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# COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS

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# 1 SUMMARY

## 1.1 Executive Summary

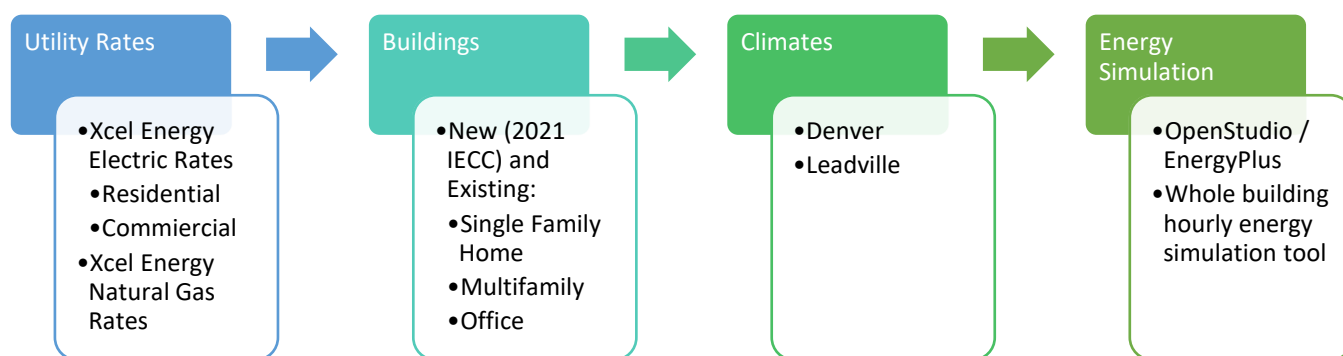
Group14 Engineering was contracted to perform a study of eleven electricity rates, including five residential rates and six commercial rates. These rates are applied to three building types: single family homes, multifamily, and office. The building types are modeled based on existing and new construction energy assumptions.

This report summarizes the modeling approach, each utility rate, and a summary of our findings. Using these modeling results, we developed an Excel application to compare electricity and natural gas rates.

## 2 MODELING APPROACH

### 2.1 Methodology

For this study, the following flow chart gives an overview of the process used to analyze the utility rates in different buildings and climates using the whole building energy simulation program OpenStudio / EnergyPlus.



The following describes the utility rates and the modeling assumptions used for the different buildings. The OpenStudio 3.3 interface for EnergyPlus 9.6 building energy simulation program is used to perform a detailed analysis of all energy flows within, into, and out of a building, doing a separate calculation for each hour of the year. The model includes details of architectural, mechanical, and lighting systems, as well as all interior loads such as occupants and plug loads. Potential outputs are extensive and include hourly monthly and annual energy use, energy cost, and details of HVAC system performance.



## 2.3 Utility Rates

The detailed electricity and natural gas rates are shown in Appendix A.

### 2.3.1 Residential Rates

All single-family home energy models are modeled using the utility rates from the Xcel Energy electric tariff as filed in August of 2022:

#### SCHEDULE R – RESIDENTIAL GENERAL SERVICE:

This is a flat residential rate with seasonal energy charges (winter and summer). The summer season is from June 1 through September 30 and the winter season is from October 1 through May 31. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

#### SCHEDULE RD – RESIDENTIAL DEMAND SERVICE:

This is a residential rate that has not been available to new customers since December 31, 2016. This is a demand rate, with demand charges fluctuating with the winter and summer seasons. The energy charge remains constant throughout the year. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

#### SCHEDULE RD-TDR – RESIDENTIAL DEMAND-TIME DIFFERENTIATED RATES SERVICE:

This is a residential rate that was only available until January 1, 2022. This is a demand rate, differentiated by the seasons and distribution demand. There is also an energy charge that is constant throughout the year. The billing demand for the generation and transmission demand charge is the measured demand between 2:00 pm and 6:00 pm on all non-holiday weekdays. The distribution demand is charged based on the maximum measured demand used during the month. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

#### SCHEDULE RE-TOU – RESIDENTIAL ENERGY TIME-OF-USE SERVICE:

This is a residential rate with a scheduled time-of-use rate, differentiated by the winter and summer seasons. Each day also has an on-peak energy charge, a shoulder energy charge, and an off-peak energy charge. The on-peak period is on weekdays except holidays, between 3:00 pm and 7:00 pm. The shoulder period is on weekdays except holidays, between 1:00 pm and 3:00 pm. The off-peak period is all other hours on weekdays and all hours on weekends and holidays. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

#### SCHEDULE R-OO – RESIDENTIAL GENERAL SERVICE OPT-OUT:

This is a residential rate that is only available to customers opting out from Schedule RE-TOU. This is a flat rate, with different energy charges in the summer and winter seasons. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

### 2.3.2 Commercial Rates

#### SCHEDULE C – COMMERCIAL SERVICE:

This is a commercial rate available to commercial and industrial customers with demand less than 50 kW at secondary voltage. This is a flat rate with energy charges varying by winter and summer seasons. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

#### SCHEDULE C-TOU – SMALL COMMERCIAL TIME-OF-USE SERVICE:

This rate is available to commercial and industrial customers with demand less than 50 kW at secondary voltage. This schedule is a time-of-use rate, differentiated by the winter and summer seasons. Each day also has an on-peak energy charge, a shoulder energy charge, and an off-peak energy charge. The on-peak period is on

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weekdays except holidays, between 3:00 pm and 7:00 pm. The shoulder period is on weekdays except holidays, between 1:00 pm and 3:00 pm and 7:00 pm and 9:00 pm. The off-peak period is all other hours on weekdays and all hours on weekends and holidays. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

**SCHEDULE SG – SECONDARY GENERAL SERVICE:**

This rate is available at secondary voltage to commercial and industrial customers. This is a demand rate that includes demand charges, including distribution demand (constant throughout the year) and generation and transmission demand charges (different for the winter and summer seasons). There is also a flat energy charge that remains consistent throughout the year. Billing for the generation and transmission demand charge is determined by the maximum measured demand in the month. The distribution demand acts as a ratchet that is determined by the greater of the measured demand during the month, or 50 percent of the highest measured demand occurring in the preceding twelve months. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

**SCHEDULE SG-TOU – SECONDARY GENERAL TIME-OF-USE SERVICE PILOT:**

This is a time of use rate available at secondary voltage to commercial and industrial customers with a maximum demand of 2,000 kW. This rate includes distribution demand charges as well as energy charges differentiated by summer and winter seasons, as well as on-peak, shoulder, and off-peak times. The distribution demand acts as a ratchet that is determined by the greater of the measured demand during the month, or 50 percent of the highest measured demand occurring in the preceding twelve months. The on-peak period is on weekdays except holidays, between 3:00 pm and 7:00 pm. The shoulder period is on weekdays except holidays, between 1:00 pm and 3:00 pm and 7:00 pm and 9:00 pm. The off-peak period is all other hours on weekdays and all hours on weekends and holidays. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

**SCHEDULE SGL – SECONDARY GENERAL LOW-LOAD FACTOR:**

This is a demand rate available at secondary voltage to commercial and industrial customers. The demand charge is distribution demand, and the energy charges are different per the summer and winter seasons. The distribution demand acts as a ratchet that is determined by the greater of the measured demand during the month, or 50 percent of the highest measured demand occurring in the preceding twelve months. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

**SCHEDULE SG-CPP – SECONDARY GENERAL CRITICAL PEAK PRICING SERVICE:**

This is a demand rate available at secondary voltage to commercial and industrial customers with a maximum measured demand of at least 25 kW. The demand charges are determined based on distribution demand and generation and transmission demand charges. There are also critical peak pricing and non-critical peak pricing energy charges. The distribution demand acts as a ratchet that is determined by the greater of the measured demand during the month, or 50 percent of the highest measured demand occurring in the preceding twelve months. The billing demand for the generation and transmission demand charge is the maximum measured demand during the month. The critical peak pricing period is a consecutive 4-hour period between the hours of 12:00 pm and 8:00 pm. There are a maximum of 15 critical peaks during a calendar year and customers may only be subject to one critical peak pricing period per day.

**2.3.3 Natural Gas Rates****SCHEDULE R – RESIDENTIAL GAS SERVICE**

This is a flat residential rate. Natural gas base rates do not change with the seasons. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.



### **SCHEDULE CSG – COMMERCIAL SMALL GAS SERVICE**

This is a commercial natural gas rate that remains constant throughout the year. The natural gas usage charge does not change with the seasons. The applicable rate adjustments are included in our calculations, as well as the service and facility charge.

## **2.3.4 Rate Riders and Adjustments**

### **ELECTRIC RATE RIDERS AND ADJUSTMENTS**

The following rate riders and adjustments were included in the electric rates as applicable (see Appendix A for exact rider costs for each schedule):

- GRSA
- GRSA-E
- Purchased Capacity
- Demand Side Management
- Electric Commodity Adjustment
- Transmission Cost
- EEAC
- Decoupling Adjustment Pilot
- Renewable Energy Standard Adjustment
- Colorado Energy Plan Adjustment
- Franchise Fee

On average, rate riders, fees, and adjustments make up 36% of an electric bill. The Schedule SG-TOU rate has the highest impact from rate riders and adjustments at 50% of the total bill.

### **NATURAL GAS RATE RIDERS AND ADJUSTMENTS**

The following rate riders and adjustments were included in the natural gas rates as applicable (see Appendix A for exact rider costs for each schedule):

- GRSA
- GRSA-P
- Rate Deferral Surcharge
- Demand Side Management
- EGCR
- GCA
- GEAC
- Franchise Fee

On average, rate riders, fees, and adjustments make up 57% of a natural gas bill. Rate riders in this analysis were set at current values, but are adjusted quarterly.



## 2.5 Model Inputs

There are 9 new construction and 6 existing construction energy models used in our analysis. Each energy model is run using two weather files: Denver, CO and Leadville, CO. The new construction energy models comply with the 2021 IECC and the existing building models meet the requirements of ASHRAE 90.1-1975. The insulation levels and glazing values in the models vary based on the climate zone. HVAC efficiencies remain constant across climate zones, however natural gas efficiencies are derated to account for the changes in elevation.

Existing buildings are modeled to reflect the expected increase in infiltration as compared to new construction buildings. The HVAC service water heating efficiencies in the existing buildings are based on the 2005 IECC to reflect the probable replacement of HVAC and service water heating equipment since the construction of the existing buildings.

In the mixed-fuel single-family homes, stoves and ovens, space and water heating are assumed to utilize natural gas. All other appliances are assumed to be electric.

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Table 1: Single Family Home – Denver, CO

Location	Denver, CO			
Building Characteristics	2,820 SF, single family home			
Climate Zone   Degree Days	ASHRAE 90.1 -1975 - HDD65: 6020, CDD50: 2732   2021 - Climate Zone 5B			
Age	Existing		New	
Building Component	Gas	Electric	Gas	Electric
Floors	U-0.08		Wood joist, R-38 U-0.028	
Foundation	Unheated Basement, No Insulation, F-0.73			
Ceiling/Roof Insulation	U-0.074		Wood Joist Attic, R-60 (U-0.024)	
Exterior Wall	U-0.23		Wood framed, R-13+10 ci (U-0.045)	
Window Assembly	Operable windows, Assembly U-0.67, SHGC-0.39		U-0.30, SHGC-0.40	
Window-to-wall Ratio	15%			
Interior Lighting	Incandescent (1.1 W/SF)		LED (0.68 W/SF)	
Exterior Lighting	120 W		60 W	
HVAC	Central gas furnace (78% efficient) with outdoor condensing unit (SEER 10)	Split heat pump with back up electric heating (SEER 10, 6.8 HSPF)	Central gas furnace (93% efficient) with outdoor condensing unit (SEER 14)	Split heat pump with back up electric heating (SEER 14 and 8.0 HSPF)
Ventilation	Ducted through Furnace/FCU (105 CFM)		Ducted through Furnace/FCU (105 CFM)	
Exhaust Fans	Kitchen and bathroom exhaust fans			
Infiltration (non-pressurized)	0.68 ACH		0.2 ACH	
Economizer	N/A			
DHW Equipment	Gas storage heater (0.5 EF), 50 gallons	50 gallon 2.0 UEF/1.8 COP HPWH with supplementary electric resistance heat	Gas storage heater (0.6 EF), 50 gallons	50 gallon 3.0 UEF/2.23 COP HPWH with supplementary electric resistance heat
Setpoint Temperatures	68 deg F heating, 72 deg F cooling		68 deg F heating, 72 deg F cooling	
Electric Equipment Load	0.83 W/SF	0.87 W/SF	0.83 W/SF	0.87 W/SF
Gas Equipment Load	0.23 BTU/SF	0 BTU/SF	0.23 BTU/SF	0 BTU/SF



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Table 2: Single Family Home – Leadville, CO

Location	Leadville, CO			
Building Characteristics	2,820 SF, single family home			
Climate Zone   Degree Days	ASHRAE 90.1-1975 - HDD65: 8383, CDD50: 1400   2021 - Climate Zone 7			
Age	Existing		New	
Building Component	Gas	Electric	Gas	Electric
Floors	U-0.08		Wood joist, R-38 U-0.028	
Foundation	Unheated Basement, No Insulation, F-0.73			
Ceiling/Roof Insulation	U-0.06		Wood Joist Attic, R-60 (U-0.024)	
Exterior Wall	U-0.185		Wood framed, R-13+10 ci (U-0.045)	
Window Assembly	Operable windows, Assembly U-0.67, SHGC-NR		U-0.30, SHGC-NR	
Window-to-wall Ratio	15%			
Interior Lighting	Incandescent (1.1 W/SF)		LED (0.68 W/SF)	
Exterior Lighting	120 W		60 W	
HVAC	Central gas furnace (78% efficient) with outdoor condensing unit (SEER 10)	Split heat pump with back up electric heating (SEER 10, 6.8 HSPF)	Central gas furnace (93% efficient) with outdoor condensing unit (SEER 14)	Split heat pump with back up electric heating (SEER 14 and 8.0 HSPF)
Ventilation	Ducted through Furnace/FCU (105 CFM)		Ducted through Furnace/FCU (105 CFM)	
Exhaust Fans	Kitchen and bathroom exhaust fans			
Infiltration (non-pressurized)	0.68 ACH		0.2 ACH	
Economizer	N/A			
DHW Equipment	Gas storage heater (0.5 EF), 50 gallons	50 gallon 2.0 UEF/1.8 COP HPWH with supplementary electric resistance heat	Gas storage heater (0.6 EF), 50 gallons	50 gallon 3.0 UEF/2.23 COP HPWH with supplementary electric resistance heat
Setpoint Temperatures	68 deg F heating, 72 deg F cooling		68 deg F heating, 72 deg F cooling	
Electric Equipment Load	0.83 W/SF	0.87 W/SF	0.83 W/SF	0.87 W/SF
Gas Equipment Load	0.23 BTU/SF	0 BTU/SF	0.23 BTU/SF	0 BTU/SF

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Table 3: Multifamily Building – Denver, CO

Location	Denver, CO			
Building Characteristics	42,000 SF, 36 units			
Climate Zone   Degree Days	ASHRAE 90.1-1975 - HDD65: 6020, CDD50: 2732   2021 - Climate Zone 5B			
Age	Existing		New	
Building Component	Gas	Electric	Gas	Electric
Foundation	No insulation (F-0.73)		R-20 for 24" (F-0.51)	
Roof Insulation	U-0.074		R-30 Insulation entirely above deck (U-0.032)	
Exterior Wall	U-0.27		Steel-framed with R-13 cavity + R-7.5 continuous (U-0.051)	
Window Assembly	Operable windows, Assembly U-0.67, SHGC-0.39		Nonmetal framing, Assembly U-0.45, SHGC-0.33	
Infiltration (non-pressurized)	1.098 Flow per Exterior Surface Area (Apartment) 0.152 (All other spaces)		0.323 Flow per Exterior Surface Area (Apartment) 0.0446 (All other spaces)	
Window-to-wall Ratio	26%			
Interior Lighting	1.0 W/SF		0.68 W/SF	
Exterior Lighting	2 kW		1.5 kW	
HVAC	Combined heating fan coil units with split DX cooling and central natural gas water heaters (SEER 10, 78% efficient water heaters)	Split heat pump with back up electric heating (SEER 10, 6.8 HSPF)	Combined heating fan coil units with split DX cooling and central natural gas water heaters (SEER 14, 93% efficient water heaters)	1 - PTHPs (9.5 EER, 2.9 COP)  2 - Split HPs with individual ERV (SEER 14, 8.0 HSPF)
Ventilation	Ventilation provided through the unit - 30 CFM/bedroom		Ventilation provided through the unit - 30 CFM/bedroom	
Exhaust Fans	Exhaust fan (balanced ventilation)		Exhaust fan (balanced ventilation)	
Economizer	None			
DHW Equipment	Individual Gas storage heater (0.5 EF)	2.0 UEF/1.8 COP HPWH with supplementary electric resistance heat	Individual Gas storage heater (0.6 EF)	3.0 UEF/2.23 COP HPWH with supplementary electric resistance heat
DHW Load	4.706 gpm		4.706 gpm	
Setpoint Temperatures	70 deg F heating, 77 deg F cooling		70 deg F heating, 77 deg F cooling	
Electric Equipment Load	1.16 W/SF	1.16 W/SF	1.16 W/SF	1.16 W/SF
Gas Equipment Load	N/A	N/A	N/A	N/A
Residential Units	36 Units (6 1-bed, 18 2-bed, 12 3-bed)			

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Table 4: Multifamily Building –Leadville, CO

Location	Leadville, CO			
Building Characteristics	42,000 SF, 36 units			
Climate Zone   Degree Days	ASHRAE 90.1-1975 - HDD65: 8383, CDD50: 1400   2021 - Climate Zone 7			
Age	Existing		New	
Building Component	Gas	Electric	Gas	Electric
Foundation	No insulation (F-0.73)		R-20 for 48" (F-0.434)	
Roof Insulation	R-15 insulation entirely above deck (U-0.063)		R-35 Insulation entirely above deck (U-0.028)	
Exterior Wall	U-0.23		Steel-framed with R-13 cavity + R-7.5 continuous (U-0.051)	
Window Assembly	Operable windows, Assembly U-0.67, SHGC-0.39		Nonmetal framing, Assembly U-0.36, SHGC-0.36	
Infiltration (non-pressurized)	1.098 Flow per Exterior Surface Area (Apartment) 0.152 (All other spaces)		0.323 Flow per Exterior Surface Area (Apartment) 0.0446 (All other spaces)	
Window-to-wall Ratio	26%			
Interior Lighting	1.0 W/SF		0.68 W/SF	
Exterior Lighting	2 kW		1.5 kW	
HVAC	Furnaces with split DX cooling and gas heating (SEER 10, 78% efficient)	Split heat pump with back up electric heating (SEER 10, 6.8 HSPF)	Combined heating fan coil units with split DX cooling and central natural gas water heaters (SEER 14, 0.6 EF water heaters)	1 - PTHPs (9.5 EER, 2.9 COP)  2 - Split HPs with individual ERV (SEER 14, 8.0 HSPF, 0.75 effectiveness)
Ventilation	Ventilation provided through the unit - 30 CFM/bedroom		Ventilation provided through the unit - 30 CFM/bedroom	
Exhaust Fans	Exhaust fan (balanced ventilation)		Exhaust fan (balanced ventilation)	
Economizer	None			
DHW Equipment	(3) 80 gallons Gas storage heater (0.5 EF)	(3) 80 gallon 2.0 UEF/1.8 COP HPWH with supplementary electric resistance heat	(3) 80 gallons Gas storage heater (0.6 EF)	(3) 80 gallon 3.0 UEF/2.23 COP HPWH with supplementary electric resistance heat
DHW Load	4.706 gpm		4.706 gpm	
Setpoint Temperatures	70 deg F heating, 77 deg F cooling		70 deg F heating, 77 deg F cooling	
Electric Equipment Load	1.16 W/SF	1.16 W/SF	1.16 W/SF	1.16 W/SF
Gas Equipment Load	N/A	N/A	N/A	N/A
Residential Units	36 Units (6 1-bed, 18 2-bed, 12 3-bed)			

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Table 5: Office Building – Denver, CO

Location	Denver, CO			
Building Characteristics	110,000 SF			
Climate Zone   Degree Days	ASHRAE 90.1-1975 - HDD65: 6020, CDD50: 2732   2016 - Climate Zone 5B			
Age	Existing		New	
Building Component	Gas	Electric	Gas	Electric
Floors above semi-heated garage	U-0.08		Steel Joist with R-30 (U-0.033)	
Foundation	No insulation (F-0.73)		No insulation (F-0.73)	
Roof Insulation	U-0.074		R-30 Insulation entirely above deck (U-0.032)	
Exterior Wall	U-0.024		Steel-framed with R-13 cavity + R-10 continuous (U-0.055)	
Window Assembly	Fixed windows, Assembly U-0.57, SHGC-0.39		Metal framing fixed, Assembly U-0.36, SHGC-0.38	
Infiltration (non-pressurized)	0.152 Flow per Exterior Surface Area		0.0446 Flow per Exterior Surface Area	
Window-to-wall Ratio	40%		40%	
Interior Lighting	1.3 W/SF Office, 0.2 W/SF Parking Garage		0.79 W/SF, 0.15 W/SF Parking Garage	
Exterior Lighting	5 kW		2.5 kW	
HVAC	Packaged VAV + gas heat with fan powered boxes in exterior zones and electric reheat (9.2-9.5 EER, 9.4-9.7 IPLV and 80% efficient)	1 - Packaged VAV heat pump + ERV + electric reheat (9.2-9.5 EER, 9.4-9.7 IPLV and 3.1 COP)	1 - Packaged VAV + hot water reheat served by condensing boilers (9.7-10 EER 11.2-11.6 IEER and 93% efficient)  2 - Packaged VAV + gas heat with fan powered boxes in exterior zones and electric reheat (9.7-10 EER 11.2-11.6 IEER and 93% efficient)	1 - Packaged VAV heat pump + ERV + electric reheat (9.7-10 EER 11.2-11.6 IEER and 8.0 HSPF)  2 - VRF with heat pump DOAS + ERV (SEER 13, 10.8 EER and 12.7-14.4 IEER, 7.7 HSPF, 3.3 COP)
Ventilation	Ventilation provided through VAV - 17,227 CFM	Ventilation provided through VAV - 17,227 CFM	Ventilation provided through VAV - 17,227 CFM	Ventilation provided through VAV - 17,227 CFM  2 - Dedicated outdoor air unit with heat pump and packaged DX cooling (9.8 EER and 3.3 COP - 17,227 CFM)
Economizer	Fixed dry bulb 75 deg F			
DHW Equipment	Central natural gas water heating - 0.5 EF	Electric resistance water heating	Central natural gas water heating - 0.6 EF	Electric resistance water heating
DHW Load	1.78 gpm			
Setpoint Temperatures	68 deg F heating, 72 deg F cooling			

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Table 6: Office Building – Leadville, CO

Location	Leadville, CO			
Building Characteristics	110,000 SF			
Climate Zone   Degree Days	ASHRAE 90.1-1975 - HDD65: 8383, CDD50: 1400   2016 - Climate Zone 7			
Age	Existing		New	
Building Component	Gas	Electric	Gas	Electric
Floors above semi-heated garage	U-0.08		Steel Joist with R-38 (U-0.027)	
Foundation	No insulation (F-0.73)		No insulation (F-0.73)	
Roof Insulation	U-0.074		R-35 Insulation entirely above deck (U-0.028)	
Exterior Wall	U-0.026		Steel-framed with R-13 cavity + R-12.5 continuous (U-0.049)	
Window Assembly	Fixed windows, Assembly U-0.57, SHGC-0.39		Fixed windows, Assembly U-0.29, SHGC-0.40	
Infiltration (non-pressurized)	0.152 Flow per Exterior Surface Area		0.0446 Flow per Exterior Surface Area	
Window-to-wall Ratio	40%		40%	
Interior Lighting	1.3 W/SF Office, 0.2 W/SF Parking Garage		0.79 W/SF, 0.15 W/SF Parking Garage	
Exterior Lighting	5 kW		2.5 kW	
HVAC	Packaged VAV + gas heat with fan powered boxes in exterior zones and electric reheat (9.2-9.5 EER, 9.4-9.7 IPLV and 80% efficient)	1 - Packaged VAV heat pump + ERV + electric reheat (9.2-9.5 EER, 9.4-9.7 IPLV and 3.1 COP)	1 - Packaged VAV + hot water reheat served by condensing boilers (9.7-10 EER 11.2-11.6 IEER and 93% efficient)  2 - Packaged VAV + gas heat with fan powered boxes in exterior zones and electric reheat (9.7-10 EER 11.2-11.6 IEER and 93% efficient)	1 - Packaged VAV heat pump + ERV + electric reheat (9.7-10 EER 11.2-11.6 IEER and 8.0 HSPF)  2 - VRF with heat pump DOAS + ERV (SEER 13, 10.8 EER and 12.7-14.4 IEER, 7.7 HSPF, 3.3 COP)
Ventilation	Ventilation provided through VAV - 17,227 CFM	Ventilation provided through VAV - 17,227 CFM	Ventilation provided through VAV - 17,227 CFM	Ventilation provided through VAV - 17,227 CFM  2 - Dedicated outdoor air unit with heat pump and packaged DX cooling (9.8 EER and 3.3 COP - 17,227 CFM)
Economizer	Fixed dry bulb 75 deg F			
DHW Equipment	Central natural gas water heating - 0.5 EF	Electric resistance water heating	Central natural gas water heating - 0.6 EF	Electric resistance water heating
DHW Load	1.78 gpm			
Setpoint Temperatures	68 deg F heating, 72 deg F cooling			

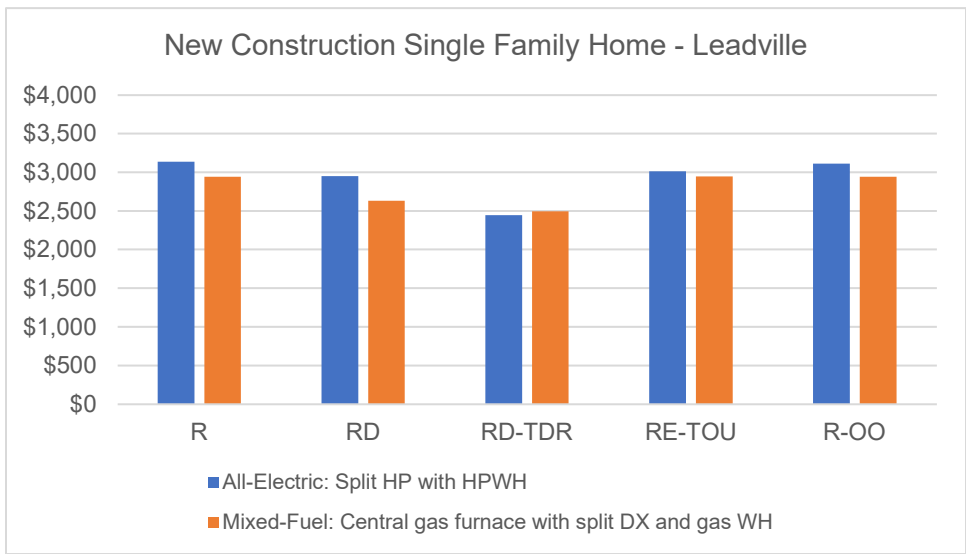
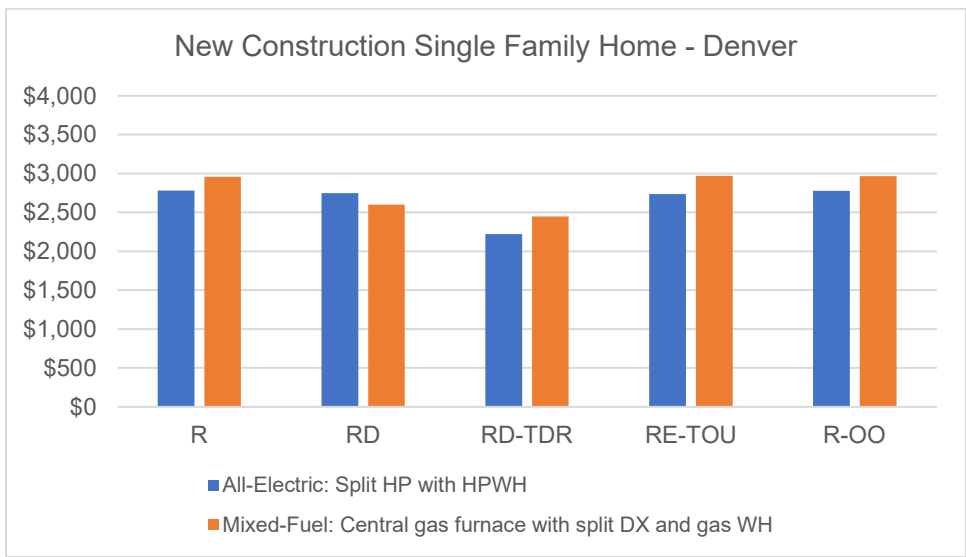


### 3 MODELING RESULTS

#### 3.1 Single Family Home

All-electric single-family homes have similar annual energy costs when compared to mixed-fuel homes. This is due to the high efficiency of the electric equipment and the recent natural gas cost increase.

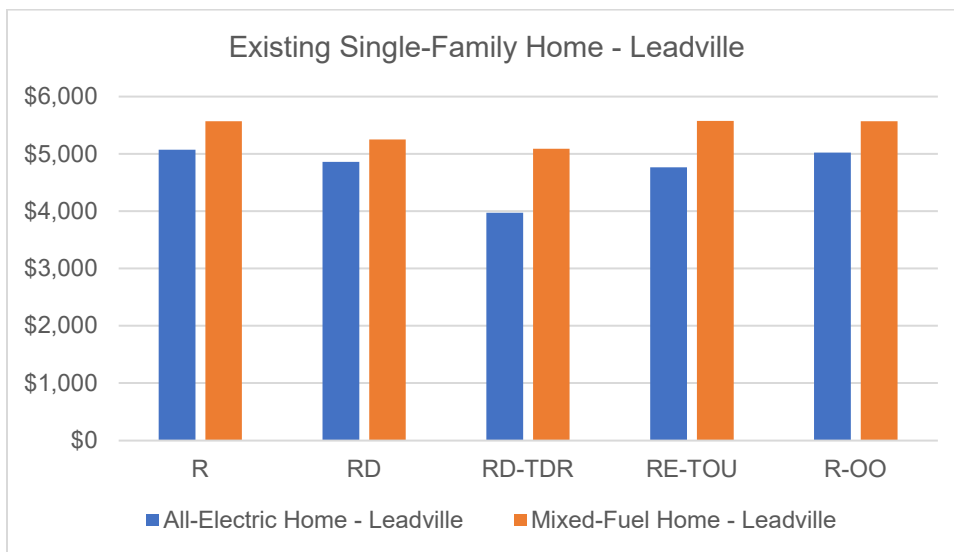
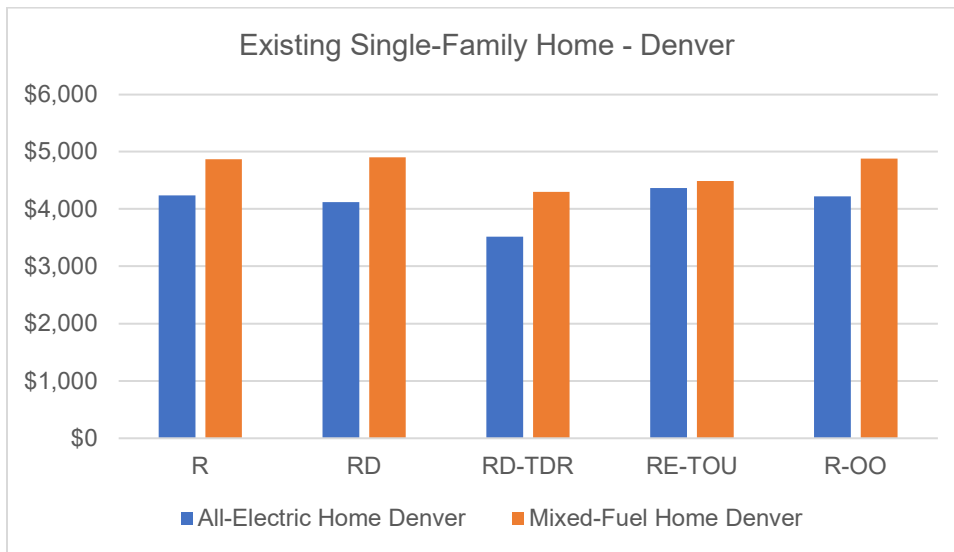
For the new construction single-family home with natural gas heating and domestic water heating, the lowest annual energy cost is seen when using Schedule RD-TDR. The all-electric new construction home has the lowest annual energy cost when using Schedule RD-TDR. The highest annual energy costs are Schedule RE-TOU for the mixed-fuel home and Schedule R for the all-electric home. This is consistent across the different climate zones.



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The existing mixed-fuel home has the lowest energy cost using Schedule RD-TDR. The existing all-electric home also has the lowest annual energy cost using Schedule RD-TDR. The highest annual energy costs are Schedule RD for the existing mixed-fuel home in Denver and Schedule RE-TOU in Leadville. Schedule RD has not been available for new customers since 2016. This rate operates similarly to how Schedule SG operates, with a low flat rate for energy use, and demand charges that fluctuate with the season.



The mixed-fuel home has the lowest energy cost with Schedule RD-TDR because it does not have electric domestic water heating which uses a significant amount of energy during the peak electric hours.

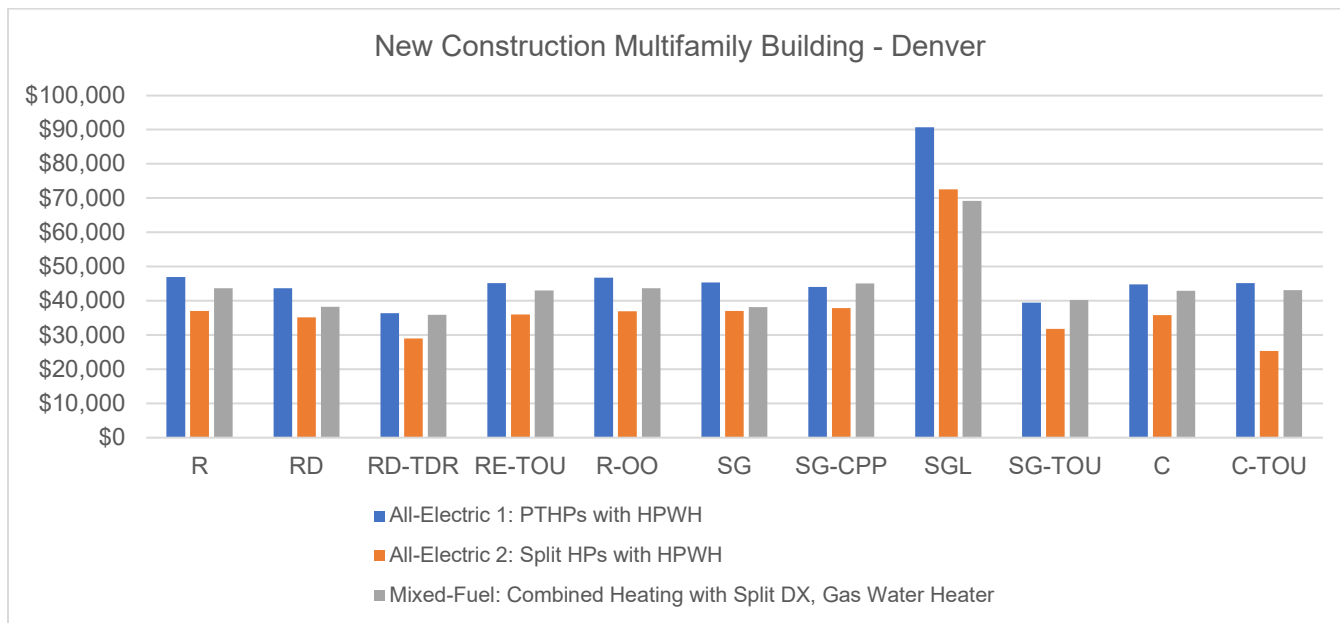


### 3.2 Multifamily Building

For multifamily buildings, the residential and commercial rates are modeled. Multifamily buildings can have individual meters serving each of the units (residential rates) or a house meter (commercial rates) serving the whole building. Note that the current energy codes require that the unit electricity be metered, and this can be accomplished with individual utility meters or third-party sub-meters.

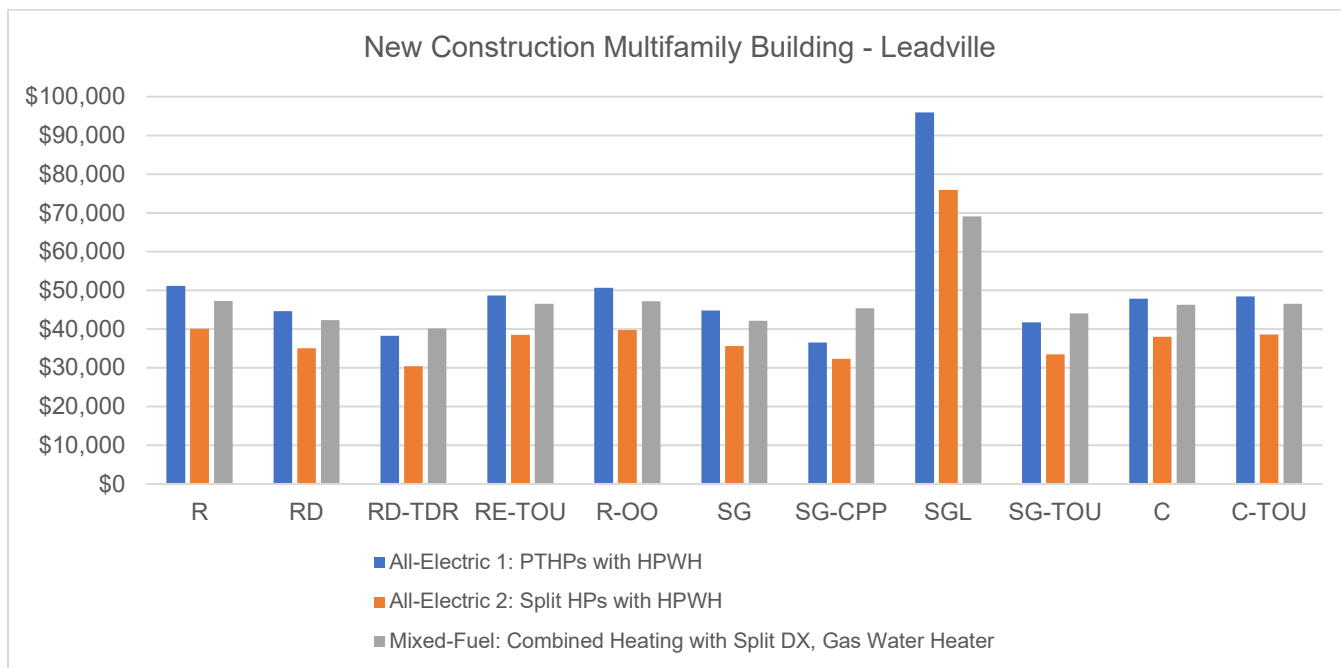
Generally, for all multifamily buildings, Schedule RD-TDR was the most affordable rate, including all-electric and mixed-fuel buildings. The only outlier is the all-electric option 2 multifamily building located in Denver – this building had the most cost-effective rate under Schedule C-TOU. Across all climate zones and heating fuel types, Schedule SGL had the highest annual energy costs.

On average, the commercial rates for multifamily buildings were more expensive than the residential rates.



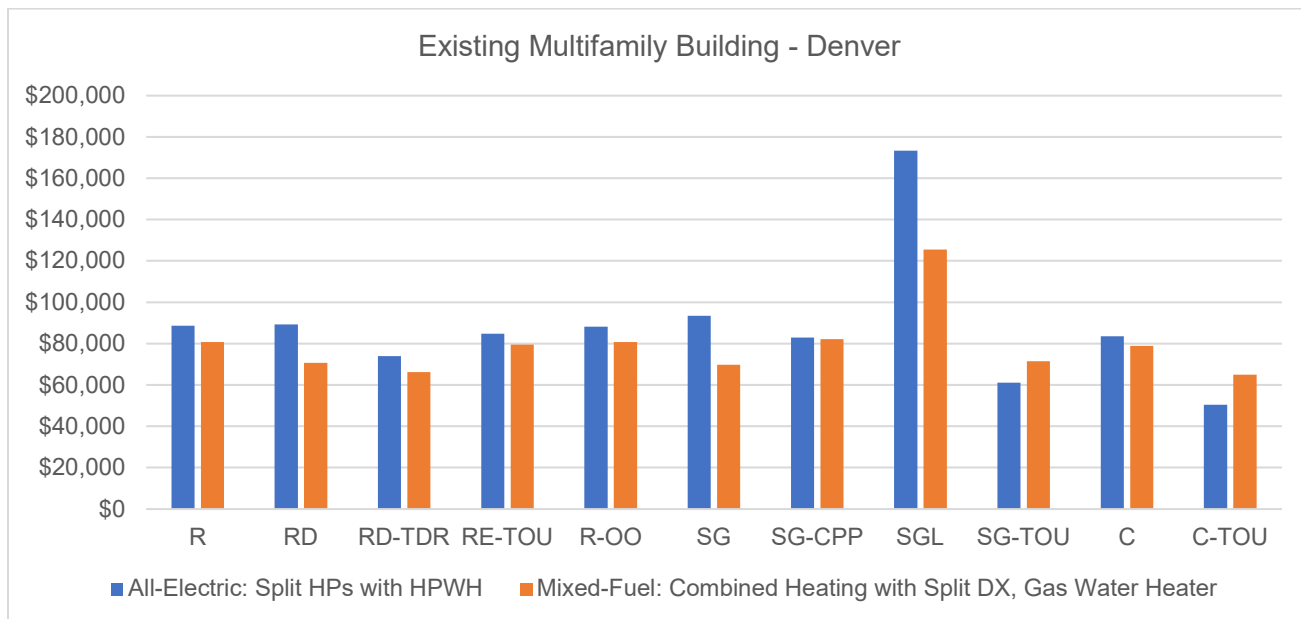


**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**

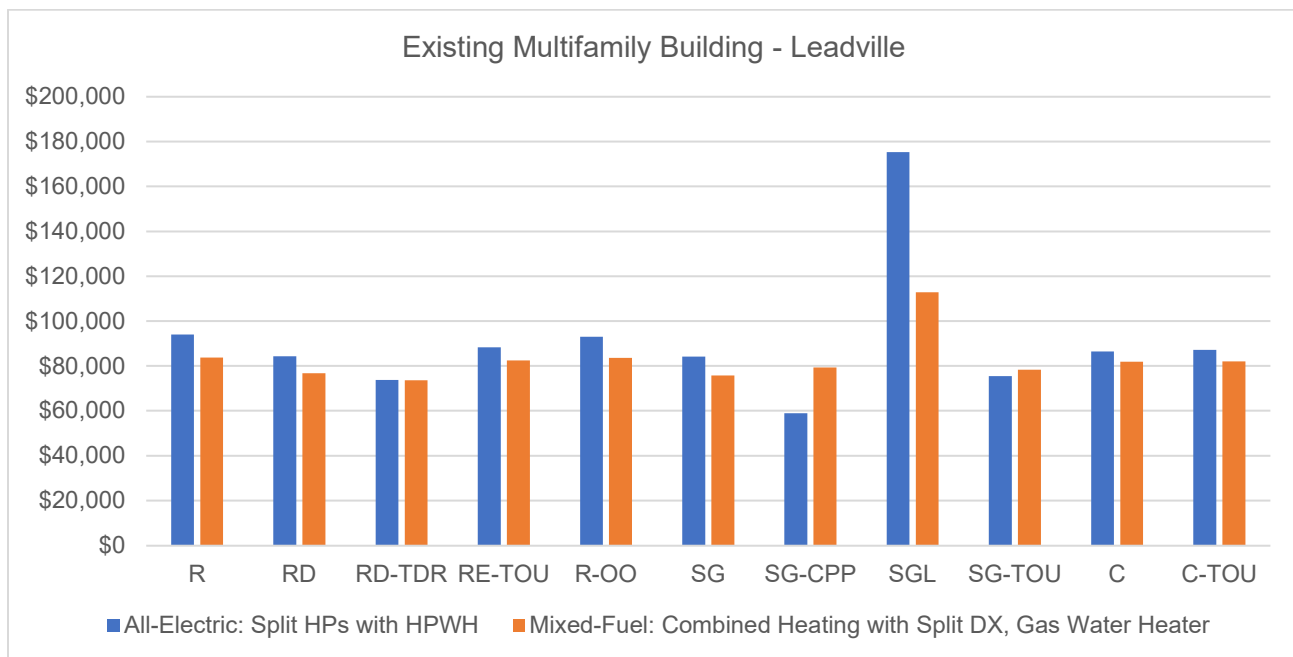


In Denver, the most affordable rate was Schedule C-TOU for both the all-electric existing multifamily building and the mixed-fuel existing multifamily building. In Leadville, Schedule SG-CPP was the most affordable rate for the existing all-electric multifamily building and Schedule RD-TDR was the most affordable rate for the existing mixed-fuel building. Across both climate zones and system types, Schedule SGL had the highest annual energy costs.

As with the new construction buildings, the residential energy rates for the existing multifamily buildings were more affordable than the commercial rates.



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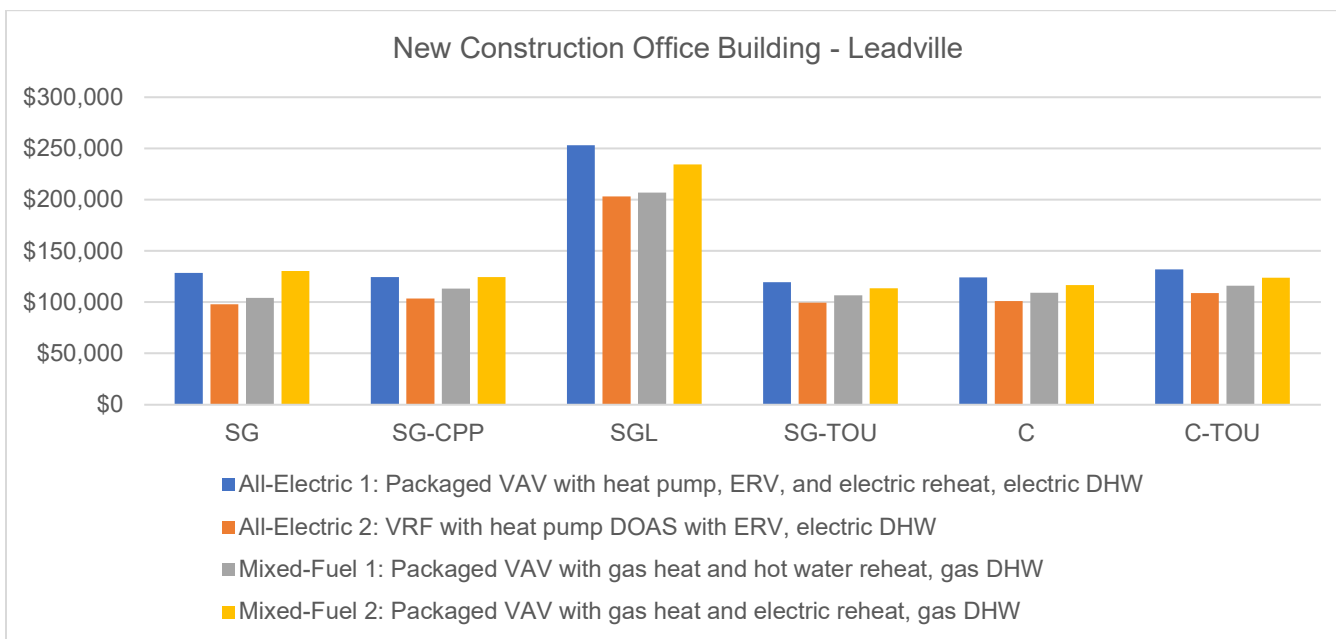
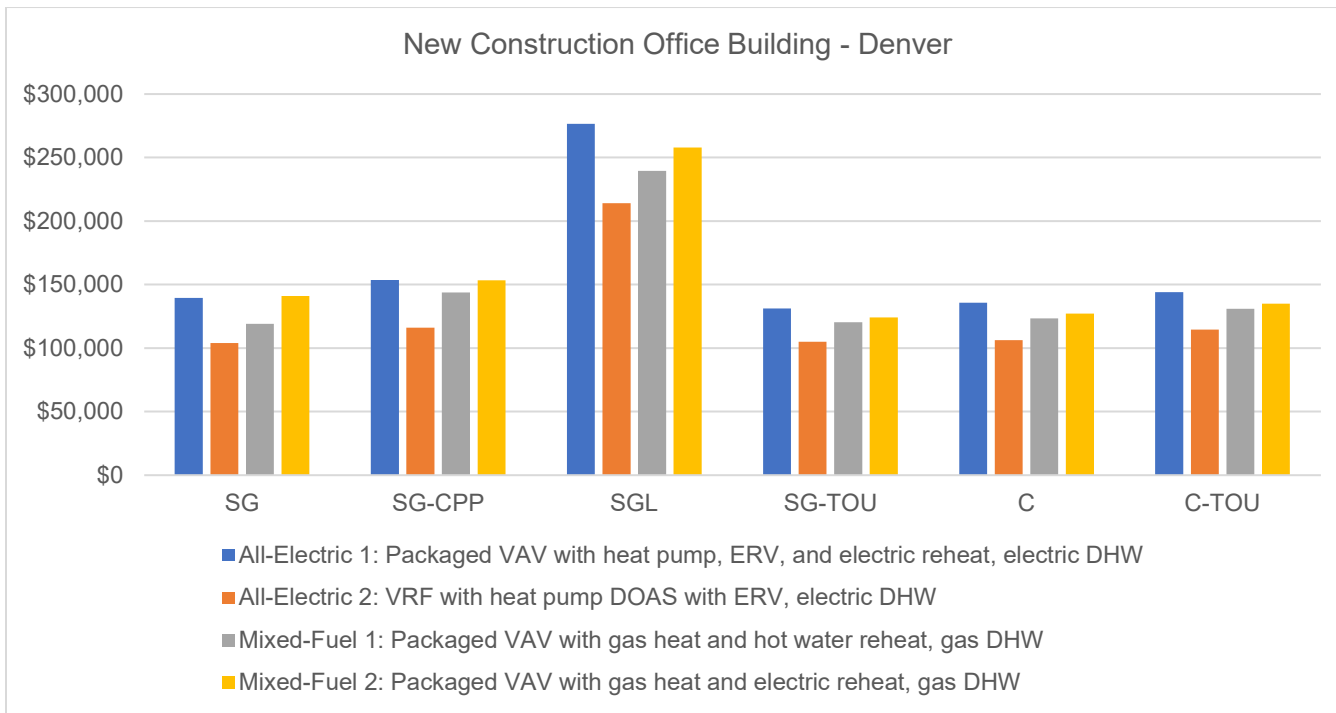
Analysis is provided to remove the common area from the new construction and existing models to determine if a house meter (commercial rate) or individual meters (residential rate) would be more cost effective for multifamily building tenants. Our analysis found that in all cases, the most cost-effective solution for multifamily building tenants would be to provide individual residential meters for each tenant and a house meter for the common areas.



### 3.3 Office Building

The office buildings show a mix of results. All-Electric Option 1 and Mixed Fuel Option 2 both showed the affordable energy rates using Schedule SG-TOU. All-Electric Option 2 and Mixed-Fuel Option 1 both showed the most cost-effective rate to be Schedule SG, although the SG-TOU rate for both options was very similar in cost.

As in the other commercial rate analyses, Schedule SGL was the most expensive rate for all building types in both climate zones.

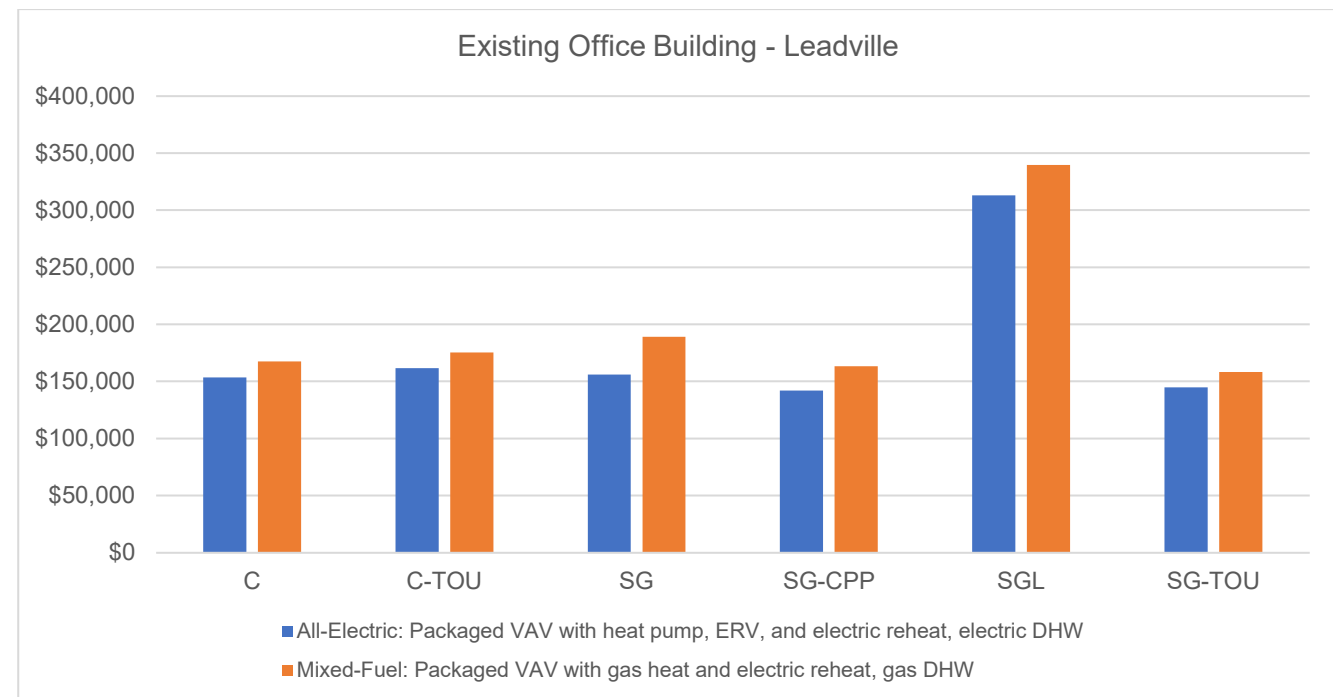
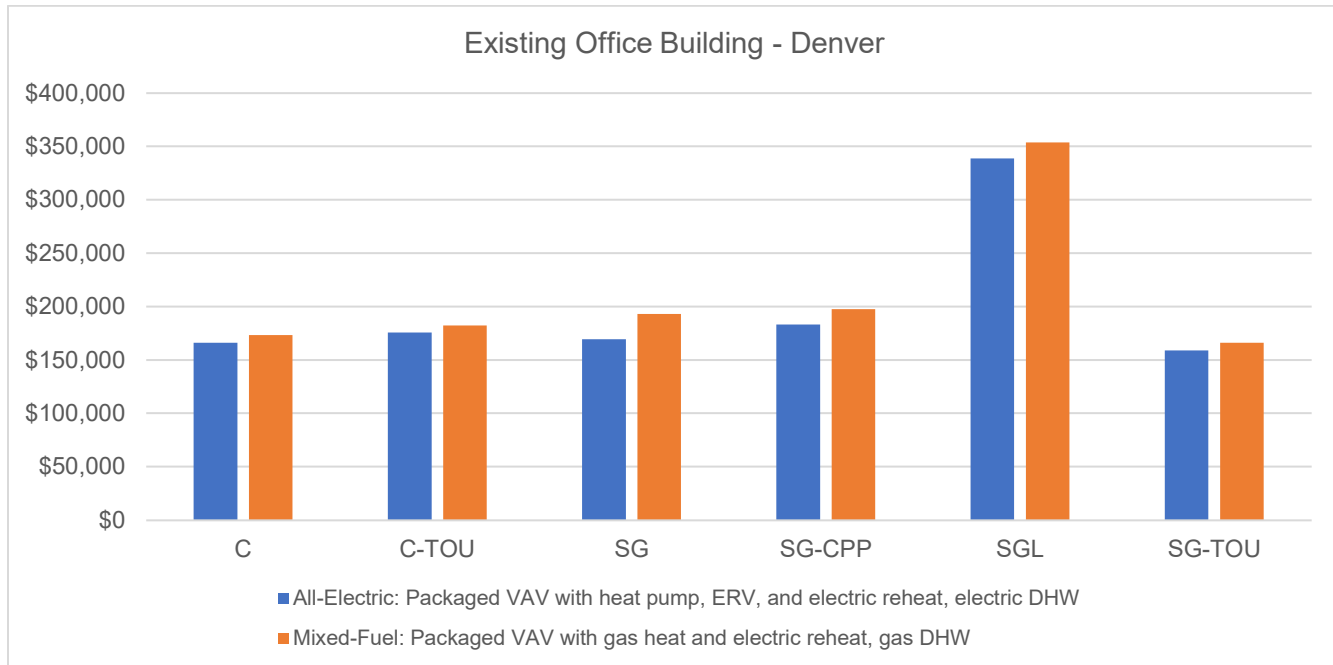


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The existing office energy models in both climate zones show that the most cost-effective rate is Schedule SG-TOU. Due to the increased cost in natural gas, the all-electric buildings in both climate zones have lower annual energy costs than the mixed-fuel buildings.

The most expensive rate in all climate zones for all building types is Schedule SGL.





## 4 DEMAND MANAGEMENT

Xcel Energy currently has a demand management program called Peak Partner Rewards. This program incentivizes participants to reduce their peak energy use during “events.” These events may only occur between 12:00 PM and 8:00 PM. They will last between 1-4 hours during this time period and customers will not be subject to any more than one event in a 24-hour period. There may be no more than 15 events for any customer throughout the year. There are two incentives available for customers who enroll in this program: Reservation Incentives and Performance Incentives. The Reservation Incentive is dependent on the amount of kW capacity reduction that the customer agrees to supply in their contract, and so cannot be calculated as a part of this analysis. The Performance Incentive is provided during the event and the rate is \$0.70/kWh.

Typically, these events are called in the summer during high expected peak demand periods, however in the past year, there were two events called in the winter. Our analysis looked at the potential kWh reduction for an event in the summer and winter to determine how much incentive would be available for each commercial building energy model.

HVAC and Plumbing System	Predicted Demand Management Action
Multifamily – Combined heating fan coils with DX cooling and central natural gas water heaters	Summer: Increase occupant thermostats by 4 degrees Winter: None
Multifamily – Packaged terminal heat pumps with HPWH	Summer: Increase occupant thermostats by 4 degrees Winter: Defer water heating recovery
Multifamily – Split heat pumps with ERV and HPWH	Summer: Increase occupant thermostats by 4 degrees Winter: Defer water heating recovery
Office – Packaged VAV with hot water reheat and natural gas water heaters	Summer – Increase thermostat setpoints by 4 degrees Winter – Decrease lighting load by 30%
Office – Packaged VAV with electric reheat and natural gas water heaters	Summer – Increase thermostat setpoints by 4 degrees Winter – Decrease lighting load by 30%
Office – Packaged VAV heat pump with ERV and electric reheat and electric water heaters	Summer – Increase thermostat setpoints by 4 degrees Winter – Decrease thermostat setpoints by 4 degrees
Office – VRF with heat pump DOAS with ERV and electric water heaters	Summer – Increase thermostat setpoints by 4 degrees Winter – Decrease thermostat setpoints by 4 degrees

Our modeling results show that the potential for incentives under the current Peak Partner Rewards program are minimal due to the short duration of the events and the low performance incentive. Most of the potential incentive comes from the contracted agreement between Xcel and the customer at \$2/kW of potential peak energy reduction.

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HVAC and SWH System Types	Estimated Performance Incentive per Summer Event	Estimated Performance Incentive per Winter Event
Multifamily – Combined heating fan coils with DX cooling and central natural gas water heaters	\$50	\$0
Multifamily – Packaged terminal heat pumps with HPWH	\$62	\$43
Multifamily – Split heat pumps with ERV and HPWH	\$50	\$43
Office – Packaged VAV with hot water reheat and natural gas water heaters	\$125	\$35
Office – Packaged VAV with electric reheat and natural gas water heaters	\$125	\$35
Office – Packaged VAV heat pump with ERV and electric reheat and electric water heaters	\$125	\$45
Office – VRF with heat pump DOAS with ERV and electric water heaters	\$95	\$32

There is potential that these incentives can be increased by combining multiple electricity reduction strategies, for example – reducing lighting power in the office buildings while also increasing or decreasing the thermostat setpoints.



## 5 RATE CASE STUDY TOOL

The Rate Case Tool predicts annual energy costs for user-selected or user-defined rates based on the hourly energy use data from the building models developed for this study. The tool has a library of existing rates from the current Xcel Energy Tariff and also allows the user to create rates based on user inputs. Users can edit the rates from the tariff and save those rates to reference at a later date. The outputs from the tool show the expected annual energy costs, costs per Btu, and provides a monthly energy cost comparison between an all-electric and mixed-fuel building. Inputs are also provided to analyze the impact of demand management and greenhouse gas emissions, with emission projects available through 2050.

Example inputs and outputs are shown below.

### 5.1 Tool Inputs

INPUTS		
<b>General Inputs</b>		
<b>Option</b>	<b>Selection</b>	
Rate Name	R	
Rate Type	Flat Rate	
Building Type	Multifamily	
Construction Type	New	
Location	Mountain	
<b>Annual Rate Escalation Factors</b>		
<b>Factor Type</b>	<b>Input</b>	<b>Unit</b>
Rate Escalation Factor - Electricity	2	%
Rate Escalation Factor - Natural Gas	2	%
GHGE Escalation Factor - Electricity	-10	%
GHGE Escalation Factor - Natural Gas	-4	%
<b>Charge Definitions</b>		
<b>Charge</b>	<b>Input</b>	<b>Unit</b>
Winter Energy Charge	\$ 0.071	\$/kWh
Summer Energy Charge	\$ 0.084	\$/kWh
<b>Electric Demand Management</b>		
<b>Option</b>	<b>Input</b>	<b>Unit</b>
Percent Reduction	0	%
Cost Incentive	\$ 0.250	\$/kWh
<b>Time Frame</b>	<b>Starting Hour</b>	<b>Ending Hour</b>
Reduction Period	13:00	17:00
<b>Additional Options</b>		
<b>Option</b>	<b>Input</b>	<b>Units</b>
Rate Riders - Cost/kWh	\$ 0.051	\$/kWh
Rate Riders - Percentage	0	%
Franchise Fee and Whole Bill Rate Riders	5	%/month
Customer Charge	\$ 6.10	\$/month

Load Rate

---

Save Rate

---

Delete Rate

---

Generate

**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



Natural Gas		
Option	Input	Units
Customer Charge	\$ 17.02	\$/month
Usage Charge	\$ 0.19	\$/therm
Rate Riders - Cost/therm	\$ 1.08	\$/therm
Rate Riders - Percentage	33.24	%
Franchise Fee and Whole Bill Rate Riders	3	%/month

Winter/Summer Definition		
Option	Start	End
Winter	Oct.	May
Summer	June	Sep.



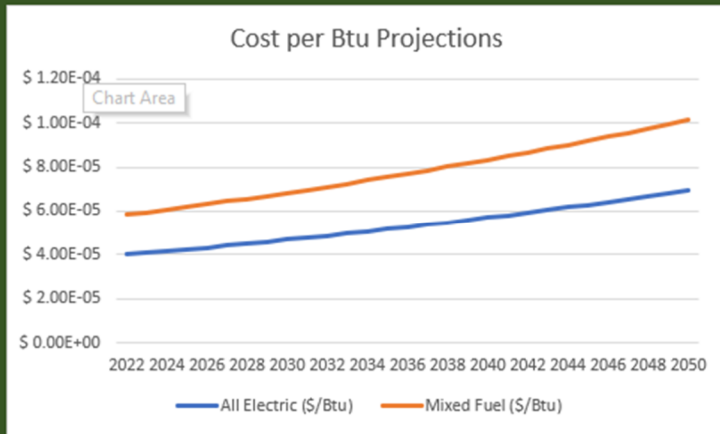
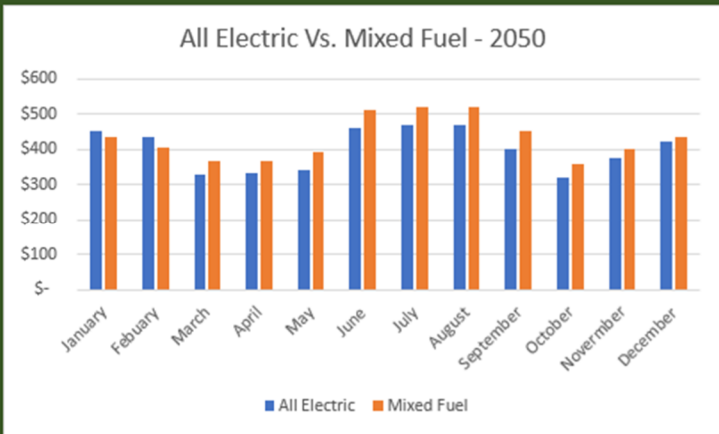
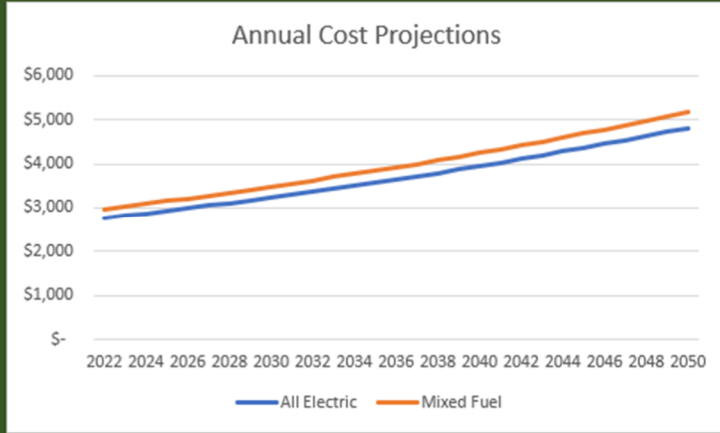
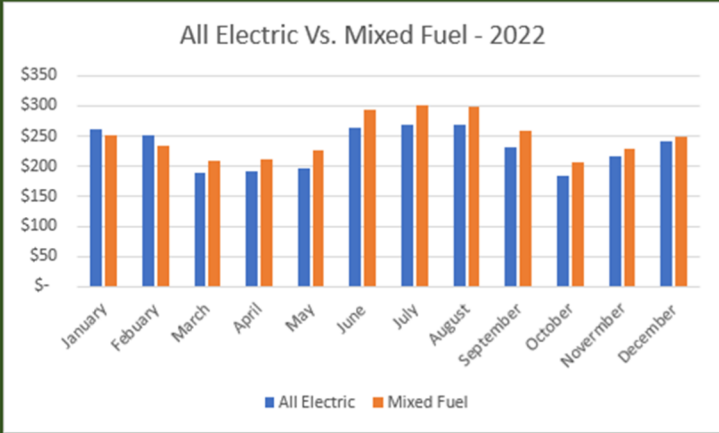
**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**

**5.2 Tool Outputs**

2022													
All Electric Cost													
	January	February	March	April	May	June	July	August	September	October	November	December	Total
Electric	\$ 260	\$ 251	\$ 190	\$ 192	\$ 197	\$ 265	\$ 269	\$ 269	\$ 231	\$ 185	\$ 216	\$ 243	\$ 2,765
Mixed Fuel Cost													
	January	February	March	April	May	June	July	August	September	October	November	December	Total
Electric	\$ 126	\$ 114	\$ 132	\$ 129	\$ 172	\$ 246	\$ 250	\$ 249	\$ 209	\$ 145	\$ 123	\$ 126	\$ 2,022
Gas	\$ 125	\$ 119	\$ 79	\$ 83	\$ 53	\$ 49	\$ 50	\$ 50	\$ 49	\$ 62	\$ 106	\$ 124	\$ 950
Total	\$ 251	\$ 234	\$ 210	\$ 211	\$ 226	\$ 295	\$ 300	\$ 299	\$ 259	\$ 207	\$ 230	\$ 250	\$ 2,971
Monthly Electric Peak Demand (kW)													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual Peak
All Electric	8	9	4	4	4	5	5	5	4	4	9	9	9
Mixed Fuel	2	2	2	3	3	5	4	4	4	3	2	2	5
Monthly load factors													
	January	February	March	April	May	June	July	August	September	October	November	December	Annual Average
All Electric	0.34	0.32	0.52	0.49	0.48	0.50	0.52	0.53	0.50	0.48	0.26	0.29	0.44
Mixed Fuel	0.62	0.62	0.53	0.51	0.53	0.52	0.57	0.56	0.53	0.44	0.56	0.59	0.55
Monthly Gas Use (therms)													
	January	February	March	April	May	June	July	August	September	October	November	December	Total
Mixed Fuel	78	74	45	47	26	23	24	24	23	33	65	77	539

Please refer back to pages 23 and 24 of this report for the tool inputs that have been used to create the above tables and following charts. All inputs are user-adjustable – the following charts are an example of the available charts in the rate tool.

**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



**APPENDIX A XCEL ENERGY ELECTRICITY RATES**

**RESIDENTIAL**

Rate	Charge	Charge Amount	GRSA 10.90	GRSA-E	Purchased Capacity	Demand Side Management	Electric Commodity Adjustment	Transmission Cost	EEAC	Transportation Electrification Program	Revenue Decoupling Adjustment Pilot	SUM	Renewable Energy Standard Adjustment	Colorado Energy Plan Adjustment	Franchise Fee	SUM
R	Service and Facility per Month	5.6	-						0.5			6.10	0.061	0.061	0.183	6.41
	Winter Energy per kWh	0.07136	-	0.01249	0.00414	0.00169	0.03382	0.00103			-0.00272	0.12181	0.0012181	0.0012181	0.0036543	0.12790
	Summer Energy per kWh	0.08356	-	0.01249	0.00414	0.00169	0.03382	0.00103			0	0.13401	0.0013401	0.0013401	0.0040203	0.14071
RD	Service and Facility per Month	12.02	-						0.5			12.52	0.1252	0.1252	0.3756	13.15
	Winter Demand per kW	10.87	-		1.56	0.69		0.39		0		13.51	0.1351	0.1351	0.4053	14.19
	Summer Demand per kW	14.12	-		1.56	0.69		0.39		0		16.76	0.1676	0.1676	0.5028	17.60
	Energy per kWh	0.01958	-	0.01249			0.03382					0.06589	0.0006589	0.0006589	0.0019767	0.06918
RD-TDR	Service and Facility per Month	5.6	-						0.5			6.10	0.061	0.061	0.183	6.41
	Distribution Demand kW	3.54	-		1.56	0.69		0.39		0		6.18	0.0618	0.0618	0.1854	6.49
	Winter Demand per kW	7.06	-		1.56	0.69		0.39		0		9.70	0.097	0.097	0.291	10.19
	Summer Demand per kW	10.08	-		1.56	0.69		0.39		0		12.72	0.1272	0.1272	0.3816	13.36
	Energy per kWh	0.00758	-	0.01249			0.03382				-0.00298	0.05091	0.0005091	0.0005091	0.0015273	0.05346
RE-TOU	Service and Facility per Month	5.6	-						0.5			6.10	0.061	0.061	0.183	6.41
	Winter On-Peak Energy per kWh	0.10858	-	0.01249	0.0059176	0.002410476	0.04833982	0.001476688		0	-0.00641	0.17280	0.00172805	0.00172805	0.00518414	0.18144
	Winter Shoulder Energy per kWh	0.08623	-	0.01249	0.0046995	0.001914306	0.0383896	0.001172728		0	-0.00641	0.13849	0.00138486	0.00138486	0.00415458	0.14541
	Winter Off-Peak Energy per kWh	0.06387	-	0.01249	0.0034809	0.001417914	0.02843492	0.000868632		0	-0.00641	0.10415	0.00104152	0.00104152	0.00312457	0.10936
	Summer On-Peak Energy per kWh	0.17246	-	0.01249	0.0093991	0.003828612	0.07677919	0.002345456		0	-0.00641	0.27089	0.00270892	0.00270892	0.00812677	0.28444
	Summer Shoulder Energy per kWh	0.11816	-	0.01249	0.0064397	0.002623152	0.05260483	0.001606976		0	-0.00641	0.18751	0.00187515	0.00187515	0.00562544	0.19689
Summer Off-Peak Energy per kWh	0.06387	-	0.01249	0.0034809	0.001417914	0.02843492	0.000868632		0	-0.00641	0.10415	0.00104152	0.00104152	0.00312457	0.10936	
R-OO	Service and Facility per Month	5.6	-						0.5			6.10	0.061	0.061	0.183	6.41
	Winter Energy per kWh	0.07136	-	0.01249	0.0038891	0.001584192	0.03176947	0.000970496		0	-0.00272	0.11934	0.00119343	0.00119343	0.0035803	0.12531
	Summer Energy per kWh	0.08356	-	0.01249	0.004554	0.001855032	0.03720091	0.001136416		0	-0.00272	0.13808	0.00138076	0.00138076	0.00414229	0.14498



**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**

**COMMERCIAL**

Rate	Charge	Charge Amount	GRSA 10.90	GRSA-E	Purchased Capacity	Demand Side Management	Electric Commodity Adjustment	Transmission Cost	EEAC	Transportation Electrification Program	Decoupling Adjustment Pilot	SUM	Renewable Energy Standard Adjustment (1% on ENTIRE BILL)	Colorado Energy Plan Adjustment (1% on ENTIRE BILL)	Franchise Fee (3% on ENTIRE BILL)	SUM
C	Service and Facility per Month	10.68	-						0.5			11.18	0.1118	0.1118	0.3354	11.74
	Winter Energy per kWh	0.05314	-	0.0117	0.00346	0.00139	0.03382	0.00086		0	0.00273	0.10710	0.001071	0.001071	0.003213	0.11246
	Summer Energy per kWh	0.08852	-	0.0117	0.00346	0.00139	0.03382	0.00086		0	0.00273	0.14248	0.0014248	0.0014248	0.0042744	0.14960
C-TOU	Service and Facility per Month	10.68	-						0.5			11.18	0.1118	0.1118	0.3354	11.74
	Winter On-Peak Energy per kWh	0.09153	-	0.0117	0.0048236	0.001940436	0.04718372	0.001199043		0	0.00273	0.16111	0.00161107	0.00161107	0.0048332	0.16916
	Winter Shoulder Energy per kWh	0.07269	-	0.0117	0.0038308	0.001541028	0.0374717	0.000952239		0	0.00273	0.13092	0.00130916	0.00130916	0.00392747	0.13746
	Winter Off-Peak Energy per kWh	0.05384	-	0.0117	0.0028374	0.001141408	0.02775452	0.000705304		0	0.00273	0.10071	0.00100709	0.00100709	0.00302126	0.10574
	Summer On-Peak Energy per kWh	0.14538	-	0.0117	0.0076615	0.003082056	0.07494339	0.001904478		0	0.00273	0.24740	0.00247401	0.00247401	0.00742204	0.25977
	Summer Shoulder Energy per kWh	0.09961	-	0.0117	0.0052494	0.002111732	0.05134896	0.001304891		0	0.00273	0.17406	0.00174055	0.00174055	0.00522165	0.18276
	Summer Off-Peak Energy per kWh	0.05384	-	0.0117	0.0028374	0.001141408	0.02775452	0.000705304		0	0.00273	0.10071	0.00100709	0.00100709	0.00302126	0.10574
SG	Service and Facility per Month	41.13	4.48317						0.5			46.11	0.4611317	0.4611317	1.3833951	48.42
	Distribution Demand per kW	6.17	0.67253									6.84	0.0684253	0.0684253	0.2052759	7.18
	Winter Demand per kW	9.09	0.99081			1	0.42				0	11.75	0.1175081	0.1175081	0.3525243	12.34
	Summer Demand per kW	15.15	1.65135			1	0.42				0	18.47	0.1847135	0.1847135	0.5541405	19.39
	Energy per kWh	0.00791	0.000862	0.00323				0.03382				0.04582	0.00045822	0.00045822	0.00137467	0.04811
SGTOU Pilot	Service and Facility per Month	41.13	4.48317						0.5			46.11	0.4611317	0.4611317	1.3833951	48.42
	Distribution Demand per kW	1.01	0.11009									1.12	0.0112009	0.0112009	0.0336027	1.18
	Summer On Peak Energy per kWh	0.15634	0.017041	0.00323	0.0081922	0.004096108	0.09972929	0.00203242		0		0.29066109	0.00290661	0.00290661	0.00871983	0.30519
	Summer Shoulder Energy per kWh	0.06642	0.00724	0.00323	0.0034804	0.001740204	0.04236932	0.00086346		0		0.12534317	0.00125343	0.00125343	0.0037603	0.13161
	Summer Off Peak Energy per kWh	0.04044	0.004408	0.00323	0.0021191	0.001059528	0.02579668	0.00052572		0		0.07757894	0.00077579	0.00077579	0.00232737	0.08146
	Winter On Peak Energy per kWh	0.09521	0.010378	0.00323	0.004989	0.002494502	0.06073446	0.00123773		0		0.178273585	0.00178274	0.00178274	0.00534821	0.18719
	Winter Shoulder Energy per kWh	0.05117	0.005578	0.00323	0.0026813	0.001340654	0.03264134	0.00066521		0		0.097306045	0.00097306	0.00097306	0.00291918	0.10217
	Winter Off Peak Energy per kWh	0.04044	0.004408	0.00323	0.0021191	0.001059528	0.02579668	0.00052572		0		0.07757894	0.00077579	0.00077579	0.00232737	0.08146
SGL	Service and Facility per Month	41.13	4.48317						0.5			46.11	0.4611317	0.4611317	1.3833951	48.42
	Distribution Demand per kW	6.17	0.67253									6.84	0.0684253	0.0684253	0.2052759	7.18
	Winter Energy per kWh	0.12519	0.013646	0.00323	0.01253	0.00608	0.03382	0.0031		0		0.19760	0.00197596	0.00197596	0.00592787	0.20748
	Summer Energy per kWh	0.17884	0.019494	0.00323	0.01253	0.00608	0.03382	0.0031		0		0.25709	0.00257094	0.00257094	0.00771281	0.26995
SG-CPP	Service and Facility per Month	41.13	4.48317						0.5			46.11	0.4611317	0.4611317	1.3833951	48.42
	Distribution Demand per kW	6.17	0.67253									6.84	0.0684253	0.0684253	0.2052759	7.18
	Generation and Transmission Demand kW	8.03	0.87527			1	0.42					10.57527	0.1057527	0.1057527	0.3172581	11.10
	Critical Peak Pricing Energy per kWh	1.44	0.15696	0.00323				0.03382		0		1.63401	0.0163401	0.0163401	0.0490203	1.71571
	Non Critical Peak Pricing Energy per kWh	0.00791	0.000862	0.00323				0.03382		0		0.05	0.00045822	0.00045822	0.00137467	0.04811

**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**

**NATURAL GAS**

Rate	Charge	Charge Amount	GRSA	GRSA-P	Rate Defferal Surcharge (Shoulder Months Only)	Demand Side Management	EGCRR	GCA	GEAC	SUM	Franchise Fee	SUM	
R	Service and Facility per Month	12.21	0.205128	1.56288	1.670328	0.620268				0.75	17.02	0.51055812	17.53
	Usage charge, per therm	0.19394	0.003258	0.024824	0.026530992	0.009852152	0.07501	1.0092			1.34262	0.04027847	1.38289
CSG	Service and Facility per Month	43.88	0.737184	6.8014	5.125184	1.167208				0.75	58.46	1.75382928	60.21
	Usage charge, per therm	0.19394	0.003258	0.030061	0.022652192	0.005158804	0.07501	1.0041			1.33418	0.040025397	1.37



## APPENDIX B ENERGY MODEL VERSUS RATES TOOL OUTPUTS

In the following charts, we compare the annual energy costs of the new construction models as calculated by the energy models and the outputs of the rates tool. All results fall within a +/- 9% difference, due to rounding in the tool. For data simplification, the tool calculates demand costs based on hourly demand outputs from the energy model. The energy models calculate demand based on 15-minute increments. This also leads to slight differences between the energy model results and the outputs from the rates tool.

New Construction Single Family Home - Denver		
Schedule	% Difference - All-Electric	% Difference - Mixed Fuel
R	1%	0%
RD	5%	-3%
RD-TDR	-7%	-1%
RE-TOU	-3%	-3%
R-OO	1%	0%

New Construction Single Family Home - Leadville		
Schedule	% Difference - All-Electric	% Difference - Mixed Fuel
R	1%	0%
RD	3%	-3%
RD-TDR	-6%	-1%
RE-TOU	8%	6%
R-OO	1%	0%

New Construction Multifamily Building - Denver		
Schedule	% Difference - All-Electric	% Difference - Mixed Fuel
R	0%	0%
RD	5%	0%
RD-TDR	-6%	0%
RE-TOU	-3%	-2%
R-OO	0%	0%
SG	9%	1%
SG-CPP	3%	9%
SGL	2%	1%
SG-TOU	1%	1%
C	2%	1%
C-TOU	2%	1%

**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



<b>New Construction Multifamily Building - Leadville</b>		
<b>Schedule</b>	<b>% Difference - All-Electric</b>	<b>% Difference - Mixed Fuel</b>
R	0%	0%
RD	4%	0%
RD-TDR	-3%	0%
RE-TOU	-3%	-2%
R-OO	0%	0%
SG	7%	1%
SG-CPP	-9%	7%
SGL	2%	1%
SG-TOU	1%	1%
C	2%	1%
C-TOU	2%	1%

<b>New Construction Office Building - Denver</b>		
<b>Schedule</b>	<b>% Difference - All-Electric</b>	<b>% Difference - Mixed Fuel</b>
SG	3%	1%
SG-CPP	6%	12%
SGL	1%	0%
SG-TOU	1%	1%
C	1%	0%
C-TOU	1%	0%

<b>New Construction Office Building - Leadville</b>		
<b>Schedule</b>	<b>% Difference - All-Electric</b>	<b>% Difference - Mixed Fuel</b>
SG	3%	1%
SG-CPP	-7%	2%
SGL	1%	0%
SG-TOU	1%	1%
C	1%	0%
C-TOU	1%	0%



# APPENDIX C ENERGY MODEL ANNUAL ENERGY COST RESULTS

New Construction Single Family Home - Denver		
Schedule	All-Electric: Split HP with HPWH	Mixed-Fuel: Central gas furnace with split DX and gas WH
R	\$2,782	\$2,959
RD	\$2,746	\$2,600
RD-TDR	\$2,222	\$2,448
RE-TOU	\$2,734	\$2,968
R-OO	\$2,779	\$2,966

New Construction Single Family Home - Leadville		
Schedule	All-Electric: Split HP with HPWH	Mixed-Fuel: Central gas furnace with split DX and gas WH
R	\$3,136	\$2,942
RD	\$2,951	\$2,629
RD-TDR	\$2,444	\$2,492
RE-TOU	\$3,012	\$2,946
R-OO	\$3,113	\$2,942

Existing Single Family Home - Denver		
Schedule	All-Electric Home Denver	Mixed-Fuel Home Denver
R	\$4,234	\$4,866
RD	\$4,117	\$4,903
RD-TDR	\$3,515	\$4,297
RE-TOU	\$4,366	\$4,489
R-OO	\$4,220	\$4,879

Existing Single Family Home - Denver		
Schedule	All-Electric Home - Leadville	Mixed-Fuel Home - Leadville
R	\$5,075	\$5,572
RD	\$4,862	\$5,250
RD-TDR	\$3,971	\$5,089
RE-TOU	\$4,768	\$5,573
R-OO	\$5,023	\$5,571



**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



**New Construction Multifamily Building - Denver**

Schedule	All-Electric 1: PTHPs with HPWH	All-Electric 2: Split HPs with HPWH	Mixed-Fuel: Combined Heating with Split DX, Gas Water Heater
R	\$46,897	\$37,045	\$43,649
RD	\$43,661	\$35,134	\$38,192
RD-TDR	\$36,315	\$28,981	\$35,884
RE-TOU	\$45,177	\$35,972	\$43,035
R-OO	\$46,708	\$36,958	\$43,685
SG	\$45,303	\$37,017	\$38,153
SG-CPP	\$44,055	\$37,882	\$45,081
SGL	\$90,711	\$72,572	\$69,176
SG-TOU	\$39,429	\$31,786	\$40,202
C	\$44,776	\$35,757	\$42,914
C-TOU	\$45,130	\$25,297	\$43,080

**New Construction Multifamily Building - Leadville**

Schedule	All-Electric 1: PTHPs with HPWH	All-Electric 2: Split HPs with HPWH	Mixed-Fuel: Combined Heating with Split DX, Gas Water Heater
R	\$51,122	\$40,037	\$47,250
RD	\$44,627	\$35,063	\$42,284
RD-TDR	\$38,219	\$30,414	\$40,183
RE-TOU	\$48,633	\$38,499	\$46,492
R-OO	\$50,675	\$39,773	\$47,202
SG	\$44,798	\$35,600	\$42,103
SG-CPP	\$36,548	\$32,262	\$45,399
SGL	\$95,925	\$75,943	\$69,118
SG-TOU	\$41,757	\$33,473	\$43,998
C	\$47,865	\$37,968	\$46,306
C-TOU	\$48,451	\$38,591	\$46,552

**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



<b>Existing Multifamily Building - Denver</b>		
<b>Schedule</b>	<b>All-Electric: Split HPs with HPWH</b>	<b>Mixed-Fuel: Combined Heating with Split DX, Gas Water Heater</b>
<b>R</b>	\$88,660	\$80,684
<b>RD</b>	\$89,273	\$70,642
<b>RD-TDR</b>	\$73,991	\$66,157
<b>RE-TOU</b>	\$84,719	\$79,560
<b>R-OO</b>	\$88,175	\$80,747
<b>SG</b>	\$93,455	\$69,675
<b>SG-CPP</b>	\$82,848	\$82,100
<b>SGL</b>	\$173,296	\$125,503
<b>SG-TOU</b>	\$61,079	\$71,441
<b>C</b>	\$83,494	\$78,859
<b>C-TOU</b>	\$50,396	\$65,015

<b>Existing Multifamily Building - Leadville</b>		
<b>Schedule</b>	<b>All-Electric: Split HPs with HPWH</b>	<b>Mixed-Fuel: Combined Heating with Split DX, Gas Water Heater</b>
<b>R</b>	\$94,012	\$83,691
<b>RD</b>	\$84,387	\$76,724
<b>RD-TDR</b>	\$73,690	\$73,680
<b>RE-TOU</b>	\$88,288	\$82,442
<b>R-OO</b>	\$92,950	\$83,596
<b>SG</b>	\$84,173	\$75,815
<b>SG-CPP</b>	\$58,950	\$79,365
<b>SGL</b>	\$175,273	\$112,783
<b>SG-TOU</b>	\$75,516	\$78,312
<b>C</b>	\$86,497	\$81,896
<b>C-TOU</b>	\$87,157	\$82,076

**COLORADO PUC STUDY: IMPACTS OF RATE DESIGN ON ELECTRIFICATION ECONOMICS**



<b>New Construction Office Building - Denver</b>				
<b>Schedule</b>	All-Electric 1: Packaged VAV with heat pump, ERV, and electric reheat, electric DHW	All-Electric 2: VRF with heat pump DOAS with ERV, electric DHW	Mixed-Fuel 1: Packaged VAV with gas heat and hot water reheat, gas DHW	Mixed-Fuel 2: Packaged VAV with gas heat and electric reheat, gas DHW
<b>SG</b>	\$139,418	\$103,861	\$118,979	\$140,838
<b>SG-CPP</b>	\$153,465	\$115,983	\$143,680	\$153,310
<b>SGL</b>	\$276,447	\$213,899	\$239,428	\$257,745
<b>SG-TOU</b>	\$131,197	\$104,991	\$120,353	\$124,107
<b>C</b>	\$135,753	\$106,124	\$123,375	\$127,103
<b>C-TOU</b>	\$144,083	\$114,395	\$130,930	\$134,812

<b>New Construction Office Building - Leadville</b>				
<b>Schedule</b>	All-Electric 1: Packaged VAV with heat pump, ERV, and electric reheat, electric DHW	All-Electric 2: VRF with heat pump DOAS with ERV, electric DHW	Mixed-Fuel 1: Packaged VAV with gas heat and hot water reheat, gas DHW	Mixed-Fuel 2: Packaged VAV with gas heat and electric reheat, gas DHW
<b>SG</b>	\$128,585	\$97,673	\$104,185	\$130,276
<b>SG-CPP</b>	\$124,290	\$103,590	\$113,156	\$124,521
<b>SGL</b>	\$253,188	\$203,207	\$206,733	\$234,387
<b>SG-TOU</b>	\$119,370	\$99,530	\$106,622	\$113,511
<b>C</b>	\$124,005	\$100,804	\$109,209	\$116,666
<b>C-TOU</b>	\$131,818	\$108,698	\$116,027	\$123,754

<b>Existing Office Building - Denver</b>		
<b>Schedule</b>	All-Electric: Packaged VAV with heat pump, ERV, and electric reheat, electric DHW	Mixed-Fuel: Packaged VAV with gas heat and electric reheat, gas DHW
<b>C</b>	\$166,147	\$173,299
<b>C-TOU</b>	\$175,509	\$182,128
<b>SG</b>	\$169,273	\$193,034
<b>SG-CPP</b>	\$182,992	\$197,441
<b>SGL</b>	\$338,466	\$353,584
<b>SG-TOU</b>	\$158,825	\$165,898

<b>Existing Office Building - Leadville</b>		
<b>Schedule</b>	All-Electric: Packaged VAV with heat pump, ERV, and electric reheat, electric DHW	Mixed-Fuel: Packaged VAV with gas heat and electric reheat, gas DHW
<b>C</b>	\$153,533	\$167,553
<b>C-TOU</b>	\$161,604	\$175,206
<b>SG</b>	\$155,915	\$189,032
<b>SG-CPP</b>	\$142,059	\$163,339
<b>SGL</b>	\$313,116	\$339,706
<b>SG-TOU</b>	\$144,601	\$158,258