386 Indian Road
Grand Junction, CO 81501
Ph: (970) 241-8709

BIGHORN
CONSULTING ENGINEERS, CO.

101 W 11th Street #109-C
Durango, CO 81301
Ph: (970) 422-7676

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Montrose School District

Energy Usage Intensity (EUI)

Summary

Please refer to the EUI spreadsheet showing actual energy consumption for each of the schools being considered. Note that source EUI is being used as the metric for the energy comparison. The source energy use intensity is a bench mark calculation to compare buildings of similar type and usage to those across the country. This metric uses total gas and electrical energy usage at the building and traces the heat and electricity requirements of the building back to the raw fuel input, thereby accounting for any losses and enabling a complete thermodynamic assessment. The actual value calculated is kbtu/ft2-yr or kilobtu's (1000's of btu's). The national reference shown in the table is an average for K-12 buildings in the U.S. See the attached technical reference from Energy Star for a further discussion on source EUI.

Of fifteen buildings analyzed, only four exceeded the national average of 104.4 kbtu/ft2-yr: Cottonwood ES (166 EUI), Cottonwood ES Modulars (107 EUI), Oak Grove ES (116 EUI), and the High School Ag building (118 EUI). Possible reasons for larger than average EUI:

1. Cottonwood ES: 59% higher than average. Systems are similar to Northside ES (94 EUI) and Oak Grove ES (116 EUI) which have lower EUI's. May be due to different scheduling and building usage than other schools. Also, the Trane building automation system (BAS) would need to be investigated to determine if setback, setup and optimal start/start features need to be revised/reviewed to see if this would reduce energy usage.
2. Cottonwood ES Modulars: 2.5% higher than average. These units use all electric heating (resistance elements) and cooling systems and would typically show a higher EUI because of this. To reduce the EUI of these buildings would involve replacing the existing systems with most likely heat pumps.
3. Oak Grove ES: This EUI was only 11% higher than the average. This may be due to similar reasons to Cottonwood (see above) and also, due to the envelope of the old stone building and the gym building having higher heat loss due to lack of insulation.
4. MHS Ag building: 13% higher than average. May be due to the nature of the building with large openings, poor envelope insulation, and large exhaust volumes.

The remaining buildings with below average EUI would indicate these buildings are being operated efficiently by the district. However, a review of BAS settings and time scheduling (as noted for Cottonwood ES above) might reveal areas that could benefit from this in reducing the EUI. This assumes that the current MEP systems and equipment would be maintained and it should be noted that as systems and equipment are replaced as indicated in the assessment documents with higher efficiency units, the resulting EUI would be reduced.

Montrose School District Source Energy Use Intensity (EUI)

SCHOOL	AREA (FT^2)	GAS USAGE (THERMS)	ELECTRIC USAGE (kWH)	OPERATIONAL ENERGY COST (ELECTRIC)	OPERATIONAL ENERGY COST (GAS)	THERMS TO BTU	GAS SOURCE ENERGY (BTU)	kWH TO BTU	ELECTRIC SOURCE ENERGY (BTU)	TOTAL SOURCE ENERGY (BTU)	SOURCE EUI ($kBTU/FT^2$)	NATIONAL REFERENCE FOR SOURCE EUI ($kBTU/FT^2$)	EUI comments
COTTONWOOD ELEMENTARY SCHOOL (CES)	33,221	27,462	276,209	$ 36,371.10	$ 12,157.46	2,746,200,000	2,883,510,000	942,425,108	2,638,790,302	5,522,300,302	166	104.4	59% higher than average. School has larger than district average gas and electric usage. Systems are similar to Northside and Oak Grove which have lower EUI's. May be a function of building usage and scheduling.
COTTONWOOD ELEMENTARY SCHOOL MODULARS	5,700	-	64,119	$ 7,971.00	$ -	-	-	218,774,028	612,567,278	612,567,278	107	104.4	2.5% higher than average. All electric cooling and heating.
EARLY CHILDHOOD CENTER (ECC) PROGRAMS	34,231	1,229	69,518	$ 931.73	$ 1,711.88	122,900,000	129,045,000	237,195,416	664,147,165	793,192,165	23	104.4	
OLATHE ELEMENTARY SCHOOL (OES)	49,860	11,102	192,276	$ 28,646.14	$ 12,922.68	1,110,200,000	1,165,710,000	656,045,712	1,836,927,994	3,002,637,994	60	104.4	
JOHNSON ELEMENTARY SCHOOL (JES)	53,060	9,398	318,536	$ 40,040.25	$ 10,206.73	939,800,000	986,790,000	1,086,844,832	3,043,165,530	4,029,955,530	76	104.4	
NORTHSIDE ELEMENTARY SCHOOL (NES)	34,750	14,412	183,081	$ 27,949.63	$ 13,633.92	1,441,200,000	1,513,260,000	624,672,372	1,749,082,642	3,262,342,642	94	104.4	
OAK GROVE ELEMENTARY SCHOOL (OGES)	29,660	12,518	222,261	$ 28,935.87	$ 11,706.90	1,251,800,000	1,314,390,000	758,354,532	2,123,392,690	3,437,782,690	116	104.4	11% higher than average. May be due to the poor envelope of the old stone building and the gym building.
POMONA ELEMENTARY SCHOOL (PES)	42,525	14,663	208,464	$ 25,822.25	$ 13,741.35	1,466,300,000	1,539,615,000	711,279,168	1,991,581,670	3,531,196,670	83	104.4	
CENTENNIAL MIDDLE SCHOOL (CTMS)	100,800	27,717	647,325	$ 76,477.97	$ 25,558.28	2,771,700,000	2,910,285,000	2,208,672,900	6,184,284,120	9,094,569,120	90	104.4	
COLUMBINE MIDDLE SCHOOL (CMS)	85,600	3,534	28,296	$ 73,894.71	$ 490.05	353,400,000	371,070,000	96,545,952	270,328,666	641,398,666	*	104.4	
OLATHE MIDDLE/HIGH SCHOOL (OMHS)	117,398	52,250	573,693	$ 103,970.17	$ 43,901.47	5,225,000,000	5,486,250,000	1,957,440,516	5,480,833,445	10,967,083,445	93	104.4	
MONTROSE HIGH SCHOOL (MHS)	164,000	74,472	851,805	$ 107,837.12	$ 66,957.12	7,447,200,000	7,819,560,000	2,906,358,660	8,137,804,248	15,957,364,248	97	104.4	
MONTROSE HIGH SCHOOL (MHS) AG BUILDING	13,888	12,996	28,000	$ 3,686.37	$ 12,709.26	1,299,600,000	1,364,580,000	95,536,000	267,500,800	1,632,080,800	118	104.4	13% higher than average. May be due to the nature of the building with large openings, poor envelope insulation, large exhaust volumes.
PEAK VIRTUAL ACADEMY (PEAK)	8,138	4,106	28,629	$ 4,967.71	$ 4,096.43	410,600,000	431,130,000	97,682,148	273,510,014	704,640,014	87	104.4	
STUDENT SERVICES ANNEX (SSA)	3,745	811	15,289	$ 2,100.33	$ 929.61	81,100,000	85,155,000	52,166,068	146,064,990	231,219,990	62	104.4	

*INCOMPLETE ENERGY DATA FOR THE 2019-2020 YEAR

The source energy use intensity is a bench mark calculation to compare buildings of similar type and usage to those across the country. This metric uses total gas and electrical energy usage at the building and traces the heat and electricity requirements of the building back to the raw fuel input, thereby accounting for any losses and enabling a complete thermodynamic assessment. The actual value calculated is kbtu/ft2-yr or kilobtu's (1000's of btu's). The national reference shown in the table is an average for K-12 buildings in the U.S. See the attached technical reference from Energy Star for a further.

For the buildings shown above, Cottonwood ES, Cottonwood Modulars, Oak Grove ES, and the MHS Ag building are slightly greater than the national average.

ENERGY STAR® PortfolioManager®

Technical Reference

Source Energy

OVERVIEW

Commercial buildings use different mixes of energy including electricity, natural gas, fuel oil, district steam, and many others. To evaluate energy performance for these buildings, we have to express these different energy types in a single common unit. ***Source energy*** is the most equitable unit of evaluation, and enables a complete assessment of energy efficiency.

You may be familiar with ***site energy***, the amount of heat and electricity consumed by a building as reflected in utility bills. Site energy may be delivered to a facility in one of two forms. ***Primary energy*** is the *raw fuel* that is burned to create heat and electricity, such as natural gas or fuel oil. ***Secondary energy*** is the *energy product* created from a raw fuel, such as electricity purchased from the grid or heat received from a district steam system. A unit of primary energy and a unit of secondary energy consumed at the site are not directly comparable because one represents a raw fuel while the other represents a converted fuel. Ultimately, buildings require heat and electricity to operate, and there are always losses associated with generating and delivering this heat and electricity. ***Source energy*** traces the heat and electricity requirements of the building back to the raw fuel input, thereby accounting for any losses and enabling a complete thermodynamic assessment.

The figure below summarizes the ratios used in Portfolio Manager to convert to source energy. We use national average ratios for the conversion to source energy to ensure that no specific building will be credited (or penalized) for the relative efficiency of its energy provider(s).

Figure 1 – Source-Site Ratios for all Portfolio Manager Energy Meter Types

Energy Type	U.S. Ratio	Canadian Ratio
Electricity (Grid Purchase)	2.80	1.96
Electricity (Onsite Solar or Wind - regardless of REC ownership)	1.00	1.00
Natural Gas	1.05	1.01
Fuel Oil (No. 1,2,4,5,6, Diesel, Kerosene)	1.01	1.01
Propane & Liquid Propane	1.01	1.04
Steam	1.20	1.33
Hot Water	1.20	1.33
Chilled Water	0.91	0.57
Wood	1.00	1.00
Coal/Coke	1.00	1.00
Other	1.00	1.00

This document explains source energy and the details behind each factor in the following sections:

THE VALUE OF SOURCE ENERGY

The purpose of the conversion from site energy to source energy is to provide an equitable assessment of building-level energy efficiency. Because billed site energy use includes a combination of primary and secondary forms of energy, a comparison using site energy does not provide an equivalent thermodynamic assessment for buildings with different fuel mixes. In contrast, source energy incorporates all production, transmission, and delivery losses, which accounts for all primary fuel consumption and enables a complete assessment of energy efficiency in a building.

When source energy is used to evaluate energy performance, an individual building's performance does not receive either a credit or a penalty for using any particular fuel type. In contrast, use of a site energy metric would provide a credit for buildings that purchase energy produced offsite by a utility (such as electricity). You can see this neutrality in the following example scenarios with different heating systems and in a comparison of ENERGY STAR certified buildings to the national commercial building stock.

Source Energy in Different Heating Scenarios

Because most buildings use electricity for lighting and other equipment, the reason that fuel mix varies by building is usually due to the choice of heating system. Another way to understand the relationship between fuel choice, source energy, and energy performance is to consider six different scenarios for heating systems in buildings, which are included in the figure below. For each scenario, the building operation and thermal envelope are the same. Therefore, the heat load for each building is identical. The differences among the buildings are solely in the type of heating fuel and the equipment used for heating. As a result of these differences, the buildings have different site and source energy consumption, as shown in the figure below.

Figure 2 – Comparison of Alternate Heating Scenarios

	Building A	Building B	Building C	Building D	Building E	Building F
Heating Fuel	**Natural Gas**	**Natural Gas**	**District Steam**	**Electric**	**Electric**	**Electric**
Heating System	Gas-fired Boiler 90% combustion efficiency 80% system efficiency	Gas-fired Boiler 70% combustion efficiency 55% system efficiency	District Steam 95% system efficiency	Geothermal COP=4.0	Air Source Heat Pump COP = 2.5	Electric Resistance Heat
Heat to Space (MBtu)	1000	1000	1000	1000	1000	1000
Site Energy (MBtu)	1250	1818	1053	250	400	1000
Source Energy (MBtu)	**1313**	**1909**	**1264**	**700**	**1120**	**2800**

Note that the U.S. source-site ratios were applied:

- *Electricity: 1 unit site = 2.80 units source*
- *Natural Gas: 1 unit site = 1.05 units source*
- *Steam: 1 unit site = 1.20 units source*

The site and source energy values in ***Figure 2*** demonstrate the key differences between the two metrics and illustrate why source energy is the more equitable comparative metric. A comparison of these building scenarios using site energy fails to recognize efficiency losses from the off-site energy generation. In contrast, source energy provides an accurate and equitable comparison of these building scenarios, as described further in ***Figure 3*** below. The metrics in Portfolio Manager (e.g., the ENERGY STAR score, Source EUI) aim to evaluate energy performance based on whole-building energy use, independent of heating system, or building technology. Using source energy allows the heating system efficiency to be fairly represented in the whole-building energy use metrics.

Figure 3 – The Benefits of Source Energy

✓ Benefits of Source Energy

- ✓ Allows for a whole-building assessment that combines all fuels
- ✓ Evaluates all buildings fairly, regardless of heating system
- ✓ Fairly evaluates electric heating in relation to natural gas and steam systems
    - ✓ Identifies geothermal heating as most efficient
    - ✓ Evaluates air source heat pump systems as efficient, on par with natural gas boilers and district steam systems
    - ✓ Identifies electric resistance heating as least efficient
- ✓ Provides equitable comparison of steam systems with natural gas-fired systems
- ✓ Fairly compares natural gas boilers with different on-site efficiency levels

Electricity Consumption in Portfolio Manager and ENERGY STAR Certified Buildings

To understand how these heating scenarios work in the real world, we can evaluate the fuel mixes of buildings across the United States, as represented by the Commercial Building Energy Consumption Survey (CBECS), a nationally representative sample of buildings. We can then compare this with buildings that have earned ENERGY STAR certification in 2017.

Across all commercial buildings in the United States, electricity accounts for 69% of energy use. Among ENERGY STAR certified buildings, the average percent electricity is slightly higher, at 79%. In addition to the average percent electricity we can also evaluate the percent of buildings that are 100% electricity (i.e. heated and cooled with electricity). Here, we see that 34% of the buildings nationally are 100% electric, as compared with 29% among ENERGY STAR certified buildings. Taken together, these statistics show that buildings with a high percentage of electricity use are just as likely to earn ENERGY STAR certification as other types of buildings.

Figure 4 – Percent Electricity in U.S. Commercial Buildings

	CBECS	ENERGY STAR Certified (2017)
Number of Buildings Represented	4,809,031	9,555
Average % Electricity	69%	79%
Number of Buildings that are 100% Electric	1,617,758	2,757
Percent of Buildings that are 100% Electric	34%	29%

CBECS is conducted by the US Department of Energy's Energy Information Administration. Filters were applied to the 2012 CBECS data for analysis purposes. ENERGY STAR Certified facilities include those that benchmarked in Portfolio Manager and earned certification in 2017.

METHODOLOGY

Ultimately, the goal of the conversion to source energy is to account for the total primary fuel needed to deliver heat and electricity to the site. Generally, this means the methodology should perform the following adjustments for energy consumed on site:

- **Primary Energy.** Account for losses that occur in the distribution, storage and dispensing of the primary fuel (e.g., natural gas, fuel oil).
- **Secondary Energy.** Account for conversion losses at the plant in addition to losses incurred during transmission and distribution of secondary energy to the building (e.g., electricity, district steam).

These adjustments quantify the total energy content of the primary fuel. In this assessment, the primary fuels are considered refined products such as coal, natural gas and oil. The analysis does not account for the energy that is consumed in mining, transporting, and refining crude products. While that type of analysis may provide an instructive look at the lifecycle impacts of energy use, it is beyond the scope of a building-level assessment. Specific details on the application of this methodology to each type of energy are provided in following sections of this document.

Use of National Average Source-Site Ratios

The efficiency of secondary energy (e.g., electricity) production depends on the types of primary fuels that are consumed and the specific equipment that is used. These characteristics are unique to specific power plants and differ by region. For example, some regions have a higher percentage of hydroelectric power, while others consume greater quantities of coal. The goal of the ENERGY STAR program is to provide comparisons of building energy efficiency relative to a national peer group, and therefore it is most equitable to employ national-level source-site ratios. Because Portfolio Manager is available in both the United States and Canada, country-specific source-site ratios are used. For each country, there is only one national source-site ratio for each of the primary and secondary fuels in Portfolio Manager, including grid purchases of electricity. Most of the factors are generally similar for the two countries, although the ratio for electricity is lower in Canada due to a higher percentage of hydroelectric power at the national level.

There are a few reasons why national source-site ratios provide the most equitable approach:

1. **Fixed Geography.** The geographic location is fixed for most buildings; there is no opportunity to relocate the building to a region with more efficient electrical production.
2. **Interconnected Grid.** For most buildings, it is not possible to trace each kWh of electricity back to a specific power plant. Across a given utility region, the grid is connected and the electric consumption of a specific building cannot be associated with any individual plant.
3. **Building Focus.** The key unit of analysis for Portfolio Manager is the building. It is the efficiency of the building, not the utility, which is evaluated. Two buildings with identical operation and energy efficiency will receive the same ENERGY STAR score regardless of their geographic location or utility company.[1]

The use of national source-site ratios ensures that no specific building will be credited (or penalized) for the relative efficiency of its utility provider.

[1] Note that two buildings with equivalent energy *efficiency* in two different regions may have different *absolute energy consumption* owing to weather conditions. The ENERGY STAR score accounts for climate differences in this situation, providing an equitable comparison for buildings in different climates. The use of source energy ensures that a building does not receive either a credit or a penalty based on its utility provider.

U.S. National Median Reference Values for All Portfolio Manager Property Types

Broad Category	Primary Function	Further Breakdown (where needed)	Source EUI (kBtu/ft²)	Site EUI (kBtu/ft²)	Reference Data Source - Peer Group Comparison
Banking/Financial Services	**Bank Branch ***		209.9	88.3	CBECS - Bank/Financial
	Financial Office*		116.4	52.9	CBECS - Office & Bank/Financial
Education	Adult Education		110.4	52.4	CBECS - Education
	College/University		180.6	84.3	CBECS - College/University
	K-12 School*		104.4	48.5	CBECS - Elementary/Middle & High School
	Pre-school/Daycare		131.5	64.8	CBECS - Preschool
	Vocational School		110.4	52.4	CBECS - Education
	Other - Education				
Entertainment/Public Assembly	Convention Center		109.6	56.1	CBECS - Social/Meeting
	Movie Theater		112.0	56.2	CBECS - Public Assembly
	Museum				
	Performing Arts				
	Recreation	Bowling Alley	112.0	50.8	CBECS - Recreation
		Fitness Center/Health Club/Gym			
		Ice/Curling Rink			
		Roller Rink			
		Swimming Pool			
		Other - Recreation			
	Social/Meeting Hall		109.6	56.1	CBECS - Social/Meeting