**KEMA**

# memo

To:  Natelle Dietrich, PSC; Brenda Wilbers, DNR
From:  Tom Franks
Date:  October 4, 2010
Copy:  Fred Coito & Kristina Kelly, KEMA; Gwen Mizell, GSM Development
Subject:  Interim Memo on Baseline Data

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This memorandum is intended to meet the following objectives:

1. To provide the Commission and stakeholders with an introduction to the methodology by which KEMA is determining the values for one set of inputs into our analysis; and,
2. To solicit comments regarding this methodology and a sample of preliminary results from the Commission.

As is the case for all interim memos provided for this project, this is a snapshot in time, and not the final work product.

**Missouri Statewide
Baseline Energy Analysis
October 4, 2010**


**Usage Summary**

To develop Missouri statewide energy use by sector, we started with breakouts from the Energy
Information Administration's State Energy Data System (EIA's SEDS, found at
http://www.eia.doe.gov/states/_seds.html). The following table shows the SEDS data by fuel and
sector, with subtotals for the commercial and industrial (C&I) sectors combined. For natural gas,
consumption is further broken out into sales and transport, a distinction which may be important
for program design. For this study, we have been directed to consider both natural gas sales and
transport for savings potential.

**SEDS energy consumption data**

|  | | NG | Electricity |
|---|---|---|---|
|  | | Trillion Btu | Million kWh |
| Residential consumption | | 114.6 | 35,390 |
| Commercial consumption | | 65.3 | 31,118 |
| Industrial consumption | | 67.1 | 17,850 |
|  | Subtotal C&I | 132.4 | 48,968 |
| Commercial sales (excludes transport) | | 50.6 | |
| Industrial sales (excludes transport) | | 9.3 | |
|  | Subtotal C&I | 59.9 | |
| Coml Transport | | 14.7 | |
| Ind transport | | 57.8 | |
|  | Subtotal C&I | 72.5 | |

It is our understanding that the SEDS sector breakouts are determined by assigning rate classes
to one sector or another in their entirety. Utilities typically have a residential rate class that
applies to residential customers, so this approach should result in accurate estimates for the
residential sector. However, because commercial and industrial rates are typically broken out by
customer demand rather than by sector, we did not want to rely on SEDS for the commercial
industrial breakouts. Instead, we relied on SEDS for overall C&I consumption, but looked for
other data to break out energy use between the sectors.

We found that Ameren, KCP&L and KCP&L/GMO each had detailed commercial and industrial
baseline electricity analyses, which were provided to us through the PSC.  These three utilities
represent a majority of Missouri's electricity consumption. While we had concerns extrapolating
the data to Missouri as a whole, we felt this approach was more reliable than SEDS rate-class
approach.[1] In the absence of detailed sector breakouts from Empire and the state's publicly

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[1] Empire District Electric also completed a potential study which may contain similar data. However, we currently
have only the body of the report, which does not contain the necessary data. We are trying to obtain the appendices
to the report, which may provide the data necessary to include Empire data on the same basis as the other three
utilities. This would improve the reliability of the estimates.

owned utilities, we believe this is the best approach. The following table shows the adjusted electricity consumption by sector.

**Adjusted energy consumption data**

|  | Electricity Million kWh |
|---|---|
| Commercial consumption | 28,577 |
| Industrial consumption | 20,391 |
| *Subtotal C&I* | 48,968 |

There were no similar baseline studies available from the natural gas utilities detailing the natural gas market. The variation between energy use profiles in different utilities, combined with the variation in industrial customers between utilities, regions, and states, limited our ability to leverage data from other studies. In the absence of a better approach, we adopted the SEDS splits for natural gas.

The resulting breakdowns of energy use by sector are shown in the charts below.

**Electricity Consumption by Sector**

Industrial 24%
Res 42%
Coml 34%

**Natural Gas Consumption by Sector**

Industrial 27%
Res 47%
Coml 26%
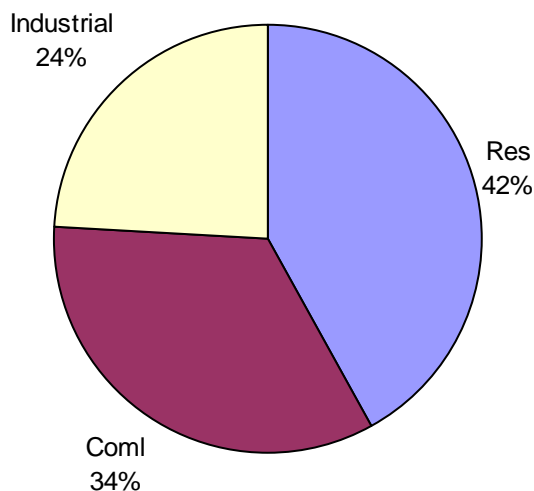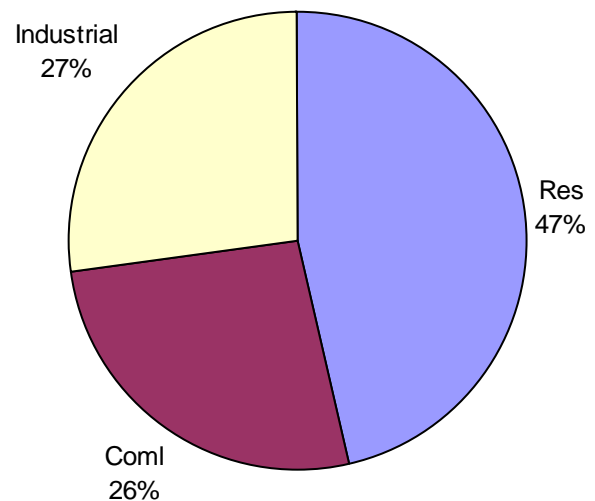
The following sections discuss how usage was broken out further by building type and end use.

## Residential Sector

*Building Type*

The residential customer class in Missouri will be disaggregated into two building types for our analysis:

- Single family
- Multifamily

Typically this is accomplished by conducting a statistically valid customer survey, matched to billing data analysis. As neither survey nor billing data is available for all of Missouri, a variety of sources will be used instead. The most recent figure available from the EIA of the total number of residential electricity customers in Missouri is 2,686, 746.[2] This figure was disaggregated into 2,149,397 single family units (80.0%) and 537,349 multi-family housing units (20.0%) based upon the most recent Census data available (from 2000). The number of residential natural gas customers was given by EIA's SEDS as 1,352,015, or 50.32% of electricity customers. The number of multifamily versus single-family housing units with natural gas will be calculated using EIA's Residential Energy Consumption Survey (RECS) microdata.[3] This portion of the analysis is not yet complete.

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[2] http://www.eia.gov/cneaf/electricity/esr/esr_sum.html
[3] http://www.eia.doe.gov/emeu/recs/

*End Use Consumption*

Residential sector consumption for both electricity and natural gas will be disaggregated into end-use consumption of the following base measures:

| Residential Electric Base Measures |
| --- |
| 13 SEER Split-System Air Conditioner |
| Early Replacement 10 SEER Split-System AC |
| Room Air Conditioner - EER 9.7 |
| Early Replacement Room Air Conditioner- EER 9.0 |
| Dehumidifier (EF =1.20) |
| Furnace Fans |
| Resistance Space Heating |
| Lighting 60-Watt incandescent, 1.8 hr/hday |
| Lighting 15 Watt CFL, 1.8 hours per day |
| Refrigerator |
| Second Refrigerator |
| Early Replacement Refrigerator |
| Freezer |
| Early Replacement Freezer |
| 40 gal. Water Heating (EF=0.88) |
| Early Replacement Water Heating to Heat Pump Water Heater |
| Clotheswasher (MEF=1.26) |
| Clothes Dryer (EF=3.01) |
| Dishwasher (EF=0.65) |
| Single Speed Pool Pump (RET) |
| Two Speed Pool Pump  (1.5 hp) (ROB) |
| Plasma Screen TV |
| LCD Screen TV |
| Other TV |
| Laptop Computer |
| Desktop Computer |
| Cooking |
| Miscellaneous |

| Residential Natural Gas Base Measures |
| --- |
| Furnace |
| Boiler |
| Room Heat |
| Water Heating |
| Clothes Drying |
| Cooking |
| Other |

Saturation estimates (the percentages of homes with the base measure installed) and end-use intensities (EUIs, the average consumption of the installed base measure) for both electricity and natural gas will be calculated based primarily on RECS microdata and the 2006 "Missouri Statewide Residential Lighting and Appliance Efficiency Saturation Study" by KEMA (formerly RLW Analytics). Two additional studies will also be consulted for the electricity analysis: Empire's "Demand-Side Resource Potential Study 2011-2013: Appendix D" and AmerenUE's 2010 "DSM Market Potential Study" Global Energy Partners.

This analysis is not yet complete.
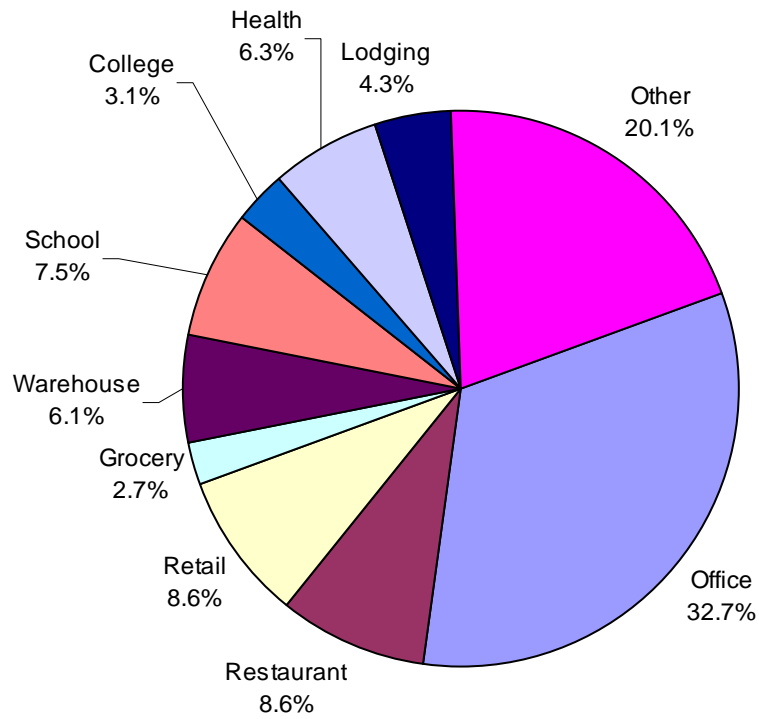
# Commercial Sector

*Building Types*

For the commercial electricity breakdown, we turned to the baseline studies performed by Ameren, KCP&L and KCP&L-GMO. The sales data by building type for the three utilities was combined and the resulting distribution of commercial electricity use by building type was applied to total Missouri consumption, developed as discussed above. The following chart shows the breakdown of commercial electricity use by building type.

**Commercial Electricity Use by Building Type**
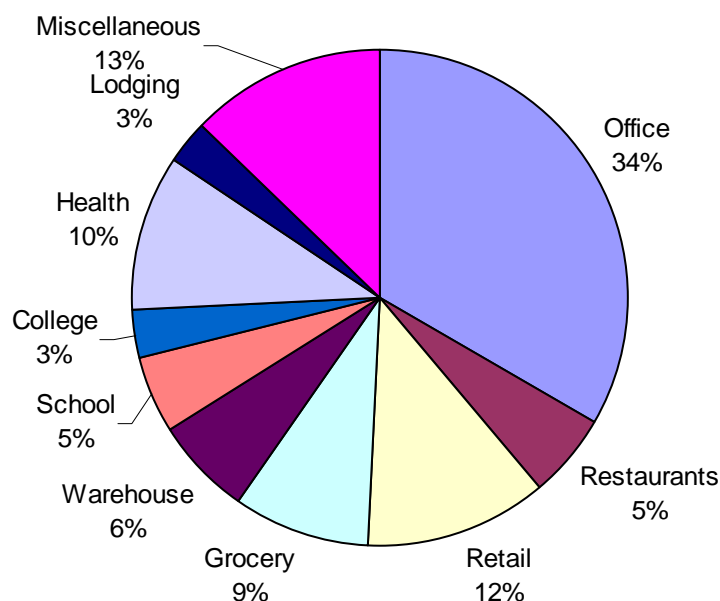


Lacking both natural gas billing data and a detailed gas market analysis, we looked to other gas studies we did for which we had access to utility billing data by NAICS (North American Industry Classification System) code. We have found the distribution of energy use across building types to be very similar across different regions. We took the energy use distribution by building type for Xcel Energy's Colorado service territory and for the state of Connecticut and reweighted them to reflect the distribution of floorspace by building type in Missouri (for example, if offices represented 36 percent of Xcel's floorspace compared to 24 percent of Missouri floorspace, we scaled back Xcel Energy's office energy use by a third before calculating the distribution of energy use). The distributions for Xcel and Connecticut were averaged and applied to Missouri commercial natural gas use, developed as discussed above. The following chart shows commercial natural gas use by building type.

## Commercial Natural Gas Use by Building Type

*End-Use Definitions*

Commercial sector electricity and natural gas consumption was disaggregated into end-use consumption of the following base measures:

| Commercial Electric Base Measures |
| --- |
| Lighting 4 Lamp 4' T12 |
| Lighting 2 Lamp 4' T12 |
| Lighting 2 Lamp 8' T12 |
| Lighting Incand-CFL Screw-in |
| Lighting CFL-LED Screw-in |
| Lighting Incand-CFL Hardwire |
| Lighting CFL-LED Hardwire |
| Lighitng High Bay |
| Lighting 4 Lamp 4' T8 |
| Lighting 2 Lamp 4' T8 |
| Lighting Exit Signs |
| Outdoor Lighting |
| Street Lighting |
| Chillers |
| DX Packaged Systems |
| Ventilation Motors 5 hp |
| Ventilation Motors 15 hp |
| Ventilation Motors 40 hp |
| Non-commercial refrigerators |
| Refrigeration System |
| Desktop PC |
| Monitor, 17" CRT |
| Monitor, 17" LCD |
| Copier |
| Laser Printer |
| Data Centers |
| Water Heating |
| Vending Machines |
| Cooking |
| Heating |
| Miscellaneous |

| Commercial Gas Base Measures |
| --- |
| Heating |
| Water Heating |
| Cooking |
| Other |

*End-use Saturations*

For the commercial sector electricity saturations, we again turned to the commercial baseline estimates done for Ameren, KCP&L and KCP&L-GMO. Each study broke out energy use by major end use (lighting, cooling, etc.). These end-use splits were weighted and used as the basis for the base measure saturations.

Because some end uses have several base measures, we needed to break out the end-use saturations developed from the utility studies into the detailed base measures. To do this, we turned to detailed on-site data from a recent Rhode Island study. This allowed us to break up the

overall cooling saturation, for example, into chillers and DX systems. No Missouri data was found to inform these splits at the necessary level of detail. For some measures, the utility data was not available or useable (for example, outdoor lighting could not be disaggregated from indoor lighting). We turned to the U.S. DOE's Commercial Building Energy Consumption Survey (CBECS) for some measures that fell outside the definitions of the utility studies, and use saturations from previous studies for outdoor lighting. Exit signs and miscellaneous were assumed to have 100 percent saturation.

For the natural gas baselines we relied on the U.S. DOE Commercial Building Energy Consumption Survey (CBECS) for end use saturation estimates.

*Energy Intensity*

The Ameren, KCP&L and KCP&L-GMO studies provided both energy intensities (energy per total building square foot) and end-use energy intensities (EUI, which is energy use per end-use square foot) when only for electricity. As with saturations, these were provided for major end-uses (such as lighting) rather than at the detailed base-measure level required for ASSYST. We therefore started with EUIs from a recent Colorado study, and then adjusted within each major end-use category to match the Missouri data. Once that was done, we calculated the overall energy intensity by building type implied by the EUIs and saturation we had just developed. A second calibration was applied to bring the overall energy intensity in line with that found by the utility studies. We compared the results to the California Commercial End-Use Survey (CEUS)[4] as a cross-check, and found, as expected, that energy use by non-weather-sensitive measures (such as lighting and cooking) were similar, while weather sensitive measures such as cooling and heating were higher in Missouri, which has more extreme weather than mild California.

For natural gas, we began with California Commercial End-Use Survey data as a starting point for EUI estimates. This California study is the most ambitious commercial analysis that we are aware of, consisting of on-site surveys and DOE-2 energy simulation analyses of over 2,500 commercial facilities. These values were adjusted to account for Missouri's climate differences.

*Floorspace*

Floorspace was calculated for electricity customers using based on the saturations, EUIs and usage by building type already developed. Data on floorspace is poor, and we have typically found this data to be the least reliable of the inputs to the ASSYST baseline analysis. We therefore rely on the other data, and derive the floorspace that makes the other inputs balance.

Because of the uncertainty in natural gas EUIs, this process is not possible for gas. We therefore used the floorspace determined for the electric analysis and scaled it to reflect the proportion of customers with gas service, using customer counts provided by the utilities.

**Commercial Baseline Results**

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[4] http://www.energy.ca.gov/ceus/

The following tables show the result of the commercial baseline analysis, as discussed above.

## Commercial Saturations for Electric Base Measures

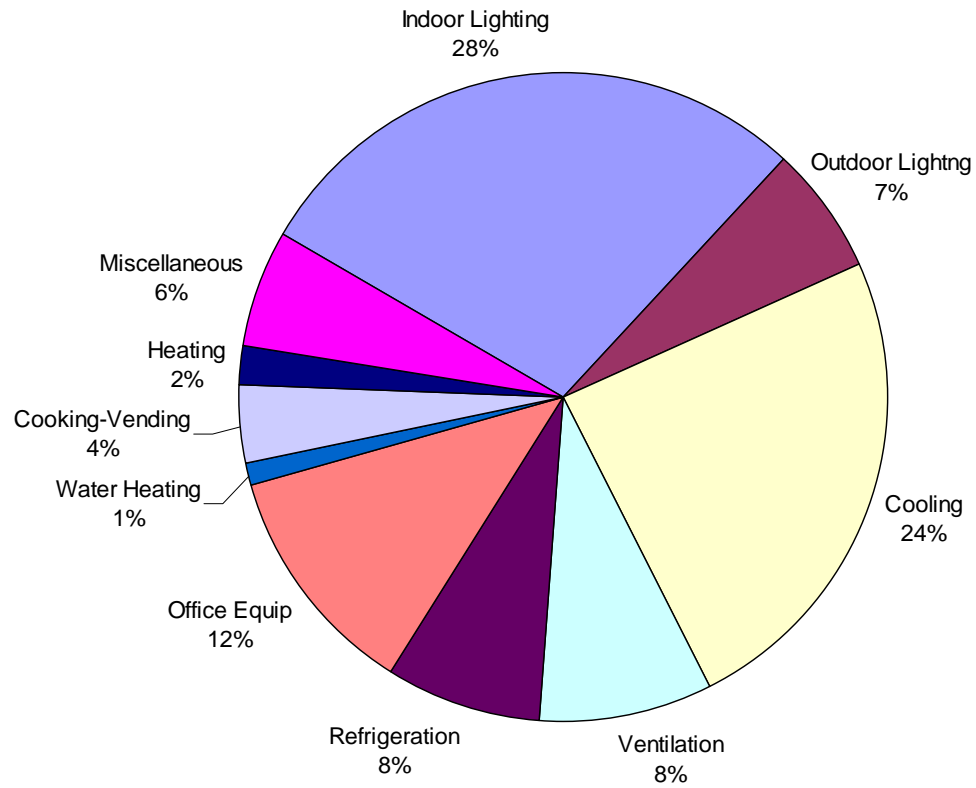| End Use | Office | Restaurant | Retail | Grocery | Warehouse | School | College | Health | Lodging | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Lighting 4 Lamp 4' T12 | 4.8% | 3.8% | 3.3% | 0.0% | 17.4% | 0.0% | 0.5% | 0.2% | 0.0% | 2.7% |
| Lighting 2 Lamp 4' T12 | 7.9% | 1.5% | 6.6% | 10.0% | 11.1% | 0.0% | 0.8% | 1.0% | 1.5% | 1.8% |
| Lighting 2 Lamp 8' T12 | 3.8% | 3.2% | 4.5% | 38.0% | 6.1% | 0.0% | 0.0% | 0.0% | 0.0% | 0.8% |
| Lighting Incand-CFL Screw-in | 15.8% | 24.5% | 10.7% | 5.0% | 1.1% | 4.8% | 0.6% | 3.8% | 4.7% | 32.9% |
| Lighting CFL-LED Screw-in | 5.5% | 13.3% | 0.5% | 0.0% | 1.8% | 0.3% | 0.0% | 6.0% | 8.7% | 5.3% |
| Lighting Incand-CFL Hardwire | 7.1% | 5.8% | 3.1% | 1.1% | 0.1% | 0.3% | 3.7% | 10.5% | 23.6% | 7.2% |
| Lighting CFL-LED Hardwire | 19.6% | 7.5% | 0.2% | 0.7% | 0.1% | 0.2% | 6.2% | 17.2% | 61.0% | 5.7% |
| Lighitng High Bay | 0.6% | 0.0% | 9.1% | 9.3% | 13.8% | 16.0% | 2.8% | 0.2% | 0.0% | 14.7% |
| Lighting 4 Lamp 4' T8 | 14.3% | 14.9% | 21.2% | 0.0% | 35.1% | 48.7% | 39.8% | 30.5% | 0.0% | 21.5% |
| Lighting 2 Lamp 4' T8 | 20.7% | 28.5% | 45.0% | 27.2% | 10.2% | 40.3% | 56.6% | 38.5% | 0.0% | 9.8% |
| Lighting Exit Signs | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Outdoor Lighting | 67.0% | 100.0% | 81.5% | 47.3% | 88.7% | 79.2% | 100.0% | 96.7% | 100.0% | 88.4% |
| Street Lighting | | | | | | | | | | 100.0% |
| Chillers | 35.4% | 4.6% | 12.3% | 0.0% | 7.2% | 21.4% | 74.7% | 76.7% | 27.9% | 14.6% |
| DX Packaged Systems | 57.2% | 88.2% | 73.8% | 94.3% | 72.8% | 62.6% | 9.3% | 18.0% | 67.9% | 69.9% |
| Ventilation Motors 5 hp | 86.0% | 72.8% | 73.3% | 49.3% | 68.3% | 77.7% | 100.0% | 47.7% | 100.0% | 83.6% |
| Ventilation Motors 15 hp | 5.5% | 12.1% | 9.0% | 0.0% | 0.0% | 42.0% | 37.1% | 14.3% | 0.0% | 12.2% |
| Ventilation Motors 40 hp | 20.2% | 0.0% | 13.6% | 0.0% | 5.7% | 0.0% | 22.3% | 0.0% | 0.0% | 52.0% |
| Non-commercial refrigerators | 67.3% | 44.0% | 53.1% | 43.4% | 49.0% | 60.3% | 73.1% | 89.7% | 61.1% | 60.0% |
| Refrigeration System | 67.8% | 87.7% | 70.1% | 96.7% | 67.1% | 86.4% | 97.2% | 96.6% | 86.1% | 63.5% |
| Desktop PC | 91.0% | 72.8% | 84.4% | 67.0% | 68.1% | 93.0% | 37.1% | 94.9% | 96.4% | 79.1% |
| Monitor, 17" CRT | 38.9% | 31.5% | 54.9% | 37.4% | 71.2% | 69.2% | 37.1% | 42.2% | 4.9% | 63.5% |
| Monitor, 17" LCD | 16.7% | 47.0% | 12.8% | 61.7% | 15.6% | 84.0% | 37.1% | 24.8% | 63.5% | 22.8% |
| Copier | 94.2% | 14.2% | 59.0% | 45.7% | 68.1% | 85.7% | 93.0% | 94.9% | 42.4% | 49.2% |
| Laser Printer | 94.2% | 72.6% | 85.8% | 87.6% | 68.1% | 93.0% | 93.0% | 94.9% | 86.0% | 65.7% |
| Data Centers | 0.7% | 0.1% | 0.0% | 0.1% | 0.2% | 0.3% | 1.3% | 1.1% | 0.1% | 0.1% |
| Water Heating | 36.1% | 21.2% | 35.2% | 8.1% | 30.9% | 27.0% | 27.0% | 9.2% | 8.0% | 34.7% |
| Vending Machines | 62.3% | 25.0% | 48.5% | 53.6% | 52.0% | 71.7% | 96.6% | 95.9% | 84.0% | 36.9% |
| Cooking | 16.7% | 67.9% | 12.8% | 61.7% | 15.6% | 84.0% | 84.0% | 24.8% | 63.5% | 22.8% |
| Heating | 20.9% | 17.0% | 19.6% | 11.6% | 14.9% | 9.0% | 9.0% | 6.1% | 56.6% | 22.8% |
| Miscellaneous | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

## Commercial Electric EUIs (kWh/end-use square foot)

| | Office | Restaurant | Retail | Grocery | Warehouse | School | College | Health | Lodging | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Lighting 4 Lamp 4' T12 | 4.7 | 4.2 | 4.3 | 15.7 | 2.2 | 3.4 | 4.1 | 7.6 | 2.6 | 1.6 |
| Lighting 2 Lamp 4' T12 | 4.7 | 4.2 | 4.3 | 15.7 | 2.2 | 3.4 | 4.1 | 7.6 | 2.6 | 1.6 |
| Lighting 2 Lamp 8' T12 | 4.7 | 4.2 | 4.3 | 15.7 | 2.2 | 3.4 | 4.1 | 7.6 | 2.6 | 1.6 |
| Lighting Incand-CFL Screw-in | 15.7 | 13.8 | 14.2 | 51.9 | 7.2 | 11.3 | 13.7 | 25.1 | 8.7 | 5.3 |
| Lighting CFL-LED Screw-in | 2.0 | 5.6 | 3.6 | 24.5 | 1.5 | 1.8 | 3.4 | 5.7 | 1.9 | 0.5 |
| Lighting Incand-CFL Hardwire | 15.7 | 13.8 | 14.2 | 51.9 | 7.2 | 11.3 | 13.7 | 25.1 | 8.7 | 5.3 |
| Lighting CFL-LED Hardwire | 2.0 | 5.6 | 3.6 | 24.5 | 1.5 | 1.8 | 3.4 | 5.7 | 1.9 | 0.5 |
| High Bay Lighitng | 4.9 | 4.3 | 4.4 | 16.1 | 2.2 | 3.5 | 4.3 | 7.8 | 2.7 | 1.7 |
| Lighting 4 Lamp 4' T8 | 2.7 | 2.4 | 2.5 | 9.0 | 1.2 | 2.0 | 2.4 | 4.4 | 1.5 | 0.9 |
| Lighting 2 Lamp 4' T8 | 2.7 | 2.4 | 2.5 | 9.0 | 1.2 | 2.0 | 2.4 | 4.4 | 1.5 | 0.9 |
| Exit Signs | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Outdoor lighting | 1.6 | 4.1 | 1.4 | 2.1 | 0.3 | 0.8 | 0.2 | 0.6 | 0.5 | 1.0 |
| Street Lighting | | | | | | | | | | 1.0 |
| Chillers | 3.8 | 6.7 | 3.0 | 7.3 | 2.4 | 1.4 | 2.0 | 4.7 | 0.9 | 1.5 |
| DX Packaged Systems | 6.5 | 11.6 | 5.3 | 12.7 | 4.2 | 2.4 | 3.5 | 8.1 | 1.6 | 2.6 |
| Ventilation Motors 5 hp | 1.5 | 3.9 | 1.2 | 9.8 | 0.65 | 0.7 | 0.5 | 5.9 | 0.7 | 0.6 |
| Ventilation Motors 15 hp | 1.4 | 3.7 | 1.1 | 9.0 | 0.60 | 0.7 | 0.5 | 5.5 | 0.7 | 0.5 |
| Ventilation Motors 40 hp | 1.3 | 3.6 | 1.1 | 8.9 | 0.59 | 0.7 | 0.5 | 5.4 | 0.7 | 0.5 |
| Non-commercial refrigerators | 0.1 | 0.1 | 0.3 | 0.1 | 0.0 | 0.2 | 0.0 | 0.1 | 0.2 | 0.0 |
| Refrigeration System | 0.1 | 13.3 | 0.2 | 33.0 | 1.2 | 0.4 | 0.5 | 0.6 | 0.5 | 0.3 |
| Desktop PC | 1.2 | 0.1 | 0.2 | 0.1 | 0.3 | 0.3 | 0.1 | 0.4 | 0.0 | 0.3 |
| Monitor, 17" CRT | 1.2 | 0.1 | 0.2 | 0.1 | 0.3 | 0.3 | 0.1 | 0.4 | 0.0 | 0.3 |
| Monitor, 17" LCD | 0.005 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.000 | 0.002 | 0.000 | 0.001 |
| Copier | 0.4 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | 0.0 | 0.3 | 0.0 | 0.1 |
| Laser Printer | 0.8 | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.0 | 0.5 | 0.0 | 0.2 |
| Data Centers | 228.4 | 268.4 | 224.0 | 316.7 | 80.5 | 91.2 | 72.0 | 134.3 | 96.4 | 59.9 |
| Water Heating | 0.3 | 1.8 | 0.3 | 1.8 | 0.1 | 1.7 | 1.7 | 2.8 | 2.6 | 0.5 |
| Vending Machines | 0.4 | 0.6 | 0.1 | 0.1 | 0.2 | 0.2 | 0.1 | 0.2 | 0.2 | 0.1 |
| Cooking | 2.9 | 2.4 | 1.4 | 0.8 | 0.0 | 1.2 | 1.2 | 0.3 | 3.2 | 1.6 |
| Heating | 1.96 | 3.81 | 1.46 | 2.04 | 0.20 | 1.53 | 1.53 | 2.01 | 1.89 | 2.01 |
| Miscellaneous | 1.0 | 4.0 | 0.5 | 1.3 | 0.56 | 0.01 | 0.01 | 2.12 | 1.22 | 1.10 |
| **Overall Energy Intensity (kWh/total sq ft)** | **20.4** | **43.8** | **13.4** | **67.6** | **8.0** | **9.4** | **9.4** | **23.5** | **11.8** | **10.5** |

## Commercial Floorspace (thousand sq ft) and Electricity Consumption (MWh) by Building Type and End Use

| | Office | Restaurant | Retail | Grocery | Warehouse | School | College | Health | Lodging | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Floorspace (thousand sq ft) | 469,705 | 35,264 | 255,435 | 37,665 | 229,753 | 151,401 | 91,593 | 125,113 | 69,734 | 344,192 | 1,809,854 |
| *Energy Consumption* | | | | | | | | | | | |
| Lighting 4 Lamp 4' T12 | 105,503 | 5,562 | 35,824 | 0 | 86,516 | 0 | 1,870 | 2,370 | 0 | 15,110 | 252,756 |
| Lighting 2 Lamp 4' T12 | 175,834 | 2,210 | 72,645 | 59,197 | 54,949 | 0 | 3,032 | 9,029 | 2,781 | 10,125 | 389,802 |
| Lighting 2 Lamp 8' T12 | 84,464 | 4,750 | 49,102 | 223,869 | 30,109 | 0 | 0 | 0 | 0 | 4,312 | 396,607 |
| Lighting Incand-CFL Screw-in | 1,158,235 | 119,501 | 390,258 | 97,060 | 17,856 | 81,471 | 8,153 | 120,115 | 28,611 | 602,300 | 2,623,561 |
| Lighting CFL-LED Screw-in | 52,135 | 26,471 | 4,804 | 0 | 6,247 | 764 | 26 | 42,826 | 11,679 | 9,438 | 154,390 |
| Lighting Incand-CFL Hardwire | 523,158 | 28,159 | 113,371 | 20,919 | 1,329 | 5,483 | 46,857 | 330,949 | 143,055 | 132,272 | 1,345,551 |
| Lighting CFL-LED Hardwire | 187,066 | 14,792 | 2,215 | 6,198 | 465 | 538 | 19,254 | 123,068 | 81,859 | 10,291 | 445,747 |
| High Bay Lighitng | 14,749 | 0 | 102,634 | 56,320 | 70,244 | 85,123 | 10,978 | 2,037 | 0 | 83,625 | 425,709 |
| Lighting 4 Lamp 4' T8 | 182,437 | 12,579 | 134,114 | 0 | 100,341 | 144,831 | 86,989 | 166,322 | 0 | 68,362 | 895,974 |
| Lighting 2 Lamp 4' T8 | 263,899 | 24,118 | 284,060 | 92,333 | 29,180 | 119,978 | 123,607 | 209,886 | 0 | 31,080 | 1,178,141 |
| Exit Signs | 9,654 | 3,173 | 4,847 | 599 | 735 | 1,265 | 1,871 | 6,203 | 1,926 | 2,267 | 32,540 |
| Outdoor lighting | 494,048 | 145,002 | 286,882 | 37,629 | 59,273 | 90,846 | 17,540 | 67,018 | 35,322 | 308,017 | 1,541,578 |
| Street Lighting | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 351,323 | 351,323 |
| Chillers | 626,006 | 10,747 | 95,600 | 0 | 39,486 | 45,519 | 137,217 | 450,004 | 18,248 | 74,581 | 1,497,409 |
| DX Packaged Systems | 1,751,856 | 360,749 | 993,502 | 451,677 | 695,149 | 231,322 | 29,452 | 183,179 | 76,961 | 620,222 | 5,394,068 |
| Ventilation Motors 5 hp | 588,206 | 101,139 | 216,652 | 181,056 | 101,572 | 86,193 | 50,344 | 353,027 | 51,028 | 158,649 | 1,887,865 |
| Ventilation Motors 15 hp | 34,988 | 15,580 | 24,600 | 0 | 0 | 43,229 | 17,318 | 98,217 | 0 | 21,390 | 255,322 |
| Ventilation Motors 40 hp | 126,019 | 0 | 36,790 | 0 | 7,729 | 0 | 10,229 | 0 | 0 | 90,053 | 270,820 |
| Non-coml refrigerators | 29,140 | 1,772 | 38,668 | 869 | 5,096 | 15,646 | 791 | 12,399 | 7,678 | 7,540 | 119,599 |
| Refrigeration System | 41,603 | 409,998 | 41,659 | 1,201,737 | 191,609 | 53,577 | 41,590 | 70,118 | 29,069 | 71,512 | 2,152,471 |
| Desktop PC | 529,300 | 3,575 | 52,436 | 3,352 | 44,414 | 44,197 | 2,280 | 52,771 | 1,856 | 70,432 | 804,613 |
| Monitor, 17" CRT | 221,181 | 1,513 | 33,375 | 1,834 | 45,464 | 32,187 | 2,233 | 22,965 | 92 | 55,353 | 416,197 |
| Monitor, 17" LCD | 370 | 9 | 30 | 12 | 39 | 152 | 9 | 52 | 5 | 77 | 754 |
| Copier | 180,599 | 433 | 24,478 | 4,289 | 17,069 | 9,062 | 1,139 | 33,340 | 394 | 22,819 | 293,622 |
| Laser Printer | 351,371 | 5,746 | 70,441 | 5,180 | 32,181 | 27,511 | 3,807 | 59,632 | 2,004 | 48,132 | 606,006 |
| Data Centers | 775,099 | 9,784 | 14,362 | 15,154 | 32,738 | 42,991 | 84,389 | 184,569 | 4,906 | 21,756 | 1,185,748 |
| Water Heating | 56,257 | 13,252 | 26,496 | 5,580 | 8,782 | 68,762 | 41,599 | 32,250 | 14,832 | 64,580 | 332,389 |
| Vending Machines | 126,993 | 4,941 | 7,956 | 2,075 | 20,230 | 23,019 | 9,918 | 18,143 | 10,459 | 11,608 | 235,342 |
| Cooking | 224,925 | 58,100 | 46,119 | 18,782 | 0 | 152,905 | 92,503 | 8,864 | 140,178 | 123,555 | 865,930 |
| Heating | 192,981 | 22,846 | 73,030 | 8,953 | 6,787 | 20,906 | 12,647 | 15,270 | 74,619 | 157,328 | 585,367 |
| Miscellaneous | 454,501 | 139,521 | 136,735 | 50,058 | 129,182 | 1,396 | 844 | 265,579 | 84,930 | 377,512 | 1,640,256 |
| **Total** | **9,562,578** | **1,546,022** | **3,413,686** | **2,544,730** | **1,834,769** | **1,428,873** | **858,486** | **2,940,201** | **822,491** | **3,625,623** | **28,577,458** |

**Commercial Electricity Consumption by End Use**

**Commercial Natural Gas Saturations**

| End Use | Office | Restaurant | Retail | Grocery | Warehouse | School | College | Health | Lodging | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Heating | 71% | 74% | 74% | 98% | 88% | 79% | 89% | 83% | 39% | 82% |
| Water Heating | 51% | 79% | 57% | 75% | 55% | 77% | 85% | 80% | 94% | 69% |
| Cooking | 31% | 88% | 28% | 66% | 0% | 69% | 0% | 80% | 36% | 29% |
| Other | 0% | 6% | 0% | 0% | 11% | 6% | 10% | 10% | 6% | 1% |

**Commercial Natural Gas EUIs (kBtu/sq ft)**

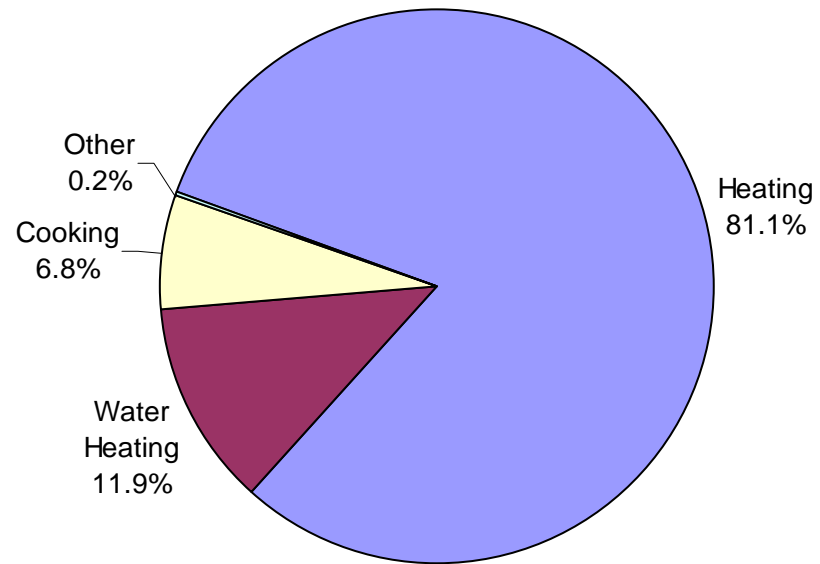| End Use | Office | Restaurant | Retail | Grocery | Warehouse | School | College | Health | Lodging | Other |
|---|---|---|---|---|---|---|---|---|---|---|
| Heating | 80.6 | 41.9 | 37.6 | 47.8 | 24.9 | 46.8 | 23.7 | 24.8 | 58.8 | 51.5 |
| Water Heating | 2.3 | 48.6 | 0.8 | 7.7 | 0.4 | 4.7 | 8.4 | 23.8 | 29.0 | 9.3 |
| Cooking | 0.2 | 153.3 | 0.5 | 10.3 | 0.2 | 1.1 | 1.7 | 2.6 | 4.4 | 1.0 |
| Other | 1.3 | 0.3 | 0.3 | 0.1 | 0.4 | 0.2 | 4.4 | 6.1 | 1.8 | 6.0 |
| Overall Energy Intensity (kBtu/ft2) | 58.6 | 205.0 | 28.3 | 59.4 | 22.1 | 41.5 | 28.7 | 42.4 | 52.0 | 49.2 |

**Commercial Natural Gas Floorspace (thousand sq ft) and Energy Consumption (Dekatherms) by Building Type and End Use**

| | Office | Restaurant | Retail | Grocery | Warehouse | School | College | Health | Lodging | Other | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Floorspace (thous. sf) | 364,978 | 27,401 | 198,482 | 29,267 | 178,526 | 117,644 | 71,171 | 97,218 | 54,186 | 267,450 | 1,406,324 |
| *Energy Consumption* | | | | | | | | | | | |
| Heating | 20,917,480 | 851,552 | 5,500,039 | 1,371,231 | 3,906,434 | 4,364,916 | 1,498,617 | 2,000,212 | 1,243,981 | 11,325,003 | 52,979,465 |
| Water Heating | 430,112 | 1,053,397 | 90,927 | 168,061 | 39,264 | 427,551 | 507,796 | 1,858,131 | 1,483,348 | 1,723,298 | 7,781,886 |
| Cooking | 22,290 | 3,711,473 | 27,530 | 197,889 | 63 | 89,485 | 0 | 199,754 | 85,751 | 77,733 | 4,411,969 |
| Other | 0 | 476 | 0 | 0 | 7,782 | 1,473 | 32,705 | 59,131 | 5,649 | 19,461 | 126,679 |
| Total | 21,369,882 | 5,616,899 | 5,618,496 | 1,737,181 | 3,953,544 | 4,883,425 | 2,039,119 | 4,117,228 | 2,818,730 | 13,145,495 | 65,299,998 |

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**Commercial Natural Gas Consumption by End Use**



Other 0.2%

Cooking 6.8%

Water Heating 11.9%

Heating 81.1%

*Commercial Peak Demand*

Commercial load shape data from KEMA's end-use databases will be utilized to allocate annual energy usage to time-of-use (TOU) periods. Peak period usage, developed on a sector-specific and end-use basis, will be calibrated across all sectors to equal the Missouri summer peak. This analysis has not yet been completed.

## Industrial Sector

*Building Type*

We used a different approach on the industrial side. The available data on energy use by industry was not very detailed. The Ameren potential study treated all industries together to protect the confidentiality of Ameren's largest customers. The KCP&L and KCP&L-GMO studies broke out a limited number of industries (for example, printing and petroleum), while presenting all manufacturing industries together. Since we wanted to break out 16 different industries, this data was inadequate, although it will act as a cross-check against numbers developed through other methods. As noted above, the distribution of industries varies greatly by region, making it impossible to apply distributions from other studies as we did with commercial gas.

We adopted an approach based on employment data by industry. The Bureau of the Census' 2007 Economic Census[5] provides state-level employment by NAICS code, which we combined with energy use per employee by industry from the Department of Energy's Manufacturing Energy Consumption Survey[6] to estimate distributions of electricity and gas use by industry for Missouri. These were then normalized to the consumption estimates developed above. The following figures show the breakdown of electricity and natural gas by industry.

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[5] http://www.census.gov/econ/census07/
[6] http://www.eia.doe.gov/emeu/mecs/contents.html

## Industrial Sector Electricity Consumption by Industry



- Fabricated Metals 4%
- Industrial Machinery 3%
- Primary Metals 16%
- Stone-Clay-Glass 4%
- Electronics 1%
- Plastics 4%
- Transportation Equipment 5%
- Petroleum 7%
- Miscellaneous 1%
- Water/Wastewater 1%
- Food 8%
- Chemicals 23%
- Textiles 0%
- Lumber-Furniture 3%
- Printing 2%
- Paper 18%
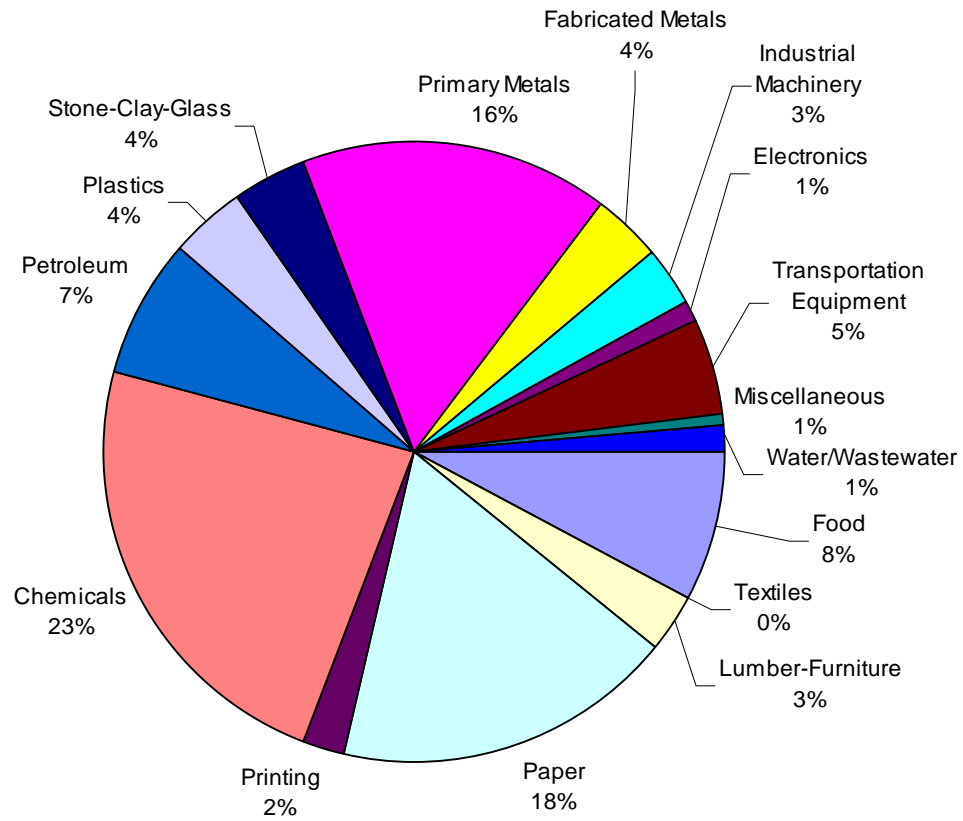
**Industrial Sector Natural Gas Consumption by Industry**
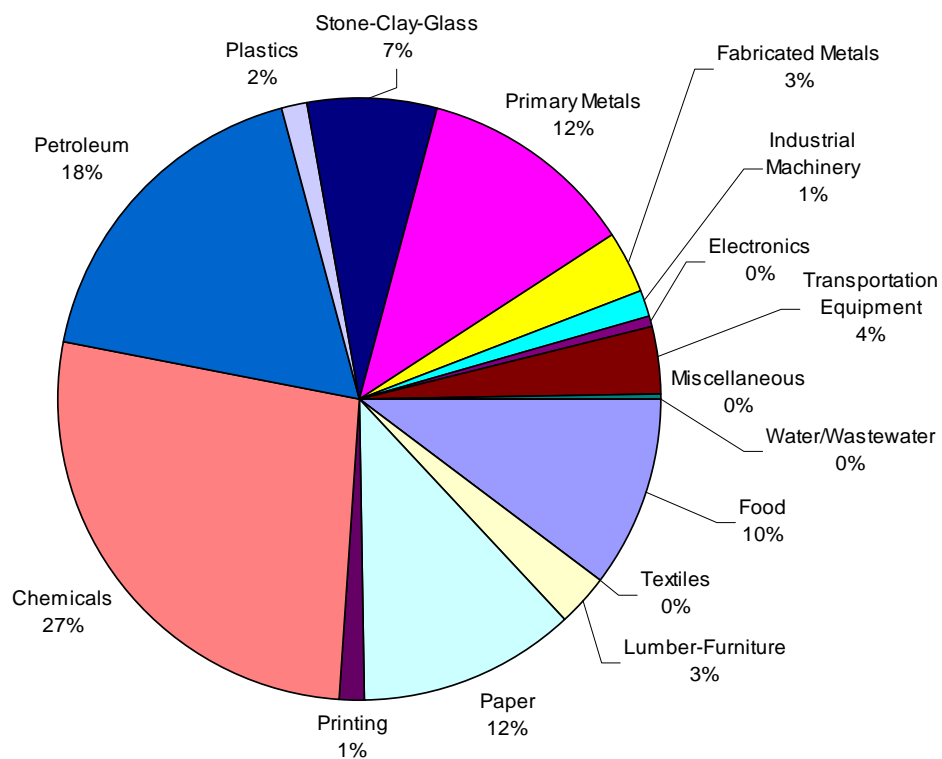
**Industrial Sector End Use Consumption**

Energy use was disaggregated into end-use consumption percentages based mainly on the Department of Energy's Manufacturing Energy Consumption Survey (MECS). Where possible, the most current end-use by industry splits were used. A minority of end use splits were withheld in the 2006 version due to sampling errors, and were informed by applying ratios derived from 2002 MECS end-use data. Further disaggregation of the motor end uses (into pumps, fans, drives, and compressed air) by industry were based on the 1998 study "United States Industrial Electric Motor Systems Market Opportunities Assessment." Water and wastewater treatment plant electric end-use splits are not included in MECS and were based on a number of surveys conducted during the course of KEMA's potential studies for Xcel Energy (Colorado) in 2004 and Rhode Island in 2010.

**Industrial Electric End-Use Consumption Splits**

| Electric End Use Consumption Splits | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Compressed Air | Fans | Pumps | Drives | Heating | Refrigeration | Other Process | Chiller | DX | Lighting | Other |
| Food | 0.08 | 0.08 | 0.15 | 0.14 | 0.08 | 0.26 | 0.01 | 0.01 | 0.07 | 0.07 | 0.04 |
| Textiles, Apprel | 0.04 | 0.07 | 0.09 | 0.30 | 0.10 | 0.12 | 0.01 | 0.07 | 0.06 | 0.10 | 0.03 |
| Lumber, Furniture | 0.05 | 0.09 | 0.11 | 0.41 | 0.09 | 0.01 | 0.01 | 0.04 | 0.03 | 0.08 | 0.09 |
| Paper | 0.04 | 0.15 | 0.24 | 0.32 | 0.12 | 0.02 | 0.02 | 0.01 | 0.04 | 0.04 | 0.02 |
| Printing | 0.04 | 0.07 | 0.09 | 0.32 | 0.04 | 0.06 | 0.01 | 0.10 | 0.09 | 0.12 | 0.07 |
| Chemicals | 0.03 | 0.06 | 0.26 | 0.21 | 0.09 | 0.08 | 0.14 | 0.01 | 0.05 | 0.04 | 0.03 |
| Petroleum | 0.12 | 0.07 | 0.49 | 0.13 | 0.05 | 0.05 | 0.01 | 0.00 | 0.03 | 0.02 | 0.01 |
| Rubber, Plastics | 0.04 | 0.07 | 0.09 | 0.31 | 0.16 | 0.09 | 0.02 | 0.06 | 0.05 | 0.09 | 0.04 |
| Stone, Clay, Glass | 0.06 | 0.14 | 0.18 | 0.20 | 0.22 | 0.03 | 0.03 | 0.01 | 0.05 | 0.05 | 0.03 |
| Prim Metals | 0.03 | 0.08 | 0.10 | 0.11 | 0.29 | 0.01 | 0.31 | 0.00 | 0.03 | 0.03 | 0.01 |
| Fab Metals | 0.12 | 0.07 | 0.09 | 0.22 | 0.20 | 0.04 | 0.05 | 0.05 | 0.05 | 0.09 | 0.03 |
| Ind Mach | 0.14 | 0.05 | 0.07 | 0.18 | 0.07 | 0.03 | 0.02 | 0.12 | 0.10 | 0.15 | 0.06 |
| Electronics | 0.10 | 0.03 | 0.04 | 0.09 | 0.15 | 0.09 | 0.08 | 0.13 | 0.11 | 0.12 | 0.07 |
| Transp Equip | 0.12 | 0.05 | 0.07 | 0.12 | 0.14 | 0.06 | 0.03 | 0.10 | 0.09 | 0.15 | 0.05 |
| Misc. | 0.09 | 0.03 | 0.04 | 0.16 | 0.10 | 0.06 | 0.02 | 0.13 | 0.11 | 0.17 | 0.08 |
| WWTP | 0.00 | 0.30 | 0.62 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.00 |

Sources: DOE 2006 & 2002 MECS, KEMA 1998 Motors Assessment

**Industrial Natural Gas End-Use Consumption Splits**

| Natural Gas End Use Consumption Splits | | | | | |
|---|---|---|---|---|---|
| | Process Heat | HVAC | Boiler | CHP and/or Cogen | Other |
| Food | 0.31 | 0.05 | 0.52 | 0.04 | 0.07 |
| Textiles, Apprel | 0.30 | 0.06 | 0.35 | 0.12 | 0.17 |
| Lumber, Furniture | 0.53 | 0.13 | 0.16 | 0.00 | 0.18 |
| Paper | 0.26 | 0.03 | 0.25 | 0.33 | 0.13 |
| Printing | 0.66 | 0.18 | 0.13 | 0.00 | 0.03 |
| Chemicals | 0.28 | 0.02 | 0.28 | 0.32 | 0.11 |
| Petroleum | 0.59 | 0.01 | 0.14 | 0.19 | 0.07 |
| Rubber, Plastics | 0.25 | 0.19 | 0.45 | 0.00 | 0.10 |
| Stone, Clay, Glass | 0.78 | 0.04 | 0.04 | 0.00 | 0.14 |
| Prim Metals | 0.78 | 0.07 | 0.05 | 0.05 | 0.05 |
| Fab Metals | 0.64 | 0.15 | 0.15 | 0.01 | 0.06 |
| Ind Mach | 0.29 | 0.37 | 0.20 | 0.05 | 0.10 |
| Electronics | 0.30 | 0.29 | 0.31 | 0.00 | 0.10 |
| Transp Equip | 0.30 | 0.34 | 0.15 | 0.02 | 0.19 |
| Misc. | 0.24 | 0.48 | 0.16 | 0.00 | 0.12 |

Sources: DOE 2006 & 2002 MECS

### Industrial Peak Demand

Industrial load shape data from KEMA's end-use databases will be utilized to allocate annual energy usage to Missouri's peak electricity use periods. Given limited information on industrial end use load shapes, typical whole-facility shapes will be applied to each end use. Peak period usage, developed on a sector-specific and end-use basis, will be calibrated to equal Missouri's summer peak. Peak demands for the process cooling/refrigeration and HVAC end uses will be adjusted upward to account for temperature sensitivity on peak days. Representative industrial peak demand estimates (from a previous study) by segment and end use are summarized in the following table. A similar analysis will be used to develop gas peak day demand estimates, an example of which (from a previous study) is shown in a second table.

### Industrial Electric Peak Demand by Industry and End Use – MW - 2008

| | Proc Heat | Proc Cool | Pumps | Fans | Comp Air | Proc Drives | Proc Other | HVAC | Lighting | Other | Boiler Use | CHP Proc | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Food | 1.5 | 15.8 | 8.1 | 4.6 | 4.2 | 7.7 | 0.2 | 4.6 | 3.4 | 3.6 | 0.4 | 0.1 | 54.2 |
| Textiles,Apparel | 0.8 | 0.9 | 0.9 | 0.7 | 0.4 | 3.1 | 0.0 | 1.7 | 0.9 | 0.5 | 0.0 | 0.0 | 9.7 |
| Lumber,Furniture | 0.8 | 0.2 | 1.7 | 1.3 | 0.7 | 6.2 | 0.0 | 1.5 | 1.4 | 1.5 | 0.1 | 0.0 | 15.5 |
| Paper | 0.1 | 0.1 | 0.9 | 0.6 | 0.1 | 1.2 | 0.1 | 0.2 | 0.1 | 0.1 | 0.0 | 0.1 | 3.6 |
| Printing | 0.5 | 0.0 | 1.9 | 1.4 | 0.8 | 6.7 | 0.1 | 0.0 | 2.5 | 3.2 | 0.0 | 0.0 | 17.0 |
| Chemicals | 0.4 | 1.4 | 3.5 | 0.9 | 0.3 | 2.8 | 2.3 | 1.0 | 0.6 | 0.4 | 0.1 | 0.0 | 13.6 |
| Petroleum | 2.1 | 2.5 | 17.0 | 2.6 | 4.3 | 4.5 | 0.1 | 1.4 | 0.9 | 0.4 | 0.1 | 0.1 | 35.9 |
| Rubber,Plastics | 2.4 | 1.6 | 1.5 | 1.1 | 0.6 | 5.2 | 0.2 | 1.9 | 1.3 | 0.5 | 0.0 | 0.0 | 16.3 |
| Stone,Clay,Glass | 5.9 | 1.3 | 5.3 | 4.2 | 1.8 | 6.1 | 0.4 | 2.3 | 1.4 | 1.3 | 0.0 | 0.0 | 30.0 |
| Prim Metals | 20.0 | 0.7 | 7.0 | 5.5 | 2.4 | 8.0 | 22.0 | 3.3 | 2.1 | 0.9 | 0.1 | 0.0 | 72.0 |
| Fab Metals | 10.2 | 1.9 | 3.5 | 2.6 | 4.7 | 8.7 | 0.4 | 5.6 | 4.2 | 4.0 | 0.0 | 0.0 | 45.8 |
| Ind Mach | 1.9 | 1.0 | 1.9 | 1.4 | 3.9 | 5.0 | 0.4 | 5.8 | 3.5 | 1.8 | 0.0 | 0.0 | 26.7 |
| Electronics | 11.2 | 8.2 | 3.4 | 2.6 | 8.7 | 7.4 | 3.3 | 26.9 | 10.8 | 8.7 | 0.1 | 0.0 | 91.2 |
| Transp Equip | 0.5 | 0.3 | 0.5 | 0.4 | 0.8 | 0.8 | 0.1 | 1.3 | 0.8 | 0.2 | 0.0 | 0.0 | 5.7 |
| Misc Ind | 0.3 | 0.5 | 0.5 | 0.3 | 0.4 | 1.7 | 0.0 | 1.5 | 0.8 | 0.9 | 0.0 | 0.0 | 7.0 |
| Mining | 1.1 | 2.4 | 3.7 | 2.8 | 1.5 | 13.2 | 0.2 | 9.7 | 4.9 | 6.2 | 0.0 | 0.0 | 45.6 |
| Water/WW | 0.0 | 0.0 | 6.5 | 1.9 | 1.9 | 0.0 | 0.0 | 0.6 | 0.3 | 1.7 | 0.0 | 0.0 | 12.9 |
| Total | 59.6 | 38.7 | 67.8 | 34.9 | 37.4 | 88.3 | 29.7 | 69.4 | 39.7 | 35.8 | 1.1 | 0.4 | 502.9 |

### Industrial Natural Gas Peak Day Demand by Industry and End Use – Dth - 2010

| | Proc Heat | HVAC | Boiler Use | CHP | Other | Total |
|---|---|---|---|---|---|---|
| Food | 338 | 507 | 425 | 64 | 100 | 1,435 |
| Textiles,Apparel | 88 | 259 | 85 | 35 | 35 | 503 |
| Lumber,Furniture | 299 | 1,124 | 129 | 3 | 70 | 1,625 |
| Paper | 43 | 50 | 48 | 54 | 16 | 211 |
| Printing | 269 | 1,733 | 90 | 69 | 21 | 2,182 |
| Chemicals | 145 | 63 | 111 | 118 | 32 | 469 |
| Petroleum | 29 | 3 | 8 | 7 | 3 | 51 |
| Rubber,Plastics | 81 | 416 | 103 | 4 | 38 | 643 |
| Stone,Clay,Glass | 476 | 211 | 14 | 4 | 40 | 745 |
| Prim Metals | 93 | 60 | 7 | 5 | 4 | 170 |
| Fab Metals | 565 | 1,453 | 81 | 53 | 25 | 2,177 |
| Ind Mach | 223 | 1,723 | 100 | 8 | 62 | 2,116 |
| Electronics | 392 | 2,940 | 348 | 2 | 118 | 3,800 |
| Transp Equip | 69 | 533 | 53 | 3 | 28 | 687 |
| Misc. | 162 | 1,245 | 112 | 29 | 32 | 1,579 |
| Total | 3,273 | 12,320 | 1,715 | 459 | 624 | 18,392 |

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