the on cycle of the DHWH. This ECM retains DHWH heat and cuts down on the amount of cold air infiltration from the outside.

- Install Electronic Ignition on Domestic Hot Water heaters (DHW): A more efficient method of beginning ignition on DHW's to use a capacitive discharge ignition system to light the pilot flames and then allow the pilots to ignite the burner. In this way, the gas is not wasted by continually operating the pilots when they are not needed.
- Insulate Domestic Hot Water Heaters: Placing a sleeve type insulation blanket over the DHWH saves energy depending on the placement of the DHW tank and the heating and cooling load of the building. Chevron ES engineers will use Department of Energy Lab calculations to determine the economics and appropriateness of this ECM.
- Replace Domestic Hot Water Heater: New hot water heaters with electronic ignition and higher efficiency ratings can replace existing older model DHW heaters. Another option to look at would be replacement of DHW with instantaneous, "on demand," pulse type hot water heaters.

Heat Recovery

- Energy Recover from Building Air Exhausts: Buildings which use large quantities of outside air will often have exhaust fans for air balance purposes. When air exhausts are located near make up units, heating or cooling energy can be recovered from the exhausted air to preheat or precool make up air.
- Heat Recovery Run-Around-Loop: Air handlers which use 100% outside air and matched exhaust streams can be fitted with coils and interconnected piping which will allow thermal energy from the exhausted stream to be recovered and used to precondition outside air.
- Recover Heat from Refrigerant Condenser Water: Heat can often be recovered from refrigerant condensers and used to heat domestic hot water or process water. A match must be made between available energy from the refrigerant condenser and a need for hot water for this ECM to be viable.

HVAC Air Side

- Control Garage Exhausts: Underground or enclosed garages are equipped with exhaust fan systems to keep carbon monoxide from internal combustion engines within safe limits. These exhausts are designed for peak load conditions which occurs a fraction of each day. Carbon monoxide sensors can be used to control the exhaust fans by varying the new time and keep carbon monoxide at a safe concentration in the air. This control will save electrical energy.
- Convert Dual Duct to Variable Air Volume (VAV) System: The building has a dual duct system, in which heated and cooled air is mixed to provide the proper supply air temperature for heating or cooling a space. This system is wasteful since a constant volume of air that has been heated and air that has been cooled are mixed to provide an intermediate temperature and essentially the air is being reheated and re-cooled. This system can be converted to VAV, in which air is heated or cooled to one temperature and the amount of air to each space is varied to satisfy that zone. This conversion results in both fuel savings and fan savings.

- Convert Reheat Air Handler Systems to Variable Air Volume (VAV) System: In reheat systems, air is cooled to a low temperature and then reheated to a temperature needed to control a room temperature. Much of this reheating could be avoided by installing a variable air volume (VAV) box in series with the reheat coil which would vary the quantity of air to the space as the first step in controlling space temperatures. Reheat coils would be activated if the VAV box could not effect control. This measure will save both heat energy and fan energy.
- Inlet Vanes to Variable Frequency Drive: Fan inlet losses through inlet vanes increase as the vanes close to reduce fan air delivery. Inlet losses through inlet vanes can be eliminated by removing or locking inlet vanes in the full open position and driving the fan motor with a variable frequency drive. This change will save electrical energy.
- Install Damper to Isolate Unoccupied Areas: When an air handler system serves areas that are occupied during a normal work day and other areas occupied much longer than a normal work day, dampers can be installed in ducts to isolate the areas occupied the least amount of time to obtain energy savings. The dampered space can be controlled to obtain a temperature setback savings, ventilation savings, and fan energy savings.
- Reactivate Economizers: Many times air handlers are equipped with outside air economizers to cool with outside air when practical. When the economizers are inoperable or not used, mechanical or absorption cooling is required to control space temperature. This measure concerns reactivating the economizer controls to avoid operating mechanical or absorption equipment when outside air temperatures are suitable for providing cooling.

HVAC Controls

- 365 Day Electronic Timeclock: HVAC equipment is turned off and temperatures are setback at night and on weekends through the use of 7 day mechanical timeclocks. By installing 365 day electronic timeclocks or a simple energy management system, this automatic scheduling of equipment and temperature setback can be extended to include other unoccupied times such as holidays.
- Add Baseboard Heating Control: Hot water perimeter fintube radiation systems run wild waste thermal energy through overheating. The addition of zone thermostats will save energy and improve comfort.
- Add Control to Cooling Coil: A cooling coil on one multizone air handler runs wild. This lack of control leads to poor room temperature control and a waste of cooling energy. Installing a control valve to affect cold deck temperature control and using worst zone reset will improve comfort in areas served by the air handler and save energy.
- Control Outside Air to Meet Needs: In some areas, more outside air is delivered to spaces than required by code for ventilation. Controls would be applied to minimize the quantity of outside air to avoid heating larger quantities of outside air than required.
- CO_2 Control to Minimize Outside Air Quantities: Many areas in buildings have a varying ventilation need because occupancy varies over time. A CO_2 sensor can be integrated into controls to vary the intake of outside air through outside air damper control based on the level of CO_2 in the return air stream. Energy will be saved by reducing the quantity of outside air requiring heating or cooling.

- Install Energy Management System (EMS): The installation of an EMS at buildings using timeclocks will facilitate scheduling equipment off and on plus setting heating temperatures back during unoccupied times. Energy costs are saved by turning off equipment and not maintaining occupied environment within the building or building areas when not needed.
- Install Local Override on Air Handlers: When some air handlers are operated on a longer schedule than actually needed to accommodate a varied use schedule of areas served by the air handlers. The unneeded operation can be reduced by providing users of the area with a local override which would allow them to turn the air handlers on for a selectable time (1 to 3 hours). Thermal and electrical energy would be saved.
- Programmable Thermostats: Furnaces and unit heaters are often continuously controlled at one set temperature even though the area served is unoccupied at night and during the weekend. The use of a seven day programmable thermostat would allow this equipment to set heating temperatures back during unoccupied times. Using these thermostats would save thermal energy plus a small amount of electrical energy.
- Schedule Exhaust Fans: Exhaust fans at many main campus buildings are operated longer than required. Since they draw condition air out of a building which has to be replaced with outside air, reduced operation will save thermal and electrical energy.
- Set Back Nighttime Temperatures: Building heating temperatures are not set back or mildly setback in buildings at nighttime. This measure would add controls which would allow nighttime heating temperatures to be set back deep.
- Setback Perimeter Radiation: Air handlers are now scheduled by an energy management system, but this system is not connected to control the perimeter radiation. Consequently, the perimeter radiation system which makes up part of the building shell losses will have little or no temperature setback during unoccupied times or during nighttime. Connecting the perimeter radiation to the energy management system will allow energy to be saved through temperature setback during unoccupied times.
- Turn Off Return Air Fans: Return air fans on some systems can be turned off with little or no change in the performance of the air handler system. This measure would try turning off return air fans to determine which fans do not need to be operated. Electrical energy is saved and electrical demand is reduced when the fans are switched off.
- Worst Zone Reset: During the heating season, the cold duct on dual duct systems and the cold deck on multizone systems are normally controlled to a fixed temperature between 55EF and 65E F even though a temperature this low may not be needed. The cold duct or cold deck temperature for selected air handlers should reset to the highest temperature possible to allow more return and less outside air to be used. This control method will minimize hot and cold air mixing penalties for dual duct and multizone air handlers.

HVAC Cooling

- Chiller Optimizer Control: Chiller optimizer control will address delivering the chilled water at the highest practical temperature and using the lowest acceptable cooling tower water temperature consistent with cooling tower capabilities and chiller limitations. The efficiency of a chiller increases about 1% per degree F that chilled water temperature is increased and 1% per degree F that cooling tower water is decreased.

- Evaporative Cooling: This form of cooling can be used in areas where the relative humidity is low. Air is cooled by evaporative water in the air stream. The water evaporation raises the air stream humidity. Single and two stage units are available. The first stage of a two stage unit evaporating water cools one side of a heat exchanger which in turn cools air blown over the other side of the heat exchanger. Water is added to the cooled low humidity air in the second stage which further cools the air. Single stage units do not use the first stage of a two stage unit.
- Free Cooling with Cooling Tower: Some buildings have been constructed with minimum outside air capability. Interior spaces require cooling throughout the year. Outside air can be used to cool the interior spaces during the heating season, but the limited quantity of outside air may not satisfy cooling needs. Consequently it is necessary to run mechanical refrigeration for cooling during the heating season. Cooling towers can be operated to generate the chilled water during the heating season instead of using mechanical generated cooling. A plate and frame heat exchanger is used between the cooling tower and chilled water piping to avoid contaminating the chilled water loop with cooling tower water. This arrangement is often referred to as a hydronic economizer.
- Ice Storage: Ice storage can be used to lower on-peak demand and energy charges by using electrical power during off-peak times to freeze ice. This ice would then be used as a cooling source during on-peak times to avoid operating electrically driven mechanical cooling equipment.
- Install Variable Speed Drives on Cooling Tower Fans: Cooling towers are designed to provide cooling water at severe design weather conditions such as 95ºF and 75% relative humidity. At less severe weather conditions, the cooling tower is over designed and can produce adequate cooled water with less than designed fan CFM. A two speed motor can be used as an alternate to the variable speed drive. This measure will save fan energy.
- Replace CFC Using Chillers with Non-CFC Units: Most existing chillers produced before 1990 use CFC refrigerants which are known to damage the ozone layer when the refrigerant leaks or is vented to the atmosphere. Energy efficient chillers are now available which use non-CFC refrigerants. Since production of CFC refrigerants was halted in 1995, the cost of CFC refrigerant has increased dramatically, detail records of CFC refrigerants are required, and high fines may be imposed by EPA when CFA's are lost to the atmosphere. Forward looking organizations are taking steps to install new energy efficient chillers that do not use CFAs. Chillers less than 10 years old may be considered for retrofitting to use non-CFAs. Electric and maintenance savings off-set part of the required investment and the potential liability associated with leakage of CFAs to the atmosphere is avoided.
- Spot Cooling: Some facilities need to run cooling equipment during times of very low occupancy because the current systems have to address the entire facility or a large area. For example, an entire facility is cooled during the night and weekends when only the security office is occupied. The installation of a dedicated spot cooling unit would allow large cooling systems to be turned off during times of low occupancy.

HVAC Heating

- Add Heating/Ventilating Roof Top Unit: A large area in one building is conditioned during unoccupied hours because a small area in the large zone served by an air handler requires continuous occupied temperature control. The installation of a small roof top unit would allow the temperature to be set back in most of the area served by the large air handler during unoccupied times and thus save energy during unoccupied times. Thermal and electrical energy would be saved.
- Automatic Oxygen Trim: An automatic oxygen trim system can be effectively used on larger boilers to improve operating efficiency through the reduction of excess air by the boiler burner. Boilers rated at 400 BHP should be considered as candidates for automatic oxygen trim control.
- Boiler Turbulators: Turbulators are configured strips of metal that can be inserted into fire tubes tube type steam boilers to improve boiler efficiency. The turbulators improve heat transfer between the combustion hot gases and the fire tubes. Turbulators should not be considered for installation in fire tube hot water boilers or boilers with atmospheric type burners.
- Convert Electric Heating Units to Natural Gas**:** The economics of this conversion vary by geographical region based on the prices of electricity and natural gas. As a rule of thumb, the cost of gas heating compared to electric is a ration of three to one. This ECM has a proven record of economic success.
- Energy Efficient Furnaces: Replace existing natural gas fired furnaces with more efficient natural gas fired furnaces.
- Infrared Heating System: Garage structures, heated by unit heaters, air handlers, or furnaces; lose heat when doors are open because hot air flows out into the garage and cold outside air flows into the garage.
- Preheat Combustion Air: The efficiency of boilers will increase 1% for every 40°F that combustion air is preheated. Warm air can be drawn from the ceiling area of the heating plant and directed to the air inlet for the boiler burner to increase boiler efficiency.
- Reduce Simultaneous Heating and Cooling: Interior and perimeter systems are normally controlled separately, but interact in buildings which use an open office desking arrangement. The interior systems cool while the perimeter systems heat. Controls need to be adjusted to eliminate or minimize system fighting (simultaneous heating and cooling).
- Stack Gas Economizer: A stack gas economizer is used to transfer the heat in the boiler exhaust gases to the boiler feedwater. On large boilers with high stack gas temperatures, this action can increase the efficiency of the boiler.
- VFD on Combustion Air Fans for Large Boilers: Combustion air is delivered to a boiler burner with a constant speed fan. The volume of air is normally controlled by inlet vanes on the blower (fan). Removing inlet vanes on the blower and installing a variable frequency drive power supply o drive the blower motor is more efficient than varying the air delivery by controlling blower inlet vanes.

Lighting

- Automatic Lighting Controls: Control devices, "People Sensors", can be installed in areas where usage is sporadic, but lights are often left on after everyone leaves. Areas normally used in this manner include: lounges, restrooms, receiving, etc.
- EMS Light Control: A number of lights were found to be used where they are not required. These lights can be connected to the energy management system to supervise when the room switches can turn the lights on.
- Occupancy Sensor Control of Lights: Areas in buildings, such as offices, conference rooms, break rooms, and classrooms, are often vacant; but lights are left on. The installation of occupancy sensors in areas that are often vacant to turn off lights when rooms are not occupied will save electrical energy.
- Photocell Control of Lights: Some buildings have large expanses of glass which allow daylight to provide more than enough light for the activities during most daylight hours. A photocell control can be installed in the lighting circuit which will turn off the lights whenever the daylight provides adequate light.
- Schedule Outside Lights: Outside building and parking lot lights are often left on after all people have left the premises. It is through that leaving lights on will deter vandalism and thievery. Experience shows that vandalism and thievery actually go down when the area is blacked out. This ECM concerns scheduling all outside lights off after everyone has left the premises.

Miscellaneous

- Audit Utility Billing Histories for Accuracy: Chevron ES audits the facilities utility billings for correct bill accounting, tax rate or tax exemptions, and rate structure. In most cases, Chevron ES finds the utility billing to be appropriate; however, we have saved clients several thousands of dollars by discovery of inaccuracies, inappropriate rate or tax applied to tax-exempt entities.
- Cogeneration: The high electric rates and low natural gas rates coupled with a continued need for hot water strongly suggest that cogeneration be considered to reduce energy costs.
- Demand Limiting: Electric power companies have a special rate when users allow the power company to turn off air conditioning for set time intervals during the power system peak demand periods. This ECM would allow the power company to install equipment which would enable them to remotely stop and start air conditioning units. The off time would be an agreed too duration.
- Digital Remote Reading Utility Meters: Some client personnel read utility meters, input data, and prepare bills. Equipment is now available to automate much of this process. The installation and use of digital remote reading utility meters could eliminate much of the labor now used and improve billing accuracy.
- Fluid Coolers for Air Compressors: Large air compressors use once through tap water for cooling. A closed loop fluid cooler can be installed to cool these large air compressors and save large quantities of potable water.
- Install Heat Tape on Water Pipe Eliminate Warehouse Heat: An entire warehouse is heated to protect a water pipe from freezing. Installing an electrical heat tape on the water pipe and covering the tape and pipe with insulation will allow warehouse heat to be turned off. The use of a small amount of electric energy will save a large amount of energy from fossil fuel.

- Power Factor Correction: Most electrical utilities assess a cost penalty when the power factor drops below a certain level, i.e., 80%. They may also pay an incentive for a high power factory, i.e., above 90%. Low power factors are normally lagging power factors which are encountered when inductive electrical motors are operated at part load. Lagging power factors can be corrected by adding a bank of capacitors at the transformer station for a facility.
- Prepare Program for Energy Training and Education: Chevron ES and the client will carefully evaluate the existing conservation practices and attitudes of the users of the client's facilities. Development of a program to address the human side of energy conservation will be produced on an individual client basis. Chevron ES training and education programs offer a menu of choices that will suit the specific needs of our clients.
- Purchase Wholesale Natural Gas: It may be possible, depending on the location of the facility and its volume of natural gas usage, to obtain the gas supply at reduced rates. This ECM is also dependent on the volume of usage of the client facility.
- Trash Compactor: At present, trash dumpsters are emptied several times per week. Trash dumping charges are based on the number of trips to unload dumpsters. The number of trips can be greatly reduced by using a trash compactor. Using a trash compactor will reduce dumping charges and transport labor.
- UtilityVision®: UtilityVision is a web-based energy tracking system that collects and reports data over the internet. This system will allow a facility to manage real time usage and minimize costs associated with time-of-day utility pricing.

Motors

- Electric Power Reducer: Efficiencies of electric motors decline at part-load operation. Most electric motors are selected to operate below rated full load and, therefore, do not operate at peak efficiency. Installation of a power reducer unit will condition the electrical power so the motor performs at or near full load efficiency even though the motor operates at less than full load.
- Energy Efficient Motors: Whenever electric motors burn out or are changed for other reasons, the replacement with energy efficient units should be considered. Energy efficient motors will operate at efficiencies ranging from 2% - 5% better than standard electric motors. Caution! Savings will not be realized in some applications such as direct drive pumps.

Pipe Insulation

- Inspect Piping for Integrity and Insulation Potential: Chevron ES survey engineers, during the course of the audit, will note the condition of the piping for leaks and insulation potential. Faulty relief valves, piping conditions and piping ECM's will be reported to the client during the audit report.

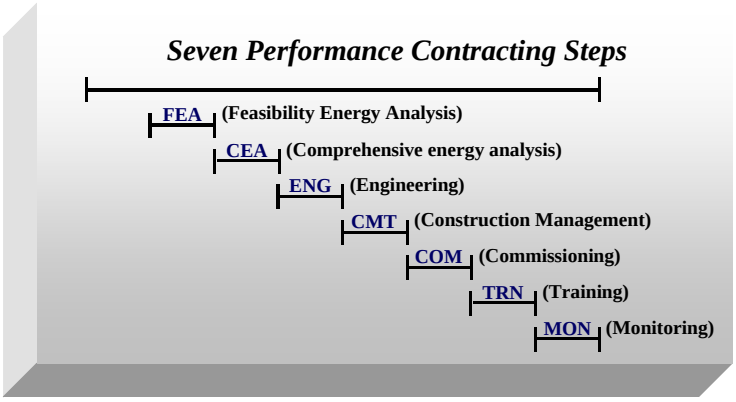
Water & Sewer

- Below Ground Surface Watering: In certain areas of the United States where water is scarce, utilities allow limited use, or water rates are very high, it is desirable to make the best use of water for irrigation. Installing a system which delivers water near the root level is a very efficient way to water vegetation. Over-spray with droplet drift and surface evaporation are eliminated.

Section 5

Approach to Performance Contracting

The *core services* we provide are described in the seven (7) steps of our Performance Contracting Program. Chevron ES' staff includes full-time licensed engineers with experience and expertise in all aspects of retrofitting buildings for energy efficiency. The majority of our design work is the retrofit of educational facilities. Retrofit design and construction are challenging. We take responsibility for every aspect of our projects, including guaranteeing energy-cost saving performance. The following is a brief description of our services and the steps of our program:



1) ***Feasibility Energy Analysis*** – The first step in our Performance Contracting Program is determining the feasibility of a project. A project is feasible if it can be paid for through savings. The study includes an analysis of the facility's last twelve months of utilities bills. We survey the facilities to determine lighting types, HVAC system types, and existing control strategies. We interview operating personnel to get general information about the facility (square footage, operating schedules, age of systems, energy conservation strategies already implemented, operational problems, desired system changes, etc.)

   An analysis is made of the energy savings potential. We identify potential Energy Conservation Measures (ECM's). These measures must improve the facility as well as save energy. We then estimate the cost and the energy savings. All this information is published in our Feasibility Energy Analysis (FEA).

2) ***Comprehensive Energy Analysis –*** A major reason for our success with energy management projects is the Comprehensive Engineering Analysis (CEA). The purpose of the analysis is to identify, quantify, and prioritize viable energy savings opportunities for all aspects of the facility — control systems, air conditioning, heating systems, lighting, building structure (envelope), water and sewer systems, miscellaneous equipment, scheduling procedures, etc.

   A thorough on-site engineering survey of the facility is made and includes measurement of electrical power usage of motors, air delivery from fans, combustion efficiency of boilers, lighting intensity levels, water usage, etc. The CEA includes interviewing appropriate administrative and maintenance personnel regarding equipment usage, operating schedules,

etc. This data is then used to rebuild the facility as a computer energy model. Definitions of building shape, size, construction, occupancy, lighting, temperatures, schedules, controls, plug load, weather locale, and other details are used to create the model. The computer then simulates the energy use of the facility for a year, taking into account the changing effects of weather, schedule variances, etc. To verify the accuracy of the model, the simulated energy usage is compared and calibrated to the history of monthly energy bills for the facility over a three-year period. The calibrated model then becomes the "baseline".

All viable ECM's are then put in to the model and simulated over a full year to determine their energy savings. "Packages" of ECM's are evaluated in the model to observe the interactive effects of the measures — for example, the effects on savings generated by implementing lighting, HVAC, and controls measures as a package.

Next, a cost estimate of each ECM is determined, and the project's cost effectiveness is reviewed. The estimate entails developing schematic diagrams and performance specifications. We solicit price proposals from subcontractors, and estimate measures in-house. All savings and cost estimates are compared to database of past projects to validate their accuracy.

The resulting CEA report includes a list of each viable energy savings modification with predicted annual savings, cost of implementation, and financial payback. We are, thus, able to assemble the most cost-effective group of energy savings opportunities possible – those that provide the greatest possible savings for the least investment.

The structure of the CEA Report is:

a) *"Executive Summary"* - This section provides an overview of the project. We detail the cost and savings of the ECM's. Recommendations, including cash-flow scenarios, are provided.

b) *"Data on Present Facilities"* – This section details all HVAC, lighting, controls, envelope, miscellaneous equipment, etc. at the facility.

c) *"Baseline Energy Use"* – This section provides a month-by-month listing of historical energy use. From this information, an energy use baseline is determined *(this baseline is used to calibrate the energy model described above)*. From this baseline, energy savings are calculated during the monitoring phase. Utility rates and energy usage indices are also included in this section.

d) *"Energy Conservation Measures"* – Recommended ECM's are described in this section, including descriptions of the current equipment, the proposed changes, and the impact to the facility environment.

e) *"Measurement and Verification"* – This section specifically details the options available for verifying the energy savings after the selected ECM's have been implemented.

f) *"Appendices"* – The Appendices include modeling input and output data, maintenance recommendations, utility rate analyses, and the measurement and verification plan.

3) ***Engineering/Design –*** This phase of the project starts after the ECM's have been reviewed and selected by the client. The work involves creating design drawings and specifications. Chevron ES' in-house engineers and CAD department prepare the documents to meet the needs of the specific project. With nearly sixty registered professional engineers on staff, Chevron ES has the knowledge and experience to design even the most challenging projects.

   Our extensive design and construction work in public facilities has provided Chevron ES engineering background in the relevant codes and standards that regulate this work.

4) ***Construction Management*** – Chevron ES manages all construction activities with staff construction managers. Depending upon the project size and complexity, a full-time, on-site construction manager will be assigned to the project. The duties of the construction manager includes the steps we follow to insure the project is installed correctly, but also focuses on job safety, handling of hazardous materials, and coordinating construction activities to ensure minimal disruption to the client.

5) ***Commissioning*** – Energy management system (EMS) commissioning is a critical process in guaranteeing project performance. Unless an EMS is properly and thoroughly commissioned, chances are high that the system will not function properly. Chevron ES' Operations Department, along with the Construction Manager, commissions every energy management system that Chevron ES installs. This process includes a point-by-point testing of each input and output, plus a software commissioning of the programming. In this manner, Chevron ES insures the client that the EMS is complete and functional at the conclusion of implementation.

6) ***Training*** – During, and at the conclusion of construction and commissioning, Chevron ES provides operator training. This training is tailored to address both the energy conservation measures that are installed and the needs of the facilities' maintenance and operating staff.

7) ***Monitoring*** – To secure maximum savings, it is essential to rigorously monitor project performance. The following services are provided as part of our Program:

   a) *Monthly reports* are provided which indicate the facility's targeted energy consumption for the month versus the actual consumption. Variances from our energy savings targets are analyzed. Problems are identified and corrected before they become significant.

   b) Chevron ES will *call-in* regularly to the facility's energy management system (EMS). The primary purpose of the call-ins is to check system operating parameters and schedules. We monitor system alarms, diagnose problems and resolve EMS software bugs. This service is provided to support the Client's maintenance and operating personnel, 24 hours per day, 365 days per year.

   c) Chevron ES provides *operator training* for the maintenance and operating staff as needed.

   d) Chevron ES *re-commissions* the EMS on an annual basis. This commissioning is similar to the startup commissioning provided at the end of construction. The purpose of the commissioning is to insure the EMS continues to operate as designed through the life of the project.

Approach to Successful Project

Chevron ES' engineers walk through each facility and prepare a comprehensive report on the energy conservation opportunities. Upon approval of these reports, Chevron ES' team of engineers conducts an on-site detailed survey of the selected facilities. A computer model of the facilities is developed to simulate current operations and energy usage for a complete year. Each potential energy saving modification is then computer-tested on the model over a simulated full year of operation to determine its energy saving potential. The recommended energy conservation measures with the supporting data from the computer analysis are then submitted for the facilities management departmental approval.

Computer Modeling

Chevron ES engineers will incorporate an industry standard, energy simulation software program, such as DOE2 or Market Manager, to provide a computer software model of the annual energy performance. A computer model is a defined set of calculations that provide a representation, "model," of an existing building. The model is "built" by entering the data for all the construction, mechanical, and electrical characteristics of a building, as well as all the buildings operation patterns, into a modeling software program.

Once the operation and construction of a facility is gathered through a detailed building survey and input into the modeling software, the facility is then "matched" to the utility history. Also, in certain cases, real time data is recorded and used, along with the utility bills, to calibrate the model calculations as close as possible to real usage. For a model to be "matched" means that the computer model energy consumption is similar to the utility history of the facility. An average of three years utility history is used to compare to the modeled energy consumption.

Once the computer "match" is obtained, the energy conservation measures can be applied to the model to predict energy savings for each energy conservation measure individually and collectively. The base model inputs are then modified to simulate each energy conservation measure. The energy conservation measure models are then compared to the base model and the difference in energy consumption is the potential energy saved for each energy conservation measures. All calculations and assumptions will be provided for the client to review in the Comprehensive Engineering Analysis document.

Upon the client's approval, Chevron ES' engineering and construction staff creates detailed drawings on our Computer Aided Drafting (CAD) System. The client approves these drawings before they are submitted to contractors for final pricing.

Our Project Engineers work within the parameters of the cost structure quoted for each project. Assuming no changes in client requirements after agreement is reached to proceed with a project, any costs not foreseen or otherwise in excess of the quoted cost for any project are absorbed by Chevron ES in their entirety.

The energy conservation measures recommended by Chevron ES and approved by the client may reduce maintenance and operational expenditures. For example, new energy efficient light bulbs and ballasts last longer, thereby, reducing labor and replacement cost. New HVAC compressors with five-year warranties replacing older compressors require less maintenance expense. Operational and maintenance savings can be theoretical unless they are supported by documentation and justified. Chevron ES' performance contracting will be self-supportive and completely financed through energy savings measured at the meter.

Chevron ES and the designated site project personnel will jointly approve all subcontractors for the performance contracting project. Although subcontractors are used for the installation of the equipment, Chevron ES retains all responsibility for the project success. Chevron ES utilizes subcontractors to purchase equipment and material and complete installation. Chevron ES utilizes local resources because of specific background knowledge of the mechanical systems and/or specific knowledge of applications.

Chevron ES will provide on-site training of the client's personnel. Chevron ES will guarantee the savings and provide funds to the client in the event of a shortfall in the energy savings. Chevron ES' in-house Energy Management Department will provide monitoring of the energy savings on a monthly basis to assure that savings do accrue. Chevron ES will oversee the maintenance performed at each facility per the recommendations of Chevron ES and the manufacturer. Monitoring and auditing of the energy savings is required by Chevron ES to assure the success of the program. After 48 months of the guarantee and monitoring, the client, through its designated representatives, may elect, without any penalty from Chevron ES, to cancel the guarantee of savings and associated monitoring expense. Chevron ES strongly recommends the continuation of the monitoring contract because statistics indicate that without monitoring, within 5 years, 50% of the savings will have disappeared.

Chevron ES does not have a list of preferred suppliers, equipment, or material. ***Chevron ES' philosophy is that our role is to recommend the most cost effective and appropriate selection of products, suppliers, and contractors for the immediate project.*** By not being tied to a single supplier or manufacturer, after analyzing the current system, sometimes the best approach for meeting the client's long-term facility requirements means utilizing equipment already in place without the added expense of having to replace it.

Chevron ES has installed central chiller loops, co-generation systems, replaced HVAC split systems, boilers, domestic hot water heaters, and thermal storage systems. Our technical analysis will include a comprehensive list of all of the identified site energy conservation measures for selection and approval by the client.

Chevron ES is willing to work with many HVAC equipment manufacturers. The various energy management systems installed by Chevron ES include, but are not limited to, Honeywell, Automated Logic, Alerton, Novar, Johnson Controls, Wattmaster, Trane Tracer, Landis & Staefa, Andover, Barber Colman, and others.

In order to achieve our mutual objectives, it is absolutely necessary that the client and Chevron ES personnel work in concert with each other. Chevron ES is the consultant to the client's management staff and the implementers of the client's decision. We value the input of all local site personnel because as operators of the facilities they are more knowledgeable regarding the opportunities that exist. We take that knowledge, add our experience, and achieve a highly beneficial energy management program.

Communication is the key element to a successful relationship and timely completion of the project. Progress reports are issued on a monthly basis with comments, if necessary. Meetings at the job site on a bi-weekly basis, or more frequently if required, are mandatory.

A team approach is beneficial with each team member's responsibilities clearly defined. We have successfully implemented programs using this approach for many multi-building, multi-location state facilities, colleges/university facilities, and federal government sites. It is most important that responsibilities and authorities be clearly defined and maintained; and, it is imperative that the client and Chevron ES personnel be party to all decisions.

The following is Chevron ES' approach to performing detailed audits, with the details in the three main areas: Field Analysis, Engineering Analysis, and Review Meetings.

I. Field Analysis

a. Confer with building personnel to ascertain type and condition of the mechanical and electrical systems in the building and operating procedures and schedules. Additionally, determine:
   (1). Lighting, temperatures, air changes, and other building requirements,
   (2). Recent building additions, and occupancy or procedural changes,
   (3). Current mechanical, electrical, and operation problems,
   (4). Energy saving measures previously implemented, and
   (5). Suggestions for energy saving improvements.

b. Chevron ES' survey engineers and technicians, under the direction of a registered professional engineer, will measure the operating characteristics of each major air handling system. The following measurements will be obtained, as appropriate:
   (1). Supply air quantity,
   (2). Outside air quantity,
   (3). Temperatures (return air, outside air, mixed air, hot deck, cold deck, etc.), and
   (4). Motor electrical characteristics (volts, amps, kW) – 5 hp and larger.

c. Investigate the operation of the chillers and/or package units:
   (1). Review chiller logs and water treatment program or filter change
   (2). Measure operating volts and amps,
   (3). Measure chilled and condenser water temperatures and flow,
   (4). Confer with building personnel on seasonal variations in operation.

d. Investigate the operation of the boilers:
   (1) Measure combustion efficiency of each boiler,
   (2) Review boiler logs and water treatment program,
   (3) Investigate the condition of steam traps, and
   (4) Confer with building personnel on seasonal variations in operation.

e. Survey the domestic water heating systems:
   (1). Measure temperature, and
   (2). Determine usage.

f. Observe the operation of the temperature control systems and energy management system, verifying the sequence of operation, condition, and calibration of the control devices.

g. Survey the lighting system, space-by-space, to determine:
   (1). Condition of lighting systems,
   (2). Lighting system performance (measured and observed). Includes representative foot-candle readings, energy use, glare and subjective quality of light,
   (3). Cataloging of existing luminaries, lamps, ballasts, controls,
   (4). Luminaries quantity,
   (5). Maintenance methods and costs,
   (6). Occupancy hours,
   (7). Reflected ceiling plans, furniture layouts, luminaries schedules and control information. Ceiling heights, luminary heights and the colors (light, medium or dark) of wall, floor and ceilings will also be required,
   (8). Brief description of any problems, issues and concerns with existing lighting systems,
   (9). Photographs of the existing spaces,
   (10). Natural light and potential for use of day lighting measures.

h. Survey the entire building and inventory energy consuming equipment.

i. Investigate identified heating, air conditioning, ventilation, lighting, or other problems, which could be contributing to excess energy usage.

j. Review equipment shop drawings and temperature control drawings along with the building's architectural, mechanical, and electrical drawings.

II. Engineering Analysis

a. Calculate building heating and cooling loads, and ventilation and air change requirements. Confirm that existing heating, cooling, and air handling equipment properly matches the calculated loads.

b. Based on the data gathered during the site analysis, Chevron ES' engineers will develop an energy usage profile for electricity and natural gas consumption. ***This usage profile will be based on actual measurements.***

c. Computer modeling will be used to simulate building energy usage and determine the interrelationships of various energy efficiency improvements.

d. Analyze three years of utility data to:
   (1). Identify historical changes in energy usage and electrical demand (and why),
   (2). Determine energy use baseline for kW and kWh.

e. Analyze electricity and fossil fuel costs to confirm that the building is on the best rate/price structures.

f. Correlate and analyze all data gathered from surveys and interviews. Confirm that energy usage is within normal parameters for the specific type and usage of the building. If not within normal parameters, determine why.

g. Identify, develop, and analyze all potential energy saving improvements. All aspects of the building and its systems will be considered in the process of identifying and developing savings opportunities.

(1). Operation and maintenance measures will be considered as well as capital measures.
(2). Interactive effects between measures will be included in the analysis.

h. Determine costs for the design, installation, and project management of each energy saving measure considered. Determine other financial impacts on each measure. Calculate simple paybacks and prioritize each measure according to financial return.

i. Prepare and present detailed energy analysis report.

III. Review Meetings

Chevron ES will meet and communicate with building personnel throughout the project.

a. Initial organizational meeting, including confirmation of final scope of work. Entire project will be scheduled with milestone dates. Specific responsibilities will be set forth for Chevron ES and Client and will be advised of particular needs and problems which should be addressed. This meeting will be held at the beginning of the on-site survey.

b. On-site survey meetings will be held at the beginning and conclusion of the site survey so as to assure proper coordination of the survey with the Client. A major objective of the concluding meeting will be to review possible energy saving opportunities developed during the survey.

c. Final Report Meeting: This meeting will include a complete review of the final report including the plan of implementation as agreed by the Client.

IV. Building Owner's Responsibilities

a. Provide three years of monthly electricity bills including kW, kWh, on peak/off peak, and dollars -- by meter.

b. Provide two to three years of monthly fuel bills including therms and dollars.

c. Provide kW tapes (if available) from electric utility.

d. Provide cut sheets and engineering data on HVAC and other energy using equipment as available.

Design engineering will begin after the energy efficiency measures have been approved by the client, financing is in place, and the implementation contract has been executed. Chevron ES uses the following steps to accomplish project scheduling:

1. **Design team selection.**
2. **Team reviews work to be done,**
3. **Schedule to perform work is established.**
4. **Reports and all preliminary design work are reviewed.**
5. **Facility is visited and data is collected.**
6. **Collected data is compiled and organized.**
7. **Design work is undertaken.**
8. **Design work documentation is prepared.**

The design team will consist of Chevron ES engineers and staff. The same Chevron ES project manager leading the engineering analysis team will also be involved in the design work directly. The first task of the project team is to review the project requirements and establish a schedule for completing the design work. The review work involves examining all engineering analyses included in reports plus drawings and other documents pertinent to the design. Once the review has been completed, the team visits the site to collect all additional information needed to perform the design. The practicalities of preliminary designs made during the engineering analysis are assessed. If needed, modifications to the design or alternatives to meet the original objectives are then developed.

The engineering design includes the preparation of drawings and specifications. The same team undertakes the preparation of specifications for implementing the energy saving improvement project.

Specifications prepared by Chevron ES engineers generally follow the Construction Specification Institute (CSI) guidelines. The specifications are utilized to implement a single energy saving improvement or to cover a group of improvements to be undertaken at one facility or number of facilities. In either case, the specifications for all applicable facility upgrades (improvements) are assembled into a specification book. This book normally contains the following items and sections: (1) a project identification page, (2) an invitation to bid, (3) instruction to bidders, (4) a bid form, (5) a bid acceptance form, (6) a bid bond form (AIA

Document A310), (7) a performance bond form (AIA Document A311), (8) a Labor and Material Payment bond form (AIA Document A311), (9) standard general conditions of the construction contract, (10) supplementary conditions, (11) general requirements - Part 1, (12) general requirements - Part 2, Special Conditions. A scope of work section is prepared for each separate energy improvement measure.

Construction administration starts on Chevron ES' guaranteed energy savings projects after specifications to implement energy saving improvements have been issued. Chevron ES has provided construction administration for over 300 energy management projects. Construction administration generally involves the following activities:

1. **Pre-bid meeting** **(not applicable for design/build projects)**
2. **Bid evaluation and selection** **(not applicable for design/build projects)**
3. **Construction contract is issued**
4. **Pre-construction meeting**
5. **Review submittals**
6. **Interim inspections**
7. **Process monthly progress payments**
8. **Final inspection**
9. **Monitor training required of contractors**
10. **Execute completion document**

A pre-bid meeting is held to answer any questions pertaining to the specification(s). This meeting is normally held at the site where energy saving improvements is to be installed. A tour of the facility is taken, and locations where improvements are to be installed are pointed out. Questions arising from the tour are answered.

After bids are received, they are reviewed for conformance to the specification(s), delivery times are noted, and economic evaluations are made of each bid and any proposed alternate bids. In addition, the bidder's ability to do the work is assessed. After the analysis of the bids is complete, a best buy selection is made and a contract is issued with the client's approval.

Once the contract is executed, a pre-construction meeting is set up to review the contract, set schedules for submittals, estimate delivery of purchased equipment, schedule installation of measures, identify interim inspection points and discuss project payment requirements. Project work and payment schedules are formalized after this meeting and used for project control purposes. Interim inspections are made to ascertain whether work conforms to the specification, acceptability of work quality, percent of total project completion, and what payment amount is justified. Any shortcomings are noted, verbally called to the attention of the contractor, corrective action is outlined and results of inspection are documented and sent to the contractor.

Chevron ES provides commissioning services as a post construction verification that all energy conservation measures are operating as specified and that the lighting and comfort levels have been maintained or have been improved.

Representative commissioning steps involved:

- Verify lighting levels are adequate and consistent with the specifications.
- Verify that all new software and existing software are performing correctly for the energy management system.
- Verify that all new and existing hardware points are operating correctly. This involves a point-by-point system checkout.
- Verify that new HVAC equipment and general mechanical components are performing properly and maintaining appropriate comfort levels.
- Identification and recommendation of additional projects that could be funded with any contingency funds that may be available.
- Preparation of punch list and final inspection.
- Receipt and evaluation of as built drawings, O&M manuals and delivery to the client.
- Client site staff training

A final inspection is made when the contractor indicates that all work is done. A punch list is prepared to document all shortcomings. This punch list is provided to the contractor. Any training required of the contractor is scheduled and monitored. Project completion documents are prepared after all items on the punch list have been satisfactorily handled and all training obligations completed.

Personnel	Team Meeting	Comprehensive Energy Audit	Design	Construction	Commissioning	M&V	Monitoring	O&M
Senior Project Manager	1	1		1		1		
Project Manager	1	1	1	1	1	1	1	1
Construction Manager			3	2	3	3		3
Project Engineer	2	2			3			
Commissioning Tech					3	2		
Monitoring				3	1	2	2	
Operations Manager					3	2	2	2
Subcontractors				2				2
Client Personnel	4	4	4	4	4	4	4	4

1 Manage/supervise work 2 Performs work 3 Technical Support 4 Client staff

Matrix of specific roles/responsibilities at each stage of the performance contracting cycle

Maintenance Planning – A Definition

During the Engineering Design Phase, Chevron ES, in concert with the client, will determine the capability of the existing maintenance staff and the desired level of maintenance to be achieved after the implementation of the energy efficiency program.

There are five categories of maintenance:

1. *Operational Analysis* – A certified technician will perform an analysis of the Owner's mechanical climate control system on a periodic basis to determine the operation efficiency as well as the condition of the equipment. The equipment will be tested for operational problems as well as inspected for parts that are worn or doubtful and evaluated as to its operating efficiency.

2. *Preventive Maintenance (PM)* – A preventive maintenance program will include all necessary adjustments to calibrate, alight, tighten, and lubricate the equipment. Equipment will be cleaned and painted on an as-needed basis. Filter replacement for all equipment is included in this program.

3. *Predictive Maintenance* – An analysis will be performed on the equipment to attempt to predict signs of deterioration in operating efficiency. When signs of deterioration are detected, action will be taken to prevent potential equipment failure.

4. *Component and Parts* – All labor, travel, parts, components, and/or devices required to repair or replace all parts that are worn or not in proper operational condition will be provided.

5. *Emergency Calls* – Priority response to all emergency calls 24 hours a day and all labor and travel required to perform all un-scheduled work resulting from mechanical problems of the equipment will be provided.

The client and Chevron ES will jointly determine if the client's staff can accomplish the desired maintenance activity or if an outside maintenance service company should be selected to perform various levels of maintenance. If it is determined that an outside service contract is necessary, the client has the option of contracting with Chevron ES or another service company. If the client elects to contract the maintenance to an outside service organization, then during the monitoring phase of the project, Chevron ES will require a preventative maintenance checklist to be completed for all mechanical equipment on a monthly basis and forwarded to Chevron ES.

As indicated above, Chevron ES often provides a computer driven Maintenance Management System to the client. The benefits of this type of program are listed below:

1. Extend equipment/facility life and lower operating costs via properly scheduled maintenance.

2. Lower job costs through better planning and scheduling.

3. Improved control of job backlog and requested, contracted, and preventive maintenance.

4. Improved operations through documentation of maintenance activities.

5. Better equipment repair/replacement justification through service/cost history accumulation.

6. Fewer emergency repairs due to insufficient or improper maintenance.

7. Improved inventory control to maintain optimum stock of parts and materials.

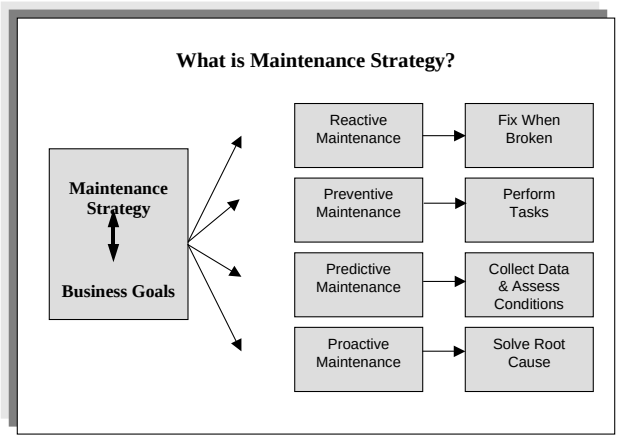
To begin evaluating building systems and serving specific areas in a facility, it is necessary to understand basic definitions of maintenance approaches. There are four maintenance approaches:

- **Reactive**
- **Preventive**
- **Predictive**
- **Proactive**

An effective maintenance strategy applies an optimum mix of these different approaches based on the risk impact or cost and consequences of failure.

Customers can elect to customize their maintenance strategy based on their individual needs and requirements.

Establishing the proper mix and focusing on continuous improvement are equally important in a successful maintenance strategy. There has been an evolution in these approaches: reactive maintenance, the oldest method, relies very little on technology; proactive maintenance, the most recent approach, relies heavily on the latest predictive maintenance technologies.



Reactive

Reactive Maintenance means fixing or replacing equipment only when it fails. For non-critical equipment, reactive maintenance makes sense if the implications of downtime are minor. For example, this would be the case with a small motor which services a restroom and costs only $500 to replace. Keep in mind, inexpensive equipment can have significant business impact if it serves critical space or is a key component in a critical system (i.e., a chilled water pump).

To rely solely on reactive maintenance for more important equipment, you can expect:

- *Costly downtime.* Machinery fails with little or no warning, so equipment is out of service until replacement parts arrive. If the equipment is critical to the area, business is disrupted or stopped entirely, resulting in lost revenue or productivity.

- *Higher overall maintenance costs.* Unexpected failures mean costly overtime to make emergency repairs. Parts costs are increased because delivery may need to be expedited.

  Also, failures are likely to be severe when failure is unexpected, possibly damaging or destroying other parts.

- *Safety hazards.* The failure of equipment can injure people nearby. For example, parts of fan blades can cut through duct-work.

Reactive maintenance is typically the most expensive and least effective approach. Although it has its place in an effective maintenance strategy, using only reactive maintenance is comparable to having no strategy at all.

Reactive Maintenance	
Advantages	Cost effective for small, non-critical equipment.
Disadvantages	Costly, downtime, extensive secondary damage, highest cost approach overall for critical equipment and medium and large equipment.

Preventive

Preventive Maintenance means scheduling maintenance at specific times. By offering a first line of defense to problems, this strategy avoids many problems of a reactive approach. Preventive maintenance can play a part in an effective maintenance strategy; for example, changing oil filters and lubricating bearings are inexpensive and important ways to reduce problems.

However, using only preventive maintenance has disadvantages in that it:

- Is often wasteful. Preventive maintenance replaces equipment components that may still have a long useful life ahead. For example, an unnecessarily scheduled centrifugal chiller overhaul can waste $15,000 by replacing good bearings.

- Does not prevent all failures. If unbalance or misalignment is causing bearing wear, bearings could fail before the next scheduled maintenance.

- Can introduce problems. In addition to not always catching problems, every disassembly creates the potential for mistakes during re-assembly or the early failure of a new component. Both events can lead to failure sooner than if the machine were allowed to run with its original components.

- Requires large inventories. Preventive maintenance requires a larger parts inventory to address all the potential problems that may arise with a piece of equipment or that may be required during a scheduled tear-down.

Preventive Maintenance	
Advantages	Provides a first line of defense.
Disadvantages	Costly, downtime, extensive secondary damage, highest cost approach overall for critical equipment and medium and large equipment.

Predictive

Predictive maintenance checks the condition of equipment as it operates. Some predictive technologies include vibration, oil, and motor current analyses, as well as infrared thermography, ultrasonic testing and power quality testing of electrical distribution systems. Equipment condition, rather than time interval, determines the need for service. If an analysis indicates problems, repairs can be made before total failure occurs, which helps avoid unscheduled downtime and secondary damage costs. This approach also "squeezes" the greatest possible life out of parts without letting them fail. By doing so, it reduces maintenance costs and downtime, so it allows the elimination of scheduled overhauls when predictive techniques show good or acceptable equipment condition.

One of the most common problems that occur when integrating predictive maintenance into an existing preventive maintenance program is that preventive elements no longer necessary to the program are not removed from the mix. In addition, predictive maintenance only provides information and does not solve the problem, nor does it correct the root cause of the problem.

Predictive Maintenance	
Advantages	Reduces maintenance costs, downtime, secondary damage, unnecessary parts replacement.
Disadvantages	By itself, does not address root cause of problems.

Equipment and systems operating log analysis should be recognized as predictive techniques as well as for data gathering. This data is what allows function analysis to be performed and corrective action to be taken.

Proactive

Proactive Maintenance relies on predictive methods (such as vibration analysis, infrared thermography, and ultrasound testing) to point out which parts are deteriorating. However, it moves beyond diagnosing problems by isolating and correcting the sources of failure altogether.

For example, instead of just replacing worn bearings, proactive maintenance seeks to eliminate the causes of wear. By addressing the root causes of fan and pump failures, such as imbalance and misalignment, the proactive approach:

- Reduces downtime costs
- Eliminates recurring problems
- Extends machinery life
- Reduces energy costs

Proactive Maintenance	
Advantages	Addresses root causes of failures; reduces maintenance costs beyond predictive levels, downtime, secondary damage, unnecessary parts replacement; and extends equipment life.
Disadvantages	None