Commercial Statistically Adjusted End-Use (SAE) Spreadsheets – 2023 AEO Update

The 2023 Commercial Statistically Adjusted End-Use (SAE) spreadsheets and models have been updated to reflect the Energy Information Administration's (EIA) 2023 Annual Energy Outlook (AEO). All comparisons within this document compare the 2023 forecast with the 2022 forecast unless stated otherwise. Elements that have been updated include:

- End-use energy intensity projections
- End-use efficiency projections
- Floor stock projections
- Census Division commercial SAE project files (MetrixND)
- Revised historical saturations and efficiencies

The 2023 Commercial Statistically Adjusted End-Use (SAE) spreadsheets and the Energy Information Administration's (EIA) 2023 Annual Energy Outlook (AEO) include impacts of the Inflation Reduction Act (IRA).

Each year, EIA develops a long-term electric and gas forecast for the commercial sector using an end-use modeling framework that is part of the National Energy Modeling System (NEMS). EIA develops forecasts for 11 commercial building types, 9 electric end uses and 5 natural gas end uses. The largest electric end uses include lighting, cooling, ventilation, refrigeration, and miscellaneous use. The largest gas end use is heating, followed by water heating and cooking.

End-use intensity projections are key inputs in the commercial SAE forecast model. Commercial electrical end-use intensities are measured on a kWh per square foot basis and natural gas end uses on a therms per square foot basis. Other than miscellaneous use, end-use intensities have been declining over the last 10 years and are expected to continue to decline over the next 20 years. The decline in energy intensities are largely driven by end-use efficiency improvements. Factors driving efficiency improvements include new building and end-use standards, the availability of more efficient technology options, declining costs for high-efficient technologies and federal, state utility efficiency programs, including efficiency investments through the Inflation Reduction Act.

Commercial Buildings Energy Consumption Survey (CBECS)

The Commercial Buildings Energy Consumption Survey (CBECS) is the foundation for the EIA commercial forecast model. End-use detail derived from the survey is used in defining the forecast base year. The 2023 AEO is based on the 2012 Commercial Buildings Energy Consumption Survey (CBECS) with a forecast base year of 2013. Prior to 2017, the AEO base year was 2004 with base-year data derived from the 2003 CBECS. The most recent CBECS was completed in 2018. Data from the 2018 CBECS is being released in 2023 and will be incorporated in subsequent AEO and SAE releases.

Electric Forecast Updates

The EIA forecast model generates end-use consumption projections starting in the base year through 2050. Annual energy projections incorporate technology efficiency projections, equipment stock and factors that drive changes in equipment stock including available technologies and associated costs, energy prices and economic conditions. Commercial electric intensities are calculated for:

- Heating
- Cooling
- Ventilation
- Water Heating
- Cooking
- Refrigeration
- Lighting
- Office Equipment (PCs)
- Miscellaneous

End-use consumption and floor space by building type are downloaded from the EIA NEMS forecast output. Data is used to generate end-use intensities for 11 building types and 9 Census Divisions. The energy intensity (EI) is derived by dividing end-use energy consumption by square footage projections:

$$EI_{bet} = {Energy_{bet}}/{sqft_{bt}}$$

Where:

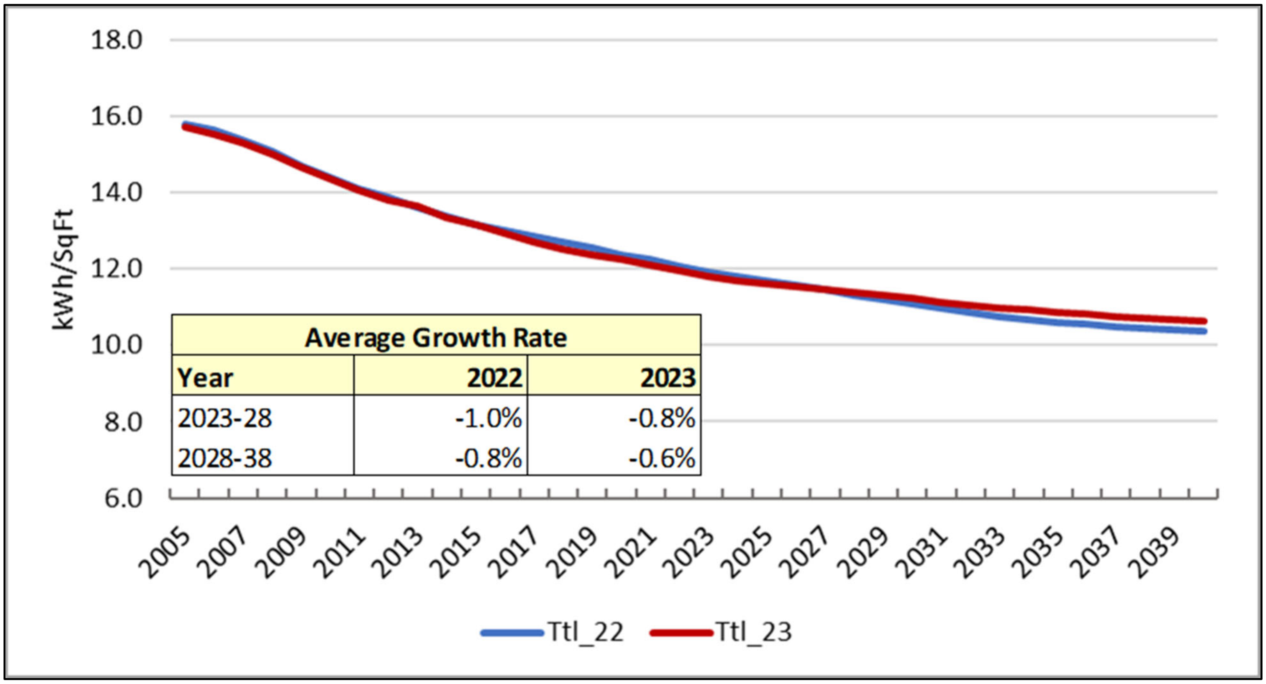
- $Energy_{bet}$ = Energy consumption for end-use e, building type *b*, year *t*
- $Sqft_{bt}$ = Square footage for building type *b* in year *t*

Total end-use energy intensities (across building types) are calculated as a weighted average of the building type intensities where the weights are based on building type square footage:

$$EI_{et} = \sum_b EI_{bet} \times \left({sqft_{bt}}/{\sum_b sqft_{bt}}\right)$$

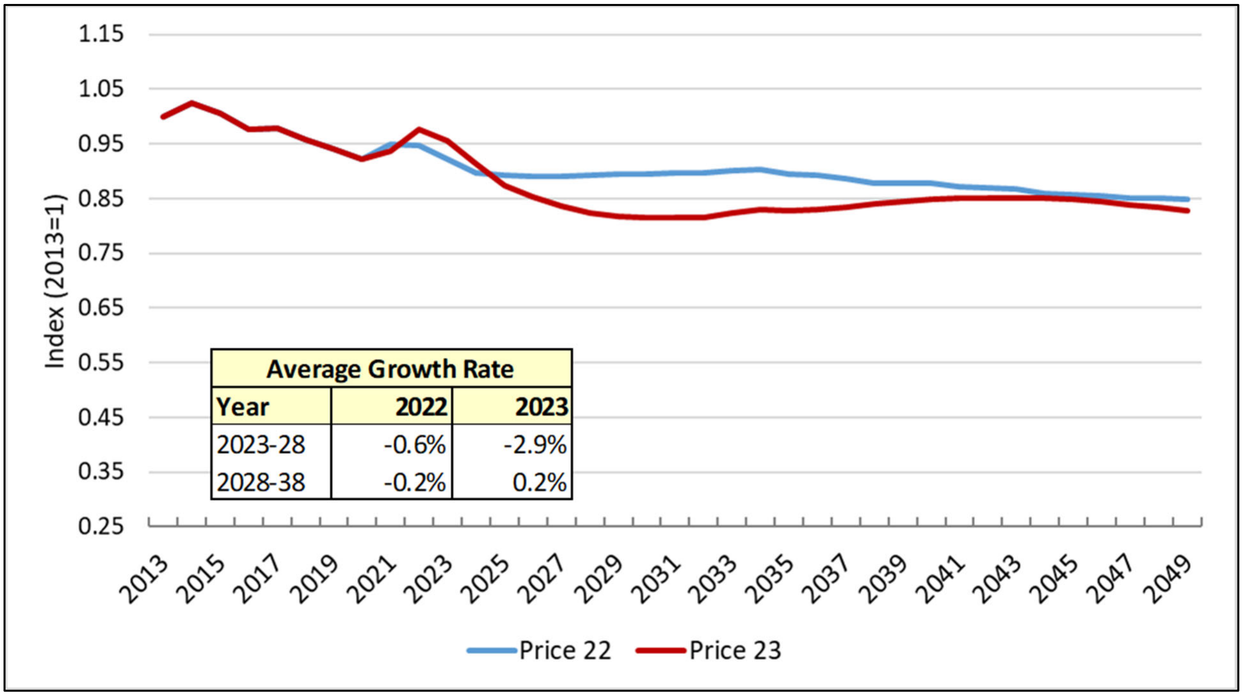
At the U.S. level, EIA projects a 0.8% annual decline in energy intensity between 2023 and 2028, this is a small decrease from the 1.0% decline projected in the AEO 2022 forecast. Over the longer term, the current forecast declines slightly slower than the prior forecast at 0.6% annual rate vs 0.8% annual rate. **Figure 1** compares total commercial electric intensity projections.

Figure 1: Total Commercial Building Electricity Intensity (kWh/SqFt)



In addition to technology options and equipment costs, energy prices are also a key factor in driving equipment efficiency choices and utilization. There have been revisions to the near-term price projections, with 2022 and 2023 prices being significantly higher than what was forecasted in the 2022 AEO. Starting at a higher level, the 2023 AEO price forecast declines faster from 2023-2028, compared to the 2022 AEO price forecast. **Figure 2** compares AEO 2022 and 2023 commercial price projections.

Figure 2: Commercial Electric Prices (Index)

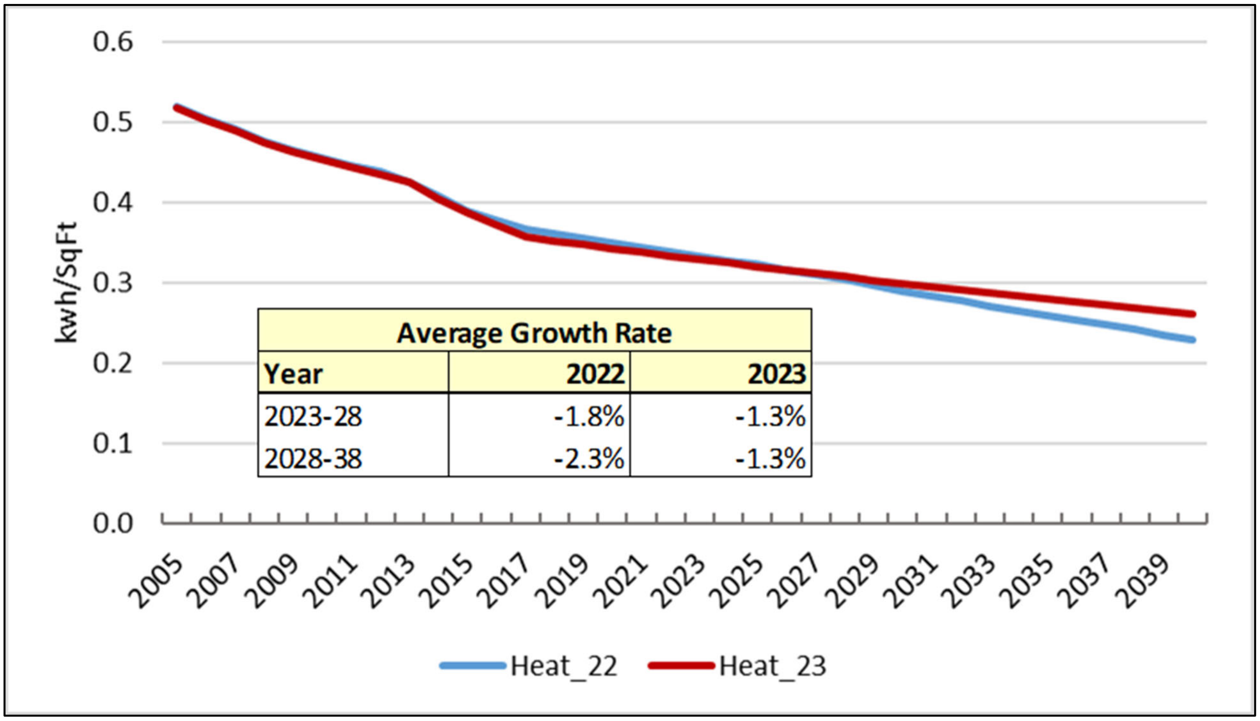


Average Growth Rate		
Year	2022	2023
2023-28	-0.6%	-2.9%
2028-38	-0.2%	0.2%

Electric Heating

Although electric heating is a relatively small end use, heating intensity projections contribute to the overall decline in commercial building usage. Electric heating intensity declines 1.3% over the forecast period. The change from the 2022 AEO is based on revised efficiency assumptions. **Figure 3** compares the 2022 and 2023 heating intensity forecasts.

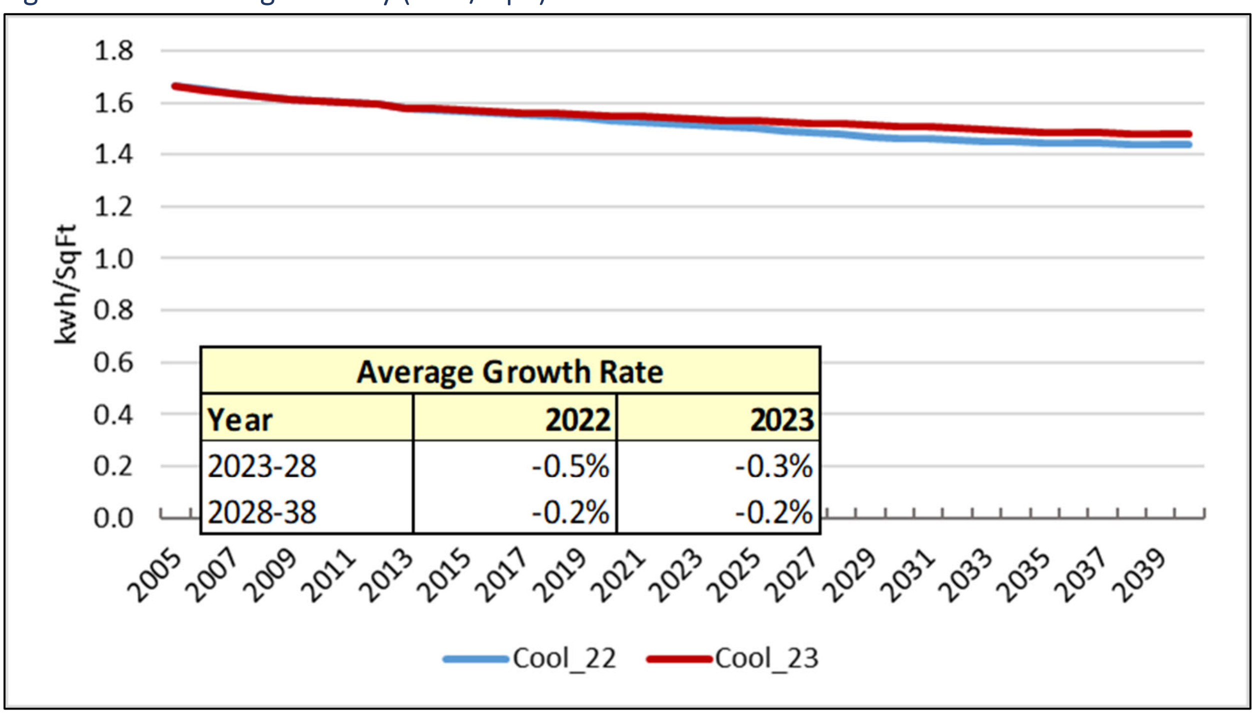
Figure 3: U.S. Electric Heating Intensity (kWh/SqFt)



Cooling

Cooling intensities are largely unchanged from the prior forecast. **Figure 4** compares AEO 2022 and AEO 2023 cooling intensity projections.

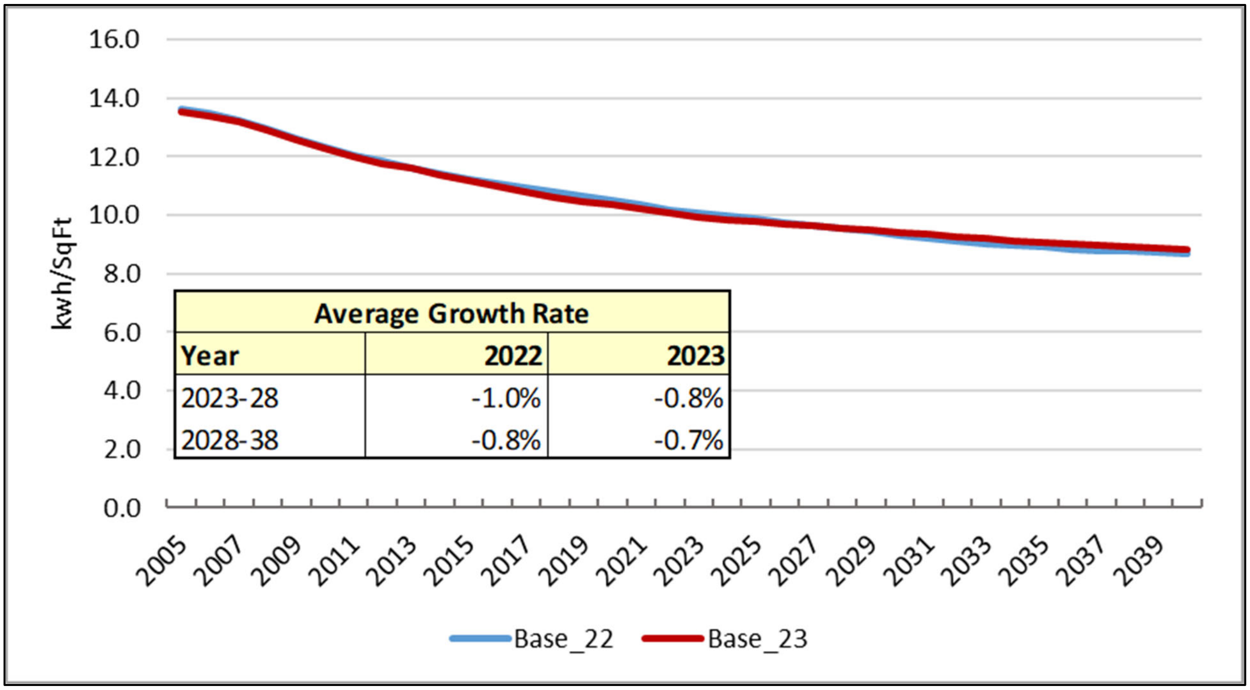
Figure 4: U.S. Cooling Intensity (kWh/SqFt)



Electric Other Use

Other large electric end uses include ventilation, refrigeration, lighting, office equipment and miscellaneous use. The 2023 base-use intensity declines slower than the prior forecast, largely due to revisions to lighting efficiency. The aggregation of these end-use intensities is shown in **Figure 5**.

Figure 5: U.S. Base Intensity (kWh/SqFt)

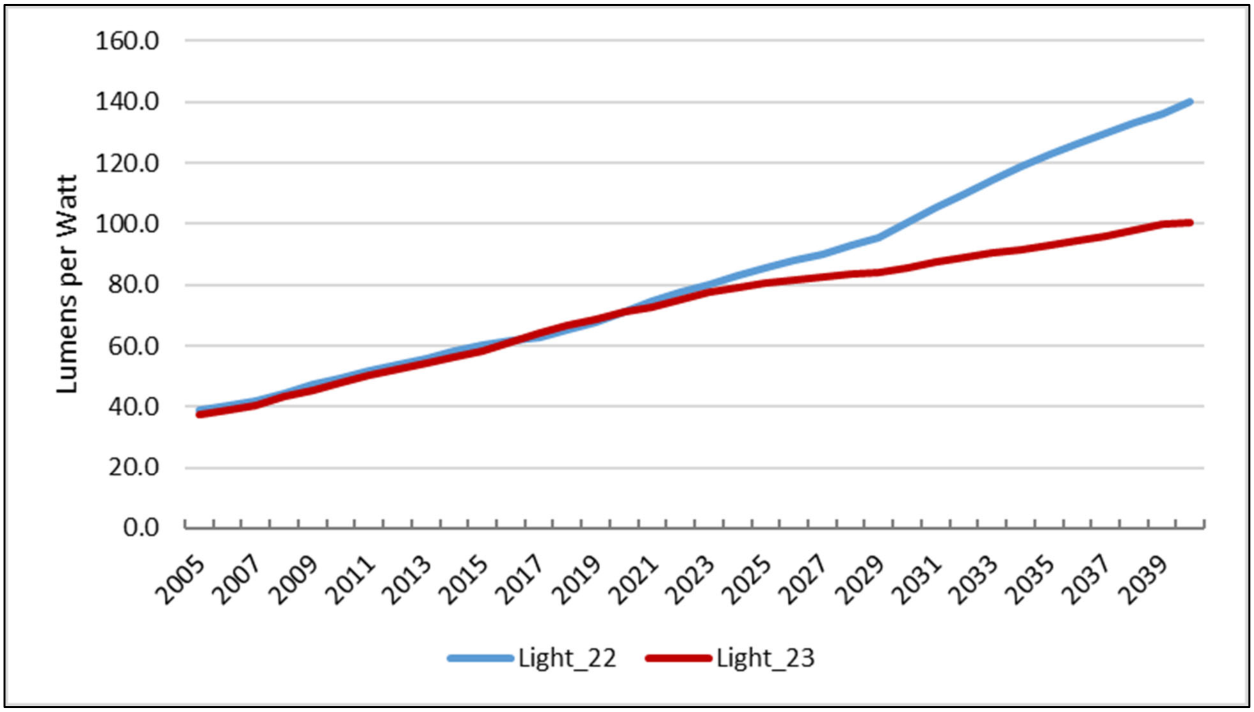


Average Growth Rate		
Year	**2022**	**2023**
2023-28	-1.0%	-0.8%
2028-38	-0.8%	-0.7%

Lighting

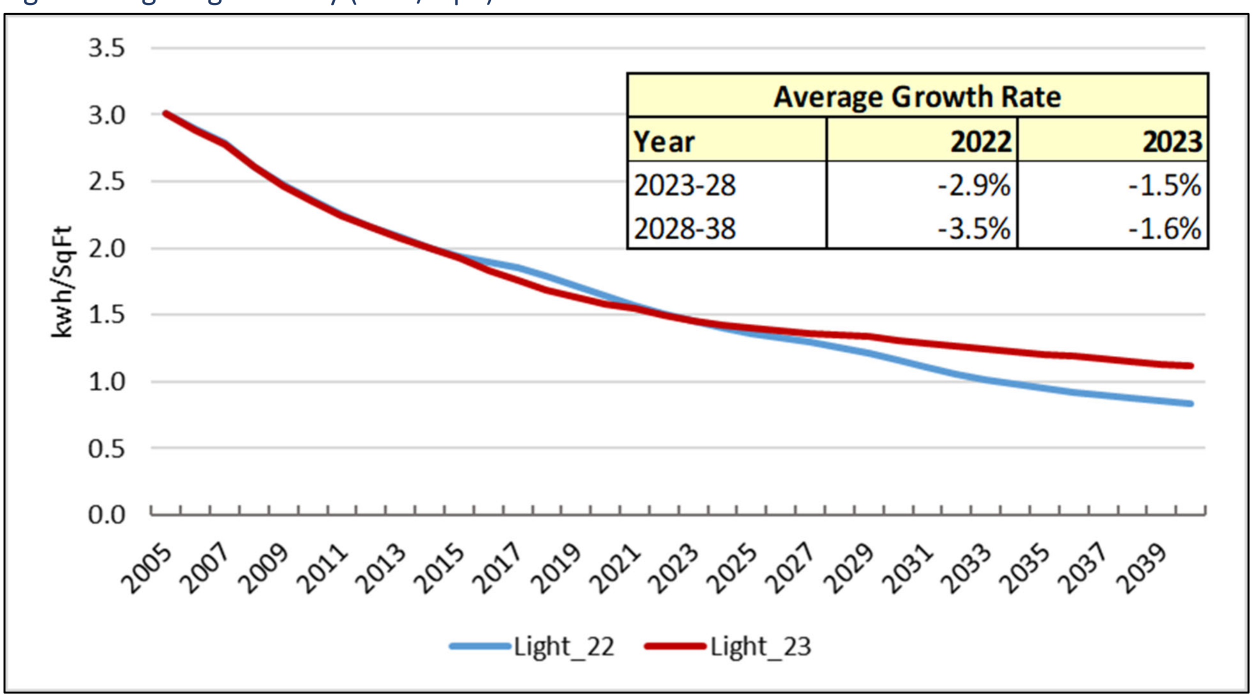
Lighting is the other large contributor to declining commercial energy intensity. In 2004, lighting accounted for 30% of commercial energy consumption. Today lighting accounts for roughly 12% of commercial building usage. Declines in lighting intensity have been driven by strong efficiency improvements with improvements expected to continue through the forecast period. The 2023 AEO incorporated new lighting cost and performance characteristics, which resulted in an upward revision to the lighting efficiency projections. **Figure 6** compares the 2023 and 2022 lighting efficiency projections, measured in lumens per watt.

Figure 6: Lighting Efficiency (Lumens/Watt)



As a result of the efficiency changes, lighting intensity projections are higher, **Figure 7** compares the 2023 and 2022 lighting intensity projections.

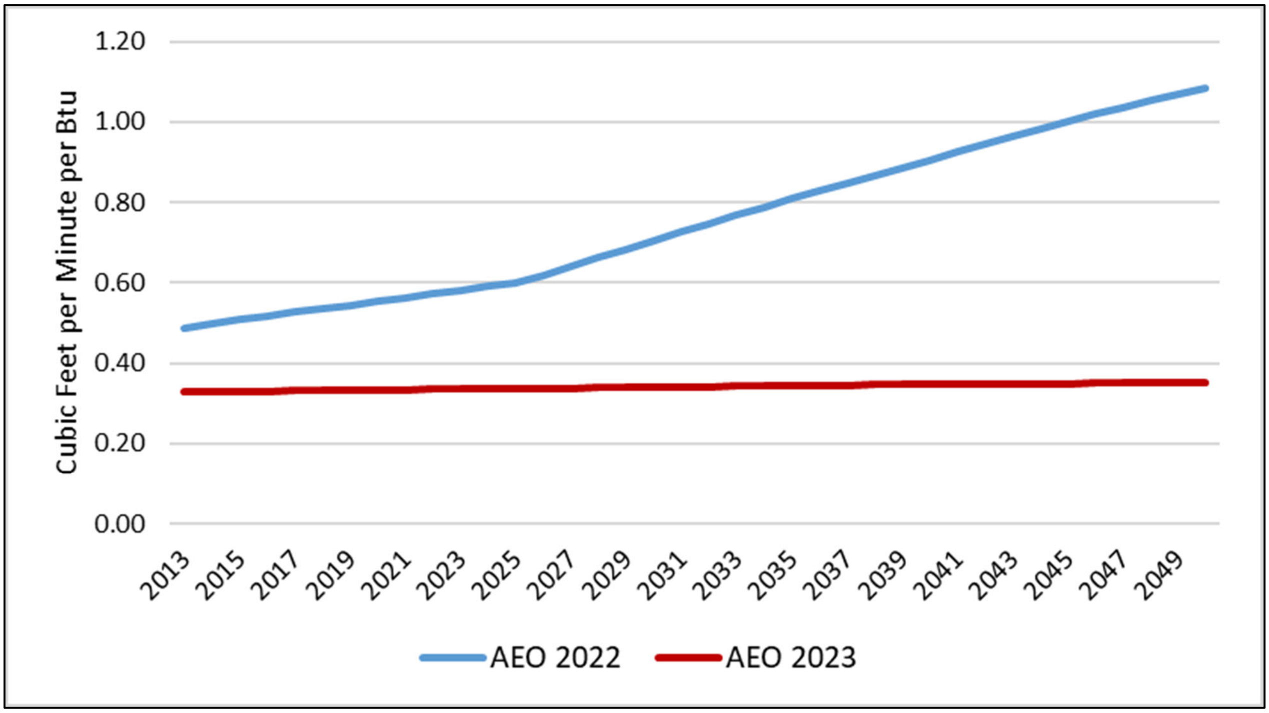
Figure 7: Lighting Intensity (kWh/SqFt)



Ventilation

Ventilation is one of the primary end uses contributing to the overall decline in commercial building use. Ventilation accounts for 13% of commercial building use. It is the fourth largest commercial end use. As commercial ventilation saturation is nearly 100 percent, changes in ventilation intensity are driven by changes in efficiency. Starting with the 2017 AEO, the EIA projected ventilation efficiency to improve 2.0% to 3.0% per year, resulting in a significant decline in intensity. The 2023 AEO incorporated new ventilation cost and performance characteristics, resulting in very different efficiency projections, as seen in **Figure 8**. Ventilation consumption projections have been revised down, which is inconsistent with the efficiency projections. This implies either lower utilization or square footage. In an effort to ensure the resulting ventilation intensity is consistent with the consumption projections, the 2023 SAE spreadsheets will utilize the 2022 ventilation projections. Further investigation and discussion with EIA will be pursued to ensure the most accurate assumptions are used going forward.

Figure 8: Ventilation Efficiency (Cubic Feet per Minute per Btu)



Solar Adjustment

Prior to the 2021 forecast, EIA subtracted solar generation from the end-use intensities. Itron would add back solar generation to reflect customer use rather than customer-delivered energy. This adjustment is no longer needed as EIA is again forecasting customer use and not delivered energy.

PV Worksheet

The PV worksheet has been populated with regional solar data from the 2023 AEO. The PV worksheet, (**Figure 9**) calculates from left to right with EIA inputs in red and calculations in blue.

Figure 9: PV Worksheet

Year	Floorspace	PVInstalls	PVStock	AvgPVSize	PVInstalledKW	PVDecayRate	PVStockKW	CapacityFactor	Generation MWh	OwnUse Share	OwnUse MWh	Excess MWh	OwnUse Intensity
1995	62,543	2,087	2,087	41.4	86,414	0.01	86,414	15.2%	114,835	100%	114,805	31	(0.0018)
1996	64,821	546	2,633	41.4	22,593	0.01	108,143	15.2%	143,711	100%	143,672	39	(0.0022)
1997	67,100	688	3,321	41.4	28,500	0.01	135,562	15.2%	180,147	100%	180,099	48	(0.0027)
1998	69,379	868	4,190	41.4	35,951	0.01	170,158	15.2%	226,121	100%	226,060	61	(0.0033)
1999	71,658	1,095	5,285	41.4	45,351	0.01	213,807	15.2%	284,126	100%	284,050	76	(0.0040)
2000	72,807	1,382	6,667	41.4	57,208	0.01	268,876	15.2%	357,308	100%	357,212	96	(0.0049)
2001	73,956	1,743	8,410	41.4	72,165	0.01	338,352	15.2%	449,634	100%	449,513	121	(0.0061)
2002	75,106	2,199	10,609	41.4	91,032	0.01	426,001	15.2%	566,109	100%	565,957	152	(0.0075)
2003	76,255	2,774	13,383	41.4	114,832	0.01	536,573	15.2%	713,048	100%	712,856	192	(0.0093)
2004	77,678	3,499	16,882	41.4	144,855	0.01	676,063	15.2%	898,415	100%	898,173	241	(0.0116)
2005	79,021	4,414	21,295	41.4	182,728	0.01	852,030	15.2%	1,132,256	100%	1,131,951	304	(0.0143)
2006	80,510	5,568	26,863	41.4	230,502	0.01	1,074,011	15.2%	1,427,245	100%	1,426,862	384	(0.0177)
2007	82,039	7,023	33,886	41.4	290,766	0.01	1,354,038	15.2%	1,799,370	100%	1,798,886	484	(0.0219)
2008	83,619	8,860	42,746	41.4	366,787	0.01	1,707,285	15.2%	2,268,797	100%	2,268,187	610	(0.0271)
2009	85,063	11,176	53,922	41.4	462,684	0.01	2,152,896	15.2%	2,860,966	100%	2,860,197	769	(0.0336)
2010	86,009	14,098	68,020	41.4	583,652	0.01	2,715,019	15.2%	3,607,967	100%	3,606,997	970	(0.0419)
2011	86,599	17,784	85,804	41.4	736,248	0.01	3,424,117	15.2%	4,550,281	100%	4,549,059	1,223	(0.0525)
2012	87,071	22,433	108,237	41.4	928,740	0.01	4,318,616	15.2%	5,738,974	100%	5,737,432	1,542	(0.0659)
2013	87,591	28,299	136,535	41.4	1,171,559	0.01	5,446,988	15.2%	7,238,459	100%	7,236,514	1,945	(0.0826)
2014	88,142	35,989	172,525	38.8	1,395,106	0.01	6,787,624	15.2%	9,020,020	100%	9,017,828	2,192	(0.1023)
2015	88,781	35,246	207,770	37.3	1,313,332	0.01	8,033,080	15.2%	10,675,096	100%	10,672,489	2,607	(0.1202)
2016	89,572	57,173	264,943	35.7	2,039,432	0.01	9,992,182	15.2%	13,278,530	100%	13,275,484	3,046	(0.1482)
2017	90,471	78,567	343,510	34.4	2,700,986	0.01	12,593,246	15.2%	16,735,064	100%	16,731,217	3,846	(0.1849)
2018	91,434	66,651	410,161	34.0	2,268,946	0.01	14,736,259	15.2%	19,582,897	100%	19,577,652	5,245	(0.2141)
2019	92,454	62,688	472,849	34.1	2,139,719	0.01	16,728,616	15.2%	22,230,524	100%	22,224,954	5,569	(0.2404)

The annual number of installed PV systems (Column C) are accumulated to total PV stock (Column D). This is translated to annual kW of installed capacity (Column F) by multiplying cumulative installed units by average system size (Column E). Capacity projection can be adjusted for solar degradation by setting a decay rate (Column G); Adjusted kW capacity (Column H) is calculated by applying the decay rate to prior year PV capacity estimate. Solar generation (Column J) is calculated as the product of adjusted solar capacity, capacity factor (Column I) and the number of hours in a year. Solar generation is either used onsite (own-use) or sold back to the grid (excess). Solar own-use is the product of total generation and own-use share (Column K); own-use share may vary significantly depending on local net metering laws. Solar own-use intensity (Column N) is derived by dividing own-use solar generation by square footage.

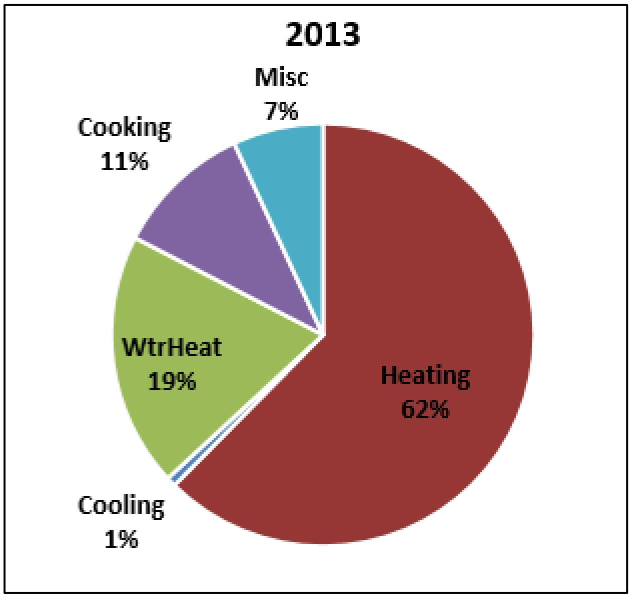
Gas Forecast Updates

Commercial gas intensities are calculated for the primary end uses, including:

- Space Heating
- Space Cooling
- Water Heating
- Cooking
- Miscellaneous

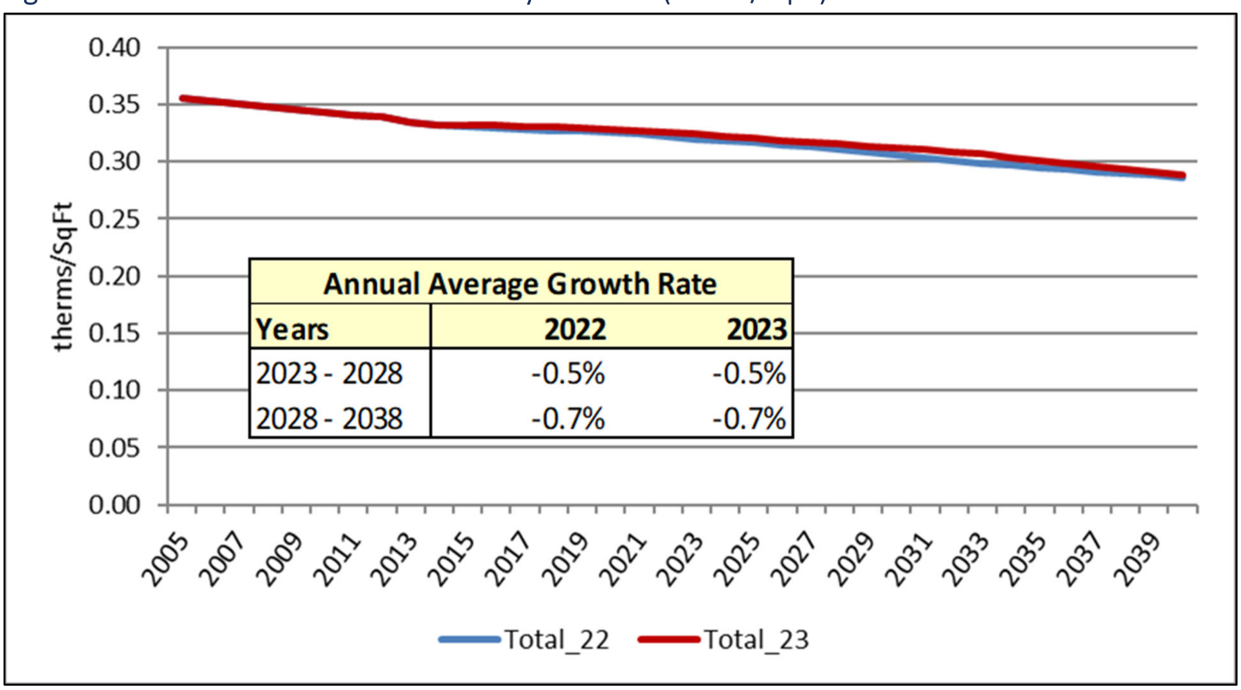
Figure 10 shows the base-year end-use shares.

Figure 10: Gas End-use Distribution



Total gas intensity (therms per SqFt) is largely unchanged from last year with intensity expected to decline 0.5% per year through 2028 and 0.7% in the subsequent 10 years. **Figure 11** compares the 2022 and 2023 total commercial building gas intensity.

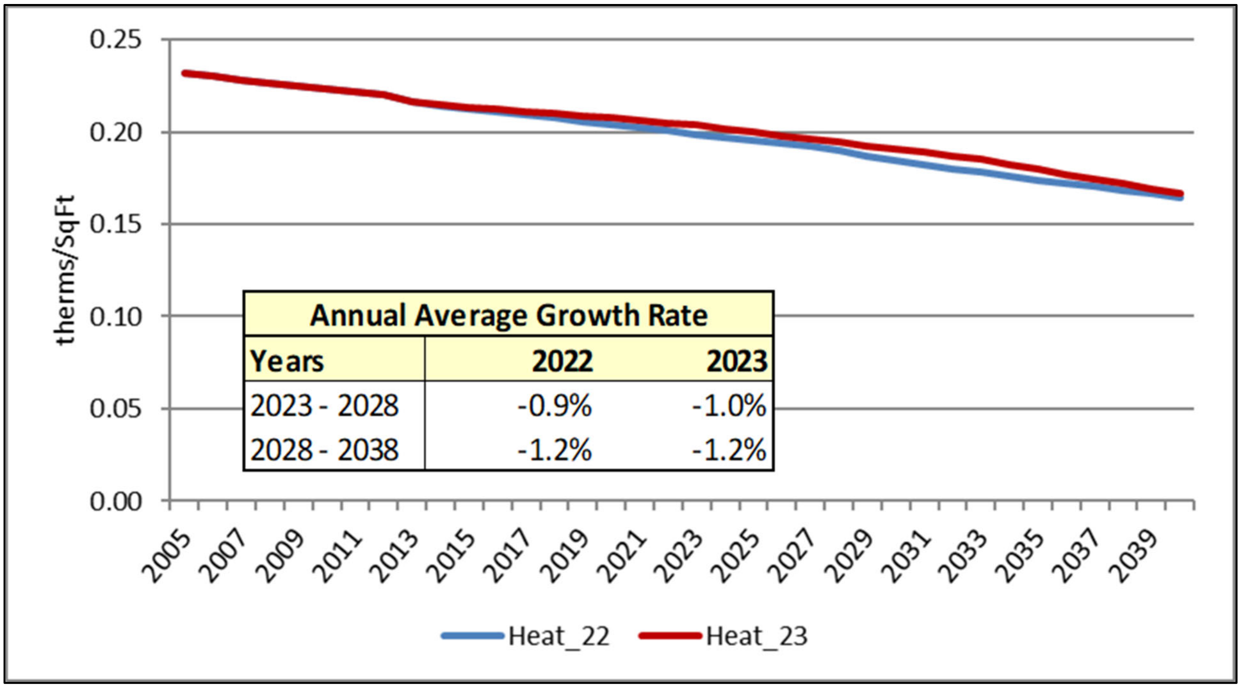
Figure 11: Total Commercial Gas Intensity Forecast (therm/SqFt)



Gas Heating

Natural gas is the predominant energy source for commercial heating. Heating intensity is expected to decline at 1.0% per year through 2027, increasing to 1.2% through 2037. Figure 12 compares gas heating intensity projections.

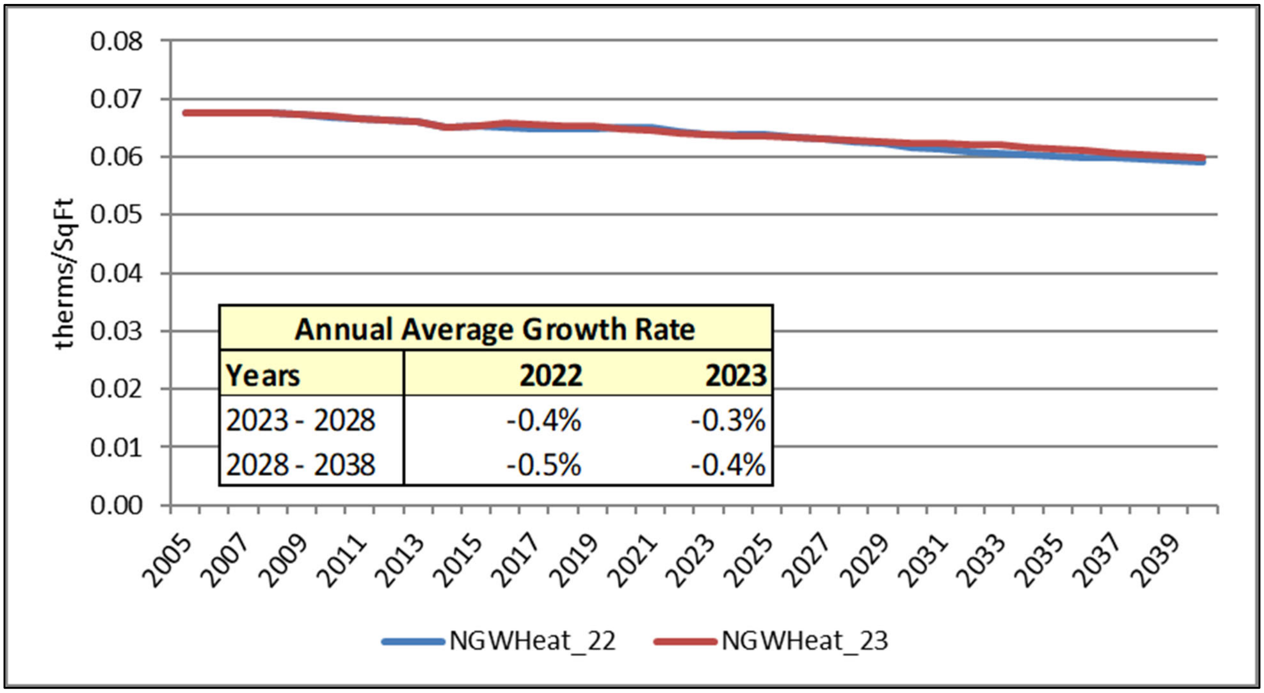
Figure 12: Gas Heating Intensity (therm/SqFt)



Gas Other End Uses

Water heating is the second largest end use accounting for approximately 20% of commercial gas use. As with heating, there are no significant changes. **Figure 13** compares the 2022 and 2023 gas water heating intensity projections.

Figure 13: Gas Water Heating Intensity Projections (therm/SqFt)



SAE Forecast Model Updates

MetrixND SAE models are constructed for each Census Division. The set of project files include simple floor stock models designed to mimic the EIA commercial sales forecast. In the floor stock models, monthly commercial sales are defined as a function of square footage (SqFt), end-use energy intensities (*CoolEI*, *HeatEI* and *OtherEI*) and monthly heating and cooling degree-day indices (*HDDIndex*, *CDDIndex*):

$$Sales_t = b_0 + b_1 \times (CoolEI_t \times SqFt_t \times CDDIndex_t) + b_2 \times (HeatEI_t \times SqFt_t \times HDDIndex_t) + b_3 \times (OtherEI_t \times SqFt_t) + e_t$$

The regional models incorporate EIA's 2023 end-use intensity and square footage projections. The models can be calibrated to an individual utility service area by replacing EIA historical and forecasted square footage with utility-specific square footage estimates. A standard approach for developing a square footage forecast is to estimate a square footage model as a function of commercial employment:

$$SqFt_{t=}a_0 + a_1 \times ComEmploy_t + e_t$$

For most utilities, historical floor stock data is difficult to construct. Further, the simple floor stock model may not adequately capture the impact of short-term variations in economic activity and rate changes. The new project files also include the SAE model specifications from earlier years. In the SAE specification, estimates of long-term monthly end-use energy are imported from the SAE spreadsheet, and interacted with GDP, price and weather conditions. An elasticity that is consistent with forecasts derived from the simple stock model is imposed on GDP. A description of the SAE model specification is outlined in Appendix A

Appendix A:
Commercial Statistically Adjusted End-Use Model

The traditional approach to forecasting monthly sales for a customer class is to develop an econometric model that relates monthly sales to weather, seasonal variables, and economic conditions. From a forecasting perspective, econometric models are well suited to identifying historical trends and to projecting these trends into the future. In contrast, end-use models can incorporate the end-use factors driving energy use. By including end-use structure in an econometric model, the statistically adjusted end-use (SAE) modeling framework exploits the strengths of both approaches.

There are several advantages to the SAE approach.

- The equipment efficiency trends and saturation changes embodied in the long-run end-use forecasts are introduced explicitly into the short-term monthly sales forecast, thereby providing a strong bridge between the two forecasts.
- By explicitly introducing trends in equipment saturations and efficiency levels, SAE models can explain changes in usage levels and weather-sensitivity over time.
- Data for short-term models are often not sufficiently robust to support estimation of a full set of price, economic and demographic effects. By bundling these factors with equipment-oriented drivers, a rich set of elasticities can be built into the final model.

This section describes this approach, the associated supporting Commercial SAE spreadsheets, and MetrixND project files that are used in the implementation. The source for the commercial SAE spreadsheets is the 2020 Annual Energy Outlook (AEO) database provided by the Energy Information Administration (EIA).

Statistically Adjusted End-Use Model Framework

The statistically adjusted end-use modeling framework begins by defining energy use ($USE_{y,m}$) in year (y) and month (m) as the sum of energy used by heating equipment ($Heat_{y,m}$), cooling equipment ($Cool_{y,m}$), and other equipment ($Other_{y,m}$). Formally,

$$USE_{y,m} = Heat_{y,m} + Cool_{y,m} + \mathrm{Other}_{y,m} \quad (1)$$

Although monthly sales are measured for individual customers, the end-use components are not. Substituting estimates for the end-use elements gives the following econometric equation.

$$USE_m = a + b_1 \times XHeat_m + b_2 \times XCool_m + b_3 \times XOther_m + \varepsilon_m \quad (2)$$

$XHeat_m$, $XCool_m$, and $XOther_m$ are explanatory variables constructed from end-use information, dwelling data, weather data, and market data. As will be shown below, the equations used to construct these X-variables are simplified end-use models, and the X-variables are the estimated usage levels for each of the major end uses based on these models. The estimated model can then be thought of as a statistically adjusted end-use model, where the estimated slopes are the adjustment factors.

Constructing XHeat

As represented in the Commercial SAE spreadsheets, energy use by space heating systems depends on the following types of variables.

- Heating degree days,
- Heating intensity,
- Commercial output and energy price.

The heating variable is represented as the product of an annual equipment index and a monthly usage multiplier. That is,

$$XHeat_{y,m} = HeatIndex_{y,m} \times HeatUse_{y,m} \tag{3}$$

Where:

- $XHeat_{y,m}$ is estimated heating energy use in year (*y*) and month (*m*)
- $HeatIndex_{y,m}$ is the annual index of heating equipment
- $HeatUse_{y,m}$ is the monthly usage multiplier

The heating equipment index is composed of electric space heating intensity. The index will change over time with changes in heating intensity. Formally, the equipment index is defined as:

$$HeatIndex_y = HeatSales_{13} \times \frac{(HeatIntensity_y)}{(HeatIntensity_{13})} \tag{4}$$

In this expression, 2013 is used as a base year for normalizing the index. The ratio on the right is equal to 1.0 in 2013. In other years, it will be greater than 1.0 if intensity levels are above their 2013 level.

$$HeatSales_{13} = \left(\frac{kWh}{Sqft}\right)_{Heating} \times \left(\frac{CommercialSales_{13}}{\sum_e {kWh}/{Sqft_e}}\right) \tag{5}$$

Here, base-year sales for space heating is the product of the average space heating intensity value and the ratio of total commercial sales in the base year over the sum of the end-use intensity values. In the Commercial SAE Spreadsheets, the space heating sales value is defined on the *BaseYrInput* tab. The resulting $HeatIndex_y$ value in 2013 will be equal to the estimated annual heating sales in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

Heating system usage levels are impacted on a monthly basis by several factors, including weather, commercial level economic activity, and prices. Using the COMMEND default elasticity parameters, the estimates for space heating equipment usage levels are computed as follows:

$$HeatUse_{y,m} = \left(\frac{WgtHDD_{y,m}}{HDD_{13}}\right) \times \left(\frac{Output_y}{Output_{13}}\right) \quad \times \left(\frac{Price_{y,m}}{Price_{13}}\right)^{-0.18} \tag{6}$$

Where

- *WgtHDD* is the weighted number of heating degree days in year *y* and month *m*. This is constructed as the weighted sum of the current month's HDD and the prior month's HDD. The weights are 75% on the current month and 25% on the prior month
- *HDD* is the annual heating degree days for 2013,
- *Output* is a real commercial output driver in year *y*,
- *Price* is the average real price of electricity in month *m* and year *y*,

By construction, the $HeatUse_{y,m}$ variable has an annual sum that is close to 1.0 in the base year (2013). The first terms, which involve heating degree days, serves to allocate annual values to months of the year. The remaining terms average to 1.0 in the base year. In other years, the values will reflect changes in commercial output and prices, as transformed through the end-use elasticity parameters. For example, if the real price of electricity goes up 10% relative to the base year value, the price term will contribute a multiplier of about .98 (computed as 1.10 to the -0.18 power).

Constructing XCool

The explanatory variable for cooling loads is constructed in a similar manner. The amount of energy used by cooling systems depends on the following types of variables.

- Cooling degree days,
- Cooling intensity,
- Commercial output and energy price.

The cooling variable is represented as the product of an equipment-based index and monthly usage multiplier. That is,

$$XCool_{y,m} = CoolIndex_y \times CoolUse_{y,m} \tag{7}$$

Where:

- $XCool_{y,m}$ is estimated cooling energy use in year y and month m,
- $CoolIndex_y$ is an index of cooling equipment, and
- $CoolUse_{y,m}$ is the monthly usage multiplier.

As with heating, the cooling equipment index depends on equipment saturation levels (*CoolShare*) normalized by operating efficiency levels (Eff). Formally, the cooling equipment index is defined as:

$$CoolIndex_y = CoolSales_{13} \times \frac{\left(CoolShare_y / Eff_y\right)}{\left(CoolShare_{13} / Eff_{13}\right)} \tag{8}$$

Data values in 2013 are used as a base year for normalizing the index, and the ratio on the right is equal to 1.0 in 2013. In other years, it will be greater than 1.0 if equipment saturation levels are above their 2013 level. This will be counteracted by higher efficiency levels, which will drive the index downward. Estimates of base year cooling sales are defined as follows.

$$CoolSales_{13} = \left(\frac{kWh}{Sqft}\right)_{Cooling} \times \left(\frac{CommercialSales_{13}}{\sum_e {}^{kWh}/_{Sqft_e}}\right) \tag{9}$$

Here, base-year sales for space cooling is the product of the average space cooling intensity value and the ratio of total commercial sales in the base year over the sum of the end-use intensity values. In the Commercial SAE Spreadsheets, the space cooling sales value is defined on the *BaseYrInput* tab. The resulting *CoolIndex* value in 2013 will be equal to the estimated annual cooling sales in that year. Variations from this value in other years will be proportional to saturation and efficiency variations around their base values.

Cooling system usage levels are impacted on a monthly basis by several factors, including weather, economic activity levels and prices. Using the COMMEND default parameters, the estimates of cooling equipment usage levels are computed as follows:

$$CoolUse_{y,m} = \left(\frac{WgtCDD_{y,m}}{CDD_{13}}\right) \times \left(\frac{Output_y}{Output_{13}}\right) \times \left(\frac{Price_{y,m}}{Price_{13}}\right)^{-0.18} \tag{10}$$

Where:

- *WgtCDD* is the weighted number of cooling degree days in year (*y*) and month (*m*). This is constructed as the weighted sum of the current month's CDD and the prior month's CDD. The weights are 75% on the current month and 25% on the prior month.
- *CDD* is the annual cooling degree days for 2013.

By construction, the *CoolUse* variable has an annual sum that is close to 1.0 in the base year (2013). The first two terms, which involve billing days and cooling degree days, serve to allocate annual values to months of the year. The remaining terms average to 1.0 in the base year. In other years, the values will change to reflect changes in commercial output and prices.

Constructing XOther

Monthly estimates of non-weather sensitive sales can be derived in a similar fashion to space heating and cooling. Based on end-use concepts, other sales are driven by:

- Equipment intensities,
- Average number of days in the billing cycle for each month, and
- Real commercial output and real prices.

The explanatory variable for other uses is defined as follows:

$$XOther_{y,m} = OtherIndex_{y,m} \times OtherUse_{y,m} \tag{11}$$

The second term on the right-hand side of this expression embodies information about equipment saturation levels and efficiency levels. The equipment index for other uses is defined as follows:

$$OtherIndex_{y,m} = \sum_{Type} Weight_{13}^{Type} \times \left(\frac{Share_{y}^{Type} \Big/ Eff_{y}^{Type}}{Share_{13}^{Type} \Big/ Eff_{13}^{Type}} \right) \quad (12)$$

Where:

- Weight is the weight for each equipment type,
- Share represents the fraction of floor stock with an equipment type, and
- Eff is the average operating efficiency.

This index combines information about trends in saturation levels and efficiency levels for the main equipment categories. The weights are defined as follows.

$$Weight_{13}^{Type} = \left(\frac{kWh}{Sqft}\right)_{Type} \times \left(\frac{CommercialSales_{13}}{\sum_e {kWh}/{Sqft_e}} \right) \quad (13)$$

Further monthly variation is introduced by multiplying by usage factors that cut across all end-uses, constructed as follows:

$$OtherUse_{y,m} = \left(\frac{BDays_{y,m}}{30.44}\right) \times \left(\frac{Output_{y}}{Output_{13}}\right) \times \left(\frac{Price_{y.m}}{Price_{13}}\right)^{-0.18} \quad (14)$$

In this expression, the elasticities on output and real price are computed from the COMMEND default values.

Supporting Spreadsheets and MetrixND Project Files

The SAE approach described above has been implemented for each of the nine census divisions. A mapping of states to census divisions is presented in Figure 1. This section describes the contents of each file and a procedure for customizing the files for specific utility data. A total of 18 files are provided. These files are listed in Table 1.

Figure 1: Mapping of States to Census Divisions

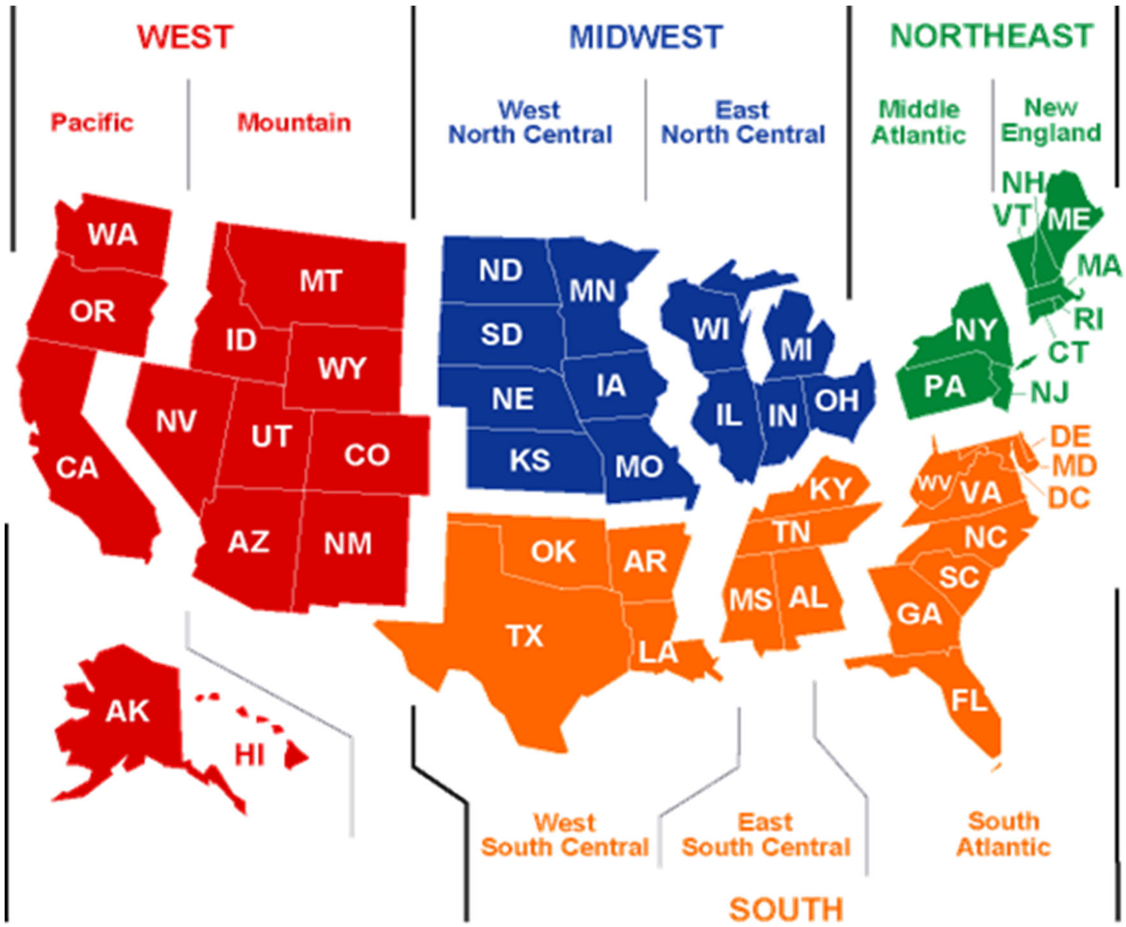


Table 1: List of SAE Electric Files

Spreadsheets	***MetrixND* Project Files**
NewEnglandCom23.xlsx	NewEnglandCom23.ndm
MiddleAtlanticCom23.xlsx	MiddleAtlanticCom23.ndm
EastNorthCentralCom23.xlsx	EastNorthCentralCom23.ndm
WestNorthCentralCom23.xlsx	WestNorthCentralCom23.ndm
SouthAtlanticCom23.xlsx	SouthAltanticCom23.ndm
EastSouthCentralCom23.xlsx	EastSouthCentralCom23.ndm
WestSouthCentralCom23.xlsx	WestSouthCentralCom23.ndm
MountainCom23.xlsx	MountainCom23.ndm
PacificCom23.xlsx	PacificCom23.ndm

As defaults, the SAE spreadsheets include regional data, but utility data can be entered to generate the *Heat*, *Cool* and *Other* equipment indices used in the SAE approach. The data from these spreadsheets are linked to the MetrixND project files. In these project files, the end-use *Usage* variables (Equations 6, 10 and 14 above) are constructed and the SAE model is estimated.

The nine spreadsheets contain the following tabs.

- **EIAData** contains the raw forecasted data provided by the EIA.
- **BaseYrInput** contains base year Census Division intensities by end-use and building type as well as default building type weights. It also contains functionality for changing the weights to reflect utility service territory.
- **Efficiency** contains historical and forecasted end-use equipment efficiency trends. The forecasted values are based on projections provided by the EIA.
- **Shares** contains historical and forecasted end-use saturations.
- **Intensity** contains the annual intensity (kWh/sqft) projections by end use.
- **AnnualIndices** contains the annual *Heat*, *Cool* and *Other* equipment indices.
- **FloorSpace** contains the annual floor space (sqft) projections by end use.
- **PV** incorporates the impact of photovoltaic batteries into the forecast.
- **Graphs** contains graphs of Efficiency and Intensities, which can be updating by selecting from the list in cell B2.

The MetrixND project files contain the following objects.

Parameter Tables

- **Parameters.** This parameter table includes the values of the annual HDD and CDD in 2013 used to calculate the Usage variables for each end-use.
- **Elas.** This parameter table includes the values of the elasticities used to calculate the Usage variables for each end-use.

Data Tables

- **AnnualIndices.** This data table is linked to the *AnnualIndices* tab in the Commercial SAE spreadsheet and contains sales-adjusted commercial SAE indices.
- **Intensity.** This data table is linked to the *Intensity* tab in the Commercial SAE spreadsheet.
- **FloorSpace.** This data table links to *FloorSpace* tab in the Commercial SAE spreadsheet.
- **UtilityData.** This linkless data table contains Census Division level data. It can be populated with utility-specific data.

Transformation Tables

- **EconTrans.** This transformation table is used to compute the output and price indices used in the usage equations.
- **WeatherTrans.** This transformation table is used to compute the HDD and CDD indices used in the usage equations.
- **CommercialVars.** This transformation table is used to compute the *Heat*, *Cool* and *Other* Usage variables, as well as the *XHeat*, *XCool* and *XOther* variables that are used in the regression model. Structural variables based on the intensity/floor space combination are also calculated here.
- **BinaryVars.** This transformation table is used to compute the calendar binary variables that could be required in the regression model.

- **AnnualFcst.** This transformation table is used to compute the annual historical and forecast sales and annual change in sales.
- **EndUseFcst.** This transformation table breaks the forecast down into its heating, cooling, and other components.

Models

- **ComSAE.** The commercial SAE model (energy forecast driven by end-use indices, price, and output projections).
- **ComStruct.** Simple stock model (energy forecast driven by end-use energy intensities, and square footage).