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SUMMARY
ENERGY EFFICIENT
TECHNICAL ASSISTANCE REPORT
ROCKWALL ISD
ROCKWALL, TEXAS

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1.0 EXECUTIVE SUMMARY

The Technical Assistance is provided by the State Energy Conservation Office (SECO), a division of the Comptroller of Public Accounts of the State of Texas. This service assists school Districts in taking basic steps toward energy-efficient facility operation. Active involvement by the District in the partnership is critical in developing a customized blueprint for energy efficiency.

One of the first steps toward energy-efficient school operation is identifying the current energy performance of District facilities. An energy performance summary is included in Section 2 and more detailed data by month for each school is in the Appendix of this report.

Successful school energy management programs include the following:

- Identify the Need – District Energy Evaluation
- Appoint an Energy Manager & Provide Training
- Adopt a District Energy Policy
- Write an Energy Management Plan & Present to the School Board
- Implement Energy Accounting System
- Conduct Energy Audits
- Establish Energy Committees
- Adopt Building Operating Procedures & Guidelines
- Involve School Personnel & Students
- Obtain Publicity
- Create Competition & Incentives
- Communicate Success
- Give Personal Contact and Feedback from Energy Accounting
- Energy Procurement

This Technical Assistance Report addresses the following specific requirements for 5 campuses:

- Energy Management Controls Evaluation (Section 4)
- HVAC Description Systems and Replacement Projects (Section 5)
- Prioritized Schedule for HVAC Replacement (Section 6)
- Lighting Systems and Projects (Section 7)
- Review Energy Portion of Bond Issue (Section 8)
- Renewable Energy (Section 9)

The Technical Assistance report addresses the following five campuses that were selected by the District and approved by SECO.

- Amy Parks-Heath Elementary School
- Doris Cullins-Lake Pointe Elementary School
- Pullen Elementary School
- Cain Middle School
- Rockwall High School

James D. McClure, P.E. visited the District and met with Mr. Javier Fernandez, Director of Facility Planning and Construction, Mr. Rusty West, Maintenance Director, and Mr. Randy Talley, Energy Manager. David Fisher, P.E. (EMA) conducted evaluations. James McClure, David Dupont, Project Manager, and Javier Garcia of EMA conducted on-site observations and evaluations for the Technical Assistance. Your personal contact at SECO is Ms. Juline Ferris (Phone: (512) 936-9283); your contact at Estes, McClure & Associates, Inc. is James McClure, P.E., David Dupont, Project Manager, and Gary Bristow, P.E. (Phone: (903) 581-2677). Please call us if you have any questions or comments about this report or other energy management issues.

Rockwall ISD is in a growing area and has responded by constructing new campuses and renovating the older campuses. Energy efficiency is a consideration and incorporated in all of RISD projects including some specifically to increase efficiency.

The following are examples of projects RISD has implemented to improve efficiency, environment (indoor and outdoor), learning environment, and maintenance.

- Energy Manager
- Central operation of Energy Management Control System
- Energy monitoring and tracking system
- Include energy efficiency in new construction and renovation
- Establish standards for architect and engineer that include energy efficiency
- Energy manager conducts audits at various times
- New schools incorporate high efficiency lighting, HVAC, and other systems
- Several retrofit projects have been accomplished for more efficient lighting and HVAC
- Rockwall High School retrofitted with new central plant and new controls for the central plant.
- Rockwall High School lighting (fluorescent) retrofits

<u>Energy Star</u>

RISD has been addressing Energy Star ratings for their campuses. As of date the following have been reported to meet Energy Star designation.

Amy Parks-Heath Elementary	Doris Cullins-Lake Pointe Elementary
Howard Dobbs Elementary	Dorothy Smith Pullen Elementary
Grace Hartman Elementary	Sharon Shannon Elementary
Administration	Celia Hays Elementary
Nebbie Williams Elementary	Amanda Rochelle Elementary
Rockwall High School	Dorris A. Jones Elementary

RISD has been very aggressive in building and managing energy efficiency into all aspects of construction, procurement, maintenance, and operations.

Review of the Energy Use Index (EUI) for 4/2009 – 3/2010 shown in Section 2 table indicates the district is energy efficient.

The EUI data EMA has for 2008-2009 averages for schools in North and East Texas shows 53,440 Btu/sqft – yr for elementary and 60,173 Btu/sqft – yr for secondary. The lower the EUI value the more energy efficient.

Every RISD elementary school EUI is below the regional average except one and it is very near the average. Every middle school is below the regional average. The high schools are above the average. Observations indicate RISD campuses are used extended times by students and also have large application of computers. Again the lower the EUI the better performance.

RISD energy management has maintained the approximate same Kw-hrs consumption while adding several new major additions.

The following is a brief summary of specific technical assistance requested by the district and approved by SECO.

Energy Management Controls Evaluation

- Section 4 provides a table showing facility, type EMCS, characteristics, settings, and efficiency improvements.
- District has two types of EMCS systems (Alerton and Delta).
- Alerton system is more user friendly.
- Delta systems observed had some variations between indicated equipment operation and corresponding data on graphics.
- Reliability issues reported with Delta system.
- Replacing the Delta controls when HVAC is replaced is recommended. The cost may be less for retrofit on old HVAC, but long term recommend doing when HVAC retrofitted.
- Est. budget: $763,000
  Est. Kw-hrs savings: 396,029
  Est. cost savings: $40,261

HVAC System and Projects

- For the subject five campuses, Section 5 table shows type HVAC, age of equipment, other characteristics, and ASHRAE median life.
- Other HVAC topics asked about are included.
- Estimate of HVAC includes controls
- Est. budget: $10,753,000
  Est. Kw-hrs savings: 626,557
  Est. cost savings: $62,654

Prioritized Schedule for HVAC Replacement

- Section 6 provides schedule based on age for five subject schools.
- Additional factors for consideration of prioritizing are included that will be useful in evaluating these five campuses as well as others.

Lighting Systems and Projects

- Section 7.0 provides lighting retrofit projects for the five subject schools.
- These include occupancy sensors for lighting control, replacing metal halide light fixtures in gymnasiums with T5 fluorescent/electronic ballasts, and replacing older T12 fluorescent lighting with energy efficient T8 fluorescent/electronic ballasts.
- Budget: $305,296
  Kw-hrs est. savings: 493,747
  Annual savings: $43,542

Review Energy Portion of Potential Bond Issue

- Section 8 addresses ideas/suggestions for consideration if and when RISD decides to conduct a future bond for capital construction.
- Topics include but are not limited to power factor correction, T5 lighting for gymnasiums,

replacement of aged HVAC, remote computer management, renewable energy, EMCS upgrades, replacement of older T12 fluorescent lighting, green building technologies, etc.

- RISD has a history of including energy efficiency in past bond issues.
- Any future bond has not been defined as of this date. This information is provided to be helpful.
- EMA is available to follow-up with RISD and discuss and plan energy efficiency in bonds.

Renewable Energy

- Section 9 provides information on the suitability of renewable energy for school applications in RISD.
- RISD is located in a region where widespread use of windturbines will not have good potential. A small demonstration unit may be useful for demonstration purposes.
- Solar photovoltics (PV) is the most suitable application of renewable energy for RISD. System costs and high paybacks are long in today's market compared to purchasing retail electricity.
- Demonstration projects at selected campuses are recommended for educational purposes. There are some grants and rebates available (see Section 10). For any LEED certified or other green building type initiatives larger scale PV would be the best renewable option.
- RISD has natural gas available for water heating. Solar water heating typically is more competitive and suitable in today's market for applications where electricity is used for large quantities of water heating.

Estimated District Savings

- For the projects that are the subject of this report estimate annual Kw-hr savings of 1,489,333 kw-hrs and $146,457/year.

Appreciation

EMA appreciates the opportunity to provide the information in this report. Our intent is to be helpful and responsive to questions that were asked. SECO is commended for sponsoring this assistance program for RISD and other school districts.

Please call to discuss or ask questions. Thank you.

2.0 DISTRICT ENERGY AND COST PERFORMANCE

Rockwall ISD has 18 campuses. The student enrollment as listed in the Texas School Directory as of October 2009 is 13,843 students.

The energy use performance or energy use index (EUI) and the energy cost performance or energy cost index (ECI) is provided below. Other detailed data is shown on the Base Year Energy Consumption History table provided in Appendix of this report.

The energy cost index is a valuable tool for comparing the energy cost ($) of different schools and campuses in a given area. The energy use index allows for comparison of schools on a quantity (BTU) basis. Since the cost of electricity varies by school and natural gas is so much less than the cost of electricity, this index is a true value of the actual energy use on a square foot basis. The energy cost index (ECI) and the energy use index (EUI) are determined by the following formulas.

$$ECI = \frac{\text{Annual Electrical Cost + Annual Natural Gas Cost}}{\text{Total Area of School}}$$

$$EUI = \frac{\text{Annual Electrical BTUs + Annual Natural Gas BTUs}}{\text{Total Area of School}}$$

Energy Cost & Performance: 4/2009 – 3/2010

Schools	ECI	EUI	KWH per Sq. Ft.	1000 Mcf per Sq. Ft.	Area (sq. Ft.)	Total Energy Cost
Amy Parks-Heath E.S.	$1.45	43,133	11.5	3.7	69,603	$100,851
Doris Cullins Lake Pointe E.S.	$1.27	48,610	10.1	13.8	104,591	$132,768
Dobbs E.S.	$1.46	52,300	10.9	14.5	62,039	$90,675
Dobbs Anex	$1.10	31,375	9.2	0	1,500	$1,652
Hartman E.S.	$1.29	50,199	10.0	15.7	78,567	$100,980
Hays E.S.	$1.20	52,658	9.5	19.7	91,489	$109,403
Jones E.S.	$1.17	48,894	9.7	15.5	78,495	$91,791
Pullen E.S.	$1.26	50,034	9.8	16.0	78,094	$98,272
Reinhardt E.S.	$1.05	40,839	7.7	14.2	61,479	$64,302
Rochelle E.S.	$0.77	34,049	5.2	15.9	70,337	$53,872
Shannon E.S.	$1.22	56,943	9.4	24.0	91,489	$111,287
Springer E.S.	$0.95	38,637	7.1	13.8	78,567	$74,626
Williams E.S.	$1.16	43,865	9.0	12.6	76,235	$88,695
Rockwall H.S.	$1.55	70,269	12.9	25.5	375,198	$581,075
Rockwall-Heath H.S.	$1.41	74,105	11.0	35.6	458,657	$647,283
Cain M.S.	$1.31	58,378	10.8	20.9	150,431	$196,806
Utley M.S.	$0.74	39,577	5.2	21.3	222,151	$163,336
Williams M.S.	$0.96	39,737	8.3	11.2	180,431	$172,493

Review of the Energy Use Index (EUI) in the table for 4/2009 – 3/2010 indicates RISD is energy efficient. The EUI data EMA has for 2008-2009 averages for schools in North and East Texas shows 53,440 Btu/sq.ft-yr for elementary schools and 60,173 Btu/sq.ft-yr for secondary schools. The lower the EUI value the more energy efficient.

Every RISD elementary school EUI is below regional average except one and it is very near the average EUI. The middle schools are all below the average EUI. Being below the average EUI is good as the lower the EUI number, the better the energy efficiency. The high schools are above the average.

RISD has reported addressing Energy Star ratings for their campuses. As of date twelve facilities have the rating. Not all have been checked so far.

RISD Kw-hrs consumption 4/2008 – 3/2009 was 22,003,003. From 4/2009 – 3/2010 Kw-hrs consumption was 22,802,938. The consumption stayed the same and several major additions were added.

3.0 ENERGY ACCOUNTING

3.1 Monitoring and Tracking

RISD has implemented a computer based energy monitoring and tracking system. This was recommended in previous SECO sponsored assistance.

3.2 Utility Providers and Rates

The District is provided electricity by Reliant (deregulated). Oncor is the regulated electric transmission and distribution company. Natural gas is provided by Atmos Energy Company.

4.0 ENERGY MANAGEMENT CONROL SYSTEMS

Rockwall ISD has DDC energy management control systems at all campuses. The following table, Rockwall ISD EMCS summarizes types, characteristics, settings observed and improvements. Portables are not connected to the EMCS and they are recommended for including on the central DDC system.

There are two types of systems, Delta and Alerton. The Alerton system was observed to be more user friendly. Feedback of the Delta system included, not reliable, not as user friendly, difficulty locating boards for replacement, inconsistent, some air-handlers with Delta at Rockwall High School must be manually operated, and outside technicians used to program new boards.

Observation of the computer graphics for the Alerton systems did not indicate any variations between equipment status to data displayed.

Observations of the computer graphics for the Delta system indicated several variations between equipment status to the data displayed. The following are observations from the Delta system in addition to the table included.

Doris Cullins Lake Pointe Elementary School – Delta System

On the main page of the Delta EMCS, it shows the school layout. The main layout shows several settings. The settings include occupied setpoint(72F), unoccupied heating(55F) and unoccupied cooling(80F) setpoints. The page also displayed the outside air temperature as well as the outside air humidity. The outside air humidity did not seem to be reading correctly.

The delta EMCS allowed the user to manually change settings. The main layout also displays the room's current setpoint and actual temperature. From the main page, time schedules could be made. There were also indicators that showed what units were on. The user could get detailed information about the AHU's. The AHU pages showed several values and setpoints that could be manipulated including hot and chilled water valve, damper positions, temperature setpoints and on/off setting.
At the time of visit, on the main page, the light indicator for AHU 1 showed that it was on. Looking at the detailed page of the AHU 1, it said the supply fan was on but it did not seem like the unit was on. The supply air temperature was too high. Looking back at the main page and looking at the temperature of the rooms that AHU 1 served, it did look as if the unit was indeed off.

The EMCS also indicated that the office area unit was on. By looking at the room temperatures and setpoints of the office area, it appeared that the unit was on and working.

Dorothy Smith Pullen Elementary School – Delta System

On the main page of the Delta EMCS, it shows the school layout. The main layout shows several settings. The settings include occupied setpoint(73F), unoccupied heating(55F) and unoccupied cooling(80F) setpoints. The page also displayed the outside air temperature as well as the outside air humidity.

The Delta EMCS allowed the user to manually change settings. The main layout also displays the room's current setpoint and actual temperature. From the main page, time schedules could be made. There were also indicators that showed what units were on.

The EMCS was very limited to what it could control on these units. Basic on/off setting and temperature setpoints were the only things that could be done.

The EMCS indicated that the office area unit was on. The office area was cooler than surrounding areas and it appeared that the unit was on.

Amanda Rochell Elementary School – Delta System

On the main page of the Delta EMCS, it shows the school layout. The main layout shows several settings. The settings include occupied setpoint(70F), unoccupied heating(60F) and unoccupied cooling(80F) setpoints.

The Delta EMCS allowed the user to manually change settings. The main layout also displays the room's current setpoint and actual temperature. From the main page, time schedules could be made. There were also indicators that showed what units were on.

The EMCS was very limited to what it could control on these units. Basic on/off setting and temperature setpoints were the only things that could be done.

The EMCS indicated that all the units were on, except for the gym unit. Looking at the room and setpoint temperatures it looks like the majority of the units are working and reaching the setpoints. One exception was room 20 in the north wing. It did not appear to be working. The setpoint was 73F but the room temperature was 79F. Also, the EMCS indicated that the gym unit was off. By looking at the gym temperatures, it appeared as the unit was actually on and working. The setpoint was 68F and the gym temperature was 68.7F.

Maurine Cain Middle School – Delta Systems

On the main page of the Delta EMCS, it shows the school layout. The main layout shows several settings. The settings for wings A, B, and C include occupied setpoint(70F), unoccupied heating(60F) and unoccupied cooling(82F) setpoints. For wind D, the settings were occupied setpoint(73F), unoccupied heating(60F) and unoccupied cooling(80F) setpoints The page also displayed the outside air temperature as well as the outside air humidity. The outside air humidity did not seem to be reading correctly.

The Delta EMCS allowed the user to manually change settings. The main layout also displays the room's current setpoint and actual temperature. From the main page, time schedules could be made. There were also indicators that showed what units were on.

The EMCS was very limited to what it could control on these units. Basic on/off setting and temperature setpoints were the only things that could be done.

The EMCS indicated that all the units were on, except for the cafeteria. Looking at the room and setpoint temperatures it looks like the majority of the units are working and reaching the setpoints.

Rockwall High School – Delta System

On the main page of the Delta EMCS, it shows the school layout. The page also displayed the outside air temperature as well as the outside air humidity. The outside air humidity did not seem to be reading correctly.

The Delta EMCS allowed the user to manually change settings. The main layout also displays the room's current setpoint and actual temperature. From the main page, time schedules could be made. The user could get detailed information about the AHU's. The AHU pages showed several values and setpoints that could be manipulated including hot and chilled water valve, damper positions, temperature setpoints and on/off setting. The occupied and unoccupied heating and cooling setpoints on these units varied. Some units unoccupied heating and cooling were 85F & 65F, respectively. Other units had setpoints of 85F & 55F.

Eighteen AHU's appeared on the EMCS. AHU's # 1,2,4,5,6,10,17 and 18 were not communicating correctly. The values and setpoints were blanked out on the EMCS. AHU #3 was showing up but some of the readout temperatures were not reading correctly. The other AHU's that were actually showing up properly seemed to be on and working. Although, AHU #11 and #12 looked as if they might have been in heating mode. The hot water valves were open 100% and the supply air temperature setpoints were 89F.

Howard Dobbs Elementary School – Delta System

On the Delta EMCS, nothing was showing up. All the values were blanked out.

EMCS Upgrading

Cain, Rochell, Pullen, Doris Cullins-Lake Pointe, and some areas of Rockwall High School have Delta controls.

Recommend that when HVAC is replaced as part of routine when equipment reaches useful life expectancy, the EMCS be upgraded (replaced) with new user friendly DDC system like the Alerton system.

Dependent on schedule of replacement of original air-handlers and terminal boxes at RHS, district may want to consider upgrading controls before this equipment is replaced. RHS has Alerton controls in the newer part including the new control plant.

Estimated Savings/Budget: EMCS

Campus	**Kw-hrs Saved**	**$ Saved**	**Est. Budget $**
Cain M.S.	130,569	$13,056	$190,000
Rochell E.S.	30,000	$3,000	$78,000
Pullen E.S.	36,684	$3,668	$85,000
Doris Cullins-Lake Pointe E.S.	55,377	$5,537	$185,000
Rockwall H.S.	143,399	$15,000	$225,000
Totals	**396,029**	**$40,261**	**$763,000**

Budgets for replacement of Delta systems when new HVAC is installed. Cost would be less if upgrade on existing HVAC system but not recommended.

5.0 HVAC DESCRIPTION AND REPLACEMENT PROJECTS

HVAC Description Table

The attached table, Rockwall ISD HVAC Description and Replacement Projects, are provided to assist in evaluation and planning of energy efficient HVAC and intended to be helpful for RISD. The district has been constructing new campuses, additions, renovations, and upgrade projects for several years. Energy efficiency has been and continues to be included. Also the table is intended to be a value in maintenance, energy, budgeting, and bond planning.

The “Year (HVAC)” in the table designates the approximate date of HVAC installation. In some cases this is the date of construction of the facility. In others it is the date of retrofit with new HVAC equipment.

The “Type HVAC & Description” column is a description of the system type and equipment. “Pkg. DX RTU” designates unitary direct expansion electric cooling individual unit that has all equipment components in one package and is located on the roof. Typically for this application there is one unit per classroom and several units per gym and cafeteria. The designation “natural gas heating” or “electric heating” refers to the type of space heating equipment in the package.

The “Split System DX” designation indicates unitary direct expansion electric cooling with an air-cooled condenser located outdoors. Refrigerant lines connect the outdoor condenser with the indoor air-handler assemble which includes the evaporator or (cooling coil). “Heat Pump” indicates a type of heating for these systems. Natural gas heating type units are also available for split system DX equipment.

“Central Chilled/Hot Water System” designates a central plant system. Chillers provide chilled water for larger air handlers with cooling coils or “smaller fan coil units having cooling coils. Chilled water produced by the chillers is pumped via piping to the air-handlers or fan coil units. The “Air-Cooled Chiller” indicates that the heat rejected by the chiller is air-cooled rather than having a cooling tower (water). “Hot Water System” indicates boilers are provided to produce hot water for space heating. This hot water is pumped from the central boiler location to the air-handlers and fan coil units.

“Refrigerant Type” is the type of refrigerant in the cooling equipment. R22 for the direct-expansion HVAC equipment has been the standard for many years. New unitary direct expansion equipment being installed in the district is R410A. CFC and HCFC refrigerants are being phased out due to their potential damaging effects on the earth’s protective ozone layer. Several important deadlines have already passed, and others are rapidly approaching.

CFC refrigerants (e.g. R11, R12) have already been banned. HCFC refrigerants (e.g. R22, R123), replacements for CFCs, are now being eliminated. Manufacturers cannot make new equipment that uses R22 or R123 beginning in 2010 and 2030, respectively. Production of R22 must stop in 2020 and R123 in 2030. There are also intermediate dates with reductions in production limits. Refrigerants are reclaimed and recycled and this will help the supply.

Prior to the 2010 deadline for ending R22 equipment production manufacturers redesigned their products for R410A.

R410A, a non-ozone depleting refrigerant, has been introduced as an alternative for R22 in new equipment. However, it is not a direct drop-in replacement for R22 due to differences in operating characteristics. Also, since R410A operates at higher pressure than previous refrigerants, technicians need additional training and new tools (e.g. hoses, gauges, etc.).

“ASHRAE Ventilation Standard” designates yes or no compliance with ASHRAE Ventilation Standard 62 which significantly increased the amount of outside air requirements introduced into a building.

ASHRAE issues industry recognized standards relating to heating, air-conditioning and ventilation that are often incorporated into building codes. ASHRAE Standard 62 with increased ventilation rates is now in the building codes. As HVAC renovation projects occur, providing outside air per the current standard/codes is recommended.

"CO2 Ventilation Control" designates yes or no if the quantity of ventilation (outside air) is automatically adjusted based on CO2 measured levels within a space. A few years ago ASHRAE introduced a strategy called demand control ventilation. This allows automatically adjusting the amount of outside air introduced into a building as CO2 concentration may be used as an indicator of occupancy or number of occupants. As the CO2 level increases more outside air up to the ASHRAE Standard 62 requirement is introduced. As the CO2 level decreases outside air quantity is moderated and this results in energy savings. A CO2 sensor is in the conditioned space with the sensor controlling room space temperature. This strategy utilizes the energy management control system for operations.

"ASHRAE Equipment Life Estimate" in the table is from 2007 ASHRAE Handbook – HVAC Application Chapter 36 (pages 36.2 and 36.3). "Years" is the median life (ASHRAE) and "Year" is the year the equipment will meet ASHRAE's median life. Local conditions, maintenance, preventive maintenance, vandalism, quality of original equipment and original design/construction may affect usable life of equipment and systems.

EMA equipment life observations are that in non-coastal, non-marine, and non-corrosive emission industrial environments, unitary direct expansion (Dx) either packaged roof top or split-system equipment practical useful life exceeds the ASHRAE median service life. To achieve the ASHRAE median service life or EMA equipment life observations, HVAC equipment must be of good quality manufacturer, suitable application, and maintained properly (per manufacturer's instructions) including good filter changing practice and good maintenance procedures.

For example EMA observations of schools are that many districts exceed the ASHRAE median life for unitary Dx HVAC equipment by 5 years or more. ASHRAE median for unitary Dx HVAC equipment is 15 years. Looking at ASHRAE dates for components, they show Dx coils as 20 years, air-cooled condensers as 20 years, and electric motors 18 years.

EMA observations are that maintaining good equipment and installations will extend the life. There may be some component replacements needed in addition to routine and preventive maintenance. Tracking work orders (frequency and type) along with reliability for occupant comfort and effective student learning environment may provide an indication of the costs and benefits. Practices to monitor and extend the life are cost effective and sustainable as long as the efficiency is reasonably maintained. Early demolition and removal of equipment is not a green or sustainable practice.

"Budget Estimate ($)" designates estimated cost to upgrade or replace the HVAC equipment. Budgets are provided for HVAC projects that may be scheduled in the next several years. Costs are based on today's estimates and do not include any inflation factor.

"Comments" provides additional information about the HVAC system or facility.

Data in the table, Rockwall ISD HVAC Description and Replacement Projects, is derived from meetings, observations, plan review and other data review. Site visits and opening of equipment were beyond the scope of this work.

Continuous Updating

Periodic updating of this table and expanding for all campuses is useful for maintenance or bond budgeting and planning. As retrofit projects are implemented or new campuses constructed we recommend adding to or revising the table.

Field Testing A/C Units

The question was asked by maintenance about how to evaluate the performance of unitary direct expansion equipment in the field (installed). The following may be useful as a maintenance comparison indication to other same equipment at the same campus but not for comparison to manufacturer's ratings.

$$OperatingPerformance(BTUH) = 4.5 * \Delta Enthalpy * CFM$$

In the equation above, 4.5 is a constant that converts CFM to lbs/hr. It is 60 min/hr multiplied by the density of air, which is about .075 lbs/cu.ft.

$$EER = \frac{OperatingPerformance}{PowerInput}$$

Definition:
EER – Stands for energy efficient ratio and is the measure of air conditioner efficiency at maximum air conditioning load. It is a measure of the instantaneous energy efficiency of cooling equipment. EER is the steady-state rate of heat energy removal by the equipment in BTUH divided by the steady-state rate of energy input to the equipment in watts. This is not to be confused with SEER rating.

SEER - Stands for seasonal energy efficiency rating. The measurement units of SEER are exactly the same as EER, but the difference lies in the data used for the measurement.

Values for SEER, is determined through averaging readings of different air conditions, to represent air conditioner efficiency throughout the season.

When manufacturers release specifications for their units, the tests that are performed are done in labs where certain conditions are maintained. Manufacturers EER testing is done according to AHRI 210/240 standards. Testing is done with a fixed outdoor temperature of 95° F and fixed air temperature of 80°(dry bulb)F/67°(wet bulb)F entering the evaporator coil. When performing the actual real world test, the EER rating will differ from the manufacturer's because exact lab conditions cannot be duplicated on an installed system.

1. Connect a wattmeter inline with the power supply of the unit. The wattmeter has to be capable of handling the voltage and current that the unit is capable of using.

2. Start the unit and set the setpoint to 55 Deg. F to ensure the unit is in cooling mode. Allow the unit to run 10 mins in order for it to stabilize and reach steady state.

3. In order to test the unit, several temperatures need to be taken. The average wet and dry bulb temperatures of the space and the average wet and dry bulb temperatures of the supply air need to be known. Once the temperatures are taken, by using the normal ASHRAE psychrometric chart, the enthalpy of the space and supply air can be found. The difference in enthalpy is what is needed and should be in BTU/lb.

4. Measure the total supply air that is coming into the space in CFM. Use air-flow hood at supply grilles.

5. Take an average reading of the power consumption given by the wattmeter.

With the data, the operating performance and EER can be found using the equations above. This test will give you the instantaneous reading. The information is useful only for maintenance comparisons of DX units at the same school, on the same side of building, at the same time.

Energy Savings

Energy savings are estimated for HVAC projects that based on the Table would be considered/evaluated for upgrading in the next several years. These include the following;

Energy Est. Savings HVAC Replacement
(See Table RISD HVAC Description and Replacement Projects)

Facility	Savings Estimated KW-HRS	Savings Annual $	Est. Budget
Amy Parks-Heath E. S.	97,984	$9,798	$1,308,000
Doris Cullins-Lake Pointe E. S.	115,725	$11,572	$2,970,000
Pullen E. S.	88,695	$8,869	$1,350,000
Cain M. S.	254,153	$25,415	$2,900,000
Rockwall H. S.	70,000	$7,000	$2,225,000

KW-HR Total Saved = 626,557
KW-HR Total $ Saved = $ 62,654
Total Estimated Cost = $ 10,753,000

The payback is relatively long but as the equipment/infrastructure reaches its useful life it will need to be replaced and will provide opportunities for energy savings.

Comfort/Energy Survey

One of the questions asked by the RISD facility department was about conducting a comfort survey of campus staff (e.g. administrative, support, teachers).

Informal discussions with several area school districts did not identify any having conducting occupant surveys. Most indicated they had no interest in such a survey.

We are aware of one church many years ago that placed location marked cards in the sanctuary seats asking about thermal and overall comfort during the church service. The results were not beneficial as numerous occupants adjacent to each other reported complete opposite feedback.

Survey Questions

The following are provided as initial planning questions to consider if an occupant comfort/energy survey were conducted. There are likely to many questions below for a survey but are provided for initial planning.

1. Campus: ______________________

2. Season:
   - ☐ Spring
   - ☐ Summer
   - ☐ Fall
   - ☐ Winter

3. Age:
   - ☐ Under 30
   - ☐ 31-50
   - ☐ Over 50

4. Gender: ☐ Male ☐ Female

5. How many hours per week do you spend in your workplace? __________Hrs

6. How many years have you worked in this building?
   - ☐ Less than 1 year
   - ☐ 1-5 years
   - ☐ More than 5 years

7. Can you see an exterior's window from your workplace?
   ☐ Yes ☐ No

8. How satisfied are you with the light in your workplace?
   - ☐ Very satisfied
   - ☐ Satisfied
   - ☐ Indifferent
   - ☐ Unsatisfied
   - ☐ Very unsatisfied

9. How satisfied are you with the cleanliness of the building?
   - ☐ Very satisfied
   - ☐ Satisfied
   - ☐ Indifferent
   - ☐ Unsatisfied
   - ☐ Very unsatisfied

10. How satisfied are you with the temperature in your workplace?
- ☐ Very satisfied
- ☐ Satisfied
- ☐ Indifferent
- ☐ Unsatisfied
- ☐ Very satisfied

11. Does how you feel above, vary during the day?
☐ Yes ☐ No

12. If yes above, what time of day is your workplace most comfortable ____________, most uncomfortable _______?

13. Is your room comfortable at:
a. 8 a.m. ☐ Yes ☐ No
b. 4 p.m. ☐ Yes ☐ No

14. Which of the following do you personally adjust or have some control? Check all that apply.
- ☐ Window blinds or shades
- ☐ Thermostat
- ☐ Door to interior space
- ☐ Door to exterior space
- ☐ Light switch
- ☐ None of the above

15. Do you have sound/noise not generated in your workplace that is a distraction?
☐Yes ☐ No

16. I mange my workspace to conserve energy usage?
☐ Yes ☐ No

17. I have the following suggestion(s) that would help reduce energy usage:

18. I would like helpful hints for energy conservation (school and home).
☐ Yes ☐ No

19. When I leave my room, I do the following. Check all that apply.
- ☐ Turn off lights
- ☐ Adjust thermostat
- ☐ Adjust shades/blinds
- ☐ Turn off computer(s)
- ☐ Turn off copier(s)

20. I carpool to work

☐ Yes ☐ No

21. The following are suggestions for water conservation at my campus.

☐ ____________________________________

☐ ____________________________________

☐ ____________________________________

Many surveys are accomplished without the responder indentifying themselves. This could be accomplished but to be specific in being helpful, the room and time of day as well as the campus would be needed. Many surveys conducted are limited to a few questions. The above are provided for district's evaluation/planning.

Non-Occupant Comfort Survey

The following are suggestions for a follow-up of any occupant survey or an alternative to an occupant survey.

- Use EMCS to monitor or trend space temperatures for 24 hours in selected rooms.
- Interview the principal at each campus and get feedback on general comfort or temperature.
- During general energy audit walk-through of campuses take instrumentation and measure selected rooms for temperature, CO2, and humidity.

General

There are inconsistencies on research as to the effect of space temperature on subjective comfort and on performance of tasks.

Observations Five Subject Campuses (Comfort – Temperature)

Of the five campuses visited as part of the Technical Assistance, Cullins-Lake Pointe was the only campus where anyone commented about comfort. Cullins-Lake Pointe's area served by the old chilled water system was the only area at that school where temperature or comfort problems were reported.

6.0 PRIORITIZED HVAC SCHEDULE FOR REPLACEMENT

In general, priority consideration of HVAC replacement or upgrading projects include but are not limited to the following;

- High maintenance costs or issues
- High down time and frequency (reliability)
- Age of equipment
- Condition of equipment
- Indoor environment and comfort
- Refrigerant type and availability
- Capacity of equipment
- Function or use change
- Increased load from new electronic or other equipment, etc.
- Adequate outside air
- Unavailability of parts
- Maintenance frequency and cost

RISD Priorities for HVAC Replacement

The following are recommended priority for replacement for the five campuses on this report.

Priority #	Facility
#1	Doris Cullins-Lake Pointe E.S.
#2	Rockwall High School
#3	Amy Parks-Heath E.S.
#4	Cain M.S.
#5	Pullen E.S.

The District has been successful and has done a good job in keeping up with energy efficient HVAC equipment replacement. The above are just routine normal part of the process.

See Table: Rockwall ISD HVAC Description and Replacement Projects in Section 5.0.

The priorities are based on equipment age. Other factors as listed above may be considered such as maintenance issues that develop and also extending the useful life of equipment.

7.0 LIGHTING SYSTEMS & PROJECTS

The following lighting retrofit opportunities are for some or all of the five schools that were audited. Some recommendations may also be applied to other facilities in the District.

Replace Gym Lighting

In all gyms the District should consider replacing the existing metal halide fixtures with energy-saving T-5 HO fixtures. An existing 400 Watt metal halide fixture consumes 458 watts as compared to the 6-lamp T-5 HO fixture which consumes approximately 351 watts. The 4-lamp T-5 HO fixture uses approximately 234 watts. Additional savings may be realized because the fixtures are instant on/off requiring no warm up time and, therefore, are more likely to be turned off when not in use. The addition of occupancy sensors may also enhance energy savings.

Gym Lighting Retrofits

	School	Est. Cost	Est. Annual Energy Savings (Kwh)	Est. Annual Savings	Simple Payback (Yrs)
a	Rockwall High School	$31,600	36,540	$3,837	8.1
a	Cain Middle School	$21,600	73,310	$3,030	7.1
b	Doris Cullins-Lake Pointe Elementary School	$9,600	14,490	$1,883	5.0
b	Dorothy Pullen Elementary School	$4,800	7,503	$825	5.8
b	Amy Parks-Heath Elementary School	$4,800	7,076	$946	5.0
a	Multipurpose Facility (RHS)	$43,200	63,660	$6,684	6.5
a	6-lamp T-5 HO Fixtures				
b	4-Lamp T-5 HO Fixtures				

Provide Energy Efficient Lamps and Ballasts

Retrofit existing 4-foot and 8-foot fluorescent T-12 lamps and electromagnetic ballasts with new energy efficient T-8 lamps and electronic ballasts. Existing ballasts with two 34-watt lamps consume approximately 72 watts, while electronic ballasts with two 32-watt T-8 lamps consume about 58 watts. This is a savings of 14 watts per two-lamp ballast changed. There will also be maintenance savings since T-8 lamps have longer life and electronic ballasts have a 25-year rated life. All light fixtures should be cleaned when this work is accomplished.

Fluorescent Lighting Retrofits

Campus	Est. Cost	Est. Annual Energy Savings (Kwh)	Est. Annual Savings	Simple Payback (Yrs)
Rockwall High School	$1,386	2,187	$284	4.9
(corridors in athletic area)				
Cullins-Lake Pointe Elementary School	$50,390	54,245	$6,230	8.0
Amy Parks-Heath Elementary School	$37,120	42,489	$4,870	7.6

Install Occupancy Sensors

Occupancy sensors turn lights off in spaces after a preset time when no people are detected. They can be utilized in all spaces – classrooms, halls, offices, meeting rooms, etc. a variety of studies indicate that lighting energy savings of 20 percent or more may be realized from utilizing occupancy sensors.

Occupancy Sensors Retrofit – Lighting Control

Campus	Est. Cost	Est. Annual Energy Savings (Kwh)	Est. Annual Savings	Simple Payback (Yrs)
Cain Middle School	$29,600	67,141	$6,042	4.9
Doris Cullins Lake Pointe Elementary School	$27,600	48,838	$4,395	6.3
Dorothy Pullen Elementary School	$20,400	35,413	$3,187	6.4
Amy Parks-Heath Elementary School	$14,400	32,175	$418	5

Replace Lobby Lights – Rockwall H.S.

The District should consider replacing the existing 400W metal halide fixtures in the lobby at Rockwall High School. As in the gyms a 400W metal halide fixture consumes about 458 Watts as compared to approximately 351 Watts for a 6-lamp T-5 HO fixture, which produces approximately the same amount of light. Energy savings can be realized from the reduction in consumption, and may be enhanced with the use of occupancy sensors.

Rockwall High School – Lobby Lighting Retrofit

Campus	Est. Cost	Est. Annual Energy Savings (Kwh)	Est. Annual Savings	Simple Payback (Yrs)
Rockwall High School	$8,800	8,680	$911	9.7

Summary Lighting Retrofits

Campus	Est. Cost	Saved Kw-Hrs	$ Saved
Rockwall H.S.	$84,986	111,067	11,716
Cain M.S.	$51,200	140,451	9,072
Doris Cullins-Lake Pointe E.S.	$87,590	117,573	12,508
Dorthy Pullen E.S.	$25,200	42,916	4,012
Amy Parks-Heath E.S.	$56,320	81,740	6,234
Total	$305,296	493,747	43,542

The overall payback for the above is 6.8 years.

8.0 REVIEW ENERGY PORTION OF POTENTIAL BOND

This section addresses ideas/suggestions for consideration if and when RISD decides to conduct a future bond for capital construction.

HVAC Retrofits

See Section 5.0 for the five campuses included in this SECO sponsored Technical Assistance. Similar evaluations at other district facilities are recommended.

Energy Management Controls (EMCS) Retrofits

See Section 4.0 for district EMCS retrofits.

Lighting Retrofits

See Section 7.0 for lighting retrofit recommendations for the five campuses subject of this report.

For other campuses include the following:

Install Occupancy Sensors

Occupancy sensors turn lights off in spaces after a preset time when no people are detected. They may be utilized in most spaces, classrooms, offices, halls, meeting rooms, gyms, lockers, etc. A variety of studies indicate that lighting energy savings of 20 percent or more may be realized from using occupancy sensors. The district has retrofitted several campuses.

Replace T12 Fluorescent Lighting With T8 Fluorescent Systems

Retrofit any remaining T-12 fluorescent lighting and electromagnetic ballasts with T-8 lamps and electronic ballasts. Existing systems with 34-watt T-12 lamps and energy saving ballasts consume 72 Watts per two-lamp fixture. Electronic ballasts with 32-watt lamps consume about 59 watts, or less depending on ballasts selected. The district has made significant retrofits.

Where large numbers of T-12 light fixtures remain, the district may want to include replacement in a bond package. In-house maintenance crews can retrofit small areas of lamps and ballasts.

T5 Lighting for Gymnasiums (Replace Metal Halide)

Provide for remaining gyms in district.

LED Lighting

LEDs are semiconductors that convert electricity into light. At one time they were used only as indicator lights on electronic devices. LEDs are now being developed for use in downlights, troffers, and outdoor area lighting. One day they may replace most or all of the conventional light sources we currently use.

LEDs require a special power source commonly called a driver, which is similar to a fluorescent ballast. They can be produced in a variety of color temperatures, from warm to cool, just like other lamp types.

The Department of Energy's (DOE) long-term goals call for luminous efficacies of 160 lumens per watt (lpw) for LEDs. Efficacies of more than 100 lpw have been achieved under laboratory conditions. In the latest round of testing by the DOE, market available LED products exhibited a wide range of efficacies from 17 to 79 lpw, with an average of 46 lpw. For comparison, compact fluorescent and T-8 fluorescent fixture efficacies are about 65 and 90 lpw, respectively.

Costs of fixtures utilizing LED lamps are considerably higher than similar fixtures with fluorescent or HID lamps, and their light output is considerably lower. Therefore, more LED fixtures would be required to attain the same light levels.

Given the status of LED products, we do not recommend the widespread use of fixtures utilizing LED lamps. Research and development is occurring at a fast pace. Therefore, in the near future, products will likely be offered that rival currently available fluorescent and HID models. As demand for LED based fixtures increases, prices will fall, making the items more attractive.

In the meantime, the district may want to consider purchasing or obtaining a limited number of sample LED fixtures to install and monitor on a test basis.

Evaluation of LED Lighting

Wallpacks – Wallpacks, used to illuminate building exteriors, often use metal halide lamps ranging in size from 70-watt to 400-watt. Exterior wall fixtures utilizing LED lamps are available; however, these fixtures currently are equivalent to only a couple of compact fluorescent lamps.

Downlights – Screw-in LED replacement lamps are available for recessed downlights, such as over the counter in the library. An example is a 6-inch unit by Cree Lighting that uses about 10 watts and produces about 700 initial lumens. The product costs about $80 or more. In comparison, a 13-watt compact fluorescent lamp produces about the same light output and costs approximately $5.

Parking lots and canopies – LED light fixtures are available that are intended to replace parking lot and canopy lights. Typically, most parking lot light fixtures incorporate 400-watt metal halide lamps. These produce about 36,000 initial lumens. Currently, the largest LED fixtures available use about 175 watts and produce approximately 6000 initial lumens (about the same as a 70-watt metal halide lamp). The LED fixtures cost at least twice as much as the metal halide fixtures.

Update: LED Lighting

While LED technology is advancing rapidly, they are not yet as efficacious as fluorescent or metal halide lamps in actual installations. That is, they do not produce as much light for the same amount of energy used. Fluorescent and metal halide lamps often produce 60 to 90 lumens per watt. In the most recent round of testing by the Department of Energy, LED fixtures produced, on average, about 45 lumens per watt.

We recommend that the District monitor developments in LED technology. At some point in the near future, fixtures with LED lamps are likely to perform as well as those with fluorescent and metal halide lamps. In the meantime, the District may want to obtain a few LED fixtures to install for evaluation and test purposes.

EMA employees attended the International Light Fair in May 2010 and a manufacturer's LED Lighting class in June 2010. Standards are being developed for uniform rating and testing of LED lamps and fixtures by various organizations including the Department of Energy. There apparently is much variation between lamps, fixtures, and suppliers/manufacturers. A key recommendation is to look at the fixture and request standard uniform test reports on light source and photometrics. Also work with established manufacturers with a good reputation. Try selected fixtures for testing/evaluation. Monitor the changing technology.

Remote Computer Management Software

Electricity to power desktop computers can represent a considerable expense for school districts. A typical PC running continuously throughout the school year costs about $60 annually to operate. For a district with, for example, 4,000 computers, this would total some $240,000. Turning the same computers off after hours, weekends, and holidays would result in an approximate 60% savings. The actual costs are likely less, since at any given time some computers may be off or in standby mode etc., but they would still be significant.

Empirical evidence indicates that voluntary compliance with requests to shut down computers not in use is not very high. Operating systems, such as Windows, come with available power management settings to put computers into standby or “sleep” mode after a period of inactivity; however, these settings must be enabled by the user. They can be changed or even disabled, which makes them virtually ineffective.

Remote management software can reduce electric consumption and costs. A shut down signal is sent from a central server via the network to remote machines at a predetermined time. Many remote management programs give any users that are working a warning that their workstation is to be shut down shortly. Users can override the shut down or save their work and allow the shut down. Some software programs automatically save any open files the user may have inadvertently left open before shut down so that no work is lost. For districts with a large number of networked desktop computers, the payback period on the software may only be a period of months.

Information technology (IT) departments and energy managers sometimes disagree regarding turning off computers at the end of the day. PCs that are off use virtually no electricity, which maximizes savings for the energy manager. IT department personnel often want to push software updates during nights and weekends, and, therefore, want machines left on. Remote management software can wake up computers, push software updates, then turn the computers off again. Also, some available software can provide audit reports prior to activation to assist in determining actual energy savings. In other words, before sending out the shut down signal, the number of computers left on is determined.

When deciding whether or not to invest in remote management software to enhance energy savings, districts should take a look at their long range IT plans. The software provides the greatest potential for energy savings, and the shortest payback period, when controlling desktop computers, since they use the most energy. Networked laptop computers can also be controlled; however, the reduction in electric use will not be as great. Also, in some schools laptops are charged overnight and used only from battery power during the day. We understand that the future of computing in schools may head toward the use of dumb terminals, which are basically a monitor and a keyboard, without any processing capabilities. Energy consumption by these units would be quite low, so the purchase of remote management software may not be a good long term investment if the use of dumb terminals is planned. The software is often purchased with a license that expires after a given period of time, such as one year or five years. Therefore, the length of the license purchased should be considered in terms of how long it will benefit the district. The selection and implementation of computer management software should be a joint effort between the IT department and energy manager.

Renewable Energy Demonstration

See Section 9.0. Recommend including small photovoltaic renewable energy demonstration project at an elementary school and a middle school. See Section 10.0 on potential sources for rebates and grants.

Power Factor

Power factor is a measure of how efficiently electrical equipment uses the electricity supplied to it. Many devices consume electrical power that cannot be converted to useful work (lighting a bulb or turning a motor for example). However, electric circuits must still have the capacity to carry this "unusable" power. The more facilities require, the larger utility transformers and wires must be. Higher power factors allow utility systems to carry more power, therefore, many utility companies (such as Oncor) bill larger customers for low power factor. Capacitors reduce the amount of "unusable" power that equipment consumes and increases the power factor. Contributors to low power factor are generally motors and magnetic ballasts. Retrofitting these components with high power factor models can raise a facility's overall power factor. Where retrofits are impractical or have already been completed, installing capacitors will be necessary to improve the power factor.

For each meter with power factor penalty charges, peak demand (kw) and power factor was taken from bills obtained from Reliant Energy for a 12-month period. Billing demand (the higher of the actual kW for the current billing month or 80% of the highest monthly kW established in the 11 months preceding the current billing month), adjusted billing demand (billing demand (kw) x 0.95 / power factor), and the amount of the power factor penalty charges were estimated from this billing data. Oncor imposes a penalty for any billing month where the power factor is below 0.95 at the time of the monthly peak.

Of the five campuses evaluated, the following locations were found to have been billed for low power factor in the past 12 months:

Rockwall High School	(ESID 6968555)
Cain Middle School	(ESID 9137594)
Doris Cullins-Lake Pointe Elementary School	(ESID 5357485)
Amy Parks-Heath Elementary School	(ESID 7738068)
Pullen Elementary School	(ESID 9245784)

The amount of correction, in kilovars (kvar), needed to bring the power factor to a minimum of 0.95 was then calculated in order to size power factor correction capacitors. An estimated cost was also determined.

A capacitor installation consists of the capacitors plus controls to measure the actual power factor and adjust the amount of correction as required. Since the capacitors will be used to improve the entire facility's power factor, the units should be installed near the main electrical service entrance. This location would ideally be in the main electrical room if space is available. If any equipment in the school has variable speed drives, special engineering studies may be necessary to determine the proper method of installation.

The billing data obtained reflects current conditions. Additions or changes in major equipment or significant changes in building electrical use could change power factor correction requirements.

Recommend evaluating all campuses for need/benefits. Typically larger facilities are more likely to benefit.

POWER FACTOR CORRECTION SUMMARY (Units sized for month requiring maximum correction)							
Facility	ESID	Month	P.F.	Annual Penalty (Est.)	Capacitor Unit Size (Est.)*	Cost (Est.)**	Payback, years (Est.)
Rockwall HS	6968555	Sep-09	0.894	$3,073	250	$25,000	8.1
Cain MS	9137594	Aug-09	0.907	$1,100	100	$10,000	9.1
Doris Cullins Lake Pointe ES	5357485	Aug-09	0.876	$952	100	$10,000	10.5
Amy Parks-Heath ES	7738068	Aug-09	0.852	$1,058	100	$10,000	9.5
Pullen ES	9245784	Aug-09	0.866	$1,024	100	$10,000	9.8

* Next standard size larger than calculated required capacitance

** Cost includes capacitor unit and standard installation only. Special circumstances at a location may increase cost.

Other

- Demand control ventilation with CO_2 sensors
- Groundsource heat pumps
- High efficiency equipment
- For unitary direct expansion include energy reclaim from condenser as part of humidity control strategy as well as energy.
- Upgrade EMCS when replace old HVAC
- Add portable buildings to EMCS
- Use of foam type hand cleaner dispensers to reduce water consumption.
- Light or white color roofs
- Update district standards
- High efficiency chillers
- Variable speed pumping and airflow

9.0 RENEWABLE ENERGY

Solar Hot Water

Solar hot water (solar water heating) involves heating water through the use of solar energy. Systems typically consist of solar collectors, a storage tank, pump, controller, and interconnecting piping. Solar water heating can be used to supply some or all of a facility's hot water needs. The application tends to be most economical where large quantities of hot water are needed, but can be used wherever hot water is required.

Flat plate solar collector installation

The most common types of solar collectors are flat plate and evacuated tube. A flat plate collector consists of a network of pipes passing through a glass-covered box. The surface behind the pipes is painted black to absorb more heat energy from the sun. This heat is transferred to the pipes within the collector. With evacuated tube types, a glass tube surrounds each individual pipe in a vacuum. The vacuum nearly eliminates the influence of the ambient air temperature. Evacuated tubes perform better than flat plate collectors in cloudy weather and can achieve higher temperatures. They are also more expensive. Solar collectors are usually mounted on the roof. An unshaded, south facing roof is optimal.

Most commercial systems are closed loop systems. This means that the domestic water does not actually pass through the solar collectors. Instead, a heat transfer fluid, generally a glycol solution, is circulated through the collectors where it picks up heat. The heated solution the goes through a heat exchanger where it transfers heat to the water. The cooled solution then circulates back to the collectors where it picks up more heat, and the process is repeated.

A system controller starts and stops the pump that circulates the heat transfer fluid. Sensors measure temperature readings in the storage tank and collectors and cause the pump to be switched on and off as needed.

System first costs are approximately $100 to $125 per square foot of collector area, which is based on the system hot water demand. Costs can vary depending on the system type selected. Where existing water heating by natural gas fired heaters, paybacks can be long. However, if replacing or supplementing electric water heating, payback periods can be shortened.

For the RISD schools included in this study:

<u>Amy Parks-Heath Elementary</u>
The existing domestic hot water system is natural gas; therefore, solar water heating is not recommended.

<u>Doris Cullins-Lake Pointe Elementary</u>
The existing domestic hot water system is natural gas; therefore, solar water heating is not recommended.

<u>Dorothy Pullen Elementary</u>
The existing domestic hot water system is natural gas; therefore, solar water heating is not recommended.

Cain Middle School
The existing domestic hot water system is natural gas; therefore, solar water heating is not recommended.

Rockwall High School
The existing domestic hot water system is natural gas; therefore, solar water heating is not recommended.

Solar Power/Photovoltaics

Photovoltaics (PV), is the direct conversion of sunlight into electricity. Sunlight striking the solar cells activates them to produce electric current.

A PV system consists of hundreds or even thousands of solar cells. An outer glass cover protects each cell. Individual cells vary in size from about ½" to 4" across. Cells are arranged in rows into modules. An assembly of modules is called an array. The quantity of arrays needed is dependent on the power requirements of the application. In general, on the order of 100 square feet of area is needed per kilowatt (kw) of capacity. For reference, an installation large enough to provide all the power needed for a typical elementary school at peak would be about the size of a football field.

In addition to arrays of cell modules, an installation includes other components such as inverters (to convert the dc power generated by the cells to ac power), controls, wiring, etc.

Photovoltaic systems may be stand-alone or hybrid. In the stand-alone mode, the PV system provides all the electrical needs of the facility it serves. A hybrid system is combined with another power source, usually the electric utility. The utility provides power beyond what the PV system is able to supply. The electric utility will require that the PV system meet certain standards before allowing it to connect to their system. In some cases, the electric utility may purchase excess power produced by the PV system when the school does not need it (e.g. nights and weekends).

High initial costs and large physical size of installations generally make photovoltaics unsuitable for supplying all power needs to schools. However, the technology could be useful for providing some fraction of energy needs or to small remote users such as entrance signs, etc. A smaller demonstration project for students to see this technology in action might also be practical.

The following table shows the potential power that may be generated from a PV array in the north Texas area, as well as estimated costs.

Kw	Area (ft^2)	Est. annual energy production (kwh)	Est. system cost ($)
1	125	1,300	8,000
10	1,250	13,000	70,000
25	3,125	33,000	150,000
50	6,250	66,000	300,000
100	12,500	132,000	600,000

PV systems that generate large amounts of energy represent big initial investments and can take up large amounts of space. However, demonstration or smaller projects may be feasible. For additions or future schools, the district might consider incorporating PV into structures such as canopies or covered walkways. For smaller projects funding assistance or rebates may be available from Oncor. Additionally, the district should monitor the availability of funds from the State Energy Conservation Office.

Amy Parks Elementary
Space appears to be available on the south side of the site for a PV array.

Cullins-Lake Pointe Elementary
There appears to be space available on the site for a small (demonstration) size PV installation.

Dorothy Pullen Elementary
This site is crowded even for a demonstration size.

Cain Middle School
There appears to be space available on the site for a small (demonstration) size PV installation.

Rockwall High School
The site does not appear to be conducive to a visible PV installation. Limited space may be available for a small demonstration project that is accessible only to students.

Wind Power

Wind power turns the wind's energy into electrical energy that can be put to practical use. This is done thorough wind turbines, which closely resemble the windmills of yesteryear. Wind turbines can be used to supply power in a wide range of applications, from small users in rural areas to large-scale utility company wind farms.

A wind turbine typically consists of a rotor with blades that turn a generator at the top of a tower. The tower is typically some 80 to 120 feet tall, depending on the size of the generator and prevailing wind conditions. Towers are tall to take advantage of the fact that wind speed generally increases with height. Also, a tall tower decreases interference that might be created by obstacles such as hills, buildings, and trees nearby.

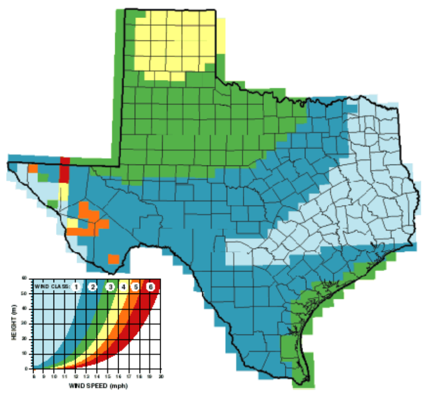
When the wind exceeds the minimum required speed for rotation, the rotor begins to turn. The rotor is connected to an electric generator through a shaft and gearbox. As long as the generator is kept turning, it creates electricity.

To be effective, wind turbines must be used in locations with adequate average wind speeds. Areas of west Texas, the Panhandle, and High Plains are considered good, while central and east Texas are generally marginal to poor. Although wind power can be utilized anywhere, lower wind speeds reduces the potential energy production.

Installations may be stand-alone or connected to the utility grid. The electric utility will require that the system meet certain standards before allowing it to connect to their system. In some cases, the electric utility may purchase excess power produced by the system when the school does not need it (e.g. nights and weekends).

Wind power systems cost approximately $3,000 to $5,000 per kw. They do require some annual maintenance.

The map below illustrates wind power potential for the state of Texas. Areas that are classified as class 3 or better (green yellow, red, or orange) are considered to have good potential for widespread use of wind turbines. Rockwall ISD falls in the class 2 (dark blue) area; therefore, the extensive use of wind power is not recommended. However, smaller installations for demonstration purposes may be appropriate.



Amy Parks Elementary

Site space is limited. However, there may be room for a small (demonstration size) wind turbine

Cullins-Lake Pointe Elementary

Because the school is in a residential area with limited site space, a wind turbine installation is not recommended.

Dorothy Pullen Elementary

Space is available for a wind turbine on the site. Due to area wind conditions and limited wind power potential, a wind turbine is not recommended.

Cain Middle School

Space is available for a wind turbine on the site. Due to area wind conditions and limited wind power potential, a wind turbine is not recommended.

Rockwall High School

Due to the proximity of the school to neighboring facilities and limited space on the site, a wind turbine installation is not recommended.

Summary

The following is a summary of renewable energy potential, costs, and benefits:

- Renewable energy installations could be used to promote community awareness and student learning.
- Renewable energy can offset some purchased energy (electricity and natural gas) requirement.
- Economic paybacks can be long, and in some cases exceed the expected life of the equipment.
- The District should contact local utility companies for any rebates and incentives that may be available and be on the lookout for any stimulus program grants that may be offered.
- Demonstration renewable is suitable for awareness and student learning.
- Benefits will be maximized if grants and rebate is obtained.
- At this time recommend district consider small (1KW) photovoltaic demonstration unit and apply for rebate/grant. Monitor large grant sources for photovoltaic.
- Solar photovoltaics (PV) is the most suitable renewable energy application for RISD. Systems costs are high and paybacks are long in today's market compared to purchasing retail electricity. For any LEED certified, Net Zero Energy, or other green building type approaches, PV would be the best renewable type option.
- Review codes/ordinances for any restrictions on renewable energy, screening, etc.

10.0 GUIDELINES TO ASSIST IN DEVELOPING LONG-RANGE ENERGY PLANS (PER SB 300) FOR PUBLIC ENTITIES

Background

The 2009 Texas Legislature passed SB 300 that accomplished the following;

- Requires a school board approved long range plan to reduce annual electric consumption by 5%.
- Repeals requirements to reduce electric consumption by 5% each year for 6 years.
- Left reporting and posting of energy requirements intact (HB 3693 from 2007 session).

SB 300 requires five percent annual electric consumption reduction beginning with 2008 state fiscal year and consume electricity in subsequent fiscal years in accordance with the district's energy plan. The act applies beginning with the 2009-2010 school year.

The district plan must include strategies for achieving energy efficiency that result in net savings for the district or can be achieved with financial cost to the district. For each strategy in the plan include short term capital cost and lifetime cost and savings that may result from implementation of the strategy. In determining if a strategy may result in financial cost to the district, consider the total net savings that may occur over the seven year period following implementation of the strategy.

Helpful Hints

- Read and understand SB 300
- Document 2008 state fiscal year electricity and natural gas consumption
- Determine if district is complying with prior requirement left intact by SB 300 (i.e. HB 3693) for reporting and posting energy consumption.
- Establish an energy tracking system and keep updated monthly
- Document maintenance, operations, and custodial strategies to reduce energy usage.
- Document energy efficiency projects already accomplished
- Document energy efficiency projects in progress
- Assign someone for responsibility of energy manager in district
- Perform energy audits of existing facilities
- Develop strategies for reducing energy consumption that had no first cost
- Prioritize strategies
- Document plan in accordance with SB 300

11.0 FUNDING OPTIONS

School Districts have traditionally tapped bond money, maintenance dollars, or federal grants to fund energy efficient equipment change-outs or additions such as energy efficient lighting systems, high efficiency air conditioning units, and computerized energy management control systems. Today, a broader range of funding options is available. Consult with district financial consultant and attorney. A number of these are listed below.

Texas LoanSTAR Program
The LoanSTAR (Saving Taxes and Resources) Program, which is administered by the State Energy Conservation Office, finances energy-efficient building retrofits. The program's revolving loan mechanism allows borrowers to repay loans through the stream of cost savings realized from the projects. Projects financed by LoanSTAR must have an average simple payback requirements and must be analyzed in an Energy Assessment Report by a Professional Engineer who meets criteria. Upon final loan execution, the District proceeds to implement funded projects through the traditional bid/spec process. For more information contact Juline Ferris at 512/936-9283 for more information.

Capital Acquisition Program or Municipal Financing Program
This program also offers loans to purchase and install energy-saving equipment. The minimal loan amount is $100,000 and interest rates are competitive. Rates depend on current financial market conditions, the length of the loan, and the District's bond rating. Loan terms are set at three year, four year, seven year, or ten year periods and are not related to project payback. The application procedure is simple: completion of a one-page form and submission of the most recent budget and audit. For more information call 512/467-3695 or contact Texas Association School Boards.

Private Lending Institutions or Leasing Corporations
Banks, leasing corporations, and other private lenders have become increasingly interested in the energy efficiency market. The financing vehicle frequently used by these entities is a municipal lease. Structured like a simple loan, a municipal leasing agreement is usually a lease-purchase arrangement. Ownership of the financed equipment passes to the District at the beginning of the lease, and the lessor retains a security interest in the purchase until the loan is paid off. A typical lease covers the total cost of the equipment and may include installation costs. At the end of the contract period a nominal amount, usually a dollar, is paid by the lessee for title to the equipment.

Rebates
Many electrical transmission and distribution companies offer rebates for energy projects that reduce the peak electrical demand (kw). Contact the provider in your area for detail. For example Oncor offers energy efficiency rebates for various projects such as upgraded new energy efficient air-conditioning, lighting, and others. The availability of rebates, the amounts, and eligibility requirements vary. Contact the provider before beginning a project as most times they require prior approval and documentation of existing conditions or items to be upgraded.

Grants
There are numerous sources of grants and their requirements, availability, and eligibility vary at times. Examples of some opportunities to monitor included the following:

- State Energy Conservation Office (SECO) monitor SECO's website and the Electronic State Business Daily
- Oncor school matching grant (www.takealoadofftexas.com)
- Oncor Solar PV Program (www.txreincentives.com/opv/)

- Discretionary and other grants offered by the federal government may be searched at www.grants.gov
- Foundations
- Public Independent School District Energy Efficiency Grants. Monitor SECO (www.seco.cpa.state.tx.us) and the Electronic State Business Daily
- Renewable energy technology grants (SECO).
- Alternative fuel and hybrid vehicle grant program (SECO).

Stimulus
The American Recovery and Reinvestment Act (ARRH), provides stimulus funding in various methods and for different energy projects. The Texas Comptroller of Public Accounts provides convenient Stimulus Tracking Reports (www.tx.comptroller@service.govdelivery.com) For energy project announcements refer to SECO website.

Qualified School Construction Bonds (QSCB's) and Build America Bonds (BAB)
QSCB and BAB bonds are debt financing tools that came out of the federal AARA stimulus. Recent legislation revised the process of QSCB's and BAB. The Hiring Incentives to Restore Employment (HIRE) Act is supposed to simplify the process and result in reduced interest cost to the district. The bonds are taxable to the purchaser and they receive the interest (currently about 5.76 percent).

The federal government pays the district the "lesser of" the taxable issuance rate or the current tax credit rate as of sale date. The district under current conditions pays near zero interest. Depending on use of the QSCB, districts can potentially use with maintenance tax note.

For BAB this is a 30 year taxable bond and the district receives a federal subsidy.

The conditions and suitability of the above bonds are subject to change. Consult with the district's financial consultant with these and all other financial methods, instruments, and options.

Bonds
Traditional school bonds are approved by the voters. These bonds are tax-exempt. Typically these bonds are used for new construction, major renovations, and infrastructure upgrades. Consult district financial planner.

Department of Energy Resource
Refer to DOE's Guide to Financing Energy Smart Schools. See www.eere.energy.gov

12.0 PROCUREMENT METHODS

School Districts have several options available for procurement methods. The following are some of the options available.

Competitive Bidding

Plans and specifications are prepared for specific projects and competitive sealed bids are received from contractors. This traditional approach provides the District with more control and projects are specifically defined. Competitive pricing is achieved because the contractors are competing for the same equipment and work. This method results in lower cost and better quality.

Design/Build

Design/Build contracts are usually structured where the Engineer and Contractor are under the same contract to the District. This team approach was developed for fast-track projects, and to have a contractor involved in decisions during the process of preparing plans/specifications. The disadvantage is that the District does not have the independence of the Engineer to totally represent the District. There is less control and protection for the District in substitution of equipment and in quality control.

Purchasing Standardization Management

Purchasing Standardization Management may result in significant dollar savings if integrated into facility improvements that are being planned. The benefits of this approach are in part dependent on market conditions such as stability of pricing, forecasting, and availability of commodities, equipment and labor. For example, District have standardized purchasing of District-wide energy management controls, air conditioning equipment, etc. This approach includes the traditional competitive bidding with pricing structured for present and future, or phased purchasing.

Performance Contracting

Performance contracting is a procurement method of that guarantees performance of selected energy conservation measures. An agreement between the company and the school district is executed. The intent is to structure the agreement where the energy savings will meet the district's debt obligations of the contract.