Technical Resource Manual

for

Church & Congregational Buildings

June 24, 2020

Comprehensive Services Program

DREMC Representative

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Introduction

Duck River Electric Membership Corporation (DREMC) requested that the Comprehensive Services Program (CSP) prepare this resource manual as a tool for DREMC members to improve energy efficiency at church and congregational buildings. CSP is a partnership between DREMC and TVA that provides engineering and technical services promoting the efficient use of electrical energy for commercial and industrial members. Some of the services provided by CSP are: Energy Audits, Power Quality Studies, Electrical Metering, Lighting Recommendations, HVAC Sizing/Replacement Analysis, Infrared Studies, Power Factor Studies, and Ultrasonic Testing/Compressed Air Leak Scans. Our mission is to serve the people of the Tennessee Valley to help the region thrive and grow.

Electric Billing

The electric bill for commercial members consists of several charges. These are primarily the customer charge, demand charge (based on peak kilowatts), energy charge (based on used kilowatt-hours) and fuel cost adjustment.

- **Customer Charge:** The customer charge is fixed and covers the utility's administrative expenses. Grid access and facilities charges cover utility fixed costs.
- **Demand Charge:** The demand is the average electrical load (measured in kW), measured over 30 minutes. The demand charge is the charge for the highest kilowatt demand recorded during the billing period.
- **Energy Charge:** The energy charge is the charge for the use of energy during the billing cycle (measured in kilowatt-hours).
- **Fuel Cost Adjustment:** A fuel cost adjustment charge is added to the energy rate and is based on the cost of fuel purchased to generate electricity such as coal and natural gas.

Most church buildings are billed based on either the GSA-1 or GSA-2 rate structure. Constraints for the following GSA-1 and GSA-2 rate classes for DREMC members are listed below:

GSA-1 rates are applied to members when the contract demand or actual demand is less than 60 kW and the energy takings for one month are less than 15,000 kWh.

GSA-2 rates are applied to members when the contract demand or actual demand is greater than 60 kW and less than 1,000 kW or the energy takings for one month are greater than 15,000 kWh.

Billing examples showing how the customer, demand, energy, and fixed charges apply are shown for the GSA-1 and GSA-2 rate structures in the following examples.

Electric Billing Examples

The following examples are based on the current rate structures and statement of amounts for DREMC for May 2020. The rate structures and statement of amounts are subject to change and are shown here to provide an understanding of how an electric bill is currently determined by the GSA-1 and GSA-2 rate structures.

GSA-1 Billing Example

GSA-1 member with an energy consumption of 5,000 kWh and 30 kW.

Charge Type	**$ Amount**				
Customer Charge	$42.98	x	1	=	$42.98
Grid Access Charge	$1.02	x	1	=	$1.02
First 1,000 kWh	$0.09863	x	1,000	=	$98.63
Next 2,000 kWh	$0.09874	x	2,000	=	$197.48
Over 3,000 kWh	$0.09249	x	2,000	=	$184.98
				Total	$525.09

GSA-2 Billing Example

GSA-2 member with an energy consumption of 16,000 kWh and 75 kW with a 12-month demand maximum of 90 kW.

Charge Type	**$ Amount**				
Customer Charge	$103.00	x	1	=	$103.00
Facilities Charge	$1.00	x	90	=	$90.00
kW, 0-20	$6.00	x	20	=	$120.00
kW, 21-1,000	$14.07	x	55	=	$773.85
1st 7,500 kWh	$0.07851	x	7,500	=	$588.83
Additional kWh	$0.05523	x	8,500	=	$469.46
				Total	$2,145.13

Energy Benchmarking

Energy Utilization Index

Benchmarking energy data can be a useful tool to determine how a building is operating in comparison to similar buildings. Items that are needed to determine a building's Energy Utilization Index (EUI) are the following: building square footage, electric utility billing energy consumption (kWh) for one year, and gas utility billing energy consumption (Therms or CCF) for one year. The electric and gas energy consumption values are to be converted to a similar unit of measure, the unit of measure typically used to determine the EUI is the Btu or kBtu. The EUI is determined by the energy use per unit area per year or (kBtu / yr / ft^2). **A lower EUI indicates that the building is operating more efficiently.**

The table provided below is taken from the 2019 ASHRAE (American Society of Heating, Refrigerating, and Air-Conditioning Engineers) HVAC Applications manual and provides the benchmarking values for church and congregational buildings. The data provided in the table below is originally from the Department of Energy's Energy Information Administration 2012 Commercial Buildings Energy Consumption Survey.

Benchmarking Values for Church and Congregational Buildings

Calculated, Weighted Energy Use Index (EUI) Values Site Energy, kBtu /yr / ft^2						
	Percentiles					
Building Use	10th	25th	50th	75th	90th	Mean
Religious Worship	9.3	17	33	63	88	46

Energy Star Benchmarking

Energy Star's Portfolio Manager is a free, online tool that provides benchmarking and allows energy use tracking and analysis to help energy consumers save energy. Energy Star also provides an Action Workbook for Congregations which, contains a wealth of information that helps building owners and operators put a plan into action to save on energy costs.

The Energy Star for Congregations website is currently located at:

https://www.energystar.gov/buildings/owners_and_managers/congregations

Energy Saving Opportunities

Lighting

The replacement of existing lighting with lower wattage LED lamps/fixtures is typically one of the easiest and most cost-effective ways to reduce energy costs. Over the past few years, LED lighting prices have decreased while LED lighting has become more reliable in terms of operation and lifespan. The main emphasis for church and congregational buildings is to prioritize replacing higher wattage lighting with longer run times first to see a quicker return on the investment. An example of this would be a church office that may be occupied for 30-40 hours per week and the church sanctuary which may only be occupied on average for 8-10 hours per week. Since the church office lighting is in use 3-4 times longer than the sanctuary lighting, it will typically be more cost-effective to replace the church office lighting before the church sanctuary. Lamp and fixture types also play an important role in which type of lighting should be replaced. The example listed below shows typical lighting solutions for church and congregational building spaces. The hours of run time have been estimated based on typical use.

Demand - $14.07 / kW Energy - $0.05523 / kWh	Lighting Upgrade Summary											
Location	**Existing**	**#**	**Watts/ Fixture**	**Proposed**	**#**	**Watts/ Fixture**	**Annual Hours**	**Annual kWh Savings**	**kW Savings**	**Annual $ Savings**	**Equipment Cost $**	**Estimated Payback**
Interior Lighting												
Church Lobby	4F32T8	1	115	4 LED Tubes	1	60	2,080	115	0.06	$16	$20	1.3
Church Office	60 W Inc	1	60	LED A19	1	9	2,080	106	0.05	$14	$2	0.1
Church Gym	400 W MH	1	440	LED Fixture	1	165	3,650	1,004	0.28	$102	$200	2.0
Exterior Lighting												
Parking Lot	400W MH	1	440	LED Parking Lot	1	200	3,650	876	0.24	$48	$200	4.1
Wall Packs	400 W MH	1	440	LED Wall Pack	1	75	3,650	1,332	0.37	$74	$100	1.4

Warning: The above Energy Saving Opportunity (ESO) includes removing linear fluorescent lamps and potentially their associated ballasts and installing linear LED lamps. Since the new LED tubes may be wired with line voltage to the tombstones (end-caps), via bypassing or removing the ballast, there is a risk of a maintenance worker replacing an LED with a fluorescent lamp. There is a risk of lamp explosion if a fluorescent lamp is installed in a retrofitted fixture with line voltage to the tombstones. It is recommended to ensure all maintenance personnel are properly trained and all retrofitted fixtures are properly labeled if this ESO is implemented. It is strongly recommended that UL Certified products be used if current fixtures are retrofitted. Tube LED retrofits that are wired directly to line voltage, such as Type B or C LED retrofits should be installed with caution and the installations could pose possible safety hazards in the future.

Lighting General Recommendations

- Establish a regular cleaning schedule for lighting fixtures. Clean fixtures deliver more light. A fixture that is not cleaned in 18 months can lose approximately 10% of its initial lumen output.
- Develop regular "in-house" communications that remind building occupants to turn off all lights when not in use. Turn off lights when away from a space; when a space is unoccupied for any period of time; during downtimes like nights and weekends; and in common areas not in use, like copier rooms, lunchrooms, storage rooms, conference rooms, and restrooms. Occupancy sensors automate this process.
- Take advantage of daylight whenever possible, especially in areas with large, glass windows.
- Switch any incandescent lamps to LEDs.
- Any EXIT signs in the facility containing two 20-watt lamps should be changed to LED fixtures with one 2-watt lamp. These generally achieve payback in less than one year.
- Use timers or photocells to automatically turn on/off exterior lighting.

Occupancy Sensors

By automatically controlling lighting to turn lights off when spaces are unoccupied, occupancy sensor controls give building owners and operators additional opportunities to improve energy savings without compromising lighting service to building occupants. Occupancy sensors are recommended for all offices, mechanical rooms, conference rooms, restrooms, and special-use spaces. Due to the coverage provided, ceiling-mounted, dual-mode occupancy sensors are preferred. To ensure energy savings, it should not be possible to override the automatic "off" setting. Ensure that all controls (timers, occupancy sensors, photosensors) are calibrated and working correctly. The sensors should be mounted and positioned as recommended by the manufacturer.

Heating Ventilating and Air Conditioning (HVAC)

HVAC Replacement Strategy

Typically, air-source HVAC equipment is manufactured to provide a service life of 15-20 years. The most economical time to upgrade the efficiency of HVAC units is when they are at or approaching the end of their expected service life. At the next major equipment failure of any HVAC units approaching the end of their expected service life, it is recommended to consider replacement with a high-efficiency alternative. Specific information regarding recommended energy efficiency ratings as well as any incentive offerings can be found at TVA's Energy Right Solutions for Business & Industry website.

All commercial and industrial participants are welcome to apply for EnergyRight® Solutions for Business and Industry (ERSB+I) incentives. These incentives are subject to *eligibility requirements and program funding availability. References to potential incentive opportunities in this report are preliminary in nature and are included for information purposes only. Actual incentive opportunities may be different than those included in this report. For more information on available incentives, please visit the ERSB+I website: https://www.energyright.com/For-Business-%2B-Industry*

HVAC Controls

One of the best ways to reduce the energy consumption of HVAC systems is by providing better system control. HVAC systems controlled by either building automation systems (BAS) or programmable thermostats are capable of saving energy by using temperature setbacks to allow for decreased HVAC system run times.

During the cooling season, it is recommended to use temperature setbacks for all areas of the building that are capable of having higher temperature setpoints. It is recommended to stage the units' occupied temperature scheduled start time to avoid setting an electrical demand peak from having all units simultaneously operate due to the occupied temperature mode occurring at the same time.

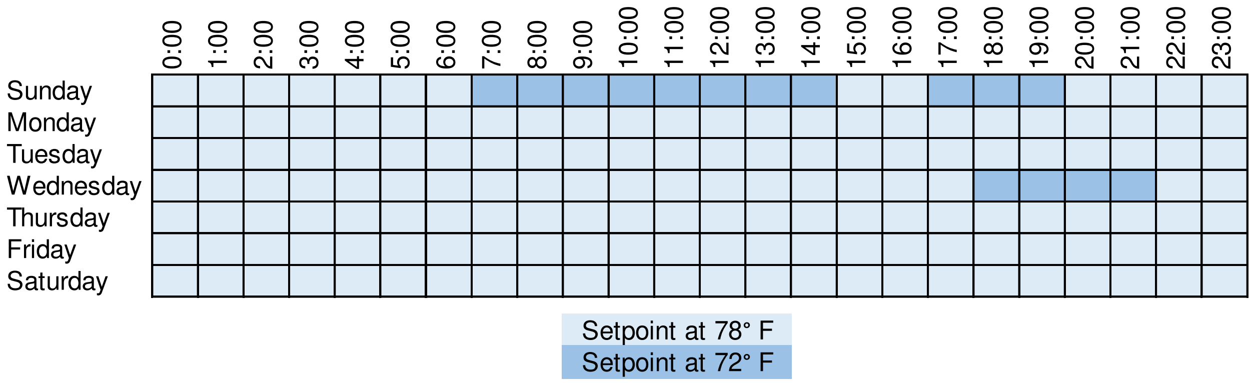
During the heating season, using temperature setbacks will depend on the type of heat source that is currently in operation. Temperature setbacks are recommended for gas units and dual-fuel units (heat pump with gas auxiliary/emergency heat). It is currently **not** recommended to use temperature setbacks for heat pump units with electric resistance auxiliary/emergency heat in most cases. When heat pump units with electric resistance heat strips are controlled with temperature setbacks, the auxiliary electric heating will operate to return the building temperature to the occupied setting as quickly as possible. Electric resistance heating is inefficient when compared to heat pump or gas heating. Heat pump units should typically be set to a comfortable temperature for occupants and remain at this set point during the heating season to avoid potential high demand and excessive use from electric resistance heating.

If a temperature setback strategy is used with heat pump units with supplemental electric resistance heat, a staging strategy is recommended to avoid setting demand peaks due to units operating simultaneously with electric resistance heating.

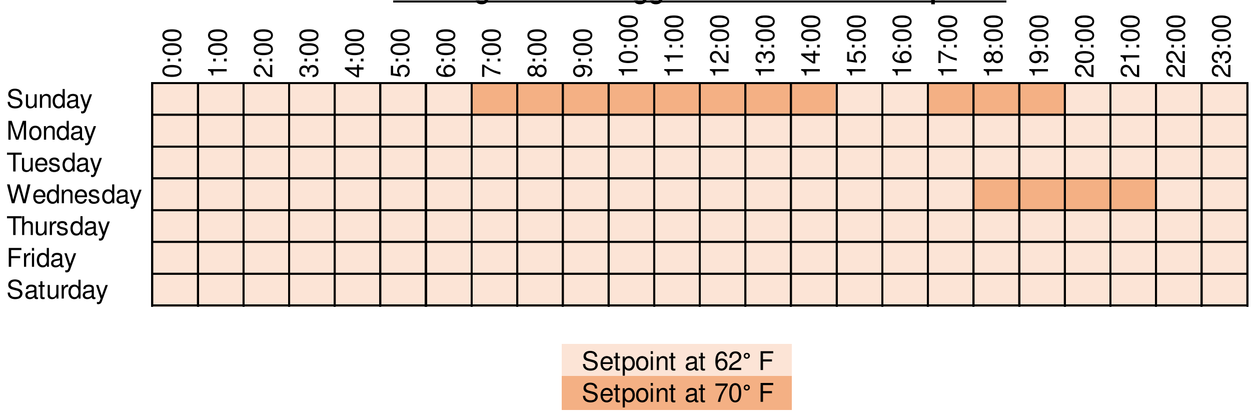
An example figure showing a possible temperature setback strategy for the cooling and heating seasons for a typical sanctuary space is shown in the tables below.

Example Temperature Setbacks for Churches and Congregational Buildings

Cooling Season Suggested Thermostat Setpoints



Heating Season Suggested Thermostat Setpoints



HVAC Building Envelope

The building envelope is defined as the building elements that separate conditioned spaces from the exterior or unconditioned areas of a building. The building envelope consists of the following elements: walls, roofing, flooring, windows, and doors. ASHRAE has compiled specific building requirements for the building envelope for climate zone 4, which most Tennessee counties fall under, including those in the DREMC service area. These requirements are provided below.

ASHRAE Standard 90.1 2019 Building Envelope Requirements for Climate Zone 4

	Nonresidential			*Residential*			Semiheated		
Opaque Elements	**Assembly Maximum**	**Insulation Min. *R-Value***		**Assembly Maximum**	**Insulation Min. *R-Value***		**Assembly Maximum**	**Insulation Min. *R-Value***	
Roofs									
Insulation entirely above deck	U-0.032	R-30 c.i.		U-0.032	R-30 c.i.		U-0.093	R-10 c.i.	
Metal building[a]	U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*		U-0.037	R-19 + R-11 *Ls* or R-25 + R-8 *Ls*		U-0.082	R-19	
Attic and other	U-0.021	R-49		U-0.021	R-49		U-0.034	R-30	
Walls, above Grade									
Mass	U-0.104	R-9.5 c.i.		U-0.090	R-11.4 c.i.		U-0.580	NR	
Metal building	U-0.060	R-0 + R-15.8 c.i.		U-0.050	R-0 + R-19 c.i.		U-0.162	R-13	
Steel-framed	U-0.064	R-13 + R-7.5 c.i.		U-0.064	R-13 + R-7.5 c.i		U-0.124	R-13	
Wood-framed and other	U-0.064	R-13 + R-3.8 c.i. or R-20		U-0.064	R-13 + R-3.8 c.i. or R-20		U-0.089	R-13	
Wall, below Grade									
Below-grade wall	C-0.119	R-7.5 c.i.		C-0.092	R-10 c.i.		C-1.140	NR	
Floors									
Mass	U-0.057	R-14.6 c.i.		U-0.051	R-16.7 c.i.		U-0.107	R-6.3 c.i.	
Steel joist	U-0.038	R-30		U-0.038	R-30		U-0.052	R-19	
Wood-framed and other	U-0.033	R-30		U-0.033	R-30		U-0.051	R-19	
Slab-on-Grade Floors									
Unheated	F-0.520	R-15 for 24 in.		F-0.520	R-15 for 24 in.		F-0.730	NR	
Heated	F-0.843	R-20 for 24 in.		F-0.688	R-20 for 48 in.		F-0.900	R-10 for 24 in.	
Opaque Doors									
Swinging	U-0.370			U-0.370			U-0.370		
Nonswinging	U-0.310			U-0.310			U-0.360		
Fenestration	**Assembly Max. U**	**Assembly Max. *SHGC***	**Assembly Min. *VT/SHGC***	**Assembly Max. U**	**Assembly Max. SHGC**	**Assembly Min. *VT/SHGC***	**Assembly Max. U**	**Assembly Max. *SHGC***	**Assembly Min. *VT/SHGC***
Vertical Fenestration, 0% to 40% of Wall									
Fixed	0.36	0.36	1.10 (for all types)	0.36	0.36	1.10 (for all types)	0.50	NR (for all types)	NR (for all types)
Operable	0.45	0.33		0.45	0.33		0.65		
Entrance door	0.63	0.33		0.63	0.33		0.77		
Skylight, 0% to 3% of Roof									
All types	0.50	0.40	NR	0.50	0.40	NR	0.75	NR	NR

* The following definitions apply: c.i. = *continuous insulation* (see Section 3.2), FC = filled cavity (see Section A2.3.2.5), *Ls* = *liner system* (see Section A2.3.2.4), NR = no (insulation) requirement.

a. When using the *R-value* compliance method for *metal building roofs*, a thermal spacer block is required (see Section A2.3.2).

HVAC Ventilation

Ventilation is the introduction of outside air into a building. Ventilation is necessary to provide indoor air quality (IAQ) that is acceptable to human occupants to minimize adverse health effects. Demand-controlled ventilation is recommended for congregational buildings since they are often unoccupied and will require much less ventilation during these times. Demand-controlled ventilation is typically controlled by measuring the carbon dioxide differential from the indoor space and the outdoor carbon dioxide levels. Economizers or separate outside air ventilation units are often used to bring in fresh, outdoor air into buildings. Economizers are known to fail (remain open) and may potentially be allowing ventilation rates much greater than what is actually required for the conditioned space. This can lead to bringing in hot/humid air during the summer or cold air in the winter. Both lead to increased run times of HVAC equipment to offset the introduction of the outside air into the conditioned space. It is recommended to have a trained HVAC technician check equipment at the beginning of each cooling and heating season to ensure the appropriate ventilation is being introduced into the conditioned space.

HVAC General Recommendations

- Monitor and reduce outside air infiltration.
- Inspect HVAC filters on a monthly basis and change as needed.
- Clean condenser coils on a regular basis to maintain cooling efficiency.
- Inspect weather strips on doors annually and replace them as needed.
- Inspect and caulk all windows and door jambs to reduce air infiltration.
- Have an HVAC technician check refrigerant levels, airflow distribution, and diagnose the units to determine if they are operating efficiently.

Appliances General Recommendations

- Look for the ENERGY STAR® label when replacing appliances.
- Use power strips for electronics, and turn off power strips when equipment is not in use.
- Use a timer on coffeemakers so that they are not operating during off-hours.
- Turn off computer monitors when they won’t be used for more than 15 minutes and at the end of the day, and use the Energy Star power management features on all devices. Screen savers do not save energy.
- Less frequently used devices like video equipment and phone chargers should be unplugged after use; they waste energy when they are off but plugged in.

- Monitors and other items such as chargers and task lighting can be powered down with the use of plug strips that have occupancy sensors. Room sensors can also be installed in individual, enclosed offices.

Disclaimer

This report was prepared by Tennessee Valley Authority (TVA) representatives as a service of Duck River Electric Membership Corporation (DREMC). DREMC and TVA partner to provide services to assist commercial and industrial members in the efficient use of electricity. Although this analysis has been performed using standard engineering methods and calculations, actual conditions may differ from those estimated in this report due to differences in the operation of equipment, weather, etc. No warranty or guarantee of any kind is given with regard to the information contained in this report. Any use made of this report or any information contained in it shall be at the user's sole risk and responsibility. DREMC and TVA do not endorse any suppliers of equipment or services that are referenced in this report for specifications or prices.